#ENVECON9

ENVECON

Economics of Natural Resources and the Environment

9th Conference, 8 – 9 December 2023

HYBRID

Co-organized by:

- **Laboratory of Operations Research, UTH.**
- **Laboratory of Forest Economics, AUTH.**

SCOPE

Main issues that concern the Economics of Natural Resources and the Environment with emphasis on the various environmental problems and their management and solution policies.

AIM

Highlight the interdisciplinary nature of environmental research through the exchange of views and experiences of researchers from different scientific fields and the finding of common components of research approaches.

Co-organization of the Conference

Laboratory of Operations Research
School of Economics and Business

Department of Economics

University of Thessaly

Laboratory of
Forest Economics

Faculty of Agriculture, Forestry, and Natural Environment.

School of Forestry and Natural Environment

Aristotle University of Thessaloniki

WELCOME

Dear, Invited guests, Colleagues, and Students.

On behalf of the Scientific and Organizing Committee I welcome you at the:
9th Conference on "**Economics of Natural Resources and the Environment**".

The 9th ENVECON Conference co-organized on 8 – 9 December 2023 by the Laboratory of Operations Research of the Department of Economics, University of Thessaly and the Laboratory of Forest Economics, Aristotle University of Thessaloniki and its director Associate Professor Dr. ***Konstantinos G. Papaspyropoulos***. The 9th ENVECON theme: "Novel perspectives on Forest, Water, and Urban Ecosystems".

The conference aims to present the main issues that concern the Economics of Natural Resources and the Environment and the recent scientific research on the field. The main focus will be given on sustainability and effective environmental management, while research on the environmental and social impacts of the recent weather-related environmental hazards due to climate change will also be presented. The conference aims to promote the exchange of views and experiences of researchers from different scientific fields and the finding of common components of research approaches, since the environment is governed from interdisciplinarity.

I would also like to wholeheartedly thank the keynote speakers of the conference: Prof. Dr. ***Eftichios Sartzetakis***, Mr. ***Emmanuel Kontekakis***, and Prof. Dr. ***Anastasios Xepapadeas*** who accepted the invitation to present their long-term remarkable research experience on topics relevant to the conference.

I would also like to thank the participants, not only of the current conference but of the previous ones as well. Their support to this scientific effort is significantly important and fosters even more our efforts to contribute to the development of Economics of Natural Resources and the Environment. Personally, I promise to continue the conference at the highest possible level at a time, continuing to promote important research findings regarding sustainable development, environmental protection and natural resources management, at both theoretical and applied levels.

I hope that all academics, researchers, and students, who participate in the Conference and who either present their research results or learn and value the work of other researchers, have a pleasant and constructive experience of the attendance of the Conference.

Conference Scientific Coordinator
Professor Dr. George E. Halkos
Laboratory of Operations Research
Department of Economics
School of Economics and Business
University of Thessaly, Volos, Greece

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- Iatridis Alexandros, University of Thessaly

Concise Conference Programme

Time (Greek Time)	Sessions-Topics
	Day 1 – Friday 08/12/2023
09:45-10:00	OPENING – WELCOME
10:00-12:00	Session 1: *Chairperson: Assc Professor Trung Thanh Nguyen* Agricultural production and food consumption for a more sustainable Asia.
12:00-12:30	Keynote Speaker Prof. Eftichios Sartzetakis
12:30-12:35	Coffee Break
12:35-14:15	Session 2: *Chairperson: Assc Professor Konstantinos G. Papaspyropoulos.* Forest Economics.
12:35-14:15	Session 3: *Chairperson: Professor Zacharoula Andreopoulou.* Environmental Risks.
14:15-15:00	Break
15:00-16:40	Session 4: *Chairperson: Professor George Halkos.* Climate Change and Urban Environment
15:00-16:40	Session 5: *Chairperson: Assc Professor Konstantinos Evangelinos.* Corporate Social Responsibility –Environmental Psychology.
16:40-17:00	Coffee Break
17:00-18:40	Session 6: *Chairperson: Dr. Jaime Moll de Alba.* Circular Economy
17:00-18:40	Session 7: *Chairperson: Professor Vassilios Profillidis.* Sustainable Transport
18:40-19:10	Keynote Speaker Mr. Emmanuel Kontekakis
	Day 2 - Saturday 09/12/2023
09:30-10:50	Session 8: *Chairpersons: Assc. Prof.: Teresa A. Oliveira* Data Science & Artificial Intelligence: Improving Health Equity and Urban Environments
09:30-10:50	Session 9: *Chairperson: Assc. Professor Amílcar Oliveira* Big Data in Environmental Risk Analysis
10:50-12:50	Session 10: *Chairperson: Professor Roido Mitoula* Welfare – Regional Development
10:50-12:30	Session 11: *Chairperson: Professor George Halkos.* Sustainable Water Management – Social and Natural Capital
12:50-13:30	Break
13:30-14:00	Keynote Speaker Prof. Anastasios Xepapadeas
14:00-15:40	Session 12: *Chairpersons: Prof. K. Tsekouras - Assc Prof. K. Kounetas.* Quantitative Methods – Environmental Efficiency
14:00-15:40	Session 13: *Chairpersons: Prof. Ioannis Nikolaou & Asst. Prof. Antonios Skouloudis* Sustainable Tourism– Circular Economy II
15:40-16:00	CLOSING & FINAL GIVEAWAYS

Keynote Speakers

"Environmental Regulation with preferences of social status"

Prof. Eftichios Sartzetakis

Prof. of Environmental Economics, Department of Economics. Dean School of Economic and Regional Studies, University of Macedonia.

"Corporate perspectives of the Titan Group in Biodiversity"

Mr. Emmanuel Kontekakis

Quality & Environmental Assurance Systems Administrator QA/QC Manager Aggregates Operations, Greece. Titan Group.

"The evolution of Research in Economics of Natural Resources and the Environment"

Prof. Anastasios Xepapadeas

Prof. of Economics, University of Bologna. Prof. Emeritus Athens University of Economics & Business.

Conference Schedule

Friday 08 December 2023

Opening – Welcome **09:45-10:00**

1st Session – Tsoumis Room **10:00-12:00**

Topic: **Agricultural production and food consumption for a more sustainable Asia**

Chairperson: **Assc Professor Trung Thanh Nguyen**

10:00-10:20	*Smallholders' crop commercialization and agriculture's structural change in Southeast Asia.* Manh Hung Do, Trung Thanh Nguyen, Ulrike Grote
10:20-10:40	*Internet use, non-farm employment and investment in agriculture: Evidence from Thailand and Vietnam* Nguyet Tran Thi Minh, Trung Thanh Nguyen, Manh Hung Do
10:40-11:00	*Can sustainable intensification boost productivity and fertilizer use efficiency? Insights from wheat systems in the eastern Indo-Gangetic Plains* Gokul P. Paudel, Jordan Chamberlin, Trung Thanh Nguyen
11:00-11:20	*Natural Resource Extraction and Poverty in Thailand and Vietnam* Alexander Oetjen
11:20-11:40	*Farming efficiency and agricultural transformation: Evidence from panel data for Thailand* Kasem Kunasri , Trung Thanh Nguyen
11:40-12:00	*Promoting artificial meat to improve food security and reduce resource-environment pressure: Is it practicable in China?* Shi Min, Minda Yang, Trung Thanh Nguyen, Ping Qing

Keynote Speaker – Tsoumis Room 12:00-12:30

Topic: "Environmental Regulation with preferences of social status"

Eftichios Sartzetakis

Professor of Environmental Economics, Department of Economics
Dean School of Economic and Regional Studies, University of Macedonia

Coffee Break 12:30-12:35

2nd Session – Tsoumis Room 12:35-14:15

Topic: Forest Economics

Chairperson: Assc Professor Konstantinos G. Papaspyropoulos

12:35-12:55	*History, trends, and gaps in forest economics research* Konstantinos G. Papaspyropoulos
12:55-13:15	*Relationship of Material Flow Cost Accounting and Bioeconomy in the Forest Industry sector* Marina-Vasiliki Andreadou & Konstantinos G. Papaspyropoulos
13:15-13:35	*Implementing focus groups for studying citizens' opinions for wood biofuels* Marina-Vassiliki Andreadou, Maria Gkirtzimanaki, Victoria Datsi, Antonios Zafeiroudis & Konstantinos G. Papaspyropoulos
13:35-13:55	*Development of Forest Experience using ICT* Georgilas Argyrios & Zacharoula Andreopoulou
13:55-14:15	*Circular Economy in the European Forest Sector through the Sustainability Reports of the Leading Forestry Companies* Dimitra Panori & Konstantinos G. Papaspyropoulos

3rd Session – Amphitheatre 12:35-14:15

Topic:	**Environmental Risks**
Chairperson:	**Professor Zacharoula Andreopoulou**
12:35-12:55	*Flood risk assessment and catastrophe analysis of cropland of the Central Macedonia water district.* Alexandros Tzavidis & Dionysios Latinopoulos
12:55-13:15	*Green digital finance nexus with traditional investments during crises.* Nikolaos Kyriazis
13:15-13:35	*Global Water Players, usage behavior and economic power classification.* Theodore Krintas
13:35-13:55	*A dynamic approach of climate change performance and weather-related environmental hazards: The effect of macroeconomic factors to climate indicators.* George Halkos & Argyro Zisiadou
13:55-14:15	*Assessment of vulnerability to reaction of forest fires in wildland urban interface. A Case study of Regional Unit of Zakynthos.* Kapsopoulou E. & Latinopoulos D.

Break 14:15-15:00

4th Session – Tsoumis Room 15:00-16:40

Topic: **Climate Change and Urban Environment**

Chairperson: **Professor George Halkos**

15:00-15:20	*Novel Methodologies with Virtual Reality Applications in Environmental Economics: The Arsinoe Project.* George E. Halkos, Phoebe Koundouri, Conrad Landis, Lydia Papadaki and Panagiotis – Stavros Aslanidis
15:20-15:40	*Comparing Air Pollution levels in Greece: The case of Athens and Salonica* Christos P. Kitsos C-S. Nisiotis
15:40-16:00	*Pathways2Resilience. Co-developing pathways towards climate resilient regions in Europe.* Phoebe Koundouri, Konstantinos Dellis, Kit England, Conrad Landis, Angelos Plataniotis, Paul Watkiss, Argyro Zisiadou
16:00-16:20	*Hydrological Assessment and Sustainable Development Prospects: Insights from a Training Course on Municipalities with Rivers.* Maria Kapouniari, Anastasia Katsoulea, Antigoni Zafeirakou, Eleni Papadopoulou
16:20-16:40	*Smart Sustainable Cities: A Greek Case Study.* Paraskevi Boufounou, Ilias Moustairas, Kanellos Toudas & Chrysovalantis Malesios

5th Session – Amphitheatre 15:00-16:40

Topic:	**Corporate Social Responsibility – Environmental Psychology**
Chairperson:	**Assc Professor Konstantinos Evangelinos**
15:00-15:20	*Corporate Social Responsibility CSR and the effects on employees' mental health.* Kristina Kucheruk & Konstantinos Evangelinos
15:20-15:40	*The significance of stakeholder engagement for promoting the Energy Efficiency First Principle (EE1st) in regional energy policy.* Stavros Spyridakos, Stefania Zourka, Sofia-Natalia Boemi, Stefanos Dodouras, Nikolaos Ntavos & Ioannis Fallas
15:40-16:00	*Integrating Environmental Education Techniques for Organizational Employees: A Sustainable Approach to Corporate Responsibility.* Kristina Kucheruk & Pavlina Papilia & Konstantinos Evangelinos
16:00-16:20	*The Psychology of non-market Environmental Valuation: research evidence, theoretical insights, and policy considerations.* Anastasia Gkargkavouzi & George Halkos
16:20-16:40	Environmental psychology of religion and environmental crisis. Georgios Fountoulakis

Coffee Break 16:40-17:00

6th Session– Tsoumis Room **17:00-18:40**

Topic:	**Circular Economy**
Chairperson:	**Dr. Jaime Moll de Alba**
17:00-17:20	*Circular economy in European Fashion Industry.* George E. Halkos, Jaime Moll de Alba and Panagiotis – Stavros C. Aslanidis
17:20-17:40	Fast *Fashion and Circular Economy.* Kristina Kucheruk & Konstantinos Evangelinos
17:40-18:00	*Local products entrepreneurship as a tool for sustainable regional development: the case of N. Chalkidiki.* Varvaris I., Strantzali P., Varvari E., Andreopoulou Z.
18:00-18:20	*Study of the impact of using SRF/RDF alternative solid fuels on the cement industry environmental footprint.* Nikolaos Morfopoulos & Maria C. Samolada
18:20-18:40	*Forest road pavement construction based on recycled materials is an economic and environmental neutral footprint implementation?* Stergiadou Anastasia, Tampekis Stergios, Kolkos George, Moutsopoulos Dimitrios, Stergiadis Charalampos

7th Session – Amphitheatre **17:00-18:40**

Topic: **Sustainable Transport**

Chairperson: **Professor Vassilios Profillidis**

17:00-17:20	*Forecasting Greenhouse Gas Emissions of Passenger Traffic to the Aegean Islands with the Use of Machine Learning.* Konstantinos Christidis, Vassilios Profillidis, George Botzoris, Lazaros Iliadis, George Nellas.
17:20-17:40	*Integrating bike paths into peri-urban environment: the case of Serres.* Foteini Mikiki, Vassilios Hortomaris & Athanasios Galanis
17:40-18:00	*Investigation of bicycle travel conditions in the cities of Thessaloniki and Lamia.* Athanasios Galanis, Artemis Gioldasi, Anna Rinota, Stavros Papaioannou, George Botzoris & Panagiotis Lemonakis
18:00-18:20	*Predicting the Societal Acceptance of Mega Road Infrastructure Projects in Greece: A Statistical Model Anchored in Sustainable Development Principles.* Angelos Papavasileiou, Roido Mitoula, Alexandros Zangelidis, Panagiotis Kaldis
18:20-18:40	*The Role of Big Data in Environmental Sustainability of Aviation: A Literature Review* Athanasios Georgakis, Vassilios Profillidis, George Botzoris

Keynote Speaker – Tsoumis Room **18:40-19:10**

Topic: "Corporate perspectives of the Titan Group in Biodiversity"

Emmanuel Kontekakis

Quality & Environmental Assurance Systems Administrator
QA/QC Manager Aggregates Operations, Greece.
Titan Group.

Saturday 09 December

Online

8th Session **09:30-10:50**

Topic: **Data Science and Artificial Intelligence Improving Health Equity and Urban Environments**

Chairperson: **Assc. Professor Teresa A. Oliveira**

09:30-09:50	*Bridging the Gap between Artificial Intelligence and Information Geometry: A Path to Efficient Decision-Making* Teresa A. Oliveira & Carla Cardoso
09:50-10:10	*Exploring statistical control methods in epidemiological scenarios and process management: A comparative study.* Gleice Leidenfrost, Elisa Henning & Teresa Oliveira
10:10-10:30	*Exploring Dental Health, Immunity, and HDL: A Comparative Study Using GAMLSS and PPR Models* J.A. Pereira, Luzia Mendes[1] & Teresa A. Oliveira
10:30-10:50	*A Statistical contribution to Decision Making: On Preventing Covid-19 in Mozambique selected regions.* M. Filomena Teodoro, Teresa Oliveira & Francisco Arune

9th Session 09:30-10:50

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Topic:	**Big Data in Environmental Risk Analysis**
Chairperson:	**Assc. Professor Amílcar Oliveira**
09:30-09:50	*Big data sets in environmental studies* Amílcar Oliveira
09:50-10:10	*Entropy and Uncertainty: Theoretical Framework and Fuzzy Logic for Environmental Economics.* George Halkos & Christos P. Kitsos
10:10-10:30	*A Review on the Impact of ESG on the Economy and Financial Risk* Catarina Seruca, Ana Gomes, Débora Nascimento, Rui Prata, Afshin Ashofteh
10:30-10:50	*Analysis of the inequality into distributions. An alternative approach to the Gini index applied to the environmental spending in EU.* A.Seijas-Macias, A. Oliveira & T. A. Oliveira

10th Session — 10:50-12:50

Topic: **Welfare – Regional Development**

Chairperson: **Prof. Roido Mitoula & Assc Prof. Eleni Sardianou**

10:50-11:10	*Consumer barriers to bio-based transitions: A study on food products.* Skouloudis Antonis, Malesios Chrysovalantis & Lekkas Demetris-Francis
11:10-11:30	*Assessing the feasibility of the Bellagio Process in the European Union.* Vasilis Nikou, Eleni Sardianou
11:30-11:50	*The Determinants of Heating Oil Consumption in the Household Sector.* Charitomeni Markantonaki, Eleni Sardianou, Roido Mitoula, & Ioannis Kostakis
11:50-12:10	*Millennials' Perspective on Sustainable Banking Practices.* Eleni Sardianou, Athanasia Stauropoulou, Ioannis Nikolaou & Konstantinos Evangelinos
12:10-12:30	*Environmental multipliers in Sraffian frameworks: derivation, implications, and empirical illustration.* Theodore Mariolis & Christos Tsirimokos
12:30-12:50	*Evaluation of Indoor Environmental Quality (IEQ) of Transport Cabins Using an Optical Particle Counter.* Bertrand Tchanche, Sotirios Papathanasiou, Anil Namdeo

11th Session **10:50-12:30**

Topic:	**Sustainable Water Management – Social and Natural Capital**
Chairperson:	**Professor George Halkos**
10:50-11:10	*Impact of Fuel Costs on Fish Prices: An Econometric Analysis in the Ionian Sea.* George Halkos, Phoebe Koundouri, Angelos Plataniotis, Vassiliki Vassilopoulou, Angelos Liontakis
11:10-11:30	*The dependence of the industries of the Greek economy from the fisheries and aquaculture sector.* Christos Tsirimokos, Irene Tzouramani, Angelos Liontakis, Stamatis Mantziaris & Alexandra Sintori
11:30-11:50	*The economic aspects of water management practices in Classical Athens.* George E. Halkos & Emmanouil M. L. Economou
11:50-12:10	*Exploring links between local social capital and social effectiveness of protected areas.* Nikoleta Jones & Chrisovaladis Malesios
12:10-12:30	*The geography of environmental migration. Greece: Case studies and affected areas.* Polyxeni Soufla, Dritsas Sofoklis, Matsiori Steriani, Paraskevopoulos Stefanos

Break **12:50-13:30**

Keynote Speaker 13:30-14:00

Topic: "The evolution of Research in Economics of Natural Resources and the Environment"

Professor Anastasios Xepapadeas

Professor of Economics, University of Bologna.
Professor Emeritus Athens University of Economics and Business.

12th Session 14:00-15:40

Topic: **Quantitative Methods – Environmental Efficiency**

Chairperson: **Prof. K. Tsekouras - Assc Prof. K. Kounetas**

14 :00 - 14:20	*Dynamic Modeling of Environmental Quality with Embodied Technological Progress.* George Halkos, George Papageorgiou, Emmanuel Halkos, John Papageorgiou
14:20 - 14:40	*European firms productivity growth and environmental regulation. Re-examining the Porter hypothesis.* Tsekouras Konstantinos, Kounetas Konstantinos, Capasso Salvatore, Rigas Nikos
14:40 - 15:00	*Testing the Environmental Kuznets Curve hypothesis in the case of tourism in the Eurozone member states.* George Ekonomou & George Halkos
15:00 - 15:20	*Are climate change policy instruments the sword of Damocles on fostering green technology independence to achieve green growth and sustainability in Europe?* Nikos Chatzistamoulou, Andriana Dimakopoulou
15:20 - 15:40	*Suitability evaluation of broadleaved wood for multiple uses with the application of PROMETHEE II method* Stefanos Tsiaras & Marina Chavenetidou

13th Session **14:00-15:40**

Topic:	**Sustainable Tourism – Circular Economy II**
Chairperson:	**Prof. Ioannis Nikolaou & Asst. Prof. Antonios Skouloudis**
14 :00 - 14:20	*Exploring the role of tourism in environmental degradation* George Ekonomou & George Halkos
14:20 - 14:40	*Tourism Local Development and Destination Management – The sustainability of small and medium-sized tourism enterprises and the environment in which they are based.* Ioanna Grigoriadou, Georgios Tsekouropoulos, Ourania Gouna, Sotirios Mandalidis
14:40 - 15:00	*Local Tourism Development and Destination – The buying behavior of the consumer-tourist based on the organizational culture for the environmental footprint of the enterprise.* Ioanna Grigoriadou, Georgios Tsekouropoulos, Ourania Gouna, Greta Hoxha, Dimitrios Theocharis
15:00 - 15:20	*Developing and implementing Corporate Social Responsibility and Circular Economy strategies in the Hotel Industry.* Panagiotis Vouros, Peni Lamprou, Christos Mitsokapas, Petros Dallas, Akrivi Vagena, Panagiotis Tridimas, Konstantinos Evangelinos & Panagiotis Grammelis
15:20 - 15:40	*A Methodological Framework and Typology to classify the regulatory- or proactive-driven corporate environmental and social behavior.* Ioannis Nikolaou, Nikolaos Trevlopoulos, Konstantinos Evangelinos and Thomas Tsalis

Closing **15:40-16:00**

Topic: Closing & Giveaways

Professor George Halkos

Department of Economics, School of Economics and Business Administration,
University of Thessaly

Proceedings Summary

The **9th ENVECON Conference** program consisted of *13 sessions* that included *66 presentations* by *156 participants* from *78 institutions*, and *3 Keynote speakers*. The 13 thematic sessions presented concerned agricultural production and food consumption, forest economics, environmental risks, climate change and urban environment, social and natural capital, sustainable tourism, welfare and regional development, circular economy, sustainable water management, sustainable transport, corporate social responsibility, environmental psychology, big data in environmental risk analysis, quantitative methods, and environmental efficiency, data science and artificial intelligence on improving health equity and urban environments. In total, **28 studies** were included in the conference proceedings, however, a number of papers has not been included in the book of proceedings since they have already been submitted to the conference special issues journals.

The 1st paper by *M.-V. Andreadou, M. Gkirtzimanaki, V. Datsi, A. Zafeiroudis and K. Papaspyropoulos* delves into citizens' opinion for wood biofuels as wood-based energy products can promote the transition from traditional fuels to novel green energy forms. Interestingly, the conclusion for the residents of Thessaloniki is that they remain dependent on non-renewable energy sources for their heating comfort due to the energy crisis. Making the transition to biofuels a challenging matter.

The 2nd paper by *A. Georgilas & Z. Andreopoulou* focuses on the development of forest experience using information and communication technology (ICT). The advantages of ICT-based technologies can minimize the human-driven negative externalities like the footprint on places such as the Olympus National Park, Greece. The ICT advancements might also ameliorate eco-tourism, provide alternative and sustainable development for local communities, and preserve the Olympus National Park.

The 3rd paper by *D. Panori and K. Papaspyropoylos* examined how the leading companies in the forestry sector can adopt circular economy business models. The study employs both qualitative and quantitative approaches in order to monitor the sustainability reports of the aforementioned companies. Overall, the examined reports showcase that the leading forestry companies have adopted such circular economy practices, however there is room for improvement as there are plenty of opportunities and prospects from the diffusion of circular economy strategies.

The 4th paper by *A. Tzavidis and D. Latinopoulos* focused on the assessment of the potential economic losses of the agricultural sector due to floods as unexpected events. The paper presents different scenarios with return periods of T-50, 100, 1000 years and though the AGRIDE-c (AGRIculture DamagE model for Crops) that evaluates the expected yield reduction. Providing a holistic understanding on how pivotal is to blueprint for flood countermeasures in order to establish a well-rounded flood disaster management.

The 5th paper by *T. Krintas* gave insights on water management and the high-water stress of this natural resource. Moreover, this study examines how companies can deal with water-related challenges via the application of principal component analysis, using global data and categorizing companies based on their water usage. Therefore, the paper provides policy insights on sustainable water management strategies and practices.

The 6th paper by *E. Kapsopoulou and D. Latinopoulos* gives insight into the vulnerability assessment to forest fires reaction in wildland-urban interface and more specifically at the case study of regional unit of Zakynthos Island, Greece. The geographical, social, and economic vulnerability dimensions have been recognized, leading to the conclusion that there is a profound weakness in authorities prevention policies and lack of proper planning.

The 7th paper by *C. Kitsos and C. S. Nisiotis* compares the air pollution levels in two case studies: Athens and Salonica, Greece. The study monitors the impact of several air pollutants, inter alia CO, NO, NO_2, SO_2 and O_3. The conclusion is that for all pollutants, apart from O_3, and for all areas their concentrations seem to be eliminated during the time.

The 8th paper *G. Halkos, P. Koundouri, A. Plataniotis, V. Vassilopoulou, & A. Liontakis* estimated the effects of fuel costs on fish prices by applying an econometric analysis in the Ionian Sea. The paper monitors four key fish species: Hake, Shrimp, Striped Red Mullet, and Red Mullet. As a result, there is a complex picture: while Hake and Shrimp prices exhibit a small sensitivity to fuel cost fluctuations, Striped Red Mullet and Red Mullet prices are significantly impacted by changes in fuel costs. These results suggest a nuanced interplay between operational costs and market dynamics in the fisheries sector.

The 9th paper by *K. Kucheruk and K. Evangelinos* delve into the effects of corporate social responsibility on the employees' mental health. This study gives prominence on the human resources management as it is seemingly overlooked by scientists and policymakers. Therefore this research offers practical solutions on businesses in order to optimize the inclusion of employees and address their needs.

The 10th paper by *S. Spyridakos, S. Zourka, S. N. Boemi, S. Dodouras, N. Ntavos, I. Fallas and G. Marnellos* studies how stakeholder engagement can boost energy efficiency first principle (EE1st) in regional energy policy. The EE1st takes into account both energy conservation and demand into account, moreover, it gives focus on how stakeholders can affect these policies. Ultimately, the paper can map the implementation of EE1st in stakeholder regional energy ecosystem.

The 11th paper by *K. Kucheruk, P. Papilia and K. Evangelinos* observes the influence of environmental education under the scope of social corporate responsibility. Apparently, the impact of environmental education is pivotal as it can foster responsibility in business culture and ethics. Ultimately, the employees as carriers of knowledge can be accelerators to sustainable development through voluntary participation in sustainability initiatives.

The 12th paper by *G. Fountoulakis* sheds light on the prominence of environmental psychology of religion in an era of environmental crisis. An interesting issue is how pro-environmental behaviours can be strengthened by the individual religious beliefs. Moreover, the paper observes how ethical practices and moral education can lead to a better understanding of the natural environment. As a conclusion, the paper finds that the dynamic relationship between people and their environment can be boosted by shared moral values within communities.

The 13th paper by *G. Halkos, J. Moll de Alba, and P. S. Aslanidis* monitors the eco-efficiency in the fashion industries of 22 European countries under the scope of circular economy during the period 2000 – 2021. The paper employs a hybrid window data envelopment analysis with two models, with window widths 3 and 5 respectively. The paper shows that the highest eco-efficiency performance is linked to Norway, France, and Italy, whereas the lowest in Czech Republic, Estonia, and Latvia. As a result, there is a two-tier categorization of the European countries, the Western and Northern countries show greater performance, while the Eastern Europe and Portugal present lower performance.

The 14th paper by *K. Kucheruk and K. Evangelinos* delve into the interrelations between fast fashion and circular economy. Circular economy solutions can cope with the negative externalities the derive from the excessive consumption due to fast fashion. The study finds that the fundaments of a sustainable understanding is proper education and the promotion of awareness campaigns.

Overall, the paper necessitates for agile and adaptable approach on how to establish an environmentally conscious global community.

The 15th paper by *I. Varvaris I., P. Strantzali, E. Varvari, and Z. Andreopoulou* observes how local products entrepreneurship can be used as a powerful policymaking tool for sustainable regional development. The paper uses as a case study the Chalkidiki region, Greece. Alternative tourism can entail positive aspects on local products and businesses; hence, policymakers should take these aspects into account in order to strengthen regional development.

The 16th paper by *N. Morfopoulos and M. Samolada* monitors how alternative fuels can impact industrial environmental footprint. The paper studies how SRF/RDF fuel can minimize the concentration of carbon footprint in the atmosphere. However, an important prerequisite for the utilization of SRF/RDF fuels is that these fuels ought to follow specific specifications regarding their recycling efficiency in order to avoid any negative externality such as the presence of pollutants in this waste-driven fuel.

The 17th paper by *K. Christidis, V. Profillidis, G. Botzoris, L. Iliadis, and G. Nellas* forecasted greenhouse gas emissions of passenger traffic through machine learning. The case studies are the islands of Cyclades and Dodecanese in the Aegean, Greece. In this analysis takes into account the evaluation of effectiveness of potential policies on strengthening the adoption of modal shifts and on observing the impact of different economic-related scenarios.

The 18th paper by *F. Mikiki, V. Hortomaris, and A. Galanis* that monitors the integration of bike paths into peri-urban environment. The paper monitors the case study of the Serres region, Greece. The paper offers a novel understanding on how forest scientists, engineers, and policymakers can appreciate the environmental benefits from a cycling path. Therefore an interesting eco-tourism case study can shed light on the environmental benefits and economic profitability.

The 19th paper by *A. Galanis, A. Gioldasi, A. Rinota1, S. Papaioannou, G. Botzoris, and P. Lemonakis* investigate the bicycle travel condition in the cities of Thessaloniki and Lamia, Greece. The survey incorporates a questionnaire of 220 participants (110 participants in each sub-sample) and conducted during January and February 2023. Overall this paper contributes to the broader understanding of how bicycle travel conditions can affect people's well-being.

The 20th paper by *A. Georgakis, V. Profillidis, and G. Botzoris* reviews the role of big data in environmental sustainability of the aviation industry. The paper supervises the environmental sustainability of the aviation industry via novel big data techniques. As a result, the state-of-the-art literature review reveals a plethora of technical intricacies, economic barriers, and institutional conundrums.

The 21st paper by *C. Seruca, A. Gomes. D. Nascimento, R. Prata, and A. Ashofteh* reviewed from the Scopus, Web of Science, and Google Scholar databases the latest research articles on ESG determinants on economic dynamics and financial risk and address major challenges associated with this highly researched topic. As a result, the ESG-related credit rating might impact customer behavior for better access to credit. Overall the paper provided policy insights regarding, inter alia, the influence credit ratings, economic growth, and to conduct corruption risk management strategies.

The 22nd paper by *A.Seijas-Macias, A.Oliveira, and T. A Oliveira* gives novel insights on the Gini index, moreover, the paper provides a modern reinterpretation of the Gini index as well as the provision of alternative measures.

The 23rd paper by *T. Mariolis and C. Tsirimokos* monitored the theoretical and empirical aspects of environmental multipliers in a Sraffian framework. The paper provides an extension of the Kurz matrix demand multipliers for the Sraffian framework. In this case, the effectiveness of traditional demand management can be put into question, but also it gives an alternative solution applicable to individual industries or sectors.

The 24th paper by *C. Tsirimokos, I. Tzouramani, A. Liontakis, S. Mantziaris, and A. Sintori* studied the Greek industries' dependence on the fisheries and aquaculture sector. Two models were applied, on the one hand the Leontief demand-driven model, and on the other hand, the Ghosh supply-driven input-output model. As a result, there are inter-industrial connections between the Greek industries and the sector of fisheries and aquaculture, offering policymakers a novel insight to foster economic resilience and sectoral sustainability.

The 25th paper by *G. Halkos and E.M. Economou* presents the economic aspects of water management in the Classical Athens era. Two central issues on water management were the investments on water management and the effectiveness of these practices. The paper presents a complex water management system in respect to the ancient times, by shedding light on the incentives and disincentives for proper water treatment.

The 26th paper by *G. Halkos, M. Papageorgiou, E. Halkos, and G. Papageorgiou* shed light on the dynamic modelling of environmental quality with embodied technological progress. The paper employes a multi-stage optimal control model that leads to the conclusion that the abatement process jumps upwards after the adoption of a novel technological advancement. Another result is that before the adoption of a novel technology the abatement processes is reduced by the social planner.

The 27th paper by *S. Tsiaras and M. Chavenetidou* employes the PROMETHEE II method in order to evaluate the suitability of broadleaved wood. This methodology is a multiple- criteria decision analysis that can incorporate qualitative and economic characteristics as well. The main conclusion is that walnut, chestnut, and oak can be the deemed suitable for furniture manufacturing and production of sawn timber, in constast with beech and poplar.

The 28th paper by *G. Halkos, G. Papageorgiou, E. Halkos, and G. Papageorgiou* compared the effectiveness of counter pollution policies. Both aggressive and defensive policies have been monitored via optimal control theory. The paper concludes that even though the defensive strategy can be any time applied. However, the optimal control theory on this issue necessitates that the aggressive strategy be used if the volume of pollutants is below a certain limit.

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Conference Papers

Session 1

Agricultural production and food consumption for a more sustainable Asia

Smallholders' crop commercialization and agriculture's structural change in Southeast Asia

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Abstract

Given the importance of understanding the impacts of agricultural commercialization on agriculture's structural change and equality at the micro level, we examine the effects of smallholders' crop commercialization on structural change and assess how the impacts of crop commercialization on smallholders' income are distributed across farm and household income quantiles. To address these research issues, we use balanced panel of 2,867 rural smallholders collected in three survey waves from two middle-income countries in Southeast Asia for empirical analysis. For the first research issue, our results from a simultaneous equation model show that crop commercialization has a positive interrelationship with crop mechanization. Besides, the results from panel fixed-effects with control function approach indicate that crop commercialization has a positive influence on two indicators of structural change, namely the share of livestock income and the share of non-farm laborers. For the second research issue, results from an unconditional quantile regression model point to the fact that smallholders in the poorest quantile groups benefit the most from crop commercialization.

Keywords: panel data; simultaneous equation; fixed-effects with control function; income inequality.

JEL Codes: C33; Q00; Q12.

Internet use, non-farm employment and investment in agriculture: Evidence from Thailand and Vietnam

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Abstract

Using data from the Thailand Vietnam Social Economic Panel (TVSEP) in 2016 and 2017, we analyze the relationship between internet use and non-farm employment indicators. This step employs the instrumental variable fixed-effect regression to address the endogeneity issue of internet use. We further examine the impacts of non-farm income on farm expenditure (e.g., hiring labor, family labor, hiring machinery, and fertilizer) and agricultural investment (e.g., machinery, livestock, and farm expansion) by applying the heteroscedasticity-based instrument approach. Our results show that internet use increases the probability of non-farm participation, the number of laborers, and per capita non-farm income. Higher education of household members increases income from non-farm employment. Furthermore, findings reveal that rural households utilize their non-farm earnings to invest in long-term machinery and farm expansion but move out of crop production. The effect of moving out of cropping is stronger among the ethnic groups with higher income from non-farm employment. We recommend facilitating internet use among rural households and promoting education as these factors provide rural members opportunities and higher earnings from non-farm employment. Moreover, target policies may be addressed to stimulate the positive effect of non-farm income on investment in machinery and farm expansion to promote agriculture.

Keywords: Internet; Non-farm employment; Agricultural investment; Instrumental variable fixed-effect estimation; Hetero-based instrument.

JEL Codes: D13, O33, O53, Q12.

Can sustainable intensification boost productivity and fertilizer use efficiency? Insights from wheat systems in the eastern Indo-Gangetic Plains

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Abstract

Sustainable intensification (SI) has been promoted within smallholder farming systems to improve agricultural productivity and reduce negative environmental externalities associated with agri-food production. However, limited knowledge exists regarding the impact of SI on crop productivity and fertilizer use efficiency in the Indo-Gangetic Plains of South Asia. This study assesses the impact of early sowing of wheat on productivity, nitrogen, phosphorous, and potash use efficiency in eastern India. We use an instrumental variable approach to control the potential endogeneity that arises from both observed and unobserved sources of heterogeneity. We find that early sowing enhances wheat productivity, nitrogen, phosphorus, potash, and combined fertilizer use efficiency. However, these impacts are unevenly distributed. Early sowing on large farms and farms applying doses of nitrogen exceeding the recommended levels are negatively associated with productivity and fertilizer use efficiency. Our findings suggest that while SI has potential to enhance crop productivity and fertilizer use efficiency, significant policy initiatives are required to minimize the over-application of fertilizers and mitigate the negative environmental externalities associated with agri-food systems in India.

Keywords: Sustainable intensification; Agricultural productivity; Environmental externalities; Nitrogen use efficiency; Impact heterogeneity; South Asia.

JEL Codes: O13; Q01; Q12; Q15.

Natural Resource Extraction and Poverty in Thailand and Vietnam

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Abstract

Rural poor households are highly reliant on natural resource extraction. Understanding the relationship between poverty and environmental resources can help implement effective policies that lift households out of poverty. This study identifies factors driving the decision to extract natural resources in rural Thailand and Vietnam and explores its effect on household welfare and welfare distribution. The data is derived from a survey of 4400 households in 6 provinces in Thailand and Vietnam undertaken in 2010, 2013, and 2016. A Heckman model is conducted to identify the factors driving a households' decision to extract natural resources. To identify welfare effects of natural resource extraction on different welfare measures, an endogenous switching regression is used. Lastly, quantile regression gives insights in the welfare distribution of households extracting natural resources. The results demonstrate that the poor are more reliant on natural resources and that extraction reduces household welfare. Further findings of this study suggest that promoting off-farm employment, education, and other livelihood opportunities reduces the extraction of environmental resources.

Keywords: Poverty, environmental income, multidimensional poverty, regression models, Thailand, Vietnam.

JEL Codes: Q57; Q20; Q12.

Farming efficiency and agricultural transformation: Evidence from panel data for Thailand

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Abstract
In this study, we explore the relationship between farming efficiency and agricultural transformation at the micro-level. We utilize a panel dataset of more than 1,400 rural households collected between 2007 to 2019 in three provinces of Thailand. We first assess farming efficiency by employing a true random-effects model with Mundlak's adjustments (CRE). We then examine the association between farming efficiency and agricultural transformation indicators using a two-stage least squares (2SLS) instrumental variables (IV) regression approach. In addition, we employ a random-effects probit model to analyze how farming efficiency influences the transition of households from full-time farming to part-time farming. Key findings show that farming efficiency is a driver of agricultural transformation, and that it relieves labour from the farm to non-farm sectors. We suggest measures for supporting farmers to increase their farming efficiency through, for example, promoting knowledge transfer and technical training.

Keywords: Agricultural transformation, Farming efficiency, Thailand.

JEL Codes: D04; F16; Q12;O12

Promoting artificial meat to improve food security and reduce resource-environment pressure: Is it practicable in China?

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Abstract

This study aims to understand the practicability of promoting the consumption of artificial meat to achieve the dual goals of improving food security and reducing resource-environment pressure by evaluating Chinese consumers' willingness to pay (WTP) for artificial meat. A conjoint choice experiment was conducted to state consumers' preferences and WTP for artificial meat, including plant-based and cultured meat. The estimation results show significantly lower WTP of consumers toward both cultured meat and plant-based meat than farm-raised meat, while consumers' WTP for plant-based meat is relatively high compared to that for cultured meat. The intervention of positive information regarding artificial meat significantly narrows the disparity in the WTP for artificial meat compared to that for farm-raised meat. The findings reveal that the marketization of artificial meat in China is confronting a considerable challenge, while the practicability of promoting artificial meat consumption to achieve the dual goals of improving food security and reducing resource-environment pressure is poor at present. Several policy recommendations are proposed to promote artificial meat consumption in future. The study supplements the literature about Chinese consumers' attitudes toward artificial meat, while the findings provide an essential reference for policy design of promoting the consumption of artificial meat.

Keywords: Willingness to pay; Choice experiment; Information intervention; Artificial meat.

JEL Codes: P36; Q56.

Session 2
Forest Economics

History, trends, and gaps in forest economics research

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Abstract
Forest Economics is a scientific field that belongs to the wider Forestry science and is related to the methods and tools aimed at the optimal economic distribution in society of forest ecosystem services, which are in short supply. Forest Economics dates back to 1849, when the German Forester Martin Faustmann published his work on calculating the maximum value of forest land and the time for which it is economically optimal (maximizing profit) for the owner of a forest (forest owner) the felling of a plantation-culture with forest trees, or a forest stand. Faustmann's Forest Economics dominated the research of this scientific field for many years. In the last 20 years, the post-Faustmann Forest Economics has been added to the classical Forest Economics which deals with the economic valuation of forest resources and forest ecosystem services, with the examination of economic theories regarding forest economics (behavioral economics, neuroeconomics, game theory etc.), by examining issues related to the forest industry, such as Corporate Social Responsibility, Sustainability Reporting and Cost Accounting, circular economy and bioeconomy. The bioeconomy, as an economy based solely on renewable natural resources, concerns both classical and post-Fasutmann Forest economics. This research discusses the gap in the literature on combining Faustmann's model with the Bioeconomy and presents other current trends in Forest Economics research.

Keywords: Faustmann model; Bioeconomy; Economics of Forest Resources; Sustainability Reporting.

JEL Codes: M14; Q23; Q51; Q57.

Relationship of Material Flow Cost Accounting and Bioeconomy in the Forest Industry sector

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Abstract
The bioeconomy is based on the concept of applying biological principles and processes to all sectors of the economy and gradually replacing fossil-based raw materials with bio-based resources and principles. To understand how and how much biomass and bio-based materials are produced, how interconnected the bio-based value chains are, and what sustainability effects bio-based value chains or products have, a thorough understanding of the bioeconomy's material and energy flows is required. Official statistics on the production and processing and flow of materials as organic products are available, but the indicators provided do not have a requirement to calculate the flows of organic materials processed at different stages of the value chain. For this reason, the material flow cost accounting (MFCA) method was created, for which research shows that it brings many economic but also environmental advantages to the companies that use it. The present research utilized a questionnaire sent to 90 European forest industries to capture opinions regarding MFCA (Material Flow Cost Accounting), its relationship with the bioeconomy, whether it is being utilized, and if not, what factors are considered deterrents to its usage. As 24.4% responded to the questionnaire, an attempt was made to gather the same information from the companies' websites to cover the shortfall. Consequently, the responses from the websites did not differ from those obtained from the companies that responded to the questionnaire.

Keywords: Material Flow Cost Accounting; Bioeoconomy; Environmental Management Accounting; Forest industries; Europe

JEL Codes: Q00; Q50; Q23; Q56; Q59.

Implementing focus groups for studying citizens' opinions for wood biofuels

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Abstract
Wood-based energy products represent a significant category for energy conservation and reducing our dependency on traditional fuels. As an alternative fuel, these products are derived from sustainable sources like forests and can be used for energy production through combustion. Their usage contributes to reducing greenhouse gas emissions and promotes a more sustainable approach to energy production. Furthermore, the utilization of wood-based energy products underscores the importance of renewable energy in addressing our energy needs in a more environmentally friendly manner. In the present research, we examine the opinions of citizens on wood-based energy products as an alternative fuel. The method employed involved four focus groups, including university graduates with environmental studies aged 25-30, secondary education teachers aged 45-65, private sector employees in secondary education aged 35-45, and employed women aged 30-45 living at Thessaloniki Urban Area. The results indicated that despite the energy crisis, price hikes, and potential natural gas shortages, residents remain dependent on heating sources derived from non-renewable natural resources, making the transition to biofuels relying on the renewable natural resource of wood challenging

Keywords: Marketing; Biofuels; Focus groups; Alternative Fuels.

JEL Codes: L73; M31; O13; P18; Q57; Q13; Q23.

1. Introduction

According to the definition, any organic material of natural origin can be considered biomass. Thus, in addition to plants and trees, materials such as animal manure and straw are also regarded as biomass. Additionally, paper and its waste, slaughterhouse waste, organic waste from food industries, vegetable oils waste, and food residues are considered biomass and can be used in various ways in different bioenergy systems for the production of electricity, heat, and motor fuels. The European directive defines biofuels as a range of products produced from energy crops and vegetable oils. Such products include bioethanol, biodiesel, biogas, biomethanol, and others. The biofuels market can serve as a vehicle for restructuring the Greek economy, as is already happening in other countries of the European Union. High yields, low requirements for irrigation and nutrients, and environmental friendliness are the main advantages promoting the so-called energy crops, which are also promoted through marketing by the European Union (Klass,2004).

Environmental searches for alternative methods of using woody products as energy have aroused great interest in the global community. Biofuels are an original idea and have proven to be the most sustainable solution to the energy crisis so far. Today, due to the significant increases already observed in oil and natural gas prices, old habits, such as burning wood and pellets, seem to be gradually returning to Greek everyday life. This resurgence is driven by the necessity to mitigate the impact of rising energy costs and the recognition of the environmental benefits associated with renewable energy sources. However, transitioning to woody energy products presents challenges, including infrastructure development, technological advancements, and consumer perceptions. The purpose of our research was to understand to what extent consumers in today's era are willing to turn to woody energy products and if not, what are the reasons preventing them. By exploring these factors, we aim to provide insights that can inform policy decisions and facilitate the transition towards more sustainable energy practices in Greece and beyond.

2. Literature Review

Wood-based energy products stand as a cornerstone in the arena of energy conservation, presenting a tangible remedy to diminish our dependence on traditional fuels. Originating from sustainable reservoirs such as forests, these products emerge as a viable alternative fuel, adept at fueling energy production through combustion. Their utilization carries substantial environmental advantages, particularly in the realm of curbing greenhouse gas emissions, thus nurturing a more sustainable framework for energy generation. By accentuating the reliance on renewable energy reservoirs, particularly wood-based alternatives, we underscore the exigency of embracing environmentally conscientious methodologies to satisfy our escalating energy requisites (Τσεπλετίδου, 2013).

Woody biomass, utilized for various purposes including energy production, comes from a range of sources. Here are some common sources:

1. **Forestry Residues**: This includes wood residues left over from logging operations, such as branches, treetops, and stumps.
2. **Logging Residues**: These are materials left behind after timber is harvested, such as slash (leftover branches, bark, and foliage) and small diameter trees.

3. **Forest Thinnings**: Thinning forests to promote healthier growth can generate woody biomass. This involves removing smaller or less desirable trees to create space for healthier trees to thrive.
4. **Urban Wood Waste**: From tree trimmings, pruning, and removals in urban areas. This includes materials from parks, gardens, and street maintenance.
5. **Agricultural Residues**: Agricultural processes produce biomass residues such as crop residues (e.g., corn stover, wheat straw) and orchard prunings.
6. **Industrial Wood Residues**: By-products from wood processing industries, such as sawdust, wood chips, and shavings.
7. **Dedicated Energy Crops**: Some crops are grown specifically for biomass energy purposes, such as willow, poplar, and eucalyptus.
8. **Woody Biomass from Restoration and Conservation Projects**: Biomass can be harvested sustainably from restoration and conservation projects aimed at managing forests for biodiversity, wildfire risk reduction, or habitat improvement.

These sources can vary depending on regional availability, forestry practices, and industrial processes. Sustainable management and harvesting practices are crucial to ensure the long-term viability and environmental benefits of using woody biomass for energy (Heikki, 2000).

Forests, covering approximately one-third of the Earth's surface according to the Food and Agriculture Organization (FAO, 2000), wield immense influence across various dimensions. Economically, the forestry sector stands as a pivotal source of income, with timber serving as a fundamental resource for myriad construction, domestic, and industrial endeavors. Beyond mere economic significance, forests hold profound environmental importance. They are indispensable for preserving biodiversity, serving as habitats for countless plant and animal species. Moreover, forests play a pivotal role in the fight against climate change. They act as vital carbon sinks, sequestering atmospheric carbon dioxide and mitigating the impacts of greenhouse gas emissions. Additionally, forests contribute to climate change mitigation through biomass production, providing a renewable energy source that holds promise for sustainable energy generation. Thus, forests emerge not only as economic assets but also as critical ecological keystones, embodying multifaceted value in the pursuit of global sustainability.

Forest biomass can manifest in various forms, each with its own unique properties and potential uses. Here are some common forms of forest biomass:

1. **Whole Trees**: Entire trees, including trunks, branches, and foliage, can be utilized as biomass. Whole trees are typically used in cases where there's a need for large-scale energy production or in industries such as pulp and paper.
2. **Logging Residues**: These include branches, treetops, and other materials left behind after timber harvesting operations. Logging residues are often collected and utilized for biomass energy generation or converted into wood products like wood chips.
3. **Forest Thinnings**: Thinning forests involves removing smaller or less desirable trees to promote healthier growth among the remaining trees. The removed trees, known as forest thinnings, can be utilized as biomass for energy production or other applications.
4. **Wood Chips and Sawdust**: Wood chips and sawdust are by-products of wood processing industries such as sawmills and woodworking shops. These materials are commonly used as

biomass feedstock for energy production or as raw material in the manufacturing of wood-based products. (Κουτσοδήμος,2014).

5. **Tree Bark**: Bark stripped from trees during processing or harvested separately can be utilized as biomass. While not as energy-dense as other forms of biomass, tree bark can still be used for energy generation or converted into other products like mulch or landscaping materials.
6. **Wood Pellets**: Wood pellets are a densified form of biomass made from compacted sawdust or other wood residues. They are commonly used as a convenient and efficient fuel for residential heating, commercial heating, and power generation (Zawiślaka and et. al, 2020).
7. **Black Liquor**: Black liquor is a by-product of the pulping process in the paper industry. It consists of lignin, hemicellulose, and other wood components dissolved in water. Black liquor can be burned to generate heat and power within the pulp and paper mills, making it a valuable source of biomass energy.

These forms of forest biomass offer versatile options for energy generation, industrial applications, and sustainable resource management. Proper harvesting and utilization practices are essential to ensure the long-term sustainability of forest biomass resources.

Bioenergy represents a crucial component of Renewable Energy Sources (RES), harnessing the energy inherent in organic materials of biological origin. These materials, collectively known as biomass, serve as the primary source of bioenergy, having undergone the transformative process of photosynthesis. Through photosynthesis, organic matter captures solar energy from radiation and converts it into chemical energy, stored within the biomass. This chemical energy can then be unlocked and utilized through various bioenergy technologies for heat, electricity, or fuel production. In Greece, as per a census conducted by the Centre for Renewable Energy Sources in 2007, substantial biomass reserves are directly available for bioenergy production. Estimates indicate approximately 7,500,000 tons of agricultural residues sourced from cereals, maize, cotton, tobacco, sunflowers, prunings, vine shoots, olive pomace, among others. Additionally, around 2,700,000 tons of forest residues resulting from timber harvesting contribute to the country's biomass potential (Bauen,2009). These abundant biomass resources underscore Greece's significant potential for bioenergy development, offering avenues for sustainable energy production while mitigating reliance on fossil fuels (Τσεπλετίδου,2013).

The purpose of this study is to investigate the opinions of citizens in Thessaloniki regarding wood-based energy products as an alternative fuel, focusing on their current heating methods, perceptions of efficiency, willingness to transition to alternative fuels, and the motivating factors behind such a transition.

3. Methodology

The methodology of the research involved conducting 4 focus groups, with each group comprising 6 to 8 participants. Each focus group had a distinct set of participants, determined based on specific criteria.

Table 1: Members of focus group

Focus Group	Members of Focus Group
Focus Group 1	Professionals with environmental backgrounds aged 25-30 years old
Focus Group 2	Secondary education teachers
Focus Group 3	Private sector employees in secondary education aged 35-45 years old
Focus Group 4	Employed women aged 30-45 years old

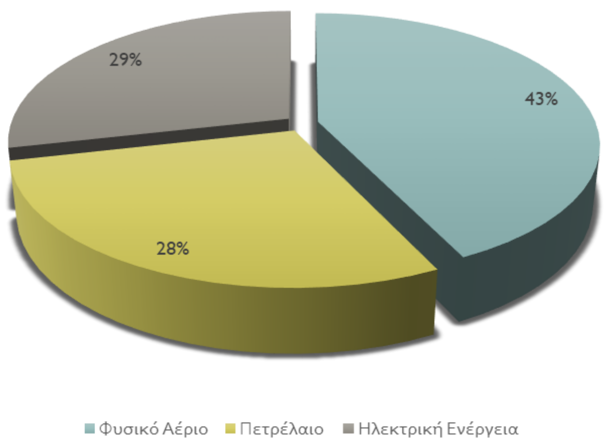
The aim of these focus groups was to gauge public acceptance of woody products as an alternative fuel, particularly in light of the rapid increase in natural gas and oil prices in today's society.

4. Empirical Results

4.1. University graduates with environmental studies aged 25-30

Among the participants surveyed, a notable pattern emerged regarding heating preferences, with natural gas being favored by 3 out of 6 individuals as their primary heating source. This preference stemmed from two key factors: environmental friendliness and lower cost. Participants recognized natural gas as a cleaner-burning fuel compared to alternatives like oil, reflecting their environmental concerns. Moreover, the perceived affordability of natural gas made it an appealing option for meeting heating needs. Conversely, another group of participants, also comprising 3 out of 6 individuals, indicated reliance on oil for heating, primarily due to the absence of natural gas infrastructure in their area. This underscores the significant role infrastructure availability plays in shaping heating choices. Interestingly, one participant, constituting 1 out of 6, specified the use of electric energy, particularly thermo-accumulators, for heating, highlighting the diversity of available heating solutions. This outlier suggests a potential niche for electric heating technologies in specific contexts. Overall, these findings underscore the multifaceted nature of factors influencing heating preferences among residents, including environmental considerations, infrastructure availability, and cost considerations.

Figure 1: Focus Group 1 – Heating System

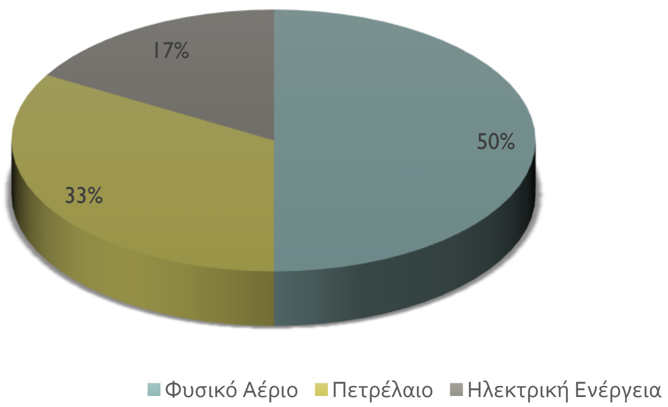


All participants demonstrated familiarity with various wood-based energy products, although two out of six lacked practical knowledge regarding their usage and applicability in urban residences. Despite this familiarity, the majority of respondents perceived natural gas or oil as the safest heating options. However, the participant utilizing electric energy faced a dilemma between heat accumulators and pellets for their home. When asked about the potential use of wood-based energy products as an alternative fuel, five out of six participants had prior experience with wood heating in their villages. However, they expressed concerns over its environmental and health impacts due to CO2 emissions, thus rejecting a return to this method. Discussing the advantages of pellets and briquettes over firewood, participants emphasized their efficiency, higher calorific output, reduced storage volume, and the potential for greater autonomy and control when used in specialized boilers. These insights highlight the nuanced perspectives and considerations shaping individuals' preferences and choices regarding heating options and alternative fuels**.**

4.2 Secondary education teachers aged 45-65

Among the participants surveyed, there was a notable split in heating preferences. Three out of six individuals cited natural gas as their preferred option, primarily due to its perceived environmental friendliness and lower cost. Conversely, another group of three out of six participants mentioned using oil for heating, largely because of the absence of natural gas infrastructure in their area. This highlights the significant role infrastructure availability plays in shaping heating choices. Interestingly, one participant, constituting one out of six, specified the use of electric energy, specifically thermo-accumulators, for heating needs. This diversity in heating choices underscores the complex considerations individuals weigh when selecting their preferred heating source, taking into account factors such as environmental impact, cost, and infrastructure availability.

Figure 2: Focus Group 2 – Heating System



All participants exhibited a level of familiarity with various wood-based energy products, although two out of six acknowledged their lack of practical knowledge regarding their usage and suitability in urban residences. Despite this, the majority of respondents leaned towards natural gas or oil as their preferred heating options, considering them the safest choices. However, one participant, utilizing electric energy, faced a dilemma between heat accumulators and pellets for their home. When queried about the use of wood-based energy products as an alternative fuel, five out of six participants had prior experience with wood heating in rural settings, primarily through stove heating. However, they expressed concerns about the associated pollution and health risks due to CO_2 emissions, leading them to avoid reverting to this method. Discussing the advantages of pellets and briquettes over firewood, participants highlighted their efficiency, higher calorific output, reduced storage volume, and the potential for greater autonomy and control using specialized boilers designed for their combustion. These insights underscore the nuanced perspectives and considerations shaping individuals' perceptions of wood-based energy products and their suitability as alternative fuels.

4.3 Private sector employees in secondary education aged 35-45

Four out of six participants revealed that they utilize a heating system fueled by oil, indicating a prevalent reliance on this traditional heating source among the surveyed individuals. The remaining two participants opted for indoor heaters powered by electric energy, showcasing a divergence from the conventional oil-based heating systems commonly found among the majority. This distribution reflects a varied landscape of heating preferences among the participants, with some favoring the convenience and reliability of oil-based systems, while others opt for electric-powered alternatives for their heating needs. Such diversity underscores the importance of considering individual preferences and circumstances when examining heating practices and highlights the range of options available to meet household heating requirements.

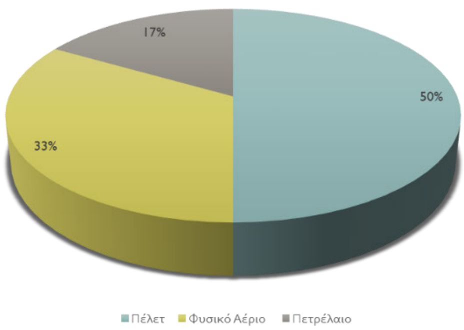
Figure 3: Focus Group 3 – Heating System

When queried about their satisfaction with the efficiency of the fuels they use, participants offered varied perspectives. One electric power user expressed dissatisfaction, citing a discrepancy between quality and price, while another highlighted the transient nature of heating generated by air-conditioning systems. In contrast, an oil user intervened to emphasize the superiority of radiator systems, which provide steady heating to floors and walls, thus enhancing comfort. Overall, oil users expressed contentment with their systems, attributing satisfaction to the benefits of individual heating. Regarding preferences for wood-based products as alternative fuel sources, all respondents cited pellets and firewood, acknowledging their efficiency but noting limitations compared to oil or natural gas in terms of flexibility and manageability. Concerns were raised about the need for continuous supply, maintenance, and cleaning associated with wood-based systems, with a prevailing sentiment favoring oil due to perceived quality and comfort, despite slightly higher costs. In terms of environmental considerations, only 2 out of 6 participants expressed a preference for biomass-based fuels to reduce carbon dioxide emissions, while the remaining 4 appeared indifferent to the environmental aspect of the matter. These insights reflect the complex interplay of factors influencing individuals' heating choices, encompassing considerations of efficiency, comfort, convenience, and environmental impact.

4.4 Employed women aged 30-45 living at Thessaloniki Urban Area

Among the respondents surveyed, there was a diverse range of heating systems currently in use. Half of the participants indicated that they currently utilize pellets for heating, reflecting a notable adoption of this biomass-based fuel source. Additionally, two participants mentioned the use of natural gas, while one participant mentioned the use of oil as their primary heating source. Interestingly, across all six cases, the selection of the heating system was primarily driven by economic considerations. Participants weighed factors such as fuel cost, system installation expenses, and ongoing maintenance costs when making their choices. Remarkably, only two individuals sought advice from technical consultants during the decision-making process, suggesting that most respondents relied on their own assessment of economic factors rather than seeking expert guidance. This underscores the importance of cost-effectiveness and financial considerations in shaping heating system preferences among the surveyed individuals.

Figure 4: Focus Group 4 – Heating System



When asked about their familiarity with the term "wood-based energy products," five out of six respondents noted that while the specific term may not be commonly used in everyday language, they could readily identify associated products such as firewood, briquettes, and pellets. In terms of efficiency, the majority of participants perceived these products as equally effective for heating purposes. However, one participant offered a distinct perspective based on extensive personal experience with various heating options. She explained, "Considering the property I inhabit is a privately-owned detached residence, we have extensively explored various heating options over the past two decades. Our preference is a heating method that is both efficient and economically viable. Thus, we have experimented with almost all available alternatives – wood, oil, and pellets. Regarding efficiency, wood is our top choice, followed by oil, and pellets." When discussing pricing disparities among the products, all participants agreed that oil was generally considered expensive, while acknowledging that pellet prices have shown an upward trend despite being initially perceived as an attractive solution. These insights underscore the nuanced perspectives and considerations shaping individuals' perceptions of wood-based energy products and their economic viability as heating alternatives.

5. Conclusions

In conclusion, the findings of this study shed light on the prevailing sentiments among respondents in Thessaloniki regarding wood-based energy products as an alternative fuel source. Despite concerns about higher prices, the majority of participants expressed a sense of security with oil and natural gas, attributing this preference to perceived inefficiencies associated with wood biofuels. The additional capital investment required to transition to a wood-based biofuel system emerged as a significant barrier to adoption, although the prospect of government grants was identified as a potential motivator for replacing existing heating systems. Moreover, the perceived long-term cost-effectiveness of oil usage and the logistical challenges associated with continuous supply and maintenance of biofuels were highlighted as factors limiting the flexibility of wood-based systems compared to conventional alternatives. These insights underscore the complex interplay of economic, logistical, and policy factors shaping public perceptions and decisions regarding alternative fuel options for heating in Thessaloniki. Efforts to promote the adoption of wood-based biofuels must address these multifaceted considerations to effectively transition towards more sustainable energy practices in the region.

From the focus groups underscore the persistent challenge of transitioning away from non-renewable heating sources towards biofuels in the studied region. Despite growing concerns about the environmental and economic impacts of reliance on fossil fuels, residents continue to exhibit a strong dependence on traditional heating sources derived from non-renewable natural resources.

Addressing this challenge requires a multifaceted approach that encompasses both technological innovation and strategic marketing efforts to enhance citizen awareness and acceptance of wood biofuels. Furthermore, aligning national strategies with the promotion of the bioeconomy can play a pivotal role in fostering the necessary transitions towards renewable energy sources. By supporting the development and utilization of renewable natural resources, such strategies not only contribute to achieving climate and energy goals but also pave the way for greater energy independence and sustainability in the future. Ultimately, concerted efforts at the local, national, and international levels are essential to overcome barriers to the widespread adoption of biofuels and advance towards a more sustainable energy future.

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Development of Forest Experience using ICT

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Abstract
Human population growth has created extended needs for goods and services that challenge the utilization of natural resources. The dependence on non-renewable natural resources can jeopardize sustainable development. The huge growth of information and communication technology ICT services sector, lifelong learning along with the development of leisure and tourism services can help achieve sustainable development by presenting opportunities with minimal use of natural resources. Outdoor activities in the forests and and eco-tourism constitute a large proportion of ecosystem services. Their upgrade to tourism forest experience can add value to the rendered services, within the new trend of era experience profit. In the Olympus National Park, investment and infrastructure can change the character of the National Park, and can create increasing pressures on the natural ecosystem. An alternative proposal is the development of experience services using ICT tools and apps given the involvement of local residents. Prioritizing the creation of ICT-based experience services with the lowest possible footprint can further increase the value of ecosystem recreational and tourism services and contribute to the sustainable development of local communities.

Keywords: Ecocystem Services, Tourism, Experience, ICT, Sustainable Development

JEL Codes: Q01, Q26, Q56

Ανάπτυξη Δασικής Εμπειρίας με χρήση ΤΠΕ

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Περίληψη

Η αύξηση του ανθρώπινου πληθυσμού έχει δημιουργήσει εκτεταμένες ανάγκες για αγαθά και υπηρεσίες που αποτελούν πρόκληση για τη χρήση των φυσικών πόρων. Η εξάρτηση από μη ανανεώσιμους φυσικούς πόρους μπορεί να θέσει σε κίνδυνο την αειφόρο ανάπτυξη. Η τεράστια ανάπτυξη του τομέα των υπηρεσιών ΤΠΕ της τεχνολογίας πληροφοριών και επικοινωνιών, η διά βίου μάθηση μαζί με την ανάπτυξη υπηρεσιών αναψυχής και τουρισμού μπορούν να συμβάλουν στην επίτευξη βιώσιμης ανάπτυξης παρουσιάζοντας ευκαιρίες με ελάχιστη χρήση φυσικών πόρων. Οι υπαίθριες δραστηριότητες στα δάση και ο οικοτουρισμός αποτελούν μεγάλο ποσοστό των οικοσυστημικών υπηρεσιών. Η αναβάθμισή τους στην τουριστική δασική εμπειρία μπορεί να προσθέσει αξία στις παρεχόμενες υπηρεσίες, στη νέα εποχή επίτευξης κέρδους μέσα από την ανάπτυξη εμπειριών. Στο Εθνικό Πάρκο Ολύμπου, οι επενδύσεις και οι υποδομές μπορούν να αλλάξουν τον χαρακτήρα της περιοχής και να δημιουργήσουν αυξανόμενες πιέσεις στο φυσικό οικοσύστημα. Μια εναλλακτική πρόταση είναι η ανάπτυξη υπηρεσιών εμπειρίας με τη χρήση εργαλείων και εφαρμογών ΤΠΕ με την συμμετοχή των κατοίκων της περιοχής. Η προτεραιότητα στη δημιουργία υπηρεσιών εμπειρίας που βασίζονται στις ΤΠΕ με το χαμηλότερο δυνατό αποτύπωμα μπορεί να αυξήσει περαιτέρω την αξία των οικοσυστημικών υπηρεσιών αναψυχής και τουρισμού και να συμβάλει στη βιώσιμη ανάπτυξη των τοπικών κοινοτήτων.

Keywords: Οικοσυστημικές Υπηρεσίες, Τουρισμός, Εμπειρίες, ΤΠΕ, Βιώσιμη Ανάπτυξη

JEL Codes: Q01, Q26, Q56

1. Introduction

The modern economic system bases its success on continuous economic growth. The growth of the human population and its needs poses challenges in the management and utilization of natural resources. Immoderate dependence on non-renewable natural resources creates problems for economic growth and reveals weaknesses in the economic system (Schmelzer, 2016). The growth of the information and communication technology services sector, lifelong learning and the development of leisure and tourism services achieve economic growth, presenting opportunities for optimal economic development, with minimal use of natural resources (Nusbaumer, 2012).

Forest ecosystems produce a multitude of ecosystem good and services that contribute to the well-being of human societies. A distinct category among valuable forest ecosystem services are cultural services, a large part of which concern forest recreation and tourism (Pukkala, 2016). Forest recreation and tourism visitors are willing to spend amounts that contribute significantly to the economic development of both forested local communities and the whole country (Matsiori et al, 2012). Especially in Greece, tourism accounted directly or indirectly for 18.5% of GDP and 23.1% of employment in 2016, while the forecast for 2026 raises its share in GDP to 22.4% and in employment by 28.6% (Triantafillidou and Tsiaras, 2018).

Infrastructure development plays a very important role in increasing arrivals, overnight stays and revenues in a tourist destination (Mandić et al, 2018). The unregulated development of tourism infrastructure and the increase of tourists in natural forest ecosystems directly threatens the conservation of biodiversity, ecological cycles and their management objectives (Marzano and Dandy, 2012). The European Union's 2030 Forest Strategy sets biodiversity conservation as a key priority.

Information and communication technologies present opportunities for economic development for protected areas through the development of tourism and leisure activities (Andreopoulou et al., 2015). In addition to economic benefits, they can contribute to environmental awareness and education of visitors (Vrasidas et al., 2007). The use of information and communication technologies improves through interaction, the visitor experience in museums (Charitonos et al. 2012) and tourism in general (PJ, 2020). Smartphone and social media usage from the visitors and tourists of protected areas, boosts visitation numbers and contributes in a richer visitor experience (Andreopoulou et al. 2022). Augmented reality mobile apps used both by locals and tourists can improve local development but may also threat direct communication between residents and visitors (Her, 2021). E-tourism improves visitors' choices, travel design, transfer, consumption of products and services and contributes ta a greater guest satisfaction, contributing to sustainable development (Koliouska and Andreopoulou, 2023).

In this paper, an effort is made to support the tourist development of the protected area of Olympus with the participation of local residents and the use of information and communication technologies. The direct goal of this combination is upgrading the services provided to visitors without the need to create additional heavy infrastructure that will alter the character of the natural environment of the area and create conditions of higher pressures from Anthropogenic activities.

2. Methods and Data

Through literature review and use of secondary research data, an attempt is made in this paper to highlight the economic importance of upgrading recreational services into a forest experience with the use of ICT as a counterweight to the development of new infrastructure that may create additional pressures on protected areas. The regional unit of Pieria was selected as the research area with a focus on the protected area of the Olympus National Park.

2.1. Research Area

According to the recent census of ELSTAT of 2021, the permanent population of the Regional Unit of Pieria consists of 119,384 inhabitants. In the Municipality of Dion-Olympus there are 23,955 permanent residents, (ELSTAT, 2022).

Mount Olympus, apart from being the highest mountain in Greece with an altitude of 2917 meters, is also an area of rich biodiversity as it hosts about 25% of the total flora of Greece (Panitsa et al. 2021). It is the first designated protected area of the country since 1938 (Royal Decree 20/09-06-1938 - Government Gazette 248/A/1938). Due to its great natural and cultural value, it has been characterized since 1981 as a Biosphere Reserve by UNESCO, having been included in the program "Man and Biosphere" (UNESCO, 2022). Areas of the mountain and the wider area are also included in the Natura 2000 network of the European Union. Thessaly and Pierikos Olympus have been declared archaeological and historical sites by the Ministry of Culture (Government Gazette 474/B/25-7-1985), (Government Gazette 342/AAP/28-12-1011), (Government Gazette 317/B/24-6-1987). The Management Body of Olympus protected earea has been operating since 2002 (Law 3044/2002 - Government Gazette 197/27-8-2002). In 2020, the management bodies were renamed and reduced from 36 to 24 new Protected Area Management Units, under the supervision of the newly established Natural Environment and Climate Change Organization (4685/2020 - A 92). In 2021 by presidential decree (Government Gazette 610Δ'/17-09-2021) Olympus protected area is characterized as a national park. On Mount Olympus there are 8 mountaineering shelters and 7 emergency shelters. The 8 mountain shelters offer hospitality services have a total capacity of 370 beds (Table 1).

Table 1: Olympus mounteneering shelters bed capacity. Source: Trailpath, 2024.

Olympus Mounteneering Shelters	Bed Capacity
Spilios Agapitos (Zolota),	120
Giosos Apostolidis	66
Christos Kakalos	17
Petrostrougas	68
Krevatia	21
Boudolas	30
Koromilia	18
Vrysopoules	30
Total Bed Capacity	370

In the regional unit of Pieria there are 355 hotel units with a total capacity of 9685 rooms and 20129 beds (Table 2).

Table 2: Pieria regional unity hotels categories and capacity. Source: HCH, 2022.

Pieria Regional Unity Hotels Stars Category	5*	4*	3*	2*	1*	Totals
Units	4	25	69	109	148	355
Rooms	598	1460	1868	2804	2955	9685
Beds	1234	3178	3915	5551	6251	20129

3. Empirical Results

According to ELSTAT data, based on the results of the 2021 census, the permanent population of the Regional Unit of Pieria is reduced by 5.8% compared to the previous census ten years ago, while in the area of the Olympus National Park, in the municipality of Dion-Olympus, the permanent population is reduced by 6.7% compared to the 2011 census (Table 3).

Table 3: ELSTAT census 2021 and 2011 comparizon Source: ELSTAT, 2022.

ELSTAT Cencus	2011	2021	Reduction %
Pieria Regional Unity	126698	119384	5.8
Dion-Olympus Municipality	25668	23955	6.7

In June 2023, a Development Study of the Chamber of Pieria entitled "The Possibilities and Ways of Utilizing Mount Olympus in a Development Direction" was delivered to the Region of Central Macedonia. Proposed actions include (Table 4).

At the same time, the Pieria Hoteliers Association stated that although tourism in Greece reached the 2019 numbers after the covid-19 era, winter and mountain hotels in the Pieria district where only by 35% occupied for 2021 winter holiday season, compared to 85% occupancy during 2019 holiday season. During a 4-month winter season the average occupancy was estimated at a poor 12% (Eptanews, 2022).

Table 4: Champer of Pieria proposed Olympus new infrastructions. Source: Makthes, 2024.

Olympus National Park Zone	Proposed new Infrastruction on Olympus
Zone C of the National Park:	Creation of a Cable Car Teleferic system
Zone D of the National Park:	Creation of a 4* hotel
Zone D of the National Park:	Creation of at least one 3* Glamping

Table 5: Pieria winter and mountain hotels occupancy. Source: Eptanews, 2022.

Season	2019 Winter Holiday Season	2021 Winter Holiday Season	2021 average winter season
Pieria Winter & Mountain Hotels Occupancy	85%	35%	12%

4. Conclusions

The prioritization in building heavy infrastructure for tourism growth in protected areas where main management goal is the protection of biodiversity should be thorough examined. In the regional unity of Pieria and very close to Olympus National Park there are plenty of organized hospitality units that can offer accommodation and food & beverage services to the visitors and tourists. When occupancy in these units is low, the creation of additional tourist accommodation units increases the supply of units/rooms/beds and poses threats for prices collapse and the survival of many hotels, especially during off season months.

Mount Olympus proximity to the sea creates opportunities for ecotourism development not only as a main but also as a complimentary tourism type. Tourists that visit the area for their summer vacation can easily enjoy visits to the National Park and enhance their vacation experiences and even may extend their stay. Tourism can contribute to socioeconomic development. Especially in rural mountainous areas, tourism can create employment opportunities. The development of thematic tourism in the National Park without the need for additional heavy infrastructure can mobilize locals' contribution and increase their interaction with visitors, creating socio-economic development synergies. This between them interaction can affect positively cognitive, affective, and conative image (Stylidis, 2022).

Information and Communication Technology can contribute to the upgrade of tourism services into forest experiences in the Olympus National Park. Cell phone signal coverage over most of the mountain can contribute to a more immediate response from the authorities in cases where the safety of visitors is threatened. The incorporation of the use of Augmented Reality application in visitors' tours in combination with the mobilization of locals as tour leaders can create significant co-benefits. Enhanced tourist experiences can increase visitors' willingness to pay, and locals enjoy diversified employment opportunities that can support their income and keep off population decrease. Social media usage and content creation from visitors, turns them into free marketing agents of the Olympus National Park.

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Circular Economy in the European Forest Sector through the Sustainability Reports of the Leading Forestry Companies

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Abstract
The current climate and energy crisis, the rapid population growth, and the consequent depletion of natural resources make imperative the implementation of sustainable business practices, such as the adoption of circular economy business models. In Europe, where the forestry sector plays a significant role in the economy, society, and the environment, understanding its relation to circular economy is of paramount importance. The present research conducts a comprehensive examination, through qualitative and quantitative approaches, of the practices employed by Europe's leading forestry companies to promote circular economy, using the information they publish annually in their reports. Specifically, content analysis techniques were used on the reports published by the sample companies for the year 2022. Factors contributing to the implementation of the circular economy at the corporate level were identified and categorized into three groups: 1) the principles of the circular economy, 2) enablers of the circular economy, and 3) GRI indicators related to circular practices. The results show that Europe's forestry sector and the dominant companies representing it, display a familiarity towards circular practices and have the potential to exert strong influence in promoting them. However, it is evident that there are still significant opportunities and prospects for the development of practices that advance the circular economy.

Keywords: Circular Economy, Environmental Accounts, ESG, Global Reporting Initiative, Forest Industry.

JEL Codes: L20; L73; O13; O44; O52; Q01; Q56.

1. Introduction

Circular economy (CE) is an industrial system which, by its design, is rejuvenating and regenerating and its application aims to terminate, ultimately, global economic growth from finite resources consumption (MacArthur, 2013). It is also, associated with material cost savings, mitigation of supply risks, significant job growth and labor market resilience (Lewandowski, 2016). It is observed that the literature on CE focuses mainly on the macroeconomic level (Nikolaou et al., 2021), but also emphasizes the examination of the microeconomics of organizations (Kristensen and Mosgaard, 2020). In recent years, in the literature, the “10R” framework has prevailed, attempting to contribute to a clearer idea of CE operations and pointing out that the principles of CE are the following ten: Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover (Potting et al., 2017; Reike et al, 2017; Campbell-Johnston et al., 2020).

Forest-based industry could play a critical role in implementing CE principles (Toppinen et al., 2020) as forestry companies are, in fact, highly dependent on natural resources and are the first to have to directly confront the threat of climate crisis. Specifically, Husgafvel et al. (2018) point out that CE and bioeconomy topics, such as renewable raw materials, bioenergy and energy self-sufficiency are of high significance for forest sector companies.

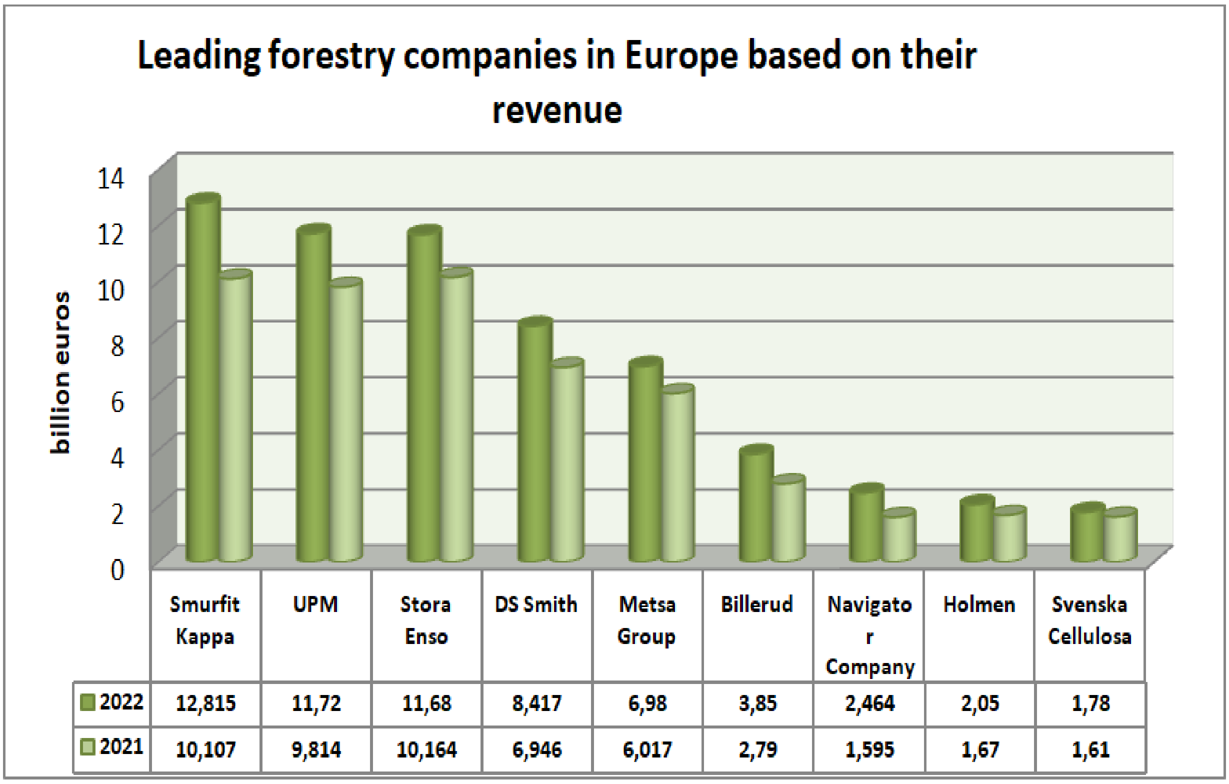
Consequently, the aim of this study is to explore how familiar the largest forestry companies are, as indicated by the information disclosed in their reports, with circularity practices, to distinguish if circularity practices are implemented voluntarily or after the regulations and directions of policymakers and to investigate whether the implementation of CE can mitigate the environmental, economic, and social challenges faced by forestry companies.

2. Methods and Data

The method that was carried out in this research is the content analysis (both with quantitative and qualitative approaches). Content analysis is a research technique for drawing conclusions from a text, which are characterized by validity and reproducibility (Giannantonio et al., 2004). The major advantage of content analysis is the fact that it is a systematic technique for categorizing and coding numerous elements of a text (Stemler, 2001). Specifically, the research focuses on large forestry and paper companies based in Europe and all, except one (DS Smith-UK), are located in EU member states. DS Smith was included in the study as, in terms of sustainability, it follows the regulatory guidelines of the EU, as well. Large European companies were selected for the following reasons: The large companies potentially have a greater influence on the natural environment compared to SMEs (Dagiliene, 2020). In addition, the European Union has demonstrated a commitment towards issues related to CE. The European Commission's action plan for the circular economy, presented in 2020, as well as the Parliament's resolution in 2021 for stricter measures to promote the circular economy comprise representative examples. Another important step is the proposal submitted by the European Commission, in 2022, for packaging, which aims to improve their design and reduce packaging waste (European Parliament, 2023).

The sample companies were drawn from Statista's research department dataset. Statista is a database that offers access to statistics on a wide range of topics in all scientific categories (Kanthara et al., 2022; Zhang et al., 2023). The data set includes the nine largest forestry companies in Europe based on their revenue for the year 2021. All companies in the sample increased their revenue in 2022. Therefore, based on their revenue for the year 2022, the companies, whose information was analysed are - in descending order - the following: Smurfit Kappa, UPM Kymmene, Stora Enso, DS Smith, Metsa Group, Billerud, Navigator Company, Holmen, Svenska Cellulosa (Figure 1).

Figure 1: Sample companies and their revenue for the years 2021 and 2022



The information- for the fiscal year 2022- was drawn from the sustainability and the annual reports that were published in 2023, in the English language, by the companies. The research focused on the sustainability reports, however, when necessary (as in the case of information related to KPIs), data included in the annual reports was used. It is noteworthy that only one third of the companies published a stand-alone sustainability report, while the remaining companies included the sustainability report in the annual report. There was, in addition, one company that did not publish a sustainability report, therefore, the information was drawn from the annual report.

After the companies' reports were collected, their analysis was carried out and the circular economy data was categorized into three thematic groups. The thematic groups are the following:

1. Implementation of the CE principles (10Rs). Specifically, information regarding the 10R framework (RLi, 2015; Reike et al., 2017; Potting et al., 2017; Vermeulen et al., 2019; Opferkuch et al., 2022) was extracted from the reports of the companies. It should be noted that the intention of the companies to apply any of the not-adopted principles in the future was not taken into consideration.
2. Adoption of CE enablers. Specifically, the factors used to assess the degree of commitment of companies towards the implementation of CE strategies are i) the use of CE terminology in the reports (circular economy, circularity, circular measures etc.) as well as chapters in the reports dedicated exclusively to CE (Kirchherr et al., 2017; Sihvonen and Partanen, 2017; Fortunati et al., 2020; Opferkuch et al., 2022), ii) the inclusion of CE in the strategy and the companies' objectives, as well as in the message of the CEO (Sihvonen and Partanen, 2017; Hopkinson et al., 2020; Dagiliene et al., 2020; Opferkuch et al., 2022), iii) the adoption of KPIs related to CE (European Union, 2020; Dagiliene et al., 2020), iv) CE as a material topic (Opferkuch et al., 2022), v) innovation and research related to circularity strategies (Potting et al., 2017; Sehnem et al., 2019; European Union, 2020; UNECE, 2021; Opferkuch et al., 2022), vi) the attitude and

behavior of employees towards CE issues (European Union, 2020), vii) circular supply chain management (circular supply chain) (Yang et al., 2018; Farooque et al., 2019) and finally viii) the implementation of business models and strategic approaches that promote CE (Sihvonen and Partanen, 2017; Yang et al., 2018; European Union, 2020; Hopkinson et al., 2020; Fortunati et al., 2020; Stumpf et al., 2021; UNECE, 2021; Opferkuch et al., 2022). These include eco-design, eco-innovation, PSSs (product-service systems), collaborative consumption and extended producer responsibility (EPR).

3. Implementation of GRI indicators (disclosures) related to the CE model (Sihvonen and Partanen, 2017; Sehnem et al., 2019; Massari and Giannoccaro, 2023; Luque-Vílchez et al., 2023). The selected GRI indicators, through the application of which companies describe circular economy strategies (although the term "circular economy" is not referred to in the GRI Standard Set) are listed in Table 1.

Table 1: GRI and CE

Disclosures	**Name**	**Relation linking the disclosure to CE**
201-2	Financial implications and other risks and opportunities due to climate change	Circular methods are an opportunity to address climate change repercussions and at the same time contribute to the maximization of financial performance (Yang et al., 2022).
203-2	Significant indirect economic impacts	
301-2	Recycled input materials used	Total amount of recycled materials and methods applied.
301-3	Reclaimed products and their packaging materials	References related to recycling and reuse of packaging (GRI, 2022) and the implementation of methods such as eco-design (Massari and Giannoccaro, 2023).
303-2	Management of water discharge-related impacts	Reuse strategies of industrial wastewater (Massari and Giannoccaro, 2023), repurposing of wastewater and its by-products (Angelakis and Snyder, 2015; Hernández-Chover et al., 2022).
305-5	Reduction of GHG emissions	The reduced use of natural resources implies a reduction of CO_2 emissions (Mongo et al., 2022). Eco-design strategies to reduce GHG emissions (Massari and Giannoccaro, 2023) and circularity practices for waste management.
306-1	Waste generation and significant waste-related impacts	Circular Economy Package (European Commission, 2015). Reducing waste by reducing the use of packaging materials or by using recycled and recyclable packaging materials.
306-2	Management of significant waste-related impacts	
306-3	Waste generated	
306-4	Waste diverted from disposal	
306-5	Waste directed to disposal	
308-1	New suppliers that were screened using environmental criteria	Supplier selection criteria such as environmental factors (waste management, environmentally friendly packaging, etc.), Top-management's respect for CE policies, economic criteria, the social and administrative support (the compliance of suppliers with legislation about CE) and finally, the technological capabilities of suppliers in terms of the implementation of circularity methods (Haleem et al., 2021).
416-1	Assessment of the health and safety impacts of product and service categories	Highlighting the improvement measures recommended to take place at all stages of the life cycle, including that of disposal, reuse and recycling (GRI, 2022).

3. Results

3.1. Implementation of CE principles (10R)

It is observed that most companies apply the following four principles: 1) reduce, applied by 100% of the sample companies, 2) reuse, applied by 80% of companies, 3) recycle implemented by 100% of the companies and 4) recover implemented by 85% of the sample companies. In fact, by applying these principles, all companies take preventive and countermeasures for issues related to waste management as well as packaging design. In addition, the above principles seem to work as indicators for the evaluation and measurement of circularity by companies (e.g. recyclability, waste recovering rate). However, it seems that companies are not particularly familiar with the remaining principles of CE. Specifically, only 10% of the companies state that they apply the refuse principle (by replacing standard packaging with mono-materials packaging to encourage consumers to refuse packaging that is difficult to recycle and is not biodegradable). In addition, 15% of the sample companies report that they apply the repair principle to design and produce sustainable packaging, to enhance energy efficiency as well as to repair and maintain renewable energy technologies and energy efficient equipment. Furthermore, the remanufacture principle is applied by only 10% of the companies. The repurpose principle, without being explicitly mentioned, is applied by one company, which uses parts of products destined for disposal (e.g. pulp) to produce products with different functions (e.g. tall oil converted into liquid fuel). Finally, there are two principles that are not applied by any company. These are the rethink and the refurbish principles. It is worth pointing out that one company uses the words "repair" and "refurbish" in the definition it proposes for CE, indicating its intention and commitment to apply the respective principles in the future.

3.2. Adoption of CE enablers

The majority of companies (95%) use CE terminology in their reports. Despite this, only 20% of the sample companies have dedicated an entire chapter to issues related to CE. Specifically, one company uses the term "circular bioeconomy" in the title of the respective chapter, one company uses the title "circularity", two companies use the title "circular economy", while one company uses the title "Circular economy and substitution of plastic. Also, notable enablers of CE are the goals, the strategy of the companies, as well as the message of the CEO. That is why, in fact, all those enablers are presented and described on the first pages of the reports of all the companies in the sample. All companies, except the one that does not use CE terminology in its report, have included CE in their short-term and long-term goals. However, 60% of companies explicitly state that CE is part of their strategy. Finally, the message of the CEO is considered to be of major importance for employees, customers and stakeholders. Moreover, the CEOs of 40% of the companies include CE in their message, pointing out the inseparable relationship of CE with innovation. Furthermore, they highlight the companies' commitment to even better performance in the future in terms of CE practices and underline the contribution of CE to mitigating and, by extension, addressing the climate crisis. Regarding KPIs, all companies report that they use them. However, only 15% of them use a KPI to measure CE practices. For one of the sample companies, the percentage of technically recyclable products is used as a KPI for CE, while for another company, the termination of activities of sending waste to landfill and incineration without energy recovery until 2030 is used as a KPI for CE, while for the last one, the set of economic activities that are aligned with activities that promote the transition to a CE, such as measures to reduce greenhouse gas emissions is used as KPI for CE. Still, all the companies have determined in their reports what their material topics are for 2022. However, the companies that represent 35% of the sample are the ones that consider CE a material topic. Furthermore, it appears that most of the sample (85%) connect CE with innovation and research. All companies representing this percentage, in their reports, state that they invest in innovation and research programs that enhance the adoption and implementation of circularity practices. Additionally, an important enabler that was considered for the assessment of circular practices, is the attitude and behavior of all the members of the staff (not only top management) of the companies regarding the implementation of circularity methods. When circularity, in companies, is linked to social goals and ethics, it seems that staff commitment is strengthened (European Union, 2020). Out of the total sample, companies representing 30% explicitly mention in their reports that CE is a commitment and priority for the staff. In the reports of these companies, it is stated that the adaptation of the employees to the circularity models and the inclusion of CE in the mentality of the staff is closely related to productivity, commitment and innovation. Furthermore, the results of the study prove that the companies representing 20% of the sample point out in their report that their value chain is circular. One of them points out that its circular value chain has a positive impact on the planet, people as well as business, while another company highlights the importance of continuing to develop circular value chains. Finally, one company states that in circular value chains the resources are used in such a way as to promote the principles of a safe and reliable working environment (giving social dimensions to CE implementation). Finally, the sample companies do not seem to be particularly familiar with the business models that promote CE (PSS, Collaborative Consumption, EPR), nor with the strategic approaches that can be included in them (eco-design, eco-innovation) . Eco-design is applied, as stated in their reports, by only 20% of the companies, with the companies representing this percentage pointing out that eco-design is directly linked to CE. One of the companies implementing eco-design states that eco-design is a primary objective of regulators and policy makers (e.g. European Council, governments), while another company notes that it focuses on the ecological design of its products, developing new pulp products that require lower consumption of raw materials and chemicals, such as products that require less wood consumption per ton of pulp produced, as well as less chemical consumption in the bleaching stage. Extended Producer Responsibility is applied by one company. Specifically, this company implements EPR systems following directives from the European Union and the United Kingdom and highlights that commitment to EPR systems entails minimizing risks, enhancing opportunities and achieving high recycling targets. It is noteworthy that Eco-innovation, PSSs and Collaborative Consumption are not mentioned in the reports of any of the companies in the sample. The results show that the companies that implement the models and strategic approaches that promote CE do not do so voluntarily, but following the instructions, directions, frameworks and guidelines set by the EU bodies and governments.

3.3. Adoption of GRI disclosures related to CE

Most companies (90% of the sample) use the GRI standards to publish information related to companies' performance in terms of financial, social, environmental and governance (ESG) issues. While the term "circular economy" is not mentioned in the Consolidated Set of the GRI Standards, the disclosures which, by using them, companies can publish data and information on the application of circularity methods are thirteen in number. It is noteworthy that none of these disclosures is used by all the companies of the sample. The disclosure that is used more by the companies, is "306-3-Waste generated" (used by 70% of the sample companies), following by the disclosure "306-2-Management of significant waste-related impacts", "305-5- Reduction of GHG emissions", "306-1-Waste generation and significant waste-related impacts", "303-2- Management of water discharge-related impacts" and "308-1- New suppliers that were screened using environmental criteria" (adoption by 65, 65, 60, 55 and 50% of the companies respectively). The disclosures "201-2- Financial implications and other risks and opportunities due to climate change", "301-2- Recycled input materials used" and "306-5- Waste directed to disposal" are applied by 45% of companies, the indicators "306-4- Waste diverted from disposal", "301-3- Reclaimed products and their packaging materials" and "416-1- Assessment of the health and safety impacts of product and service categories" are applied by 40 , 30 and 30% of the total sample, respectively. Finally, the "203-2- Significant indirect economic impacts" indicator (adoption by 25% of companies) has the lowest application rate.

4. Conclusions

The main conclusions of this study are the following: CE can find applications in all the value chain activities of the forest sector companies (packaging design, waste management, water and effluent management, reduction of GHG emissions, suppliers (environnemental performance assessment), attitude of top-management and staff, business models implementation, financial performance. However, companies adopt circularity practices, mainly, when they are included in directives and legislation of policymakers (e.g. 4R framework, implementation of eco-design). The European Union demonstrates awareness of circularity issues, and companies appear to be in compliance with its directives and regulations. Nevertheless, there are still significant opportunities for the voluntary adoption of circularity strategies.

Finally, the results indicate a familiarity of companies with CE practices, but companies have room for improvement in implementing additional measures to reinforce their CE initiatives. It is, also, noted that a way of calculating the level of CE implementation, that is applied by all companies and evaluated by specific policymakers, has not been established. Nonetheless, Europe's Forest sector has the potential to exert strong influence in promoting CE.

Further studies with a larger sample of forestry companies (and SMEs) are suggested to be conducted, so that more quantitative and statistical conclusions can be drawn. Furthermore, retrospective studies could, potentially, reach conclusions related to the progress of forestry companies concerning the implementation of circularity practices.

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Session 3
Environmental Risks

Flood risk assessment and catastrophe analysis of cropland of the Central Macedonia water district

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Abstract

The present study focuses on the assessment of the potential economic losses of the agricultural sector due to flood events. For this purpose, the flooding scenarios of the Greek Ministry of Environment and Energy are used as they are prescribed in the official studies of flooding risk management. The flooding scenarios have return periods of T=50,100,1000 years and are associated with flood damage to crops by means of the model AGRIDE-c (AGRIculture DamagE model for Crops). AGRIDE-c, can estimate the expected yield reduction (i.e., the direct crop damage) with flood characteristics such as the maximum flow depth and the flood duration. Furthermore, the biological stage of the crops during a flood event is also taken into account by associating the calendar months with them. In order to estimate the economic impact of each flood scenario on farmers' income, the cost of production and the revenue of each crop is calculated. Finally, the analysis yields the expected: (a) damage costs, (b) profit loss and (c) destroyed production based on flood risk management plan of the Central Macedonia Water District of Greece. The results of the study can contribute to better understanding the impacts of a flooding event to the studied district, which can lead to the improvement of flood disaster management.

Keywords: Natural disasters, Floods, Risk assessment, Agriculture

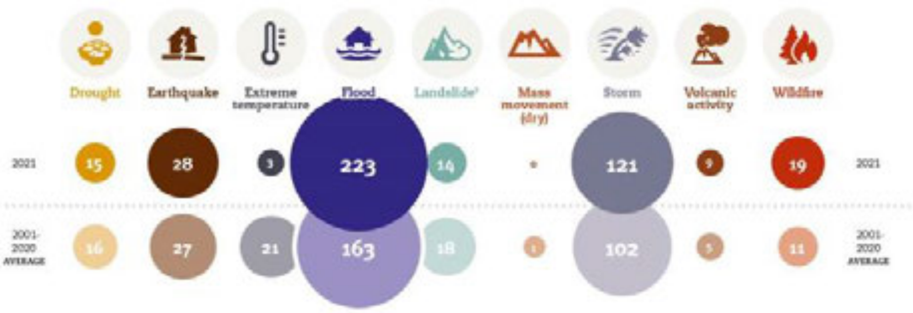
JEL Codes: Q10; Q51; Q54.

1. Introduction

Climate change has proclaimed floods as the most common and most dangerous type of natural disaster (Centre for Research on the Epidemiology of Disasters, 2022). The 2021 Global Natural Disaster Assessment Report classified flooding as the predominant type of natural disaster (Ministry of Emergency Management of the People's Republic of China, 2021), while the Intergovernmental Panel on Climate Change (IPCC) predicts more frequent extreme weather phenomena in Europe (IPCC, 2021). In addition to the above ominous forecasts, soil water retention is decreased due to urban expansion (Myronidis, D. & Ioannou, K., 2019). Notably, during the period 2001-2020 there was an average of 163 destructive floods annually. In contrast, in 2021 the number increased significantly to 223 destructive floods (Figure 1) (Centre for Research on the Epidemiology of Disasters, 2022).

The agricultural sector is highly vulnerable to climate change due to its dependence to the weather conditions. The Food and Agriculture Organization of the United Nations (FAO) ranks flooding as the second most important threat to agriculture following drought. According to FAO data for the period 2008-2018, the damage caused by floods in agriculture amounted to21 billion dollars (FAO, 2021). Furthermore, Greece recently was impacted from extreme floods in the Region of Thessaly, resulting in the flooding of 59.000hectares of agricultural land (Mapping Thessaly floods, 2023).

Figure 1: Occurrence by disaster type, 2021 compared to 2001-2020 annual average



Greece is the only country in Europe which implements a public insurance policy for the agricultural sector. The insurance is mandatory for all types of crops, and it is managed by the Hellenic Organization of Agricultural Insurances (ELGA). The insurance policy covers a percentage of the direct damages to the crop and does not cover any indirect damages (such as damage to agricultural machinery, land drainage etc.). In addition, alongside public insurances, private insurance companies also play a role by partially covering the uncompensated damage costs (European Commission, 2006). The above public insurance policy might be fair from a social point of view; however, it often leads to the neglection of the agricultural sector from flood risk analysis in Greece, since its compensation it is taken for granted.

As shown by the aforementioned arguments, the agricultural sector has an important role in the total damage caused by destructive floods. This led to the development of various damage models which try to pre-estimate the flood damage to agriculture. The first damage model to incorporate the flood risk on the agricultural sector was created by the U.S. Army Corps of Engineers in 1985, and it is still in use for the area of the United States (US Army Corps of Engineers Hydrologic Engineering Center, 1985). The present study uses the model AGRIDE-c (AGRIculture DamagE model for Crops)

(Molinari et al., 2019) which was developed and first implemented in Italy for wheat, barley, maize and alfalfa crops. The aforementioned model can estimate the direct damage to the studied crops, while its main disadvantage can be considered the lack of indirect damage estimation (e.g. damage to agricultural machinery or buildings).

More specifically, the present study estimates the damage to croplands by using the flooding scenarios of the Greek Ministry of Environment and Energy as they are prescribed in the official studies of flooding risk management. The flooding scenarios have return periods of T=50,100,1000 years and are associated with flood damage to crops by means of the model AGRIDE-c. This model can estimate the expected yield reduction (i.e., the direct crop damage) based on flood characteristics such as the maximum flow depth and the flood duration. Furthermore, the date of a flood event is considered in connection with the biological stage of the crops. The above analysis uses as a case study the Central Macedonia Water District in which the studied crops (wheat, barley, maize and alfalfa) represent the 83% of the total croplands in the region. the analysis will provide insights into the anticipated (a) costs of damage, (b) losses in profits, and (c) production destruction, for each crop type, each flooding scenario and each river basin.

2. Methods and Data

The methodology employed in the present study consists of nine (9) distinctive steps. In the initial step the geographical area under examination must be defined. The Central Macedonia water district of Greece was selected as a case study, encompassing nine river basins. Two of the river basins are neglected due to their insignificantly small water drainage area or the absence of data provided by the Greek Ministry of Environment and Energy.

The second step consists of the classification of the flooded areas in accordance with their use of land. More precisely, the data from the Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid Schemes (OPEKEPE) are used in order to calculate the area of wheat, barley, maize and alfalfa crops (OPEKEPE, 2021). The above type of crops represents the 83% of the total agricultural land of the studied area and are the only crops that can be assessed through the model AGRIDE-c.

The third step is to estimate the flood duration and the water depth. The duration of the flood is considered to be the twice the duration of the time of the development of the maximum depth (Najibi & Devineni, 2018; Serinaldi et al., 2018). The water depth is deemed to be between 0.6m-1.3m at the flooding scenario with return period of T=50 years, which align with the limits that AGRIDE-c sets for the destruction of wheat/barley and maize corps respectively. At the flooding scenarios with T=100,1000 years the water depth is anticipated to exceed the 1.3m limit.

At the fourth step of the methodology the yield of the crops must be estimated. In our study these data are derived from the Hellenic Statistical Authority (ELSTAT, 2021). Table 1 presents the yield of the crops utilized in the present paper.

Table 1: The yield of each studied crop in kg/ha for the area of Greece

Crop type	**Yield** (kg/ha)
Wheat	2,960.7
Barley	11,709.0
Maize	2,937.4
Alfalfa	11,432.2

The fifth step consist of the estimation of the production cost of each studied crop. The production cost is estimated through Eq. (1):

$$Tc = Vc + NVc \tag{1}$$

where Vc represent the variable cost and can be calculated through Eq. (2):

$$Vc = Fertilizers\ (F) + Pesticides\ (P) + Irrigation\ (Irr) + Seed/Plant\ (S/P) \tag{2}$$

and NVc represent the non-variable cost and can be calculated through Eq. (3):

$$NVc = Installation\ costs\ (Ic) + Tilling\ (T) + Harvest\ (H) + Labour\ (Lab) + Pumps\ (Pu) \tag{3}$$

The Directorate General of Agricultural Economics and Veterinary of the Central Macedonia provided us the data for the above equations (Administration of Central Macedonia Region, 2007). The agro-economic data is from 2007, since there are no more recent official data available for Greece. Table 2 presents the production cost of each studied crop as estimated.

Table 2: Cost of production of each studied crop from 2007 for the Region of Central Macedonia Greece

Cost of production (€/ha)			
	Wheat/ Barley	Maize	Alfalfa
Fertilizers (F)	124.8	250.4	122.6
Pesticides (P)	41.8	151.5	60.7
Irrigation (Irr)	5.0	117.4	136.2
Seeds/PlantS (S/P)	65.3	160.2	52.8
Harvest (H)	60.0	350.0	317.8
Installation cost (Ic)	66.2	19.9	33.6
Tilling (T)	66.2	139.0	33.6
Pumps (Pu)	-	605.0	550.0
Total	**429.3 €**	**1793.4 €**	**1307.3 €**

In the following (sixth) step the selling prices of the yielded production is determined. The average annual prices of the year 2007 are used which are derived from the Hellenic Organization of Agricultural Insurances (ELGA, 2022) (Table 3). The choice to use prices from the year 2007 is driven by the consideration that the calculation of the production cost relies on data from the same year. This choice ensures a more accurate estimation of the expected gross profit.

Table 3: Average annual selling prices of each crop of 2007 in €/kg

Crop type	**Average annual selling price of 2007** (€/kg)
Wheat	0.23
Barley	0.19
Maize	0.19
Alfalfa	0.17

The seventh step correlates the biological stages of the plants with the calendar months. This procedure is performed in accordance with relevant literature and more specifically in accordance to Feekes, Iowa and Undersander scale for the crops of wheat/barley, maize and alfalfa respectively

(Abendroth et al., 2011, Brown et al., 2017, Undersander et al., 2011). The month that the flood may occur correlates to the biological stage which affects the damage to the production yield. Therefore, two flooding scenarios are examined, the first one considers the flooding to occur in November which is the most likely to happen from a statistical point of view (Diakakis et al., 2022). The second scenario considers the flooding to occur during the summer period (e.g. in July, which is identified as the month with the highest anticipated damage to maize and alfalfa crops).

In the subsequent step (the 8th step), the study determines the avoided costs of production in the event of a flooding event. For example, if the flood occurs in November the crops of wheat/barley are supposed to partially of fully destroyed. Therefore, the costs related to harvest, irrigation, pesticide and fertilizing will occur partially or not at all according to the extent of the damage. The same principle applies to the maize and alfalfa crops for the July-flooding scenario.

The final step consists of correlating all the above data by the use of the model AGRIDE-c (Molinari, D et al., 2019). The damage estimation model consists of two parts, the first part correlates the water depth and the duration of the flood with the expected reduction yield. The second part estimates the economic impact of each flood scenario on farmers' income.

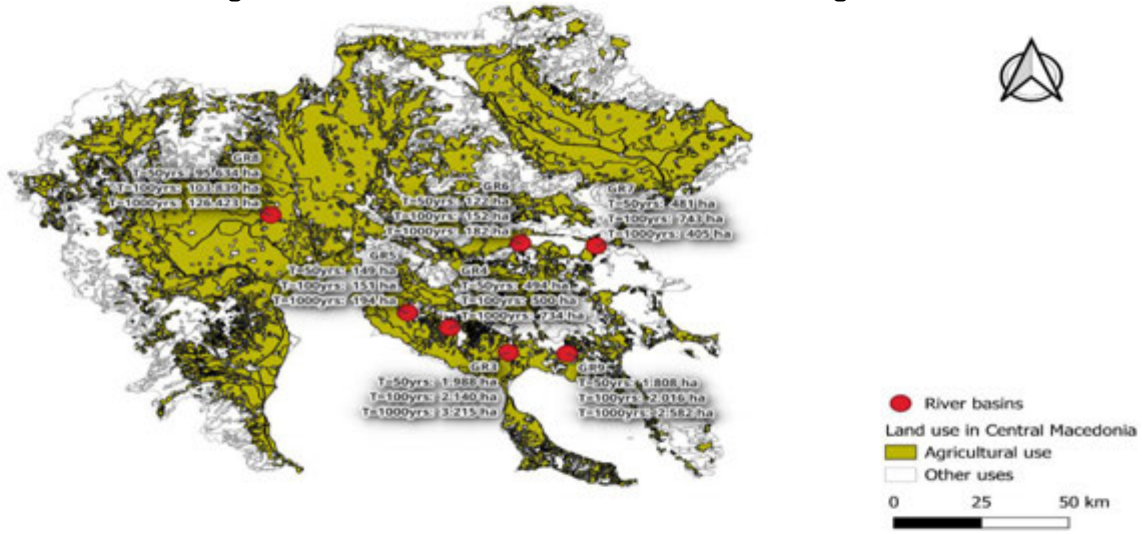
3. Results

Following the implementation of the damage estimation method, calculations are made for: i) the extent of the flooded agricultural area ii) the quantity of destroyed production, and iii) the incurred profit loss and the damage cost. These calculations are performed for each flooding scenario and each crop type under study.

4.1 Flooded agricultural area

Map 1 showcases the total flooded agricultural area (in hectares) for each river basin and for each flooding scenario. Based on this map, the total flooded agricultural area is likely to increase in floods with larger return period, which is expected since the return period does not only affect the depth but also the extent of the flood. By a significant margin, the most extensive flooded area is estimated to be within the river basin encompassing the Loudias, Axios, and Gallikos rivers (GR8), which also happens to be the largest river basin in the Region.

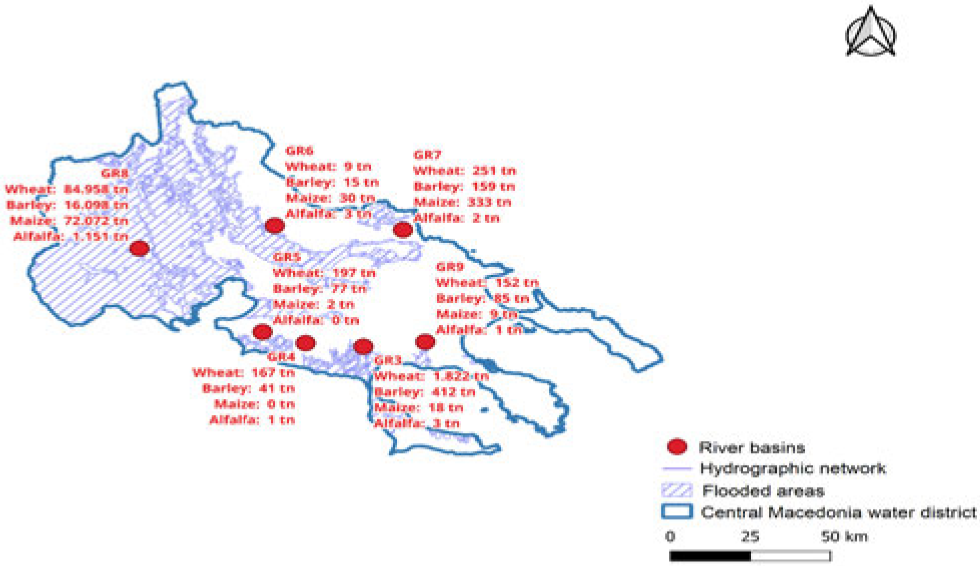
Map 1: Total flooded agricultural area for each river basin and flooding scenario



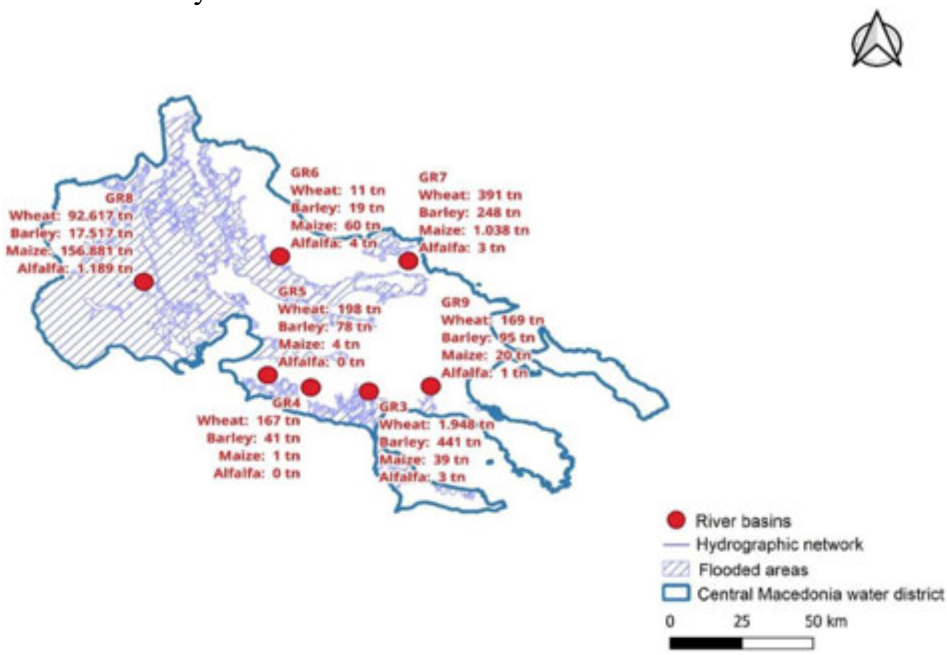
4.2 Destroyed production

The three following maps demonstrate the estimated destroyed production (in tons) for each river basin, flooding scenario and crop type. The most extensive product destruction resulting from floods occurs within the river basin of the Loudias, Axios, and Gallikos rivers (GR8). This outcome stems from both the magnitude of the river basin and the highly developed agricultural sector in the region.

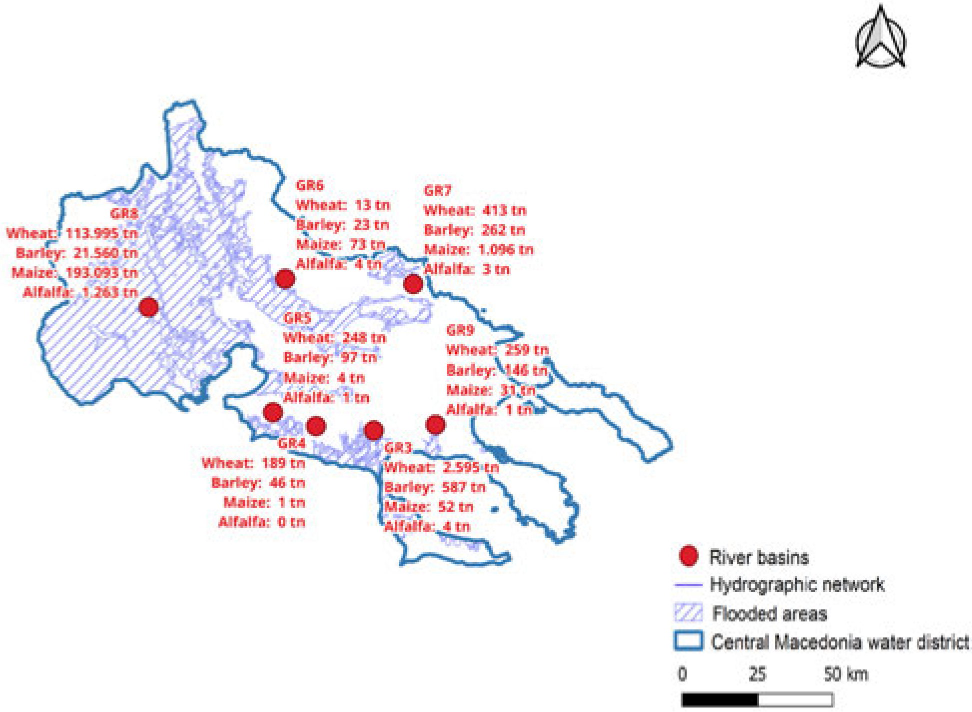
Map 2: Estimated destroyed production for each river basin and crop type, for a flooding scenario with return period of T=50yrs



Map 3: Estimated destroyed production for each river basin and crop type for a flooding scenario with return period of T=100yrs



Map 4: Estimated destroyed production for each river basin and crop type for a flooding scenario with return period of T=1000yrs



4.3 Profit loss and damage cost

Following the calculation of the overall production losses for each scenario, the anticipated economic impact of each flood scenario on farmers' income were assessed. Specifically, Tables 4-5 present the consolidated profit loss and damage cost for each river basin, considering every return period, and delineating between summer and winter flood scenarios, respectively.

Table 4: Aggregated profit loss and damage cost for each river basin and return period, for the case of the summer flood scenario

Aggregated profit loss and damage cost (€)						
Summer flood scenario (July)						
	T= 50 years		**T= 100 years**		**T= 1000 years**	
Drainage basin	Damage cost	Profit loss	Damage cost	Profit loss	Damage cost	Profit loss
Agios Nikolaos (GR2)	-	-	-	-	-	-
Nea Moudania (GR3)	1,991	2,578	2,799	5,213	3,717	6,932
Nea Iraklia (GR4)	139	168	54	98	61	113
Epanomi (GR5)	186	241	255	472	329	605
Zagliveri (GR6)	2,559	3,320	4,262	7,976	5,116	9,578
Volvi (GR7)	15,489	20,252	32,850	62,905	34,691	66,439
Loudias/Axios/ Gallikos (GR8)	7,072,739	9,243,699	10,453,899	20,000,618	12,851,461	24,599,049
Havria (GR9)	925	1,206	1,397	2,643	2,123	4,039

Table 5: Aggregated profit loss and damage cost for each river basin and return period, for the case of the winter flood scenario.

Aggregated profit loss and damage cost (€)						
Winter flood scenario (November)						
	T= 50 years		T= 100 years		T= 1000 years	
Drainage basin	Damage cost	Profit loss	Damage cost	Profit loss	Damage cost	Profit loss
Agios Nikolaos (GR2)	-	-	-	-	-	-
Nea Moudania (GR3)	52,297	180,150	55,931	192,667	74,498	256,623
Nea Iraklia (GR4)	4,850	16,718	4,850	16,718	5,493	18,935
Epanomi (GR5)	6,373	22,051	6,406	22,167	8,015	27,732
Zagliveri (GR6)	538	1,893	674	2,373	811	2,853
Volvi (GR7)	4,506	15,670	7,021	24,417	7,418	25,797
Loudias/Axios/Gallikos (GR8)	2,369,095	8,151,442	2,582,003	8,883,916	3,178,001	10,934,569
Havria (GR9)	5,491	19,069	6,100	21,184	9,395	32,626

Finally, Figures 1-2 present the per hectare damage cost and profit loss of flooded agricultural land for each studied crop and flooding scenario.

Figure 1: Damage cost and profit loss per hectare of flooded agricultural land for each studied crop and for the flooding scenario with return period of T=50yrs

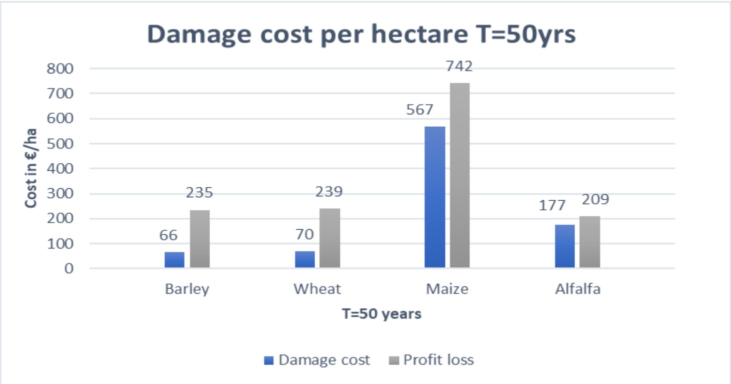


Figure 2: Damage cost and profit loss per hectare of flooded agricultural land for each studied crop and for the flooding scenario with return period of T=100yrs

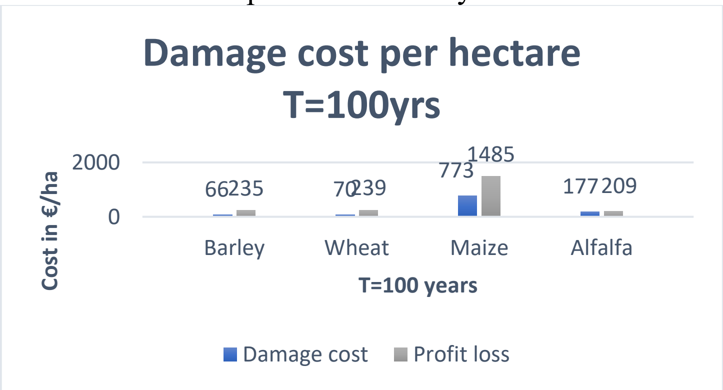
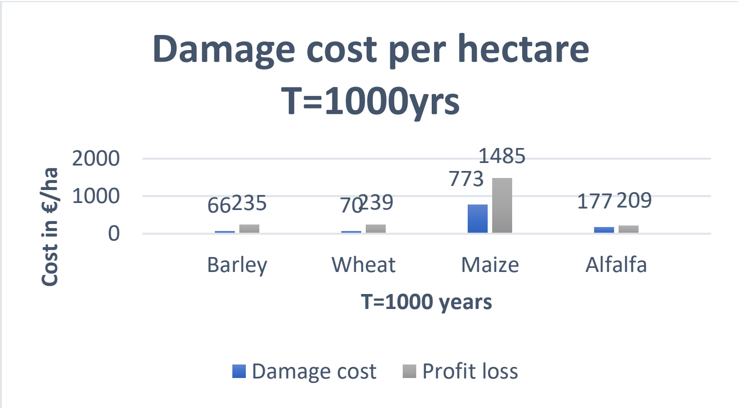


Figure 3: Damage cost and profit loss per hectare of flooded agricultural land for each studied crop and for the flooding scenario with return period of T=1000yrs



4. Conclusions

This study aimed to highlight the importance of the agricultural sector to the flood damage analysis on a regional level. Current floor risk analysis frequently neglects the agricultural sector and emphasizes mostly on infrastructures. This tendency is especially prevalent in Greece, where all crop types are mandated to be insured. Nevertheless, the compulsory public insurance scheme covers only a fraction of the projected damage. A few key results which showcase the above statements, for the flooding scenario with return period of T=1000 years, are the following:

- The total destroyed wheat production is 117.711 tones which represents a destruction of 27.6% of the total production of the studied region,
- The total destroyed barley production is 22.720 tones which represents a destruction of 31.6% of the total production of the studied region,
- The total destroyed wheat production is 194.350 tones which represents a destruction of 55.5% of the total production of the studied region.

The outcomes of this study have the potential to enhance our understanding of the impacts of a flooding event in the studied district, thereby contributing to enhancement of flood disaster

management. The implementation of a flooding damage analysis in the agricultural sector could be extended to all Greek water districts with up-to-date data on expected flooding characteristics and economic data. This proactive approach aims to provide advance awareness of the potential impacts of flooding events.

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Green digital finance nexus with traditional investments during crises

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Abstract:
This study investigates whether the US dollar index, the S&P500 index, gold and crude oil display dynamic spillover connectedness linkages with ten major green cryptocurrencies. Hedging capacities during the Covid-19 pandemic and the Russia-Ukraine conflict are examined by employing daily data and the cutting-edge Quantile-Vector Autoregressive methodology by Cunado et al. (2023). Findings reveal that 'environmentally-friendly' cryptocurrencies generate spillover impacts on all conventional assets and Algorand, Cardano, IOTA, Powerledger, and TRON constitute the strongest generators. Powerledger is the only significant transmitter in both crises. All conventional assets are mostly receivers of spillover impacts, and gold (oil) is the best net pairwise hedger (transmitter). Notably, gold displays profit-making powers during bear markets while oil is influential on higher income levels during the war. Overall, higher connectedness is found during the conflict at lower or middle quantiles. Green cryptocurrencies are risky high-performers during crises. Enhancing trust, globalization through innovation, and renewable energy leads to higher hedging effectiveness by well-established investments than orientation towards financial services, payments, or business accessibility.

Keywords: US dollar index, S&P500, Commodities, Green cryptocurrencies, Dynamic connectedness, Crises.

JEL Codes: E5, F3, G1

Global Water Players, usage behavior and economic power classification

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Abstract
Before the 80s, water was considered as a pure natural resource. During the 80s and 90s water suddenly appears as a commodity which must be managed as any other and at the end of 2000 is finally accepted a human right (Hofste and all. 2019 & Canberghe and all 2021). Literature evidence that over 25% of the world population is facing high water stress, which is nowadays leads to the perception that water is a unique resource. In this study we used the full available dataset of "Refinitive Water Market" to answer the following questions: Are companies belonging to the "Water" sector belong to concrete subsectors? Are there differences between these subsectors and as a result between those companies? Are these companies expected to behave the same under different market circumstances or will they present discrete behaviors which will affect their results, overall performance and equity returns? We attempted to classify them according to their economic power and efficiency using Principal Components Analysis (PC). And our initial findings are extremely interesting.

Keywords: Water, water stress, water scarcity, principal components, efficiency, economic power, equity returns

JEL Codes: Q5, Q2, L95, G3, H4, O1

1. Introduction

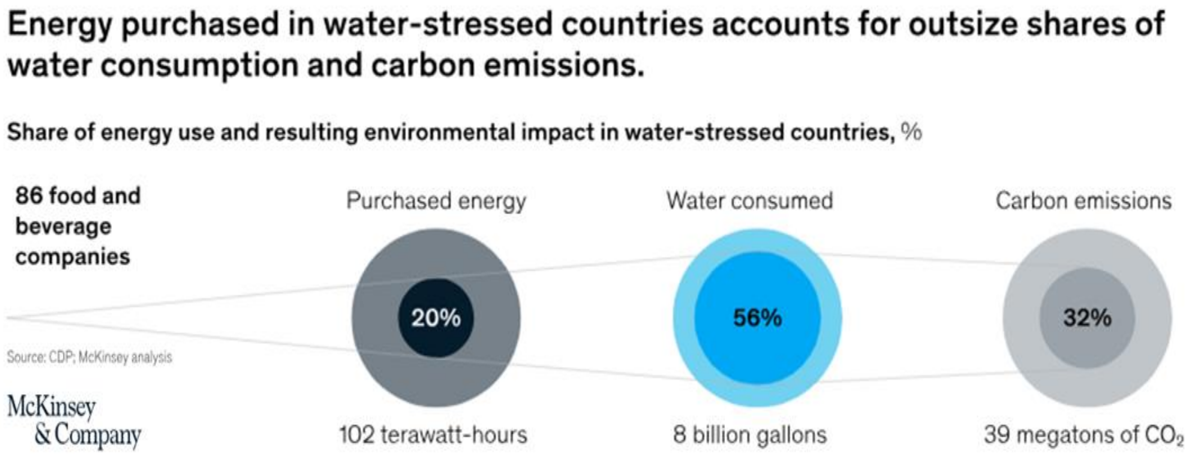
Water serves as a vital resource for human and animal survival, maintaining hydration and facilitating bodily functions essential for health. Its sustainable management is crucial for maintaining biodiversity and supporting economic development. In agriculture, water is pivotal for irrigation, ensuring crops receive the necessary moisture for growth and productivity. Industries rely on water for manufacturing processes, cooling systems, and as a solvent in various applications. Water is also integral to energy production through hydroelectric power generation. Sanitation and hygiene depend heavily on water for cleanliness and disease prevention. In cooking and food production, water is a fundamental ingredient. Beyond practical uses, water sustains ecosystems, habitats, and biodiversity, playing a crucial role in environmental balance. It supports recreational activities, such as swimming and boating, and serves as a mode of transportation for goods and people. Moreover, water contributes significantly to climate regulation through processes like precipitation and evaporation. However, climate change, demographic shifts, and economic growth pose significant challenges. This study aims to classify water-related enterprises and analyze their economic power, examining the implications of their water usage behaviors.

2. Challenges and Innovations in the Water Industry

The water industry has evolved significantly over time, beginning with ancient irrigation systems in Mesopotamia around 3000 BCE and the sophisticated water management practices of ancient Egypt and Rome. During the Industrial Revolution, advancements such as James Watt's improved steam engine enhanced water pumping capabilities, and the first municipal water treatment plant was built in 1804 in Paisley, Scotland. The 20th century saw major developments, including the continuous use of chlorine for water treatment and the establishment of the Clean Water Act in the US. In recent decades, there has been a strong focus on sustainability, with the 1992 Dublin Statement emphasizing sustainable water management and the UN recognizing access to clean water as a human right in 2010.

The water industry is undergoing significant changes, driven by the dual challenges of increasing population pressures and the impacts of climate change. These challenges have created substantial pressure on both industry and academia to innovate and develop sustainable water management strategies and technologies. It is imperative that assets, networks, and systems within the water industry are designed not only to function efficiently under normal conditions but also to anticipate, absorb, adapt to, and recover rapidly from disruptive events. This approach to resilience is crucial, as it parallels the requirements of other critical systems such as hospitals, emergency services, and education, where a lack of spare capacity and redundancy can lead to severe consequences.

In the context of the Organization for Economic Co-operation and Development (OECD) member countries, there is a pronounced financing gap that presents a significant hurdle. To achieve compliance with European Union standards by 2030, an estimated 289€ billion is required. This financial shortfall poses a considerable challenge, as countries have limited flexibility in addressing this gap. Additionally, there is substantial variation in the capacity of different countries to bridge this financing gap. Some countries may have more resources and infrastructure in place to meet these financial demands, while others may struggle significantly more.



In 2009, Peter Brabeck-Letmathe, then chairman of Nestlé, issued a stark warning about the potential consequences of a looming water crisis. He predicted that within the next 10 to 20 years, a severe shortage of water could significantly disrupt cereal production. This disruption, he explained, would not be a minor inconvenience but could instead lead to a massive global food crisis. The interconnectedness of water availability and food production underscores the critical need for sustainable water management practices to prevent such dire outcomes.

3. Methodology

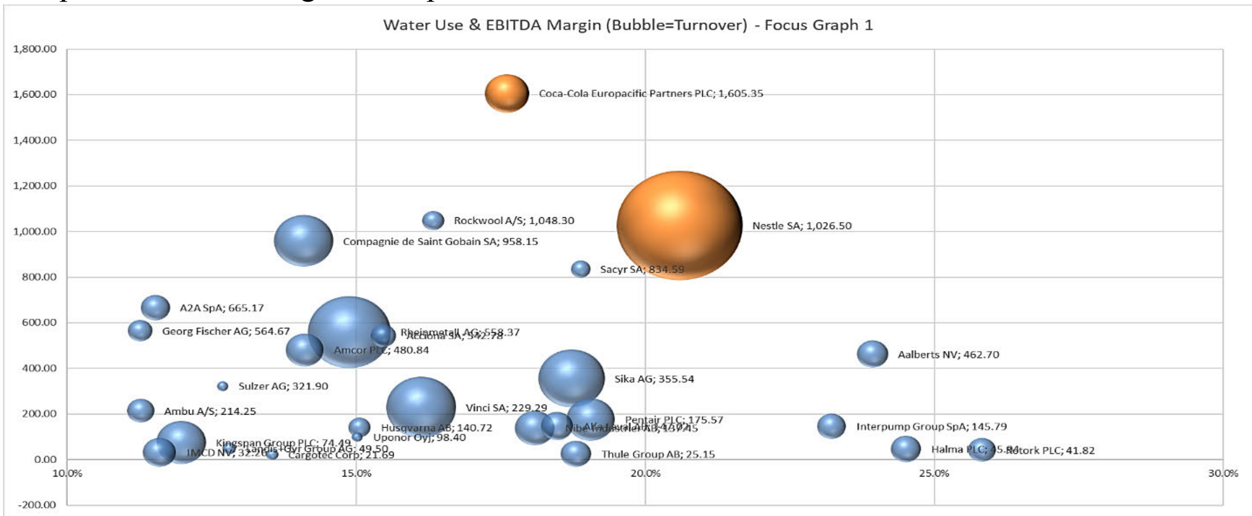
The study identified 1,259 water-related companies globally across 32 sectors using Refinitiv Data. These companies were primarily from the US (39%), Canada (15%), the UK (8%), the EU (22%), and other regions (16%). Ten key variables were calculated, including financial metrics, cost of equity, and water usage relative to revenues. Principal Components Analysis (PCA) and other statistical methods were used to categorize these companies, addressing issues of autocorrelation with the Box-Jenkins method, time-series PCA, spatial PCA, and non-negative matrix factorization (NMF).

3.1. Data Analysis and Descriptive Statistics

Our research sought to address four primary questions:

1. Do some “water-related” enterprises belong to specific groups or subsectors?
2. Are there differences between these subsectors and consequently between these companies?
3. Are they expected to behave the same under different market conditions?
4. Do they exhibit distinct behaviors that will affect their results and performance?

To answer these questions, we undertook a comprehensive data collection and analysis process. The dataset included over 10,535 observations, covering companies with a market capitalization exceeding $100 million. This represented 99.5% of the total market capitalization in the water-related sectors. Key financial metrics were analyzed, revealing significant variations in water usage and economic performance among the companies.



Market Capitalization: The total market capitalization of the analyzed companies amounted to approximately $2.75 trillion.

Water Usage: Average water usage ranged from 2,069 cubic meters to 42,418 cubic meters per company.

Financial Performance: EBITDA margins were calculated and correlated with water usage to assess economic efficiency.

3.2. Principal Components Analysis

PCA was employed to reduce the dimensionality of the dataset and categorize companies into distinct groups. The analysis remained stable across different methods, including the Box-Jenkins method, time-series PCA, spatial PCA, and NMF. The PCA revealed four to five distinct groups of companies based on their characteristics and economic performance.

Variance explained by principal components (10 components):

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Individual	0.28	0.25	0.21	0.12	0.08	0.06	0.01	0.00	0.00	0.00
Cumulative	0.28	0.53	0.74	0.86	0.93	0.99	1.00	1.00	1.00	1.00

Principal components (10 data points in rows, 10 components in columns):

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
ESG Score Grade (FY0)	-0.58	-3.62	0.17	1.48	1.06	0.75	0.06	-0.11	0.74	0.00
Turnover (EUR)	-2.05	3.79	-0.01	4.73	-4.78	-1.65	-0.10	0.02	0.02	0.00
Water Use To Revenues USD in million (FY0)	-0.04	-5.10	-3.80	-5.64	-3.57	-0.39	-0.02	0.00	-0.01	0.00
Price To Sales Per Share (Daily Time Series Ratio)	-0.27	-4.44	-0.32	2.19	1.22	0.48	-0.86	-0.71	-0.32	0.00
Market Cap	12.69	3.12	0.44	-0.21	0.10	0.21	0.02	-0.00	-0.00	0.00
EBITDA Margin - % (FY0)	-3.24	4.30	6.03	-2.49	-0.53	3.32	-0.81	0.10	-0.02	-0.00
Weighted Average Cost of Capital, (%)	-1.55	-1.09	1.98	0.58	0.29	1.39	2.13	-0.07	-0.20	0.00
ROE Common Equity %, TTM (FI0)	-1.81	1.15	4.66	-2.29	2.24	-4.63	0.00	-0.01	-0.00	0.00
Policy Water Efficiency (FY0)	-0.05	-4.95	-1.00	2.39	1.55	0.23	-0.45	0.80	-0.20	-0.00
Fresh Water Withdrawal Total (FY0)	-3.11	6.84	-8.14	-0.75	2.42	0.31	0.02	-0.02	-0.00	-0.00

4. Results

The analysis categorized companies into the following groups:

- ESG Effective (12%): Companies excelling in environmental, social, and governance criteria, demonstrating strong sustainability practices.
- Size Matters (28%): Large companies with significant economic impact, highlighting the influence of company size on market dynamics.
- Inefficient Exploiters (25%): Firms with high water usage but low efficiency, indicating potential areas for improvement in water management.
- Seriously Profitable (21%): Highly profitable companies with moderate water usage, balancing economic success with resource management.
- Mediocre Efficient (8%): Companies with average efficiency and profitability, representing a middle ground in the industry.

5. Discussion

The diverse nature of water-related enterprises and their varied responses to market conditions were highlighted. The classification provides insights into the behaviors and performance of these companies, emphasizing the importance of effective water management and sustainable practices. The findings have significant implications for policymakers and industry stakeholders, informing the development of targeted policies and strategies.

6. Implications for Policy and Practice

Understanding the classification of water-related companies can guide policymakers in designing regulations and incentives to promote efficient water usage and support the transition towards sustainable practices. For industry stakeholders, the classification provides a framework for benchmarking and improving water management practices. Companies can adopt best practices from leading groups to enhance sustainability and economic performance. Transparency and accountability in water usage are crucial, encouraging companies to report on their water management practices and progress towards sustainability goals.

7. Conclusion

Water is a vital resource that requires sustainable management to address the challenges posed by climate change, population growth, and economic development. This study provides a comprehensive classification of water-related enterprises based on their usage behavior and economic power, offering valuable insights for policymakers and industry stakeholders. Prioritizing effective water management and adopting responsible practices are essential for ensuring the sustainability and economic stability of the water industry.

A dynamic approach of climate change performance and weather-related environmental hazards: The effect of macroeconomic factors to climate indicators

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Abstract
The effects of climate change are getting worse over time. At the same time, there is a significant increase in extreme weather phenomena as well as the negative results caused by these phenomena. One of the most important factors of the extreme weather phenomena studied is the loss of human life as well as the danger to which the inhabitants of each region are now exposed. Having already statically studied the interdependence of the CCPI and CRI indices for the year 2019, as well as their interpretability from macroeconomic variables, we propose the dynamic examination of these indices. It is important to note that the Climate Change Perfomance Index (CCPI) is compiled from the countries that emit a total of 94% of Global Greenhouse Gas emissions, while in line with some other climate change factors, each country receives its overall score and rank. Respectively, the Climate Risk Index (CRI) studies and takes into account the effects of intense extreme weather events that take place in a country, again giving an overall score and rank to each country, however, in this case, the higher the score for a country, the higher the risk. This paper aims to provide evidence regarding the intertemporal correlation and interdependence between these indicators and possible macroeconomic factors.

Keywords: Climate change; climate risk index; extreme weather events; socio-economic factors, emissions

JEL Codes: O11, O40, Q20, Q30, Q43, Q54

Assessment of vulnerability to reaction of forest fires in wildland urban interface. A Case study of Regional Unit of Zakynthos

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Abstract
This paper attempts to answer the question: "what are the main factors that characterize the vulnerability of forest areas in an island and how do these factors may affect future: (a) planning decisions regarding the wildland urban interface (WUI) zones, as well as (b) prevention and preparedness policies?" For this purpose, three dimensions of vulnerability were recognized for the Island of Zakynthos: geographical, social and economic vulnerability. Geographic vulnerability involves assigning weight to both natural and human factors. Social vulnerability differs from geographic vulnerability because society is complex, with different levels of organization and complex linkages. Each dimension of vulnerability is closely interconnected. The economic robustness of a society affects and is affected when natural disasters occur. Therefore, the ability of government and local municipalities to address forest fires issues should be considered as an integral part of spatial planning. The weakness of authorities to implement prevention policies coupled with the lack of proper planning has led to an increased intensity of residential development and the existence of arbitrary (unauthorized) constructions. Consequently, this increases the likelihood of disasters and losses in the event of a fire hazard.

Keywords: wildland urban interface, vulnerability, prevention of forest fires

JEL Codes: O21, Q54, R14

1. Introduction

The wildland–urban interface (WUI) is commonly described as the zone where structures and human development meet and intermingle with undeveloped wildland or vegetative fuels. This WUI zone poses tremendous risks to life, property, and infrastructure in associated communities and is one of the most dangerous and complicated situations firefighters face. Analyzing the vulnerability is crucial for landscape planning, which is particularly relevant in vulnerable areas such as WUI. The International Federation of the Red Cross (IFRC) defines vulnerability as a condition most often associated with poverty and based on the relative ability of an individual or community to face, resist and recover from a hazard. Fire risk vulnerability is a vital issue for both forest protection and society. A thorough threat analysis for the area of interest, upon which both prevention measures and suppression preparation are structured, is central to a firefighting plan. Spatial planning is often seen as an essential tool or policy framework, particularly helpful in addressing all "cycles of disaster" from emergency prevention and management to reconstruction (Sapountzakis 2016, Lindell 2020).

Vulnerability assessment provides an important guide towards sustainable management. Environmental vulnerability is different from vulnerability of anthropogenic systems because the different levels of organization. The study of vulnerability related to natural disasters is a focus of research. In our study area (island of Zakynthos), the patterns of socio-economic and spatial development (e.g. tourism development, residential development in a mixed forest-settlement environment, etc.) seems to create multi-risk conditions. Therefore, it is deemed necessary to study the vulnerability of the area in order to analyze in depth the severity of the factors that shape vulnerability and thus to identify the suitable methods for effective mitigation. Nevertheless, an alternative approach needs to be developed for assessing the level of forest fire vulnerability, tailored for application on a smaller scale. It should be noticed that the reliability of vulnerability assessments remains uncertain due to varying local conditions. The wildfire vulnerability map is a tool used to visualize the current of the field. More specifically, for the assessment of vulnerability, a division was made into geographical, social and economic through the use of analytical equations. The selection of variables was based on an extensive literature review and the data availability.

2. Literature Review

Previous research is focused on identifying residential populations most likely to be affected by future wildfire events and the steps they can take to mitigate this risk on their private property (Collins, 2009; Gaither *et al.,* 2015; Haas *et al.,* 2014). Knowledge derived from expert opinions has been widely used in systems to solve problems related to environmental hazards (Schmoldt, 1987; Rust, 1988; Messing *et al.,* 1989).

Social factors influencing fire hazard vulnerability in a mixed forest–settlement (WUI) environment at the individual (or household) level have received considerable scholarly attention. According to Putri *et al.,* (2016), Rianawati (2005), and Akbar *et al.,* (2011) a comprehensive equation was formulated assigning weight to both human and natural factors. According to Paveglio *et al.,* (2016) socio-economic vulnerability is defined as the human population's exposure, sensitivity and ability to reduce negative impacts from risk. Income is one of several socio-demographic characteristics that influence homeowners' vulnerability to fire. The economically weaker are less likely to have the income or assets needed to prepare for or recover from a disaster (Morrow, 1999) similarly, the unemployed may lack health insurance (Brodie *et al.,* 2006). Age (children and elderly are more vulnerable), educational level, sex (women are more vulnerable) and employment (main vs.

secondary or part-time employment) of the homeowners (Kanclerz and Dechano-Cook 2013; Martin *et al.,* 2007) also play a crucial role in determining socio-economic vulnerability. Furthermore, older properties are more at risk of fire than newer properties because the former are (often) situated in rural areas and because newer homes use more fire-resistant materials. Indicatively, research examining the effects of natural disasters has indicated higher death rates among the elderly (Ryall & Demetriou, 2012), women and children (MacDonald, 2005), as well as individuals in lower social strata (Freudenburg *et al.,* 2009) and national minorities (Cutter, 2006; Norris *et al.,* 2008). Of course, depending on the way they perceive and evaluate a risk, people choose to protect themselves - or not - and react in a different way to a dangerous situation. Also, the more difficult a society's access to basic resources is, the more vulnerable that society becomes to various risks.

Concerning the geographic vulnerability, an important factor is land surface temperature (LST - Land Surface Temperature), which significantly affects the basic aspects of the functioning of the earth in both local and regional climate change (Roger & Pielke 2005). Namely, LST is intricately linked to land cover, encompassing factors, such as the presence of vegetation, anthropogenic materials, bare soil, and water bodies. LST is also contingent upon topography, which dictates the extent of surface exposure to the sun and the percentage of sky visibility, as well as the morphology and specific characteristics of the surface (Mitraka, 2011). The Normalized Moisture Index (NDMI) is also a factor that is usually taken under consideration, because it helps to evaluate the level of moisture content in various landscape elements. By interpreting the NDMI index, it is possible to immediately identify areas of vegetation with water deficits. Surfaces with water have positive values while soil and vegetation have zero or negative values corresponding to a lack of water (McFeeters, 1996). The Normalized Vegetation Index (NDVI) has been commonly used to map the distribution of ecosystems, to monitor disturbances and assess their impacts to monitor changes in ecosystem functional characteristics, to monitor the loss or degradation of evapotranspiration and carbon assimilation plants. The interpretation of the NDVI value is extremely useful, as it the prompt identification of areas with vegetation-related issues. The moisture content of vegetation in fire-prone areas determines the flammability of vegetation and thus the likelihood of fire initiation and spread. It is thought that the drier the vegetation, the more likely it is to burn (Chuvieco, Wildland Fire Danger Estimation and Mapping, 2003). Similar studies also use land cover in order to provide insight into how land is utilized for various socio-economic purposes, such as forestry, agriculture, and recreation. (FAO, 2009).

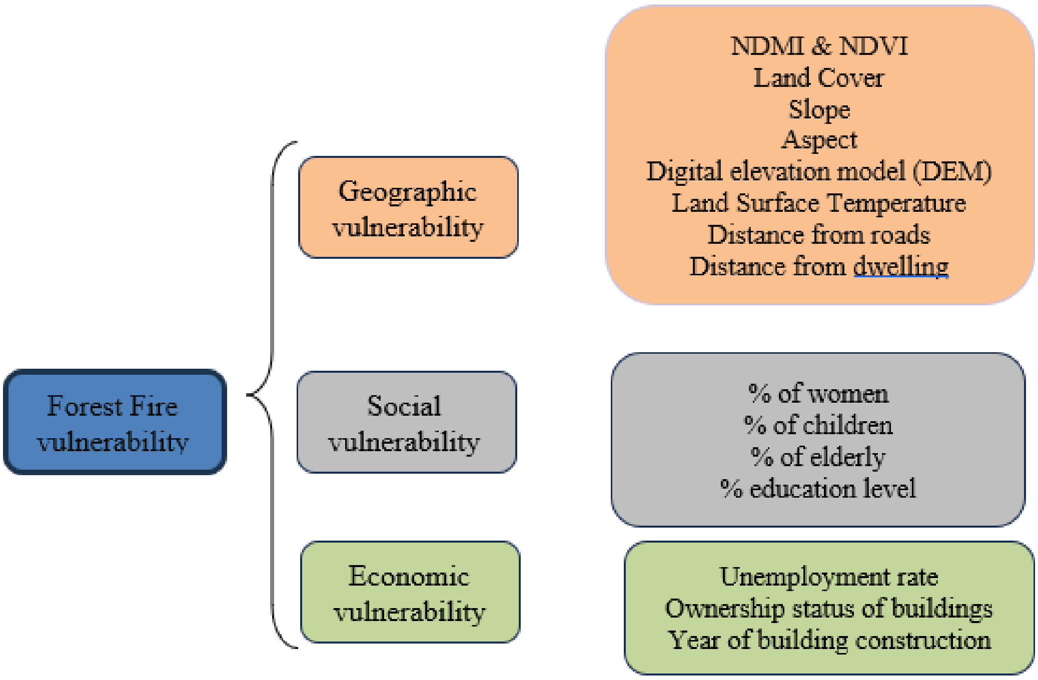
In Greece, the risk of forest fires caused by human activities has been statistically found to be high (Political Protection, 2022). Proximity (distance) to the road network is an important factor that can influence the degree of risk of an area against forest fires. This is because roads, much like human activity, contribute to an increased risk of fire. Another quite important criterion for the creation of a single risk map, is the distance from the urban formations since fires take place at the points of interface between forest areas and settlements (Wildland Urban Interface) (Cohen, 2010; Narayanaraj and Wimberly, 2012; Syphard et al., 2008).

In France, WUI is defined under the French Forest Law of July 9, 2002, which mandates clearing within a maximum radius of 100 meters around each house. Radius size corresponds to the extension of wildland-urban interfaces (Lampin, Jappiot, Borgniet, & Long, 2006; Lampin, Jappiot, Long, Mansuy, & Borgniet, 2006). This distance (i.e. 100 m around buildings) is also used by the Portuguese legislation, and falls within the distance range considered for defining WUI in other countries, such as Spain or Italy (Modugno *et al.,* 2016). Finally, accessibility is one of the important factors of fire risk. A building engulfed in flames relies on timely intervention from fire stations equipped with water, ladders, and firefighting tools. However, if the adjacent street is impassable for fire engines, the surrounding buildings become severely exposed due to the hindered access for firefighters and their critical equipment (Rahman *et al.,* 2015). Reducing fire risk and loss to homeowners is a central policy concern in fire management.

3. Methods and Data

The assessment of fire vulnerability was founded upon three distinct pillars (dimensions): geographic, social and economic vulnerability. Figure 1 depicts the framework and key variables chosen to evaluate forest fire vulnerability within the study area of Zakynthos Island. The selection of these variables is built upon insights from previous studies, as comprehensively reviewed in the literature.

Figure 1: The structure and the variables of the forest fire vulnerability model



Data analysis involved creating thematic maps for each variable was based on the existing literature. Demographic and economic data, such as population dynamics, employment figures, and unemployment rates, were sourced from Hellenic Statistical Authority's (ELSTAT) Censuses. Buildings outside the settlements were also digitized, allowing for a comprehensive assessment of the entire study area potentially affected by wildfire, and thus ensuring that no vulnerable structures are overlooked.

To assess experts' perceptions of vulnerability, a questionnaire was crafted with specific item questions covering two main aspects: (a) their evaluations of the risk and vulnerability associated with forest fires, and (b) their estimations of the likelihood of encountering danger or experiencing a disaster. Drawing from international literature, questions were carefully selected, some were adapted, and new ones were formulated to ensure comprehensive coverage. Administered in April 2023, the questionnaire reached 16 participants, timed strategically for optimal engagement. Predominantly employing closed-type questions structured across five levels, participants submitted their responses electronically.

To analyze geographic vulnerability, various factors were grouped into distinct categories for easier assessment. Each dimension was estimated based on five-distinct levels of vulnerability (Not Vulnerable, Moderately Vulnerable, Vulnerable, Very Vulnerable, Extremely Vulnerable). Equation 1 incorporates expert-assigned weights, as determined through the aforementioned questionnaire survey.

$$Geographic\ vulnerability = G_1*LC + G_2*ST + G_3*NV + G_4*NM + G_5*DS + G_6*SL + G_7*DS\_R + G_8*DS\_DW \quad (1)$$

where:
LC = Land cover
ST= surface temperature
NV = normalized vegetation index (NDVI)
NM = normalized moisture index (NDMI)
DS = digital elevation model (DEM)
SL = slope
DS_R = Distance from Road
DS_DW= Distance from buildings _ outside the settlement
G1, G2, G3, G4, G5, G6, G7, G8 = expert-assigned weights for each geographic factor

To assess social vulnerability, we followed the methodology outlined by Fekete and Nehren (2023), carefully selecting and categorizing relevant variables. Equation 2 encapsulates this integration, incorporating both the social factors and their respective influence weights.

$$Social\ vulnerability = S_1 * RE + S_2 * ST + S_3 * WP + S_4 * EL \quad (2)$$

where:
RE = retired people
ET= students up to 18 years old
WP = women population
EL= minimum educational level
S_1,S_2,S_3,S_4 = weights for each social factor

Each facet of vulnerability is intertwined with others, forming a complex web of interdependencies. For example, the economic resilience of a society not only influences the occurrence of disasters but is also influenced by them. In this context, economically disadvantaged societies are often perceived as more vulnerable than wealthy ones. While a robust economy may be able to withstand and recover from catastrophic events, weaker economies may struggle to recover and regain their previous stability.

In this paper, the assessment of economic vulnerability is of paramount importance. For this purpose, variables such as unemployment rates, years of building construction and ownership status were carefully selected based on findings from various studies (Erten et al., 2004; Jaiswal et al., 2002; Paveglio et al., 2016; Ojerio et al., 2011). These selected variables were then categorized into five vulnerability classes, following the framework proposed by Fekete and Nehren (2023) and Wood et al. (2021).

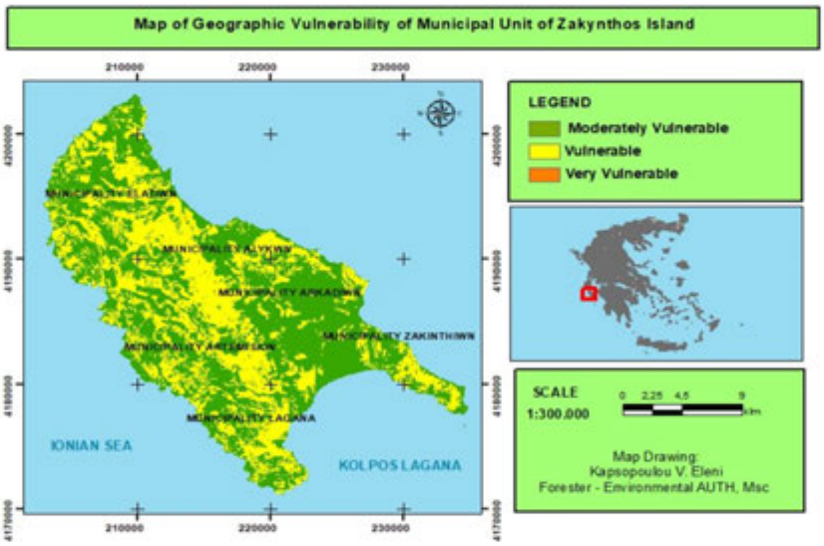
$$Economic\ Vulnerability = E_1*UP + E_2*OS + E_3*BY \quad (3)$$

where:
UP = unemployment rate
OS = building status (ownership status)
BY = building year of construction
E_1,E_2,E_3 = weight factors for each economic factor

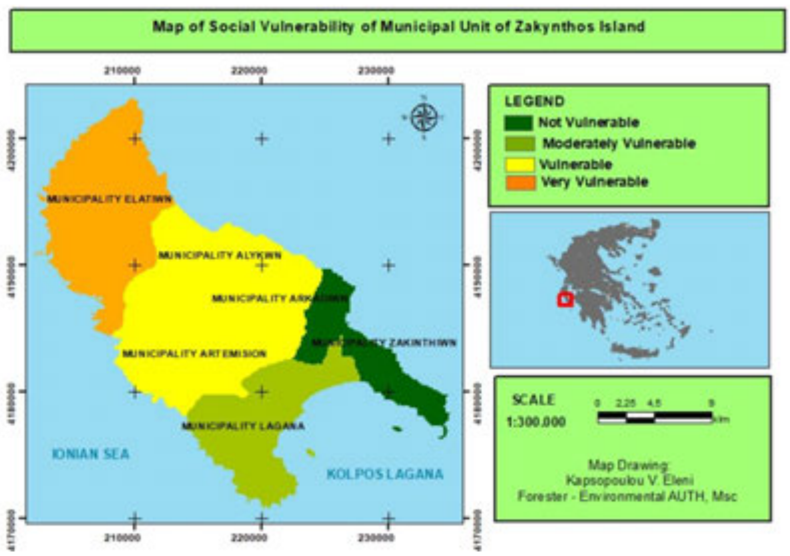
4. Empirical Results

Three maps were generated based on Eq.1-3 to assess geographic (Map 1), social (Map 2) and economic (Map 3) vulnerability in the study area concerning forest fires. These maps provide a comprehensive visualization of the selected vulnerability dimensions (pillars).

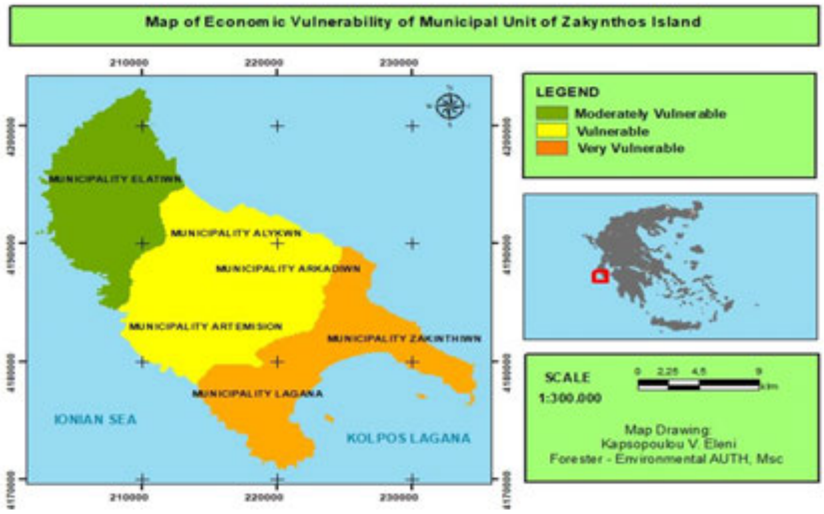
Map 1: Geographic Vulnerability of Municipal Unit of Zakynthos



Map 2: Social Vulnerability of Municipal Unit of Zakynthos Island



Map 1: Economic Vulnerability of Municipal Unit of Zakynthos Island



Then, a final/integrated multicriteria model was used (based on Figure 1), which incorporates all three dimensions of geographical, social and economic vulnerability, weighted according to their importance and overall impact (based on the experts' questionnaire survey). Therefore, Map 4 combines all three dimensions/vulnerability components and represents the consolidated wildfire vulnerability of Zakynthos Island (Map 4). Following this analysis, Table 1 delineates the distribution of vulnerability zones across Zakynthos Island. Most of the island area, approximately 74%, is deemed moderately vulnerable based on the multi-criteria analysis conducted. Very vulnerable areas cover only a small part of the island (about 400 ha), constituting approximately 1% of the total area, while areas classified as vulnerable cover around 25%. In particular, the western region contains moderately vulnerable areas, in contrast to the southern part, which is mainly in the vulnerability category and covers 25% of the island's area.

Map 2: Vulnerability Map of Municipal Unit of Zakynthos Island

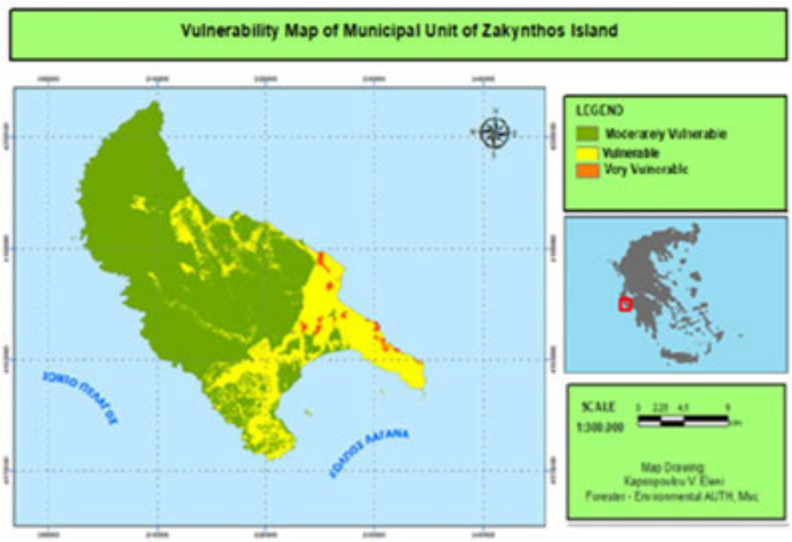


Table 2: Area (hectares) distribution for each vulnerability category

Vulnerability level	Area (Ha)
Moderate Vulnerable areas	29.428,45
Vulnerable areas	10.002,28
Very Vulnerable areas	400,59

5. Conclusions

The development of human activities in areas adjacent to forests and the spread of mixed forest-settlement zones have increased the exposure of human life and property to risk. Fires are one of the most important natural disasters in Greece and in general in the Mediterranean. The increased population density (especially during the summer months) leads to a significant increase in the risk of fire in the wider Mediterranean region. The findings underscore the importance of implementing proactive measures, especially in highly vulnerable areas identified through the assessment. Moreover, there is a pressing need for an integrated planning approach that incorporates knowledge and addresses risks to inform the development of effective prevention policies.

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Session 4
Climate Change
& Urban Environment

Novel Methodologies with Virtual Reality Applications in Environmental Economics: The Arsinoe Project.

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Abstract

Great cities are exposed to the global warming phenomenon such as heatwaves and longer periods of droughts. The present multi-crisis has posed a plethora of novel challenges to urban environment, such is the case study 1 of the Arsinoe Project, i.e., the Athens Metropolitan Area (AMA), Greece. AMA is burdened by heatwaves during summers and the urban heat island (UHI) effect aggravates the resilience to these phenomena. A way to understand citizens' opinion is through their willingness-to-pay (WTP) in order to ameliorate their conditions in comparison to the present status quo. This research would try to present the potential of comparing traditional methodologies of environmental economic to novel ones via the adoption of virtual reality (VR) questionnaire. Overall, the economic valuation of the climate change phenomenon in a case study as the AMA can offer a great potential for policymaking in greater city areas that cope with heatwaves and droughts.

Keywords: willingness-to-pay; virtual reality; urban heat island; climate change

JEL Codes: Q51; Q54; Q57

Comparing Air Pollution levels in Greece: The case of Athens and Salonica

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Abstract

This paper continues our last ENVECON work: We extend our method to more pollutants such us CO, NO, NO2, Smoke and SO2 and in two areas of Greece: Athens and Salonica. Therefore we are working towards to investigate similarities and differences within each city, as far as the pollutants concern, and between cities, as far each pollutant or even the total imposed pollution. Of course the structure of the city is essential, but we are only working with the existing data set. The linear Regression models and ARIMA models are considered, while the existed miss organized presentation of the data concerning each city and existed pollutant, create problems to the study – there are not data sets for the same time intervals, at certain time intervals there are not data for all the pollutants of the study. There are not for all the pollutants data (collected from the Greek Ministry of Environment and Energy), for the same period, between the cities, there is a uniform study on the provided data sets for specific areas within the city. We are eventually concentrated in Salonica in three areas (Center, Kalamaria, Kordelio) and in Athens also three areas (Center, Patisia, Peristeri). The different obtained models are compared, but one of the main characteristic of our research is that the Big Data Sets, ie to obtain very "long" series of data, do not offer to the next day prediction, as there is a martingale structure to these models. Certainly there are turning points, but such a research needs particular investigation and more reliable data sets.

Keywords: pollutants, air pollution; Greece

JEL Codes: Q5; Q53

1. Introduction

The effects of climate change are very strong and visible for example in the Netherlands, farmers have to reduce their herds so that to reduce nitrogen or in France where large lots had to leave 4% fallow.

For farmers, the new EU measures included reducing the use of fertilizers and pesticides, while simultaneously reducing the area of productive land used by farms.

According to the plan in the Netherlands by 2030 nitrogen emissions should be reduced on average by 50% and in Natura areas by 70%. That is, to reduce dramatically, up to 50%, the numbers of animals on Dutch farms.

Air consists mainly of nitrogen N_2 in 78,08% v/v and oxygen O_2 in 20,95% v/v. The CO_2 is in 0,03% v/v, it has been increased surprising very rapidly the last 100 years, while Ar is in 0,93% v/v. Therefore, violation for these limits might be considered dangerous.

The continuous addition of CO_2 to the atmosphere causes an increased activity in terms of the "greenhouse effect" on the Earth. Therefore, an increase in Earth's temperature has been noticed. Then, warming the oceans would cause an increased flow of CO_2 from them to the atmosphere. This would result in the greenhouse effect and a new increase in the temperature of the planet. Such a version could be repeated. However, from the temperature trends observed today, no such increase in temperature can be found.

The effect of the consequences of the increase of CO_2 in the atmosphere is compensated by the addition of various particles that cut off solar radiation. Thus, the warming of the earth is delayed, reduced somehow. However, we believe, we should control the CO_2 content of the atmosphere on a "global scale" – this might be more important than the globalization of the Economy.

2. The Air pollutants

The most common air pollutants are the following:

(i) Carbon monoxide (CO)

In principle, we would say that Carbon monoxide is a very poisonous gas that you can't see, taste or smell. Therefore, some devices should never be used (heaters, barbeques, tools with gasoline engines etc). The main symptoms of the health risk due to CO poisoning include headache, nausea, vomiting, dizziness, among others, and in some instances, permanent brain injury or death.

(ii) Nitric oxide (NO)

Nitrogen or Nitric oxide (or nitrogen monoxide) reacts with the hydroperoxyl radical HO2 to form nitrogen dioxide. NO2, which then can react with a hydroxyl radical (OH) to produce nitric acid, HNO3 . Liquid nitrogen oxide is very sensitive to detonation even in the absence of fuel. Nitric oxide should not be confused with nitrogen dioxide (NO_2), a brown gas and major air pollutant.

(iii) Nitrogen dioxide (NO_2)

Nitrogen dioxide is a highly reactive gas. It is formed by emissions mainly from motor vehicles, industry, that is why high concentrations are near busy roads and indoors where unflued gas-heaters are in use.

Outdoors, NO2 contributes to the formation of ground-level ozone, O3, as well as particulate matter pollution. The most potential health effect from exposure to nitrogen dioxide is to Increase susceptibility to lung infections in people with asthma, as well as the Airway inflammation in healthy people – which can be take place in Hospitals.

(iv) Sulphur dioxide (SO_2)

Sulphur dioxide is highly reactive gas with a pungent irritating smell. It is mainly formed by fossil fuel combustion at power plants and other huge industrial installations. The most common potential health effect to humans from exposure to SO2 is narrowing of the airways leading to wheezing, chest tightness and shortness of breath.

(v) Ozone (O_3)

Ozone is found in the upper atmosphere as well as at ground level. O3, in the upper atmosphere protects Life, by filtering out damaging ultraviolet radiation from the Sun. But, at ground level, acts as a high-risk pollutant, damaging human's health. It is the main component of smog and is the product of the interaction between sunlight and emissions from sources (motor vehicles and industry). In principle, O3 can travel long distances and accumulate to high concentrations far away from the sources of the original pollutants. This creates food for thought to work on Transfer Entropy influence by this particular Air pollutant.

(vi) Particulate matter (PM10 and PM2.5)

Particulate Matter, or PM in abbreviation, describes extremely small solid particles and liquid droplets suspended in air. The size of these particles affects their potential to cause in humans health problems:

PM10 : particles with a diameter of 10 micrometres or less so are small enough to pass through the throat and nose and enter the lungs.

PM2.5 : particles with a diameter of 2.5 micrometres or less, so small they can get deep into the lungs and into the bloodstream. It is a subclass of PM10 pollutants.

In the present paper interest is focused on pollutants (i) to (v), as above, for the areas of our interest: Athens and Salonica. The case (vi) needs a particular investigation.

3. Literature Review

The problem of Economy and Environment has been extensively discussed by Halkos (2013). There are certainly excellent papers on the Climate Change, most of them due to Intergovernmental Panel on Climate Change, IPCC, see IPCC (1990) among others, who supported the correlation between temperature and pollutants like CO_2. Moreover Statistcal techniques have been proposed for the evaluation of hazard functions for air pollution problems, Kitsos and Trandafir (2022). For the change Point methods, discussed in section 3, some Statistical methods have been developed with no too much applications in Environmental problems, Hackl (2013 Ed), Darling (1956), Carlstein (1988), among others. This paper is adopting the Exploratory Data Analysis (EDA), an analysis identifying the main hidden patterns in the data, introduced by Tukey (1977), and can be adopted to a number of applications, Behrens (1977), Adopting computational techniques, see the early work of Kitsos (1996), while the Time Series models, Halkos (2019, Chapter 9 and 11), Box et. al. (1994) are the main Statistical framework on which this paper is based.

4. The Change Point Approach

When a series of observations are received, such as from an industrial process, or from a series of daily observations we are interesting to investigate cases were a specific event occurred and the process has been violated. In such cases we are referred that the process in out of control, for the Industrial Statistics or that a Violation of the whether took place in Environmental or Economical Statistics.

When a time series of observations are examined, such as from the market, or for the weather characteristics, there is still a serious interest to examine, in statistical terms to test, if at a certain point a violation of the time series process took place. In this, latter case, the change point exists and remains, in principle, while in the Industrial case the change point can be detected, and the process return to its typical characteristics.

Therefore, we examine statistical tests were the null hypothesis H_0 states that the process is stationary, while the alternative H_1 status that the process is non-stationary since the change point.

The simplest presentation of this change point idea is to consider the standardized variables Y_i, $i = 1, 2, \dots, n$, $E(Y_i) = 0$, $E(Y_i^2) = \sigma^2$, with errors e_i, say, $i = 1, 2, \dots, n$. At the null hypothesis H_0 we consider Y_i, $i = 1, \dots, n$ to remain with the errors e_i, when in the alternative H_1 there is a change point occurred at point k_0, say i.e.,

$$H_0: Y_i = e_i, i = 1, 2, \dots, n \qquad H_1: \exists\, k_0 \in \{1, \dots, n-1\} \text{ with} \tag{1}$$

$$Y_i = \begin{cases} e_i, i = 1, \dots, k \\ \\ \mu + e_i, i = k+1, \dots, n \end{cases}$$

with $e_i, i = 1, 2, \dots, n$ being independent identically distributed (iid) errors. When inference is required, we assume that $e_i \sim N(0,1)$, $i = 1, 2, \dots, n$ with $N(0,1)$ the standard normal distribution with density function $\phi(x)$ and distribution function $\Phi(x)$, as usually. The k is known as change-point.

The average of the observations at the first and second part of the observations, divided by the change point m, are respectively

$$\bar{Y}_k = \frac{1}{k}\sum_{i=1}^{n} Y_i \ \ and \ \ \bar{Y}_k' = \frac{1}{n-k}\sum_{i=k+1}^{n} Y_i \tag{2}$$

We mention that $\bar{Y}_k'$ is the LSE of the unknown $\mu \in R$. Moreover, it holds,

$$(n-k)^{1/2}\bar{Y}_k' \sim N(0,1) \tag{3}$$

and the k_0 value is needed to be evaluated, through the chosen k.
As test statistic is considered the statistic

$$T_{n,k} = \max_{0 \le k \le n-1} \left\{ \frac{1}{\sqrt{n-k}} \sum_{i=k+1}^{n} Y_i \right\} \tag{4}$$

and therefore, the null hypothesis is rejected for a two-sided test, when

$$|T_{n,k}| > C_a \tag{5}$$

with C_a, defined constant at significant level α. For the constant value C_a the following holds.
Proposition 1. For C_a as in (5) it holds

$$C_a = z_{1-\alpha/2} \tag{6}$$

with $z_{1-\alpha/2}$ the $\left(1-\frac{\alpha}{2}\right)100\%$ quantile of the standard Normal $N(0,1)$.
Indeed:
As $Y_i,\ i=1,2,\dots,n$ are iid $N(0,1)$ then

$$T_{n,k} = \frac{1}{\sqrt{n-k}}\sum_{i=k+1}^{n} Y_i \sim N(0,1) \tag{7}$$

Thus for k known and equal to k we would reject H_0 at significant level α if

$$\left|\frac{1}{\sqrt{n-k}}\sum_{i=k+1}^{n} Y_i\right| > z_{1-\alpha/2} \tag{8}$$

and therefore, this is true also for $|T_{n,k}|$.
Although the exact distribution of $|T_{n,k}|$ it is not as easy task one could evaluate

$$Corr\{\tau_{n,k},\tau_{n,q}\} = \sqrt{\frac{n-q}{n-k}} \quad k \le q \tag{9}$$

see Hawkins (1977). Under H_0 a very nice asymptotic result, for n large was proposed by Darling and Erdos (1956).
Let us define the quantities
$\gamma_n = \sqrt{2\log\log n}\,,\quad \delta_n = \gamma_n^2 + \frac{1}{2}\xi_n - \frac{1}{2}\log\pi$
Then for n large and $x \in R$

$$P\left[|T_{n,k}| > \frac{x+\delta_n}{\gamma_n}\right] \approx 1-\exp[-e^{-x}] \tag{10}$$

Now we shall refer to another problem. Recall (1), the hypothesis definition of the testing. This can be changed to

$$\begin{gathered} H_0: Y_1,\dots,Y_n \sim N(\mu,\sigma^2) \quad H_1: \exists\, k_0 \in \{2,\dots,n-2\} \text{ with} \\ Y_1,\dots,Y_{k_0} \sim N(\mu_1,\sigma_1^2) \\ Y_{k_0+1},\dots,Y_n \sim N(\mu_2,\sigma_2^2) \end{gathered} \tag{11}$$

with $\mu_1 \neq \mu_2 \in R$ and $\sigma_1^2 \neq \sigma_2^2 \in R$. For the test statistic

$$\Psi_k^2 = n\log\left[\frac{1}{n}S(\bar{Y}_n)\right] - k\log\left[\frac{1}{k}S(\bar{Y}_k)\right] - (n-k)\log\left[\frac{1}{n-k}S(\bar{Y}_k')\right] \tag{12}$$

with $S(A) = \sum_{i=1}^{n}(Y_i - A)^2$, recall (2),

It can be proved, Horvath (1993), that

$$P\left[\max_{1\le k\le n-1}\{\Psi_k\} > \frac{x+\theta_n}{\gamma_n}\right] \approx 1-\exp[-2e^{-x}], \qquad x \in R, \qquad \theta_n = \alpha_n^2 + \xi_n, \text{ recall (10)}$$

We shall try to work on this framework completing the Explanatory Data Analysis (EDA), mainly graphically, to get the Time Series features of the Data, and work with ACF and PACF, for the data which we collected and we tried to analyze in this present paper. Therefore, the target of this paper is to provide a complete presentation of the data under EDA principles.

5. Methods and Data

5.1 Data

There is a number of different data bases concerning different areas in the World. We are focused, in this study, to compare the air pollution between the most industrialized areas in Greece, Athens and Salonica, as we explain in section 4.1.

There are not for all the pollutants data (collected from the Greek Ministry of Environment and Energy), for the same period, between the cities, there is a uniform study on the provided data sets for specific areas within the city. We are eventually concentrated in Athens also two areas (Patisia, Peristeri) and in Salonica in three areas (Aristotelous, Kalamaria). In detail:

Out of the four areas - two in Athens, Patisia and Peristeri, and two in Salonica, Aristotelous, Kalamaria - three of them (Aristotelous, Patisia, and Peristeri) have data in each of the six time periods (1984-2000, 2001-2005, 2006-2010, 2011-2015, 2016-2020, and 2021). Kalamaria has no data for the period 1984-2000. For the period 1984-2000, Aristotelous recorded measurements for four of the pollutants under investigation, and all five for Patisia and Peristeri. For the next period, 2001-2005, 5, 5, 6, 7, 6 pollutants were recorded for Aristotelous, Kalamaria, Patisia, and Peristeri, respectively. For the remaining periods, 2, 4, 6, 6, and 5 (2006-2010), 10, 2, 6, 6, and 6 (2011-2015), 10, 7, 0, 6, and 4 (2016-2020), as well as 5, 7, 0, 1, and 4 (2021) were recorded for the areas (ordered as above), respectively. Common pollutants for the areas, by time period, are CO, NO, NO_2 and SO_2 in 1984-2000, NO, NO_2 and SO_2 in 2001-2005, NO and NO_2 in 2006-2010, none in 2011-2015, NO and NO_2 in 2016-2020, and none for 2021.

5.2 Methods

For the time series models we worked with, such as AR, MA and ARMA. Interest is focused on the ACF and PACF, i.e. the Autocorrelation Function and the Partial Autocorrelation Function, respectively, plots are essential. An ACF plot indicates the existing correlation between a time series and lagged versions of itself. Recall that autocorrelation exists at zero lag, equivalently is the correlation of the time series with itself and therefore results in a correlation of 1. A PACF plot indicates the correlation between a time series and its lagged values after accounting for the correlations of shortest lags. Actually, the partial autocorrelation at lag q is the autocorrelation between X_t and X_{t-q} that is not accounted for by lags 1 through $q-1$. Presented plots, following the Augmented Dickey-Fuller test, Dickey and Fuller (1979), for stationarity of the series, are implemented for AR and MA ordering and produced for all the above mentioned (i-v) pollutants.
The following diagram offers a compact interpretation of both ACF and PACF for the given models.

Table 1: ACF and PACF compact interpretation of time series

Plot \ Model	AR(p)	MA(q)	ARMA(p,q)
ACF	T_O	$S(p,q)$	T_O
PACF	$S(p,q)$	T_O	T_O

where:
T_O: Tails off (Geometric delay), $S(t,r)$: Significant at each lag t / cuts off after lar r
Extrapolatory Data Analysis (EDA) was introduced by Tukey (1979) in order to analyze data set from different areas of interest, to obtain their main characteristics (i.e., statistical functions, test etc.) and visualize the data sets with graphical methods, see also Behrens (1997).

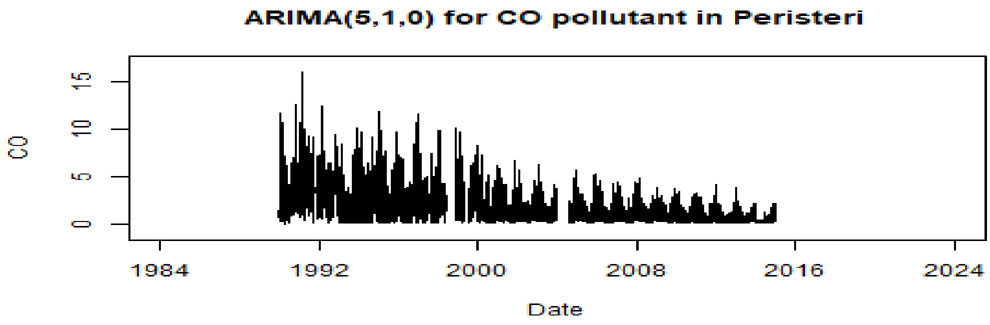
A sort manual of statistical packages was discussed by Kitsos (1996), while a detailed approach with a number of applications with a recent software to the Time Series problem see Halkos (2019).

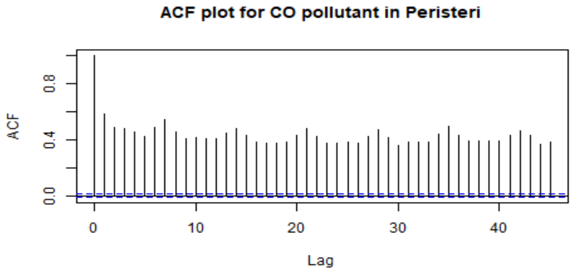
6. Empirical Results

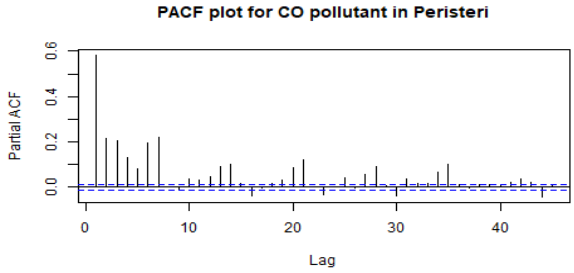
In the following figures the history of the collected pollutants for the areas discussed above are represented and the corresponding ACF and PACF plots are considered. In detail:

6.1a CO in the areas of Athens

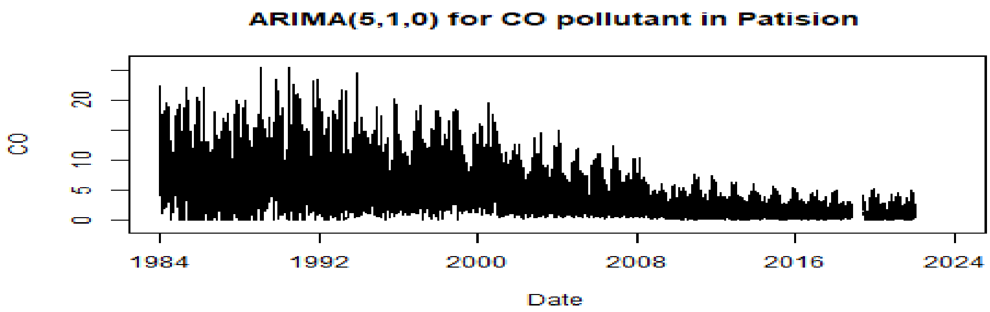
6.1a.1 Pollutant CO, Peristeri

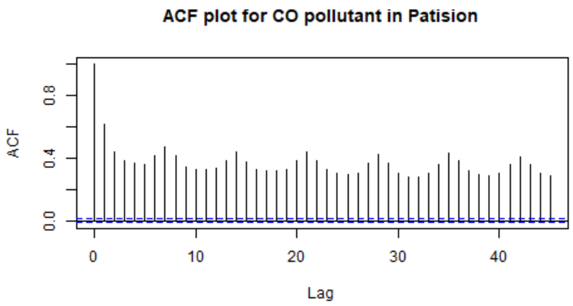


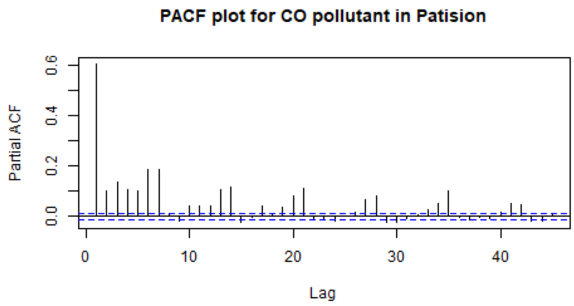




6.1a.2 Pollutant CO, Patision

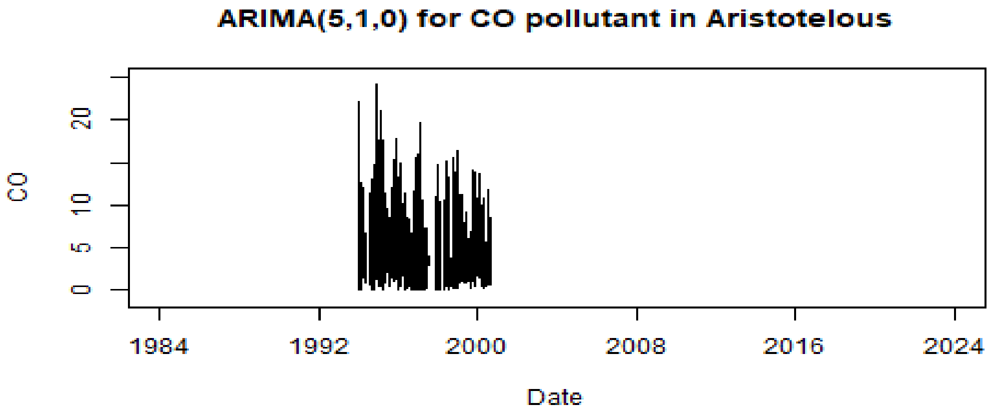


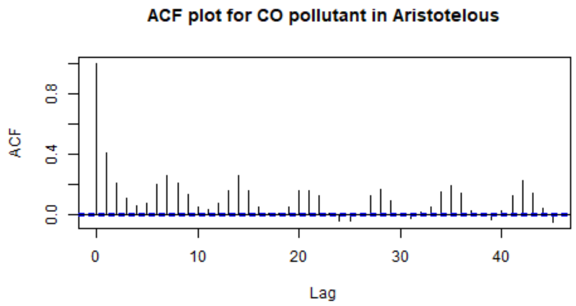


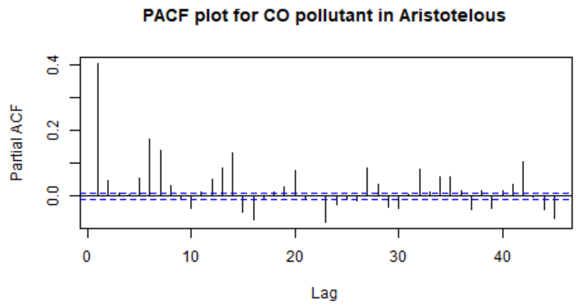


6.1b CO in the area of Salonica

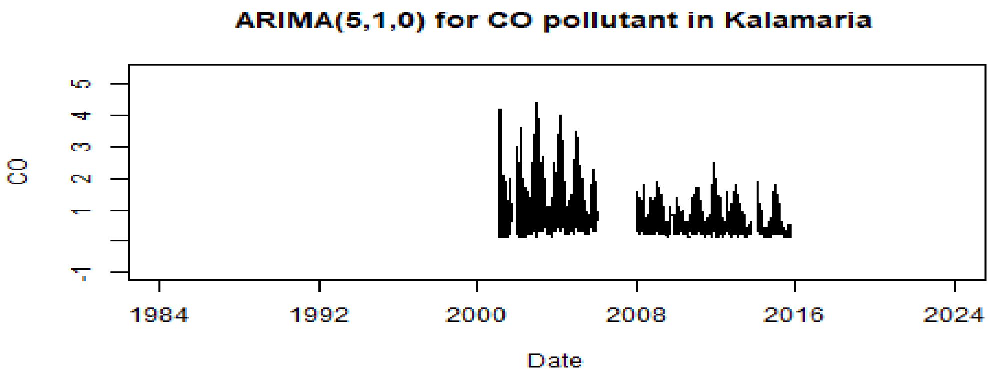
6.1b.1_Pollutant CO, Aristotelous

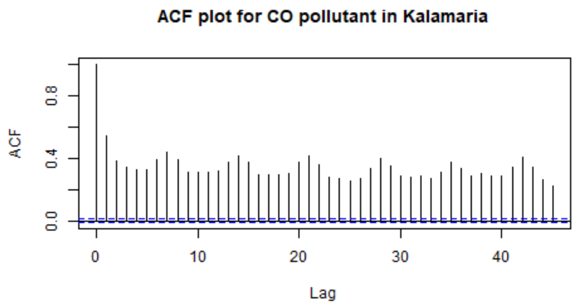


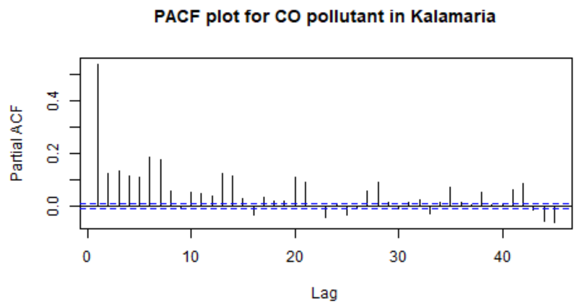




6.1b.2_Pollutant CO, Kalamaria

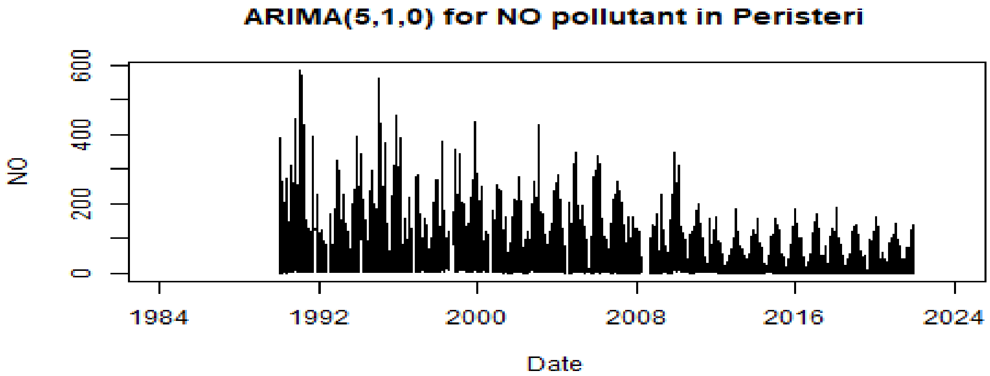


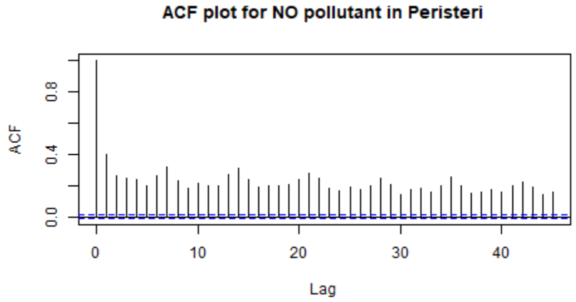


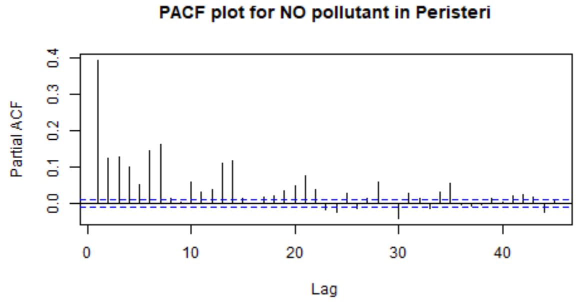


6.2a NO in the area of Athens

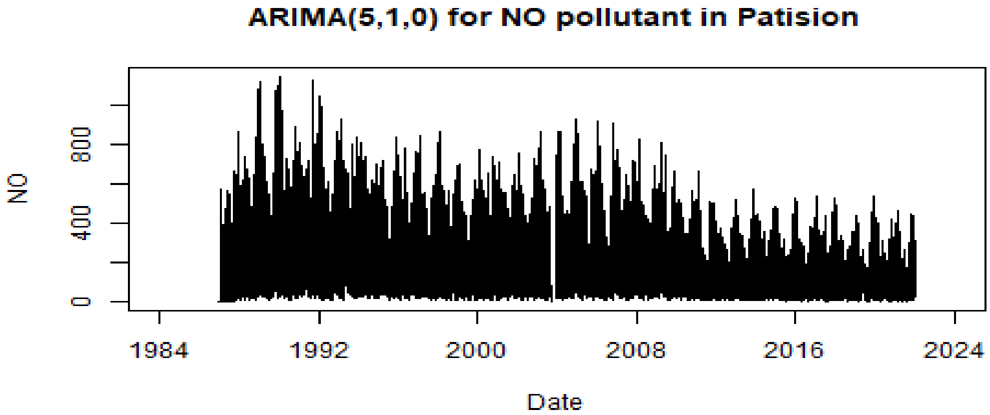
6.2a.1_Pollutant NO, Peristeri

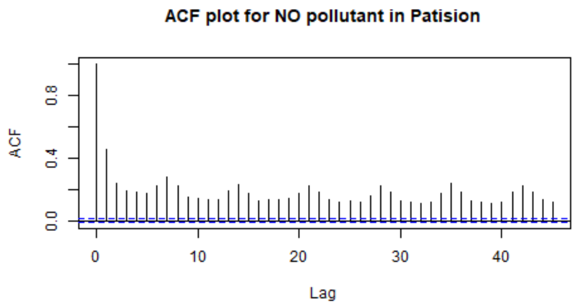


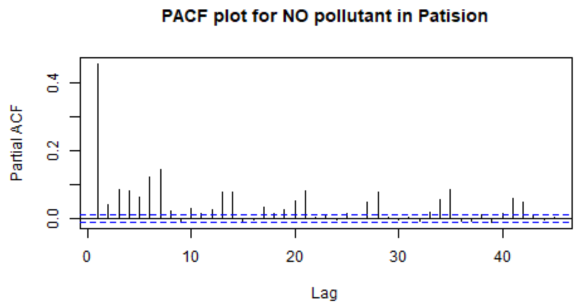




6.2a.2_Pollutant NO, Patision

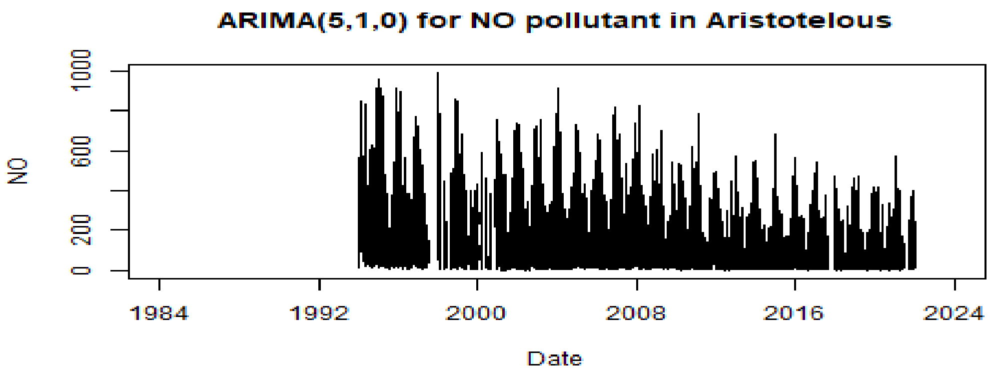


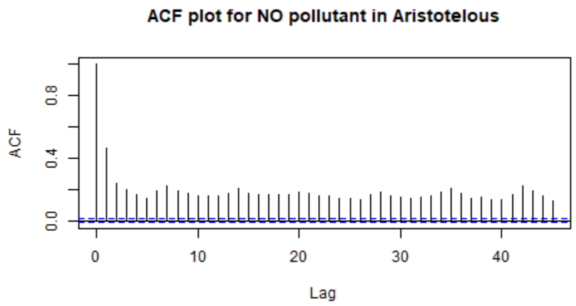


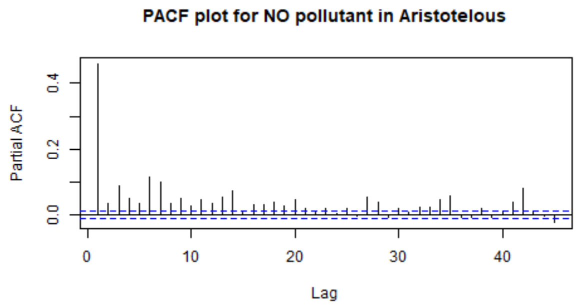


6.2b NO in the area of Salonica

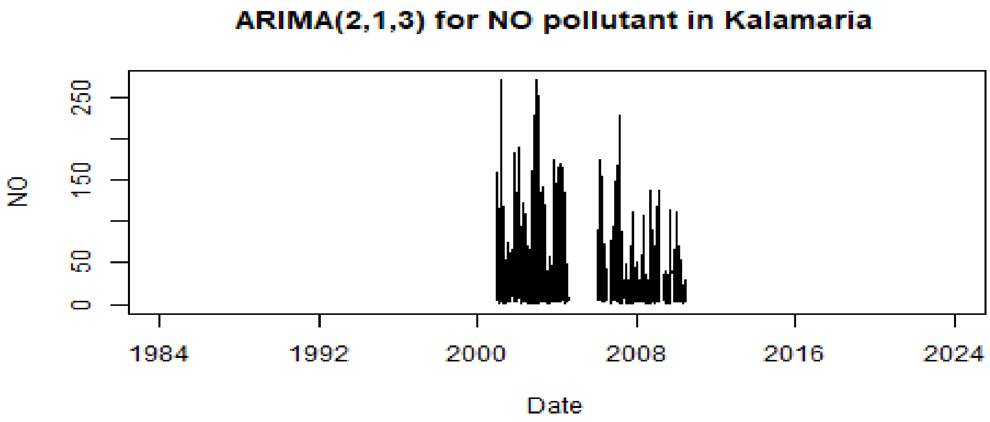
6.2b.1_Pollutant NO, Aristotelous

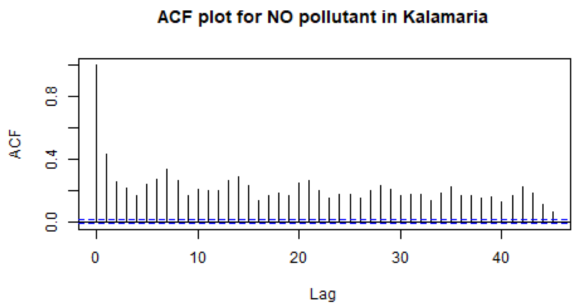


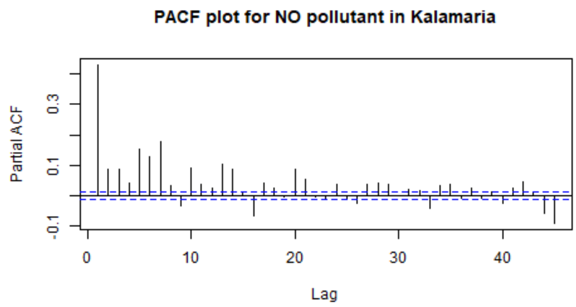




6.2b.2_Pollutant NO, Kalamaria

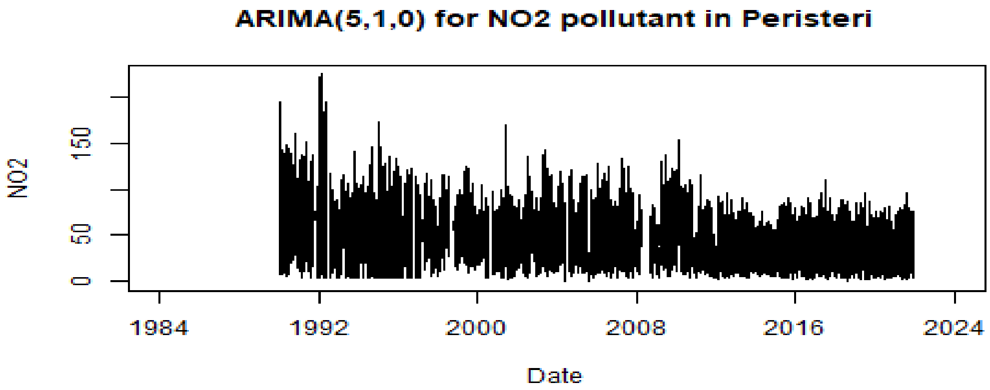


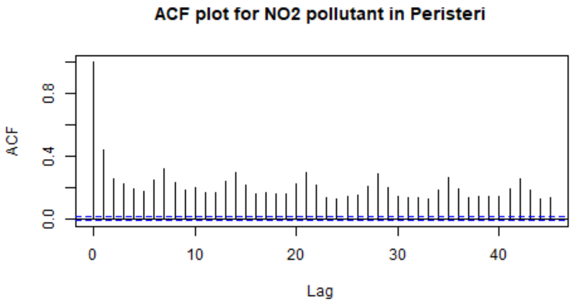


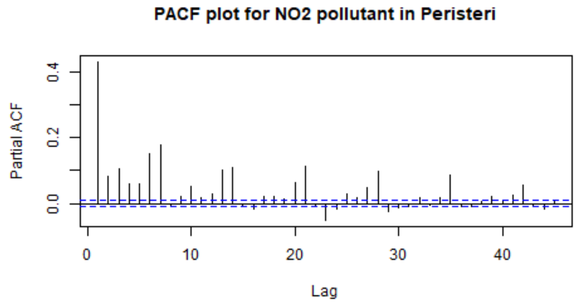


6.3a NO_2 in Athens

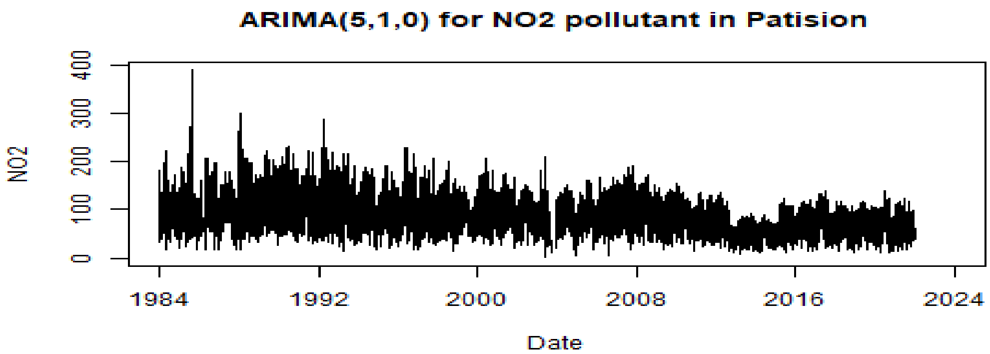
6.3a.1_Pollutant NO_2, Peristeri

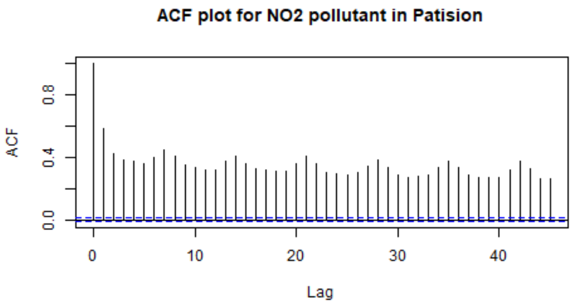


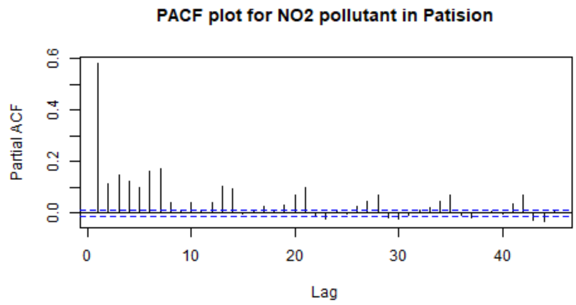




6.3a.2_Pollutant NO_2, Patision

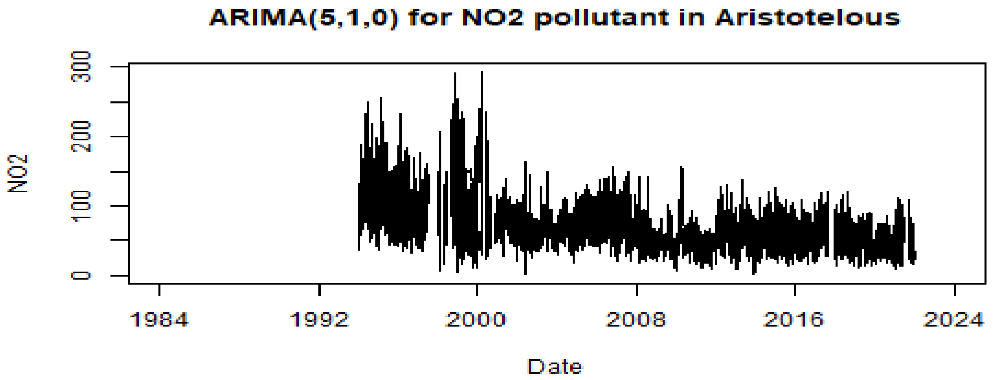


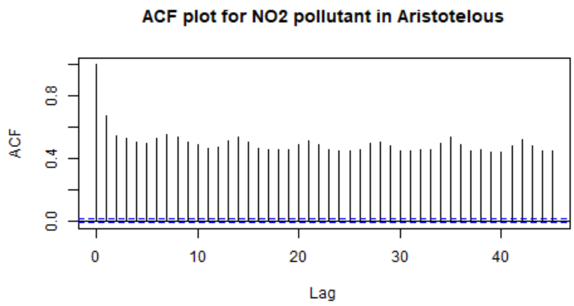


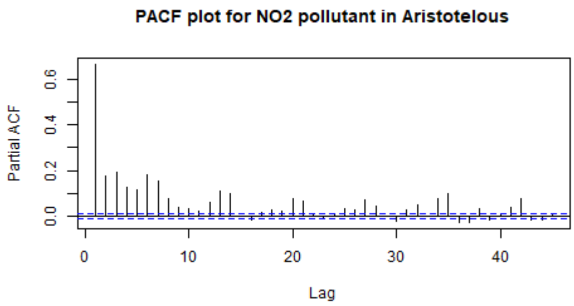


6.3b NO_2 in Salonica

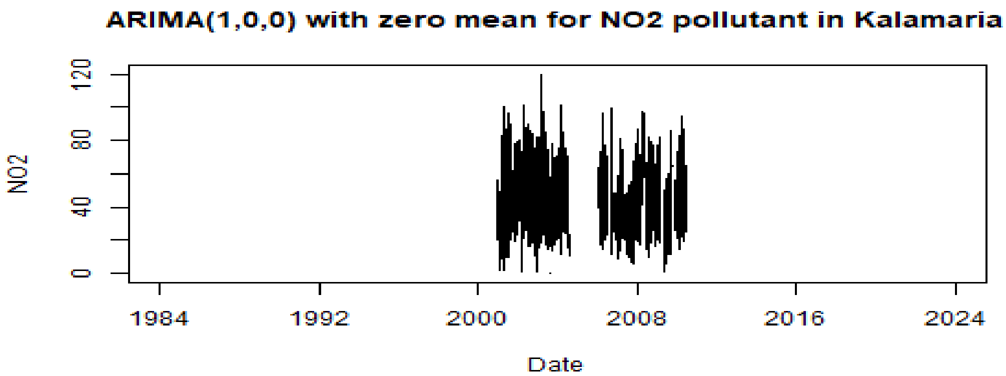
6.3b.1_Pollutant NO_2, Aristotelous

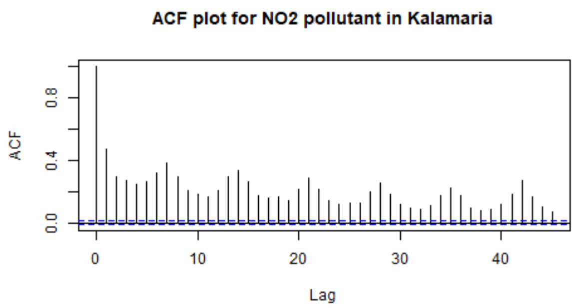


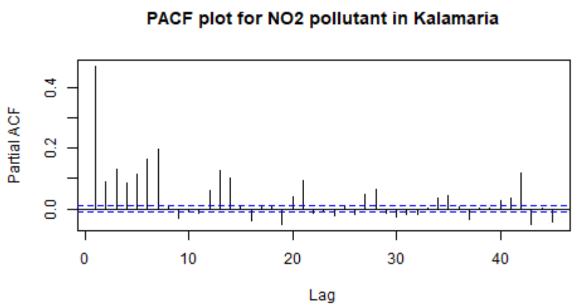




6.3b.2_Pollutant NO_2, Kalamaria

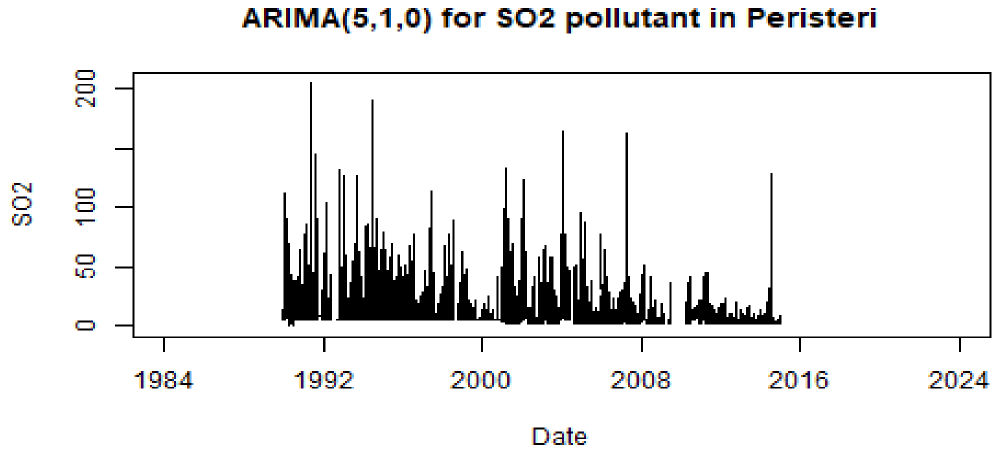


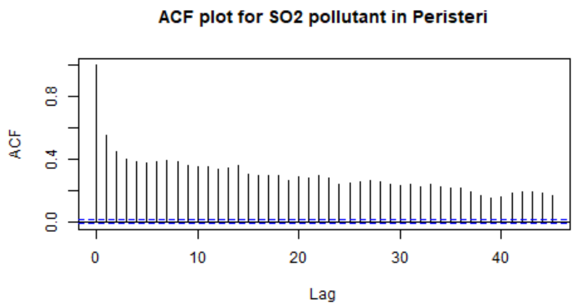


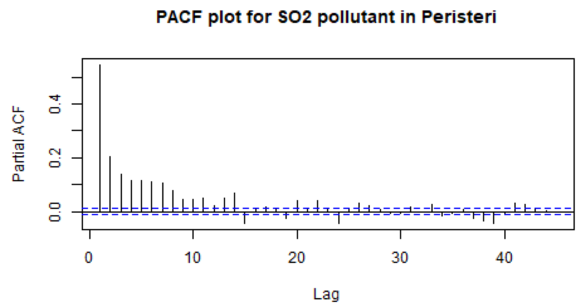


6.4a SO_2 in Athens

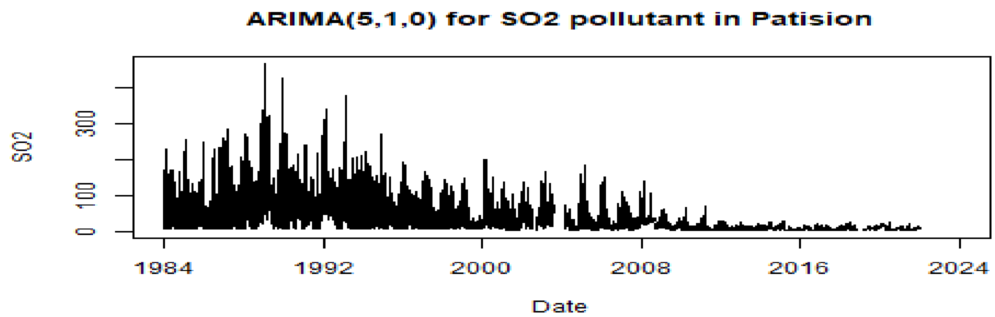
6.4a.1_Pollutant SO_2, Peristeri

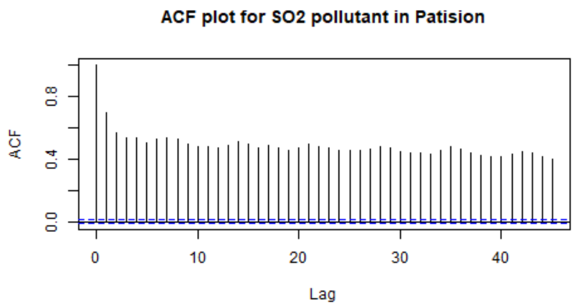


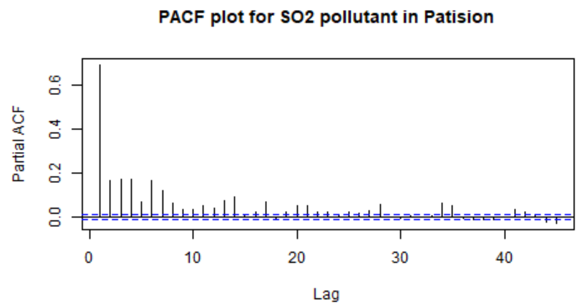




6.4a.2 Patision, Pollutant SO_2

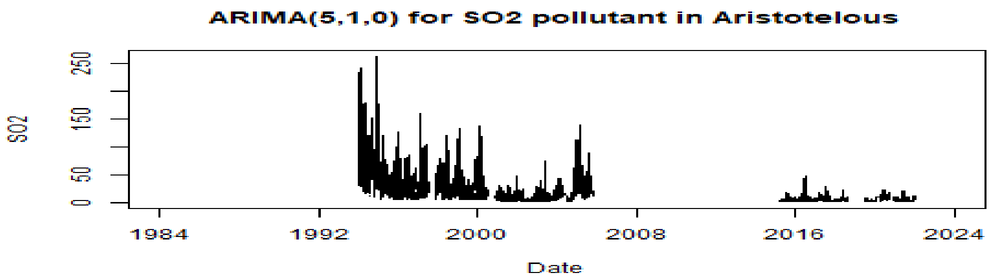


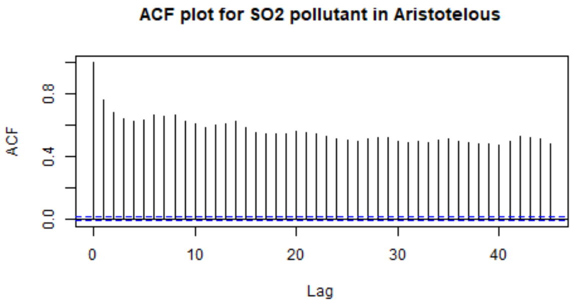


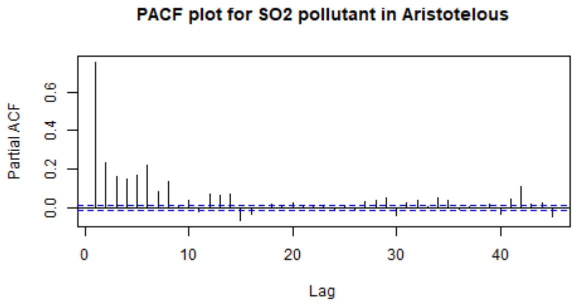


6.4b SO_2 in Salonica

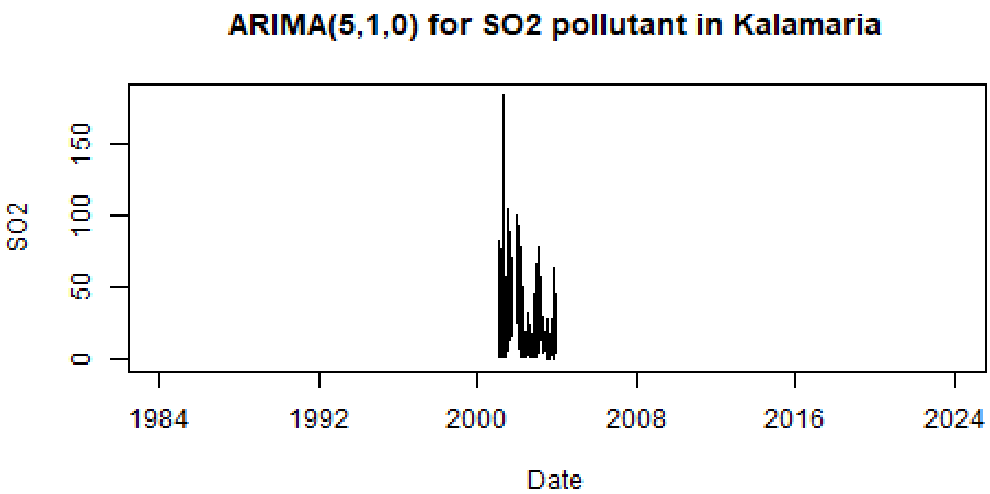
6.4b.1_Pollutant SO_2, Aristotelous

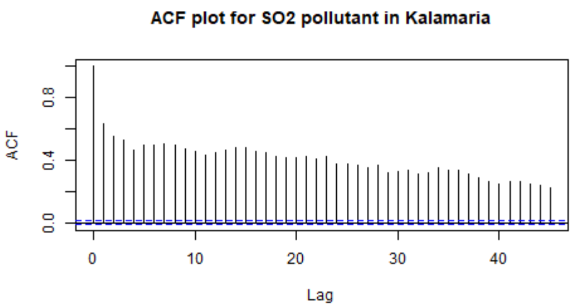


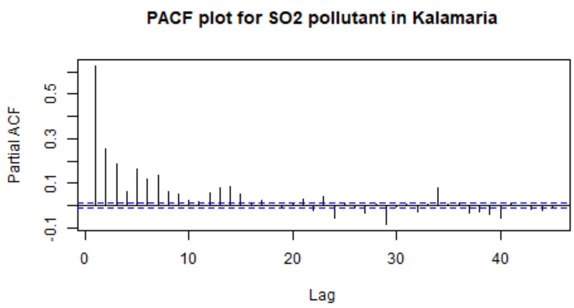




6.4b.2_Pollutant SO_2, Kalamaria

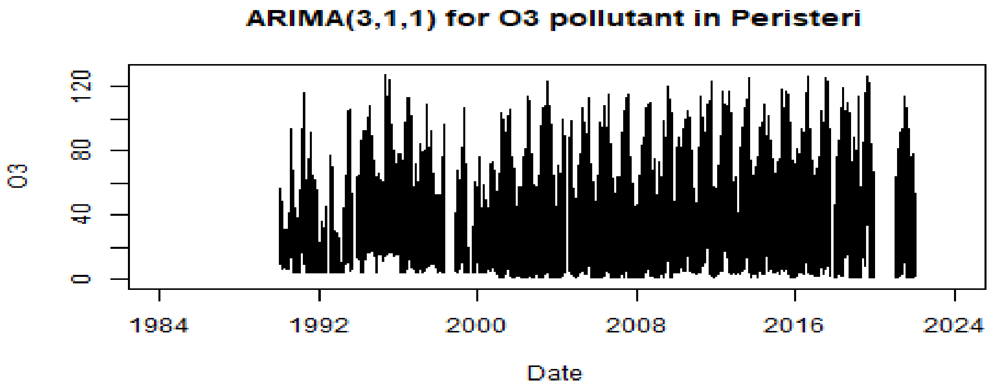


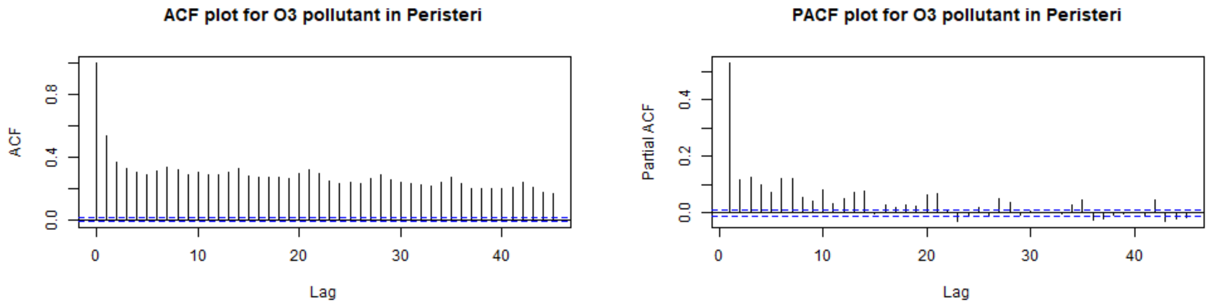




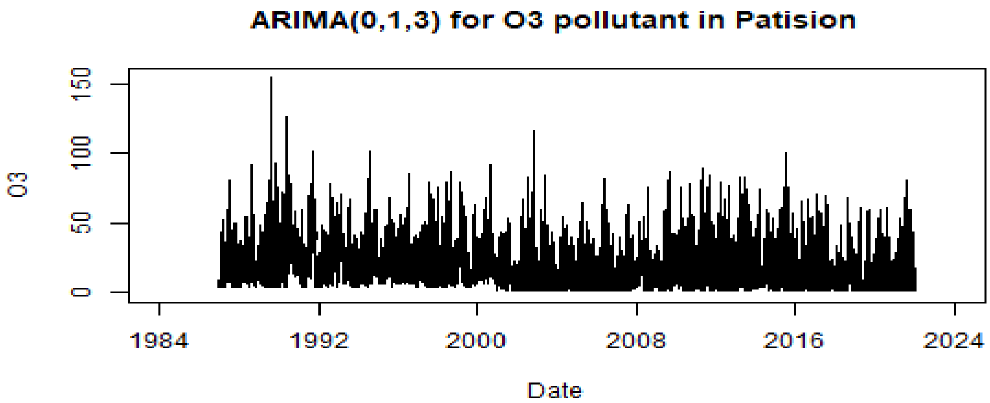
6.5a O_3 in Athens

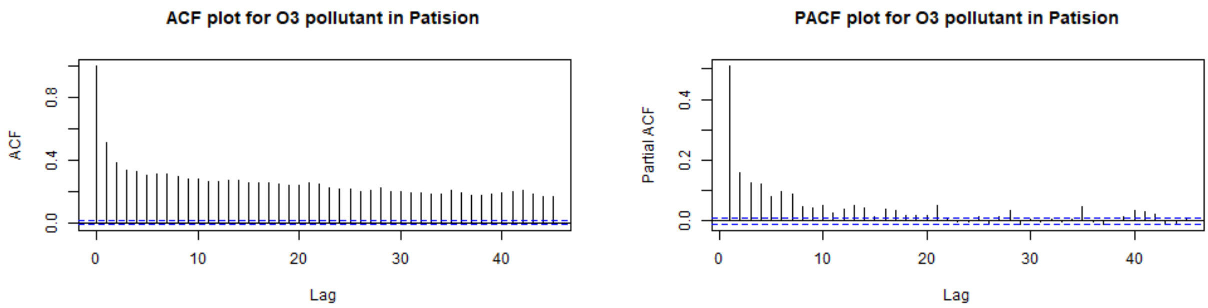
6.5a.1_Pollutant O_3, Peristeri





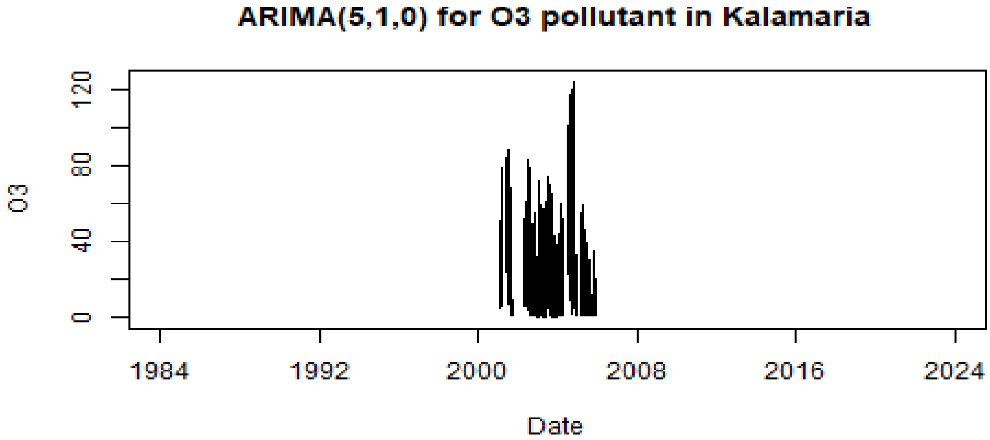
6.5a.2_Pollutant O_3, Patision

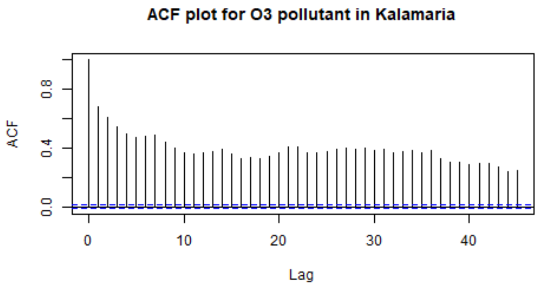


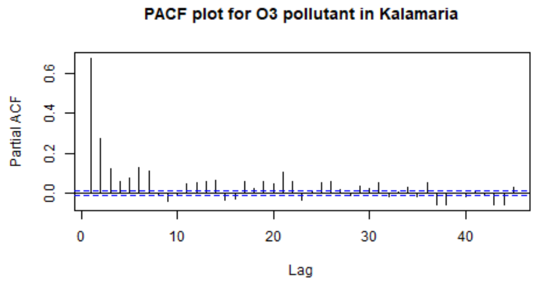


6.5b O_3 in Salonica

6.5b.2_Pollutant O_3, Kalamaria







For the above models and the presented Figures above a number of ARIMA models, Halkos (2019), have been estimated. In the following 19 Tables the appropriate model for estimating the pollutants under consideration, for Athens and Salonica, per particular area under investigation, are presented in a compact form. The declared coefficients clarify the Time Series model adopted to fit the data:

Table 2.1 :

CO Aristotelous

	ar1	**ar2**	**ar3**	**ar4**	**ar5**
Coefficients	-0,5497	-0,4418	-0,3644	-0,3324	-0,2765
SE	0,0005	0,0006	0,0006	0,0006	0,0005
AIC	9509,3				

Table 2.2

CO Kalamaria

	ar1	**ar2**	**ar3**	**ar4**	**ar5**
Coefficients	-0,5399	-0,4853	-0,3906	-0,3013	-0,2377
SE	0,0002	0,0003	0,0003	0,0003	0,0002
AIC	4339,2				

Table 2.3

CO Patision

	ar1	ar2	ar3	ar4	ar5
Coefficients	-0,4677	-0,4347	-0,3441	-0,2676	-0,2333
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	66364,8				

Table 2.4

CO Peristeri

	ar1	**ar2**	**ar3**	**ar4**	**ar5**
Coefficients	-0,6093	-0,5154	-0,3788	-0,2730	-0,2282
SE	0,0001	0,0002	0,0002	0,0002	0,0001
AIC	25005,0				

Table 2.5

NO Aristotelous

	ar1	**ar2**	**ar3**	**ar4**	**ar5**
Coefficients	-0,4867	-0,4454	-0,3338	-0,2419	-0,2008
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	113000,4				

Table 2.6

NO Kalamaria

	ar1	**ar2**	**ma1**	**ma2**	**ma3**
Coefficients	-0,4341	0,1716	-0,2380	-0,6887	0,0193
SE	0,0554	0,0047	0,0558	0,0312	0,0055
AIC	22889,7				

Table 2.7

NO Patision

	ar1	**ar2**	**ar3**	**ar4**	**ar5**
coefficients	-0,5102	-0,4682	-0,3710	-0,2609	-0,2064
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	159508,8				

Table 2.8

NO Peristeri

	ar1	**ar2**	**ar3**	**ar4**	**ar5**
Coefficients	-0,6211	-0,5254	-0,4037	-0,2775	-0,2236
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	106322,4				

Table 2.9

NO_2 Aristotelous

	ar1	**ar2**	**ar3**	**ar4**	**ar5**

Coefficients	-0,5015	-0,4618	-0,3467	-0,2702	-0,2363
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	81659,0				

Table 2.10

NO2 Kalamaria

	ar1
Coefficients	0,9290
SE	0,0001
AIC	20636,1

Table 2.11

NO2 Patision

	ar1	ar2	ar3	ar4	ar5
coefficients	-0,5028	-0,4566	-0,3650	-0,2674	-0,2161
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	127159,4				

Table 2.12

NO2 Peristeri

	ar1	ar2	ar3	ar4	ar5
Coefficients	-0,5487	-0,4851	-0,3704	-0,2889	-0,2364
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	92492,2				

Table 2.13

SO2 Aristotelous

	ar1	ar2	ar3	ar4	ar5
Coefficients	-0,5265	-0,4346	-0,3737	-0,3115	-0,2259
SE	0,0002	0,0002	0,0002	0,0002	0,0002
AIC	45005,5				

Table 2.14

SO2 Kalamaria

	ar1	ar2	ar3	ar4	ar5
Coefficients	-0,6095	-0,4710	-0,3349	-0,3226	-0,1673
SE	0,0011	0,0014	0,0016	0,0015	0,0012
AIC	7451,1				

Table 2.15

SO2 Patision

	ar1	ar2	ar3	ar4	ar5

Coefficients	-0,4604	-0,4223	-0,3430	-0,2047	-0,1883
SE	0,0001	0,0001	0,0001	0,0001	0,0001
AIC	123301,7				

Table 2.16

SO_2 Peristeri

	ar1	ar2	ar3	ar4	ar5
Coefficients	-0,5899	-0,4515	-0,3521	-0,2691	-0,1595
SE	0,0001	0,0002	0,0002	0,0002	0,0001
AIC	58946,2				

Table 2.17

O_3 Kalamaria

	ar1	ar2	ar3	ar4	ar5
Coefficients	-0,5321	-0,3240	-0,2380	-0,2155	-0,1855
SE	0,0008	0,0010	0,0010	0,0010	0,0008
AIC	10524,8				

Table 2.18

O_3 Patision

	ma1	ma2	ma3
Coefficients	-0,6501	-0,1735	-0,0753
SE	0,0001	0,0001	0,0001
AIC	97437,2		

Table 2.19

O_3 Peristeri

	ar1	ar2	ar3	ma1
Coefficients	0,3185	-0,0286	-0,0016	-0,9336
SE	0,0001	0,0001	0,0001	0,0000
AIC	87495,9			

We briefly refer that AIC is the Akaike information criterion (AIC): For the given statistical model, describing a data set, with p the number of the estimated parameters we let the maximized value of the likelihood function to be L^*. Then the AIC value of the model is AIC = $2[p – \ln (L^*)]$. We note that SE is the standard error, as usual and the fitted models.

The ARMA model used here is under the general form,

$$X_t = a_1 X_{t-1} + \cdots + a_p X_{t-p} + e_t + b_1 e_{t-1} + \cdots + b_q e_{t-q}$$

The differenced series for ARIMA models with differencing follows a zero-mean ARMA model. The exact likelihood was chosen for parameters' estimation in ARIMA process. Model selection was based on AIC value, through the stepwise algorithm outlined in Hyndman & Khandakar (2008) over possible models within the 5 order constraints provided. The variance matrix of the estimates is found from the Hessian of the log-likelihood. All analyses were carried out in the R environment, using appropriate packages (stats, forecast).

7. Conclusions

For all pollutants, apart from O_3, and for all areas their concentrations seem to be eliminated during the time (6.1a.1a Peristeri, Athens to 6.5b.2a Kalamaria, Salonica). ACF plots reveal a tiny, steady weekly periodicity, observed optically to values recorded through time. In most of the cases an ARIMA(p,1,0) is proposed -manifesting a consistent dependency on previous values, and only for the cases of NO [ARIMA(2,1,3)] and NO_2 [ARIMA(1,0,0)] in Kalamaria, O3 [ARIMA(3,1,1)] in Peristeri and [ARIMA(0,1,3)] in Patision Avenue the proposed model change. Almost all models have first order differencing in "stationarizing" the Time Series. Coefficients in Table 2.x are estimated for the majority of the models for up to 5 AR terms – i.e., an ARIMA(5,d,q) model. All coefficients for the ARIMA(p,1,0) are negative, while all coefficients for all the models presented are statistically significant (Table 2.1 to Table 2.19). The collected data were presented, not only graphically, but under the theoretical background of Time Series models. More analysis is needed, connecting the EDA, Change point framework, Time Series modelling, to collect all the appropriate information hidden in these big data sets, although crucial no such work has been proceeded in the past. This will be one of our next targets.

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Pathways2Resilience. Co-developing pathways towards climate resilient regions in Europe

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Abstract
Pathways2Resilience intends to advance a transformative and innovative approach to strengthen climate resilience. More specifically, Pathways2Resilience will: a) mobilize regional interests and networks to leverage political commitment towards the Mission Adaptation, elevate the ambition and capability of regional public administrations and connect innovation agendas, b) trigger wide engagement of citizens and diverse stakeholders in the co-creation of these transformative climate resilience pathways in a way that builds on the best available expertise and multiple understanding of current and future climate risks and opportunities, fosters local ownership and ensures long-term impact, c) facilitate learning and capability development within and across networked regional cohorts and increase knowledge on adaptation options across different Key Community Systems (KCS), tailor-made to local challenges and needs and d) boost enabling conditions, including funding and financing, to develop, test and advance systemic innovative solutions that increase local climate resilience. This European Union Project aims to provide a holistic support to regions in an attempt to recognize their vulnerabilities against climate change and overcome the barriers to adaptation finance.

Keywords: Climate change; regional; adaptation; vulnerability

JEL codes: Q01, Q28, R10, R11, R12

Hydrological Assessment and Sustainable Development Prospects: Insights from a Training Course on Municipalities with Rivers

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Abstract
The present paper draws conclusions from a 40-hour hybrid course titled "Development Prospects of Municipalities with Rivers: Best Practices and Useful Tools" conducted by the Faculty of Engineering of the Aristotle University of Thessaloniki, through the Center for Education and Lifelong Learning, with the participation of 29 Greek Municipalities that are run by rivers. An evaluation of the Municipalities' perspective on their watercourses and the river basins, their flood protection, the land uses surrounding the aqueducts, including the forested areas, and all prospective potential development of the areas, are summarized herein. The research delves into the current state of these regions, examining their correlation with recent flooding events. By scrutinizing the hydrological aspects and emphasizing the significance of forest cover, the paper aims to contribute valuable insights into sustainable municipal development and effective flood risk management strategies.

Keywords: Rivers; Municipalities; flood risk; forests; river basin.

JEL Codes: Q24, Q25, I23, I26

Smart Sustainable Cities: A Greek Case Study

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Abstract
The aim of the present paper is to investigate whether the Regional Unit of Western Attica constitutes a sustainable and smart geographic area, based on the perceptions of its residents, as well as the impact of the COVID-19 pandemic on the sustainable urban development policies it implements. To achieve this goal, quantitative research was conducted, using a questionnaire as a data collection tool, with a sample of 175 residents from the 5 Municipalities of the Western Attica Regional Unit. The research results indicated that the residents of the Municipalities in the Western Attica Regional Unit have a moderate overall level of awareness regarding sustainable and smart urban development issues. Additionally, it was found that the Municipality of Fylis ranked first in all dimensions of sustainable and smart urban development, compared to the remaining 4 municipalities of the Regional Unit of Western Attica, having the highest absorption of funds. Furthermore, the effectiveness of the implemented policies for sustainable and smart urban development in the municipalities of the Western Attica Regional Unit seems to have been significantly affected by the COVID-19 pandemic. The correlation analysis revealed a strong positive correlation between the sample's perceptions on sustainable development and the sustainable development policies implemented by the Western Attica Regional Unit in relation to the environment, economy, society, and culture.

Keywords: Sustainability Policies; Smart Cities; Greece.

JEL Codes: Q56; Q58.

Session 5

Corporate Social Responsibility – Environmental Psychology

Corporate Social Responsibility CSR and the effects on employees' mental health

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Abstract
The concept of corporate social responsibility (CSR) has garnered significant scholarly and professional attention in recent decades, emerging as a cornerstone of contemporary business theory. Notably, extensive research has underscored the positive implications of CSR activities, elucidating their pivotal role in fostering robust relationships with stakeholders, bolstering organizational legitimacy, securing societal endorsement, nurturing competitive advantages, enhancing overall organizational performance, and fortifying corporate reputation.
While existing literature has extensively explored the benefits of CSR strategies, our study uniquely focuses on the intricate interplay between CSR initiatives and their impacts on the intricate fabric of human resources within organizations. This critical investigation delves into the often overlooked dimensions of managing potential negative consequences associated with CSR endeavors, a crucial area that remains largely unexplored in current literature.
By specifically addressing the implications of CSR strategies on the dynamics of human resource management, we seek to offer actionable insights to industry professionals and decision-makers. Particularly, our research aims to deliver practical and applicable outcomes tailored to the context of companies operating within the distinct business landscape of Greece, fostering a nuanced understanding of how CSR can be optimally integrated within the fabric of organizational culture and human resource policies.

Keywords: Corporate Social Responsibility; Corporate Sustainability; Employee Mental Health; Organizational Change.

JEL Codes: I21; I31; I38; J28; J81Q01; Q52; Q56.

Εταιρική Κοινωνική Ευθύνη ΕΚΕ
και ο αντίκτυπός της στην ψυχική υγεία των εργαζομένων

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Περίληψη

Η έννοια της εταιρικής κοινωνικής ευθύνης (ΕΚΕ) έχει τραβήξει την προσοχή των επιστημόνων και των επαγγελματιών τις τελευταίες δεκαετίες, αποτελώντας τον ακρογωνιαίο λίθο της σύγχρονης επιχειρηματικής θεωρίας. Συγκεκριμένα, πλήθος ερευνών έχει υπογραμμίσει τις θετικές επιπτώσεις των δραστηριοτήτων ΕΚΕ, διευκρινίζοντας τον κεντρικό ρόλο τους στην προώθηση ισχυρών σχέσεων με τους ενδιαφερόμενους, την ενίσχυση της οργανωτικής νομιμότητας, την εξασφάλιση κοινωνικής αποδοχής, την καλλιέργεια ανταγωνιστικών πλεονεκτημάτων, την ενίσχυση της συνολικής οργανωτικής απόδοσης και την ενίσχυση της φήμης της εταιρείας. Ενώ η υπάρχουσα βιβλιογραφία έχει διερευνήσει εκτενώς τα οφέλη των στρατηγικών ΕΚΕ, η μελέτη εστιάζει μοναδικά στην περίπλοκη αλληλεπίδραση μεταξύ των πρωτοβουλιών ΕΚΕ και των επιπτώσεών τους στον περίπλοκο πλαίσιο των ανθρώπινων πόρων εντός των οργανισμών. Γίνεται εστίαση στις συχνά παραμελημένες διαστάσεις της διαχείρισης πιθανών αρνητικών συνεπειών που σχετίζονται με τις προσπάθειες ΕΚΕ, έναν κρίσιμο τομέα που παραμένει σε μεγάλο βαθμό ανεξερεύνητος στην τρέχουσα βιβλιογραφία.

Αντιμετωπίζοντας συγκεκριμένα τις επιπτώσεις των στρατηγικών ΕΚΕ στη δυναμική της διαχείρισης ανθρώπινων πόρων, επιδιώκεται να προσφερθούν χρήσιμες γνώσεις στους επαγγελματίες του κλάδου και στους υπεύθυνους λήψης αποφάσεων. Ειδικότερα, η έρευνα στοχεύει στην παροχή πρακτικών και εφαρμόσιμων αποτελεσμάτων προσαρμοσμένων στο πλαίσιο των εταιρειών που δραστηριοποιούνται στο ξεχωριστό επιχειρηματικό πλαίσιο της Ελλάδας, ενισχύοντας την κατανόηση του τρόπου με τον οποίο η ΕΚΕ μπορεί να ενσωματωθεί βέλτιστα στον ιστό της οργανωσιακής κουλτούρας και των πολιτικών ανθρώπινου δυναμικού.

Keywords: Εταιρική Κοινωνική Ευθύνη, Εταιρική Βιωσιμότητα, Ψυχική Υγεία Εργαζομένων, Οργανωσιακή Αλλαγή

JEL Codes: I21; I31; I38; J28; J81Q01; Q52; Q56.

1. Introduction

In an era marked by increasing global challenges and stakeholder demands, Corporate Social Responsibility (CSR) has emerged as a pivotal strategy for organizations aiming to adjust their operations tobroader societal and environmental objectives (Carroll, 1991; Aguinis & Glavas, 2012). CSR encompasses a wide range of practices, from environmental stewardship and ethical labor practices to philanthropy and community engagement (Aguilera et al., 2007; Banerjee, 2008). Its evolution from a peripheral concern to a strategic imperative reflects a paradigm shift in the business world, driven by the recognition that long-term success is intertwined with the well-being of various stakeholders, including employees, communities, and the environment (Bansal & Song, 2017; Carroll, 2021).

The intersection of CSR and employee well-being has garnered significant attention in recent years, with researchers exploring how CSR initiatives influence job satisfaction, engagement, and overall employee morale (Glavas & Piderit, 2009; Brammer et al., 2015). This focus is predicated on the understanding that employees are not merely internal stakeholders but also pivotal actors in the successful implementation of CSR strategies (Rupp et al., 2018; Aguinis et al., 2020). Moreover, in sectors inherently oriented towards social good, such as NGOs and the humanitarian sector, the alignment between organizational missions and CSR practices is particularly pronounced, offering unique insights into the symbiotic relationship between CSR and employee well-being (Arenas et al., 2009; Andreini et al., 2014).

Despite the burgeoning interest in this area, the potential for negative repercussions of CSR initiatives on employee well-being, such as stress, work-life imbalance, and job insecurity, remains a danger (Avanzi et al., 2012; Brieger et al., 2020). This gap in the literature underscores the need for a nuanced examination of CSR's impacts, taking into account both its positive and potential adverse effects on the workforce, especially within the context of organizations dedicated to social and humanitarian causes.

2. Literature Review

The significance of Corporate Social Responsibility (CSR) in contemporary business practices has been extensively examined across various disciplines, highlighting its multifaceted impact on organizational performance, employee well-being, and societal welfare. This review synthesizes key findings from the existing body of literature, underscoring the evolving conceptualization of CSR, its implications for employee outcomes, and its role in facilitating organizational change, particularly within the context of NGOs and the humanitarian sector.

The conceptualization of CSR has undergone significant transformation, moving beyond philanthropic efforts to encompass a broad spectrum of ethical, social, and environmental considerations integral to strategic business operations (Carroll, 1991; Elkington, 1997). The strategic integration of CSR into core business practices is emphasized with a holistic approach that aligns CSR initiatives with organizational values and objectives being advocated for.

The relationship between CSR and employee outcomes has been a focal point of research, with studies demonstrating positive correlations between CSR engagement and factors such as job satisfaction, organizational commitment, and employee engagement (Brammer et al., 2015; Glavas & Piderit, 2009). Farooq et al. (2014) and Aguilera et al. (2007) highlight the role of CSR in enhancing employee morale and fostering a positive organizational identity, contributing to a more engaged and loyal workforce.

CSR is increasingly recognized as a catalyst for organizational change, driving innovation and fostering a culture of sustainability and ethical responsibility (Bansal & Song, 2017; Schaltegger et al., 2016). Leadership plays a critical role in this context, with effective leaders articulating a clear CSR vision, embedding CSR values into the organizational culture, and engaging employees in CSR initiatives (Aguilera et al., 2007; Rupp et al., 2018).

Within NGOs and the humanitarian sector, CSR takes on a unique dimension, being inherently aligned with the core mission of these organizations (Arenas et al., 2009; Andreini et al., 2014). The literature calls for greater strategic integration of CSR into core operations and enhanced communication of CSR efforts to maintain credibility and legitimacy in these sectors (Aguilera et al., 2007; Banerjee, 2008).

In summary, the existing literature on CSR underscores its significance as a strategic imperative that extends beyond traditional philanthropy to encompass a comprehensive approach to sustainable business practices. The positive impact of CSR on employee outcomes and its role as a driver of organizational change highlight the need for strategic CSR integration and effective leadership. Within NGOs and the humanitarian sector, CSR's alignment with organizational missions underscores the importance of strategic and communicative efforts to maximize its impact.

3. Methodology

This study employed a mixed-methods approach to examine the impact of Corporate Social Responsibility (CSR) on various organizational outcomes, with a particular focus on the balance between achieving CSR goals and ensuring employee wellness. The methodology was designed to capture both the quantitative and qualitative dimensions of CSR's effects, providing a comprehensive understanding of its implications within diverse organizational contexts.

3.1. Sample and Data Collection

The research sample consisted of employees from various industries to ensure a broad representation of organizational types and sizes. A total of 126 participants were recruited through a combination of convenience and snowball sampling methods. Data collection was conducted through an online survey platform, facilitating the participation of individuals from a wide geographic range. The survey included both closed-ended and open-ended questions, allowing for the collection of quantitative data on employee perceptions of CSR and qualitative insights into their experiences with CSR initiatives.

3.2. Survey Tool

The survey instrument was carefully designed to assess various aspects of CSR and its perceived impact on employees. Likert-scale questions were used to gauge employee satisfaction, engagement, perceptions of organizational commitment to CSR, and the personal importance of working for a socially responsible organization.

3.3. Data Analysis

Quantitative data from the survey were analyzed using statistical software, focusing solely on frequencies and descriptive statistics to provide an overview of the sample characteristics. No inferential statistics, such as regression analysis, were conducted. Instead, the analysis was limited to examining the distribution and central tendencies of the data related to CSR engagement, job satisfaction, and employee well-being.

3.4. Ethical Considerations

The study adhered to ethical research standards, ensuring participant confidentiality and informed consent. Participants were informed about the purpose of the research, the voluntary nature of their participation, and their right to withdraw at any time without consequence.

4. Results

The results of the study provide empirical evidence regarding the impact of Corporate Social Responsibility (CSR) on various organizational outcomes, highlighting the nuanced relationship between CSR initiatives and employee wellness.

Employee Well-Being and Engagement: The analysis revealed a significant positive correlation between the presence of CSR initiatives and employee well-being. Employees who reported higher levels of involvement in CSR activities also reported greater job satisfaction and a stronger sense of purpose at work. The average rating for job satisfaction among employees aware of their organization's CSR efforts was 4.25 out of 5, indicating a positive perception of their work environment.

Perceptions of Organizational Commitment to CSR: Employees generally perceived their organizations as committed to CSR, with an average rating of 4.37 out of 5 for effective communication of CSR initiatives. This positive perception was linked to higher levels of organizational identification and loyalty among employees, suggesting that CSR can enhance employees' emotional and psychological attachment to their organizations.

Impact on Employee Resilience and Empowerment: The study also found that CSR initiatives contributed to employee resilience, with an average rating of 4.75 out of 5 for employee resilience in organizations with active CSR programs. Furthermore, empowering leadership related to CSR was highly rated at 4.70 out of 5, indicating that CSR can play a role in fostering leadership styles that empower employees and encourage their active participation in CSR activities.

Challenges and Areas for Improvement: Despite the positive outcomes, the study also identified challenges in CSR implementation. Some employees expressed concerns about the potential for CSR initiatives to lead to a work-life imbalance and increased stress, particularly in cases where CSR activities added to their regular workload without adequate support or resources. The average rating for work-life balance was the lowest among the factors surveyed, at 3.58 out of 5, highlighting an area for improvement in CSR strategies.

Sector-Specific Insights: For participants from the NGO and humanitarian sectors, CSR was viewed as integral to their organizations' missions. However, there was a call for greater strategic integration of CSR into core operations and more effective communication of CSR achievements and challenges, both internally and externally.

To sum up, the results affirm the positive impact of CSR on employee outcomes but also underscore the importance of strategic CSR implementation and communication. Balancing CSR goals with employee wellness, providing adequate support for CSR activities, and fostering a culture of inclusive and empowering leadership are key to maximizing the benefits of CSR for employees and organizations alike.

5. Discussion- Conclusion

The findings from this study underscore the significant impact of Corporate Social Responsibility (CSR) on various organizational outcomes, affirming the pivotal role of CSR in enhancing employee well-being, job satisfaction, and organizational commitment. The positive correlation between CSR initiatives and employee outcomes highlights the value of integrating CSR into the core strategic framework of organizations, aligning CSR efforts with organizational goals and values to foster a culture of responsibility and ethical conduct (Aguinis & Glavas, 2012; Carroll, 2021).

The empirical evidence supports the notion that CSR can serve as a powerful tool for organizational change, driving innovation, and fostering a positive work environment. The role of leadership emerged as particularly crucial in this context, with effective leaders articulating a clear vision for CSR, demonstrating ethical conduct, and engaging employees in CSR initiatives (Aguilera et al., 2007; Rupp et al., 2018). Leaders who embody CSR values and foster a culture of transparency and inclusivity can amplify the positive effects of CSR on employee and organizational outcomes.

However, the study also highlighted challenges in CSR implementation, particularly concerning the potential for work-life imbalance and increased stress among employees involved in CSR activities. These findings emphasize the need for a balanced approach to CSR that considers employee well-being and provides adequate support for CSR initiatives (Brieger et al., 2020; Avanzi et al., 2012). Organizations must strive to integrate CSR into their operations in a manner that enhances, rather than detracts from, employee wellness.

In conclusion, this study contributes to the growing body of literature on CSR by providing empirical evidence of its multifaceted impact on organizations. The findings underscore the importance of strategic CSR implementation, effective leadership, and a balanced approach that prioritizes employee well-being. As organizations continue to navigate the complexities of the modern business landscape, CSR remains a critical strategy for achieving sustainable success and making a positive impact on society and the environment. In future research, more advanced statistical tests will be employed to explore the relationships and potential causal links between CSR engagement and key employee outcomes, such as job satisfaction and well-being, to deepen our understanding of CSR's impact on organizational dynamics.

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The significance of stakeholder engagement for promoting the Energy Efficiency First Principle (EE1st) in regional energy policy

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Abstract

The Energy Efficiency First (EE1st) principle embodies a transformative approach within the EU's energy policy, accentuating the significance of energy conservation and demand in policymakers' decision-making process. Although the principle is acknowledged within the EU legal framework, it is not assimilated into the decision- making process at a regional level. Therefore, the engagement of the relevant stakeholders, including regional authorities, is essential in shaping the energy ecosystem and contributing to filling the gap in the implementation of the EE1st at the regional level. The first and most important step is mapping the relevant stakeholders. The acute understanding of stakeholders' influence dynamics and defining the diverse characteristics is fundamental to this cohesive mapping. That includes the stakeholder's influence over energy policies, capacity to mobilise resources, and contribution to the decision-making procedure. The ultimate ambition is to build a holistic and deep understanding of their various needs, requirements, and expectations to develop targeted and personalised information which can lead to the effective understanding and implementation of the EE1st principle. In that framework, the present paper presents the mapping procedure of implementing EE1st in the stakeholder regional energy ecosystem.

Keywords: Energy efficiency first principle; stakeholders mapping; energy ecosystem; European Union.

JEL Codes: E61; D61; D83; E21.

1. Introduction

The Energy Efficiency First (EE1st) principle is a cornerstone of EU energy policy, emphasizing the prioritisation of cost-effective energy efficiency measures in policymaking and investment decisions. The EE1st is enshrined in EU regulations, including the Regulation on Governance of the Energy Union and Climate Action and the Energy Efficiency Directive. It dictates that energy efficiency should be treated as a primary energy source, with demand-side solutions taking precedence over investments in energy infrastructure when they prove more cost-effective. Its legal basis is further reinforced through Article 3 of the proposed Energy Efficiency Directive, mandating EU Member States to integrate energy efficiency solutions into energy planning, policy, and investment decisions across sectors.

The recent recast of the Energy Efficiency Directive (EU/2023/1971) signifies the conclusive phase in the legislative trajectory, originating with the Commission's proposal in July 2021, as a part of the "Fit for 55" package. Notably, this legislative trajectory received further fortification through a supplementary proposal integrated into the REPowerEU plan in May 2022. The revised directive encapsulates a culmination of legislative endeavors, embodying a meticulous and structured progression withing the EU's legislative framework.

The integration of the EE1st principle into regional energy planning constitutes a strategic imperative for optimizing energy resources and achieving sustainability goals. EE1st entails prioritizing investments in energy efficiency and demand-side resources over supply-side elements, provided they offer greater cost-effectiveness and societal benefits in meeting policy objectives.

The significance of embedding EE1st in regional energy planning is multifaceted. Firstly, it fosters cost-effectiveness by promoting investments that yield long-term savings for investors and consumers alike. Secondly, it contributes to broader societal objectives such as reducing energy consumption, enhancing energy security, and mitigating climate change, aligning with the EU's climate goals. This ensures a comprehensive evaluation of alternatives. Fair assessment and valuation mechanisms are crucial to ensure equitable treatment of energy efficiency and demand-side resources compared to supply-side investments. Transparent criteria and methodologies for evaluating costs and benefits are essential for informed decision-making. Prioritising energy efficiency and demand-side resources based on assessments is pivotal, particularly when they offer superior societal benefits and cost-effectiveness, warranting precedence in regional energy planning. Through an in-depth analysis of the regional energy planning landscape, the delineation of all relevant stakeholders, as well as considering the stakeholder mapping methodology that was implemented, useful insights for the effective integration of EE1st can be gained. This paper seeks to explore the challenges and opportunities in implementing the EE1st principle at the regional level.

2. Literature review

In this section, a literature review of the studies relevant to the implementing EE1st principle and the challenges that embedding EE1st is facing from theory in practice, are presented.

The literature on EE1st has, to date, been relatively scarce, reflecting the historical absence of the principle in the EU policy framework. Notably, Stephen Wiel underscores the significance of energy-efficiency standards and labels them as highly effective, long-term policies for any government committed to advancing energy efficiency [1]. Howard Geller's research also provides a comprehensive exploration of policies aimed at promoting increased energy efficiency across diverse countries [2].

Despite this, Bayer and Rosenow pointed out that the EU is not allocating sufficient resources to energy efficiency and demand reduction measure compared to the development and utilization of energy supply infrastructures [3], [4]. According to statistics from IEA (2021)[5], capital expenditures in Europe for electricity generation, network assets, and other fossil fuel supply amounted to USD 178.8 billion in 2020, over double the investment in end-use energy efficiency measures of USD 101.4 billion. A long-standing academic debate around the existence and magnitude of the so- called energy efficiency gap has been ongoing, as noted by Brown & Wang, highlighting the deviation between the levels of energy efficiency that seen economically viable and levels actually observed in reality (Gillinmham) [6], [7].

In the realm of theoretical foundations, Mandel emphasises the complexity and challenges associated with applying the EE1st principle [8]. He contends that the principle, centered on setting decision objectives, comparing demand- and supply-side resources, and prioritising cost-effective or societal valuable options. Mandel also highlighted that the EE1st principle has a strong theoretical foundation that may guide the development of successful and efficient policy interventions that put policy into practice [8].

In 2019, Jan Rosenow provided an innovative approach to implementing the efficiency first principle in the UK, offering practical insights that have subsequently guided later implementation efforts [9]. Finally, Songmi Yi has introduced the most recent proposed strategy inside the decision-tree framework, providing an up-to-date perspective on the procedure for implementing the EE1st principle [10].

In conclusion, while the literature on EE1st remains in its initial stages, the existing works underscore both the theoretical strength of the principle and the challenges inherent in its practical application. Further research and implementation efforts are crucial for effectively integrating the EE1st principle into regional decision-making procedure as the EU's energy policy landscape still evolves.

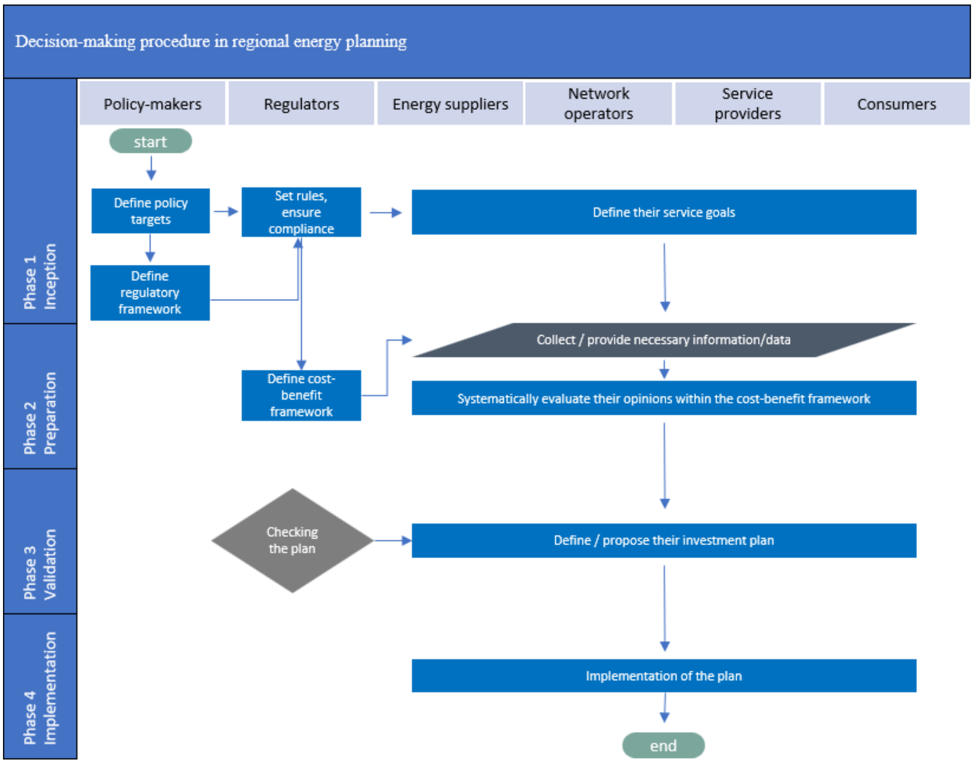
3. Methodology approach

This section argues the necessity of extending the stakeholder mapping and engagement insights, aligning them with sustainability goals in regional planning, while addressing conflicting interests in energy efficiency.

3.1. Decision-making process in regional energy planning and the tree-like diagram

Identifying the methodology of the decision-making process in regional planning is essential for stakeholder mapping and engagement. The decision-making process in regional planning, guided by the EE1st principle, employs a decision-tree approach commonly used in project management. This structured approach entails a tree-like diagram to depict decision-makers, decision-points, actions taken, and potential outcomes. The decision-tree provides a holistic view of the entire process, aiding in regional planning, implementation, and control, providing the ability for adaptation in each case study, utilizing specific symbols and shapes for information display, as noted by Songmi Yi [10]. The decision-making process in the realm of regional energy planning unfolds through a series of meticulously defined phases. These phases include the inception, preparation, validation, and implementation, as depicted in Figure 1. During the inception phase, policy-makers take the lead in defining policy targets and regulatory frameworks. Concurrently, regulators ensure that business interests and policy targets are aligned, particularly in terms of system planning and investment. Moving into the preparation phase, market and planning entities, including energy suppliers, network operators, consumers, and demand response service providers, gather requisite information. Validation marks the next crucial step, particularly in vertically integrated sectors. In this phase, market actors propose investment plans, subject to rigorous assessment by regulatory authorities. The core of the decision- making process unfolds during the implementation phase. Market entities conscientiously execute agreed plans in alignment with established objectives and legal frameworks. This ensures the consistent translation of decisions into actionable initiatives. The holistic nature of this decision-making procedure reflects the concerted efforts of diverse stakeholders, that have a stake in the regional planning processes and who are relevant interlocutors and impactful at regional level for the adoption and implementation of the EE1st principle. Together, they contribute to the development and implementation of sustainable energy policies within the regional ecosystem. The key target groups include policy-makers, regulators, energy suppliers, network operators, service providers, and consumers.

Figure 1: Decision-tree of the decision-making procedure in regional energy planning



3.2. Stakeholder mapping and the influence/interest matrix

The methodological approach to stakeholder mapping is a pivotal component of energy planning and decision-making process, especially when adhering to the EE1st principle. Stakeholder mapping systematically categorizes and analyzes various actors in energy systems, such as policymakers, regulators, energy suppliers, network operators, service providers, and consumers. By differentiating stakeholders based on significance, influence, interest, and contribution to energy policy formulation, a more comprehensive view of the energy landscape is achieved.

This decision tree methodological approach facilitates the integration of stakeholder inputs into energy planning processes. Through iterative engagement and consultation, energy planners can leverage stakeholder perspectives to inform policy development, prioritize initiatives, and optimize resource allocation. Importantly, this approach acknowledges the contextual nuances and intricacies inherent in energy systems, allowing planners to tailor engagement strategies to the specific needs of different regions and communities.

Concerning stakeholder mapping, various methodologies exist, with Mendelow's framework [11] providing a comprehensive model tailored for environmental scanning within the context of stakeholder analysis. This model, designed to fit the complex and dynamic nature of the environmental context, defines and illustrates varying levels of stakeholder influence in projects. To enhance its applicability to energy efficiency and aligning it with regional planning, dynamism in the model has been replaced with interest, resulting in the influence/interest matrix. This matrix serves as an analytical instrument, raising pivotal inquiries concerning stakeholders' involvement in the decision-making procedure, specifically addressing the extent to which each stakeholder group is motivated to influence decisions according to their expectations and interests in energy efficiency.

4. The case study

In this section, the interest and influence stakeholders have had on regional planning is described by the stakeholder mapping and analysed with the interest/influence matrix for the case study of the Region of Western Macedonia.

4.1. Brief introduction of the Region of Western Macedonia

The Region of Western Macedonia (RWM) faces formidable challenges in its energy landscape and climate planning, particularly in the field of rapidly decarbonizing its energy sector. Despite legal hurdles hindering coal phase-out, the RWM is committed to transitioning towards green energy sources[12]. In order to facilitate its Just Transition' goals, the RWM is repurposing existing district heating systems previously reliant on lignite, through the implementation of the Just Development Transition Plan (JDTP)[13]. In parallel, the RWM is currently developing a comprehensive sustainable energy plan, prioritizing energy efficiency and new technologies to align with national goals and address regional energy needs sustainably. Efforts also include the energy renovation of public buildings and participation in initiatives like the Covenant of Mayors, aimed at achieving net-zero greenhouse gas emissions by 2030[1]. Through collaboration and strategic planning, RWM aims to navigate the energy transition, mitigate climate risks, and foster socio-economic development while ensuring energy self-sufficiency and resilience for the region[14].

The engagement of a broad spectrum of stakeholders in RWM demonstrates a commitment to participatory decision-making and long-term energy strategy. Effective coordination among stakeholders and local governments is critical for plan effectiveness, as it promotes alignment with larger governmental programs such as energy efficiency schemes and sustainable urban transportation plans. This coordinated strategy guarantees that regional energy and climate plans represent RWM's stakeholders' needs, objectives, and aspirations while moving toward a more sustainable future.

[1] Municipality of Kozani has been selected among others, to become "Climate Neutral by 2030".

4.2. Key target groups identification regarding energy planning in the Region of Western Macedonia

The key target groups/stakeholders regarding energy planning in the Region of Western Macedonia were divided between Collaborator, Planner, Supporter, Advisor, Campaigners, Influencers based on their involvement to the EE1st regional planning, as presented in Table 1. All of the stakeholders who need to be frequently involved, informed, and actively engaged in the energy generation, management, and distribution processes have been identified based on the present national, regional, and local governance landscape as well as the individuals currently in charge of these processes.

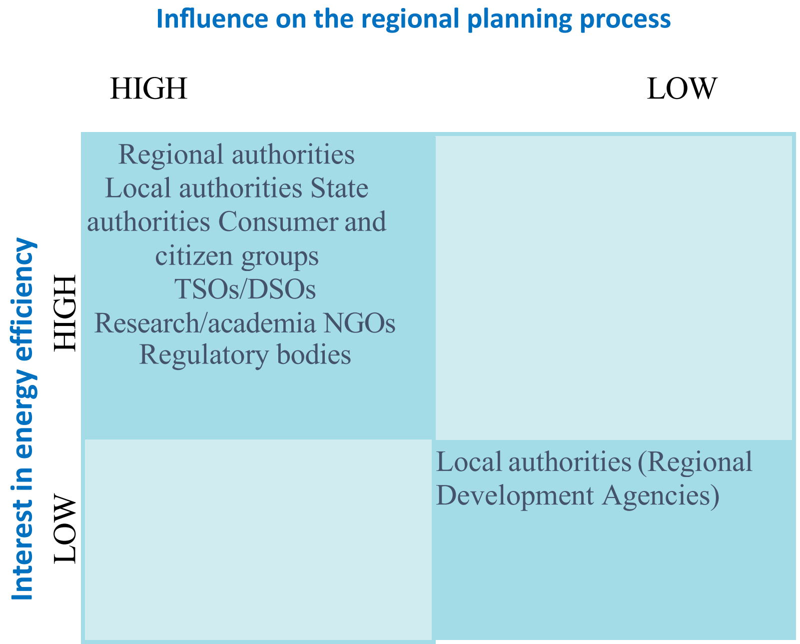
Table 1: Key target groups identification regarding energy planning in the Region of Western Macedonia

Type of actor	Role in regional planning	Role in regional planning
Regional authorities	Region of Western Macedonia	Collaborator, Planner, Supporter
Local authorities	Regional Association of Local Government of Western Macedonia, Municipalities of Kozani, Eordaia, Voios, Grevena, Deskati, Amyntaio, Kastoria, Nestorio, Orestido, Prespa, Velventos,	Collaborator, Planner, Supporter
	Regional Development Agency of Western Macedonia S.A. (ANKO GR) Regional Development Agency of Florina Regional Development Agency of Kastoria (ANKAS GR)	Collaborator, Supporter
State authorities	Ministry of Environment and Energy Center for Renewable Energy Sources and Saving Technical Chamber of Greece – Department of Western Macedonia	Planner Supporter
Regulatory bodies	Administrative Authority of Western Macedonia	Collaborator
Consumers and citizens groups	Kozani Chamber of Commerce and Industry Chamber of Florina, Kastoria, Grevena, Commercial Association of Kozani	Campaigners, Influencers
Electricity producers	Public Power Corporation (PPC) Energy Community of Kozani Association of PV investors of Western Macedonia Region (SEFPE WM) Hellenic Petroleum Renewable Energy Sources S.A. (HELPE Renewables) ENEL Green Power	Planner
TSO/DSO	Municipal Irrigation and Sewage Enterprise of Kozani (DEYAK) District Heating Municipal Company of Ptolemaida Municipal District Heating Company of the wider area of Amyntaio	Collaborators
Research/ Academia	University of Western Macedonia	Supporter, advisor, collaborator
NGOs	Association of Active Youths of Florina	Supporters, influencers

It is essential to acknowledge the distinct role of each key target group in the energy policy planning, and to interact with them, as they offer the strategic directions needed to accomplish sustainability objectives and maximise energy resources at the regional level, ensuring the successful implementation of the EE1st principle.

Identifying all key stakeholders involved in the planning process and categorising them based on their level of influence and interest is critical for tailoring the most suitable engagement strategies and tactics for each stakeholder. The stakeholders involved in the planning procedure of the Region of Western Macedonia were classified in the influence/interest matrix based on their influence on regional planning process and their interest in energy efficiency, as shown in Figure 2.

Figure 2: The influence/interest matrix of stakeholders engaged in the planning procedure of the Region of Western Macedonia



Stakeholders with high influence and high interest are crucial decision-makers who greatly affect the outcome of the planning procedure. Establishing a robust relationship with these stakeholders is mandatory for efficiently handling their expectations. Stakeholders with high influence but low interest should be informed about planning developments. Despite their lack of interest in the outcome, they nonetheless possess influence and have impact. These stakeholders should be managed with caution since, if dissatisfied, they may abuse their position of influence. Stakeholders with low influence but high interest should be kept well-informed and engaged in discussions to ensure that no major issues arise. These individuals are frequently valuable and vital in providing essential support during the planning procedure. Stakeholders with low influence and low interest should be monitored, but extensive communication should be avoided.

5. Integrating the EE1st principle in the decision-making process – Results

In order for the EE1st principle to be integrated in the decision-making process, it is essential to engage in this procedure all the relevant stakeholders, that have been identified. A regional workshop took place on 26.04.2023 in Kozani, Western Macedonia, Greece, where, with the utilization of the Mentimeter tool, all the relevant stakeholders were engaged. In this section, the data, gathered about energy transition and the implementation of EE1st in the decision-making process, are presented. All data were subjected to quality control and measurements not satisfying the requirements were rejected.

Table 2: Main characteristics of the sample.

Area	Age (Year)	Family Members	Education	Occupational groups	Family net income (Euros)	Income reduction (%)
Municipality of Kozani 86%; Municipality of Grevena 7%; Municipality of Amuntaio 7%	19-29 27%; 30-39 18%; 40-49 55%	1 (18%); 2 (18%); 3 (27%); 4 (27%); 5 (9%)	University 25%; MSc - PhD 75%	Employed 17%; Part time 8%; Freelancer 75%	10.001,00 € - 20.000,00 € 25%; 20.001,00 € - 30.000,00 € 33%; 30.001,00 € - 40.000,00 € 17% 40.001,00 € - 50.000,00 € 8% >50.000,00 € 8%	11-25 27%; 26-50 36%; 51-75 18%; >75 9%; N/A 9%

The main characteristic of the surveyed population are given in Table 2. As shown, the average persons are being part of 3-4 family members (55%) while the region's average is {2.6}. In parallel, age distribution revealed that 55% fell within the 40-49 years bracket, while the remaining were distributed among the 19-39 years age group, while region's average is close to 46 years. Educational attainment highlights a well-educated cohort, with 75% holding MSc or PhD diplomas. The unexpected fact was that 75% of the participants identified as freelancers, contributing to an annual family income ranging from 10,000 € - to 40,000 €. Notably, 64% of participants faced a significant income reduction, ranging from 11% to 50% in the last decade.

5.1. General perspectives on Energy Transition and Energy Efficiency

The gathered data from this workshop provide crucial insights into the attitudes and perceptions of the stakeholders regarding energy transition and the implementation of the EE1st principle in the decision-making process. The workshop revealed a diverse range of opinions among the stakeholders, reflecting the varied demographic characteristics observed in the surveyed population. Key findings include a strong association of 42% of participants linking energy transition to reducing carbon footprints and 56% emphasizing cost efficiency measures. Moreover, the workshop highlighted the importance of addressing social cohesion (53%) as a significant challenge in the context of energy transition. Additionally, 75% of the stakeholders expressed a belief that energy transition is an inclusive effort for everyone. Notably, 29% expressed concerns about the readiness of the current energy system, indicating potential areas for improvement. Furthermore, the survey results unveiled that 26% of stakeholders relate energy efficiency to participation in decision-making processes, emphasizing the need for collaborative approaches. Almost half of the participants (47%) expressed a desire to become more involved in energy efficiency initiatives, underlining the importance of fostering active engagement. Importantly, the high awareness (100%) of the Green Fund and the Just Transition Fund among the stakeholders suggests a solid foundation for financial support in sustainable practices.

5.2. *The role of regional and local stakeholders*

Table 3: The role of regional and local stakeholders

	Local level					Regional Level				
	1*	2	3	4	5	1	2	3	4	5
Energy transition with sensitivity	17%	25%	8%	42%	8%	18%	9%	9%	45%	18%
Positive response to energy transition and changes	8%	0%	15%	54%	23%	9%	18%	9%	18%	45%
Vocational training opportunities	17%	25%	8%	50%	0%	17%	17%	17%	42%	8%
Local / Regional plan for energy transition	17%	17%	8%	25%	33%	8%	25%	0%	42%	25%
NECPs should be also in regional level	-	-	-	-	-	0%	8%	0%	50%	42%

*(1 = Strongly Disagree; 2 = Disagree, 3 = Neither agree or disagree, 4 = Agree, 5 = Strongly Agree)

As presented in Table **3**, in comparing stakeholder perspectives at the local and regional level, interesting patterns are revealed, demonstrating both common feelings and notable differences. Regarding the sensitivity of energy transition initiatives, 50% of stakeholders at the local level agree/strongly agree, signifying a complex landscape of recognition. At the regional level, a higher 63% expressed agreement (i.e. agree/strongly agree), showing a stronger recognition of the significance of regional energy transition efforts. This 13 percentage-point gap highlights how region-specific factors might influence the perception of energy transition efforts in relation to sensitivity.

Moreover, the aspect of positive responses to energy transition changes reveals compelling insights. Nationally, a robust 77% either agree or strongly agree, showcasing strong support for the adoption of changes, as depicted in Table **3**. In contrast, at the regional level, 63% express strong agreement, indicating a slightly lower but still substantial level of support for embracing changes in the energy transition landscape. This discrepancy of 14 percentage points underscores potential variations in regional priorities or considerations when endorsing changes. These findings emphasise the complexity of stakeholder perspectives and highlight the importance of tailoring strategies to regional contexts for effective energy transition implementation.

Stakeholders across both regional and national levels show a consensus, with 50% expressing agreement on the importance of vocational training opportunities. This shared perspective indicates a uniform recognition of the significance of vocational training in the context of energy transition efforts.

When evaluating the necessity of a local or regional plan for energy transition, a notable 58% of stakeholders at the national level express agreement (i.e. agree/strongly agree), while at the regional level, an even higher 67% can be observed. This consensus across both levels suggests a shared understanding among stakeholders regarding the importance of comprehensive plans to guide energy transition initiatives.

Last but not least, regarding the inclusion of National Energy and Climate Plans (NECPs) at the regional level, a substantial consensus is evident among stakeholders, with an overwhelming 92% expressing agreement (i.e. agree/strongly agree). This high level of agreement emphasizes a strong collective belief in the significance of extending NECPs to the regional context. The recognition among regional stakeholders highlights a shared understanding of the value and necessity of incorporating regional considerations into Regional Energy and Climate Plans. This finding emphasises a widely held perspective among stakeholders regarding the role of Regional Plans in guiding energy transition initiatives.

6. Conclusion

In conclusion, this paper delves into the crucial importance of stakeholders' mapping in embedding the Energy Efficiency First (EE1st) principle in regional energy policy frameworks. The EE1st, principle, a fundamental aspect of EU energy policy, highlights the need of prioritizing cost-effective energy efficiency measures, fostering sustainability and aligning with the broader societal objectives. Although EE1st is incorporated in EU policy, integrating in into regional decision-making procedure remains a challenge.

The mapping procedure in this study is essential for effective stakeholder engagement in regional energy ecosystems. By identifying key target groups and employing and influence/interest matrix, a systematic approach to categorize stakeholders based on their significance, influence, and interest in energy efficiency is provided. This methodological approach serves as a pivotal stage for decision-makers to navigate the complex landscape of regional planning, ensuring inclusivity and thorough consideration of diverse stakeholders.

The case study of the Region of Western Macedonia demonstrated the practical implementation of the stakeholder mapping approach. Engaging multiple stakeholders is a crucial tactic in this region, as it tackles the issues of decarbonizing its energy industry and shifting towards green energy sources and energy efficiency. The collaborative efforts of regional and local authorities, stake bodies, consumers, NGOs, and other entities illustrate the commitment to participatory decision-making and the long-term energy strategy required for a sustainable future.

However, challenges persist due to the diversity of regional objectives, resource constraints, and the need for tailored strategies. The paper emphasizes the importance of recognizing the unique needs of each region and employing nuanced, localized solutions. Furthermore, the potential conflicts that may arise from various stakeholder interests highlight the importance of employing effective engagement strategies.

Implementing the EE1st principle at the regional level necessitates a consistent and flexible approach for engaging stakeholders. The influence/interest matrix supports continuous consultation, repetitive processes, and flexible mapping to address evolving regional dynamics. Developing robust connections with high-influence stakeholders, informing those with low interest, and strategically engaging others, can assist decision- makers effectively navigate the complex landscape of regional energy planning.

In essence, the key to successfully incorporating the EE1st principle into regional energy planning is to effectively utilize the combined information and cooperation of diverse stakeholders. This paper enhances the discourse by providing structured methodology and practical insights, paving the way for a more sustainable, inclusive, and efficient regional energy ecosystem.

7. Next steps

To advance the integration of the EE1st principle in regional energy policies, a multifaceted approach is proposed. Micro interventions will target specific stakeholder groups, ensuring nuanced solutions tailored to diverse regional dynamics. Simultaneously, creating detailed training modules and hosting workshops in various regions would provide stakeholders with the necessary information and skills to promote energy efficiency in decision-making. Moreover, strategic assistance inside existing frameworks, like the Covenant of Mayors process, seeks to effectively incorporate EE1st principles. Lastly, a mentoring programme within the EU will facilitate knowledge exchange, fostering an ecosystem of continuous learning among stakeholders. Through these strategic next steps, this paper envisions a holistic and inclusive pathway towards sustainable and energy-efficient regional energy policies.

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Integrating Environmental Education Techniques for Organizational Employees: A Sustainable Approach to Corporate Responsibility

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Abstract

The escalating need for environmental awareness and sustainability has emerged as a critical priority amid the array of pressing global challenges characterizing the modern era. This discourse delves comprehensively into the imperative significance of implementing robust environmental education methodologies within organizational frameworks, aiming to instill a pervasive culture of sustainability among employees. Central to this perspective is the vital integration of a comprehensive understanding of ecological systems, climate change dynamics, and the profound ramifications of human activities on the delicate fabric of the environment.

This deliberation particularly underscores the pivotal role of effective educational strategies, emphasizing the efficacy of workshops, meticulously designed training modules, and interactive learning interventions aimed at nurturing a profound and intrinsic sense of environmental stewardship among employees. This approach underlines the importance of adopting innovative pedagogical practices to engender active employee involvement and engagement in the pursuit of sustainable practices.

Furthermore, this discussion accentuates the pivotal role of environmental education in fostering a more sustainable and ecologically responsible work culture, underscoring its far-reaching and positive impact on overall business practices, contributing to the holistic betterment of the global ecosystem.

Keywords: Education, Environment, Eco-Systems, Staff, Organizations, Corporations, Theory of Change, Sustainability

JEL Codes: A13; I21; I31; I38; J28; J81; Q01; Q52; Q53; Q56; Q57

Ενσωμάτωση Τεχνικών Περιβαλλοντικής Εκπαίδευσης για Υπαλλήλους Οργανισμών: Μια Βιώσιμη Προσέγγιση στην Εταιρική Υπευθυνότητα

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Περίληψη
Η κλιμακούμενη ανάγκη για περιβαλλοντική ευαισθητοποίηση και βιωσιμότητα έχει αναδειχθεί ως κρίσιμη προτεραιότητα εν μέσω των συνεχόμενων πιεστικών παγκόσμιων προκλήσεων που χαρακτηρίζουν τη σύγχρονη εποχή. Η παρούσα ομιλία εμβαθύνει στη σημασία της εφαρμογής ισχυρών μεθοδολογιών περιβαλλοντικής εκπαίδευσης εντός οργανωτικών πλαισίων, με στόχο να προωθήσει την κουλτούρα της βιωσιμότητας μεταξύ των εργαζομένων. Κεντρική θέση σε αυτή την προοπτική είναι η ενσωμάτωση μιας συνολικής κατανόησης των οικολογικών συστημάτων, της δυναμικής της κλιματικής αλλαγής και των βαθιών προεκτάσεων των ανθρώπινων δραστηριοτήτων στο περιβαλλοντικό πλαίσιο.

Υπογραμμίζεται ο κεντρικός ρόλος των αποτελεσματικών εκπαιδευτικών στρατηγικών, δίνοντας έμφαση στην αποτελεσματικότητα των βιωματικών δράσεων, των προγραμματισμένων εκπαιδεύσεων και των διαδραστικών μαθησιακών παρεμβάσεων που στοχεύουν στην καλλιέργεια μιας βαθιάς αίσθησης περιβαλλοντικής διαχείρισης μεταξύ των εργαζομένων. Αυτή η προσέγγιση υπογραμμίζει τη σημασία της υιοθέτησης καινοτόμων παιδαγωγικών πρακτικών για την ενεργό συμμετοχή και δέσμευση των εργαζομένων στην επιδίωξη βιώσιμων πρακτικών.

Επιπλέον, στη συζήτηση τονίζεται ο καίριος ρόλος της περιβαλλοντικής εκπαίδευσης στην προώθηση μιας πιο βιώσιμης και οικολογικά υπεύθυνης εργασιακής κουλτούρας, υπογραμμίζοντας τον εκτεταμένο και θετικό αντίκτυπό της στις συνολικές επιχειρηματικές πρακτικές, συμβάλλοντας στην ολιστική βελτίωση του παγκόσμιου οικοσυστήματος.

Keywords: *Εκπαίδευση, Περιβάλλον, Οικοσυστήματα, Προσωπικό, Οργανισμοί, Εταιρείες, Θεωρία της Αλλαγής, Αειφορία*

JEL Codes: A13; I21; I31; I38; J28; J81; Q01; Q52; Q53; Q56; Q57.

1. Introduction

The traditional concept of development has long been tethered to economic progress, where a country's advancement is measured by its economic achievements. This involves enhancing the standard of living, infrastructure, and overall economic well-being.

However, the singular focus on economic development raises significant concerns. While improving the economy is essential, an exclusive emphasis on economic growth can result in unintended consequences. This includes environmental degradation, exacerbated social inequalities, and the persistence of poverty. Furthermore, this exclusive focus fails to ensure a fair distribution of wealth, leading to a widening gap between the rich and the poor.

According to UNESCO's definition, sustainable development is based on three pillars, where the economic aspect focuses on promoting inclusive development and equitable distribution of wealth.

The need for economic development to coexist with environmental and social considerations sets the stage for exploring sustainable practices in corporate environments. Linking education with sustainability in corporations becomes crucial, as these entities significantly influence society, the environment, and individuals. Scholars like Hoffman (2001) emphasize the importance of corporate education, which fosters responsible corporate citizenship, empowers employees to make sustainable choices, and enhances individual understanding of sustainability.

Recognizing the pivotal role of workplaces in shaping mindsets and behaviors, the paper examines methods through which corporate environments can contribute to sustainable development. Employing a case study methodology, the focus is on practical strategies already implemented. The proposed approach includes defining clear objectives, setting selection criteria, comprehensive data collection, developing an analysis framework, and considering various stakeholder perspectives.

Proposing the implementation of educational processes within corporate environments related to sustainable development, the paper suggests creating protocols prioritizing employee education on sustainability. This involves establishing a specific, official, and written framework, making education a company-wide goal. Training for staff should not only remain theoretical but be implemented, with regular sessions covering practices like recycling, facilities for special needs, and violence prevention. External awareness of corporate actions is deemed crucial, and corporate volunteering is identified as an avenue for education. The paper concludes by emphasizing the peer-to-peer approach, where employees become carriers of knowledge, fostering a sustainable culture within corporate environments. The effectiveness of this approach is heightened when employees share experiences and actions, setting an example for future generations within the corporate sphere.

2. Literature Review

Development, conventionally perceived as synonymous with economic progress and growth, has long been assessed through the lens of economic achievements. This review delves into key literature exploring the multifaceted dimensions of development, emphasizing the challenges associated with an exclusive focus on economic aspects.

Economic development encapsulates a comprehensive enhancement of a country's standard of living, infrastructure, and overall economic well-being. Indicators such as GDP growth, industrialization, technological advancements, and increased employment opportunities serve as benchmarks for gauging this progress (Nafziger, 2012)

While acknowledging its crucial role, the exclusive emphasis on economic facets has yielded unintended consequences. Environmental degradation, escalating poverty levels, and exacerbated inequalities emerge as adverse effects accompanying an overly zealous pursuit of economic growth (Zhang & Wen, 2008). Notably, when economic development is fueled by greed, it often leads to environmental destruction, such as deforestation and water pollution. The improved economic status of individuals may also contribute to issues like increased car purchases and housing construction without consideration for eco-friendly alternatives (Awan, 2013).

Economic growth, when not accompanied by equitable wealth distribution, widens gaps between the affluent and the impoverished. Social injustices, such as limited access to education, healthcare, and basic services, hinder overall social well-being (Harper, 2014). Recognizing these challenges, the concept of sustainable development has emerged, advocating for a holistic approach that integrates economic, environmental, and social dimensions (Vanclay, 2002).

According to WHO (2015), rampant industrialization for more profit and unbridled exploitation of natural resources have contributed to widescale environmental destruction. This includes deforestation, pollution, and climate change, with far-reaching consequences on ecosystems, biodiversity, and planetary well-being. Sustainable development, as defined by UNESCO, revolves around three pillars, with the economic dimension emphasizing inclusive development and fair wealth distribution. Encouraging businesses to adopt ethical standards, fair labor practices, transparency, and sustainable use of natural resources are crucial components of this approach.

It is a disconcerting reality that economic growth does not inherently guarantee the equitable distribution of wealth and resources. Despite overall economic development, marginalized communities often grapple with heightened poverty levels and exacerbated social disparities" (Mehrotra & Delamonica, 2007).The socio-economic imbalances arise from a singular focus on economic metrics. This tunnel vision exacerbates existing inequalities, leading to social injustices. Limited access to education, healthcare, and basic services further entrenches vulnerable populations in a cycle of poverty, hindering their overall well-being (Hurst Gibbon, & Nurse, 2016).

The overall impact, therefore, on economic, social, and the natural environment, arising from the one-sided focus on economic development and profit, highlights the need for a sustainable solution to restore balance. Thus, there is also an introduction to the necessity of creating and implementing the concept of sustainable development.

UNESCO defines sustainability as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Emphasizing a long-term perspective, this definition underscores the integration of economic, social, and environmental considerations (UNESCO, n.d.).

There are three dimensions of sustainability: the economic one which includes the development of an inclusive economy that supports the well-being of all members of society; the social one which focuses on social equity, justice, and inclusivity by promoting access to education, healthcare, and basic human rights for all; the environmental one which concentrates on the protection of the environment for current and future generations (Seghezzo, 2009).

To secure the aforementioned objectives, the United Nations has embarked upon the formulation and promotion of the Sustainable Development Goals (SDGs) which underscore the vision for a balanced and sustainable world (Carlsen & Bruggemann, 2022).

Considering the paramount importance of sustainable development for our existence, a comprehensive examination of this concept is imperative across all spheres. Typically, discussions surrounding socialization and personal development predominantly revolve around familial, societal, and educational influences, with limited attention directed toward the workplace. It is noteworthy that individuals spend a substantial portion of their day, ranging from 8 to 10 hours, in their professional environment, surpassing the time devoted to family or personal relationships. This underscores the profound responsibility borne by workplaces in shaping the attitudes and behaviors of their employees (Hodgkinson & Ford, 2007).

The dynamics of adult life introduce shifts in lifestyle, thereby emphasizing that a company adopting sustainable operational practices fosters employees who are likely to exhibit sustainable behaviors. The overarching goal is to exemplify methods through which corporate environments can actively contribute to sustainable development. The interconnected relationship between home and work life underscores the bi-directional influence each exerts on the other; thus, achievements in the workplace translate into impacts within personal spheres (Woodward et al., 2010).

To achieve this symbiosis, fostering a culture of continual learning and sustainability awareness within the corporate framework is essential. Noteworthy examples of companies seamlessly integrating sustainability education into their corporate culture, such as The Body Shop and Starbucks, exemplify the positive outcomes of this approach.

The chosen methodology for promoting sustainability within corporate environments employs a detailed case study analysis approach, focusing on strategies that have already proven successful in various companies. By examining real-world examples, this method allows for a comprehensive understanding of effective sustainability practices, including waste reduction, energy efficiency, and responsible sourcing. The analysis not only highlights the environmental benefits of these strategies but also showcases their potential for cost savings and enhanced corporate reputation. This approach ensures that the proposed sustainability initiatives are grounded in practical evidence, making them more likely to be adopted and successfully implemented within different corporate settings. Through this, companies can learn from the successes and challenges faced by their peers, adapting and innovating upon these strategies to suit their unique operational contexts.

To enhance proposals for educational processes related to sustainable development within corporate settings, the establishment of comprehensive protocols becomes imperative. These protocols should distinctly prioritize employee education on sustainability issues and include the creation of a specific, official, and documented framework. By institutionalizing sustainability education as a pervasive corporate objective, it transcends individual managerial or employee commitments (Stegmeier Consulting Group, 2020).

The envisioned objective extends beyond theoretical understanding, emphasizing the necessity for practical implementation. Recurrent staff training sessions, designed to instill sustainable practices, should be a consistent feature throughout the year. Tangible actions within the workplace, such as the introduction of recycling bins, provisions for individuals with special needs, and the use of audiovisual materials addressing workplace violence, should be incorporated (Eisner, 2017).

Strategic collaborations with entities specializing in sustainability further amplify the efficacy of training sessions. Partnerships with external organizations enable a holistic approach to sustainability education, leveraging external expertise to reinforce the importance of sustainable practices. A robust evaluation system for the implementation of sustainable practices is imperative, scrutinizing the consistent adherence to documented practices across all departments. This evaluation framework should facilitate ongoing adjustments to protocols, ensuring their sustained relevance and effectiveness by creating a safe environment (Marshall & Suárez, 2013). Transparent reporting mechanisms that inspire confidence among employees need to be established. These mechanisms empower employees to report violations or concerns without fear of reprisal. Imposing impartiality on recipients handling these reports is critical, ensuring anonymity and conducting thorough investigations to preserve the integrity of employees and prevent backlash from superiors (Gaventa & McGee, 2013).

External awareness initiatives play a pivotal role in sensitizing employees to corporate actions. Corporate volunteering emerges as an educational avenue, facilitating collective employee participation in public initiatives and community actions centered around sustainable development. This external engagement not only fosters awareness but also encourages employees to actively contribute to broader sustainability efforts (Kim et al., 2010).

Another aspect of corporate education is the one that introduces a dual perspective on information and activation, highlighting the roles of both the trainer and the trainee. Employees participate in actions where they acquire insights into sustainable education issues, fostering a hands-on learning experience. Simultaneously, employees assume the role of trainers, sharing their knowledge within their field to support groups in need. This mutual exchange within the workplace cultivates a culture of shared responsibility and equality, particularly when engaging with vulnerable populations (Blanchard et al., 2023).

Acknowledging the contemporary challenges of work environments, companies should introduce incentives to encourage voluntary participation in sustainability initiatives. These incentives, ranging from time off for blood donation to first aid certifications and personalized training aligned with employees' interests, provide tangible benefits, motivating employees to actively contribute to sustainable practices (Teller, 2009).

The peer-to-peer (P2P) approach, emphasized in the conclusion, underscores that employees evolve into carriers of knowledge. This approach not only facilitates the transfer of necessary information but also amplifies the efficacy of action implementation. Learning from someone within their team resonates effectively with employees, fostering a sustainable culture within corporate environments. The attitudes of past employees and the ongoing implementation of sustainable actions serve as exemplars, setting the stage for the successive generations of employees to continue and enhance sustainable practices (Blanchard et al., 2023).

The ultimate goal of corporate education and social responsibility initiatives is the assimilation of a lifestyle that promotes sustainable development both within and beyond the corporate environment.

3. Methodology

Case Studies Methodology

Analyzing case studies provides valuable insights into successful sustainability initiatives. Understanding the methodology behind these studies is key to extracting actionable lessons.

Methodological Components: (Tellis, 1997)

Objective Definition: Clearly outline the objectives of the case study, such as identifying best practices, evaluating impact, or understanding challenges.

Selection Criteria: Establish criteria for selecting case studies, considering industry.

Data Collection: Gather data on sustainability practices, implementation strategies, challenges faced, and measurable outcomes.

Analysis Framework: Develop a framework for analyzing the case study, focusing on economic, social, environmental, and cultural dimensions.

Stakeholder Perspectives: Consider the perspectives of various stakeholders, including employees, customers, and the broader community.

4. Results

- Development and Implementation of the Corporate Sustainability Protocol
  The newly developed corporate protocol prioritizes sustainability training for employees, establishing it as a cornerstone of the company's educational agenda. The implementation of this protocol was marked by the introduction of specific training modules, including the provision of recycling bins, visual materials addressing workplace violence, and infrastructural improvements to accommodate individuals with disabilities.

- Strategic Collaborations and Practical Implementation
  The execution of sustainability training leveraged strategic partnerships with organizations specializing in various sustainability domains. These collaborations enhanced the content and delivery of training modules, ensuring they were both comprehensive and practical.

- Monitoring and Evaluation
  A robust monitoring and evaluation framework was put in place to assess the effectiveness of the implemented protocols. Adjustments were made as necessary, based on a continuous feedback mechanism that included an anonymous reporting system managed by an impartial third-party. This system helped in identifying areas needing improvement without causing stigma or professional disfavor.

- Experiential Learning and Corporate Volunteerism
  Experiential learning was a key component of the educational initiatives, with employees participating in corporate volunteerism. Activities included blood donation drives, tree planting, and engagement in creative workshops designed to reinforce the sustainability lessons learned. These activities not only provided practical learning experiences but also enhanced community engagement and corporate social responsibility.

- Awareness and Role Adaptation
  The dual approach to raising awareness—assuming roles as both trainee and trainer—proved effective in deepening employees' understanding of sustainability issues. This approach allowed employees direct exposure to real-world applications and vulnerabilities, thus fostering a greater sensitivity and personal connection to the sustainability goals.

- Incentives for Engagement
  In response to potential employee reluctance toward organizational changes, the company introduced incentives to encourage voluntary participation in sustainability efforts. These

incentives included additional days off for community service, first aid certification, and training opportunities aligned with personal interests such as balcony gardening, which significantly increased participation rates.

- Peer-to-Peer Training
  The peer-to-peer training model was successfully implemented, with knowledgeable employees taking on the role of trainers for newer or junior staff. This method not only facilitated the effective transfer of knowledge but also fostered a culture of continuous learning and sustainability within the workforce.

- Budget Allocation for Sustainability Training

The company committed to sustainability not only in practice but also financially, with a designated portion of the annual budget allocated specifically for sustainability training. This financial commitment ensured the sustainability initiatives were well-supported and could evolve as needed to meet emerging challenges and opportunities.

5. Conclusion

In summary, this research challenges the conventional view that development is solely synonymous with economic progress. It explores the unintended consequences of an exclusive emphasis on economic aspects.

The pursuit of profit without considering sustainability has led to widespread environmental destruction and exacerbated social inequalities. This highlights the necessity for a more comprehensive approach to development. The introduction of sustainable development, aligned with UNESCO's definition emphasizing present and future needs, offers a holistic perspective that integrates economic, social, and environmental considerations.

The three dimensions of sustainability, as outlined by Seghezzo, provide a framework for a more inclusive and equitable approach. The United Nations' Sustainable Development Goals (SDGs) emerge as a crucial initiative for achieving balanced and sustainable development. The dissertation extends its focus to the corporate environment, emphasizing the significant role workplaces play in shaping attitudes and behaviors.

To foster symbiosis between personal and professional life, promoting a culture of continual learning and sustainability awareness within the corporate framework is essential. Case study analyses of companies like The Body Shop and Starbucks illustrate the positive outcomes of integrating sustainability education into corporate culture.

Proposed methodologies for promoting sustainability within corporate environments include comprehensive protocols prioritizing employee education. Practical implementation involves recurrent staff training sessions and tangible workplace actions, such as recycling initiatives. Strategic collaborations, transparent reporting mechanisms, and external awareness initiatives contribute to cultivating a sustainable culture within corporate environments.

The peer-to-peer (P2P) approach, highlighted in the conclusion, emphasizes employees as carriers of knowledge, facilitating the transfer of information and enhancing the efficacy of action implementation. Acknowledging contemporary challenges, the dissertation recommends introducing incentives for voluntary participation in sustainability initiatives.

Corporate education and social responsibility initiatives aspire to foster a culture that champions sustainable development, both within the confines of the corporate world and in broader societal spheres, aiming for widespread adoption of such principles.

6. Future Direction

The comprehensive exploration of development, sustainability, and corporate responsibility in the provided content opens up various avenues for future discussions and research.

The research can be expanded at an international level by incorporating companies outside Greece that have successfully integrated sustainability into their corporate culture. This will broaden the scope of the research and provide a more comprehensive picture of sustainability practices in various cultural and economic contexts.

Another aspect that could be further analyzed and researched is the psychological and behavioral aspects of sustainable practices in both personal and professional settings. Research could delve into the motivations, attitudes, and behavioral changes associated with individuals adopting sustainable practices, particularly in the workplace.

Moreover, the research could be expanded by examining the role of education in promoting sustainability within different workplaces. Research could focus on the design and impact of workplace protocols, training programs, and educational initiatives, exploring how these contribute to a culture of sustainability within organizations.

Additionally, it is of paramount importance to examine the factors influencing employee participation in sustainability initiatives. Research could investigate the impact of incentives, such as time off, certifications, and personalized training, on motivating employees to actively contribute to sustainable practices in the workplace.

Finally, a longitudinal study could be conducted so that the progress of companies that have adopted sustainable practices over time can be tracked. Research could assess the long-term impacts on environmental conservation, social equity, and economic stability, providing insights into the sustainability journey of organizations.

These potential future discussions and research directions can contribute to the ongoing discourse on sustainable development, offering valuable insights for policymakers, businesses, and academics striving for a more balanced and sustainable world.

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The Psychology of non-market Environmental Valuation: research evidence, theoretical insights, and policy considerations

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Abstract

The current study sheds light on the psychological insights embedded in environmental valuation research. It attempts to unravel the complex interplay between individuals' psychological considerations and how they value environmental goods, services, and various aspects of natural capital in monetary terms. Drawing on an extensive frame of literature, this work synthesizes how a wide range of psychological factors, including attitudes, environmental values, perceived behavioral control, norms, place attachment, and environmental/climate beliefs are incorporated into environmental valuation studies, especially focusing on the concept of willingness to pay (WTP) for environmental conservation. These psychological attributes have been found to account for a significant variation in peoples' environmental preferences and serve as important predictors of individual behavioral decisions. The review concludes with an integrative theoretical framework of the psychology of non-market environmental valuation. Research evidence highlight several policy implications that enable policymakers to leverage psychological research to the design and implementation of effective policy measures aligned with the EU Green Deal, and ultimately pursue environmental conservation and increased public support.

Keywords: Environmental Valuation, Psychological Factors, Willingness to Pay, Environmental Policy.

JEL Codes: A14; Q00; Q51; Q56; Q5; Q58, Q59.

Environmental psychology of religion and environmental crisis

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Abstract
The ecological and environmental crisis is a constant threat to the survival of the human species.This threat is practically dealt with by various methods and ways of adapting to local conditions and on-the-ground know-how, but also with an increased sense of social responsibility.The specific issue of the environmental crisis needs a political or state response which, due to its importance, causes negative effects on people's daily lives.In the turbulent times of the environmental crisis, there are radical ideas such as (deep ecology, ecophilosophy and ecotheology, ecopsychology), which make a strong and absolute critique of anthropocentrism which is considered to be mainly responsible for the threat of the coming destruction of the environment.In the announcement we will show how the environmental psychology of religion, through environmental ethics and business ethics, can help with its findings on the big issue of the climate crisis.

Keywords: Environmental Psychology of Religion, Environmental Crisis, Ecopsychology, Deep Ecology.

JEL Codes: A13; I21; I31; I38; J28; J81; Q01; Q52; Q53; Q56; Q57.

1. Introduction

In the face of escalating environmental challenges, the intersection between environmental psychology, religion and the global environmental crisis has emerged as a critical area of study. The environmental psychology of religion delves into the intricate connections between human beliefs, spirituality, and the natural world, exploring how these elements shape perceptions, attitudes, and responses to environmental issues.

As the planet faces environmental crises such as climate change, deforestation and biodiversity loss, understanding the role of religion in influencing environmental behaviour is becoming increasingly important. The diverse array of religious traditions worldwide offers unique perspectives on humanity's relationship with nature, ranging from stewardship and reverence to notions of sovereignty and exploitation (York, 2022).

This study involves not only understanding the psychological mechanisms that link religious beliefs to environmental behaviours, but also examining the potential of religious institutions and communities as catalysts for positive change. The environmental psychology of religion explores how religious teachings, rituals, and community practices can promote environmental stewardship, foster sustainable lifestyles, and inspire collective action to address ecological challenges. In addition, potential conflicts between religious perspectives and environmental conservation efforts are examined, identifying instances where certain beliefs may hinder or enhance environmental advocacy.

2. Environmental Psychology and Environmental Psychology of Religion

2.1. Definition and principles of Environmental Psychology

Environmental psychology can be defined as the study of the dynamic and reciprocal interactions between individuals and their physical environment. It explores how people perceive, experience and respond to their environment, from natural landscapes to built environments. Still, it is governed by key principles, some of which are discussed below (Steg, Van Den Berg & De Groot, 2018).

At the core of environmental psychology is the principle of human-environment interaction. This principle holds that individuals and their environment are inextricably linked, mutually influencing each other. People actively engage with their environment and these interactions, in turn, shape their experiences and behaviours. Whether in natural or built environments, the reciprocal relationship between people and their environment underscores the importance of understanding and designing spaces that promote positive interactions. In addition, another principle is environmental perception and knowledge. Specifically, environmental psychology explores how people process information about their environment, examining factors such as spatial awareness, wayfinding, and the impact of sensory stimuli. Understanding these cognitive processes is crucial for designing environments that support cognitive well-being and facilitate optimal functioning (Steg, 2019).

2.2. Environmental Psychology of Religion

One aspect of environmental psychology is the study of the link between religious beliefs and environmental attitudes. Religion, with its profound influence on human knowledge and behaviour, plays a critical role in shaping individuals' perspectives on the environment.

A fundamental aspect of the environmental psychology of religion is the way in which religious beliefs shape individuals' connection to nature. Many religious traditions embody respect for the natural world, viewing it as a divine creation. For example, in Christianity, the concept of stewardship is often emphasized, urging believers to care for the Earth as responsible custodians. This perspective encourages a deep connection between individuals and the environment, influencing their attitudes and behaviours towards nature. Research also shows that individuals who strongly identify with a religion that emphasizes nature as sacred are more likely to engage in pro-environmental behaviors. This association arises from a sense of responsibility embedded in religious teachings, motivating adherents to act in ways that align with their environmental values. Conversely, those from religious traditions that emphasize human sovereignty may exhibit lower levels of environmental concern. These findings highlight the differential interaction between religious beliefs and environmental attitudes (Taylor, Van Wieren & Zaleha, 2016, pp. 306-378).

Still, religious communities influence followers to increase environmental awareness and activism. Many religious organizations actively promote environmental stewardship as part of their moral obligations. These communities can mobilize their members to engage in environmental initiatives such as conservation projects, sustainable practices and climate change advocacy. The sense of community within religious groups provides a supportive environment for individuals to collectively address environmental challenges. Studies have shown that belonging to a religious community that values environmental stewardship can significantly influence an individual's likelihood of engaging in environmentally friendly behaviors (Johnston, 2014).

3. Cause of Environmental Crisis

3.1. Anthropogenic factors

The environmental crisis is a global issue that threatens the delicate balance of our planet's ecosystems. While the natural world has faced various challenges throughout Earth's history, the current environmental crisis is largely exacerbated by man-made factors. As population increases and industrialization intensifies, the impact of human activities on the environment has reached unprecedented levels, leading to a range of interconnected issues such as climate change, biodiversity loss, deforestation and pollution (Sachs, 2015).

One of the main anthropogenic factors contributing to the environmental crisis is the emission of greenhouse gases, particularly carbon dioxide, methane and nitrous oxide. The burning of fossil fuels for energy, deforestation and industrial processes release significant quantities of these gases into the atmosphere. This results in an enhanced greenhouse effect that traps heat, causing global temperatures to rise - a phenomenon commonly known as climate change. This change in climate patterns has far-reaching consequences, including more frequent and severe weather events, rising sea levels and disruptions to ecosystems (Wei et. all, 2016, pp. 632-643)

3.2. Social and cultural aspects affecting environmental degradation

One of the main social factors contributing to environmental degradation is the rapid population growth that is occurring worldwide. As human populations expand, the demand for resources intensifies, leading to increased deforestation, habitat destruction and overexploitation of natural resources. Also, the rise of consumerism and the pursuit of economic growth have exacerbated environmental problems as societies prioritize short-term gains over long-term sustainability (Buhaug & Urdal, 2013, pp. 1-10).

In addition, social inequalities play an important role in environmental degradation. Vulnerable communities, often marginalised and without political power, bear the greatest burden of environmental issues, as they are more likely to live in pollution-prone areas, experience the negative impacts of climate change and have limited access to resources for adaptation. Thus, environmental degradation becomes not only an ecological crisis but also a social justice issue (Brehm & Pellow, 2022).

4. Business Ethics - Environmental Ethics

4.1. Corporate Environmental Responsibility

Corporate Environmental Responsibility is a vital aspect of modern business practices, emphasising the need for companies to consider their environmental impacts. In this context, the ethical dimensions of resource extraction and consumption are of particular importance. As companies play a central role in the global economy, their actions in these areas can have far-reaching consequences for the environment and society at large (Schaltegger, Burritt & Petersen, 2017).

Resource extraction for economic development must give priority to ethical considerations. Companies that engage in environmentally destructive practices, such as deforestation and fossil fuel extraction, should minimise long-term consequences such as biodiversity loss and climate change. Ethical corporate behaviour includes adopting sustainable practices and addressing the creation and overconsumption of waste (Kurth et. all, 2021).

In resource consumption, companies should adopt the principles of the circular economy, promote recycling and develop innovative technologies to reduce waste. Corporate responsibility extends to social and cultural impacts, especially on indigenous communities facing displacement. Ethical behaviour requires meaningful engagement, respect for rights and inclusion in decision-making. Overconsumption of resources can exacerbate social inequalities, requiring corporate assessment and action to contribute to sustainable development and social justice. Overall, ethical challenges in resource extraction and consumption require a focus on sustainability, accountability and social inclusion (Velenturf & Purnell, 2021).

4.2. Religious ethics and environmental management

Religious ethics play an important role in shaping perspectives on environmental management, as various religious traditions provide moral frameworks and values that guide human interactions with the environment. These ethical principles often emphasize the interconnectedness of all living beings and humanity's responsibility to steward the Earth (Haluza-DeLay, 2014, pp. 261-279).

Many religious traditions regard the environment as a divine creation, and as such, believers feel a moral obligation to care for and protect the natural world. In Christianity, for example, belief in God as creator is accompanied by a responsibility to be stewards of creation, as articulated in the Bible's Genesis narrative. Similarly, Islam teaches that humans are stewards (caliphs) of the Earth and are responsible for their actions, including those that affect the environment. In Hinduism, the concept of "dharma" emphasizes the duty to uphold justice and harmony, extending one's relationship with nature. Buddhism emphasizes the interconnectedness of all life and the importance of compassion, promoting an ecological ethic rooted in awareness and non-harm (Taylor, 2016).

These religious values influence environmental attitudes and behaviours, fostering a sense of responsibility and stewardship. Supporters are motivated to engage in environmentally sustainable practices such as waste reduction and ethical consumption. In addition, religious communities can support policies that address environmental issues and promote ecological justice.

However, it is important to note that interpretations and applications of religious ethics may differ in each tradition, and that not all adherents may hold the same views. However, the influence of religious values on environmental stewardship is a powerful force that continues to shape ethical debates and actions worldwide. In an era characterized by environmental challenges, integrating religious perspectives with environmental values can contribute to a more holistic and sustainable approach to managing our planet (Haluza-DeLay, 2014).

5. Solving the environmental crisis

5.1. Ecological Psychology

Ecological psychology emphasizes the dynamic relationship between individuals and their environment. Unlike traditional psychological perspectives that often isolate individuals from their environment, ecological psychology recognizes the mutual influence between people and the natural world.

One of the fundamental principles of ecological psychology is the concept of possibilities. Potentialities refer to the perceived possibilities for action that the environment offers to an individual. In the context of environmental crisis, an understanding of potentialities is crucial for recognizing the impact of human behavior on the ecosystem and vice versa. By recognizing the reciprocal relationship between individuals and their environment, this provides the basis for developing sustainable behaviors that promote environmental health (Chemero, 2018).

Ecological psychology also emphasises the role of sensory perception in shaping the individual's relationship with the environment. The way individuals perceive and interact with their environment influences their attitudes and behaviour towards nature. For example, a person who experiences nature as an immersive and aesthetically pleasing environment is more likely to develop positive attitudes and pro-environmental behaviours. By understanding how sensory experiences shape connection to the environment, interventions can be designed to enhance these experiences and encourage a deeper appreciation for nature (Cassidy, 2013).

5.2. Ecological Theology

Ecological theology, rooted in the belief that the divine is present in all creation, offers a unique perspective on the environmental crisis. This theological approach emphasizes the interconnectedness of all forms of life and recognizes the intrinsic value of the natural world beyond its usefulness to humans. By integrating ecological principles into religious teachings, ecological theology encourages a shift in consciousness, urging individuals and communities to become stewards rather than exploiters of the Earth. At the core of ecological theology is the concept of 'creation care', which sees the Earth as a sacred gift that requires responsible and ethical stewardship. This perspective challenges the anthropocentric view that places human needs above the well-being of the planet. Instead, creation care emphasizes the moral imperative to protect and preserve the environment, recognizing that its degradation has profound moral implications, affecting both current and future generations (Hrynkow, 2017, pp. 81-87).

Still, ecological theology recognizes the power of communities to bring about positive change. By encouraging a sense of shared responsibility for the environment, religious communities can become powerful advocates for sustainability and ecological justice. This can include initiatives such as community gardens, environmentally friendly practices in religious institutions, and collaborative efforts with environmental organizations. Through collective action guided by the principles of ecological theology, communities can enhance their impact and contribute to the larger movement for environmental healing (Ruiz-Mallén & Corbera, 2013).

6. Conclusions

In conclusion, the integrated exploration of Environmental Psychology, Environmental Psychology of Religion, the causes of the environmental crisis and the role of business ethics and ecological perspectives provide a multifaceted understanding of the complex dynamics between humans and their environment. Environmental Psychology reveals the fundamental principles underlying human-environment interactions, helping to design spaces that support well-being and positive behaviors. The integration of religious beliefs into this framework highlights the important role of spirituality in shaping individuals' attitudes towards nature and promoting environmental stewardship within religious communities.

In addition, ecological psychology emphasizes the dynamic relationship between individuals and their environment, guiding collective efforts within communities to establish norms that prioritize environmental preservation. Rooted in the belief in the divine presence in all creation, ecological theology promotes responsible stewardship and the interconnectedness of life forms by incorporating ecological principles into religious teachings. Still, addressing the environmental crisis requires a holistic understanding of human-environment interactions, integrating insights from environmental psychology, business ethics and religious perspectives. A collective and interdisciplinary approach is needed to promote sustainable practices, mitigate anthropogenic impacts and foster a harmonious relationship between humanity and the environment.

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Session 6
Circular Economy

Circular economy in European Fashion Industry

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Abstract

The interconnectedness of fashion industry and waste generation is pivotal for policymakers in the circular economy sector. Fashion industry creates a great bulk of waste in an era of rapid consumption and production – the waste crisis. Fast fashion is indeed a conundrum for policymakers and ought to be observed in order to be easily coped with. In the present research we employ a hybrid window data envelopment analysis (WDEA) methodology in order to measure panel data eco-efficiency via the application of moving average principle. The examination of 22 European countries, in the period 2000 – 2021 led to the conclusion that a meso-term plan performs better than a short-year plan on the matter of eco-efficiency. Moreover, the lowest mean performance can be spotted on Czech Republic, Estonia, and Latvia, on the other hand, the highest mean performance can be attributed to Norway, France, and Italy. Geographical disparities can be spotted also, as western Europe has greater eco-efficiency than Eastern Europe and Portugal.

Keywords: Fast Fashion, Circular Economy, Waste Management, eco-efficiency, DEA

JEL Codes: Q53; Q56; Q57.

1. Introduction

Nowadays, the fashion industry faced a significant rise in sales, especially at second-hand clothes. Globalization paved the way for fashion industries to easily and rapidly expand their market shares in other countries and continents. However, Fast fashion has detrimental effects on the natural environment due to the excessive negative externalities such as waste generation and greenhouse gas emissions from fashion-related products and by-products (Halkos and Aslanidis, 2024, 2023a, 2023b).

Fernie and Sparks (1998) noted about fashion "Fashion is defined as an expression that is widely accepted by a group of people overtime and has been characterized by several marketing factors such as low predictability, high impulse purchase, shorter life cycle, and high volatility of market demand". Moreover, Fast fashion has been referred to as "McFashion" because of the speed with which gratification is provided (Joy et al., 2020).

Apparently, fast fashion can provide a variety of opportunities and risks towards society, industry, and the environment. Cortez et al. (2014) in a SWOT analysis found that strengths can be linked to brand name, market position, and high inventory turnover, as well as opportunities through e-commerce, and reducing costs due to outsourcing. Nevertheless, there are some weaknesses and threats. The weaknesses are targeting the qualitative aspects of textile industries and product innovation or design, whereas the threats are in line with the high production costs, new market entries, and the social challenge of "sweatshops".

Another issue of fast fashion is its implications on environmental injustice. For instance, the norm for big name fashion brands, increased demand for *large amounts of inexpensive clothing* has resulted in environmental and social degradation along each step of the supply chain as mentioned by Bick et al. (2018).

Fast fashion can be linked to the current waste crisis. In a recent publication by Niinimäki et al. (2020), fast fashion provokes enormous waste generation for several reasons such as: (1) the complexity in the supply chain, (2) environmental impact on water, material, and energy use, (3) waste generation from textiles, and (4) the excessive production patterns in fashion industries.

2. Methodology

In this paper we are examining the eco-efficiency of fashion industries in 22 European countries in the period 2000 – 2021. We make efforts to cover this literature gap in fashion industry regarding eco-efficiency measurement and the impact of fast fashion in climate change due to greenhouse gas emissions.

The studied countries are: .Austria (AUT), Belgium (BEL), Czech Republic (CZE), Spain (ESP), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRE), United Kingdom (GBR), Hungary (HUN), Ireland (IRL), Italy (ITA), Lithuania (LTU), Latvia (LVA), Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), Slovakia (SVK), Slovenia (SVN), Sweden (SWE).

Data envelopment analysis (DEA) enables the measurement of (eco-)efficiency (Charnes et al., 1978). The window data envelopment analysis (WDEA) is an alternative methodology suggested by Charnes et al. (1984) that enables for copying with panel data via the application of moving average principle.The idea of WDEA is simple: each window is treated as a novel DMU, additionally, each DMU is approximated with the other DMUs and at the same time with its own eco-efficiency (Halkos and Polemis, 2018).

What comes to mind when dealing with DEA methodology is what approach is more suitable to follow, or as Tone (2004) stated that efficiency measurement ought to denote which input(s) and output(s) variables are either radial or non-radial. In order to overcome the above dilemma, the hybrid DEA by Tone (2004) has created room of improvement by taking into account both radial and non-radial aspects.

3. Results

The main result is that a 5-year plan (meso term policy) has higher eco-efficiency than a 3-year plan (short-term policy) in the 22 European countries. The studied period is 2000 -2021 and shows fluctuations in the eco-efficiency performance.

Figure 1: Average eco-efficiency in 22 European countries.

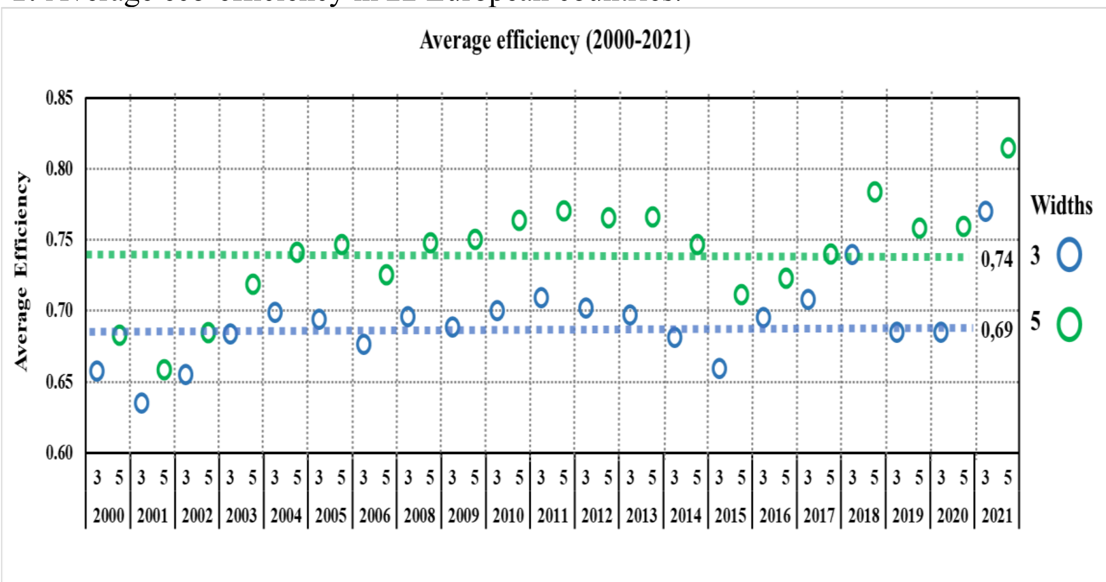

Figure 1 illustrates the average eco-efficiency for the two models. A DMU might achieve higher eco-performance though the adoption of a meso-term policy than a short-term strategy. Additionally the highest eco-efficiency performances are in Norway, France, and Italy, whereas the lowest in Czech Republic, Estonia, and Latvia.

Figure 2: Average eco-efficiency in 22 European countries considering geographical disparities.

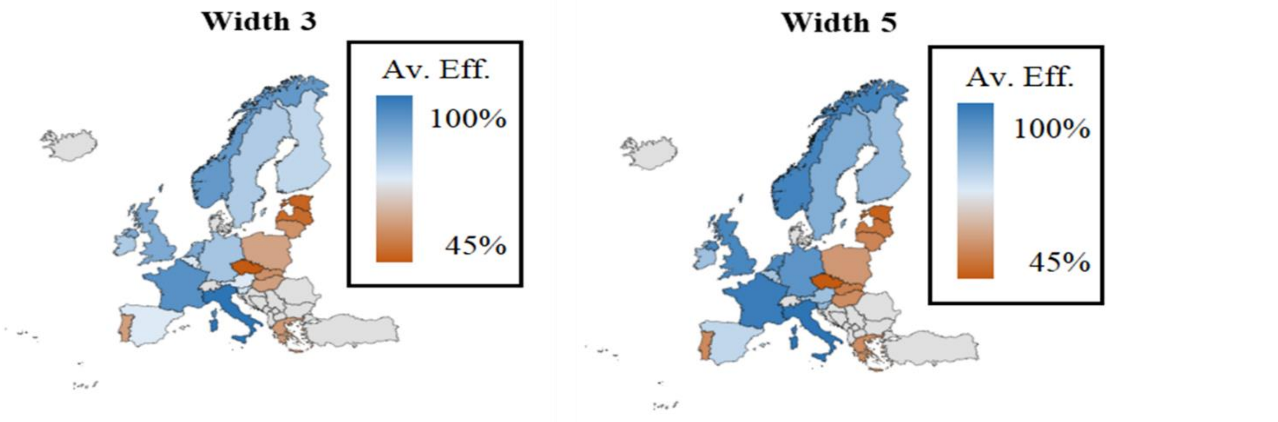

Figure 2 presents the average eco-efficiency of both models. Figure 1 shows that western Europe that is the spearhead of circular economy and the fashion industry. On the other hand Eastern Europe and Portugal have more feeble operations in the fashion industry, leading to lower eco-efficiency performance.

4. Conclusions and Policy implications

To recapitulate, the best time horizon for policymaking is a meso-term policy (5-year plan) instead of a short-term policy (i.e., a 3-year plan). Leading to the conclusion that a meso-term policy might be a better guidance for circular economy in the European fashion industry.

Additionally the highest eco-efficiency performances are in Norway, France, and Italy, whereas the lowest in Czech Republic, Estonia, and Latvia. Furthermore, regarding the geographical disparities, Western Europe which is the spearhead of circular economy and the fashion industry. However, more feeble operations are exhibited on the Eastern European part and at Portugal as well.

Above all, fast fashion negative externalities should be dealt with in order to maintain environmental sustainability. In short, circular economy solutions can be powerful tools to policymakers that aim to cope with waste generation and climate change.

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Fast Fashion and Circular Economy

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Abstract
This discussion explores the potential of the circular economy as a solution to the negative This discussion examines the transformative potential of the circular economy as a panacea for the deleterious impacts wrought by the rapid expansion of the fast fashion industry. Although the democratization of trendy attire has been a boon, the collateral environmental and socio-economic damages are undeniably profound. The circular economy, with its regenerative principles and emphasis on closed-loop systems, emerges as a beacon of hope amid the escalating sustainability crisis. A meticulous case study analysis dissects the multifaceted strategies adopted by key players in the fast fashion sector to integrate circular practices. The empirical insights underscore the undeniable potential of the circular economy to address the negative externalities of fast fashion. However, amidst this optimism, formidable challenges and hurdles loom large on the horizon, demanding urgent attention and collective action. In essence, this study advocates a holistic shift towards a more sustainable and circular fashion paradigm, urging the industry to recalibrate production methods, material sourcing, and consumption patterns. Emphasis is placed on the urgent need for policy reforms and robust regulatory frameworks to incentivize and facilitate the adoption of circular business models. Furthermore, fostering collaboration across the entire value chain, from designers and manufacturers to consumers and waste management stakeholders, is imperative to engender a comprehensive transformation. The study underscores the critical importance of education and awareness campaigns to cultivate a conscious consumer base that actively champions sustainable fashion choices. This research underscores the pressing imperative for continued scholarly investigations and interdisciplinary collaborations to unravel the complexities of implementing circular strategies within the dynamic landscape of the fast fashion industry. While acknowledging the strides made, the study accentuates the enduring nature of the challenges and underscores the dynamic nature of sustainable fashion, necessitating an agile and adaptable approach to address the ever-evolving demands of a more environmentally conscious global community.

Keywords: Fast Fashion, Circular Economy, Reuse, Sustainable Reports, Waste

JEL Codes: A13; J28; J81;Q01; Q52; Q53; Q56; Q57.

Γρήγορη μόδα και κυκλική οικονομία

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Περίληψη
Σε αυτή τη συζήτηση εξετάζεται το μετασχηματιστικό δυναμικό της κυκλικής οικονομίας ως πανάκεια για τις επιβλαβείς επιπτώσεις που προκαλεί η ταχεία επέκταση της βιομηχανίας της γρήγορης μόδας. Αν και ο εκδημοκρατισμός της μοντέρνας ενδυμασίας ήταν όφελος, οι παράπλευρες περιβαλλοντικές και κοινωνικοοικονομικές απώλειες είναι αναμφισβήτητα βαθιές. Η κυκλική οικονομία, με τις αναγεννητικές αρχές της και την έμφαση στα συστήματα κλειστού βρόχου, αναδεικνύεται ως ελπίδα εν μέσω της κλιμακούμενης κρίσης της βιωσιμότητας. Μια σχολαστική ανάλυση αναλύει τις πολύπλευρες στρατηγικές που υιοθετήθηκαν από βασικούς παράγοντες στον τομέα της γρήγορης μόδας για την ενσωμάτωση κυκλικών πρακτικών. Οι εμπειρικές γνώσεις υπογραμμίζουν τις αναμφισβήτητες δυνατότητες της κυκλικής οικονομίας να αντιμετωπίσει τις αρνητικές εξωτερικές επιδράσεις της γρήγορης μόδας. Ωστόσο, μέσα σε αυτή την αισιοδοξία, μεγάλες προκλήσεις και εμπόδια φαίνονται ανυπέρβλητα, απαιτώντας επείγουσα προσοχή και συλλογική δράση.
Ουσιαστικά, αυτή η μελέτη υποστηρίζει μια ολιστική στροφή προς ένα πιο βιώσιμο και κυκλικό πρότυπο μόδας, προτρέποντας τη βιομηχανία να επαναβαθμονομήσει τις μεθόδους παραγωγής, την προμήθεια υλικών και τα πρότυπα κατανάλωσης. Δίνεται έμφαση στην επείγουσα ανάγκη για μεταρρυθμίσεις πολιτικής και ισχυρά ρυθμιστικά πλαίσια για την παροχή κινήτρων και τη διευκόλυνση της υιοθέτησης κυκλικών επιχειρηματικών μοντέλων. Επιπλέον, η προώθηση της συνεργασίας σε ολόκληρη την αλυσίδα αξίας, από τους σχεδιαστές και τους κατασκευαστές έως τους καταναλωτές και τους ενδιαφερόμενους φορείς διαχείρισης απορριμμάτων, είναι επιτακτική για να γίνει ένας ολοκληρωμένος μετασχηματισμός. Η μελέτη υπογραμμίζει την κρίσιμη σημασία των εκστρατειών εκπαίδευσης και ευαισθητοποίησης για την καλλιέργεια μιας συνειδητής καταναλωτικής βάσης που υποστηρίζει ενεργά βιώσιμες επιλογές μόδας.
Συμπερασματικά, υπογραμμίζεται η επιτακτική ανάγκη για συνεχείς επιστημονικές έρευνες και διεπιστημονικές συνεργασίες για την αποκάλυψη της πολυπλοκότητας της εφαρμογής κυκλικών στρατηγικών στο δυναμικό τοπίο της βιομηχανίας της γρήγορης μόδας. Τονίζεται η διαρκής φύση των προκλήσεων και υπογραμμίζεται η δυναμική φύση της βιώσιμης μόδας, απαιτώντας μια ευέλικτη και προσαρμόσιμη προσέγγιση για την αντιμετώπιση των συνεχώς εξελισσόμενων απαιτήσεων μιας περιβαλλοντικά πιο συνειδητοποιημένης παγκόσμιας κοινότητας.

Keywords: Γρήγορη Μόδα, Κυκλική Οικονομία, Επαναχρησιμοποίηση, Αναφορές Βιωσιμότητας, Απορρίμματα

JEL Codes: A13; J28; J81; Q01; Q52; Q53; Q56; Q57.

1. Introduction

In the last few decades, the fashion industry has undergone a significant transformation, giving rise to the phenomenon known as 'fast fashion'—a term that encapsulates the industry's shift towards rapid production and turnover of trendy, affordable clothing. This shift, as Abdulla (2018) describes, has been driven by consumer demands for immediacy and variety in fashion, enabling brands like Zara and H&M to flourish by delivering the latest styles at high speeds and reduced costs.

Fast fashion's ascendancy is marked by its ability to respond swiftly to changing fashion trends, often translating runway designs into high-street collections in mere weeks (Joy et al., 2012). This model thrives on the creation of inexpensive, fashionable garments that encourage frequent consumption, a practice that has fundamentally altered consumer behavior and expectations around fashion (Niinimäki, 2017).

However, this rapid consumption model comes at a high cost. The environmental impact of fast fashion is significant, contributing to a surge in textile waste, increased pollution, and heightened greenhouse gas emissions (Kirchherr, Reike, & Hekkert, 2017; Radcliffe, 2021). Moreover, the social implications, particularly concerning labor practices in developing countries, have raised ethical concerns about the true cost of affordable fashion (Cline, 2019).

In response to these challenges, there is a growing discourse around the need for sustainable practices within the fashion industry. The concept of a circular economy, as outlined by Accenture Strategy (2019), offers a promising alternative to the traditional linear model. This approach emphasizes the importance of designing products for reuse, repair, and recycling, aiming to create a more sustainable, waste-free fashion industry.

This article focuses on the origins, impacts, and potential sustainable transformations within the fast fashion industry, examining how brands are addressing (or failing to address) the urgent need for sustainability in their practices. By exploring the commitments of leading fashion brands to circular economy principles, this analysis sheds light on the path forward for a more sustainable fashion industry.

2. The Origins of Fast Fashion

The beginning of fast fashion can be traced back to the 1990s, marking a pivotal shift in the fashion industry's approach to production and consumption. This era, characterized by a departure from traditional fashion cycles, was defined by an accelerated pace of manufacturing that catered to an ever-growing consumer appetite for trendy, affordable apparel. As Abdulla (2018) notes, brands such as Zara and H&M emerged as frontrunners, epitomizing the fast fashion model with their ability to swiftly translate runway trends into accessible high-street collections.

This new trend was underpinned by a set of business criteria that revolutionized the industry: the acceleration of production processes, the reduction of manufacturing costs through global outsourcing, the democratization of fashion through low pricing, and a model built on high-volume production. These elements together fostered an environment where clothing became not only more accessible but also more disposable (Joy et al., 2012).

The attraction of fast fashion lay in its promise of constant novelty and affordability, driving consumer engagement to unprecedented levels. This model capitalized on the burgeoning trend of 'micro-seasons', encouraging consumers to buy more frequently by offering a continuous influx of new styles (Niinimäki, 2017). The rapid turnover of collections meant that consumers were no longer bound to traditional seasonal fashion cycles, but could instead indulge in the immediacy of fashion trends as they emerged.

However, the fast fashion model has not been without its critics. The prioritization of speed and cost-effectiveness has raised significant concerns about the sustainability of such practices. The environmental footprint of fast fashion, characterized by excessive textile waste and pollution, alongside the ethical implications concerning labor practices in manufacturing countries, has prompted a re-evaluation of this model (Kirchherr, Reike, & Hekkert, 2017; Wicker, 2017).

In light of these challenges, the conversation around fast fashion has increasingly shifted towards the integration of sustainable practices. The circular economy, as proposed by Accenture Strategy (2019), offers a framework for rethinking fashion's environmental and social impact, advocating for a model that emphasizes durability, reuse, and recyclability.

As the fashion industry continues to cope with the repercussions of its rapid growth, the origins of fast fashion serve as a critical reflection point for understanding the complexities of modern consumer culture and the pressing need for sustainable reform.

3. Environmental and Social Implications of Fast Fashion

The rapid ascent of fast fashion has brought with it a slew of environmental and social challenges that significantly undermine the industry's successes in accessibility and affordability. The model's reliance on continuous production and consumption cycles has led to an unsustainable increase in textile waste, as garments are discarded at an alarming rate to make room for the latest trends. This disposability culture has contributed significantly to the burgeoning textile waste crisis, with vast quantities of clothing ending up in landfills where they can remain for centuries (Hoskins, 2019; Smithers, 2019).

The environmental toll of fast fashion extends beyond waste. The production processes integral to fast fashion, particularly the dyeing and finishing of textiles, are major sources of water pollution, releasing harmful chemicals into aquatic ecosystems. Furthermore, the industry's dependence on synthetic fibers, derived from fossil fuels, exacerbates its carbon footprint, contributing to the global greenhouse gas emissions that drive climate change (Radcliffe, 2021; Saluja, 2021).

On the social front, the fast fashion industry has been scrutinized for its labor practices, especially in manufacturing hubs located in developing countries. The drive to minimize production costs often leads to the exploitation of workers through low wages, poor working conditions, and a lack of respect for labor rights. These practices raise profound ethical questions about the human cost of cheap, fast fashion (Cline, 2019).

Despite these challenges, the industry has begun to acknowledge the need for change. The concept of a circular economy presents a viable path forward, offering strategies to reduce waste and pollution through sustainable product design and manufacturing processes (Accenture Strategy, 2019). This approach advocates for a systemic shift in the fashion industry, from a linear "take-make-dispose" model to one that emphasizes longevity, resource efficiency, and the minimization of environmental impact.

The environmental and social implications of fast fashion underscore the urgent need for the industry to adopt more sustainable practices. As consumers become increasingly aware of these issues, there is a growing demand for transparency, accountability, and genuine commitment to sustainability from fashion brands. The transition to a more sustainable and ethical fashion industry is not only a moral imperative but also a business necessity in response to changing consumer expectations and the global environmental crisis.

4. The Need for a Circular Economy in Fashion

The fast fashion industry, with its rapid production cycles and high turnover rates, poses significant sustainability challenges, necessitating a paradigm shift towards a circular economy. This shift is critical not only for mitigating the environmental impact associated with fast fashion but also for addressing the pressing social issues it engenders.

The circular economy represents a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the traditional linear model of "take-make-waste," a circular economy emphasizes the importance of keeping resources in use for as long as possible, extracting the maximum value from them while in use, and then recovering and regenerating products and materials at the end of each service life (Ellen MacArthur Foundation, 2020). This model is particularly relevant to the fashion industry, where the rapid consumption and disposal of clothing have led to substantial waste and environmental degradation.

Environmental concerns such as textile waste, water pollution from dyeing processes, and greenhouse gas emissions from synthetic fiber production are well-documented issues within the fast fashion industry (Radcliffe, 2021; Saluja, 2021). These challenges are compounded by social implications related to labor practices in the global supply chain, where the pursuit of lower production costs often results in compromised worker safety and rights (Cline, 2019). The circular economy offers pathways to address these challenges through principles like designing for longevity, encouraging reuse and recycling, and prioritizing the use of sustainable materials.

Accenture Strategy (2019) underscores the potential of the circular economy to drive a significant transformation in the fashion industry, advocating for a shift in focus from merely minimizing negative impacts to actively creating positive economic, social, and environmental value. This entails rethinking design processes to create durable, repairable, and recyclable garments, as well as reimagining business models to support the reuse and sharing of clothes.

The adoption of circular economy principles in fashion not only holds the promise of reducing environmental harm but also opens up new opportunities for innovation and competitiveness in a rapidly evolving market. Brands like H&M and Zara have begun to explore circular initiatives, albeit with varying degrees of commitment and transparency, indicating a growing industry awareness of the need for sustainable transformation (H&M Group, 2020; Inditex, 2020).

The transition towards a circular economy in fashion is not merely a trend but a necessary evolution to ensure the industry's long-term viability and its alignment with broader sustainability goals. By embracing circular principles, the fashion industry can contribute to a more sustainable and equitable world, setting a precedent for other sectors to follow.

5. Methodology for Assessing Fast Fashion Sustainability

To effectively gauge the sustainability efforts of fast fashion brands, a comprehensive methodology was employed, focusing on the analysis of sustainability reports and the integration of circular economy principles. This methodology aimed to provide a quantitative assessment of each brand's commitment to sustainability, offering insights into the industry's progress and areas in need of improvement.

Context Analysis: The foundation of this methodology was a thorough context analysis of sustainability reports from leading fast fashion brands. This analysis sought to identify and quantify references to circular economy practices, reflecting each brand's engagement with sustainable practices. Brands were selected based on their revenue and market influence, ensuring a representative sample of the fast fashion industry.

Scoring System: A scoring system was developed to quantitatively assess the sustainability commitments of these brands. The system allocated points based on the frequency of circular economy-related terms within the sustainability reports:

Score of 0 for no references, indicating a lack of engagement with circular principles.
Score of 1 for 1 to 5 references, suggesting minimal engagement.
Score of 2 for 6 to 10 references, indicating moderate engagement.
Score of 3 for 11 to 19 references, reflecting a significant commitment.
Score of 4 for 20 or more references, demonstrating a high level of commitment to circular economy practices.

Objectives: The primary objectives of this methodology were to evaluate the depth of circular economy integration within the sustainability strategies of fast fashion brands and to understand the overall commitment level of the industry to sustainable practices. This included an examination of initiatives related to design for longevity, recycling programs, and the use of sustainable materials.

Data Collection and Analysis: Data were collected from publicly available sustainability reports, company websites, and third-party sustainability assessments. This comprehensive approach ensured a holistic view of each brand's sustainability efforts and allowed for an accurate scoring based on the predefined criteria.

Significance: The significance of this methodology lies in its ability to provide a clear, quantifiable measure of fast fashion brands' sustainability efforts. By focusing on circular economy principles, the methodology highlights areas where the industry is making progress, as well as gaps that require further attention and action.

This methodological approach offers a clear and replicable framework for assessing the sustainability of fast fashion brands, contributing to a better understanding of the industry's impact and its efforts to move towards a more sustainable future.

6. Results and Analysis

The application of the defined methodology to assess the sustainability commitments of fast fashion brands has yielded illuminating results, offering a nuanced understanding of the industry's engagement with circular economy practices.

The scoring system revealed a broad spectrum of engagement levels among the fast fashion brands analyzed. Notably, certain brands such as H&M and Mango stood out with scores of 4, indicating a high number of references to circular economy practices within their sustainability reports. This suggests a substantial commitment to integrating sustainability into their business models (H&M Group, 2020; GAP Inc., 2020). Conversely, other brands displayed minimal engagement, with scores as low as 0 or 1, highlighting a significant disparity within the industry.

H&M's high score reflects its publicized commitments to sustainability, particularly in reducing emissions and water usage. However, the analysis revealed a lack of detailed information on the implementation of circular practices such as design for durability and clothing reuse, suggesting a gap between stated commitments and actionable strategies (H&M Group, 2020).

Similar to H&M, Zara demonstrated a commitment to sustainability through efforts to reduce its carbon footprint and utilize sustainable materials. Despite these efforts, Zara's lower score compared to H&M indicates room for improvement, particularly in areas such as clothing reuse and repair (Inditex, 2020).

The analysis highlighted a general trend among fast fashion brands towards acknowledging the importance of sustainability. However, there remains a notable variation in the depth and breadth of these commitments. While some brands have taken significant steps towards integrating circular economy principles, others lag behind, often focusing on recycling initiatives without addressing the broader spectrum of circularity, including product longevity and reduction of resource use.

A key finding from the analysis is the evident disparity in circularity emphasis between fast fashion and more traditional fashion brands. This discrepancy underscores the need for fast fashion brands to adopt a more comprehensive approach to sustainability, moving beyond recycling to embrace the full scope of circular economy principles.

The scrutiny of sustainability reports revealed that while many fast fashion brands are beginning to incorporate sustainable practices, there is often a lack of transparency and specificity in their reporting. The use of vague language and the absence of quantifiable targets and achievements make it challenging to assess the true extent of their commitment to circularity and sustainability.

The results underscore a critical insight: the fast fashion industry's current sustainability efforts, though varied, predominantly fall short of the comprehensive, systemic change needed to mitigate its environmental and social impacts. The focus on recycling and the use of sustainable materials, while important, does not fully address the industry's overproduction and consumption issues.

The findings from this analysis call for a more holistic adoption of circular economy principles by the fast fashion industry. It is imperative for brands to not only articulate their sustainability goals but also to implement tangible, measurable strategies that encompass the entire lifecycle of their products. This includes designing for durability, encouraging reuse and repair, and fostering a culture of sustainability among consumers.

The industry must adopt innovation and transparency, leveraging technology and collaboration to drive real change. Brands should be held accountable for their sustainability commitments, with consumers, regulators, and the broader industry pushing for greater transparency and action.

7. Conclusion and Call to Action

Concluding this analysis of fast fashion sustainability, it is evident that while some brands have made strides towards integrating circular economy principles, there remains a significant gap between current practices and the comprehensive adoption of sustainability measures that the industry urgently requires. The environmental and social repercussions of fast fashion, characterized by excessive waste, pollution, and exploitative labor practices, necessitate a paradigm shift towards more sustainable and ethical practices.

The circular economy presents a viable framework for transforming the fashion industry into a more sustainable and responsible entity. As highlighted by the Ellen MacArthur Foundation (2020), adopting circular economy principles involves rethinking design, production, and consumption practices to minimize waste and make the most of resources. This approach not only addresses environmental concerns but also opens up new avenues for innovation and competitiveness.

The disparity in sustainability efforts among fast fashion brands, as evidenced by the varying scores in our analysis, underscores the need for an industry-wide commitment to change. Brands like

H&M and Mango have shown that it is possible to incorporate circular practices into their business models, yet there is a clear need for more brands to follow suit with tangible, measurable actions (H&M Group, 2020; GAP Inc., 2020).

A critical challenge identified in this analysis is the lack of transparency and specificity in the sustainability reporting of fast fashion brands. As Cline (2019) and Hoskins (2019) have articulated, consumers and stakeholders require clear, detailed information about the sustainability initiatives of brands, including their impacts and outcomes. This transparency is crucial for holding brands accountable and for consumers to make informed choices.

To catalyze the transition to a more sustainable fashion industry, supportive policies and regulations are essential. Governments and regulatory bodies should consider implementing standards and incentives that promote sustainable practices, such as the use of sustainable materials, waste reduction, and the implementation of circular economy models.

Consumers play a pivotal role in driving change within the fashion industry. By making more conscious choices, such as supporting brands that prioritize sustainability and opting for quality over quantity, consumers can exert pressure on brands to improve their practices. Educational initiatives and campaigns can further raise awareness about the impacts of fast fashion and the benefits of sustainable alternatives.

The complexity of the fast fashion supply chain means that no single entity can drive change alone. Collaboration among brands, suppliers, NGOs, governments, and consumers is crucial for achieving systemic change. Industry-wide platforms and alliances can facilitate the sharing of best practices, innovation, and the development of common standards for sustainability.

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Local products entrepreneurship as a tool for sustainable regional development: the case of N. Chalkidiki

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Abstract

The sustainable development of an area depends on many different factors, such as: the composition and structure of the local community, the sectors that make up the economic activity of the area (e.g., agricultural, touristic, commercial), the morphological and climatic characteristics of the area, etc. It is of primary importance to select and promote policies and actions in a way that gives the best economic results without depleting natural resources. The promotion of the nutritional value of local products and their promotion through businesses operating in the food sector, significantly enhance the development of the local economy. In this thesis, research is carried out on local food businesses in North Chalkidiki.

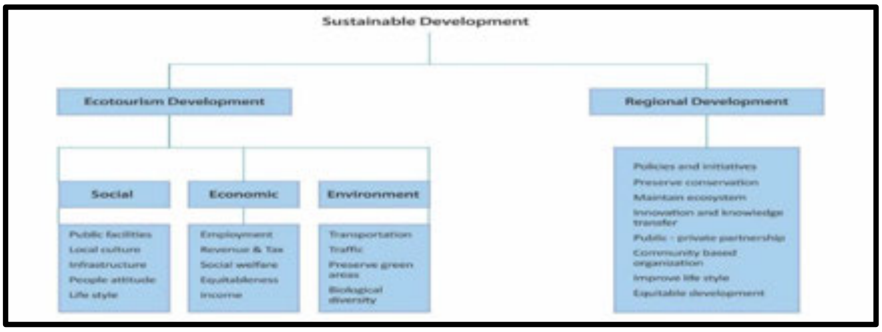
Keywords: Sustainable Regional Development, Local Products, Food Businesses, North Chalkidiki Region.

JEL Codes: O13; Q1; Q22.

1. Introduction

Sustainable regional development involves a specific set of collective and continuously improving processes of analysis, discussion, planning and investment, which integrates the economic, social and environmental objectives of society, seeking alternative solutions in sectors where this is not typically possible (OECD / DAC, 2001). The local development of an area depends on many factors such as: the composition and structure of the local society, the sectors that make up the economic activity of the area (e.g., agricultural, touristic, commercial) and is implemented with the participation of the members of the area, with effective partnerships, transparency and accountability (Figure 1). Local products and the entrepreneurship that develops around them largely determine the economic development of the region.

Figure 1: Sustainable development (Bhuiyan, M., et.al. 2012)



2. Literature Review

2.1 Local products of Chalkidiki

There are many local products produced in Chalkidiki that support local development (Table 1). Following are the most important ones along with some information about each product.

- **Olive oil:** It consists of 99% fatty substances (triglycerides and free fatty acids) and 1% of other components (polyphenols, tocopherols and natural antioxidants) (www.moh.gov.cy). The olive oil is produced relatively early, before the olive fruit ripens and contains a large percentage of two important medicinal substances, oleasin and oleocanthal (www.medlabgr.blogspot.com).
- **Olives:** They are the foundation of the Mediterranean diet. They contain significant amounts of vitamin A, tocopherols, carotenoids and in small amounts vitamins B1, B6 and B12 (www.mednutrition.gr).
- **Honey and Honey products:** It is a natural, healthy food, the sugars of which are immediately absorbed by the body, quickly providing energy. It contains a series of vitamins and antioxidants, trace minerals, amino acids, etc. (www.mednutrition.gr).
- **Wine - Vine Products:** It is the grape, raisin, juice, must, petimezi, retseli, mustard, mustokouloura, mustalevria, mustolampades (sujuk lokum), spoon sweets, jam, composta, grape leaves, grape tops, vinegar, wine (www.wineplus.gr).
- **Fruits:** Fruits contain many vitamins, water, traces of fat and are rich in minerals (minerals and trace elements). In Chalkidiki, apricots, pomegranates, pears and, in smaller quantities, apples, peaches, etc. are produced.

• **Mushrooms:** They are considered an excellent food, as they contain very small amounts of fat and sugars, but significant amounts of fiber. Mushroom proteins, due to the presence of all the necessary amino acids, are of high biological value (www.mednutrition.gr).
• **Kritamo:** Contains many nutrients, such as iodine, vitamins E and C, K, mineral salts, antioxidants and omega-3 fats (www.rodosreport.gr).
• **Nuts:** Almonds, Pistachios, Walnuts, Chestnuts.
• **Organic products:** Agricultural products based on natural processes, not using chemical synthetic fertilizers, plant protection products or genetic modifications and using non-chemical methods to deal with enemies, diseases and weeds (www. mednutrition. gr).
• **Cheese:** Milk and yogurt are whole foods because they provide all three macronutrients: proteins, carbohydrates and fats, while cheese provides proteins and fats (www.mednutrition.gr).
• **Seafood:** First of all, fish contain protein of high biological value and omega-3 fatty acids. Seafood such as shrimp, crab and clams are low in fat, while others such as squid, crab, oysters and clams are low in omega-3 fatty acids. They are a very good source of trace elements, such as selenium, zinc, iodine and copper (www.logodiatrofis.gr).
• **Eggs:** Food with high biological value protein and choline. Eggs together with milk are the only whole natural foods, i.e. they contain all the necessary ingredients for a complete and balanced diet.
• **Herbs:** They are used in the preparation of medicine and are rich in antioxidants.

Table 1: Local Products of Chalkidiki

Προϊόντα
Λάδι
Ελιές
Μέλι και προϊόντα μελιού
Προϊόντα Οίνου - Αμπέλου
Γλυκά κουταλιού, Μαρμελάδες, Λικέρ
Ζυμαρικά, Τραχανάδες, Χυλοπίτες,
Φρούτα, Κηπευτικά, Μανιτάρια, Κρίταμο, Ξηροί καρποί
Σαπούνια, Καλλυντικά, Κεριά
Βιολογικά προιόντα
Υφαντά, φορεσιές & άλλα χειροτεχνήματα
Τυροκομικά προϊόντα
Ψάρια, Μαλάκια, Οστρακόδερμα
Κοτόπουλα, Αυγά, Πτηνά
Βότανα, Αρωματικά φυτά
Προϊόντα εκτροφής (Σαλιγκάρια, Χοιρινά κλπ.)
Έλατα

Several local products of Chalkidiki are Products of Designation of Origin (PDO) such as Cheese: Feta, Kaseri, Manouri, Batzos, Anthotyros, Kefalotyri, Myzithra and Telemes, Halkidiki Agoureoli, Galano Metaggitsiou Olive Oil and Plagies Melitona Wine. There are also Geographical Indication Products (PGI) such as: Chalkidiki Olive Oil and Wines: Chalkidiki, Sithonia and Mount Athos.

2.2. Alternative tourism / Agrotourism

Alternative tourism is a form of entrepreneurship that highlights and promotes local products. Alternative tourism is environmentally friendly, pays respect to local culture and religious tradition, is approached and measured in aesthetic and ecological terms. It includes rural/agrotourism, cultural tourism, nature tourism, adventure and eco-tourism. It is an alternative source of livelihood for the local community and helps in its sustainable development. However, although it is recognized as one of the best ways to link economic development with environmental sustainability, the pace and scope of its development must be adapted to the carrying capacity of the local area.

"Agrotourism" is a special form of rural tourism which concerns the provision of reception and hospitality services or catering in areas functionally integrated with agricultural facilities, which are offered in combination with activities related to agricultural production, with the protection and promotion of the natural and man-made rural landscape, while its activity is required to be combined with the production of agricultural products (Law, 4276. 2014). In our country, a specialized agrotourism model could be created for each region as it has a significant diversity with beautiful and special landscapes, history, tradition and a rich morphological environment. Initially it was a smart alternative to support the economy of the region combined with a number of tourists attracted by coastal and mountain landscapes that preserve an older way of life and architectural interest that are not exploited for agriculture. It presents an alternative use of agricultural resources that can bring economic benefits to farmers and ranchers. It connects agriculture with tourism and covers a wide range of activities and products. Agrotourism in our country was associated with staying in some type of accommodation and was not developed according to the European standard. Staying at the guest house is not so much combined with the visitor's participation in the agricultural productive activity, but with the participation in the social activities of the rural settlement.

In many rural areas, small and isolated agricultural enterprises have been created that offer the visitor (through tourism activities) a quality experience with the natural environment or traditional agricultural activities, such as participation in various agricultural harvesting operations (herbs, fruits, olives, grapes), visiting nearby forests, lakes, springs, waterfalls, canyons, visiting local architectural monuments, churches, monasteries, bridges, etc., traditional cooking, local flavors, and wine tasting, etc. Visitors can participate in sports and nature activities such as horseback riding, archery, mountain biking, hiking, off-road driving, visit the local museums of folklore, natural history, attend cultural events, festivals, and local celebrations and other activities always from the perspective of protecting the natural environment and providing quality hospitality (Andreopoulou, Z. 2020).

In the effort to search for factors of sustainable regional development and to promote policies and actions in a way that gives the best economic results in North Halkidiki, agrotourism is an important tool in the development process of the region and the protection of the environment. The entrepreneurship that develops through agrotourism significantly strengthens the local economy, as it is directly linked to the use and promotion of local products and the businesses around them.

3. Materials and Methods

3.1 Introduction

The internet with the help of the current digital innovations has become a sustainable alternative business channel, while simultaneously business information systems are very widespread in all of the business sectors and are important tools in business sales promotion (Andreopoulou, Z., et.al. 2014, 2015, Zopounidis, C., et.al. 2014). The internet is adopted for the sustainability of local product and tourism businesses. In sustainable development there is a special relationship between the concept of sustainable tourism and rural tourism. In a path towards the sustainable development of Northern Chalkidiki, its local product businesses linked to ecotourism - agrotourism, are analyzed and ranked according to the type of product they trade and the results of the research are discussed.

3.2. Case Study: North Chalkidiki

Chalkidiki is a large peninsula surrounded by the Aegean Sea and is connected to the main part of Macedonia through Thessaloniki. In the southern part of Chalkidiki, three characteristic elongated peninsulas are formed which give the area its characteristic shape ("foot of Chalkidiki"). From west to east are the Kassandra peninsula, the Sithonia peninsula and the Athos peninsula. It is administratively divided into the prefecture of Chalkidiki and the autonomous monastic state of Mount Athos. It covers an area of 2,918 square km, a coastline of 558 km and a population of 105,908 according to the 2011 census (Table 2). Its capital is Polygyros. Administratively, it belongs to the Region of Central Macedonia and is divided into 5 Municipalities: Aristoteli, Kassandra, Nea Propontida, Polygyro, Sithonia (Figure 2).

Table 2: Municipalities of Chalkidiki Prefecture - Population

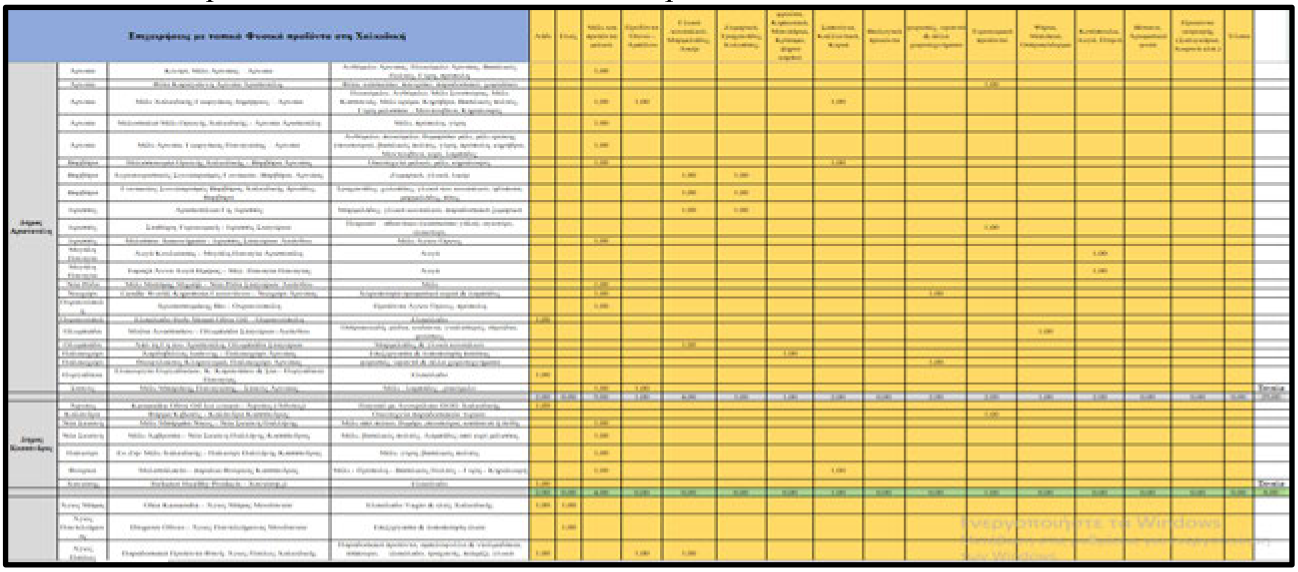
Δήμος	Έδρα	Πληθυσμός
Αριστοτέλη	Ιερισσός	18.294
Κασσάνδρας	Κασσανδρεία	16.672
Νέας Προποντίδας	Νέα Μουδανιά	36.500
Πολυγύρου	Πολύγυρος	22.048
Σιθωνίας	Νικήτη	12.394

Figure 2: Municipalities of Chalkidiki Prefecture (www.2.bp.blogspot.com)

The climate shows a transition from coastal mediterranean in the low areas, to terrestrial mediterranean in the higher areas and to humid continental in the high areas. The topography is formed by a mountainous or semi-mountainous zone that includes part of the northern and central parts. In the northern part of the prefecture there is the edge of Hortiatis (1,009m), while in the center of the peninsula rises the rich with vegetation Holomontas (1,165m). Characteristic of the mountains of Chalkidiki are the many forests: almost half of the area of land of the prefecture is covered by forests (www.gohalkidiki.com).

In Chalkidiki we find Special Conservation Zones (ZZD), Special Protection Zones (ZEP), Wildlife Refuges, Sites of Community Importance (SCI), Protected Natural Monuments, such as: the pine tree of Nikiti, the sycamore tree in Hieroplatanos, the natural reservoir "Mavrobara" Polychronou etc. Also, there are 40 species of mammals and 160 species of birds, 12 of the 22 species of amphibians, 28 species of reptiles and terrestrial invertebrates (www.travelguide.Halkidiki booking.gr), forests of beech, oak, sycamore, conifers (Black and Forest Pines), etc.) and a wide variety of mixed forests, aromatic flora rich in species and especially of beekeeping (thyme, thrumbi, oregano, mint, willow, myrtle and many other annuals and perennials).

Table 3: Correspondence of businesses and natural products of Chalkidiki



The need to approach sustainable development, alternative tourism and sustainable tourism that serve the objectives of the study, led to a search for sources from books, scientific writings, magazines, publications in tourist guides, conference presentations such as: Writings by Weaver, D. (1998), Hunter, C., & Green, H. (1995), Butler, R. (1992), W.T.O. (2001). The research on the local products of Chalkidiki and the discovery of the businesses related to them was carried out using the internet, Google and Google scholar search engines, thematic portals, the Mendeley application, etc. The search was done on websites with tourist guides, agricultural cooperatives, local businesses, producer groups, restaurants, environmental and hiking clubs, as well as public organizations such as: O.PE.KE.PE., National Nutrition Guide, Union of Agricultural Cooperatives of Chalkidiki, Chamber of Chalkidiki, EL.G.O DIMITRA, National Interprofessional Vine and Wine Organization (EDOAO), Region of Central Macedonia, Ministry of AAT, www.ypaithros.gr, etc.

The products produced, standardized and processed in the prefecture of Chalkidiki were recorded and clustered into groups (Table 1).

With the use of IT tools, a database was created with the details of local product businesses (Table 3) such as: the municipality they belong to (1st column), their headquarters (within the municipality) (2nd column), the name of the business/cooperative (3rd column), the total types of products produced by each company (4th column) and for each type of product (e.g. olive oil, olives, honey and honey products, wine-vine products, etc.) which company it corresponds with (5th-20th column).

Then the total number of businesses in the prefecture was summarized, per municipality they belong to and per type of product they have. After the classification - processing of the material, tables were created (for the municipalities of Aristoteli and Polygyros) with the registered office, brand name and products of each company. Then the tables are displayed in graphs for the prefecture and for each municipality separately.

4. Results

Analysis - Data Correlation

The initial data of the enterprises were organized in tables for each municipality of the prefecture of Chalkidiki (Tables 4, 5)

Table 4: Businesses with natural products of the Municipality of Aristotle

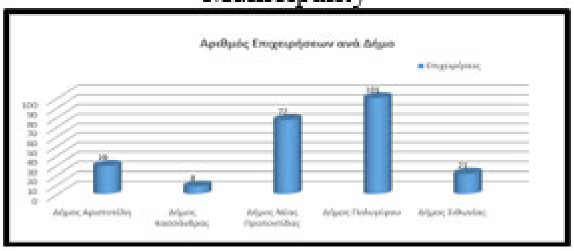
Table 5: Businesses with natural products of the Municipality of Polygyros

From the correlation of the tables that were organized and the data, there were results extracted, which are presented in the tables and shown in the graphs that follow: a) In table 6 the number of businesses per municipality (based on their headquarters) has been calculated, as well as the total number of businesses with local products in the Prefecture of Chalkidiki.

Table 6: Number of Businesses per Municipality

Αριθμός Επιχειρήσεων ανά Δήμο	
Περιοχή	Επιχειρήσεις
Δήμος Αριστοτέλη	29
Δήμος Κασσάνδρας	8
Δήμος Νέας Προποντίδας	77
Δήμος Πολυγύρου	101
Δήμος Σιθωνίας	21
Σύνολο Επ/σεων στο Νομό	236

Figure 3: Number of Businesses per Municipality



The values of table 6 are shown in figure 3. From the analysis of the results, we see that the number of businesses found in the municipalities of Polygyros and Nea Propontida is greater than in the rest of the municipalities. 101 businesses are located in the municipality of Polygyros, while 77 are located in the municipality of Nea Propontida. These two are the most populated municipalities in the prefecture of Chalkidiki with 22,048 people in the municipality of Polygyros and 36,500 in the municipality of Nea Propontida. Therefore, as it can be expected in larger populations we also have greater professional activity as the headquarters of the business are closer to the main residence. It also appears that even though the municipality of Nea Propontida has a much larger population than the municipality of Polygyros, the number of businesses is significantly smaller when we would expect more businesses based on the population. This may be due to the different morphology of the municipality. A large part of the municipality of Nea Propontida is located by the coastline, with the result that the population is active in other sectors, such as tourism. For the same reason, the municipalities of Kassandra and Sithonia (which cover the elongated peninsulas) have a very small number of businesses in the field of local products, because they have many famous beaches that focus the residents’ professional interest in other areas.

In table 7, the number of businesses in the Prefecture of Chalkidiki has been calculated based on the type of product they have. The prices of the table are shown in figure 4. We notice that there is a fairly large variety in the production of products in the prefecture, which is possibly due to the diversity of its morphology. Olive oil, olive and honey products are the most abundant. The cultivation of the olive can be done in all types of soil, in saline, barren and coastal areas and the low altitude of the prefecture favors its cultivation

Table 7: Number of Businesses per type of product in the Prefecture of Chalkidiki

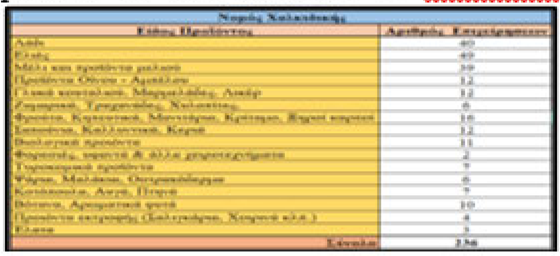
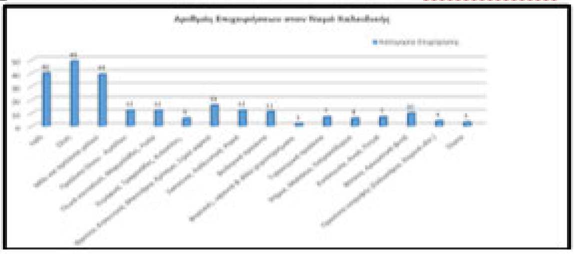


Figure 4: Number of Businesses per type of product in the Prefecture of Chalkidiki

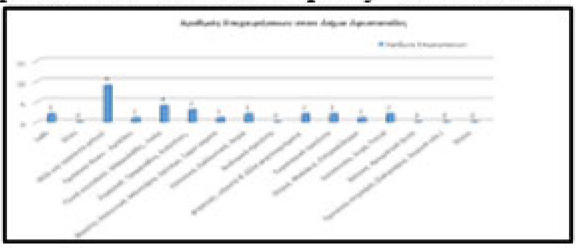


Also, another factor that promotes olive cultivation is that the main agricultural work is done in the winter, so it can be combined by the farmers with other types of work, such as tourism, that flourishes in the prefecture in the summer. On the other hand, we have honey. The climatic conditions of Chalkidiki and the variety of flora encountered are particularly favorable for the development of beekeeping and create the right conditions for the production of quality honey.

b) In table 8, the number of businesses operating in the municipality of Aristoteli has been calculated based on the type of product they have and is shown in figure 5.

Table 8: Number of Businesses per type of product in the municipality of Aristotle

Figure 5: Number of Businesses per type of product in the municipality of Aristotle



It seems that we have a significantly larger production of honey and its products, compared to the rest. The increased production is directly related to the environment, as within the municipality are the NATURA 2000 areas, the E.Z.D. (GR1270005) on Mount Stratoniko-Koryphi Skamni, the Z.E.P. (GR1270012) and the E. Z.D. (GR1270001) on Mount Holomonta. A wide variety of types of honey are produced: pine honey, flower honey, susoura honey, chestnut honey, cream honey, honeysuckle, royal jelly, bee pollen, "Mundovina" (an alcoholic drink made from "honey distillate" which was recognized as a local Product of Geographical Indication-P.G.I.. of mountainous

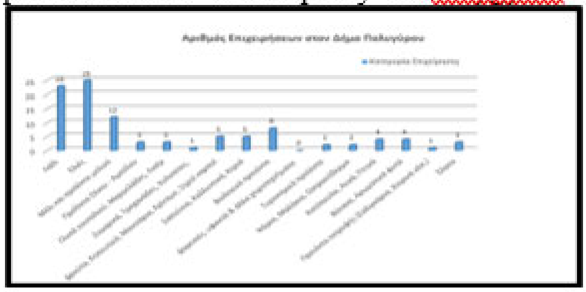
Chalkidiki and is considered very promising as an export product) (www.business-travelblog.com), wax ointments, propolis, thyme honey, candles, rakomelo. Also, groups of agricultural and women's cooperatives are active in the processing of primary products, such as fruits in jams and sweets (www.womenassociations.gr), grains in noodles, pasta and trachanades, greens they collect from their region in pies, making soaps, candles, natural cosmetics and other handicrafts based on local items. Another category is cheese products (P.O.P). such as: feta, goat's cheese, paneraki, traditional, village, agiotiri, elaiotiri, stone, athonite. Smaller productions are olive oil, eggs, seafood, mussels, shellfish, oysters and quinces.

c) Below is table 9 and figure 6 where the number of businesses active in the municipality of Polygyros has been calculated based on the type of product they have. As it can be seen, there is a great variety in the types of foods that are leading businesses with the greatest interest being concentrated in olive oil, organic olive oil and grapeseed oil (P.O.P.). and in the olives available: in green or black Chalkidiki (P.O.P.), organic, crushed or paste, stuffed or raisined. Also, a significant number of businesses are active in honey and honey products, such as: pollen, royal jelly, propolis, beeswax, honeydew, propolis tincture.

Table 9: Number of Businesses per type of product in the municipality of Polygyros

Δήμος Πολυγύρου	
Είδος Προϊόντος	Αριθμός Επιχειρήσεων
Λάδι	23
Ελιές	25
Μέλι και προϊόντα μελιού	12
Προϊόντα Οίνου - Αμπελιού	3
Γλυκά κουταλιού, Μαρμελάδες, Λικέρ	3
Ζυμαρικά, Τραχανάδες, Χυλοπίτες	1
Φρούτα, Κηπευτικά, Μανιτάρια, Κάστανα, Ξηροί καρποί	5
Σαπούνια, Καλλυντικά, Κεριά	5
Βιολογικά προϊόντα	8
[illegible]	0
Τυροκομικά προϊόντα	2
Ψάρια, Μύδια, Οστρακοειδή	2
Κοτόπουλα, Αυγά, Πτηνά	4
Βότανα, Αρωματικά φυτά	4
Προϊόντα εκτροφής (Σαλιγκάρια, Χοιρινά κλπ.)	1
Ελαια	3
Σύνολο	101

Figure 6: Number of Businesses per type of product in the municipality of Polygyros



Last, but not least we have businesses a) with organic products such as almonds, wines, herbs and aromatic plants (sage, rosemary, oregano, lavender, thyme, mountain tea), eggs, olive paste, etc. b) with local products such as chestnuts, pomegranates, wild mushrooms, mushroom truffles, truffle oil, salt and truffle sauces. c) with farmed processing products such as eels, chickens and rabbits. d) with growing fir trees for sale (these are rooted fir trees in a pot or in a ball) e) with vine products, wine, tsipouro, vinegar, petimezi, cheese, feta cheese (P.O.P.).

12 Conclusions

At a time when Europe is trying to transform into a green continent with sustainable regional development that is climate-friendly and with lower energy consumption, promoting entrepreneurship in alternative tourism is important in building a sustainable and competitive local economy, in which resources are used efficiently (Bhuiyan, M., et.al. 2012).

The importance of the work lies in the fact that it captures an image of the situation regarding local products and the corresponding businesses operating in the region of Northern Chalkidiki. It provides information on local products and businesses that can be used by agencies and professionals to identify potential weaknesses and search for best practices that promote local products through an alternative tourism model and that lead to the sustainable economic development of Northern Chalkidiki.

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Study of the impact of using SRF/RDF alternative solid fuels on the cement industry environmental footprint

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Abstract
Environmental footprint is an appropriate indicator to monitor the impact on climate change of various industrial processes via measuring the effective replacement of valuable non-renewable energy sources. A solution to decreasing CO_2 emissions is to replace conventional fossil fuels with solid secondary fuels, such as RDF/SRF, derived from the effective valorization of the residues of the municipal solid wastes management processes. In an eco-friendly and sustainable development context, the cement industry can contribute to environmental protection by lowering its footprint via the effective use of alternative fuels. In this paper, the use of RDF/SRF as an alternative fuel in cement kilns co-processed with conventional fuels is discussed. These alternative fuels following appropriate specifications could be effectively incorporated in cement production, thus covering both the high-energy requirements of the process and contribute to reducing the environmental impact. Following this approach, the goal for the drastic reduction of the landfilled wastes can be finally realized.

Keywords: CO_2 emissions, alternative fuels, SRF, RDF, co-processing, environmental impact

JEL Codes: O3, Q42

1. Introduction

Environmental protection has always been an important issue. Especially in recent years, the need to protect the environment is stronger, as pollution is one of the most important problems on the planet. At the same time, with the improvement of living standards and the increase in energy requirements, it becomes necessary to find environmentally friendly energy sources, which will simultaneously ensure the necessary coverage of energy requirements.

The global climate crisis is a consequence of the reckless use of fossil fuels, which contribute to global warming, one of the most critical environmental problems that humanity is facing. One of the most important greenhouse gases from human activities is carbon dioxide (CO_2). Its concentration in the atmosphere increases rapidly with the burning of fossil fuels-oil, coal and gas (Nithikul, 2007). Global warming will have serious negative effects over generations, so it is important to reduce greenhouse gas (GHG) emissions to achieve sustainable development (Iwata and Okada, 2014).

Thus, the global scientific community is constantly looking for alternative energy sources to address this issue and achieve energy independence from fossil fuels. A proposed solution to limit carbon dioxide emissions is to replace conventional fossil fuels with solid secondary fuels derived from discarded materials. Any materials or substances that can be used as fuel, apart from conventional fossil fuels (oil, coal and natural gas), are alternative fuels, also known as unconventional or advanced fuels. Refuse-derived Fuel (RDF) and Solid Recovered Fuel (SRF) are of interest for use as an energy source as alternative fuels in cement kilns. In the present work, the co-firing of RDF/SRF with conventional fuels in cement industries is considered, substituting part of pet coke, the conventional fossil fuel used. Pet coke is a solid by-product of petroleum refining and is classified in the European Waste Inventory as an inert sulfur-containing petroleum waste (Olmeda et al., 2013).

2. Literature Review

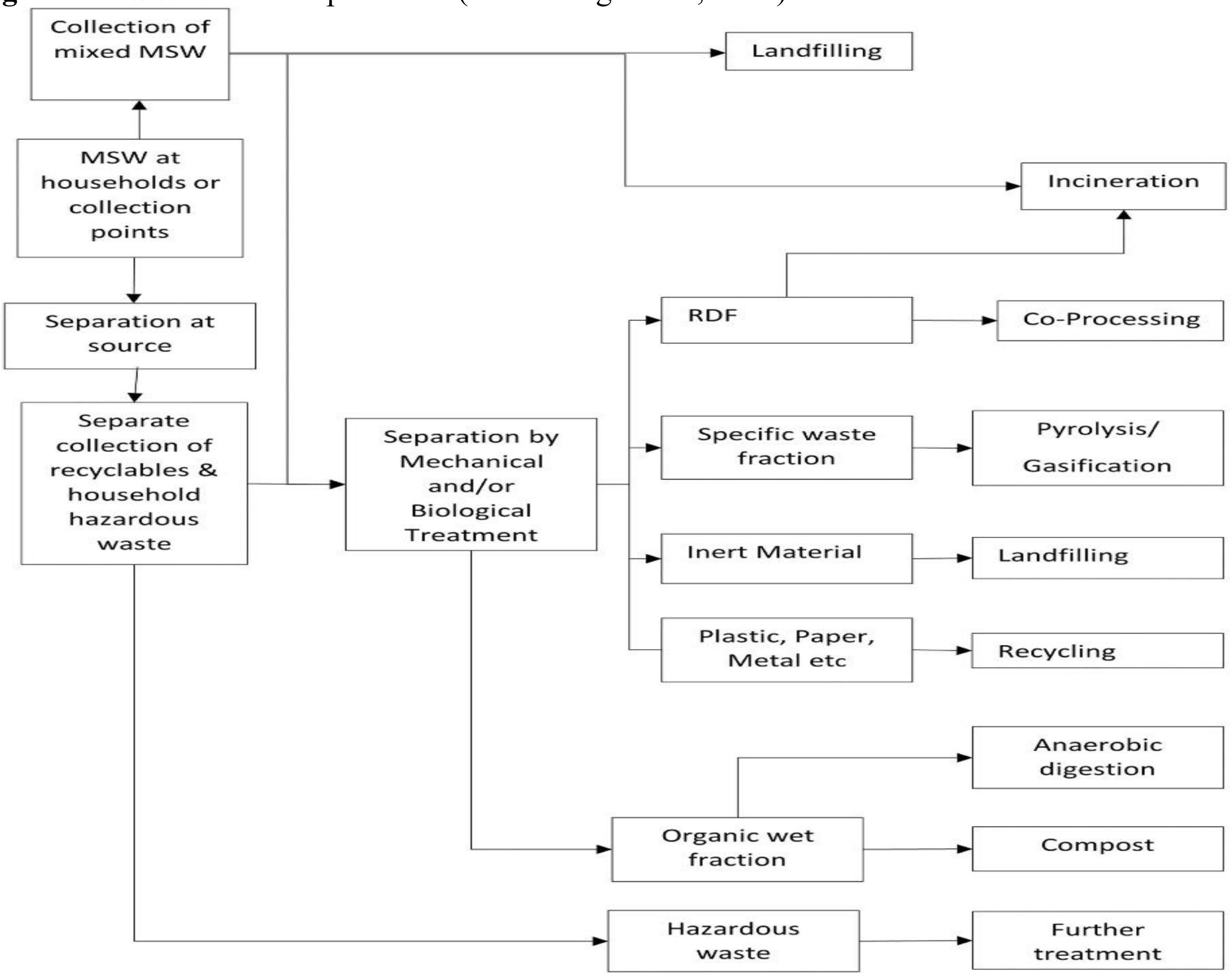
Sustainable development can be defined as a form of development that meets the needs of people living today without compromising the ability of future generations to meet their own (CSI, 2005). In recent decades, there has been a huge increase in solid waste generation around the world and there is no sign of it slowing down. This is due to various factors such as population growth, urbanization and economic development, as well as consumer purchasing habits. The rate of urbanization throughout the world, especially in the world of developing countries, has been increasing greatly in recent years (Balwan et al., 2022).

The 17 Sustainable Development Goals (SDGs), introduced by the United Nations in 2015, aim to address economic, social and environmental issues that have emerged strongly in recent years around the world, as well as to promote the concept of sustainability (Halkos and Gkampoura, 2021). This thesis refers to technologies that serve the goals of sustainable development, emphasizing the following goals: 7) Affordable and clean energy, as it refers to the reduction of the use of pet coke by the cement industry, and 13) Climate action, as it refers to the reduction of the environmental impacts resulting from the energy utilization of waste.

Figure 1: The 17 Sustainable Development Goals as defined by the United Nations in 2015 (European Commission, 2023)

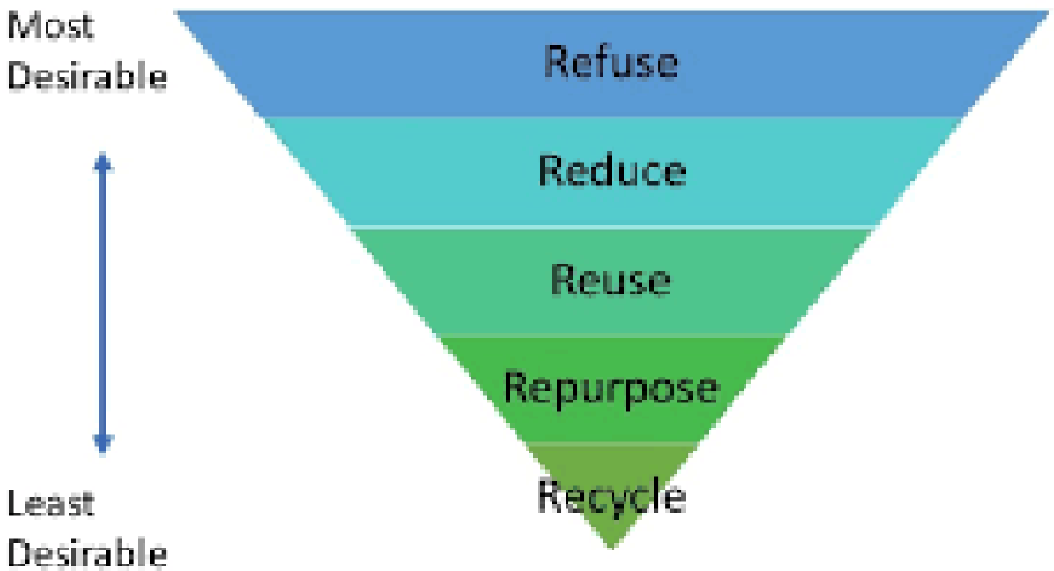
In the following figure, a schematic representation of the process followed during the management of MSW is presented, where the route of the waste for its recovery is presented (Mutz et al., 2017, Kahawalage et al., 2022). According to this, mixed municipal waste has multiple possible pathways. In addition to their disposal in landfills, it is possible to use them for energy in a variety of ways, such as for example in the production of alternative fuels. MSW collected as "mixed waste" or "source separated waste" is treated either mechanically, biologically or chemically to recover valuable materials.

Figure 2: MSW utilization processes (Kahawalage et al., 2022)



For the recycling hierarchy, the 5 R's act as guidelines for achieving sustainability. According to the 5 R's, four actions should be taken, if possible, before "recycling", which are: "refuse to use materials", "reduce" them, "reuse" them, "use with another purpose" and finally "recycling". Incorporating this methodology into household and business waste reduction and recycling efforts helps minimize waste going to landfill (Balwan et al., 2022).

Figure 3: The 5 R's of waste management (Balwan et al., 2022)



RDF and SRF are two main ways to recover energy resources from non-recyclable fractions of municipal solid waste (MSW) (Gerassimidou et al., 2020). The terms describe alternative fuels derived from waste and used as secondary fuels (Kara, 2012). Refuse Derived Fuel (RDF) is derived from municipal solid waste through Mechanical - Biological treatment processes, which aim to remove substances hazardous to combustion, to ensure a minimum lower calorific value (LHV) and to comply with technical specifications for its characterization (Rada and Andreottola, 2012).

Solid Recovered Fuel (SRF) is the final alternative fuel produced, like RDF, from non-hazardous waste, in a joint Mechanical-Biological Treatment unit (Samolada and Zabaniotou, 2014). It is prepared after processing, homogenization and upgrading to marketable quality between producers and users in order to meet appropriate classification and specification requirements (Rada and Andreottola, 2012).

Unlike RDF, SRF has a standard production process. The main requirement is that the SRF is specified and classified by a specified international or local standard and may also require external certification depending on the customer. Thus, SRF is, compared to RDF, a better refined fuel used for energy recovery in incineration or co-processing plants (Rada and Andreottola, 2012).

The characterization of SRF plays an essential role because it determines its correct classification, production and application methods. The specific criteria that a material must meet to be considered a fuel are usually determined by cement producers according to their own standards (Rahman et al., 2015). The parameters under study are the physical, chemical and biological characteristics of SRF that are useful in deciding on end-user applications (CSI, 2005; Rahman et al., 2015; Garcés et al., 2016; Kahawalage et al., 2022; De la Torre-Bayo et al., 2023):

- **grain or particle size**: Alternative fuel injection into the main burner of a cement kiln requires the particle size to be less than 10 mm. For use as an injection fuel in a prelimer, the particle size must be less than 100 mm
- **net calorific value (NCV)**: The value determines how much heat is released (at standard temperature and pressure) when the fuel is completely burned. In order to make an SRF sample suitable for co-processing in the cement industry, its calorific value must be above 14.0 MJMJ/kg
- **chlorine and sulfur content**: These can build up in the furnace system, leading to build-up, clogging and erratic operation. The chlorine content must be less than 0.2% by weight, while the sulfur content by less than 2.5% by weight.
- **ash content**: The ash content affects the calorific value and the chemical composition of the cement, while at the same time it may require an adjustment of the composition of the mixture of raw materials, so its percentage is sought to be less than 30% by weight.
- **moisture content**: High water content can reduce the productivity and efficiency of the furnace system. The moisture content is sought to be less than 35% by weight.
- **content of heavy metals** (such as AsAs, SbSb, PbPb, CdCd, CrCr, CoCo, CuCu, ZnZn, NiNi, HgHg, TlTl, VV, Sn and MnMn.): less than 2500 ppm [of which: mercury (Hg) less than 10 ppm, and total cadmium (Cd), thallium (Tl) and mercury (Hg) less than 100 ppm]

In a study by Krawczyk et al. (2018), compared the environmental footprints of the combustion process for two types of fuels: refuse-based fuel (RDF) and lignite. The analysis was performed for a typical pulverized coal boiler. A comparative assessment was carried out by analyzing the total environmental impact of all combustion products of the two fuels.

The use of solid waste has been studied as a supplementary fuel or as a substitute for raw material in cement kilns and is one of the best technologies for the complete and safe destruction of waste, due to the simultaneous benefit of waste destruction and energy production (Conesa et al., 2011).

The cement industry produces, through the combustion process it uses, a variety of pollutants, both toxic and non-toxic to the environment. These pollutants are classified into toxic and non-toxic. The cement industry is considered one of the highest carbon-emitting industries in the world, accounting for approximately 5 - 7% of global anthropogenic carbon dioxide emissions (Chen et al., 2010). The process emits around 900 kg of CO_2 for every tonne of cement produced. This emission comes from both energy use and the firing process, which is a chemical reaction in the furnace. The CO_2 emissions of cement production depend on the fuel mix and the clinker to cement ratio ranging from 0.5 to 0.95 (Hasanbeigi et al., 2010).

Chlorine (Cl) in municipal solid waste (MSW) is an important reactive element during combustion. It produces the acid pollutant HCl and, in addition, is associated with the formation of stable organic chlorinated compounds. Sulfur (S) produces the acid pollutants SO_x (especially SO_2). The following pollutants are also produced: NOx, CO, HF, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins and furans (PCDD/Fs) and heavy metals such as cadmium (Cd), thallium (Tl), Mercury (Hg), zinc (Zn), lead (Pb) etc. (Genon and Brizio, 2008; Conesa et al., 2011; Pembina Institute, 2014).

The production of fuels derived from waste is associated with various environmental impacts. The most important advantages of substituting alternative fuels are: the utilization and preservation of non-renewable energy sources, the protection of the environment and the reduction of waste disposal sites. In a general view, resource conservation is one of the most important motivations for the production and use of waste-derived fuels. RDF/SRF production is an innovative solution, both for waste and energy, as it helps to solve the problems caused by the consumption of energy resources.

In addition, alternative fuels are cheaper than fossil fuels, which leads cement industries to use them in the optimal ratio. However, before RDF/SRF is used in industry, there are a variety of factors that must be considered to ensure the smooth operation of the process. Ensuring adequate calorific value, presence of heavy metals, need to regulate moisture and ash content, higher chlorine content and differences in quality and composition are the main variables associated with the use of SRF in cement kilns (Kara, 2012, Rahman et al., 2015).

3. Conclusions

As the technology of utilizing alternative fuels requires continuous further research, it is important that the necessary limitations of the use of alternative fuels have been determined, so that an effort can be made to address them. Combustion in the cement industry utilizes raw materials at very high temperatures. Because the high-temperature processes occurring in cement plants require large amounts of energy, they are an ideal site for RDF/SRF alternative fuels. These alternative fuels, following appropriate specifications, could be effectively integrated into cement production, thus meeting both the high energy requirements of the process and contributing to the reduction of environmental impacts. By following this approach, the goal of drastically reducing landfill waste can finally be realized.

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Forest road pavement construction based on recycled materials is an economic and environmental neutral footprint implementation?

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Abstract
The present research addresses the challenge faced by the European Union (EU) to achieve a sustainable low-carbon economy and in particular, to reduce carbon emissions up to 2030, according to the targets set in its "energy and climate package". Forest road pavements are an expensive part of construction or maintenance that require large amounts of resources and materials as a part of transportation infrastructures. The use of recycled materials or aside waste of industry has been shown to lower the carbon footprint of the construction sector. The use of recycled materials can be the solution to natural resource conservation or the reduction of harmful emissions and the minimization of overall costs for pavement construction and maintenance. Is the use of recycled materials economical and environmentally neutral? Life cycle assessment and life cycle cost analysis are two approaches to quantify and assess the environmental performance and the costs based on the selection of materials used to forest road-pavement construction. This research is going to present how different types of recycled material in different quantities can show limitations based on environmental or economic analysis. Tests and evaluations gave the required quality and durability of the pavements under several traffic volumes and loads even in severe climate actions. Based on the trends it is possible for the use of recycled materials to be a part of pavement technology that uses recycled materials for constructing road pavement.

Keywords: recycled waste materials; low carbon forest road pavement; CO_2 emission; economic pavement; environmental neutral footprint

JEL Codes: Q23; Q5

Session 7
Sustainable Transport

Forecasting Greenhouse Gas Emissions of Passenger Traffic to the Aegean Islands with the Use of Machine Learning

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Abstract

Greenhouse Gas Emissions are a major driver of Climate Change, the effects of which can already be seen around the world. Transport is a major source of GHG emissions, accounting for 15% of all GHG emissions. A significant proportion of transport regards to tourism, which is the leading economic activity in the Greek islands. We examine the case of the selected Cyclades and Dodecanese islands by developing Passenger Traffic Forecasting Models using Machine Learning and then predicting GHG emissions based on forecasted traffic volumes and passenger-km figures. The effectiveness of potential policies for modal shift and the effect of different economic growth scenarios is discussed by comparing different forecasting outcomes.

Keywords: Air Transport, Sea Transport, GHG Emissions, Forecasting, Machine Learning

JEL Codes: R41, R42, R48, Q41, Q42, Q47, Z32

1. Introduction

Predicting Greenhouse Gas (GHG) emissions, which is necessary for the formulation of policies to combat climate change, depends on forecasting the volume and nature of the underlying economic activities. Given that transport accounts for 35% of energy consumption (International Energy Agency, 2021) and 15% of GHG emissions (Intergovernmental Panel on Climate Change, 2022), forecasting transport demand and GHG emissions are inextricably linked.

GHG emissions from transport heavily depend on the mode used to move passengers and freight: in the particular case we examine, passenger traffic to the Cyclades and Dodecanese islands, sea and air travel modes are of interest. Given that travelers choose mode based on a number of considerations which are usually condensed in the concept of the generalized cost of travel (Profillidis and Botzoris, 2019), it is possible to examine policies that may cause modal shifts from air to sea travel.

2. Materials and Methods

2.1 Data

Publicly available data was used to develop the traffic forecasting models. More specifically:

- Socio-economic indicators for Greece and the Region of Cyclades (population, Gross Domestic Product (GDP) per capita, unemployment rates, Harmonized Consumer Price Index), (Hellenic Statistical Authority, 2023).
- Socio-economic indicators for the European Union (population, GDP, GDP per capita, unemployment rates, Harmonized Price Index), (Eurostat, 2023).
- Fundamental Tourism Figures for the South Aegean Region (INSETE Intelligence, 2023), which includes sea and air passenger traffic data for the Cyclades and Dodecanese, hotel and rooms to rent capacities, and tourist countries of origin.

Standardized values per passenger-km, see (UK Government, 2020), were used for the calculation of GHG emissions from forecasted passenger traffic.

2.2 Explanatory variables

The following explanatory variables were considered for the development of different models:

- Island distance from the ports of Piraeus or Rafina or the Athens International Airport in terms of average door-to-door time-distance (Dist_Sea and Dist_Air). If an island did not have an airport, the time distance for air travel was set to 9999 minutes. This was done to reflect the unavailability of air travel without using null values that could be misinterpreted by the MLP.
- Harmonized Consumer Price Index (HCPI).
- GDP per capita for EU-27 (GDPpC_EU).
- GDP per capita for the UK (GDPpC_UK).
- GDP per capita for the US (GDPpC_US).
- GDP per capita for the Cyclades or Dodecanese Region (GDPpC_Isl).
- GDP per capita for Greece (GDPpC_GR).
- Island population (Isl_Pop).
- Hotel bed capacity (Hot_Cap).

- Rent a room bed capacity (RtR_Cap).
- Pseudo-variables for:
- The existence of an airport at the island in question (Airport – Boolean).
- The intensity of travel restrictions because of a pandemic [Covid (0 for no restrictions, 1 for limited restrictions, 2 for strong restrictions)].
- Ship or air route cost for domestic connection (Ticket_Sea and Ticket_Air). Similar to the case of time distance, if an island does not have an airport, the ticket cost was set to €9999.
- Generalized cost of travel based on the time distance and ship or air route cost (GCoT_Sea and GCoT_Air).

Four different combinations of the above variables were used for the different models (Table 1).

Table 1: Explanatory variable combinations

Explanatory Variable	Combination					
	G	H	I	J	K	L
Dist_Sea	YES	NO	YES	NO	YES	NO
Dist_Air	YES	NO	YES	NO	YES	NO
HCPI	YES	YES	YES	YES	NO	NO
GDPpC_EU	YES	YES	YES	YES	YES	YES
GDPpC_UK	YES	YES	YES	YES	YES	YES
GDPpC_US	YES	YES	NO	NO	NO	NO
GDPpC_Isl	YES	YES	NO	NO	NO	NO
GDPpC_GR	YES	YES	NO	NO	NO	NO
Isl_Pop	YES	YES	YES	YES	YES	YES
Hot_Cap	YES	YES	YES	YES	YES	YES
RtR_Cap	YES	YES	YES	YES	YES	YES
Airport	YES	YES	NO	NO	NO	NO
Covid	YES	YES	YES	YES	YES	YES
Ticket_Sea	YES	NO	YES	NO	YES	NO
Ticket_Air	YES	NO	YES	NO	YES	NO
GCoT_Sea	NO	YES	NO	YES	NO	YES
GCoT_Air	NO	YES	NO	YES	NO	YES
Number of explanatory variables	**15**	**13**	**11**	**9**	**10**	**8**

2.3 *Model outputs*

Two different model output combinations were considered:

- Output A: Sea Traffic, Domestic and International Air Traffic.
- Output B: Sea Traffic and Domestic Air Traffic.

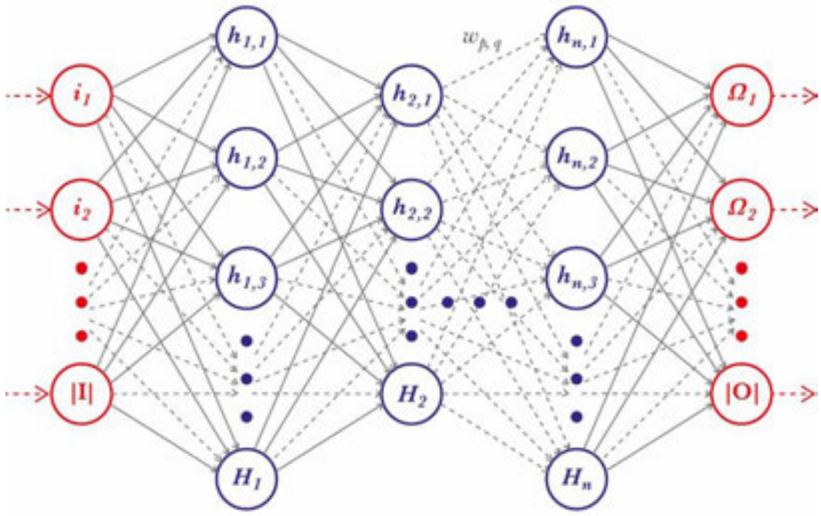
2.4 *Modelling techniques*

The Multilayer Perceptron (MLP), (Werbos, 1975), is used to forecast passenger traffic to the Cyclades and Dodecanese islands on a regression with three concurrent outputs: sea passenger foot traffic, sea passenger car traffic, and air passenger traffic. Bayesian Regularization is used for training over the Root Mean Squared Error loss function (MacKay, 1992a and 1992b). The general form of MLP models is given in Figure 1.

Structures with a single layer of hidden neurons are used; MLPs with one hidden layer have been proven to be a universal function approximator in (Cybenko, 1989) and as such using a more complex Artificial Neural Network structure may lead to overfitting rather than improve forecasting capacity.

In order to test the model's capacity for generalization, data for islands X and Y was excluded from the training dataset and the candidate models were tested against them to select the ones that best fit the available data.

Figure 1: Generalized Multilayer Perceptron structure



2.5 Model selection

In order to select the best-performing models, a multicriteria approach is adopted, building on previous work by the authors, (Christidis, et al., 2022), (Christidis, et al., 2023a and 2024), where a single metric is used to compare different models. This metric is determined as follows:

- The Average Absolute Error (AAE) for each model's output is calculated.
- The Standard Deviation of the Absolute Error σAAE is calculated for all input vectors.
- A Multicriteria Model Score (MCMS) is used to account both for the size and variability of the error as well as model complexity. Models with the minimum MCMS are considered to perform the best.

$$MCMS_i = \sum_{j=1}^{n} \frac{AAE_{i,j}}{\overline{AAE_j}} + \sum_{j=1}^{n} \frac{\sigma_{AAE_{i,j}}}{\overline{\sigma_{AAE_j}}} + \frac{EV_i}{EV_{max}} + \frac{HL_i}{HL_{max}} \quad (1)$$

where:

j = Output index (sea passengers, domestic air passengers, etc.)
EV = The number of explanatory variables.
HL = The number of neuros in the hidden layer of the MLP.

2.6 *Forecasting scenarios*

The projection of the future evolution of explanatory variables is critical in the development of any forecast. The inherent uncertainty of projections regarding aspects such as GPD per capita figure or price inflation necessitates the development of alternative scenarios.

With regards to island population, projections are made based on 2010–2021 data and are shown in Figure 2. For the development of GDP per capita, projections scenarios are developed based on long-term International Monetary Fund forecasts (Table 2).

The Harmonized Consumer Price Index in Greece is assumed to develop as per the graphs of Figure 3.

Figure 2: Population projections for the period 2023–2035.

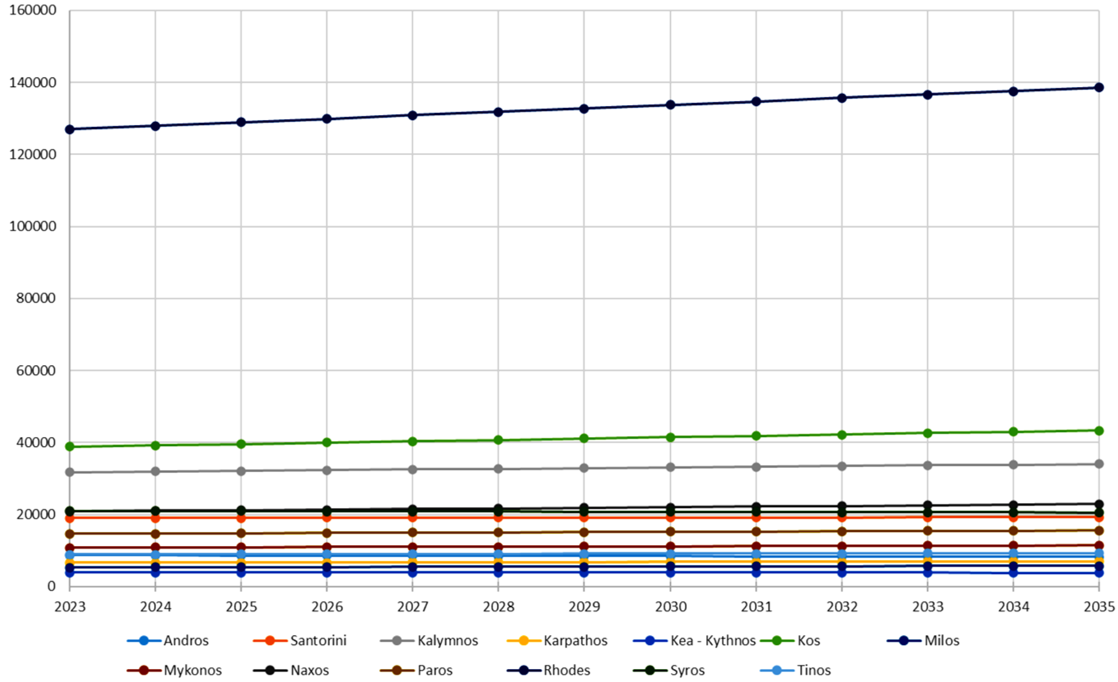
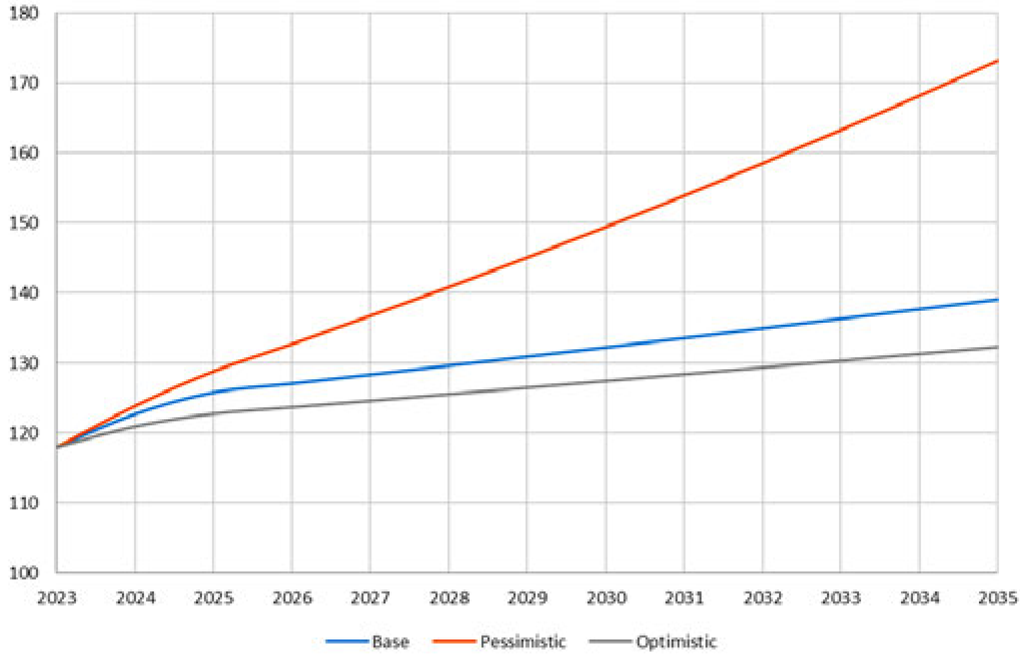


Table 2: GDP per capita evolution scenarios

	Base scenario	**Pessimistic scenario**	**Optimistic scenario**
GDPpC_EU	+1.5% p.a.	+1.0% p.a.	+2.0% p.a.
GDPpC_UK	+1.5% p.a.	+0.5% p.a.	+2.5% p.a.
GDPpC_US	+2.0% p.a.	+1.0% p.a.	+3.0% p.a.
GDPpC_Isl	+2.5% p.a.	+2.0% p.a.	+3.0% p.a.
GDPpC_GR	+1.5% p.a.	+0.5% p.a.	+2.5% p.a.

Figure 3: Greek Harmonized Consumer Price Index scenarios



With regards to ticket prices, the following scenarios are considered:

- Sea and air ticket prices remain constant after inflation.
- Sea ticket prices cumulatively increase by 25% over the first five years of the forecast period and then remain constant after inflation.
- Sea and air ticket prices cumulatively decrease by 10% as above.
- Air ticket prices increase by 20% on year 2 as a result of climate-change aversion policies.

Air travel durations are assumed to remain constant. For sea travel, durations are expected to decrease by 2027 by 10% due to the introduction of new, faster ships or the shifting of traffic from Piraeus to Rafina in the optimistic scenario, while in the base scenario they remain unchanged.

Hotel and rent-a-room bed capacity is assumed to follow the Cyclades and Dodecanese GDP per capita growth rates. With regards to travel restrictions, it is assumed that there will not be restrictions in the forecast period.

2.7 GHG emissions calculation

As already stated, GHG emissions are derived from forecasted passenger traffic by considering the passenger-kilometers as follows:

- With regards to air traffic:
  - For domestic traffic forecasted passenger numbers are multiplied with the island's weighted average distance from the Athens Thessaloniki international airports, the weights being 80:20 respectively. Domestic air travel causes 0.2443 kg of CO_2-eq (carbon dioxide equivalent) per passenger-km for the trip and 0.02674 kg of CO_2-eq per passenger-km for the Well-To-Tank (WTT) segment. (UK Government, 2020).
  - For international traffic forecasted passenger numbers are multiplied with the weighted average distance from the major tourism origin country capitals (e.g., Berlin for Germany, London for

the UK, and so on). As above, trip GHG emissions are 0.18181 kg of CO_2-eq per passenger-km and 0.01991 kg of CO_2-eq per passenger-km for WTT.

- With regards to sea traffic:
  - It is assumed that all foot passenger traffic pertains to domestic travel, and therefore, the distance from the ports of Piraeus or Rafina is considered, rather than a combination of travel to mainland Greece and then a ship route to the island, as would be the case for international travel. This assumption is reasonable, given that foreign tourists, who predominantly arrive in Greece by air, are unlikely to fly to Athens to then board a ship, as it is more cost-effective and time-efficient to purchase a direct ticket to their destination or to transfer to a domestic flight. Trip GHG emissions are 0.01874 kg of CO_2-eq per passenger-km and 0.00362 kg of CO_2-eq per passenger-km for WTT.
  - Similarly, passenger car traffic is considered to be domestic only given that the high cost of transporting a car compared to renting one at the destination island makes it a particularly unlikely choice for international tourists. Trip GHG emissions are 0.12952 kg of CO_2-eq per passenger-km and 0.02505 kg of CO_2-eq per passenger-km for WTT. Based on available data, passenger car traffic is assumed to regard to 15% of total sea passenger traffic (UK Government, 2020).

Based on the tourist countries of origin distributions for the years 2016–2022 from (INSETE Intelligence, 2023), the trip distances for the calculation of passenger-km are given in Table 3.

Table 3: Weighted average trip distances

Island	Domestic sea	Domestic air	International air
Santorini	276	276	4920
Kalymnos	363	334	4883
Karpathos	503	455	5029
Kos	416	354	4885
Mykonos	163	188	4821
Naxos	178	213	4854
Paros	163	202	4858
Rhodes	541	452	4950
Syros	133	161	4822

3. Results

3.1 Model regression performance

Twelve different input and output combinations were examined (Table 4). The dataset was randomly split into a training and testing dataset, at an 85% to 15% ratio. Given that the resulting models' performance depends on initial conditions, such as the dataset split and initial network weights, they were tested multiple times for different hidden layer sizes (5, 10, 15, and 20, based on the number of explanatory variables). In all cases, the coefficient of determination R^2 for both the training and testing dataset was over 0.93, while for most models it was above 0.95 (Table 5).

3.2 Model selection

Given the very high R^2 achieved for all models, model selection is based on the MCMS described previously. Forecast outputs will need to be checked for their logical consistency; the complexity of artificial neural networks means that overfitting is a probable outcome which in the case of regression tasks can manifest itself as illogical or inconsistent outputs (Christidis, et al., 2021), (Tables 6 and 7).

Table 4. Model inputs and outputs

Model code	Explanatory variable combination	Output
MLP_01	G	A
MLP_02	G	B
MLP_03	H	A
MLP_04	H	B
MLP_05	I	A
MLP_06	I	B
MLP_07	J	A
MLP_08	J	B
MLP_09	K	A
MLP_10	K	B
MLP_11	L	A
MLP_12	L	B

Table 5: Candidate model Coefficient of Determination R^2

Model	Training dataset R^2	Testing dataset R^2
MLP_01_05	0.9977	0.9918
MLP_01_10	0.9997	0.9810
MLP_01_15	1.0000	0.9604
MLP_02_05	0.9979	0.9848
MLP_02_10	0.9999	0.9399
MLP_02_15	1.0000	0.9672
MLP_03_05	0.9957	0.9894
MLP_03_10	0.9993	0.9670
MLP_04_05	0.9960	0.9762
MLP_04_10	0.9998	0.9498
MLP_05_05	0.9962	0.9867
MLP_05_10	0.9991	0.9920
MLP_06_05	0.9962	0.9702
MLP_06_10	0.9997	0.9870
MLP_07_05	0.9949	0.9873
MLP_07_10	0.9988	0.9909
MLP_08_05	0.9947	0.9540
MLP_08_10	0.9992	0.9313
MLP_09_05	0.9958	0.9957
MLP_09_10	0.9988	0.9953
MLP_10_05	0.9934	0.9406
MLP_10_10	0.9989	0.9680
MLP_11_05	0.9955	0.9951
MLP_11_10	0.9982	0.9585

Model	Training dataset R^2	Testing dataset R^2
MLP_12_05	0.9918	0.9836
MLP_12_10	0.9987	0.9663

Table 6: Multicriteria model score for output A

Model	AAE_1	AAE_2	AAE_3	σ_{AAE1}	σ_{AAE2}	σ_{AAE3}	EV	HL	MCMS
MLP_01_05	26438.66	21157.58	23306.53	24893.96	27850.21	35765.72	15	5	7.93326
MLP_01_10	16008.43	8840.43	14882.06	29938.18	10148.62	32131.18	15	10	5.82010
MLP_01_15	7602.92	3907.84	12082.34	24893.96	27850.21	35765.72	15	15	6.29924
MLP_03_05	39550.26	21666.71	27075.43	41083.55	20550.45	38010.90	13	5	8.62467
MLP_03_10	30279.99	9934.95	16775.01	72784.43	14177.59	30496.89	13	10	7.75579
MLP_05_05	33961.48	21475.25	28055.45	37564.75	24616.11	42049.97	11	5	8.55298
MLP_05_10	20611.77	10703.84	17026.50	29364.42	10175.99	24752.93	11	10	5.71014
MLP_07_05	45312.60	26891.58	26608.72	39747.57	24482.45	28386.06	9	5	8.76917
MLP_07_10	20773.22	13974.84	19774.03	33044.97	18443.76	30439.13	9	10	6.62474
MLP_09_05	29296.79	19305.11	28515.11	28109.85	24346.79	32164.75	10	5	7.63032
MLP_09_10	19685.40	11875.97	15857.52	21291.71	10965.26	23925.61	10	10	5.41638
MLP_11_05	41200.12	21152.68	23786.49	29026.40	20426.02	26747.01	8	5	7.48756
MLP_11_10	30265.26	12733.88	26282.78	40414.84	12420.44	70661.79	8	10	8.17565
Average or max	27768.22	15663.13	21540.61	34781.43	18957.99	34715.20	15	15	5.41638

Table 7: Multicriteria model score for output B

Model	AAE_1	AAE_2	AAE_3	σ_{AAE1}	σ_{AAE2}	σ_{AAE3}	EV	HL	MCMS
MLP_02_05	19233.65	11843.27	N/A	16971.33	11148.19	N/A	15	5	4.78192
MLP_02_10	12195.19	4722.21	N/A	32386.51	9335.17	N/A	15	10	4.43447
MLP_02_15	10933.99	3244.02	N/A	35398.11	10266.88	N/A	15	15	4.74981
MLP_04_05	22457.33	19013.47	N/A	30441.30	15805.20	N/A	13	5	6.27102
MLP_04_10	36192.07	11970.00	N/A	36192.07	11970.00	N/A	13	10	6.36725
MLP_06_05	21846.25	14752.54	N/A	31531.03	14687.75	N/A	11	5	5.64692
MLP_06_10	9885.20	5922.07	N/A	21120.42	5485.53	N/A	11	10	3.49616
MLP_08_05	29551.54	14234.56	N/A	32270.59	12688.58	N/A	9	5	5.63903
MLP_08_10	18277.10	8093.06	N/A	54508.81	7618.12	N/A	9	10	5.09742
MLP_10_05	31315.55	14386.68	N/A	55414.26	12623.76	N/A	10	5	6.46513
MLP_10_10	37314.51	8574.85	N/A	37314.51	8574.85	N/A	10	10	5.62363
MLP_12_05	31595.84	15517.05	N/A	30280.94	12872.65	N/A	8	5	5.73861
MLP_12_10	17958.74	8555.08	N/A	32173.63	8490.41	N/A	8	10	4.48863
Average or max	22981.31	10832.99	N/A	34307.96	10889.78	N/A	15	15	3.49616

When examining the output of forecasts for the base scenario, we note that there are cases where forecasted passenger traffic is negative for models for Output B or that it exhibits extreme changes in value from year to year (Figure 4).

For the same scenario and island for output A the negative results for forecasted sea traffic are less pronounced, however outputs for the case of Covid-like travel restrictions are obviously erroneous (Figure 5).

If the base forecast for the island of Mykonos is examined, the results are more in line with expectations (Figure 6).

Figure 4: Base scenario MLP_10_10 forecast for Karpathos (Covid-like travel restrictions assumed for year 2031)

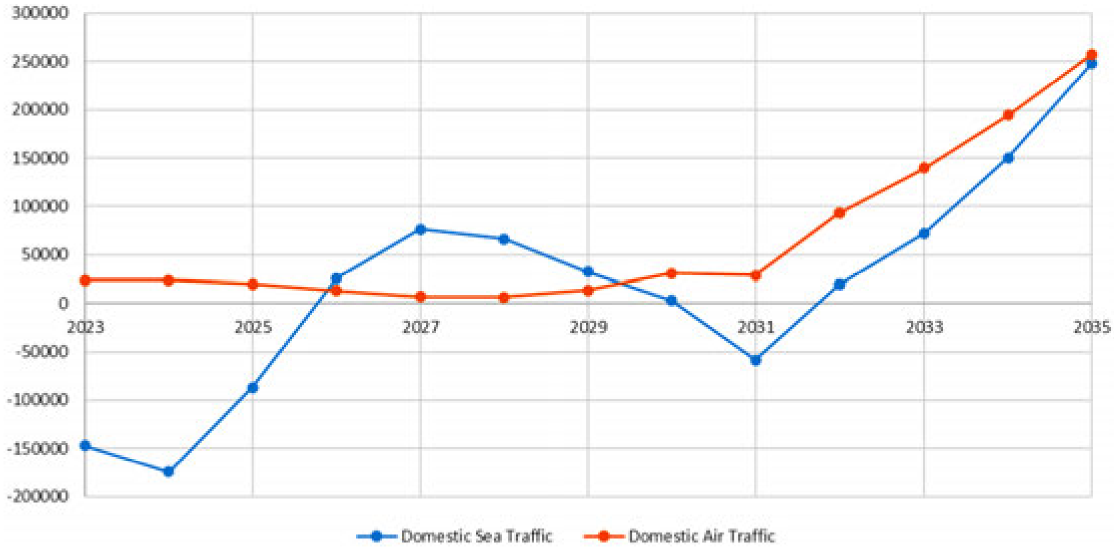


Figure 5: Base scenario MLP_09_10 forecast for Karpathos (Covid-like travel restrictions assumed for year 2031)

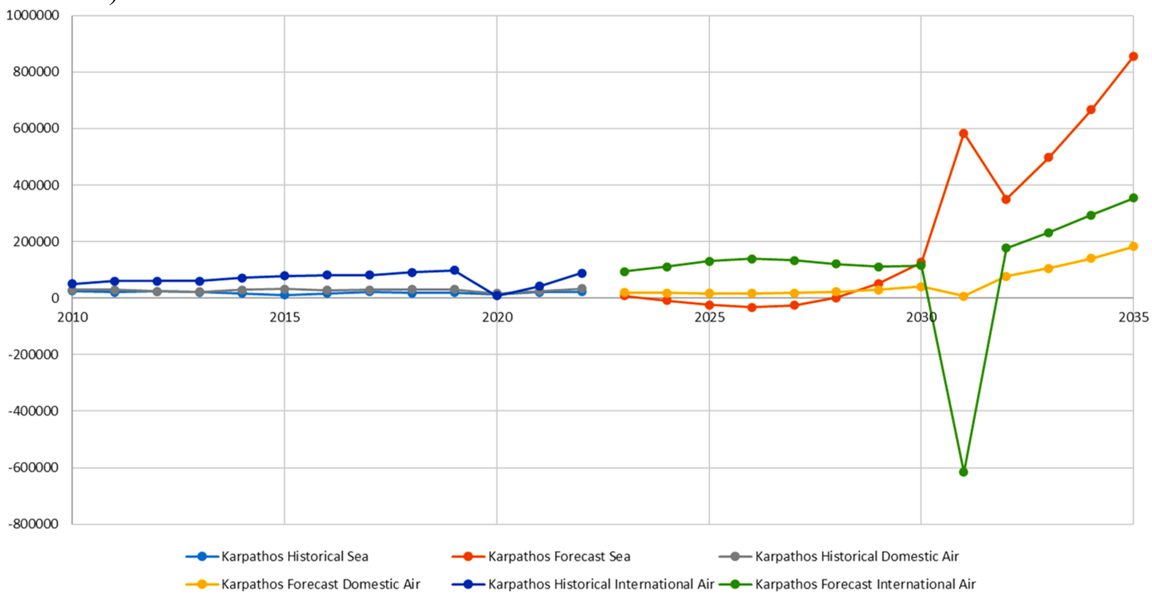
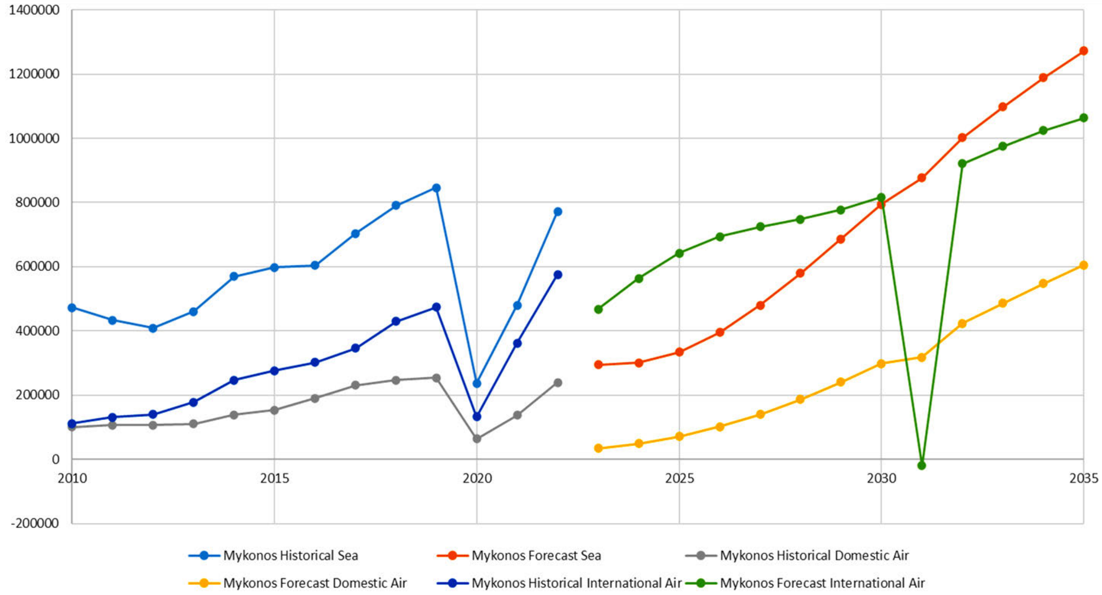


Figure 6: Base scenario MLP_09_10 forecast for Mykonos (Covid-like travel restrictions assumed for year 2031)



Negative outputs for output A models regard to Dodecanese islands domestic sea traffic and smaller Cyclades islands domestic air traffic. These can be explained as follows:

- It may be the case that sea traffic to the main Dodecanese islands mainly regards to traffic from the smaller islands of the region rather than Athens. Given that the models only consider the time-distance from Athens, this may overestimate the impedance to domestic sea traffic yielding unrealistic results.
- Smaller Cyclades islands domestic air traffic is historically low to begin with. Given that domestic air travel to the Cyclades islands probably regards to particularly affluent Greek individuals or foreign tourists transiting through Athens, air and sea travel time-distances from Athens may not properly represent the factors considers in such individuals' decision.

Further to the above, only model MLP_09_10 will be considered. Where forecasted passenger traffic is negative, it is set equal to half of the historical value for 2022.

3.3 Forecasted traffic

Based on the scenarios presented in Section 2.6 and the model selection of Section 3.2, forecasts for passenger-km by mode are developed for a period of six years (2023–2028), given that forecasts for a period longer than half of the historical data period may be unreliable (Profillidis, 2015). For example, passenger-km forecasts for Mykonos are presented in Figures 7 to 9.

As expected, policies that decrease the cost of sea travel and increase the cost of air travel cause a shift of traffic from domestic air trips to domestic sea trips, and even a less pronounced shift from international air to domestic sea trips. Similarly, high economic growth scenarios result in higher traffic than the base scenario, while the opposite is true of the low growth scenario.

The aggregated passenger-km forecasts by mode for the nine islands under study are presented in Figures 10 to 12.

Figure 7: Mykonos domestic sea passenger-km forecasts

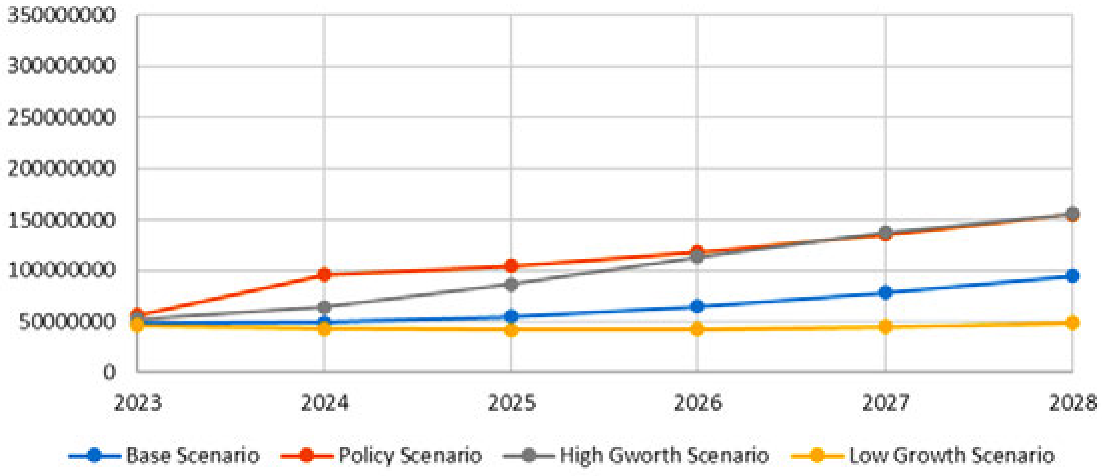


Figure 8: Mykonos domestic air passenger-km forecasts

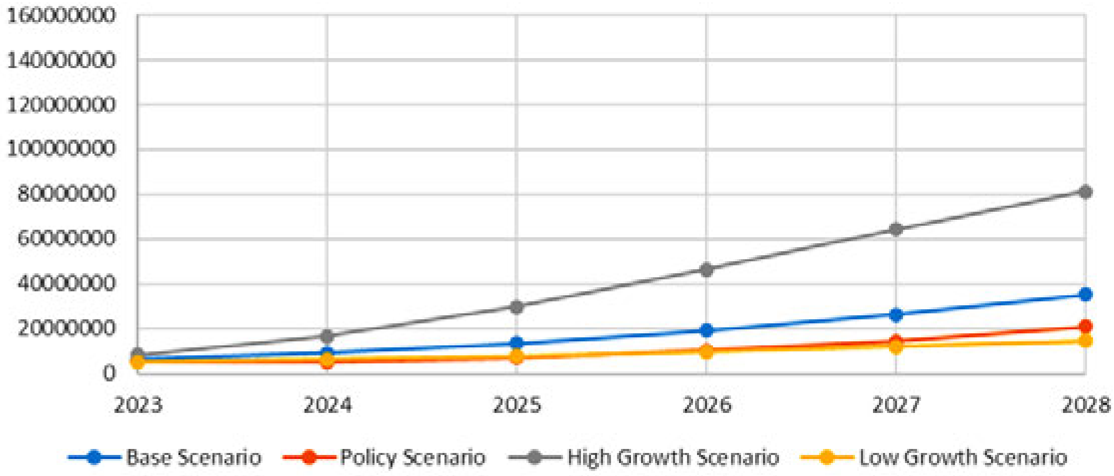


Figure 9: Mykonos international air passenger-km forecasts

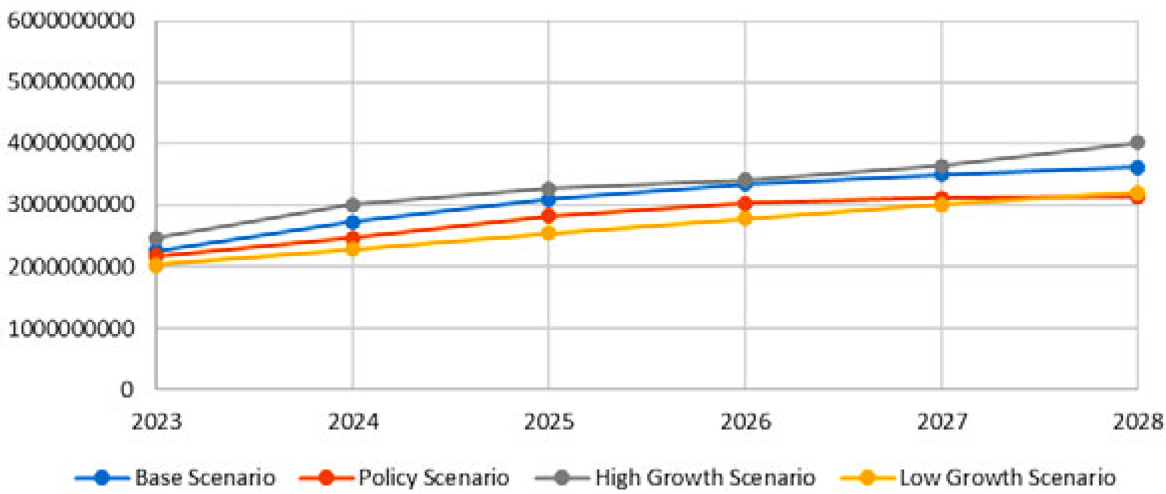


Figure 10: Overall domestic sea passenger-km forecasts

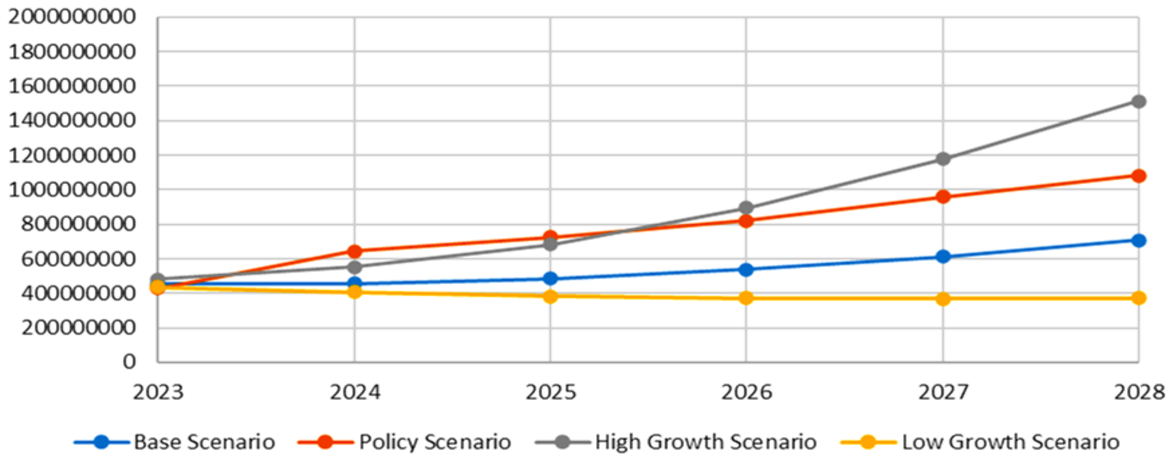


Figure 11: Overall domestic air passenger-km forecasts

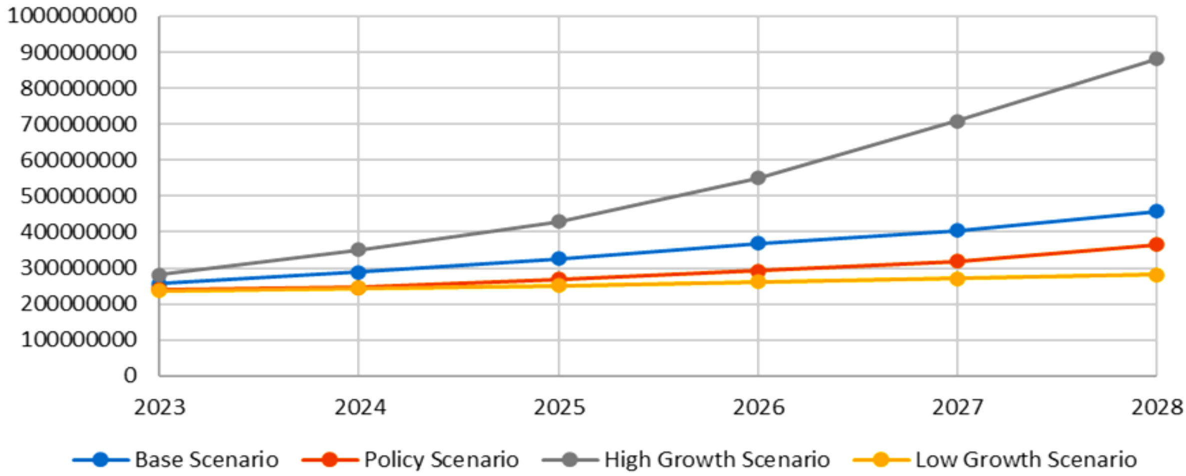
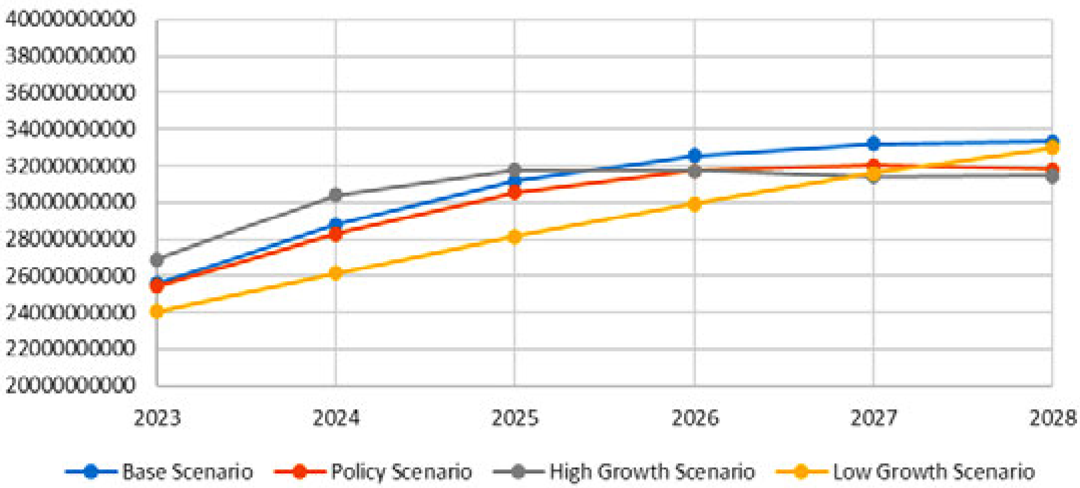


Figure 12: Overall international air passenger-km forecast



There are two possible explanations with regards to the flatlining international air passenger traffic forecast for the high growth scenario:

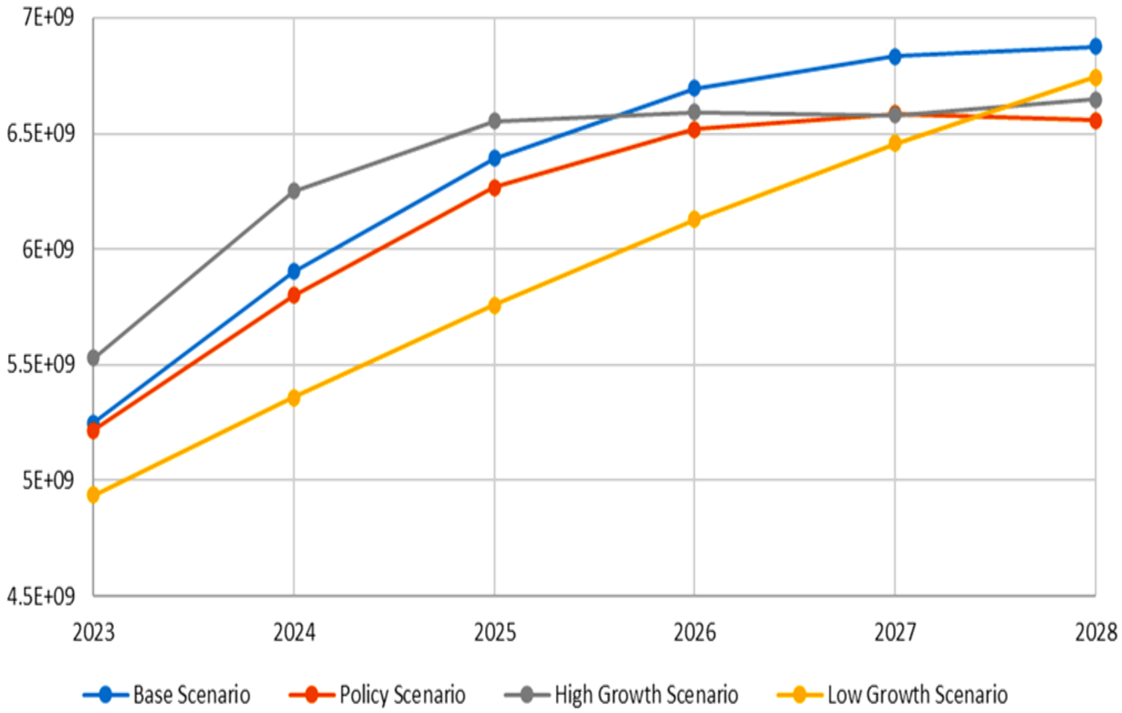
- The model has problems extrapolating out of the training space. High growth pushes GDP per capita numbers out of the training space quickly and as such forecasts beyond three or four periods may be unreliable. There is a chance this can be addressed by considering a longer time period for the training and/or additional island data (e.g., Crete, Ionian islands) to improve the coverage of the problem space or by considering different or more explanatory variables to more reliably capture the effects of income on traveling patterns.
- The model actually captures the effects of high growth in the Greek economy, whereby increased income levels lead to a substitution of foreign tourism by domestic one, given that the high growth scenario is accompanied by strong growth in domestic traffic. Such a scenario may cause a faster growth in hotel or room to rent bed capacity than already considered, which may allow foreign traffic to increase along with domestic one. Future research will address this point further.

3.4 Forecasted GHG emissions

Given the passenger-km forecasts and the GHG emissions values (UK Government, 2020), the GHG emissions for the different scenarios are presented in Figure 13.

The main driver of GHG emissions is international air travel, for which there is little alternative mode of travel. Given that specific Cyclades islands (Mykonos, Santorini) increasingly attract affluent tourists from beyond Europe, it is unlikely that this will change in the future. Nevertheless, the enactment of policies to increase the cost of air travel relative to the sea alternative can lead to GHG emissions savings, whereas strong economic growth in Greece may lead to crowding out lower income foreign tourism from the EU and UK.

Figure 13: GHG emissions (in kg of CO_2-eq) forecasts



4. Conclusions

Multilayer Perceptron models were developed to forecast passenger traffic to selected Cyclades and Dodecanese islands. Given the limited extent of training data (2010 to 2022), the different models exhibited good performance. Using a multicriteria performance metric that considers model complexity along with regression error distribution, one model was selected for further examination.

The behavior of the model generally was as expected; however, further investigation is needed regarding international air passenger traffic. Given the effect that airliner policies have on such traffic, e.g., by introducing new lines or discontinuing existing ones, and that in recent years a shift of origin countries from Europe to Asia and North America has been anecdotally reported, further investigation is needed to model traveler behavior and account for changing tourist tastes.

Lastly, the model shows that a shift in traffic from domestic air travel to sea travel, which can have a significant impact on GHG emissions, is possible if the cost of air travel greatly increases compared to its competition. At present, the generalized cost of travel by air is in most cases lower than that by sea; air ticket prices are generally lower than sea ones, while door-to-door travel times are comparable or better for air travel. As such, air travel has been gaining shares in traffic in recent years, a trend that will require considerable effort to reverse.

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Integrating bike paths into peri-urban environment: the case of Serres

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Abstract
Benefits of cycling as well as of human interaction with nature are well substantiated. Integrating cycling paths into the landscape is a crucial task for engineers, forest scientists and cyclists as well, but can be broadly appreciated by the committed funs and not only. However, services and equipment are needed to enhance cycling in nature and create a strong sport and tourism local potential. This paper presents part of activities undertaken in Serres in Northern Greece, where cycling is gaining ground in the urban setting and beyond. Mapping peri-urban bike paths was undertaken for the first time in the framework of two EU funded projects, accompanied by relevant works in order to provide the users with appealing and useful infrastructure. This work discusses the initiatives of upgrading and promoting cycling paths in the region of Serres and their contribution to local sustainable tourism potential. Moreover, the versatility of the path network and its contribution to other ecofriendly activities like running or hiking provides extra benefits for the local community. Facilitating sustainable forms of tourism can create societal and personal benefits, while economic profitability in an environment-friendly perspective can be the added value generated by such initiatives for the broader region.

Keywords: bike paths mapping, peri-urban environment, sustainable tourism

JEL Codes: O18, R42, Z20, Z32.

1. Introduction

An increasing body of evidence suggests that physical activity in general is associated with a range of positive mental health, wellbeing outcomes and higher perceived quality of life (Kelly et al., 2018; King et al., 2019). This beneficial physical activity uptake can be performed through active travel, so replacing automobile trips with active trips allows for more physical activity within a community and according to the U.K. Department of Health, regular walking and bicycling is the only realistic way that adults can meet physical activity requirements (Litman et al. 2006). More recently, cycling and walking have been increasingly recognized as promising approaches to promote regular physical activity among wide ranging population groups (WHO, 2018; Kelly et al., 2014; Gotschi, et al, 2016). Evidence indicates that cycling benefits are broadly similar to other forms of physical activity, thus to maximize gains in public health, it would be important to increase participation in cycling amongst individuals who currently undertake little physical activity, rather than encouraging those who are currently active in other pursuits to switch to cycling (Logan et al.,2023). Moreover, as advocated by Kahlmeier et al. (2021), active travel being a sustainable mobility practice, promoting physical activity through cycling and walking as a means of travel also contributes to sustainable urban environments (Edwards and Tsouros, 2006; ISPAH, 2016; UNECE, 2014).

Travel behavior research views the built environment, the surrounding land use and bicycle facility, as the motivator of cycling behavior (Krizek et al. 2009). If the facilities are in place, people will use them, giving weight to the presence of bicycle facilities. In this respect, urban areas have been in the heart of relevant policies and sustainable strategies call for a built environment that hosts active travel infrastructure (Ruprecht, 2013).

Beyond urban settings, benefits of human contact with nature have been thoroughly advocated, involving positive emotions and feelings of vitality (Tyrväinen et al., 2014) and according to a growing body of evidence, people are happier and healthier when living in urban areas with more green space (White et al., 2013), so experiencing open nature can even more beneficial. Keniger et al (2013) advocate that interactions with nature can deliver a range of psychological well-being, cognitive, physiological, social, tangible and spiritual benefits and that access to green space and natural areas is important for facilitating activities that are beneficial for human well-being.

Given the above, it is clear that performing physical activity in natural environments can help individuals make the most of it and peri-urban areas should also rejoice of cycling related infrastructure, services and equipment to facilitate well-being activities of both citizens and visitors. Community-level benefits of cycling within and beyond urban environment are noticeable, as this upgrade can be an essential asset for the city's tourism potential (Ciascai et al., 2022), enhancing local economy.

This paper presents part of the work performed within two EU-funded projects that aimed at boosting cycling in the region of Serres further, focusing on peri-urban areas, namely the peri-urban forest of Serres and the Natura protected Kerkini lake area, at 35 km from the city. The structure is as follows: departing of actions undertaken for cycling integration in urban fabric, this works gives briefly the situation within the city and attempts to go further, in the periurban area. The methodology followed covers the work performed in the framework of two EU-funded projects on the mapping of cycling paths in natural environments and enhancing their visibility and usage. A discussion of the achievements so far is presented detailing on the potential of the area as a cycling tourism destination. Conclusions refer to lessons learnt and needed steps to be taken.

2. Cycling in and out of urban setting in the region of Serres

Urban car dominance is lately faced with a range of non-motorized urban mobility policies as cities worldwide, seeking for sustainable choices, are adopting urban development choices oriented to active modes (Buehler and Pucher, 2012). Sustainable Urban Mobility Plans (SUMPs) call for integrated urban strategies where cycling is a core component (Ruprecht, 2013).

Literature abounds on urban cycling strategies, however a bike-friendly city identity may be more than that, bikeability going beyond utilitarian cycling and encompassing broadly cycling purposes, like recreation and leisure, physical activity uptake and sports. Primarily urban attributes need to be cycling facilitating and the term bicycle/bike-friendly city refers to a city that has efficient infrastructure, transportation policies and societal consensus to make cycling a main transport mode (Zayed, 2016), that is, a type of city showing a dedication to creating more suitable spaces for cycling (Williams, 2015) and thus making bicycle is a realistic choice for short-distance trips (Joo et al., 2015). This commitment can be materialized by extending the network to the peri-urban environment and provide local people with a range of facilities, which may attract visitors as well. Differently viewed, investments for tourism enhancement may be beneficial for local stakeholders and citizens, as well (Morfoulaki et al., 2023).

Serres is a medium size city, located in the Northern Greece with a flat terrain that encourages active mobility. According to Serres' SUMP (CONSORTIS, 2020), cycling is a core component for the city sustainability strategy and cycling paths are gradually forming a safe and qualitative network, allowing for utilitarian cycling and not only. Local infrastructure is accompanied by urban equipment for bike safe locking, bike repair spots and a bike-sharing system, which will be soon extended with e-bikes. Admittedly, the focus on cycling promotion concerned urban environment, while peri-urban potential was left aside. Departing from the capital, Serres region includes a unique natural environment, which is worth to explore by bike as well, namely the Kerkini lake in the shadow of Belles Mountain, at 40 Km from Serres and about 100 Km from Thessaloniki, second largest Greek city. The wetland has been declared as a National Park according to the Ramsar Convention and it is one out of the ten wetlands of International Importance in Greece. It is also part of the European Natura 2000 network and one of the most important, in terms of its biodiversity, wetlands in Europe. The place is ideal for outdoor activities and cycling in the area can be really rewarding. Kerkini is a key tourist attraction for Serres region and integrating bike paths in peri-urban environment could boost further Serres' attraction as a local pole.

Ciascai et al (2022) underline the importance of adequate infrastructure for cyclo-tourists like roads with low gradients, paved roads or nice trails through the nature. Another research regarding the potential of job creation through the promotion of cycling shows that the benefit for local communities could be as great as other profitable businesses. There are good practices like the city of Copenhagen in Denmark, where municipal and sub-national authorities facilitated cycling to develop economy (Scotini et al., 2017), or in Wallonia area in Belgium since 2000, where the initial idea regarding the bicycles routes was to combine signed sections of low-traffic rural roads, separated paths from the main road and traffic-free paths (Cox, 2012). Bakogiannis et al (2020) explore in their research various motivators and deterrents of cycling tourism in Greece. They concluded that apart from the physical environment that attracts mostly the cycle tourists, infrastructure (signed roads, adequate paths, etc) is a critical factor to enhance cycling tourism. In the same way, digital services are also appreciated by end-users, helping then to plan their tours in advance and to receive a better experience when visiting the desired destination (GoBike consortium, 2022). Hence, mapped routes presented through a proper application in a mobile phone that provides additional useful information (hotels, cycling service spots, points of interest, etc) would help cycle tourist to receive an advanced experience.

Given the dynamic character of sport tourism and the potential positive impact of it in improving an area's attractiveness while supporting sustainable growth (Morfoulaki et al., 2023), the present paper presents the work of two projects in the field of cycling tourism promotion in the region of Serres, in Northern Greece, where paths mapping was a core activity and a promising lever for local development.

3. Methods and Data

This work focused on Serres region, in the Northern Greece, where two EU funded projects worked on infrastructure enhancement and digital services elaboration in the field of sport tourism, by focusing on existing cycling paths in the peri-urban forest of Serres and near to the most popular regional attraction, the Kerkini lake.

The selection of the paths for both projects (Serres & Kerkini) was based upon consultation of project leaders with the local stakeholders such as entrepreneurs, local clubs that use these routes, the public greenery department, the forestry office and external experts (forest scientists and civil engineers). In a synergetic framework, the final aim was to meet the users' needs (cyclists and hikers) for a useful and practical network of paths. Another issue was the property of land especially in the project of Serres. There were many private plots around the peri urban forest that caused a delay in the project planning. The process to find proper public space to set up paths seemed like solving a puzzle.

Both projects had secured funds that was very helpful through the whole process, from perception to implementation in the field. Hence, there was a specific timetable how to implement the projects. In the case of Serres project, the most time-consuming part was to receive the permission from the forestry office that lasted around 7-8 months.

3.1 The case of BIKE CITIES project

Cycling infrastructure in Serres, despite the fact that it is not very well developed, has a long history. The first bike lane (1km length) was constructed in the early of 80's in Agioi Anargiroi valley, a place that is very popular in the summer time and has various sports facilities till today. Today, there exist more than 4,2km of bicycle roads and many bicycle racks for bike parking all around the town. In addition, there are plans for the future to develop further the bike lane network; however, the local authorities had no plans to create paths in the peri-urban forest till recently. As it was mentioned previously, the demand for recreational routes is present and probably it may grow in the upcoming years. Moreover, these paths would be an additive value in the touristic assets of the region. Thus, the inauguration of Serres BIKE CITIES project was warmly embraced by the local community. The partnership of the project consisted by the Municipality of Serres (Lead Partner) and the regional Life-long learning center of Central Macedonia from Greece, and from North Macedonia, the Municipality of Strumica and the Association Center for development and promotion 'Promo Idea' Strumica. The content of the project included the creation of infrastructure (bike routes, map, app and web site that includes necessary information for cyclotourists), the supply of equipment (bike repair spots and bike racks), the development of various services (accommodation, food, guiding, etc), synergies of agencies in order to exchange know-how, the organization of sports events (cycling competition), the strengthening of entrepreneurship through educational seminars and lastly the encouragement of job creation. The following table present information regarding the bicycle routes, upgraded under the funds of BIKE CITIES project.

Table 1: Paths mapped within BIKE CITIES project

Path code	Length (km)	difficulty	type
B1	3,9	**	Dirt road
B2	0,8	**	Path
B3	2,3	**	Path & dirt road
B4	4,0	***	Dirt road
B5	1,1	**	Path & dirt road
B6	0,2	**	Path
B7	0,6	**	Path
B8	0,4	****	Path
B9	1,5	**	Path & dirt road
B10	1,3	***	Path & dirt road
B11	0,5	**	Path & dirt road
B12	0,6	*	Path
B13	1,3	**	Path
B14	0,8	**	Dirt road
B15	4,7	****	Dirt road
B16	1,0	***	Path

Source: Theoharis and Hortomaris, 2023

In order to make the routes more usable, they are supplemented with a special app and a web page (https://serresbikeroutes.eu), through which the user can explore the paths on digital maps or download the tracks of the paths in order to use them in his device (cyclocomputer, mobile phone, etc). In addition, these two platforms provide other useful information such as public bike repair spots, bike parking racks, bike shops and tourism attractions of Serres.

The Municipality of Serres in order to promote the works of the project to the public and to raise the awareness of the path network to the locals organized a two days international MTB competition in September of 2023 and various conferences and seminars through the whole duration of the project. Both activities attracted the interest of the participants and most of them claimed that either they could come again in Serres to compete in a cycling event or they would encourage the promotion of the infrastructure.

3.2 The case of Kerkini project

Another project in the region of Serres, integrating cycling into nature was held in the greater area of Kerkini lake under the name of “Utilizing TOGETHER cycling tourism and hiking in 4 seasons”. The concept of this project is similar with the BIKE CITIES, with the difference that it is still in progress, so the final outcome of it is not available yet. The partnership was between the following institutions: Development Agency of Serres, Development Agency of Larissa (Greek partners) and Mixed Syndicate for Development and Equipment of Mont Ventoux, France. The EU funded project around the Kerkini lake was an initiative that engaged three similar areas (Serres and Larissa in Greece, Mont Ventoux in France) in order to utilize cyclo-tourism and hiking potential to develop entrepreneurship as well as to increase the number of visitors all year long in an eco-friendly way. The consortium worked together for a long period to explore the current situation on field, to observe the potential of the specific areas and to suggest how to implement strategies and policies to improve the desired infrastructures for cycling and hiking tourism. The study of the project logged 10 routes, including four MTB paths. According to the study, those are the most identical and attract various visitors throughout the whole year. Additionally, the research suggested two more routes, one hiking path and one cycling route in order to be developed further in the near future. These two routes already draw the most attention of the visitors, either hikers or cyclists. The following table depicts data regarding these two routes.

Table 2: Paths mapped within Kerkini project

Path code	Length (km)	difficulty	type
D1 Ano Poroia Mavi Giol	10,2	Hard	Hiking Steep slopes, Marked path
Tour of Kerkini	58,0	Hard	Cycling Dirt road & asphalt Non marked

Source: Hortomaris, 2023

The Kerkini project, similarly to BIKE CITIES, included various field visits and seminars in order to collect the demands of the local community, local entrepreneurs and visitors. Moreover, workshops were organized regarding the potential of the suggested routes and the possibilities of receiving funds in order to implement these. Moreover, the consortium of Kerkini lake project suggested that after the creation of the adequate infrastructure (mapped routes with signs, creation of a useful digital information platform, etc.), the best way to promote it would be to organize various events and happenings around the cycling routes and paths that could inform the greater (cycling) community about the infrastructure in place.

4. Empirical Results

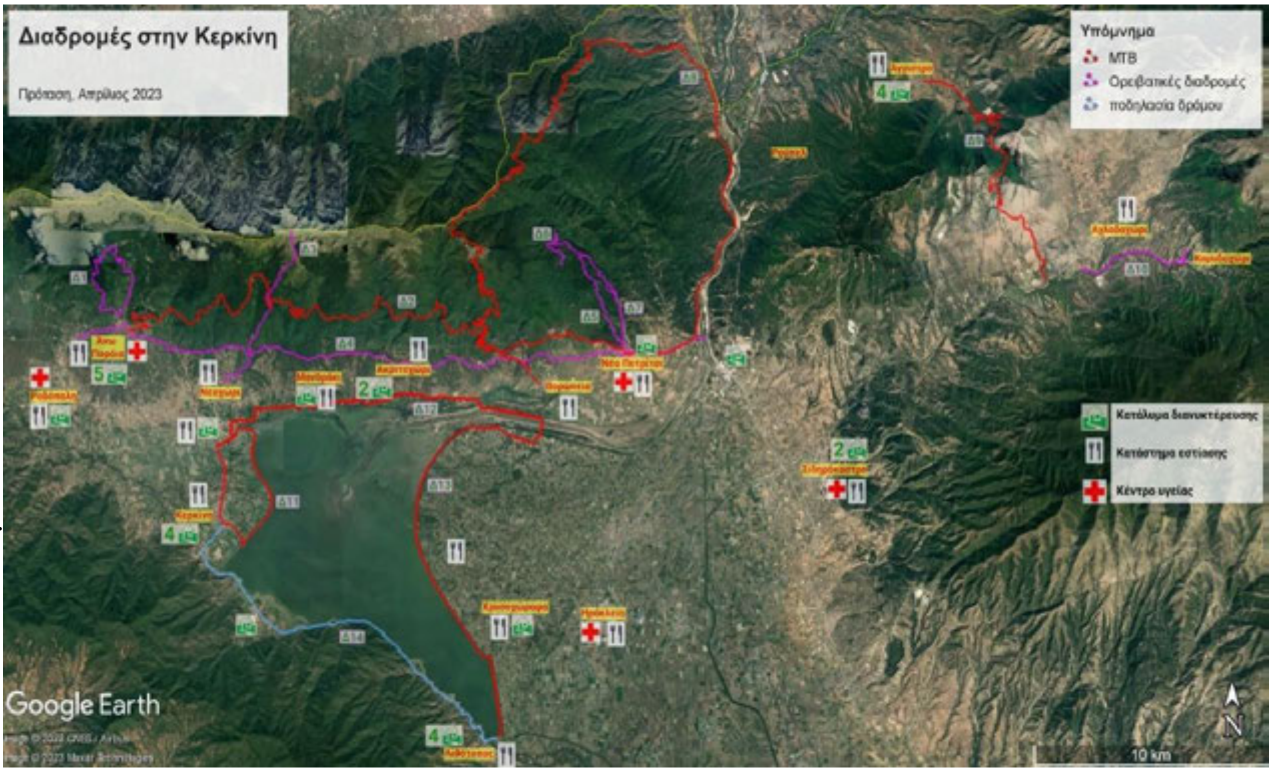
The two case-studies provided detailed studies of cycling paths with technical characteristics and useful sport tourism related information. The studies elaborated permitted field works for the upgrade of existing paths and especially in the case of the peri-urban forest of Serres, works included field restoration, path deliberation of obstacles and installation of appropriate signs with a twofold purpose: orientation of ordinary users and sports event organization milestones. The works and equipment installation aimed at a minimum environmental footprint and they took place under the supervision of competent local authorities. Bike Cities project resulted to a certified network of multipurpose paths around Serres that aims not only the tourists but the locals too. Maps, *.gpx tracks and special app for the routes help all users to obtain a better and safer outdoor experience. Additional equipment was installed within the project, such as the bike repair spots and bike racks in neighboring urban parts of Serres. Fig. 1 presents a map of Bike Cities project, deducted by the relevant study in Greek.

When it comes to the Kerkini project, so far a preliminary study of the greater area of Kerkini Lake is available, presenting the current situation in infrastructure and other touristic data. In addition, it includes two suggested routes (one for hiking and one for cycling) that should be implemented as soon as there exist a possibility for funds.

As already mentioned, the above information is available through the project website and through various bikers-oriented webpages and platforms Accordingly, in Fig.2 the routes in Kerkini lake surroundings are illustrated. More results are expected by the assessment of the Serres paths usage and the completion of Kerkini project.

Figure 1: Map of cycling paths in Serres periurban forest

Figure 2: Map of cycling paths in Kerkini lake surroundings



5. Discussion – Conclusions

Increasingly strong evidence is revealing that introducing appropriate signage, local facilities (bicycle racks, etc), dedicated and high-quality cycle paths, comprehensive networks, and traffic calming measures leads to an increase in cycling and such infrastructure improvements may work best when combined with actions at other levels (Logan et al, 2023). There is also a substantial body of evidence emerging, demonstrating the consistently positive effects of bicycle sharing schemes at wider community and city levels. However, it is important to recognize, that "Infrastructure is generally regarded as necessary but not sufficient to boost cycling" (Fell and Kivinen, 2016), thus the work so far performed within Serres and the recent initiatives in its peri-urban environment is not negligible but should be continued, assessed and enriched.

A success indicator of the Serres project that should be acknowledged was the achievement of local authorities accompanied by local stakeholders and national Cycling Association to include a local event within the international calendar of the International Cyclists Union, that permitted the first use of the recently upgraded and mapped paths and made Serres an actual sport tourism destination in September 2023.

Of course, field and digital services are useful but to make the most of local potential, fruitful synergies are required. It is highly recommended to work more closely with local academia and local HORECA industry representatives. Fostering cooperation with local Faculty of Physical Education and Sports Science of the Aristotle University of Thessaloniki or the International Hellenic University (Serres Campus) given their expertise in tourism management, promise a broader reach-out and further achievements.

To conclude, this work was only the first step, presenting the field intervention, mapping of cycling paths into nature in particular, which calls for an appropriate follow-up: what needs to be done is an assessment of the paths by the end-users and of course, their getting broadly known, used and appreciated. To overcome main barriers to cycling, local authorities should operate on both environmental and individual levels (Logan et al., 2023). There is a need for integrated approaches to encourage utilitarian cycling in combination with cycling for fun beyond the built environment, in more appealing open-air spaces. Of course, the sustainable target to maximize uptake of cycling requires efforts on the promotion of cycling as an everyday (useful, enjoyable and social) activity, however, integrating cycling into nature nearby urban settings will be of a remarkable added value for the local community and economy.

A multi-faceted strategy is therefore needed to overcome barriers to cycling and a well-conceived place marketing approach targeting different population groups in different contexts aiming at creating a bike city identity and eventually forming a sports tourism destination. As stated by Pucher et al. (2010) what will be needed to best promote cycling is "a coordinated package of complementary infrastructure measures, programs and policies" addressing both urban and peri-urban areas respecting sustainability.

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Investigation of bicycle travel conditions in the cities of Thessaloniki and Lamia

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Abstract
This study examines the bicycle travel conditions in the cities of Thessaloniki and Lamia in Greece, through a questionnaire survey with 220 participants, 110 in each examined city. The questionnaire is formed of 20 questions, it was distributed in person during the months January and February 2023 and the participants answered the questions anonymously.
The study focuses on the bicycle ownership, the use of shared bicycles, the frequency of bicycle usage during the examined time period (the last months before the study) and the time period of Covid-19 pandemic restrictive measures that implemented in Greece. Furthermore, it examines the existence and use of cycling infrastructure in the examined cities, and the level of bicyclists' safety during daytime and nighttime both on bikeways and urban roads. More questions focus on the construction or expansion of the cycling infrastructure, and the selection of bicycle as a transport mode for daily urban trips in relation to the improvement of cycling infrastructure and travel conditions, and the impact of energy crisis and cost of living. Finally, the participants were asked about their knowledge of the Greek Highway Code related to bicycle use.
The results of this study can contribute to the understanding and improvement of the bicycle travel conditions in the examined cities.

Keywords: Transportation; Bicycle; Cycling infrastructure; Safety; Travel conditions.

JEL Codes: O18; R41.

1. Introduction

Bicycle is a sustainable transport mode and transportation planning efforts are in favor of increasing the level of bicycling. The intension is to increase commuters' willingness to use their bicycle and reduce car usage for their daily urban trips, thus increasing the sustainability level of an area or a city. Commuting by bicycle has advantages both for commuters and for society, comparing to other transport modes, and it is important to identify the determinants for commuting by bicycle (Heinen et al., 2010). Research reveals that there are strong effects of individual attitudes and physical and social environment factors on bicycle ownership and use (Handy et al., 2010). Moreover, users' perceptions are key elements to understand bicycle use, and there are factors linked to individual perceptions (Fernández-Heredia et al., 2016). Bicycle infrastructure must provide a safe environment for its users (DiGioia et al, 2017). The improvement of bicyclists' urban road environment and travel conditions is important in order to increase bicycle usage and improve bicyclists' level of safety, and the evaluation of the bikeability of selected routes or a city is important in order to achieve that goal (Eliou et al., 2009; Galanis et al, 2014).

The Covid-19 pandemic affected urban mobility, and bicycling was one of the transport modes that enjoyed attention (Nikitas et al., 2021; Kraus and Koch, 2021; Schwarz et al., 2022). Furthermore, the increased cost of living acts as a motivation factor in order to change transportation habits in favor of walking, bicycling, and public transportation. Greece is a country that suffered economic depression in previous years, and research revealed that people were willing to increase use of sustainable transport modes in order to reduce the transport cost (Galanis et al., 2017).

2. Methodology and Data Collection

This paper examines the bicycle travel conditions in the cities of Thessaloniki and Lamia in Greece, through a questionnaire survey. A total of 220 respondents engaged in the survey, 110 in Thessaloniki and 110 in Lamia. The questionnaire is formed of 20 questions, it was distributed face-to-face during the months of January and February 2023 within both cities under examination, ensuring anonymity of responses, thus encouraging open and unbiased feedback.

The questionnaire comprised five distinct sections delineated for systematic inquiry. The initial section (questions 1-4) was designed to elicit demographic information from participants. Subsequently, the second section (questions 5-10) focused on aspects related to bicycle ownership, utilization of shared bicycle schemes within urban locales, frequency of bicycle usage during the examined timeframe (specifically, the preceding months leading up to the survey), and during periods marked by Covid-19 pandemic-induced restrictive measures in Greece. The third section (questions 11-16) scrutinized the presence and utilization of cycling infrastructure, alongside assessing bicyclists' perceptions of safety during both daytime and nighttime traversals on dedicated bikeways and urban thoroughfares within the surveyed municipalities. The fourth section (questions 17-19) centered on participants' perspectives regarding the necessity for, and potential expansion of, cycling infrastructure within urban environments, considering factors such as daily commute mode selection, infrastructure enhancement initiatives, and the broader socioeconomic context encompassing energy scarcity and rising living costs. Finally, the fifth section (question 20) probed respondents' familiarity with Greek Highway Code regulations pertinent to bicycle operation.

Upon completion of data collection, subsequent steps involved data analysis and the extraction of results and conclusions. Utilizing Microsoft Excel, the data underwent analysis employing descriptive statistical methods.

3. Results

The results of the survey are presented in the following Figures 1-4. In Figure 1, are presented the demographic characteristics of the participants (gender, age, education, and profession), (questions 1-4). In Figure 2, are presented the results of the questions 5-10 about bicycle ownership and use, and the examination of bicycle usage in relation to Covid-19 pandemic. In Figure 3, the results of the questions 11-16 about cycling infrastructure existence and usage, and bicyclists' level of safety are illustrated. In Figure 4, are presented the results of the questions 17-19 about the cycling infrastructure construction or expansion, and bicycle use in relation to various factors. Finally, in Figure 5, the results of the question 20 about Highway Code knowledge regarding bicycle use are illustrated.

It should be noted that the high bicycle ownership rates (Figure 2, Q5) are attributable to the fact that the question concerned (and thus included) ownership by both the respondent and any other member of their household of any type of bicycle.

Figure 1: Demographic characteristics of participants (questions 1-4)

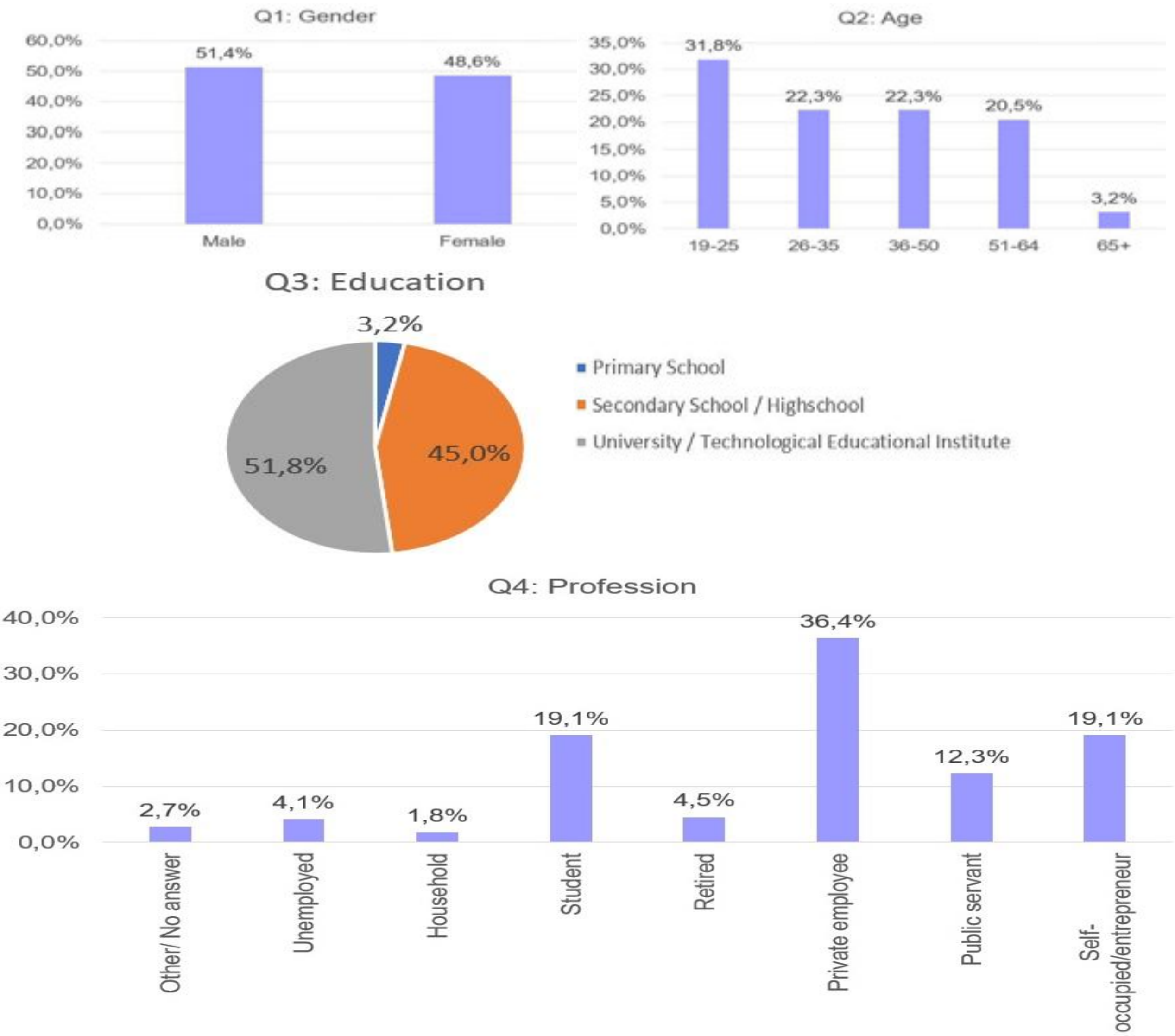
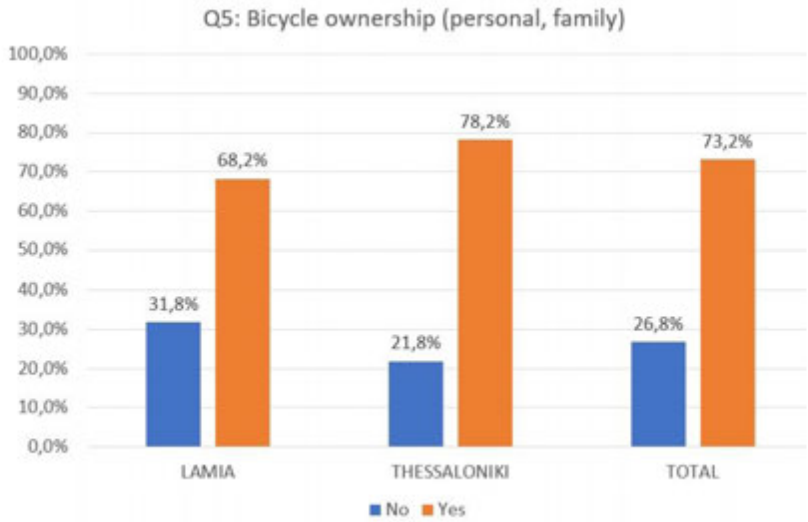
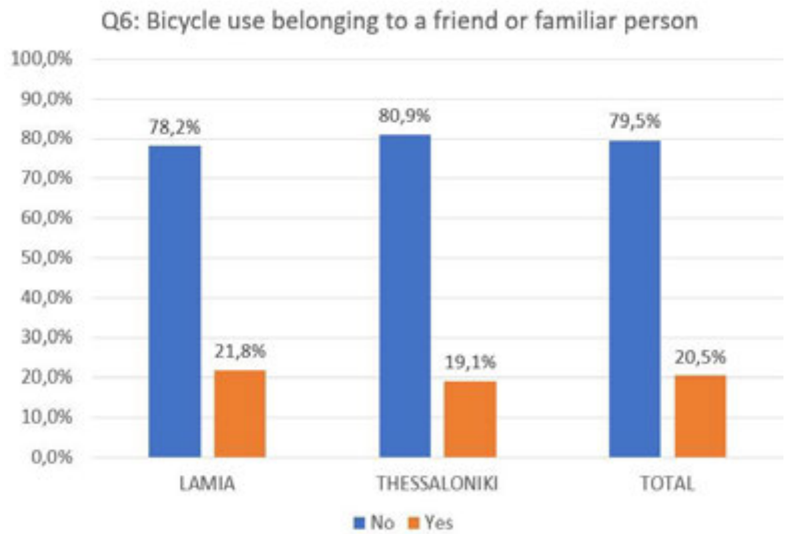
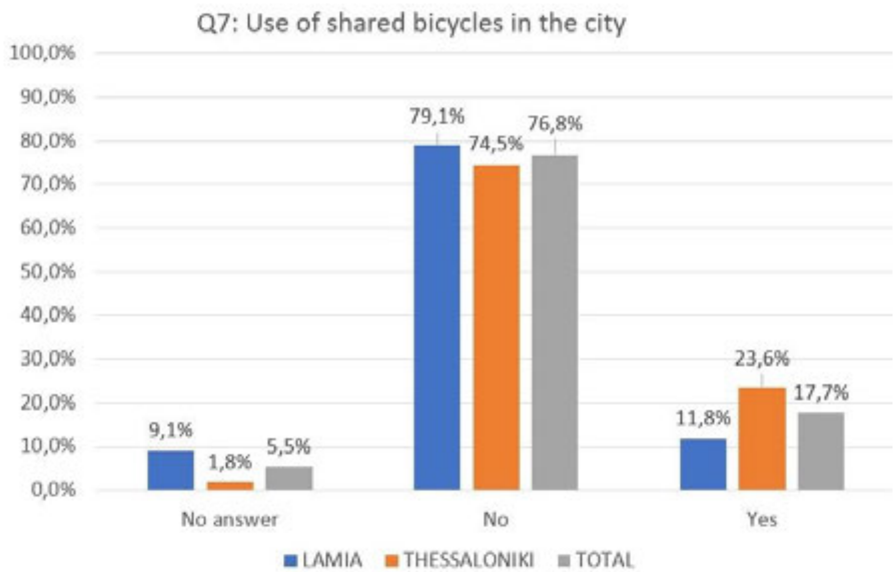
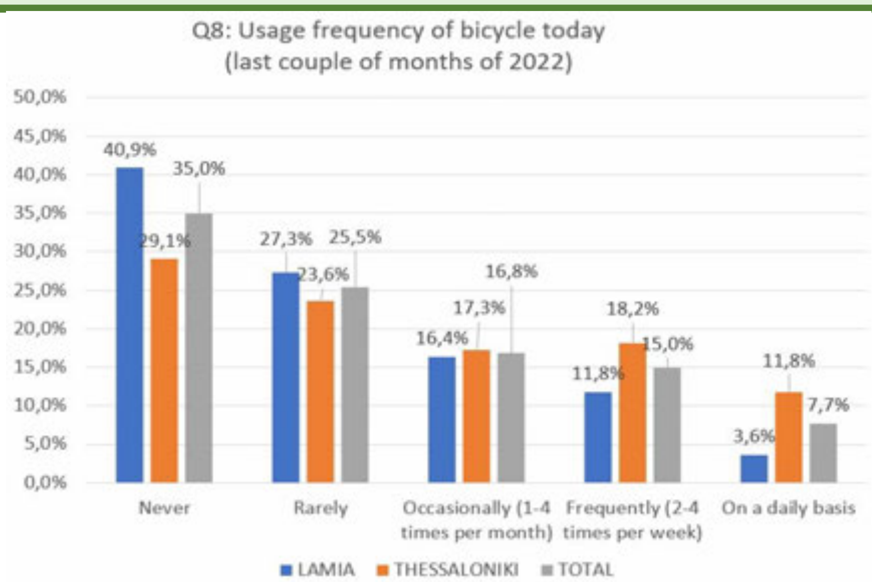


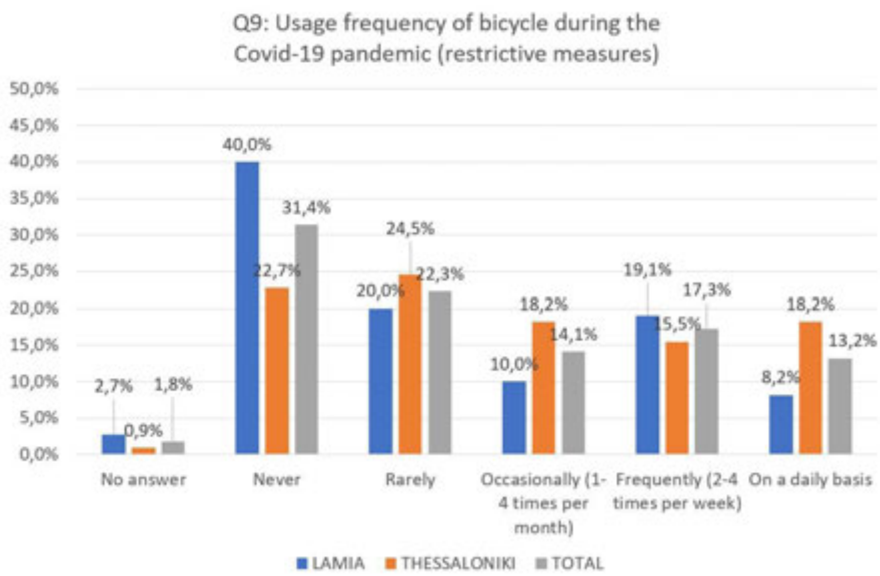
Figure 2: Bicycle ownership and use (questions 5-10)








Q8: Usage frequency of bicycle today
(last couple of months of 2022)
50,0%
45,0%
40,0%
35,0%
30,0%
25,0%
20,0%
15,0%
10,0%
5,0%
0,0%
40,9%
29,1%
35,0%
27,3%
23,6%
25,5%
16,4%
17,3%
16,8%
11,8%
18,2%
15,0%
3,6%
11,8%
7,7%
Never
Rarely
Occasionally (1-4 times per month)
Frequently (2-4 times per week)
On a daily basis
LAMIA
THESSALONIKI
TOTAL


Q9: Usage frequency of bicycle during the
Covid-19 pandemic (restrictive measures)
50,0%
45,0%
40,0%
35,0%
30,0%
25,0%
20,0%
15,0%
10,0%
5,0%
0,0%
2,7%
0,9%
1,8%
40,0%
22,7%
31,4%
20,0%
24,5%
22,3%
10,0%
18,2%
14,1%
19,1%
15,5%
17,3%
8,2%
18,2%
13,2%
No answer
Never
Rarely
Occasionally (1-4 times per month)
Frequently (2-4 times per week)
On a daily basis
LAMIA
THESSALONIKI
TOTAL

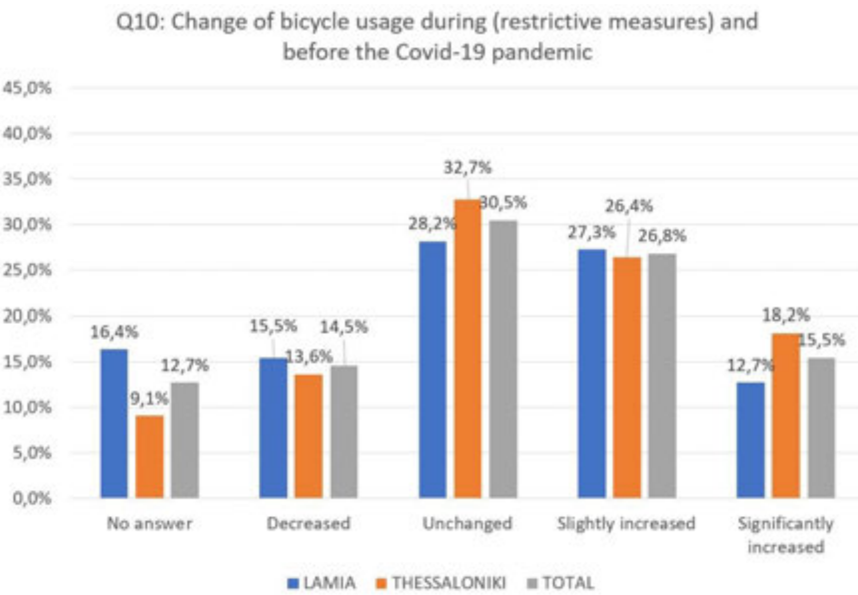
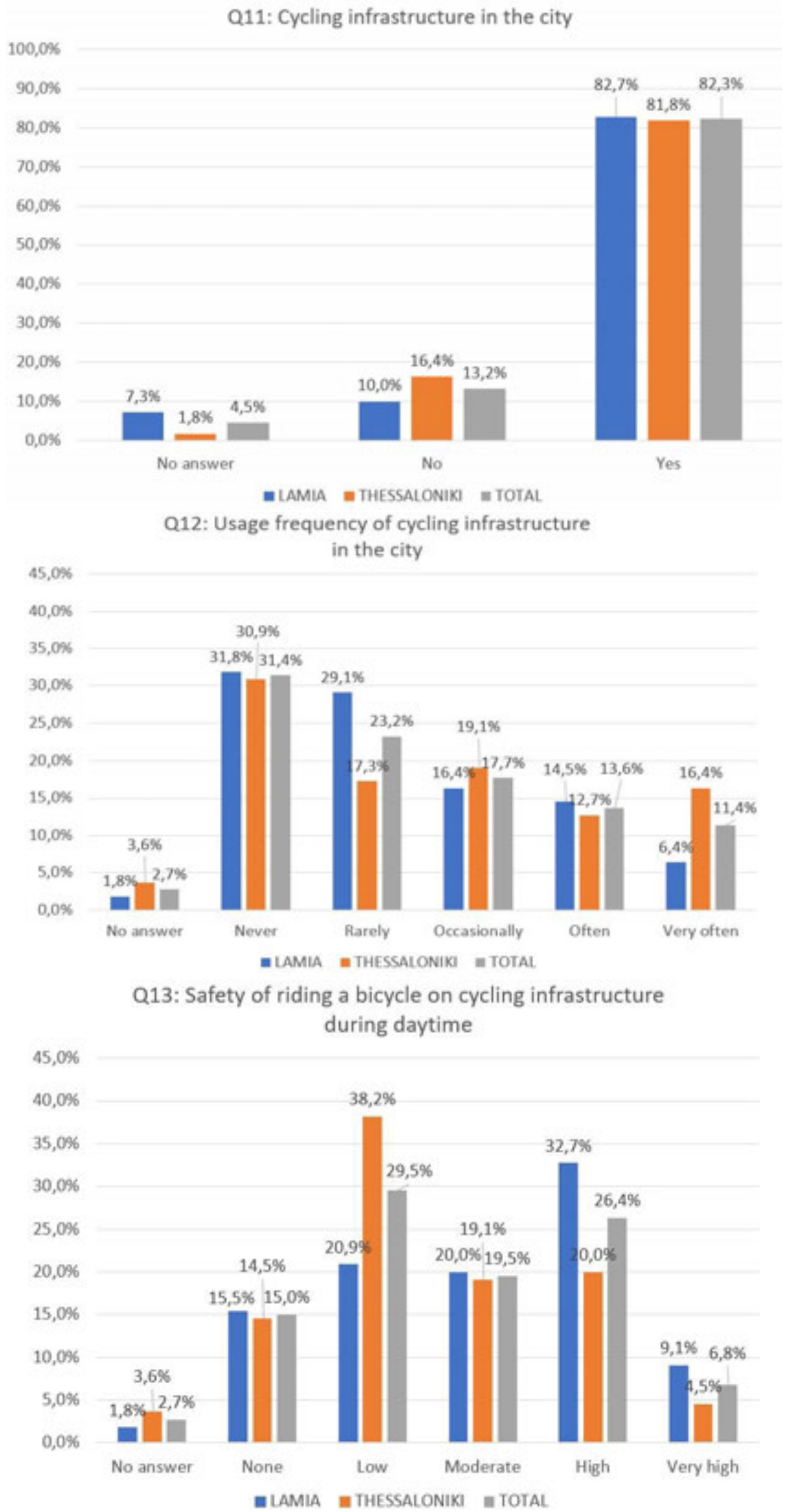
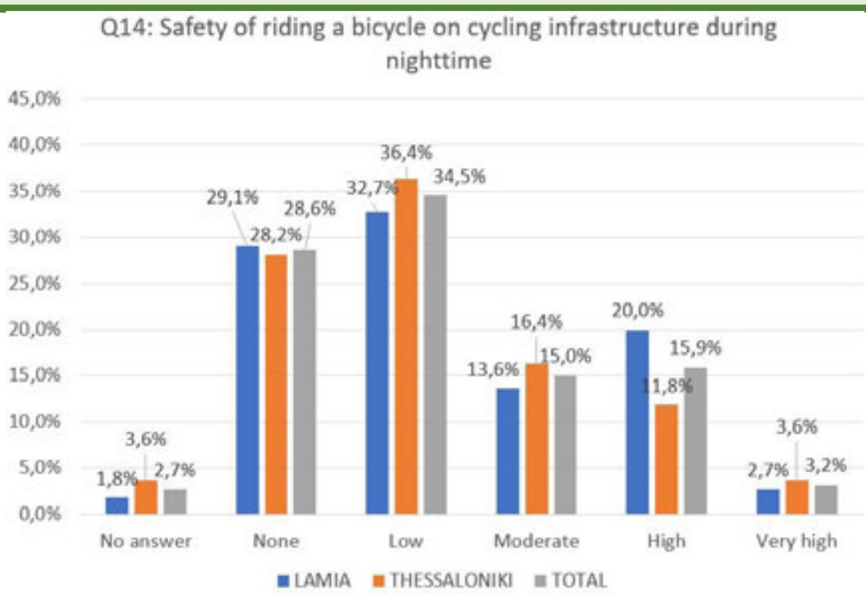
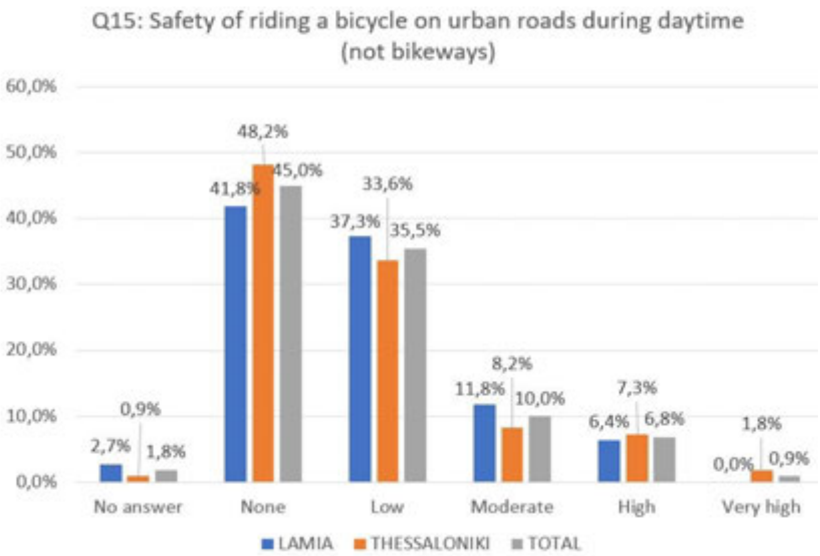

Q10: Change of bicycle usage during (restrictive measures) and
before the Covid-19 pandemic
45,0%
40,0%
35,0%
30,0%
25,0%
20,0%
15,0%
10,0%
5,0%
0,0%
16,4%
9,1%
12,7%
15,5%
13,6%
14,5%
28,2%
32,7%
30,5%
27,3%
26,4%
26,8%
12,7%
18,2%
15,5%
No answer
Decreased
Unchanged
Slightly increased
Significantly increased
LAMIA
THESSALONIKI
TOTAL

Figure 3: Cycling infrastructure and bicyclists' level of safety (questions 11-16)




Q14: Safety of riding a bicycle on cycling infrastructure during nighttime
45,0%
40,0%
35,0%
30,0%
25,0%
20,0%
15,0%
10,0%
5,0%
0,0%
1,8%
3,6%
2,7%
29,1%
28,2%
28,6%
32,7%
36,4%
34,5%
13,6%
16,4%
15,0%
20,0%
11,8%
15,9%
2,7%
3,6%
3,2%
No answer
None
Low
Moderate
High
Very high
LAMIA
THESSALONIKI
TOTAL


Q15: Safety of riding a bicycle on urban roads during daytime (not bikeways)
60,0%
50,0%
40,0%
30,0%
20,0%
10,0%
0,0%
2,7%
0,9%
1,8%
41,8%
48,2%
45,0%
37,3%
33,6%
35,5%
11,8%
8,2%
10,0%
6,4%
7,3%
6,8%
0,0%
1,8%
0,9%
No answer
None
Low
Moderate
High
Very high
LAMIA
THESSALONIKI
TOTAL

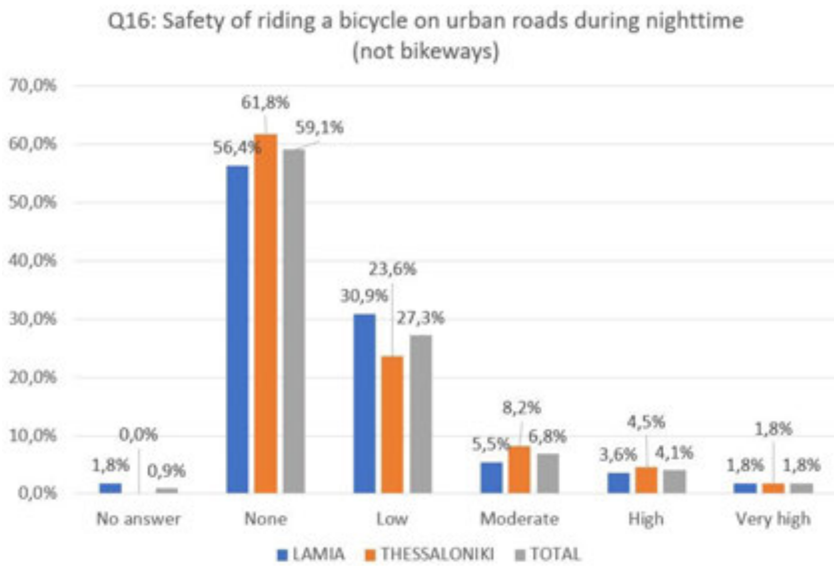

Q16: Safety of riding a bicycle on urban roads during nighttime (not bikeways)
70,0%
60,0%
50,0%
40,0%
30,0%
20,0%
10,0%
0,0%
1,8%
0,0%
0,9%
56,4%
61,8%
59,1%
30,9%
23,6%
27,3%
5,5%
8,2%
6,8%
3,6%
4,5%
4,1%
1,8%
1,8%
1,8%
No answer
None
Low
Moderate
High
Very high
LAMIA
THESSALONIKI
TOTAL

Figure 4: Cycling infrastructure construction /expansion, and bicycle use in relation to various factors (questions 17-19)

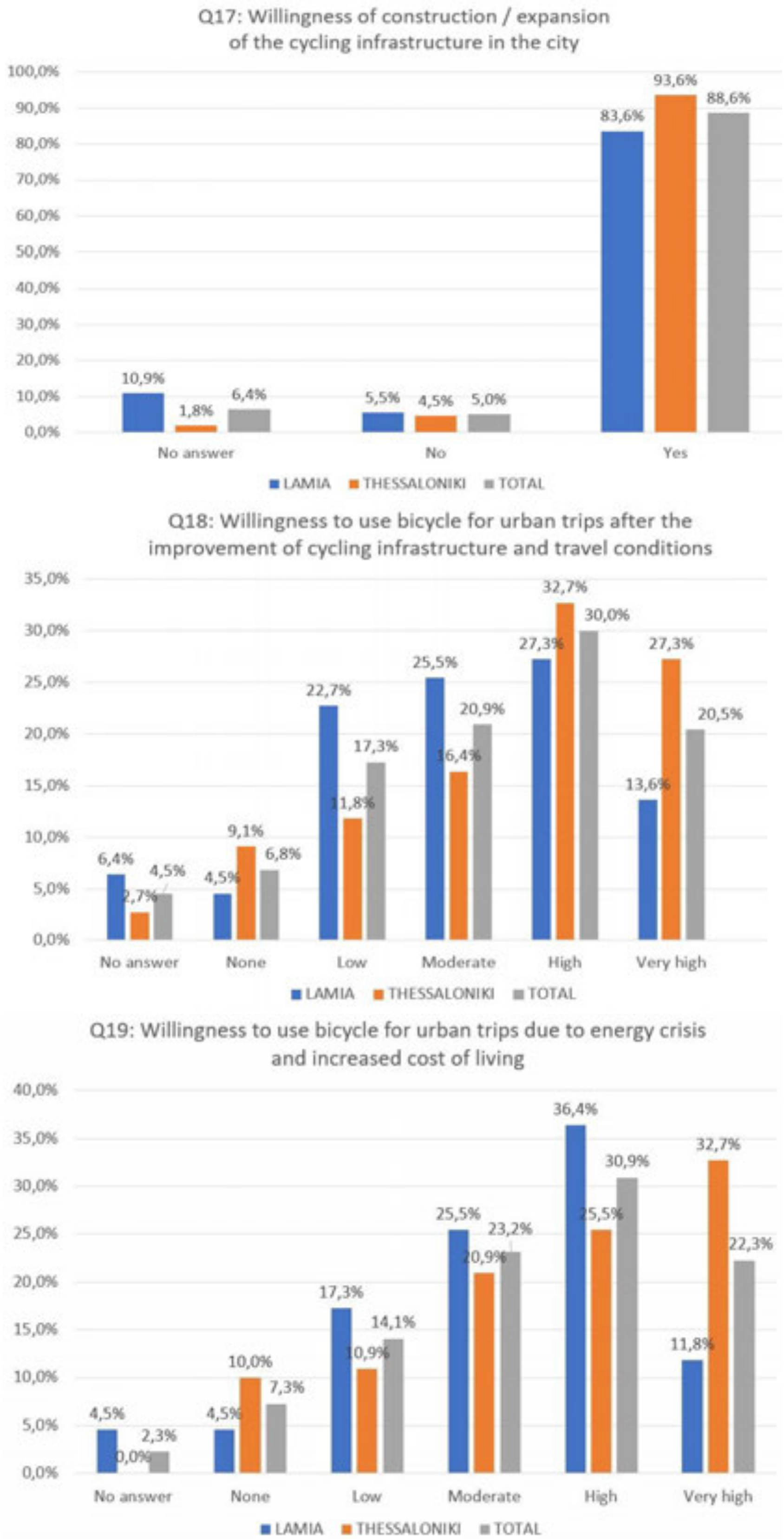
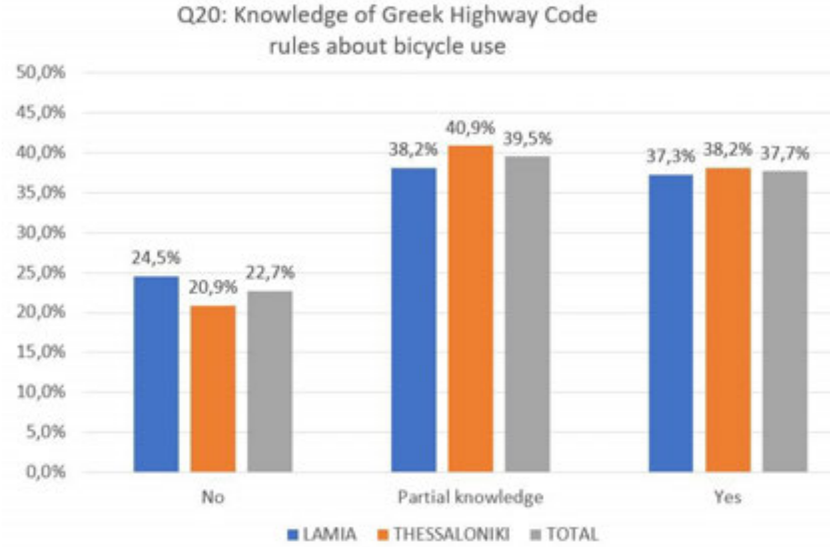


Figure 5: Highway Code knowledge about bicycle use (questions 20)



4. Conclusions

This study examines the bicycle travel conditions in the cities of Thessaloniki and Lamia in Greece, through a questionnaire survey. The main conclusions are the following:

- High level of bicycle ownership (personal, family): 73,2%.
- Low level of shared bicycles usage in the cities: 17,7%.
- Low usage frequency of bicycle (last couple of months of 2022): never (35%), rarely (25,5), occasionally (16,8%), frequently (15%), daily (7,7%).
- Slightly increased usage frequency of bicycle during the Covid-19 pandemic (restrictive measures): no answer (1,8%), never (31,4%), rarely (22,3%), occasionally (14,1%), frequently (17,3%), daily (13,2%).
- Noticeable change of bicycle usage comparing the periods during (restrictive measures) and before the Covid-19 pandemic: slightly increased (26,8%), significantly increased (15,5%).
- Low level of usage frequency of cycling infrastructure in the cities: no answer (2,7%), never (31,4%), rarely (23,2%), occasionally (17,7%), often (13,6%), very often (11,4%).
- Moderate level of safety riding a bicycle on cycling infrastructure during daytime: 44,5% (none and low), 19,5% (moderate).
- Low level of safety riding a bicycle on cycling infrastructure during nighttime: 63,1% (none and low), 15% (moderate).
- Low level of safety riding a bicycle on urban roads (not bikeways) during daytime: 80,5% (none and low), 10% (moderate).
- Very low level of safety riding a bicycle on urban roads (not bikeways) during nighttime: 86,4% (none and low), 6,8% (moderate)
- Very high level of willingness for construction/expansion of the cycling infrastructure in the cities: 88,6%
- Noticeable willingness to use bicycle for urban trips after the improvement of cycling infrastructure and travel conditions in both cities: 50,5% (high and very high).
- Noticeable willingness to use bicycle for urban trips due to energy crisis and increased cost of living: 53,2% (high and very high).

- Noticeable lack of knowledge of the Greek Highway Code rules about bicycle use: no knowledge (22,7%), partial knowledge (39,5%).

The bicycle represents a sustainable mode of transport, aligning with contemporary efforts to mitigate environmental impact and promote healthier lifestyles. The ongoing endeavor to enhance its safe integration into daily urban commuting necessitates persistent attention. This paper endeavors to elucidate factors influencing the safety and convenience of bicycle travel within urban environments. Through rigorous analysis of various parameters such as infrastructure, traffic patterns, and user behaviors, this research aims to provide insights that can inform policy decisions and infrastructure improvements. By fostering a deeper understanding of the dynamics surrounding bicycle transportation, advancements towards more sustainable urban mobility can be realized.

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Predicting the Societal Acceptance of Mega Road Infrastructure Projects in Greece: A Statistical Model Anchored in Sustainable Development Principles

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Abstract
Mega road infrastructure projects and their impact on sustainable development in Greece are examined in this paper. Research focuses on four major road megaprojects: Attiki Odos, Egnatia Odos, Ionia Odos, and Olympia Odos. Utilising a novel statistical model based on the triad of Economy, Environment, and Society, the study aims to forecast societal acceptance of these projects. Data was gathered through questionnaires and archival research. The statistical model employs equations tailored to predict societal perspectives using indicators of economic, social, and environmental sustainability. Empirical findings corroborate that these projects stimulate regional development and employment (Aschauer, 1989; Bannister & Berechman, 2000), enhance public services and quality of life, albeit unevenly across communities, and pose challenges like ecological degradation and carbon emissions (Litman, 2013; Richardson & Bae, 2004). The model reveals a societal paradox: while long-term economic and social gains are acknowledged, reservations about environmental and social sustainability persist, aligning with Flyvbjerg's "iron law of megaprojects" (Flyvbjerg, 2014). The paper advocates for integrated planning, where societal perspectives are central to aligning infrastructure projects with sustainable development goals (WCED, 1987). By applying a statistical model to forecast societal acceptance, the research fills a criticalacademic research gap, providing invaluable insights for policymakers and planners for a balanced approach to future infrastructure projects.

Keywords: *RoadProjects, Mega Infrastructure Projects, Sustainable Development, Societal Acceptance, Greece*

JEL Codes: Q01; Q50; Q56; R11; R40; R42;

The Role of Big Data in Environmental Sustainability of Aviation: A Literature Review

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Abstract

This paper offers a comprehensive literature review on the critical role of big data in advancing environmental sustainability in the aviation industry. It explores the sector's use of big data to address major environmental challenges, such as reducing carbon emissions, minimising noise pollution, and optimising energy consumption. The review highlights the potential of big-data analytics in supporting strategic decision-making processes, emphasising its utility in addressing environmental and social issues in aviation. Moreover, it critically examines the inherent challenges and ethical considerations associated with the implementation of big data solutions in this sector, including technical complexities, financial constraints, and regulatory barriers, while also addressing the pivotal issues of data privacy and security. The paper concludes with an insightful discussion on emerging trends and future innovations in big data, emphasizing their potential impact on aviation's environmental sustainability and indicating directions for future research and development.

Keywords: Aviation; Environmental Sustainability; Big Data

JEL Codes: Q55; Q58; Q54; Q56; C55; L93

1. Introduction

The aviation industry is a cornerstone of global transportation and economic development, playing a vital role in our interconnected world (Singh et al., 2022). Yet, its contribution to environmental issues, such as carbon emissions, noise pollution, and high energy consumption, cannot be overlooked (Lee et al., 2009). In recent years, the focus on the environmental sustainability of the aviation sector has intensified, reflecting a growing recognition of its significance in the broader context of climate change (Yildiz et al., 2022). The industry's rapid expansion, coupled with its notable impact on global warming, underscores the critical need for sustainable initiatives. This is especially pressing given projections of annual industry growth rates of 4-5% over the next two decades (Dray & Schäfer, 2023).

Concurrently, big data technologies have emerged as a groundbreaking force across numerous sectors, including aviation. These technologies have not only revolutionised the way airports and airlines manage their operations, contributing to more efficient flights and better passenger experience, but also hold the promise of significantly advancing sustainable practices in the industry (Dou, 2020). The potential of big data to drive environmental sustainability in aviation offers a compelling area of study, particularly in its applications for reducing the sector's ecological footprint.

Thus, the primary objective of this paper is to investigate how big data can be leveraged to bolster environmental sustainability in aviation. Through an extensive literature review, this paper delves into the specific applications of big data in promoting sustainable practices within the industry. The aim is to unearth and discuss potential strategies and initiatives that could mitigate the environmental impact of aviation operations. This exploration is anchored in the hypothesis that big data when effectively leveraged, can play a critical role in enhancing the environmental sustainability of the aviation sector.

2. Environmental Challenges in Aviation

The environmental challenges faced by the aviation sector are well-documented and include both local and global impacts. Locally, aviation contributes to air and noise pollution, adversely affecting the health and well-being of communities near airports. On a global scale, aviation is a substantial contributor to greenhouse gas emissions, exacerbating climate change and its associated impacts.

2.1 Air Pollution

Aviation-induced air pollution stems from various pollutants, notably carbon dioxide (CO2), nitrogen oxides (NOx), sulphur oxides (SO2), ground-level ozone (O3), and particulate matter (PM). These pollutants degrade air quality and are linked to respiratory diseases, cardiovascular issues, and premature mortality. While a significant portion of these emissions originates from airport operations, including aircraft engines and ground support equipment, emissions from surface access road transport and on-site energy generation also contribute notably to air quality degradation in the vicinity of airports (EASA, 2023a).

2.2 Climate Change

Aviation is among the fastest-growing sources of greenhouse gas emissions, primarily from its dependence on fossil fuels. The combustion of jet fuel, predominantly releasing CO2, significantly contributes to the Earth's atmospheric warming and exacerbates climate change. The International Energy Agency (IEA) reported in 2023 that aviation accounted for 2% of global energy-related CO2 emissions in 2022, marking the sector as having one of the fastest rates of increase compared to other transportation modes (IEA, 2023).

2.3 Noise Pollution

Noise pollution is another critical environmental challenge associated with aviation. Aircraft noise significantly contributes to stress, annoyance, and sleep disturbances in residential communities near airports. Research has linked aviation noise to a higher risk of heart disease, premature mortality from ischemic heart disease, and learning impairments in children (EASA, 2023b). The sources of noise include aircraft engines and ground support operations at airports.

2.4 Use of resources

The aviation industry is also a major consumer of non-renewable resources, such as fuel and water. The burgeoning demand for air travel and sector growth has led to escalated fuel consumption, primarily fossil fuels, resulting in resource depletion and environmental degradation. This consumption exacerbates climate change and water scarcity challenges. Effective water management practices are vital in airports, particularly in regions with limited water resources or competing local community needs. Additionally, safeguarding water quality from fuel leaks and spillages is crucial. The construction and expansion of airports also entail substantial land and natural resource use, potentially causing habitat destruction, deforestation, and biodiversity loss (Aydin et al., 2021).

2.5 Waste Production

Aviation activities generate significant amounts of waste, including solid waste, wastewater, and hazardous materials. This waste encompasses materials from in-flight services, waste produced at the airport terminals, and waste resulting from the construction of new airport infrastructure. Efficient waste management, emphasizing recycling and reuse, is crucial in airport operations (Civil Aviation Authority, 2023).

2.6 A brief history of sustainability efforts in aviation

The aviation industry has progressively intensified its sustainability efforts in response to its substantial environmental impact. A key focus has been on reducing greenhouse gas emissions, especially carbon dioxide (CO2), which is primarily emitted during aircraft operations. The sector has been actively pursuing the development and implementation of sustainable aviation fuels, alongside exploring innovative technologies, to mitigate these emissions (Aydin, 2021; Abrantes et al., 2021).

Improvements in aircraft design, notably through the integration of lightweight materials, have further contributed to reducing the industry's carbon footprint (Abrantes, 2024). In parallel, significant strides have been made in reducing noise pollution. These include the adoption of advanced engine technologies and the optimisation of flight paths, thereby diminishing noise impact on communities near airports (Khardi, 2013).

Sustainability in the aviation industry is increasingly quantified and validated through various programs and certifications. These accreditations are designed to both recognise and incentivise airlines and airports that exhibit a strong commitment to environmental sustainability. One prominent accreditation for airports is the Airport Carbon Accreditation (ACA) Programme. This program specifically focuses on evaluating and acknowledging the efforts of airports to manage and reduce their carbon emissions. As of November 2021, the ACA Programme had included 362 airports worldwide, illustrating its global impact and recognition (EASA, 2023c).

In addition, the role of international bodies and organizations is instrumental in shaping the sustainable future of aviation. The International Civil Aviation Organization (ICAO) and the Airports Council International (ACI), along with various Environmental Non-Governmental Organizations (NGOs), are pivotal in establishing standards and guidelines for sustainable practices within the industry. Their collective efforts ensure a cohesive and comprehensive approach towards reducing the environmental footprint of aviation, promoting a sustainable trajectory for the entire sector.

3. Big Data in Aviation: An Overview

Big Data has emerged as a transformative tool in various industries. It refers to the enormous and complex datasets that traditional data processing software cannot adequately handle. These datasets include structured, unstructured, and semi-structured data, offering insights and patterns that are invaluable for decision-making. In academia, big data is often characterised by the 4Vs: Volume, Velocity, Variety, and Veracity. 'Volume' ' pertains to the sheer amount of data generated from various sources such as sensors, social media, and transaction records. 'Velocity' refers to the speed at which this data is generated and processed, often requiring real-time or near-real-time handling. 'Variety' points to the different types of data, including text, images, videos, and sensor data, while 'Veracity' centres on the accuracy and reliability of the data (Yang et al., 2016).

The transformative impact of big data is evident across multiple sectors. In healthcare, it has become instrumental for advanced patient care, enabling predictive analytics for disease trends, and fostering operational improvements in medical facilities (Raghupathi & Raghupathi, 2014). The finance sector has seen a revolution in decision-making processes, where big data aids in enriching information bases for forecasting, enhancing decision-making relevance, and building new competitive advantages (Ren, 2022). In education, big data technologies have found applications in performance prediction, attrition risk detection, data visualisation, intelligent feedback mechanisms, course recommendations, student skill estimation, behaviour analysis, student grouping and collaboration, and in the planning and scheduling of educational processes. This broad array of applications has empowered educational institutions to make more informed, efficient, and effective decisions, thereby improving both managerial functions and the educational process itself (Kalim, 2021). In the retail sector, big data is pivotal, especially in marketing and logistics functions. It supports business strategies aimed at cost reduction and differentiation through customer segmentation. Retailers leverage big data for targeted customer analytics, understanding client dynamics, adapting offerings, managing commercial channels, optimising firm processes, reducing operating costs, and forecasting budgets for new store openings. Retail firms also emphasise building skilled internal teams dedicated to data collection and analysis, highlighting the strategic importance of data for future business strategies (Santoro et al., 2018). Lastly, in logistics and supply chain management, big data analytics is extensively employed to enhance business performance. It provides invaluable insights into demand planning, procurement, production, inventory, and logistics, thereby offering a comprehensive view of supply chain operations (Wang et al., 2016).

Similarly, the aviation industry is also ripe with opportunities for leveraging big data. Airlines and airports, in particular, stand to benefit significantly from the wealth of data generated within the industry. This data, characterised by its large volume, diverse variety, high velocity, and complexity, includes elements such as flight paths, air traffic control communications, booking information, travel history, meteorological data, and more. By effectively harnessing the power of big data analytics, entities within the aviation industry can gain profound insights that can lead to substantial improvements in various operational aspects.

3.1 Big Data for Maintenance

One critical application area of big data is in the field of maintenance. By analysing data collected from sensors mounted on aircraft, airlines can identify patterns and anomalies indicative of potential maintenance issues. This proactive approach allows for timely maintenance interventions, significantly reducing the likelihood of unscheduled downtime and thereby enhancing overall operational efficiency and safety (Moftah Attia et al., 2022).

3.2 Big Data for Forecasting Passenger Demand

Another significant application of big data in aviation lies in forecasting passenger demand. By analysing historical passenger data, airlines and airports are able to predict future demand patterns with a greater degree of accuracy. This enables them to adjust their flight schedules and capacities, accordingly, leading to optimised operations and better resource management (Dou, 2020). Similarly, airports can employ big data analytics to optimise their resources and facilities, particularly during peak travel times, thereby enhancing the overall passenger experience.

3.3 Big Data for Flight Operations

Furthermore, big data analytics plays a crucial role in enhancing flight operations. Through the analysis of real-time flight data, airlines and air traffic control can make more informed decisions regarding flight routes, landing slots, and other key operational aspects. This not only contributes to more efficient and safer air travel but also enables airlines to reduce fuel consumption, thereby minimising their environmental impact (Dou, 2020).

3.4 Big Data for Customer Experience

Big data also plays a pivotal role in improving the customer experience within the aviation industry. By collecting and analysing data from various customer touchpoints, such as booking systems, customer feedback, and social media interactions, airlines and airports are able to gain valuable insights into customer preferences and behaviours. This, in turn, allows them to personalise their service offerings, provide tailored recommendations, and overall enhance the customer journey, making it more enjoyable and satisfying (Papagiannopoulos & Lopez, 2018; Narongou & Sun, 2021).

3.5 Big Data for Safety and Security

Lastly, big data contributes significantly to enhancing safety and security within the aviation industry. By analysing data from a variety of sources, such as flight records, maintenance logs, and security systems, airlines and aviation authorities can identify potential risks and vulnerabilities. This proactive approach allows for the implementation of measures to ensure the safety of passengers and prevent security threats, thereby maintaining high standards of safety and security in aviation operations (Mohamed & Al-Azab, 2021).

In summary, the role of big data in the aviation industry is multifaceted and crucial. It has the potential to revolutionise various aspects of the industry, including maintenance, forecasting passenger demand, flight operations, customer experience, and safety and security.

4. Big Data and Environmental Sustainability

The integration of big data in aviation operations not only revolutionises the industry but also significantly contributes, directly or indirectly, to its environmental sustainability. This section explores how current big data applications are being employed to enhance the environmental sustainability of aviation.

4.1 Weather Forecasting and Flight Planning

Effective weather forecasting and flight planning are crucial for optimising flight schedules and improving fuel efficiency. Big data analysis of macroeconomic and weather data, as noted by Moftah Attia et al. (2022), can refine forecasting of customer demand, enabling airlines to tailor flight schedules and capacities efficiently. Integrating real-time weather data into flight operations allows for route optimisation, avoiding adverse weather conditions, reducing flight delays, and enhancing overall safety (Goodman & Griswold, 2019). This approach leads to more fuel-efficient flight paths, indirectly contributing to reduced carbon emissions.

4.2 Maintenance and Fuel Efficiency

Big data analytics can also contribute to improving the maintenance and fuel efficiency of aircraft, thus reducing their environmental impact. By utilising sensor data and predictive maintenance models, airlines can detect potential equipment issues before they lead to major failures or disruptions (Ushakov et al., 2022). This proactive approach to maintenance can minimise the need for unscheduled repairs, reduce fuel wastage, and ultimately decrease carbon emissions.

4.3 Influencing Customer Behaviour

Airlines can utilise big data to shape customer behaviour towards more environmentally sustainable practices. By analysing passenger data, airlines can discern trends and preferences in sustainable travel. This insight enables targeted marketing campaigns to promote eco-friendly destinations or encourage participation in carbon offset programs (Mayer et al., 2014).

4.4 Pricing and Marketing

Through the analysis of customer behaviour, travel trends, and market demand, airlines can use big data to refine their pricing and marketing strategies in an environmentally conscious manner. Dynamic or continuous pricing models can be employed to maximise flight load factors (Alauddin & Ting, 2020), ensuring efficient use of fuel per passenger, and thereby reducing the overall environmental footprint (Payán-Sánchez et al., 2022).

4.5 Energy Consumption

Big data analytics offers significant benefits for airports, particularly in managing energy consumption. By analysing data from various airport systems, such as lighting, heating, and cooling, airports can pinpoint inefficiencies. Implementing corrective measures based on these insights can lead to significant energy savings and a reduction in the environmental impact (Huang et al., 2015)

4.6 Environmental Impact Assessment

Big data analytics is instrumental in assessing and predicting the environmental impact of aviation operations. By collating and analysing data on air and noise pollution, a comprehensive understanding of the sustainability of aviation practices can be developed (Wan et al., 2020; Pretto et al., 2020). This assessment is crucial for devising strategies to mitigate environmental impacts.

4.7 Construction Monitoring

In the context of airport infrastructure development, big data analytics can be utilised effectively in construction monitoring. The deployment of systems like MONVID 1.0, developed by Kang et al. (2021), exemplifies the use of real-time automated monitoring in managing environmental pollutants such as noise, vibration, and dust during construction. This technology not only streamlines the construction process but also plays a significant role in minimising the environmental impacts associated with such projects.

In conclusion, big data analytics offers a spectrum of applications that significantly contribute to the environmental sustainability of the aviation industry. From optimising flight operations to influencing customer behaviour and monitoring construction projects, big data is a key enabler in reducing the environmental footprint of aviation activities.

5. Challenges and Ethical Considerations

Despite the significant benefits offered by big data analytics in enhancing the environmental sustainability of aviation, several challenges and ethical considerations must be addressed.

5.1 Technical Challenges

The technical complexities involved in integrating and analysing the vast and diverse data sources in aviation pose significant challenges. These include data storage and processing capacities, crucial for managing the enormous volume of data generated by aircraft systems, airport operations, and environmental monitoring systems. While advancements in big data technologies have simplified the collection and storage of large datasets, and data science has provided tools for insightful predictions, the integration of cross-sectional data in real-world scenarios remains a significant obstacle (Burmester et al., 2018).

5.2 Data Source Diversity and Integration Complexities

In addition, the aviation sector faces the challenge of integrating structured and unstructured data from various sources, necessitating sophisticated data integration frameworks and algorithms capable of handling multiple data formats and structures. This complexity is compounded by the need for high data quality and accuracy, as poor data can lead to misleading insights, affecting decision-making and operational efficiency (Mohamed & Al-Azab, 2021).

5.3 Workforce and Skill Development

Another challenge is the shortage of skilled professionals proficient in big data analysis and interpretation within the aviation industry (Mohamed & Al-Azab, 2021). To effectively utilise big data for environmental sustainability, the industry needs to invest in training and development programs that enhance employees' skills in areas such as advanced statistical analysis technologies, security and data privacy. However, as noted by Moftah Attia et al. (2022), there exists a notable gap in such training programs, highlighting an area of concern for the industry's capability to fully leverage big data.

5.4 Financial Barriers

The implementation of big data infrastructure in aviation is accompanied by substantial financial challenges. These include the costs associated with technology acquisition, data storage, processing infrastructure, and the hiring and training of skilled personnel. Rajapaksha and Jayasuriya (2020) specifically highlight these financial barriers, which can be prohibitive for many organizations in the aviation sector.

5.5 Data Security, Regulatory Compliance and Ethical Considerations

In its journey towards leveraging big data, the aviation industry must navigate complex regulations and ethical considerations. Compliance with data privacy laws is not merely a regulatory requirement but a fundamental aspect of protecting sensitive information. This necessity becomes increasingly critical as aviation companies handle and analyse substantial volumes of personal data.

At the core of ethical data handling is the principle of transparency and obtaining explicit consent for data collection. It is incumbent upon aviation stakeholders to secure explicit consent from individuals and rigorously adhere to pertinent privacy laws in their big data analytics endeavours.

Concurrently, the responsibility to guarantee data security and privacy intensifies with the expanding scale of data collection and analysis. A study by Lykou et al. (2018) on the level of cyber-security preparedness at the busiest airports in Europe and the USA underscores this challenge, revealing that the primary concern of the respondents is the lack of security awareness (76%), combined with risks associated with internet connectivity (29%). In response, aviation companies are compelled to implement robust data security measures to prevent unauthorised access, breaches, and misuse of sensitive information, while also complying with data protection laws to safeguard individual privacy.

Lastly, a notable challenge in implementing big data solutions in aviation is the intricate and inconsistent landscape of data privacy laws across various countries. The COVID-19 pandemic exemplified this complexity, as airlines grappled with managing health information amidst divergent and often conflicting national laws. Some countries mandated the retention of health data, while others required its deletion or restricted its international transmission. This disparity, coupled with the increasing reliance on personal information for border management and security, threatens to amplify operational complexities in the aviation sector. Despite the influence of the General Data Protection Regulation (GDPR) as a model, it is part of a broader mosaic of laws that vary significantly in nature and application, presenting a daunting scenario for international airlines (Airlines IATA, 2022).

This evolving scenario underscores the urgent need for comprehensive guidelines that balance the operational requirements of the aviation industry with the privacy rights of individuals. As the aviation sector continues to evolve and integrate big data into its operations, aligning with global data privacy regulations and establishing effective cooperation mechanisms is crucial for its ongoing success and sustainability.

6. Future trends and innovations

The future of big data in the aviation industry is marked by several promising trends and innovations, poised to further revolutionise the sector (So & Wang, 2022). These advancements encompass a range of technologies and applications, each contributing uniquely to the industry's evolution.

6.1 Integration of AI and Machine Learning

A significant trend is the integration of artificial intelligence (AI) and machine learning algorithms into big data analytics. This integration is set to enhance the accuracy and efficiency of data analysis, leading to various improvements. For example, predictive maintenance can be made more precise, enabling airlines to pre-emptively address potential issues. Route optimisation can be refined for greater fuel efficiency and reduced travel times. Additionally, personalised recommendations can be developed for passengers, enhancing their overall experience. These advancements are a testament to the evolving capabilities of AI and machine learning in transforming aviation operations (Rajapaksha & Jayasuriya, 2020).

6.2 Expansion of IoT in Aviation

The utilisation of the Internet of Things (IoT) devices in aviation is another area of growth. The integration of IoT can lead to an increased volume of real-time data from aircraft, airports, and other aviation infrastructure. This data can be used to optimise operations further, improve safety measures, and boost the overall efficiency of the aviation industry. The real-time nature of this data collection provides a dynamic layer to operational management, enabling quicker and more effective decision-making (Baláž et al., 2023).

6.3 Robotics and Automation

Moreover, robotic technology and automation are becoming more and more prominent in the aviation industry. Robots and automated systems are being employed in various airport functions, such as baggage handling, maintenance inspections, and passenger assistance. These systems generate substantial data, which, when analysed, can uncover patterns, streamline processes, and enhance overall operational efficiency. When coupled with AI and IoT, these robotic systems can gather and analyse data in real-time, leading to more efficient processes and expedited decision-making (Baláž et al., 2023).

6.4 Digital Twin Technology

Another exciting innovation is the development of digital twins, virtual replicas of physical aircraft and airport infrastructure (Jiang et al. 2021). A report by Capgemini (2023) indicates a significant 40% increase in digital twin technology investment by aerospace and defence companies. The primary drivers for this investment include cost savings, reduced time-to-market, increased sales, improved employee training, and enhanced sustainability. Digital twins have the potential to revolutionise the aviation industry by enabling advanced simulations of operating scenarios, designs, and processes, and identifying potential improvements or issues proactively before they happen in the real world.

6.5 Advancements in Data Visualisation

Finally, advancements in data visualisation tools and techniques are expected to play a crucial role in the future of big data in aviation. These tools will enable aviation companies to extract actionable insights from complex datasets more efficiently and effectively. Improved data visualisation capabilities will facilitate better decision-making and problem-solving, allowing companies to respond swiftly and effectively to emerging trends and challenges (Dou, 2020).

7. Conclusions

In conclusion, this paper has comprehensively explored the crucial intersection of big data and environmental sustainability in the aviation sector, a domain where rapid growth and environmental challenges necessitate innovative approaches. Big data, characterised by its volume, velocity, variety, and veracity, emerges as a transformative tool that can significantly mitigate the environmental impacts of aviation, thereby contributing to sustainable practices in this critical industry.

The aviation sector, a substantial contributor to global greenhouse gas emissions, noise pollution, and resource depletion, faces pressing environmental challenges. Sustainable practices are vital for mitigating these impacts, and the integration of big data analytics offers a promising pathway. By harnessing big data, the aviation industry can optimise operations, reduce fuel consumption, enhance maintenance efficiency, forecast passenger demand more accurately, and significantly improve flight planning and operations. These advancements not only contribute to operational efficiency but also play a pivotal role in reducing the environmental footprint of aviation activities.

Moreover, this paper highlights the potential of big data in influencing customer behaviour towards more sustainable travel choices, optimising pricing and marketing strategies, and managing energy consumption more efficiently at airports. Big data's role in assessing and predicting the environmental impact of aviation operations and its application in construction monitoring further underscore its significance in advancing environmental sustainability within the sector.

However, realising the full potential of big data in enhancing environmental sustainability is not without challenges. Technical complexities, data integration issues, workforce skill gaps, financial barriers, data security concerns, and regulatory compliance are significant hurdles that the aviation industry must overcome. Ethical considerations, especially regarding data privacy and security, also warrant careful attention.

Looking ahead, the future of big data in aviation is marked by exciting trends and innovations. The integration of AI, machine learning, the IoT, robotic technology, automation, digital twins, and advanced data visualisation tools promise to further enhance the capabilities of big data analytics. These advancements are poised to revolutionise the aviation industry, offering new avenues for operational optimisation, safety improvement, and, most importantly, the advancement of environmental sustainability.

In summary, this paper affirms the transformative potential of big data in driving environmental sustainability within the aviation industry. As the sector continues to evolve, strategic utilisation of big data analytics will be crucial in balancing growth with environmental stewardship. The review demonstrates that aviation stakeholders, including airlines, and airports can harness the power of big data analytics to improve fuel efficiency, reduce emissions, and optimise their operations to minimise environmental impact. While significant strides have been made, there is ample scope for further integration and innovation.

The findings offer actionable insights and highlight challenges for stakeholders, including airport managers, policymakers, and regulatory authorities at national and international levels. It's imperative to recognise that big data applications in aviation for environmental sustainability should be continuously evaluated, considering the entire lifecycle and the importance of cross-industry data sharing. As the industry advances, the comprehensive and ethical application of big data will be vital in ensuring a sustainable future for aviation, balancing technological advancements with ecological responsibility.

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Session 8

Data Science and Artificial Intelligence Improving Health Equity & Urban Environments

Bridging the Gap between Artificial Intelligence and Information Geometry: A Path to Efficient Decision-Making

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Abstract
Information Geometry (IG) is an emerging field of Mathematics with various applications in the field of Artificial Intelligence (AI). Using geometric and metric concepts, IG provides the necessary mathematical tools to understand the data manipulation, probability distributions and models used in AI, enabling the development of more efficient algorithms in extracting information from complex data and facilitating more informed, accurate and sustainable decision-making. Applications in computer vision and natural language processing will benefit from geometric techniques to boost pattern recognition and semantic understanding. Moreover, the role of IG in network analysis and graphs, will assist in modeling and interpreting complex network structures, and will play a significant setup in autonomous robotics and robot navigation, enabling an efficient environment representation. On the other hand, AI security will be enhanced with the application of IG, by detecting threats and ensuring resilience against adversarial attacks. In an increasingly data-driven and AI-oriented world, IG is a valuable asset and, by joining both areas in close collaboration, it will revolutionize the way of taking advantage of technology to address future challenges. This work presents fundamental concepts and connections between AI and IG, providing a foundational overview for future research development.

Keywords: Information Geometry; Artificial Intelligence; Security; Decision-Making.

JEL Codes: C10; C49; C69; D89.

Exploring statistical control methods in epidemiological scenarios and process management: A comparative study

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Abstract
In this study the authors investigate the practical application of statistical control methods in organizational and epidemiological contexts. It explores challenges in business, examines potential benefits in analyzing epidemiological scenarios, and evaluates the understanding of statistical methods among process management professionals in Brazil. It compares the application of statistical control in operational processes and epidemiological studies, emphasizing potential contributions to public health. An introductory exploration delves into the similarity of using these methods, covering the fundamental concepts and techniques.
By effectively managing and controlling the spread of diseases, healthcare systems can save costs related to treatment, hospitalization, and containment efforts. The comparative analysis of different statistical control methods, can contribute to building economic resilience against outbreaks and, by understanding and implementing effective control measures, economies can reduce the duration and severity of health crises, allowing for quicker recovery and minimizing economic damage.

Keywords: Control Charts; Risk Analysis; Public Health; Sustainability.

JEL Codes: C19; I10; L15; Y1.

Exploring Dental Health, Immunity, and HDL: A Comparative Study Using GAMLSS and PPR Models

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Abstract

Our aim in this work is to investigate the link between periodontal health, as indicated by Pocket Probing Depth (PPD), and HDL levels, incorporating factors like age and diabetes status. This can help in identifying potential risk factors and developing preventive measures for periodontal diseases. Moreover, it will facilitate healthcare professionals to identify individuals who are at a higher risk of periodontal diseases and related systemic conditions. Early detection can result in timely intervention and reduced healthcare costs.

Based on a sample of 158 adult individuals, the study employs two advanced statistical methods: Generalized Additive Models for Location, Scale, and Shape (GAMLSS) and Projection Pursuit Regression (PPR). GAMLSS extends traditional models by accommodating varying variances, skewness, and kurtosis, while PPR, a supervised technique, excels in modeling non-linear relationships without predefined assumptions.

The study's findings, derived from both GAMLSS and PPR models, highlight significant interactions between HDL, age, diabetes, and their collective impact on periodontal health. These insights are critical for healthcare professionals, linking oral health to broader systemic health factors. The study also provides a comparative analysis of GAMLSS and PPR, showcasing their respective strengths and complexities in statistical modeling.

This work not only furthers our understanding of the interplay between dental health, immunity, and systemic factors but also demonstrates the effectiveness of advanced statistical methodologies in uncovering such complex relationships. Likewise, a better management of health in general, will be recognized in the fostering of economic benefits, and sustainable healthcare practices.

Keywords: Dental Health; GAMLSS; Projection Pursuit Regression Sustainability; Health Risks.

JEL Codes: A19; C10; C23; I10.

A Statistical contribution to Decision Making:
On Preventing Covid-19 in Mozambique selected regions

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Abstract
In China more than 77,000 cases of COVID 19 were reported, until February 23, 2020 and 60% of confirmed cases have been reported in the city of Wuhan. Similarly to other countries, Mozambique declared state emergency at March 2020 and different prevention measures were implemented to control and provide a timely response to the pandemic, including early diagnosis of disease cases. Regarding the evolution of COVID-19 cases, this work presents the Analysis and Visualization of COVID-19 data for the particular case of Mozambique, considering data from 2020 and 2022 relatively to some selected regions. This theme can be considered in the interdisciplinary areas of statistics, biomedicine, demography, economy and sustainability, and, in particular, on risk analysis. Qualitative and quantitative data analysis are performed, useful to the decision-making, considering the economic sustainability in the health sector, namely on health measures pandemic prevention and, moreover, to infer on the trend of cases and deaths from this disease in the considered regions.

Keywords: COVID-19; biomedicine; data analysis; economic sustainability; decision-making

JEL Codes: I15; I18

Session 9

Big Data in Environmental Risk Analysis

Big data sets in environmental studies

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Abstract

Big Data datasets for environmental studies play a crucial role in understanding, monitoring and addressing large-scale environmental issues. Big Data datasets for environmental studies deal with huge volumes of data coming from various sources such as satellites, remote sensors, weather stations, sensor networks and mobile devices. These datasets include detailed information on climate change, biodiversity, air quality, water resources and other environmental parameters. Integrating and analyzing data from different sources allows for a more comprehensive understanding of environmental standards and helps in making informed decisions. The generation of environmental data occurs in real time, especially with the increased use of sensors and continuous monitoring technologies. The ability to handle the velocity of data is essential for detecting rapid changes in the environment and responding to critical events such as natural disasters. Predictive models help predict climate patterns, identify areas of environmental risk and assess the impacts of human activities on the ecosystem. This data is crucial for developing mitigation strategies, adapting to climate change and conserving biodiversity. In summary, Big Data datasets play a fundamental role in environmental studies, providing a comprehensive and real-time understanding of environmental challenges, enabling the implementation of effective strategies for conservation and sustainability.

Keywords: Big Data; data sets; environment.

JEL Codes: C4; C8; Q5.

A Review on the Impact of ESG on the Economy and Financial Risk

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Abstract
This study employed Scopus, Web of Science, and Google Scholar databases to review the latest research articles on the influence of environmental, social, and governance (ESG) factors on economic dynamics and financial risk and address major challenges associated with this highly researched topic. With a blend of systematic literature review and bibliometric techniques, this study highlights seven hundred and fifty-five texts and classified them into four main topics about the impact of ESG Measures on Credit Ratings (238 articles), Economic Growth (153 articles), Corruption Risk (58 articles), and Sustainable Banking (306 articles). Among the main results, findings suggest that credit rating related to ESG performance could influence customer behavior for better access to credit and fostering socially responsible behavior, which includes building strong internal controls and anti-corruption policies. Additionally, a significant correlation between GDP and CO2 emissions has been confirmed, and it has been concluded that countries' sustainability improvements could be expected to have a net positive effect on economic prosperity. The content analysis identified research gaps in this field, such as which ESG pillar impacts credit ratings, how ESG can affect economic growth, how to conduct corruption risk management strategies, and what measures financial institutions should take to promote sustainability without harming the sector.

Keywords: ESG; Risk management; Financial risk; Credit risk; Corruption risk; Financial performance; Economic impact; Sustainability; Sustainable banking; Green finance; Green banking; Circular economy.

JEL Codes: G30; O44; Q01; Q56.

1. Introduction

Since the beginning of the twenty-first century, sustainable development has been a significant concern on a global scale. This concern was triggered by the measures/objectives imposed by the United Nations: Sustainable Development Goals (SDGs). The traditional definition of sustainable development (SD) given by Gro Harlem Brundtland in a Commission Report is in terms that development should meet the needs of the present without compromising the ability of future generations to meet their own needs. This definition highlights the importance of balancing economic prosperity, environmental protection, and social well-being for the long term. (World Commission on Environment and Development (WCED), 1987)[1].

In this regard, environmental, Social, and Governance (ESG) are three essential components to assess a company's sustainability and social impact. According to Kim & Li (2021), "ESG factors are also considered non-financial performance indicators and are used to identify issues related to business ethics, corporate social responsibility, and corporate governance." The main aim of ESG is to capture all the non-financial risks and opportunities inherent in a company's day-to-day activities.

There are three essential components to assess a company's sustainability and social impact based on ESG. First, Environmental criteria (E pillar) help stakeholders understand the organization's impact on the climate, like its greenhouse gas emissions, water and energy consumption and efficiency, carbon footprint, and resource conservation. In other words, the environmental pillar focuses on a company's commitment to sustainability and its efforts to keep its negative impact on the environment to a minimum. As we explore sustainable growth, the focus extends beyond environmental impacts to include social equity, inclusivity, and community well-being. The S pillar examines an organization's social impact. It seeks understanding how well leadership manages relationships with employees, customers, stakeholders, and communities. Finally, the governance pillar (G pillar) considers the management and supervision of a company. This pillar underscores the importance of effective and transparent governance structures in ensuring the success of both sustainable growth and green financing initiatives. Good governance is pivotal in directing resources efficiently, enforcing regulations, and fostering an ethical framework for sustainable economic development. stakeholders" (S&P Global, 2020).

Recent findings highlight financial institutions' role in guiding the global economy towards sustainability by influencing investment choices and establishing a deep link between environmental, social, and governance (ESG) performance. ESG factors influence an asset's credit quality, and incorporating more ESG factors into credit risk will be strongly related to better creditworthiness (Brogi et al., 2022). Looking deeper into ESG, it was found that good performance in these areas not only promises better access to credit for companies but also serves as a catalyst for shaping investment scenarios. As we navigate the relationship between ESG and economic growth, a significant correlation emerges - drawing attention to the profound impact of sustainability improvements on global economic prosperity. ESG measures emphasize sustainable development, the role of green finance in environmentally responsible projects, and the relevance of these issues. Recognizing these interdependencies is crucial to creating a sustainable, resilient, and equitable global economy. Additionally, corruption risk

[1] https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

management is necessary for this sustainable economy and financial stability. Corruption risk can be defined as a comprehensive approach to prevent and address corruption, including mainstreamed measures such as project risk assessments and financial review checklists (Trivunovic et al., 2011). Examining corruption risk management allows institutions to identify possible dangers and weaknesses and reinforce their safeguards against these threats. It frequently necessitates cooperation among stakeholders such as financial institutions, regulators, and civil society. SDG 16 of the UN addresses corruption particularly, intending to promote peace, justice, and strong institutions. Overall, corruption risk management strategies play a crucial role in fostering sustainable financial practices and aligning with UN SDG 16 social impact responsibility. Despite the growing emphasis on sustainability within the economy and financial risks, there exists a lack of agreed-upon standards for companies and financial institutions to use for reporting on sustainability issues. Another issue is a lack of high-quality firm-level data to serve as critical inputs in assessing a company's risks and adherence to ESG criteria (Antoncic, 2020). These issues can have a negative impact on sustainable development with business strategies without sustainable financial risk management (Liu et al, 2022). They can expose businesses to various risks, regulatory changes, and, increasingly, environmental and social pressures. As the world embraces sustainability as a core value, there is a growing need to adapt to this changing landscape.

This article investigates the fundamental intersection between ESG, risk management, sustainability, and the monetary sector of the economy by systematically reviewing recent articles to fill the research gap in this area. It presents four approaches regarding ESG performance in economics and finance, specifically the impact of ESG measures on credit ratings, the impact of ESG on economic growth, corruption risk management and socially responsible practices in financial institutions, environmental risk management, and sustainability in financial institutions.

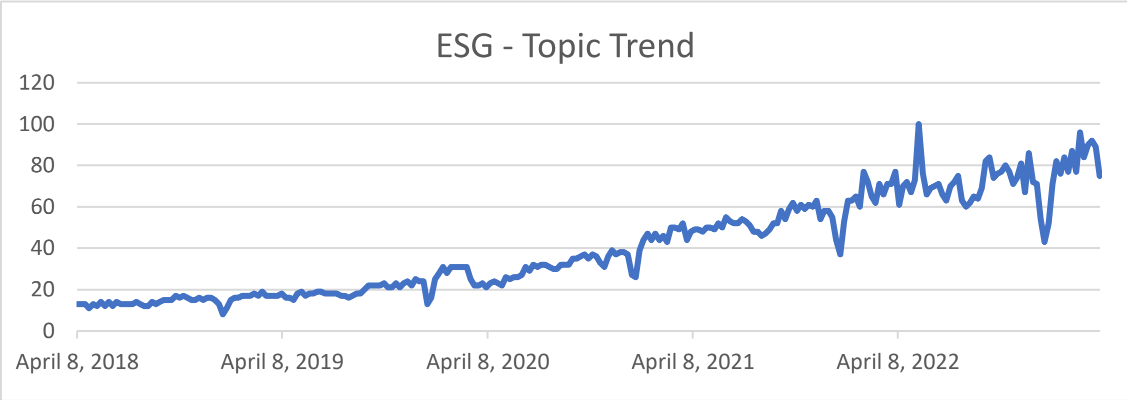
Subsequently, in Section 2, titled "Bibliometric Analysis Methods," this paper outlines the approaches employed for selecting the most relevant literature to the current study. Section 3 presents the outcomes of the bibliometric research, enclosing a content analysis of the selected articles. The concluding section, Section 4, derives insights and identifies research gaps based on this review of relevant works.

2. Bibliometric analysis methods

The topic of ESG is being discussed more and more, as we can see by the trend of this topic according to the Google Trends tool. A clear positive trend can be observed in the topic's popularity over time.

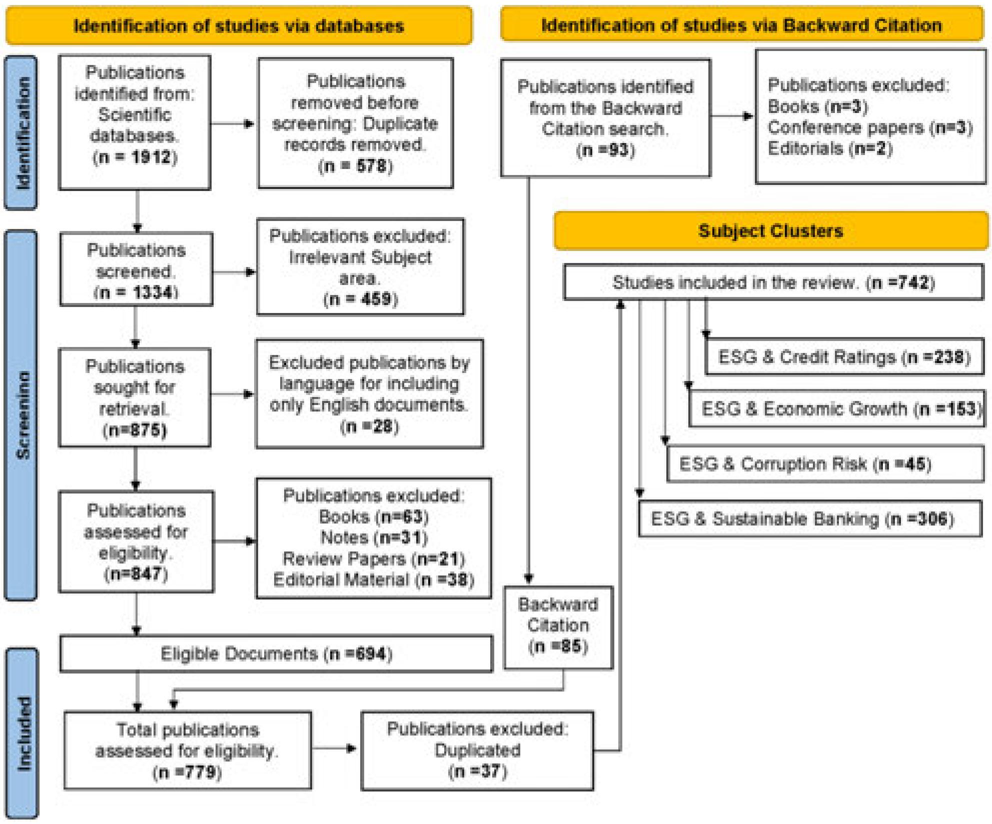
As shown in Figure 1, there was growth, especially from 2017 onward. A negative peak in this trend over the years was identified in December, which can be explained by the end of the year and the holiday seasons. As a result, the articles after 2017 were considered, including some articles as exceptions with high ranks of citations per year from previous years.

Figure 1: Graphic of the ESG topic trend (Source: Google Trends).



In this hybrid systematic review of literature, we used methodological tools for investigating the various studies of this specific subject, such as comprehensive review and conceptual review with meta-analysis of the articles classified into four main topics, namely, the impact of ESG Measures on Credit Ratings, Economic Growth, Corruption Risk, and Sustainable Banking.

Figure 2: Articles selection flow diagram.



We searched the Scopus, Web of Science, and Google Scholar platforms to find the most relevant articles related to the topic based on the following keywords limited to the English articles, in the subject area Economics, Econometrics, and Finance, and the main keywords of "ESG," "Sustainability," "Sustainable Development," "ESG Performance," "Sustainable Finance," "Corruption," "Sustainable Development Goals."

(("ESG" AND "Credit ratings*") OR ("ESG*" AND "Banking*") OR ("ESG*" AND "Creditworthiness" *) OR ("ESG*" AND "Financial performance" *)) OR (("Economic Growth" OR "Economic Impact" OR "Country Sustainability" OR "Sustainable Growth" OR "Green Financing") AND ("ESG" OR "ESG Performance" OR "ESG Factors")) OR (("corruption*" AND "risk management" AND "sustainability") OR ("corruption risk" AND "sustainability") OR ("corruption risk management*" AND "sustainability")) OR (("Financial performance*" OR "Financial sustainability*") AND ("Bank value*" OR "Bank performance" OR "COVID19*")).*

Figure 2 shows the details of the selection process, which resulted in 742 articles eligible for content analysis, divided into four main categories: ESG and Credit Ratings (238 articles), ESG and Economic Growth (153 articles), ESG and Corruption Risk (45 articles), and ESG and Sustainable Banking (306 articles).

The VOSviewer software was used to create visual maps of bibliographic data for keyword occurrences. The software allows users to identify groups of related keywords and analyze the links' strengths. Appendix 1 shows the relationships between different keywords based on their co-occurrence in the literature. The keywords with the highest occurrence in the selected articles are the following: ESG, financial performance, risk management, sustainability, environmental performance, credit ratings, banking, sustainable development, economic impact, finance, risk assessment, bank performance, and corporate governance (See Appendix-1).

Based on the frequent keywords, citations per year, and a review of the abstracts and conclusions of selected documents for all the approaches, we identified the most relevant articles for content analysis; for instance, the first 25 articles are listed in Table 2.

Table 5: The first 25 articles, ordered by year.

Year	Author(s)	Title
2024	Lamanda G. & Tamásné Vőneki Z.	Is ESG disclosure associated with bank performance? Evidence from the Visegrad Four countries
2023	Azmat, F., Lim, W. M., Moyeen, A., Voola, R., & Gupta, G.	Convergence of business, innovation, and sustainability at the tipping point of the sustainable development goals
2023	Wang, J., Yu, J., & Zhong, R.	Country environmental, social and governance performance and economic growth: The international evidence.
2022	Del-Aguila-Arcentales, S., Alvarez-Risco, A., Jaramillo-Arévalo, M.,	Influence of Social, Environmental, and Economic Sustainable Development Goals (SDGs) over

Year	Author(s)	Title
	De-la-Cruz-Diaz, M., & de las Mercedes Anderson-Seminario, M.	Continuation of Entrepreneurship and Competitiveness
2022	Fatimah Y. & Kannan D. & Govindan K. & Hasibuan Z.	Circular economy e-business model portfolio development for e-business applications: Impacts on ESG and sustainability
2022	Hao Li, Xuan Zhang & Yang Zhao	ESG and Firm's Default Risk
2022	Hiroaki Kambe & Masatoshi Tamamura	Effects of firm-level ESG performance on creditworthiness in Japanese listed companies
2022	La Rosa, F., Bernini, F., & Terzani, S.	Does corporate and country corruption risk affect CEO performance? A study of the best-performing CEOs worldwide
2022	Landi G. & Iandolo F. & Renzi A. & Rey A.	Embedding sustainability in risk management: The impact of environmental, social, and governance ratings on corporate financial risk
2022	Veronica M. & Ida I. & Peteriandi D.	Factors Predicting Financial Sustainability in the Banking Sector
2021	Dengjun Zhang	How environmental performance affects firms' access to credit: Evidence from EU countries
2021	Kim S. & Li Z.	Understanding the impact of ESG practices in corporate finance
2021	Narapong Srivisal, Natthawat Jamprasert, Jananya Sthienchoak & Pornpitchaya Kuwalairat	Environmental, Social and Governance and Creditworthiness: Two contrary evidence from major Asian markets
2021	Patrycja Chodnicka-Jaworska	Esg as a measure of credit ratings
2020	Di Tommaso C. & Thornton J.	Do ESG scores affect bank risk taking and value? Evidence from European banks
2020	Wang, J., Yu, J., & Zhong, R.	Country sustainable development and economic growth: The international evidence.
2019	Cardoni, A., Kiseleva, E., & Lombardi, R.	A sustainable governance model to prevent corporate corruption: Integrating anti-corruption practices, corporate strategy and business processes
2019	Sonali Bhattacharya & Dipasha Sharma	Do environment, social and governance performance impact credit ratings: a study from India
2019	United Nations	Corruption and the Sustainable Development Goals
2018	Dimant, E., & Tosato, G.	Causes and Effects of Corruption: What Has Past Decade's Empirical Research Taught Us? A Survey
2018	Krishnamurti, C., Shams, S., & Velayutham, E.	Corporate social responsibility and corruption risk: A global perspective

Year	Author(s)	Title
2010	Olaf Weber, Roland W. Scholz & Georg Michalik	Incorporating sustainability criteria into credit risk management
2008	Olaf Weber, Marcus Fenchel & Roland W. Scholz	Empirical analysis of the integration of environmental risks into the credit risk management process of European banks
2007	Fritzen, S. A.	Crafting performance measurement systems to reduce corruption risks in complex organizations: the case of the World Bank
2005	Méon, P. G., & Sekkat, K.	Does corruption grease or sand the wheels of growth?

3. Content Analysis

The following subsections discuss the impact of ESG on the economy and financial risk in each of the four subgroups to present the findings of this literature review in more detail.

3.1. Impact of ESG on credit ratings

Brogi et al. (2022) studied if the awareness of Environmental, Social, and Governance factors could potentially mitigate credit risk. Applying a two-step methodology to 3331 companies from different industries and geographic locations, their results show the importance of ESG factors in assessing a borrower's creditworthiness and ability to impact a wide range of factors and metrics in credit analysis (Ashofteh & Bravo, 2021). According to this study, ESG can affect expected loss through the probability of default, exposure to default, and loss given default.

Other researchers have studied the effects of ESG on credit risk in specific countries or particular sectors. For example, applying a fixed effects model, Li et al. (2022) studied the impact of the ESG rating on the default risk of Chinese listed companies. Three different periods were considered for the default risk term structure: short-term (1 month), medium-term (6 months), and long-term (12 months), to assess the behavior of the default risk over time. As a result, it was shown that better ESG ratings reduce the likelihood of a company default. As the term structure increases, the mitigation effect of ESG on credit default increases. In this study, they also mentioned that the impact of ESG ratings is smaller for manufacturing firms than for non-manufacturing firms. This study shows another interesting and expected conclusion that, for firms from different industries, the impact of ESG on default risk is heterogeneous.

On the same continent, a study was also conducted about the effect of ESG disclosure on Indian companies' credit ratings. Bhattacharya & Sharma (2019) chose S&P BSE (Bombay Stock Exchange) 500 listed firms that have disclosed their ESG practices and have received ratings from various credit rating agencies. Once again, it was concluded that, in general, the ESG performance and the individual ESG components' performance positively impact creditworthiness. This study added that ESG had a substantial positive influence on credit rating for small and middle-sized firms. In contrast, for large firms with better credit ratings, ESG has no visible implications.

Considering a specific sector of activity, Singal (2014) compares the hospitality industry to other types of businesses in order to understand if there is a relationship between sustainability and economic performance. According to the analysis, businesses in the hospitality industry invest, on average, more in environmental initiatives than companies in other industries do, which might be explained by the fact that the hospitality industry has significantly fewer environmental concerns when comparing it, for example, with the energy, agriculture or construction industries, which contribute the most to the global pollution nowadays and have a negative impact on ecosystems. They reinforced that even in times of crisis, business leaders should keep making investments in environmental initiatives because "although this analysis finds that firms reduce their focus on the environment when they are passing through difficult financial times, investment in the environment seems almost more important in lean times because of its impact on future performance and the positive externalities on the firm's reputation and customer perceptions" (Singal, 2014).

One of the studies about the positive effect of ESG performance on firms' better access to credit was conducted by Zhang (2021), which focused on the effect of environmental performance on credit lending. It was found that firms with good environmental performance have a better chance of credit approval from banks and are less likely to be exposed to collateral obligations.

Most studies found one unique relation between ESG performance and creditworthiness. Friede et al. (2015) compiled evidence from over 2000 studies. It was concluded that "the large majority of studies report positive findings," in other words, good ESG performance positively impacts corporate financial performance. This last point leads us to another analysis, which is the impact of each pillar (Environmental, Social, and Governance) on creditworthiness. For example, the inclusion of environmental risks in all phases of the credit risk management process, such as rating, costing, pricing, monitoring, and work-out were analyzed by Weber et al. (2008), who say it is essential to do it since it influences all phases of this process and not only one or some of them. A couple of years later, Weber et al. (2010), once again, focused on the environmental pillar and verified that a significant improvement in correct risk classification happens when incorporating sustainability criteria into credit risk management.

More recently, Chodnicka-Jaworska (2021) stated in a study that among the ESG factors, the environmental measure is the most significant one. ESG scores have different impacts on different sectors, and according to this study, the energy, industrial, materials, and utility sectors are the most sensitive ones, which is associated with the regulations about pollution reduction, energy, and water conservation. It was also confirmed in the study that ESG has a considerable impact on credit ratings, which in turn mirrors the creditworthiness of a debtor. The authors believe that a reason for seeing the environmental measure as the most significant one might be because the two other factors already have been covered with many regulations and frameworks, such as the Basel Accords and corporate governance regulations. As a result, financial institutions have been working on those two earlier than environmental factors. Of course, the results may not always be expected, and they may be influenced by the different natures, cultures of markets, and even political matters.

Srivisal et al. (2021) have proven this by showing contradictory evidence from two major Asian markets, China and Japan. This investigation failed to identify a trend between the Chinese credit rating and the ESG score. At the same time, the results for Japan indicate that having ESG coverage is significantly related to a higher credit rating. The study adds that stronger ESG performance may not always translate into a higher credit rating because the pillars have opposing effects: "positive links from the environmental (E) and governance (G) pillars, but sometimes the negative links from the social (S) pillar."

A study by Kambe & Tamamura (2022) also investigated the relationship between ESG performances and creditworthiness using the ordered logit model, where S&P Credit Ratings were used as the dependent variable and ESG evaluations by Arabesque S-Ray as the independent variables. This research also shows that, overall, ESG performance positively affects companies' creditworthiness. However, it shows that the individual impact of each pillar causes different effects. A positive effect is verified for governance, while environmental and social performances represent an insignificant effect.

Kim & Li (2021) state that ESG factors benefit companies' profitability, like so many other studies conducted, but the effect is stronger for larger firms. It adds that ESG variables positively influence credit rating, most notably the social factor. In contrast, the environmental factor represents a negative effect on credit rating, the opposite finding to many studies such as Chodnicka-Jaworska (2021) study.

Focusing more on the connection between ESG performance and credit ratings, Devalle et al. (2017) concluded that ESG performance significantly affects credit ratings, especially social and governance measures. This study is in line with the findings of other studies, such as Brogi et al. (2022), in the sense that ESG factors should be incorporated into the credit risk evaluation process since they influence the borrower's ability to pay their credit obligations.

Samaniego-Medina & Giráldez-Puig (2022) studied whether the ESG debate impacted credit ratings in the European banking sector, with the final result showing a negative effect between these two. It is also added that ESG controversies are "a relevant negative factor in the probability of obtaining a better rating in future reviews of credit assessments".

More recent literature also investigates the integration of ESG into credit rating assessments. Ilango (2023) infers that the ESG credit score is a "tool developed to improve transparency, which aims to articulate or quantify ESG factors in credit rating analysis". According to Ilango (2023), agencies' traditional credit evaluation has not changed from the ESG incorporation into credit analysis.

Companies attempting to operate in a sustainable way are at a disadvantage due to the present credit rating methodology, which only takes into account ESG factors that are apparent, expected to manifest, and likely to have a major impact on creditworthiness in the short term (three to five years) while, especially, environmental risks, which are difficult to quantify and uncertain, are not taken into account. Even if these risks are significant, the assigned credit ratings today barely change as a result of their short-term perspective. Due to the longer time horizon, higher uncertainty, and the difficulty of quantifying environmental risks into possible financial losses, these risks are more challenging to measure. With that said, Ilango (2023) concludes that "the conventional rating methodology requires an overhaul to include long-term risk and produce a tangible outcome on credit rating due to ESG factors."

3.2. Economic Growth, Green Financing, and Sustainable Development

Economic growth is one of the primary macroeconomic objectives for governments, given their capacity to generate positive externalities within a nation. The role of natural resources, often sensed as either a blessing or a curse, significantly influences economic growth trajectory. Recent research demonstrates that economic growth can be driven by factors beyond traditional capital formation and labor force intensity (Khan et al., 2022). For instance, green finance directs financial resources toward initiatives enabling sustainable progress and environmentally friendly economic development. This shift aims to balance natural resource use and economic growth. Green finance offers a comprehensive perspective, ensuring variables for sustainable development are considered.

Efficiently channeling resources positively influences the ecological environment, economic efficiency, and overall economic structures, contributing to high-quality economic development (Nenavath et al., 2023).

The findings of Singh & Mishra (2022) indicate a favorable influence of green financing on the GDP per capita across the 30 sampled countries on their economic growth against the background of the COVID-19 pandemic outbreak in 2020. Additionally, the study reveals that the percentage of exports concerning the GDP positively affects economic growth, while inflation negatively impacts the GDP per capita. The model suggests that integrating green financing into economic recovery plans can contribute to a mutually beneficial scenario, enhancing the economic development of nations. Consequently, governments are encouraged to prioritize green project financing as part of comprehensive strategies for sustainable and resilient economic growth.

Consequently, a company should not establish sales growth and ESG targets in isolation; instead, it should adjust its financial growth objectives considering its ESG standing in the economy. From a managerial standpoint, competitive strategies should mature to encompass both dimensions within an integrated framework rather than treating them as isolated elements (Bellandi, 2023).

Shobande et al. (2023) find that the correlation between energy consumption and economic growth is well-established. Moreover, the emission of greenhouse gases (GHGs) from energy consumption has been identified as a significant contributor to climate change. Lagoarde-Segot (2020) and Wang et al. (2024) studies emphasize the impact of green financing on promoting advancements in renewable energy technology. So, green financing can indirectly reduce the negative impacts of traditional energy consumption by supporting the development and adoption of renewable energy technologies. This shift towards renewable energy would empower economic growth from the environmental point of view and greenhouse gas emissions, thereby addressing climate change concerns.

3.3. Corruption Risk Management

Transparency International defines corruption risk as the potential probability that corruption may occur and the possible costs it might cause. The annual cost of corruption is estimated to be US$1.5–2 trillion annually, roughly 2% of the 2017 global GDP based on the World Bank National Accounts Data report in 2018[1]. Almost one in five firms worldwide have reported receiving at least one bribery payment request when engaged in regulatory or utility transactions (UN Global Compact, 2019[2]).

"Corruption hinders progress towards achieving the SDGs. The World Economic Forum estimated that corruption costs at least USD 2.6 trillion—or 5 percent of the global gross domestic product—and the World Bank found that USD trillion is paid in bribes each year.

The African Union assessed that 25 percent of the GDP of African states, amounting to USD 148 billion, is lost to corruption every year. World Bank estimates suggest that 20 to 40 percent of official development assistance (USD 20 to USD 40 billion) is lost to high-level corruption every year" (Corruption and the Sustainable Development Goals[3]).

[1] https://data.worldbank.org/

[2] UN Global Compact. (2019). The sustainable development goals report 2018. Retrieved from https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf

[3] Corruption and the sustainable development goals. www.un-ilibrary.org. https://doi.org/10.18356/9b4bda79-en

La Porta et al. (1999) define three main categories of corruption determinants: (1) economic, (2) political, and (3) cultural. Poverty and economic dissimilarity are facilitative to corruption since people may be forced into criminal tactics to meet basic requirements or gain money (Acemogluet al. 2013, Bravo & Ashofteh 2023). Political variables have a significant impact on corruption. Weak governance mechanisms that lack transparency, accountability, and effective rule of law produce a corrupt atmosphere. The quality of institutions, such as law enforcement and the courts, is essential since weak and corrupt institutions promote corrupt practices. Political instability makes people more vulnerable to corruption (Kaufmann & Kraay, 2002). Cultural factors matter when it comes to corruption. Such as what society considers normal and how much corruption it can tolerate. Also, in cultures where personal relationships are more important than doing things fairly, corruption tends to happen more (Andvig et al., 2001; Barr & Serra, 2010). The anticorruption programs within the private sector usually rely on a compliance framework containing a code of conduct, training modules, decision-making processes, and reporting mechanisms (Lombardi et al., 2019).

Corruption within a country occurs when resources meant for economic and social development are diverted into private pockets, suppressing growth and diminishing the quality of essential services (such as education or health care), all of which can contribute to good national development results. Corruption also suppresses the growth of the regional economy and entrepreneurship, both needing transparency and trust that the same standards apply to everyone and need to assume anticorruption as a part of sustainable corporate governance (SCG) and environmental, social, and governance (ESG) issues (Cardoni et al., 2020).

Companies have also started to develop formal anticorruption systems and check the existence of popular anticorruption tools. The concept of legitimacy has been discussed, revealing its multidimensional complexity. Through the use of current data analytics and technology, the capacity of an organization to combat unethical behavior inside may be increased (Martins & Ashofteh 2023). These technologies aid in the effective monitoring of financial transactions, the detection of abnormalities, and the full assessment of risks (Corruption & Fraud Survey Portugal 2023, Deloitte[1]).

Furthermore, maintaining robust internal controls and performing frequent internal audits provides additional levels of protection against dishonesty (Fritzen, 2007; Krishnamurti et al., 2018). Institutions actively decrease corruption risks in their operations by establishing and implementing sound internal processes (Del-Aguila-Arcentales et al., 2022). It is important to stay updated about and comply with the constantly evolving anticorruption legislation and regulations (Dreher & Schneider, 2006). Regularly assessing and revising policies and practices ensures that an institution's risk management initiatives become successful and in line with the shifting regulatory environment (Lu et al., 2019; Wong, 2014). In a nutshell, firms may improve their internal ability to resist corruption by using technology, enforcing internal controls, and sticking to legal requirements with anticorruption laws through regular policy reviews and updates. An organization's CSR engagement is associated with a reduction in its corruption risk (Krishnamurti et al., 2018), and anticorruption practices are likely to reduce a corporation's exposure to corruption risk.

[1] Corruption & Fraud Survey Portugal 2023. Deloitte Portugal. Retrieved November 26, 2023, from https://www2.deloitte.com/pt/pt/services/financial-advisory/corruption-and-fraud-survey.html

3.4. Environmental Risk Management and Sustainability in the Banking Sector

The studies show that the banking sector can be considered a way of implementing sustainable measures. The term "green banking" describes how banks can reach their full potential by taking on responsibility, being socially conscious, and, most importantly, lending money to borrowers who behave well regarding the environment, society, and government (Sharma et al., 2014). This study examines the relationship between green banking practices and the sustainability performance of the banking sector in Indonesia based on information provided in sustainability reports over nine years.

Kim & Li (2021) discovered a connection between company financial performance and environmental, social, and governance (ESG) factors through their research. They analyzed various ESG subcategories, assessing their merits and drawbacks and examining their impact on corporations' profitability and financial risk. They discover that ESG considerations have a favorable impact on corporate profitability, with a substantial impact on large businesses. Additionally, corporate governance in the ESG category has the most significant impact, especially for companies with poor governance. Surprisingly, they mentioned that environmental scores have a negative effect on credit rating, but social aspects have the most impact. In general, this study offers a justification for integrating ESG.

Certain individual and aggregate ESG variables have a favorable impact on the selected performance measures despite the fact that it is challenging to generalize the positive impact of ESG factors on corporate financial performance. However, corporate profitability seems positively impacted by the overall ESG score. Corporate governance is the ESG component that most significantly affects corporate profitability. Only companies with flexible governance were found to have a positive correlation between corporate profitability and governance.

Lamanda G. et al. (2024) conducted a study investigating the dynamic relationship between ESG (Environmental, Social, and Governance) disclosure and bank performance. They applied theoretical frameworks such as Stakeholder theory, Legitimacy theory, Resource-based view, and Agency theory. Analyzing data from banks situated in Hungary, the Czech Republic, Poland, and Slovakia, the researchers categorized information from 26 banks into four main groups: Framework, Environmental aspects, Social aspects, and Corporate governance aspects. Using a coding system where one signified that the question was answered in reports and 0 otherwise, the authors calculated the ESG Disclosure based on annual reports. The application of the Breush-Pagan test confirmed the absence of heteroskedasticity issues. The regression models suggested a positive correlation between banking sector disclosures and the size of the banks. Their findings underscored that up to 2019, bank reports predominantly highlighted social issues and corporate governance, possibly in response to boosted regulatory demands. Poland emerged as the leader in ESG Disclosure within the study period, followed by the Czech Republic, Hungary, and Slovakia.

Di Tommaso et al. (2020) investigated the relationship between ESG scores and risk-taking, as well as their value, based on the testing of six hypotheses supported by the Stakeholder Theory View and the Overinvestment View. Through the estimation of linear models, they concluded that elevated ESG scores are associated with a reduction in risk-taking for banks, whether they have high or low risks. The impact of these values depends on the characteristics of the boards of directors, where composition and size are crucial for effective ESG management. The ESG activities undertaken by banks, associated with their management, supported by independent and gender-diverse boards of directors, can effectively mitigate risk-taking and contribute to financial stability. The authors argue that these findings should serve regulatory bodies, boards of directors, and banks that promote ESG activities.

In the current digital landscape, the circular economy is a driver for advancing sustainability. Enterprises engaged in the circular economy have played key roles in boosting employment and the gross domestic product. We need novel strategies to effectively respond to emerging global trends in digitalization and ecological challenges. Digital e-business must not only take care of the sustainable growth of the circular economy but must also focus on environmental problems. Fatimah et al., (2022) study is feature-based and aims to improve sustainability and environmental, social, and governance (ESG) performance. The development of an ESG-based sustainable circular economy e-business model to assist the enhancement of ESG performances for overall business developments has been illustrated by Morea et al., (2022) study. Under the consideration of ESG dimensions factors, this study offers particular and crucial digital approaches and applications that the circular economy industry might implement in a sustainable and intelligent environment. It offers some insightful instances of how sectors that encourage the creation of fresh and creative circular economy company models have adopted the circular economy e-business. Also, it makes clear that stakeholders in the circular economy need to work together more thoroughly. The growth of e-business in the circular economy holds promise for social and environmental benefits in addition to financial gains. Goals such as "sustainable development goals" and "climate action plans" can be considered good initial targets for promoting sustainability in companies.

With banks being one of the main sectors driving sustainability measures, the COVID-19 pandemic has put not only this sector but also many of the areas involved in sustainable measures to the test. The banking sector is struggling to maintain its operations despite the challenges posed by the Covid-19 outbreak. In order to increase financial performance and enable community service provision, innovation is required. Thus, the purpose of Veronica (2022) study was to examine how financial performance functions as a mediator between intellectual capital and financial sustainability. Siswanti et al., (2019), showed the outcome that the relationship between intellectual capital and financial sustainability is mediated by the financial performance variable. Consequently, the banking industry must prioritize the development of its intellectual capital, as this initiative not only enhances its bottom line but also promotes long-term commercial viability.

4. Conclusions and Research Gap

The content literature review indicates that integrating environmental, social, and governance factors into financial initiatives is essential for promoting long-term economic prosperity while addressing environmental and social challenges. Many studies have confirmed that implementing ESG measures and green financing is crucial in finance and the economy.

The existing literature confirms a relationship between ESG measures and credit ratings. It was not concluded from the selected studies which ESG pillar has the most significant impact on credit ratings, which the different nature of the data can explain it, such as different geolocations or different sectors. Additionally, the findings underscore the significance of green financing in advancing sustainable development goals and its significant impact on economic growth within the framework of ESG considerations. It should be emphasized that the dynamic and constantly changing scenarios require an adaptive and innovative approach from monetary and financial institutions. Incorporating emerging technologies, responding to regulatory changes, and continually understanding stakeholder expectations are essential elements in promoting effective and sustainable environmental risk management.

Furthermore, it is concluded that corruption risk management has a critical role in financial institutions, especially its influence on achieving the United Nations SDG 16 for a peaceful and inclusive society. The description of the three main factors affecting corruption - economic, political, and cultural - provides an in-depth analysis of its complex nature. It explores the social responsibility in corruption risk management, highlighting elements such as advancing economic growth, protecting the weakest, and establishing equality and trust. The inclusion of sustainable financial practices consists of transparency, accountability, risk management, compliance, governance, and environmental and social responsibility. The conclusions presented led us to identify research gaps in this field, such as which ESG pillar impacts the most credit ratings, how ESG can affect economic growth, how to conduct corruption risk management strategies in practice, and what measures financial institutions should take to promote sustainability without harming the sector. These gaps show the long way ahead for research works on ESG's effect on the Economy and Financial Risk Management, especially in the era of emerging technologies (Ashofteh, 2023), AI, and Big Data.

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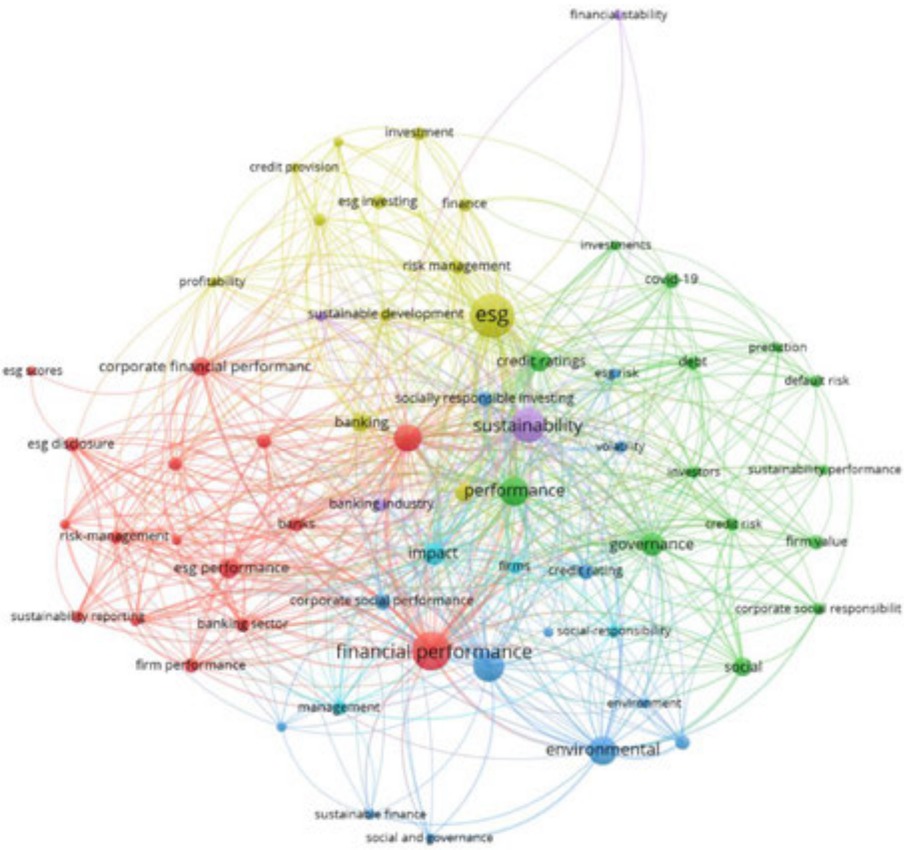
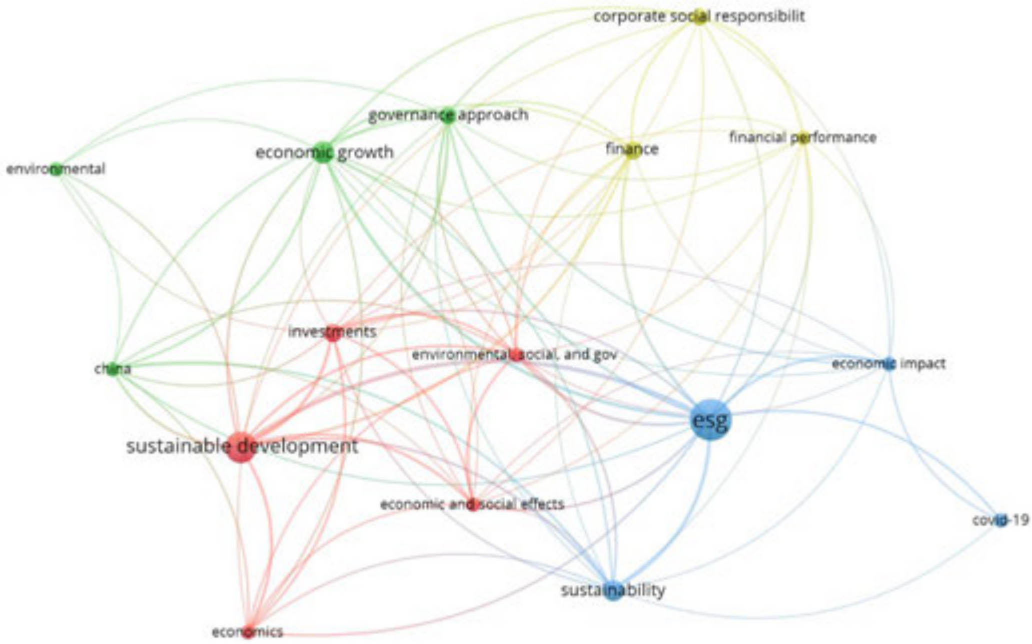
Appendix 1: Visualization analysis of the main keywords

(1) Credit Ratings

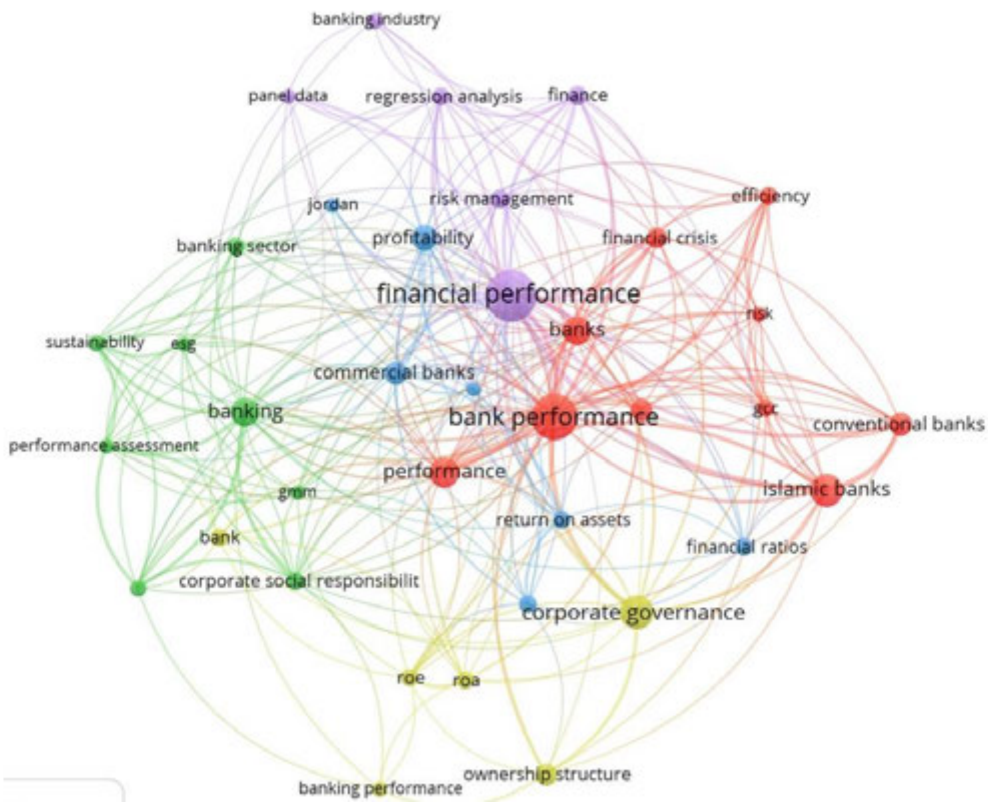


(2) Economic Growth



(3) Corruption Risk

(4) Sustainable Banking



Entropy and Uncertainty: Theoretical Framework and Fuzzy Logic for Environmental Economics

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Abstract
Entropy describes the disorder (or order, depending on the sign + or – we adopt for it) of a "given system". This system at the early steps pf development was coming from the Thermodynamics. Uncertainty links a real-valued function of events with probability. Recently there is a competition between probability and Fuziness, as Fuzzy Logic, is closer to the real situation and not a binary response situation. Moreover both Uncertainty and Entropy are faced under Fuzzy Logic and we shall present this line of thought as well as the classical one. In economic theory and not only, a number of sources of uncertainty, such as model choice uncertainty, data uncertainty, the right mathematical framework chosen might cause uncertainty have been worked already extensively discussed. We shall work for the family of the γ –ordrer Generalized Normal distributions$G_\gamma = \{N_\gamma(\mu, \Sigma), \gamma \in \mathbb{R} - [0,1]\}$ describing the problems of the Environmental Economics under two different theoretical approaches.

Keywords: environmental economics; generalized normal distribution; fuzzy logic; uncertainty

JEL Codes: Q5

Analysis of the inequality into distributions. An alternative approach to the Gini index applied to the spending environmental in EU

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Abstract
The Gini index is the most common tool to measure inequality into two distributions. Traditionally, the Gini index and the curve of Lorenz are focused on inequalities measures in the income distribution between countries or regions. But, in the last years, several authors have shown some limitations of the Gini index. In particular, it's less sensitive to inequality at the tail of income distribution. This type of problem in the Gini index could produce two types of reactions: a new reinterpretation of the Gini index and the proposal of some alternative measures to it. In this paper, we follow the previous work using the Csiszar f-divergence to propose using the α-divergences approach to analyze the differences between the Gini index approach and these alternatives. The Gini index has been applied to the measure of resource inequalities. The AR-Gini is an area-based measure of resource inequality that estimates inequalities between neighbourhoods regarding the consumption of specific consumer goods (Druckman and Jackson, 2008). The AR-Gini could be a useful tool to monitor the distributional impacts of resource-related interventions, but this indicator presents the same overcomes as the Gini index. We can use the Gini concentration coefficient as a measure of the concentration of distribution of a random variable, especially applied to time series of data. In recent years, several studies have studied environmental spending in the European Union (EU). We focus our analysis on the distribution of this type of spending between the countries of the EU.
The objective of this study is to show the differences in indexes applied to the study of the distribution of the distribution of monetary resources to environmental conservation and the extension of environmental protected areas into the countries of the European Union (EU). In our comparative study, we use the Gini index and the α-divergence measure and compare the results to get the most accurate measure of the equity of the distribution.

Keywords: Gini Index, Gini coefficient, α-divergences, AR-Gini, Environmental protected areas, Conservation policies.

JEL Codes: C43, D63, H53, Q51.

1. Introduction

Analysis of divergence between two elements is a very common problem in the scientific literature. Various divergence measures are used to show how elements are separated (Amari, 2009).

There are several examples on trying to optimize the differences between two distributions and one of those is in politics - an open problem to establish proportional methods to mitigate the unavoidable distortion arising when votes are translated to seats (Pretolani, 2013). The divergence of the distribution of votes and the distribution of seats was analysed using several measures, but, more recently, some authors evidence preference in considering the use of the Lorenz Curve and Gini Index (Mouzon et al., 2020) or the α-divergence methods (Wada & Yamahara, 2018). Another example it's the analysis of equity in the income distribution in a country. The Gini Index is a common measure of these distortions and is used to compare the situation in several countries. Using this Index is related to the Lorenz Curve (Kakwani & Podder, 1973) which depicts a graphical representation of the divergence of the distribution of two elements, for example, population and income (Rogerson, 2013).

Applications of the Gini index to environmental data can be seen in (Ivanova & Wood, 2020), where the authors consider the distribution of household carbon footprints and consumption within 27 European Union (EU) countries.

In this paper, we analyse the divergence between the distribution of environmental spending in the EU and the distribution of natural protected areas in the countries of the EU. Previous papers analyse the data divergence using an area-based measure (Druckman & Jackson, 2008) or the share of public expenses on environmental protection in total public spending in the EU (Rokicki et al., 2019). Following these papers results, now we consider the Gini Index to measure the divergence between the environmental spending of the EU countries based on the protected area.

The rest of the paper contains three sections. The next section is a review of the literature on the Gini Index and environmental spending. In the third section, we proceed to the calculation of the Gini Index and the Lorenz Curve and distortions of these values when there are small differences between distributions, in particular, tail differences. We propose the use of alternative approaches to avoid/overcome this problem. Section 4 considers the concentration of environmental spending in the EU countries. We analyse data from the period 2014-2020. Conclusions are described in the last section.

2. The Gini Index and the environmental spending

The Gini Index (Gini, 1912) is one common measure to represent income inequality and compare it between regions (Mahinpei, 2020). Although focused on income distribution, it could be used to measure the inequality of a distribution, not only in socioeconomics, but considering applications to several disciplines of science, like astrophysics, ecology, econophysics, engineering, finance, geography, medicine, biology, and transport (Sitthiyot & Holasut, 2020). Interpretation of the Gini Index is very simple: the nearest to zero the more equity distribution. The maximum value is 1, and it points out that the whole welfare belongs to one agent; it represents the maximum level of inequality.

Calculation of the Gini index evolves from the original approach of Gini. The first alternative approaches: The absolute Mean Difference (Dalton, 1920) and the Relative Mean Difference Approach (Kendall & Stuart, 1958) produce the same values for the index. But the Geometric Approach (Lows, 1984) and Gini Coefficient (Dixon et al., 1987) produce different values and it could be used to improve the accuracy of the index.

The Gini Index can be derived from the Lorenz curve (Lorenz, 1905). Lorenz curve is a graphical representation of wealth distribution that plots the cumulative proportion of the population on the x-axis and the cumulative proportion of income on the y-axis, both from the lowest to the highest. The Gini Index is the ratio of the area between the area closed between the equity line and the Lorenz Curve and the total area between the equity line. Let F(x) be the cumulative distribution function (cdf) of a continuous random variable X, then:

$$L(p) = \frac{\int_0^p F^{-1}(y)dy}{\int_0^1 F^{-1}(y)dy}, 0 \leq p \leq 1 \tag{1}$$

where $F^{-1}(y) = \sup\{x: F(x) \leq y\}$, is the Lorenz Curve (LC) associated with F(x). Lorenz Curve satisfies the following conditions: $L(0) = 0, L(1) = 1$. The LC function $L(p)$ is an increasing and convex function for $p \in (0,1)$. Several authors consider the use of parametric models to calculate LC, the most used approaches consider the use of one parameter (Chotikapanich, 1993), two parameters (Ortega et al., 1991) and three parameters (Sarabia et al., 1999). Results indicate that the more parameters the more accuracy (Castillo et al., 1998).

The increased importance of environmental protection in people's awareness has also led to the need to count cash flows in this area (Rokicki et al., 2019). These authors show the level of public spending on environmental protection in the European Union countries. The analysed period corresponds from 2005 to 2017, and the first conclusion is that the public expenditure on environmental protection in EU countries has been systematically growing, and there was a very high concentration of this type of expenditure (Gini coefficient = 0.73) in several EU countries (Rokicki et al., 2019). Although there were changes in the value of total public expenditure for environmental protection, there were virtually no changes in the structure. The countries with the largest expenditure on environmental protection still had a dominant position (Rokicki et al., 2019).

In 2017, Ercolano and Romano published a paper where the authors analysed the national spending policies for environmental protection: "This paper has empirically examined trends in government expenditure for environmental protection in recent years at the European level, analysing whether or not European countries significantly diverge in the composition of environmental public expenditure, and identifying those countries that display greater similarities in their spending behaviour concerning environmental protection." (Ercolano & Romano, 2017). The authors use Cluster Analysis and Principal Component Analysis to create several clusters of similar countries. In line with other studies, the authors confirm that there is no convergence between environmental spending in the EU countries.

Some previous studies consider the concept and methodology for an area-based indicator of inequalities in resource use: the AR-Gini (Druckman & Jackson, 2008). The AR-Gini differs from the Gini coefficient: it's a measure of inequality in terms of the mass of resources instead of being a monetary measurement, and it's calculated on an area basis, giving a measure of inequality by comparing the resource uses of neighbourhoods, whereas the conventional Gini compares on a household or per capita basis (Druckman & Jackson, 2008). Their study focused on the UK case and considered the period from 1996/7 to 2003/4. The paper is focused on illustrating that different consumer commodities have different inequalities that are quantified by the AR-Gini index. The results may have several implications for public spending policies.

Our paper is focused on the EU environmental spending distributed by the countries of the EU, but we consider the distribution of spending based on the protected area of the country: The bigger the protected area, the higher the level of environmental spending.

3. The Gini Index and the Lorenz Curve

The Gini index is a measure of statistical dispersion introduced by Corrado Gini (1912). Traditionally in economics, it's used as a measure of the concentration of income among the population in a country (Xu, 2004).

The Lorenz Curve (Lorenz, 1905) is a curve that defines the cumulative proportion of income and the cumulative proportion of income-receiving units (Kakwani & Podder, 1973).

The Gini Index is calculated as the area between the equity line and the Lorenz Curve (LC). However, there are several approaches to calculating this area, and we must choose high accuracy to get the right conclusions from our analysis.

3.1. The Gini Index

The first approach to the Gini Index considers the differences between the distribution of two variables. Let be two distributions: Cumulative Proportion of Population x_p and Cumulative Proportion of Income y_p. Then, we can use the following approaches to calculate the Gini Index:

1. Gini's formula: x_p presents *n* equal groups and μ_y is the average income: $\frac{\sum_{i=1}^{n} y_i}{n}$:

$$G = \frac{1}{2\mu_y n^2} \sum_{i=1}^{n} (n+1-2i)(y_{n-i+1} - y_i) \quad (2)$$

Mean Absolute Differences: We consider *n* equal groups of the population and μ_y is the mean:

$$G = \frac{\sum_i^n \sum_j^n |y_i - y_j|}{2\mu_y n^2} \quad (3)$$

Brown's Formula: We consider *n* equal groups of the population x_i and the income y_i:

$$G = 1 - \sum_{i=1}^{n-1} (x_{i+1} - x_i)(y_{i+1} + y_i) \quad (4)$$

But these approaches present some limitations: the limitation of the Gini index in ranking income inequality when the Lorenz curves of the two distributions cross and another limitation is whenever two or more distributions share the same value of the Gini index but distribution inequality among them could be different (Sitthiyot & Holasut, 2020).

We consider the following 2 scenarios of income distribution into a region:

Table 6: Scenario 1

District	Population	Income	Acum. Pop.	Acum. Income	Aver. Income
1	2000	1000000	0,33	0,16	500
2	2000	1000000	0,66	0,33	500
3	1000	1000000	0,83	0,5	1000
4	1000	3000000	1	1	3000

Table 7: Scenario 2

District	Population	Income	Acum. Pop.	Acum. Income	Aver. Income
1	3000	1000000	0,5	0,16	333.33
2	1000	1000000	0,66	0,33	1000
3	1000	2000000	0,83	0,66	2000
4	1000	2000000	1	1	2000

In Table 1, the first scenario, we can observe that people with low-income (≤ 500) is 4000, which represents 66,66% of the total population. But in Table 2, the second scenario, the low-income people are only 3000, which represents, 50% of the total population. In Scenario 1, we can observe that the first and second districts (the most populated) have an average income of only 500, and the fourth district has an average income of 3000. But in Scenario 2, we increase the population of District 1, which reduces the average income to only 333.3, but we move partially the income of Districts 3 and 4 to equalize them. The results are that the difference between the low-income people and the high-income people ranges from 2500 to 1666,67.

However, the two Scenarios have the same value for the Gini Index: 0.3889 (calculated using Brown's Formula (4)). We can observe that the Gini index is not fully sensitive to changes in the tails of the distribution, a conclusion that aligns with (Amari, 2009).

3.2. The Lorenz Curve

Some authors (see Rogerson, 2013) consider a new interpretation of the Gini Index from the Lorenz Curve because the Lorenz Curve is more sensitive to changes in the tails of distributions. Let $F(x\,|\alpha)$ be the cumulative distribution function (cdf) of a continuous random variable x, following a distribution with parameter α. Then, the Lorenz curve is:

$$L(x,\alpha) = \frac{1}{\mu}\int_0^x F^{-1}(y\,|\,\alpha)dy, \qquad x \in\ [0,1] \tag{5}$$

where μ is the mean of F and $F^{-1} = inf\{z\colon F(z\,|\,\alpha)\ \geq\ y\}$.

Using this geometrical approach the Gini Index is:

$$G\ =\ 1 - \frac{2}{\mu}\int_0^{+\infty} z\,F(z\,|\,\alpha)f(z\,|\,\alpha)dy\ = 1\ - 2\ \int_0^1 L(y\,|\,\alpha)\,dy \tag{6}$$

To improve the performance of the Lorenz Curve, we can use several distributions and increase the number of parameters to consider.

Following Castillo et al. (1998) some approaches of the Lorenz curve could be defined from different base distributions:

1. Lorenz Curve with 1 parameter. Pareto Distribution.

$$L_{CP}(x\,|\alpha) = 1 - (1-x)^{\frac{\alpha-1}{\alpha}}, \qquad \alpha > 1 \tag{7}$$

2. Lorenz Curve with 1 parameter. Chotikapanich (1993).

$$L_1(x\,|\alpha) = \frac{exp(\alpha\, x) - 1}{exp(\alpha) - 1}, \qquad \alpha > 0. \tag{8}$$

3. Lorenz Curve with 2 parameters. Ortega et al. (1991).

$$L_2(x\,|\alpha,\beta) = x^{\alpha}(1-(1-x)^{\beta}), \quad \alpha \geq 0, \qquad 0 \leq \beta \leq 1. \tag{9}$$

4. Lorenz Curve with 3 parameters. Sarabia et al. (1999).

$$L_3(x\,|\alpha,\beta,\gamma) = x^{\alpha}(1-(1-x)^{\beta})^{\gamma}, \; \alpha \geq 0, 0 \leq \beta \leq 1, \gamma \geq 1. \tag{10}$$

The percentile method is used to estimate the parameters and fit the Lorenz curves to observed data (Castillo et al., 1998). “The results indicate that proposed methods perform as good as the currently used methods … but in many other cases they outperform current methods ...” (Castillo et al., 1998)

Other approaches (Chotikapanich & Griffiths, 2002) consider estimating the Lorenz Curve assuming a particular distribution: Dirichlet Distribution (Minka, 2000). “Maximum likelihood estimates under the Dirichlet Distribution assumption provide better fitting Lorenz curves than nonlinear least squares and another estimation technique that has appeared in the literature” (Chotikapanich & Griffiths, 2002). An alternative approach (Chotikapanich & Griffiths, 2005) uses the Bayesian model averaging to estimate the parameters of the Lorenz Curve. A more sophisticated method of estimating generalized beta distribution parameters based on grouped data is in Kakamu & Nishimo (2019), where the authors consider the application of their method to the accuracy of the Gini coefficients estimation. A new Bayesian approach to estimating the Gini coefficient and the Lorenz curves is in Kobayashi & Kakamu (2019).

In Table 3, we compare the different values for the Gini Index calculated for the two Scenarios defined in Table 1 and Table 2. We have used the Maximum likelihood estimation (MLE) (see Chotikapanich & Griffiths, 2002). Results show that for the Gini Index estimated for a Lorenz curve with only one parameter the two Scenarios present a very similar value for the Gini Index but, increasing the number of the parameters of the estimated Lorenz Curve, produces bigger differences for the Gini Index.

Table 8: The Gini Index – Scenario 1 and Scenario 2

Lorenz Curve	Scenario 1	Scenario 2
One Parameter (Chotikapanich)	0.410503	0.413772
Two Parameters (Ortega et al.)	0.425199	0.433045
Three Parameters (Sarabia et al.)	0.408994	0.518753

For the whole three approaches, the Gini Index is worse in Scenario 2 than in Scenario 1. This fact is common to the three Lorenz Curves, and it is not shown when we use Brown's Formula for the Gini Index. In Figure 1 to Figure 3, we depict the Lorenz Curves for the different scenarios.

Figure 3: Lorenz Curve (Chotikapanich) – Scenario 1 and Scenario 2.

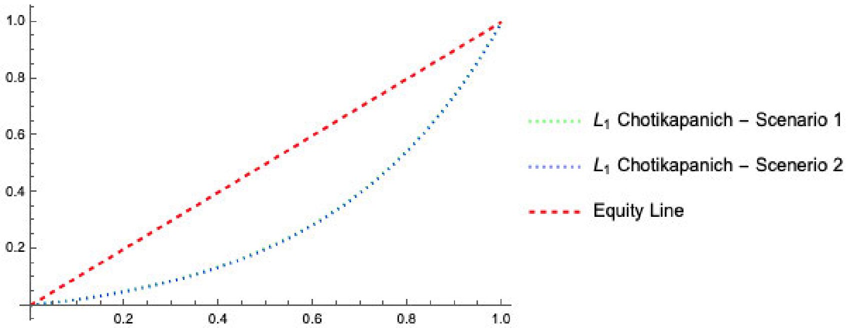


Figure 2. Lorenz Curve (Ortega et al.) – Scenario 1 and Scenario 2.

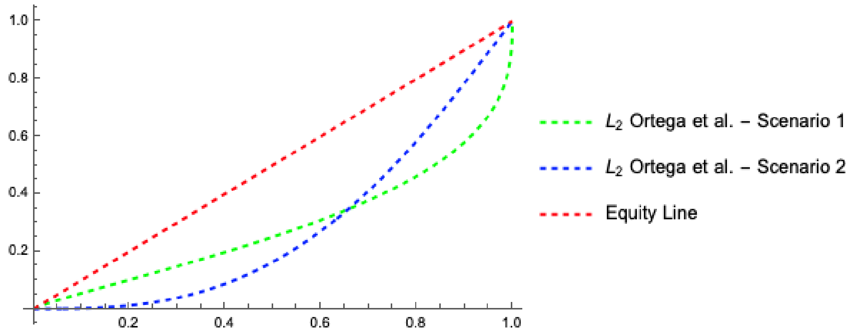
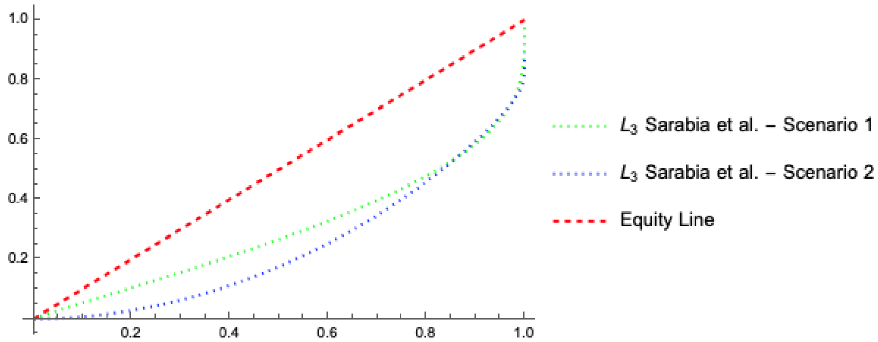


Figure 3. Lorenz Curve (Sarabai et al.) – Scenario 1 and Scenario 2.



The value of the Gini Index is sensitive to the number of parameters used on calculations of the Lorenz Curve. With only one parameter, the values for the two Scenarios are very similar, although the greater value of Scenario 2 indicates that the concentration is greater in the second scenario. When two parameters are considered, the difference is greater, and the second scenario presents a greater concentration of income. Finally, for the Lorenz Curve with 3 parameters, the difference is bigger than 0.1 in absolute value.

The Lorenz Curve is more sensitive to changes. Between Scenario 1 and Scenario 2, we have made two modifications. For low-income people we have increased the population for the first quantile, and for the high-income people we have made a redistribution of the income between the two last percentiles. This change is observed in Figure 2, Figure 1 presents the same curve and the differences in Figure 3 are only for low-income people.

4. Environmental Spending in the EU.

Environmental protection has been increasing in the EU during the last few years. The influence of people's awareness produces the need to increase cash flows on this area (Rokicki et al., 2019). The analysis of environmental protection expenditures is of strategic importance and allows the assessment of existing environmental policies. A low level of expenditure does not always mean that the country does not effectively protect its environment (Rokicki et al., 2019). Some authors associate expenditure with the level of adverse effects on nature (Rokicki et al., 2019). But in this paper, as we already mentioned, we consider the relation between the expenditure and the protected surface area.

The research period of our study concerned the years 2014-2020, and we have considered the 27 countries of the EU. The available data used were EUROSTAT data with two specific tables. Spending data were in the table National Expenditure Environmental Protection (S1) data. This table reports the environmental total spending in millions of Euros. For the surface of the protected area, we use the table Natura 2000 Protected Areas. This table reports the protected area of the EU countries in square kilometres (km^2).

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For analysing the concentration of the spending, we studied the Gini Index and the Lorenz Curve of the environmental spending, according to the total protected surface. During the analysed period the protected surface increased from 760353 km^2 in 2014 to 764222 km^2 in 2020, which represents about 0,51%. But for the same period the environmental spending increased from 238559.5 million euros to 297492.2 million euros, that is, about 24,7%. Those values point out the increasing level of environmental spending in the EU. Although the protected area stayed almost constant during these years, the spending increased by almost 25%, which clearly shows evidence of protection concerns and consequent changes in the political measures.

In Table 4 and Table 5, we present the data on the evolution of the protected area and the evolution of the environmental spending in the EU countries for the years 2014 to 2020. We can visualize this evolution in Figure 4.

The observed data of Protected Areas in the EU countries generally increased during the period 2014 to 2020. The 27 countries increase or conserve the same protected area for the analysed period. While Denmark, Hungary and Latvia kept the same area in 2017 as in 2020, Ireland and Slovenia decreased a little bit, Netherlands also decreased the area, but the worst result was in Portugal, where there was the biggest decrease in the Protected Area verified from 2019 after, while a bigger fixed Protected Area was considered in the previous 5 years.

Table 9: Natura 2000 Protected Area in EU countries (km^2)

Country	2014	2015	2016	2017	2018	2019	2020
Austria (AT)	12691	12691	12691	12701	12891	12895	12895
Belgium (BE)	3887	3887	3887	3892	3891	3891	3894
Bulgaria (BG)	38222	38222	38222	38222	38222	38728	38728
Cyprus (CY)	1653	1653	1653	1653	1654	1669	1680
Czechia (CZ)	11061	11061	11148	11148	11148	11148	11149
Germany (DE)	55170	55170	55200	55200	55214	55228	55228
Denmark (DK)	3594	3594	3594	3594	3616	3594	3594
Estonia (EE)	8083	8083	8083	8106	8106	8106	8106
Greece (EL)	35747	35747	35747	35982	35982	35982	35982
Spain (ES)	137757	137757	137872	137952	138016	138111	138083
Finland (FI)	42495	42495	42495	42495	42495	42495	42498
France (FR)	69974	69974	70515	70625	70750	70875	71030
Croatia (HR)	20704	20704	20704	20704	20704	20716	20716
Hungary (HU)	19949	19949	19949	19949	19949	19949	19949
Ireland (IE)	9227	9227	9226	9230	9229	9226	9225
Italy (IT)	57172	57172	57173	57265	57265	57258	57354
Lithuania (LT)	7938	7938	8086	8086	8103	8136	8185
Luxembourg (LU)	702	702	702	702	702	702	702
Latvia (LV)	7446	7446	7446	7447	7447	7447	7446
Malta (MT)	41	41	41	41	42	42	42
Netherlands (NL)	5518	5518	5520	5522	5522	5522	5495
Poland (PL)	61165	61165	61165	61165	61156	61168	61220
Portugal (PT)	19010	19010	19010	19010	19010	18968	18968
Romania (RO)	53781	53781	54214	54214	54214	54214	54214
Sweden (SE)	55250	55250	55280	55647	55611	55611	55534
Slovenia (SI)	7674	7674	7675	7675	7672	7672	7672
Slovakia (SK)	14442	14442	14442	14633	14633	14633	14633

In general, the National Expenditure increased by almost 25% during the years 2014 to 2020. The increase was very high for the whole of the countries, but the distribution of this spending varies during the period. In 2014 the country with the lowest amount of environmental expenditure was Malta (139.4 million euros), and the highest spending was Germany (63744.5 million euros). But in 2020, the environmental expenditure of Malta increased to 307.3 million euros, (the second lowest) and then Cyprus with only 230.6 million euros occupied the lowest position. In the highest position, there was no difference in the three highest countries (Germany, France, Italy). There were some modifications of the positions of the countries during the analysed period. Although most of the countries have increased environmental expenditure, some countries have reduced the spending for the analysed years: the Netherlands reduced environmental spending from 18358 (2014) to 15039.8 (2020) a -18.07%, and it moves from the fourth highest position to the sixth. The other countries that have reduced environmental spending are Latvia (-16.62%), Hungary (-10.85%), Finland (-21.96%), Greece (-12.32%), Denmark (-8.05%), Cyprus (-16.30%). On the positive side, the highest verified increase was in Romania (365.08%) and Malta (120.44%).

We have analysed the concentration of environmental spending in the countries of the EU according to the protected area. We based our research on the available observations on cumulative proportions of protected area (x_i) and corresponding cumulative proportions of environmental spending (y_i), obtained after ordering the countries according to increasing spending. Using these data, we were able to calculate the Gini Index and depict a Lorenz Curve for the different years.

Table 10 : National Expenditure Environmental Protection EU countries (Million €)

Country	2014	2015	2016	2017	2018	2019	2020
Austria (AT)	10211.4	10454.4	11320.5	12544.7	13454	13875.1	13071.1
Belgium (BE)	13341.7	13103.6	13286.7	14438.6	15292.4	15438.9	15985.1
Bulgaria (BG)	1096.2	982.3	662.1	764.2	711.7	924.6	1248.9
Cyprus (CY)	275.5	320.9	302.6	289.1	304.7	380.2	230.6
Czechia (CZ)	4397.3	4660	4752.6	5260.2	5775.1	5848.2	5869.9
Germany (DE)	63744.3	64748.1	67477.6	70053	74004.5	76272.8	80048.8
Denmark (DK)	5478.6	5989.2	5942	6126.4	6026	6198.8	5037.8
Estonia (EE)	525.6	588.1	498.5	555.3	635.2	620	631.5
Greece (EL)	2540.2	2368.4	2105.2	2042.6	2198.6	2278.2	2227.3
Spain (ES)	16281.4	16891.7	16985	18479.4	19494.6	19892.7	19386.9
Finland (FI)	3543.6	3746.1	3776.6	3694.3	3568.5	3388	2765.3
France (FR)	42795.2	42473.5	42651.3	44070.2	45615.6	48379.7	46726.2
Croatia (HR)	1029.4	1065.7	1102.1	1192.7	1218.5	1250.5	1005.2
Hungary (HU)	2471.6	2778.4	2111	2436.9	2123.3	2487.2	2203.5
Ireland (IE)	2179	2069.7	2032.9	2017.9	2052.3	2325.7	2302.9
Italy (IT)	26550.6	27861.9	31075.8	31887.3	32758.8	32987.1	43102.7
Lithuania (LT)	658.1	638.4	710	703.8	858.3	851.2	758.5
Luxembourg (LU)	436.5	460.8	501.3	567	624.4	617.6	815.2
Latvia (LV)	462.7	427.1	444.3	431.2	487.6	607.8	385.8
Malta (MT)	139.4	196.2	142	153.8	175.1	208.6	307.3
Netherlands (NL)	18358	18710.9	17813.8	17930.2	18968	19329.4	15039.8
Poland (PL)	7457.2	7970.1	8665.7	8815.8	9217.6	15045.4	14743.8
Portugal (PT)	2482	2442.2	2289.4	3175.6	3430.2	3595.8	3334.4
Romania (RO)	1577.4	2323.2	1386.9	1220.5	1585.3	1837	7336.2
Sweden (SE)	8180.6	8505	9089.3	9514.4	9790.2	9823.2	10004.4
Slovenia (SI)	891.1	822.8	810.9	838	917.3	1001.9	1162.3
Slovakia (SK)	1454.9	1826	1520.1	1592.9	1536.2	1671	1761.3

Using Brown's approach to the Gini Index it is possible to calculate the value of the Gini Index as:

$$GI = 1 - \sum_{i=1}^{n-1}(y_{i+1} + y_i)(x_{i+1} - x_i) \quad (11)$$

The evolution of the data (see Table 6) shows that, for the whole period, concentration of the spending was decreasing. The Gini Index moves from 0.45 (2014) to 0.42 (2020). Although there was a bit increase in 2016, the other years show that the trend is diminishing. There is a better distribution of spending according to the protected area surface in 2020 than in 2019, although the value of the Gini index is high (>0.4) which points out that the distribution of spending is far from equity.

As we have commented, Brown's formula for the Gini Index presents some problems of insensitive changes in the tail of the distribution. So, we considered another approach to the Gini Index by using an estimation of the Lorenz Curve with two parameters $y = L(x;\, \alpha, \delta) = x^{\alpha}(1-(1-x)^{\delta})$ with $\alpha\ \geq 0\,, 0 \leq \delta \leq 1$. (Ortega et al., 1991).

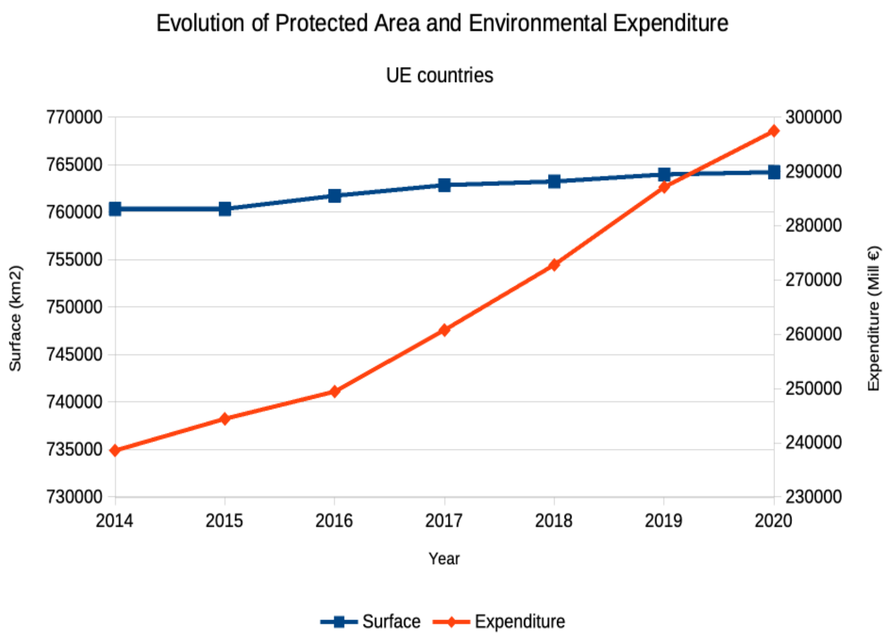
The spending shares can be defined as $q_i = y_i - y_{i-1}$, and supposing they are random variables with means $E(q_i) = L(x_i, \alpha, \delta) - L(x_{i-1}, \alpha, \delta)$, following a Dirichlet distribution (Chotikapanich & Griffiths, 2002). Thus, the probability density function for q can be written as:

$$f(q \mid \lambda, \alpha, \delta) = \Gamma(\lambda) \prod_{i=1}^{28} \frac{q_i^{\lambda(L(x_i;\, \alpha,\delta) - L(x_{i-1};\, \alpha,\delta)) - 1}}{\Gamma\left(\lambda\left(L(x_i;\ \alpha, \delta) - L(x_{i-1};\ \alpha, \delta)\right)\right)} \tag{12}$$

There is then the need to estimate the parameters: λ, α, δ, where α, δ are the Lorenz Curve parameters and λ acts as an inverse variance parameter. The larger the value, the better the fit of the Lorenz curve to the data. Taking into account the Maximum Likelihood Estimation, the values of parameters can be obtained by maximizing the log-likelihood function:

$$Log[f(q \mid \lambda, \alpha, \delta)] = Log\,\Gamma(\lambda) + \sum_{i=1}^{28}\left(\lambda\left(L(x_i;\ \alpha, \delta) - L(x_{i-1};\ \alpha, \delta)\right) - 1\right) Log\, q_i - \sum_{i=1}^{28} Log\,\Gamma\left(\lambda\left(L(x_i;\ \alpha, \delta) - L(x_{i-1};\ \alpha, \delta)\right)\right) \quad (13$$

Figure 4: Evolution Spending/Surface EU (2014-2017)



The Gini Index is defined as

$$GI = 1 - 2\int_0^1 L(x;\ \alpha, \delta)dx \tag{14}$$

Table 6: The Gini Index

Gini Index	2014	2015	2016	2017	2018	2019	2020
Brown's Formula	0.4589	0.4515	0.4676	0.4388	0.4381	0.4235	0.4212
L_2 (Ortega et al., 1991)	0.4936	0.4886	0.4747	0.4769	0.4782	0.4759	0.4324

Figure 5: Lorenz Curve Distribution Environmental Expenditure EU (2014-2017)

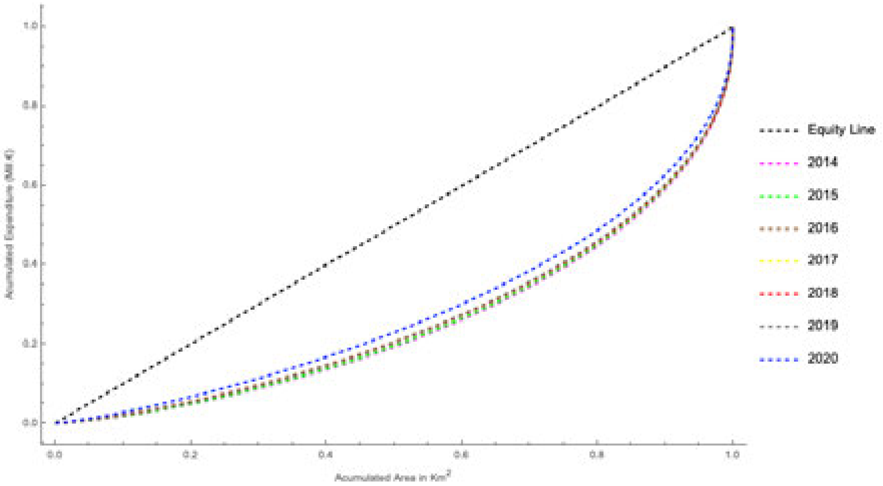
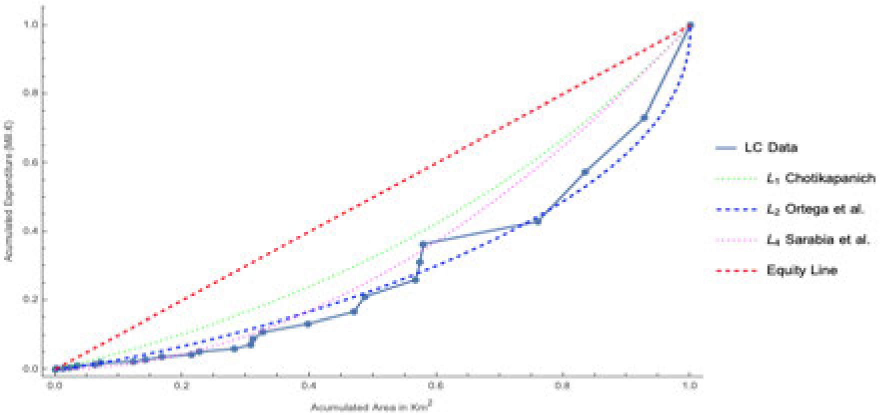


Figure 6: Lorenz Curves using different approaches (2020)



As we can observe (see Table 6) the concentration of spending was diminishing along the years 2014 to 2020, moving from 0.49 (2014) to 0.43 (2020). The value of concentration is high, although the reduction of it into the analysed period is about 0.06 points. Lorenz Curve for several years is depicted in Figure 5.

There are other approaches to estimate the Lorenz Curve using different numbers of parameters. In Figure 6, we have represented the estimation of different approaches to the Lorenz

Curve, and we have compared it with the Equity Line and with the Real Data for the year 2020. Graphical results show that L_2 is the most accurate curve to real data.

5. Conclusions

The Gini Index is the most used index to analyse the divergence between two data series. Usually, the Gini Index is used to analyse the distribution of income between populations in a country. A comparative study between countries was performed, based on the Gini Index values.

However, the optimal version for the Gini Index is an open problem, let's call it OGIV (Optimal Gini Index Version), and it is our aim to continue our research looking for it. The original Gini Index formula produces values that are not sensitive to small changes, especially on the tails of the distribution. Some authors consider that a more accurate value is reached when we use the Lorenz Curve and consider one or several parameters to define the most accurate curve. Then, the Gini Index is calculated by integrating the area between the Lorenz Curve and the equity line.

In this paper, we have used the Gini Index to measure the concentration of the national environmental expenditure based on the national protected area for the 27 countries of the EU, during the years 2014-2020. We have used the L_2 Lorenz Curve approach (Ortega et al., 1991) to calculate the Gini Index of the different years. Parameters of the model were calculated using Maximum Likelihood Estimation and Dirichlet Distribution.

The data show that the evolution of national expenditures, in general, during these years increased by about 25%, although the protected area remains very stable with a general little increase (0.5%). The distribution of the spending reflects some changes between the different countries' policies at which may possibly be one of the reasons for some variations in the order of the countries year by year.

The Gini Index diminished from 0.49 to 0.42, that is, a fall in the concentration of the spending. Although the concentration is very high, it seems that the evolution of the expenditure tends to have a more equity distribution between the countries based on the protected area.

We have considered an alternative approach to estimate the Lorenz Curve, only for the year 2020. Finally, we observed that the most accurate approach to the Real Data distribution was given by using the L_2 curve.

Acknowledgement

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Session 10

Welfare – Regional Development

Consumer barriers to bio-based transitions: A study on food products

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Abstract

This study investigates the effect of nine consumer barriers to bio-based food products in shaping purchase intentions. A structural model is developed to assess: (i) the influence of prior experience with bio-based products and demographics on the perceived impact of the consumption barriers, (ii) how these nine barriers affect consumers' interest and attitudes to bio-based foods, and (iii) whether the latter are predictors of purchase intention. The proposed model is examined using data collected from a self-administered field survey in Greece (n=308). Findings suggest age, gender and prior bio-based consumption experience have a significant effect on most barriers. Moreover, the nine barriers have a non-uniform effect on consumers' interest and attitudes towards bio-based products but both of these latent variables (interest and attitudes) have significant positive effects on purchase intention. Based on these results, academic contributions to the existing body of knowledge of consumer (green) behaviour are offered with regard to potential structural linkages describing consumer adoption of bio-based food products in Greece. The study offers meaningful insights to policymakers and marketers seeking to increase market penetration of bio-based food products and, thus, endorse more sustainable food systems.

Keywords: Consumer barriers, purchase intention, bio-based products, food products, structural equation modelling, Greece.

JEL Codes: D19; Q01; Q57; Q59.

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Assessing the feasibility of the Bellagio Process in the European Union

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Abstract
The paper examines the economic, environmental, and social aspects required to achieve a transition towards a circular economy, commonly referred to as the Bellagio process. The analysis endeavors to assess the relationship between environmental sustainability, population density, innovation and circularity rate. A panel data analysis was conducted utilizing various econometric techniques including Ordinary Least Squares (OLS), Fixed Effects, Random Effects and Fully Modified OLS (FMOLS). The study employed a sample comprising 28 EU countries for the period 2010 - 2019. The findings of the analysis indicate a strong and positive relationship between circular activity and factors such as innovation, resource productivity, and recycling. It was observed that higher rates of domestic material consumption often coincide with lower rates of treated waste, leading to reduced levels of circularity across EU countries. The current body of literature lacks comprehensive understanding of the connection between circularity rate and socio-economic and environmental conditions to empirically explain the potential Bellagio process. It is of utmost importance to provide support for innovative projects that prioritize resource efficiency. National initiatives aimed at reducing energy consumption during both production and consumption stages play a vital role. European economies can effectively achieve these objectives by implementing environmental taxes on energy and natural resources, thereby addressing the issue of ecological footprint resulting from resource over-exploitation.

Keywords: CMU, Socioeconomic determinants, Sustainable Development

JEL Codes: Q01; Q53; Q56; Q57.

The Determinants of Heating Oil Consumption in the Household Sector

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Abstract

The subject of this study is analyzing the determinants of residential oil heating consumption. It aims to assess how socioeconomic, demographic and regional variables might affect household oil heating consumption. The case of Greece is taken as an example of our empirical analysis, using cross-sectional data from the Household Budget Survey of the Hellenic Statistical Authority. The results of the empirical analysis demonstrate that household oil heating consumption is positively related to the household's disposable annual income and the household head's educational level. On the contrary, the number of household members is negatively related to the demand for residential oil for house heating reasons. Furthermore, a non-linear relationship between the age of the head and oil heating consumption was estimated. In addition, there is an effect of gender, as well as significant regional heterogeneity of household oil consumption, related to urbanization and weather conditions. The assessment of the empirical findings leads to policy implications in designing energy-saving strategies for the residential sector in the framework of an effective energy policy aimed at decarbonizing fossil fuels.

Keywords: Household oil heating consumption; Greece; Cross section data; Socioeconomic factors.

JEL Codes: Q5; O18

Millennials' Perspective on Sustainable Banking Practices

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Abstract
This study adds to our understanding of how the incorporation of sustainability practices in the banking sector affects their customer satisfaction, employing cross section data from Millennials. The results showed that awareness has a significant positive effect on the satisfaction of Millennials toward the environmental practices of banking institutions. Results suggest that the overall corporate image of the banking institution significantly influences Millennials' satisfaction. Examining the outlook of Millennials regarding sustainable banking practices is crucial for predicting future trends, instigating favorable transformations in the banking sector, meeting customer expectations, guaranteeing enduring sustainability, tackling social and environmental issues, encouraging innovation, and advocating for corporate responsibility.

Keywords: sustainability, banks, satisfaction, millennials

JEL Codes: M14; O44; Q50; Q56;

Environmental multipliers in Sraffian frameworks: derivation, implications, and empirical illustration

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Abstract
This paper develops a theoretical and empirically applicable environmental extension of the Kurz matrix demand multipliers for Sraffian open–with state-economies and, thus, offers an integration of income distribution–value, heterogeneous produced means of production, open economy, effective demand, pollutant emissions and energy use considerations. The overall findings, on the one hand, call into serious question the effectiveness of traditional effective demand and environmental tax policy measures to reduce greenhouse gas emissions, energy use or/and unemployment and, on the other hand, forms an alternative, fairly general and flexible framework for providing policy-oriented analyses at the levels of individual industries and sectors, both nationally and transnationally

Keywords: Demand composition; environment–economy modelling; income distribution; Kurz multipliers; post-Keynesian–Sraffian theory

JEL Codes: C67, E11, E12, Q43, Q52

Περιβαλλοντικοί Πολλαπλασιαστές σε Σραφφαϊανό Πλαίσιο:
Θεωρία και Εμπειρική Απεικόνιση

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Περίληψη
Το παρόν άρθρο αναπτύσσει μία θεωρητική και εμπειρικά εφαρμόσιμη περιβαλλοντική επέκταση των πολλαπλασιαστών ζήτησης του Kurz, για σραφφαϊανές ανοικτές, με κρατικό τομέα οικονομίες και, έτσι, προσφέρει μία ενοποιημένη πραγμάτευση των ζητημάτων κατανομής εισοδήματος–αξίας, ετερογενών παραγόμενων μέσων παραγωγής, ανοικτής οικονομίας, ενεργού ζήτησης και περιβαλλοντικών επιπτώσεων. Τα συνολικά ευρήματα, αφενός, θέτουν υπό αμφισβήτηση την αποτελεσματικότητα των παραδοσιακών πολιτικών διαχείρισης της ενεργού ζήτησης και περιβαλλοντικής φορολόγησης για τη μείωση των εκπομπών ρύπων, της χρήσης ενέργειας ή και της ανεργίας και, αφετέρου, διαμορφώνουν ένα εναλλακτικό, επαρκώς γενικό και ευέλικτο αναλυτικό πλαίσιο για τη μελέτη των περιβαλλοντικών πολλαπλασιαστικών επιπτώσεων σε επίπεδο επιμέρους κλάδων και τομέων.

Keywords: Κατανομή εισοδήματος, μετα-κεϋνσιανή–σραφφαϊανή θεωρία, περιβαλλοντική–οικονομική μοντελοποίηση, πολλαπλασιαστές Kurz, σύνθεση ζήτησης.

JEL Codes: C67, E11, E12, Q51, Q58.

1. Introduction

It need hardly be stressed that the Keynesian-type income multiplier is one of the most important macroeconomic concepts for both theoretical and policy-related purposes. In a pioneering contribution, Kurz (1985) re-formulated the static version of this multiplier in Sraffa's (1960) closed–without state-economy framework of analysis and, thus, showed that, contrary to conventional (post-)Keynesian views, the multiplier linking net investment to income is a matrix quantity, the proximate determinants of which are the (i) technical conditions of production; (ii) distributive variables–relative commodity prices; (iii) savings ratios out of wages and profits; (iv) consumption patterns related to wages and profits; and (v) physical composition of net investment. It then follows that, in the empirically relevant case, i.e. the case of circular production–consumption flows with positive profits, there can be no such thing as 'the' multiplier and, in particular, a higher volume, in price terms, of net investment is not necessarily associated with higher levels of income and labour employment (Kurz, 1985, pp. 130–131). Subsequent studies have further explored the specific characteristics and implications, both theoretical and empirical, of the Kurz static multipliers; thus, it has also been pointed out that the Kurz multipliers include, as special versions or limiting cases, the conventional (post-)Keynesian multipliers, the corresponding multipliers of traditional input–output analysis, and their Marxian versions, and that they are efficient and flexible tools for studying the effective demand mechanism in real-world economies.[1]

Exogenous-autonomous demand multipliers also play, explicitly or otherwise, central roles in environmental economic modelling and policy research. These 'environmental multipliers' are measures that seek to quantify the total, direct and indirect, effects that changes in autonomous demand for domestically produced commodities have on various environmental variables, such as pollutant emissions, waste generation, and energy, land and water uses. Hence, from a theoretical point of view, they appear as extensions of the Keynesian multiplier logic to the study of interactions amongst economic activities, the natural environment and economic-social policy, while, from an empirical point of view, they merge national accounts statistics with environmental data. However, most of the studies on environmental multipliers so far have been based exclusively on the traditional input–output analysis framework (including, for instance, the 'hypothetical extraction method' and the 'social accounting matrix' modelling).[2] Therefore, they do not account for the full range or/and potential interdependencies of proximate determinants of the multiplier effects of demand.

This paper aims to help fill this gap by formulating an environmental extension of the Kurz multipliers for open–with state-economies, which is also applicable to actual, usually available,

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[1] Kurz (1985, pp. 126–127 and 133–134) offered relevant proofs followed by valuable suggestions and hints for future work. Further, see Kurz et al. (1998), Mariolis (2008, 2018), Mariolis and Ntemiroglou (2023), Mongiovi (2011) and White (2013), as well as the references provided in those publications. For a recent contribution, from the perspective of the logical history of political economy, to the re-formulation of the 'principle of effective demand' in classical–(post-)Keynesian–Sraffian frameworks, see Kurz (2021).

[2] This line of research was initiated by Cumberland (1966), Ayres and Kneese (1969), Leontief (1970), Leontief and Ford (1972), Bullard and Herendeen (1975a), Wright (1975), Park (1982), Hannon et al. (1983), and further developed, amongst others, by Wu and Chen (1990), Baumol and Wolff (1994), Duarte et al. (2002), Lenzen (2003) and Lenzen et al. (2004). More recent contributions include those of Parikh et al. (2009), Gallardo and Mardones (2013), Zhao et al. (2015), Guo et al. (2018), and Alcántara and Padilla (2020). For a detailed and up-to-date survey on the topic, see Miller and Blair (2022, Chaps. 12 and 13).

input–output and environmental data: Section 2 unfolds the theoretical results. Section 3 is an empirical illustration of key results by applying the model to input–output table and carbon dioxide emissions data for the US economy, retrieved from the Organisation for Economic Co-operation and Development (OECD) database, and the year 2018 (the latest data available at the time of this research). Finally, Section 4 concludes the paper.[1]

2. Modelling and Multipliers

We assume an open, linear economy involving only single products, 'basic' commodities (in the sense of Sraffa, 1960, pp. 7–8), circulating capital, and competitive imports. Moreover, (i) the economy is 'viable', namely, the Perron–Frobenius (P–F hereafter) eigenvalue of the matrix of total (domestic and imported) input–output coefficients is less than 1; (ii) labour is homogeneous within each industry but heterogeneous across industries; (iii) the net national income is distributed between profits and wages that are paid at the end of the common production period; (iv) the patterns of household consumption demand for domestically produced and imported commodities are uniform, across income types, given and constant; (v) the savings ratios out of wages and profits are given, and the former ratio is less than the latter; (vi) the price of a commodity obtained as an output at the end of the production period is the same as the price of that commodity used as an input at the beginning of that period ('stationary prices'); (vii) there is neither taxation nor impediments to trade, and the domestic currency prices of imported commodities equal those of domestically produced commodities; (viii) all input–output coefficients and sectoral profit and money wage rates are given and constant; hence, the commodity prices are also given and constant ('fix-price economy'); (ix) domestic output is determined by effective demand, that is, household consumption demand, which is endogenously determined, and autonomous demand (government consumption, net investments, and exports), while there are no limitations to the multiplier process; and (x) the amounts of pollutants emitted by each industry are homogeneous (or can be homogenised), measurable (in physical units, e.g. tons of CO_2) and vary in direct proportion to the level of activity of that industry.[2]

The price side of the economy can be described by $\boldsymbol{p}^T = \boldsymbol{w}^T\hat{\boldsymbol{l}} + \boldsymbol{p}^T\boldsymbol{A}[\boldsymbol{I}_n + \hat{\boldsymbol{r}}]$, where $\boldsymbol{p}^T$ ($> \boldsymbol{0}^T$) denotes the $1 \times n$ vector of commodity prices, $\boldsymbol{w}^T$ ($w_j > 0$) the $1 \times n$ vector of money wage rates, $\hat{\boldsymbol{l}}$ ($l_j > 0$) the $n \times n$ diagonal matrix of direct labour coefficients, $\boldsymbol{A} \equiv \boldsymbol{D} + \boldsymbol{M}$ the $n \times n$ matrix of total input–output coefficients, $\boldsymbol{D}$, $\boldsymbol{M}$ the irreducible matrices of domestic and imported input–output coefficients, respectively, $\boldsymbol{I}_n$ the $n \times n$ identity matrix, and $\hat{\boldsymbol{r}}$ ($r_j > 0$) the $n \times n$ diagonal matrix of the sectoral profit rates.

The quantity side of the economy can be described by $\boldsymbol{x} = \boldsymbol{D}\boldsymbol{x} + \boldsymbol{c}_d + \boldsymbol{f}_d$ and $\boldsymbol{Im} = \boldsymbol{M}\boldsymbol{x} + \boldsymbol{c}_m + \boldsymbol{f}_m$, where $\boldsymbol{x}$ denotes the $n \times 1$ vector of activity levels, and equals the vector of gross outputs ($\boldsymbol{I}_n\boldsymbol{x}$), $\boldsymbol{c}_d$ ($\geq \boldsymbol{0}$) the $n \times 1$ vector of household consumption demand for domestically produced commodities, $\boldsymbol{f}_d$ ($\geq \boldsymbol{0}$) the $n \times 1$ vector of autonomous demand (government consumption, net investments, and exports) for domestically produced commodities, $\boldsymbol{Im}$ the $n \times 1$ vector of total

[1] The part of the modelling that does not include environmental aspects draws directly on Mariolis and Ntemiroglou (2023, Section 2). For the data used and the construction of the modelling variables, see the Appendix at the end of the present paper.

[2] Mariolis and Ntemiroglou (2023, Section 2) provide a detailed discussion of assumptions (i) to (ix). Some of these assumptions facilitate the empirical illustration of the derived multipliers, while others will be relaxed in what follows. Assumption(s) (x), which is not uncommon in the relevant literature, simplifies the modelling without, however, affecting the main arguments of this paper.

demand for imports, $\boldsymbol{c}_m$ ($\geq \mathbf{0}$) the $n \times 1$ vector of household consumption demand for imported commodities, and $\boldsymbol{f}_m$ ($\geq \mathbf{0}$) the $n \times 1$ vector of autonomous demand (government consumption and net investments) for imported commodities. Adding these equations yields $\boldsymbol{x} + \boldsymbol{Im} = \boldsymbol{Ax} + \boldsymbol{c}_d + \boldsymbol{c}_m + \boldsymbol{f}_d + \boldsymbol{f}_m$ or, setting $\boldsymbol{c} \equiv \boldsymbol{c}_d + \boldsymbol{c}_m$, $\boldsymbol{f} \equiv \boldsymbol{f}_d + \boldsymbol{f}_m$ and $\boldsymbol{y} \equiv \boldsymbol{c} + \boldsymbol{f} - \boldsymbol{Im}$, $\boldsymbol{y} = [\boldsymbol{I}_n - \boldsymbol{A}]\boldsymbol{x}$, where $\boldsymbol{c}$ denotes the vector of total household consumption demand, $\boldsymbol{f}$ the vector of total autonomous demand, and $\boldsymbol{y}$ the net output vector.

If $\boldsymbol{\gamma_d}$ ($\geq \mathbf{0}$), $\boldsymbol{\gamma_m}$ ($\geq \mathbf{0}$) denote the patterns of household consumption demand for domestically produced and imported commodities, respectively, and $\boldsymbol{C_d} \equiv \boldsymbol{\gamma_d p^{*T}}$, $\boldsymbol{C_m} \equiv \boldsymbol{\gamma_m p^{*T}}$ denote the matrices of household consumption demand for domestically and imported commodities, respectively, where $\boldsymbol{p^{*T}} \equiv (\boldsymbol{p^T\gamma})^{-1}[(\mathbf{1} - s_w)\boldsymbol{w^T\hat{l}} + (\mathbf{1} - s_p)\boldsymbol{p^T A\hat{r}}]$, $\boldsymbol{\gamma} \equiv \boldsymbol{\gamma_d} + \boldsymbol{\gamma_m}$, s_w (s_p) denotes the savings ratio out of wages (out of profits) and $\mathbf{0} \leq s_w < s_p \leq \mathbf{1}$, then it can be shown that (Mariolis and Ntemiroglou, 2023, pp. 662–664):

(i). The matrix of multipliers linking autonomous demand for domestically produced commodities to gross outputs is $\boldsymbol{\Pi}^x \equiv [\boldsymbol{I}_n - \boldsymbol{D} - \boldsymbol{C}_d]^{-1}$ ($> \mathbf{0}$). Hence, the employment multiplier matrix is $\boldsymbol{\Pi}^L \equiv \boldsymbol{\hat{l}\Pi}^x$ ($> \mathbf{0}$).
(ii). The net output multiplier matrix is $\boldsymbol{\Pi^y} \equiv [\boldsymbol{I_n} - \boldsymbol{A}]\boldsymbol{\Pi^x}$. Although this matrix may contain negative elements, it holds that $\boldsymbol{p^T\Pi^y} > \mathbf{0^T}$ (since $\boldsymbol{p^T}[\boldsymbol{I_n} - \boldsymbol{A}] > \mathbf{0^T}$ and $\boldsymbol{\Pi^x} > \mathbf{0}$).
(iii). The import multiplier matrix is $\boldsymbol{\Pi^{Im}} \equiv [\boldsymbol{M} + \boldsymbol{C_m}]\boldsymbol{\Pi^x}$ ($> \mathbf{0}$).

Now let $\boldsymbol{g}^T$ ($\geq \mathbf{0}^T$) be the exogenously given $1 \times n$ vector of pollutant emissions (PE) per unit of gross output of each commodity, i.e. the vector of direct PE coefficients. The volume of PE, $G \equiv \boldsymbol{g}^T\boldsymbol{x}$, is given by $G = [\boldsymbol{\pi}^g]^T\boldsymbol{f}_d$, where $[\boldsymbol{\pi}^g]^T \equiv \boldsymbol{g}^T\boldsymbol{\Pi}^x$ ($> \mathbf{0}^T$) is the vector multiplier linking $\boldsymbol{f}_d$ to PE.

It then follows that the increases in (i) the monetary value of net outputs, Δ_y^i (individual income multiplier); (ii) the monetary value of imports, Δ_{Im}^i (individual import multiplier); and (iii) PE, Δ_G^i (individual PE multiplier), induced by a unit increase in autonomous demand for domestically produced commodity i, are given by $\Delta_y^i \equiv \boldsymbol{p}^T\boldsymbol{\Pi}^y\boldsymbol{e}_i$, $\Delta_{Im}^i \equiv \boldsymbol{p}^T\boldsymbol{\Pi}^{Im}\boldsymbol{e}_i$ and $\Delta_G^i \equiv [\boldsymbol{\pi}^g]^T\boldsymbol{e}_i$, respectively, where $\boldsymbol{e}_i$ denotes the ith unit vector. Thus, on the basis of these multipliers, which reflect *socio*-technical intra- and inter-national total (direct and indirect) 'backward linkages–leakages', we can obtain the following two environmental indices: (i). The ratio of the PE multiplier effect to the income multiplier effect, induced by a unit increase in autonomous demand for domestically produced commodity i, i.e.

$$\delta_1^i \equiv \Delta_G^i/\Delta_y^i \tag{1}$$

which measures the incremental PE intensity (IPEI) of commodity-industry i. (ii). The PE and import multiplier effects induced by a unit increase in exports of commodity i equal Δ_G^i and $\boldsymbol{\Pi}^{Im}\boldsymbol{e}_i$, respectively. If the domestic economy produced these imports, then the corresponding PE effect would be equal to $[\boldsymbol{\pi}^g]^T\boldsymbol{\Pi}^{Im}\boldsymbol{e}_i$. Hence, it can be stated that

$$\delta_2^i \equiv \Delta_G^i/[[\boldsymbol{\pi}^g]^T\boldsymbol{\Pi}^{Im}(\boldsymbol{p}^T\boldsymbol{e}_i/\boldsymbol{p}^T\boldsymbol{\Pi}^{Im}\boldsymbol{e}_i)\boldsymbol{e}_i] = \Delta_G^i/[[\boldsymbol{\pi}^g]^T\boldsymbol{\Pi}^{Im}(p_i/\Delta_{Im}^i)\boldsymbol{e}_i] \tag{2}$$

measures the incremental PE-savings/use (when $\delta_2^i < 1$ or > 1, respectively) from balanced trade associated with a unit increase in exports of commodity i (IPE-S).

In the more realistic case of direct taxation, the terms $(1-s_q)$, $q=w,p$, should be replaced by $(1-s_q)(1-t_q)$, where t_q denote the tax rates. Since all elements of both $\boldsymbol{\Pi}^x$ and $\boldsymbol{\Pi}^{Im}$ are decreasing functions of s_q, and $\boldsymbol{p}^T\boldsymbol{\Pi}^y > \boldsymbol{0}^T$, all individual commodity-industry multipliers are decreasing functions of both s_q and t_q; that is, a short-run version of the so-called 'paradox of thrift' is always valid (for short- and long-run versions of the post-Keynesian paradoxes of thrift and costs, see, e.g. Lavoie, 2014, Chaps. 5 and 6, respectively). However, the corresponding monotonicity of the two environmental indices is a priori unknown, and this is one of the characteristics of the multiplier process in circular flow–positive-profit frameworks.

Finally, on this basis it should be noted that: (i). The – consistently derived – PE and import multipliers of traditional input–output analysis are $\boldsymbol{g}^T[\boldsymbol{I}_n-\boldsymbol{D}]^{-1}$ ($<[\boldsymbol{\pi}^g]^T$) and $\boldsymbol{M}[\boldsymbol{I}_n-\boldsymbol{D}]^{-1}$ ($<\boldsymbol{\Pi}^{Im}$), respectively (however, this is not always the case, or not always clearly stated, in the relevant literature). (ii). In the one-commodity–uniform savings ratio case, our income and import multipliers reduce to those of the traditional Keynesian model (for that model, see, e.g. Gandolfo, 2002, pp. 99–109). (iii). The logic of the 'hypothetical extraction method' can be applied to our multiplier matrices. (iv). In the more realistic case of m types of PE, $\boldsymbol{g}^T$ should be replaced by an $m\times n$ matrix and, therefore, the individual PE multipliers become vectors of dimensions $m\times 1$. (v). Under highly restrictive assumptions, $\boldsymbol{g}^T$ may alternatively represent the vector of energy use per unit of gross output of each commodity (consider Herendeen, 1978, and Miller and Blair, 2022, Chap. 12). In that case, which greatly simplifies the modelling without, however, affecting the main arguments of *this* paper, the previous analysis leads to the derivation of 'energy multipliers'; thus, these two types of environmental multipliers become formally equivalent to each other.

Provided that both distributive variables exhibit stable structures in relative terms (see Kurz and Salvadori, 1995, pp. 324–325, and Steedman, 1977, pp. 180–181), the price system can be written as $\boldsymbol{p}^T = w\bar{\boldsymbol{w}}^T\hat{\boldsymbol{l}} + \boldsymbol{p}^T\boldsymbol{A}[\boldsymbol{I}_n + r\hat{\bar{\boldsymbol{r}}}]$, where w, r denote the overall levels of wage and profit rates, respectively, and $\bar{\boldsymbol{w}}^T$, $\hat{\bar{\boldsymbol{r}}}$ represent their relative magnitudes in different industries (for instance, $\bar{\boldsymbol{w}}^T \equiv (min\{w_j\})^{-1}\boldsymbol{w}^T$ and $\hat{\bar{\boldsymbol{r}}} \equiv (min\{r_j\})^{-1}\hat{\boldsymbol{r}}$). Thus, setting $\bar{\boldsymbol{l}}^T \equiv \bar{\boldsymbol{w}}^T\hat{\boldsymbol{l}}$ and $\boldsymbol{A}(r) \equiv \boldsymbol{A}[\boldsymbol{I}_n + r\hat{\bar{\boldsymbol{r}}}]$, we obtain

$$\boldsymbol{p}^T = w\bar{\boldsymbol{l}}^T + \boldsymbol{p}^T\boldsymbol{A}(r) \tag{3}$$

which implies that the maximum feasible value, R, of 'the' profit rate equals the reciprocal of the P–F eigenvalue of $\boldsymbol{H} \equiv \boldsymbol{A}\hat{\bar{\boldsymbol{r}}}[\boldsymbol{I}_n-\boldsymbol{A}]^{-1}$, i.e. $R=\lambda_{\boldsymbol{H}}^{-1}$. If the unit of total household consumption is chosen as the *numéraire*, i.e. $\boldsymbol{p}^T\boldsymbol{\gamma}=1$, then equation (3) implies that $w(r) = (\bar{\boldsymbol{l}}^T[\boldsymbol{I}_n-\boldsymbol{A}(r)]^{-1}\boldsymbol{\gamma})^{-1}$, where $0\le r<R$, gives the trade-off between 'the' wage rate, measured in terms of $\boldsymbol{\gamma}$, and the profit rate ($\dot{w}(r) \equiv dw(r)/dr < 0$ and $w(R)=0$). Moreover, $\boldsymbol{p}^T(r) = w(r)\bar{\boldsymbol{l}}^T(r)$ gives the vector of commodity prices measured in terms of $\boldsymbol{\gamma}$ ($\boldsymbol{p}^T(R)$ equals the left P–F eigenvector of $\boldsymbol{H}$), where $\bar{\boldsymbol{l}}^T(r) \equiv \bar{\boldsymbol{l}}^T[\boldsymbol{I}_n-\boldsymbol{A}(r)]^{-1} = \sum_{k=0}^{+\infty}\bar{\boldsymbol{l}}^T[\boldsymbol{A}(r)]^k$ ($\dot{\bar{\boldsymbol{l}}}_{(r)} > \boldsymbol{0}$) can be conceived of as the sum of the series of 'dated quantities of direct labour' and indicates that these prices can change in a complex way as the profit rate changes (Sraffa, 1960, Chap. 6; for a generalised, spectral analysis, see Mariolis and Veltsistas, 2022). It then follows that any change in relative commodity prices, induced, directly or indirectly, by changes in the distributive variables, alters the elements of the matrix multipliers and, thus, the income, employment, import and PE multiplier effects become ambiguous (even when the volume of autonomous demand, in physical terms, increases, i.e. $d\boldsymbol{f}_d \ge \boldsymbol{0}$). For instance, expressing the individual PE multipliers in terms of $\boldsymbol{p}^T(r)$, and differentiating with respect to r, finally gives $\dot{\Delta}_G^i(r) = [\boldsymbol{\pi}^g(r)]^T\dot{\boldsymbol{C}}_d(r)\boldsymbol{\Pi}^x(r)\boldsymbol{e}_i$, which suggests that, in the general case, the direction of change in the level of PE is a priori unknown , and that the paradox of costs is not always valid. In the polar case where $s_p = 1$, both $\dot{\boldsymbol{C}}_d(r)$ and $\dot{\boldsymbol{C}}_m(r)$ are non-positive (since $\dot{w}(r) < 0$) and, therefore, $\dot{\Delta}_G^i(r)$ and $\dot{\boldsymbol{\Pi}}_L(r)$ are necessarily negative; nevertheless, the signs of both $\dot{\Delta}_y^i(r)$ and $\dot{\Delta}_{Im}^i(r)$, as well as the directions of change in the elements of $\boldsymbol{\Pi}^y(r)\boldsymbol{e}_i$, remain ambiguous.

Finally, when a tax is levied on PE, the price equation (3) becomes $\boldsymbol{p}^T = w\bar{\boldsymbol{l}}^T + t\boldsymbol{g}^T + \boldsymbol{p}^T\boldsymbol{A}(r)$, where t denotes the quantity-based tax rate; or, solving for $\boldsymbol{p}^T$,

$$\boldsymbol{p}^T = w\bar{\boldsymbol{l}}^T(r) + t\boldsymbol{g}^T(r) \tag{4}$$

where $\boldsymbol{g}^T(r) \equiv \boldsymbol{g}^T[\boldsymbol{I}_n - \boldsymbol{A}(r)]^{-1} = \sum_{k=0}^{+\infty}\boldsymbol{g}^T[\boldsymbol{A}(r)]^k$ ($\dot{\boldsymbol{g}}(r) > \boldsymbol{0}$) and $g_i(0)/\bar{l}_i(0)$ can be conceived of as the sum of the series of 'dated quantities of direct PE' and the 'technical total (direct and indirect) PE-to-labour intensity' of industry i, respectively. Post-multiplying equation (4) by the *numéraire* commodity, $\boldsymbol{\gamma}$, and solving for w gives

$$w = (1 - t\boldsymbol{g}^T(r)\boldsymbol{\gamma})(\bar{\boldsymbol{l}}^T(r)\boldsymbol{\gamma})^{-1} \tag{5}$$

that is, a '$w - t - r$ surface' in which each variable is inversely related to each of the others; $0 \le t \le (\boldsymbol{g}^T(0)\boldsymbol{\gamma})^{-1}$, while the maximum feasible value, t_{max}, of the environmental tax rate, which corresponds to an exogenously given value, $\bar{r}$, of the profit rate, is $t\bar{T}^{-1}{}_{max}$. Equations (4) and (5) imply that $t^{-1}\boldsymbol{p}^T(t,r) = (t^{-1} - \boldsymbol{g}^T(r)\boldsymbol{\gamma})(\bar{\boldsymbol{l}}^T(r)\boldsymbol{\gamma})^{-1}\bar{\boldsymbol{l}}^T(r) + \boldsymbol{g}^T(r)$.

Hence, when the profit rate (the wage rate) is held constant, an increase in t involves a reduction in both the wage rate (the profit rate) and $t^{-1}\boldsymbol{p}^T$; however, it also causes unpredictable changes in relative commodity prices. It then follows that an increase in t (or, more generally, a decrease in w/t): (i). Does not necessarily imply an increase in the relative prices of relatively 'PE-intensive' commodities (and when there are alternative techniques of production, it does not necessarily induce cost-minimising producers to switch to less 'PE-intensive' techniques). For instance, when the profit rate is held constant, differentiation of equation (4), with respect to w/t, finally gives

$$\partial(p_i/p_j)/\partial(w/t) > (<)\, 0 \Leftrightarrow \delta_{ji}(r) \equiv (g_j(r)/\bar{l}_j(r)) - (g_i(r)/\bar{l}_i(r)) > (<)\, 0 \tag{6}$$

which indicates that the direction of relative price movements is not necessarily governed by the differences in the relevant total PE intensities, $\delta_{ji}(0)$. (ii). Affects the underlying multiplier relationships by altering the distributive variables–relative prices and, thus, possibly the quasi-autonomous characteristics and components of demand (e.g. consumption patterns, and levels and composition of government expenditure or exports). That is, in the general case, environmental taxation alters both the multipliers and the multiplicand and, therefore, has unpredictable multiplier effects.[1]

[1] For a detailed derivation and thorough discussion of the first proposition, see Gehrke and Lager (1995) and Lager (1999). Compare with Perman et al. (2011, Chaps. 5–8), who provide a comprehensive overview of environmental tax policy issues in traditional (neoclassical and input–output) analytical frameworks, as well as with the contributions of Bullard and Herendeen (1975b) and, for instance, Gemechu et al. (2014), Llop (2008), Mardones and Munõz (2018), which are based on environmental extensions of the Leontief (1946) price model.

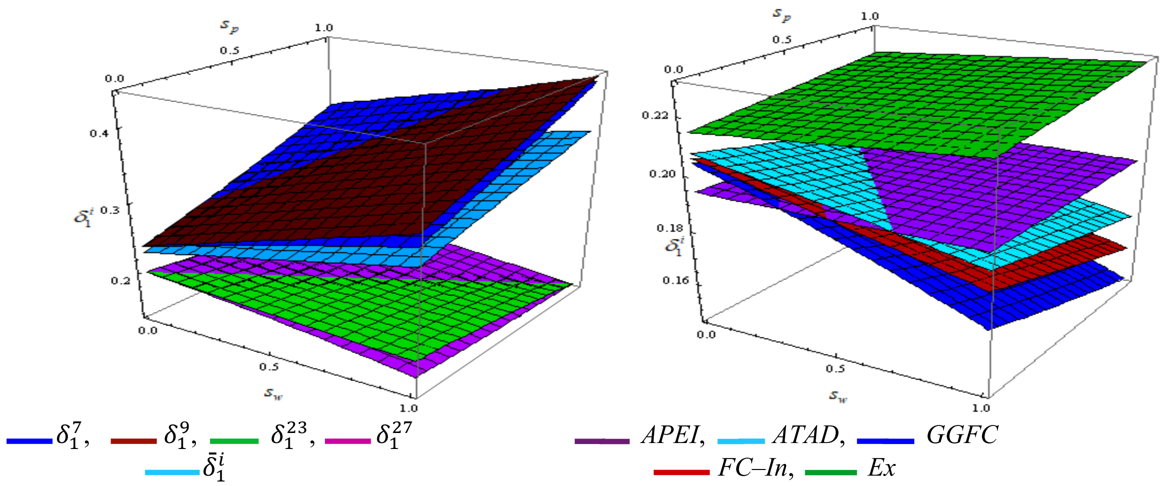
3. Empirical Illustration for the US Economy

The application of the model to the National Input–Output Table (NIOT) and carbon dioxide (CO_2) emissions data for the US economy (year 2018) gave the following representative results, which we report in correspondence with the proximate determinants of the relevant PE (CO_2) multipliers.

3.1. Autonomous demand composition and savings ratios

The individual IPEI, δ_1^i (defined by equation (1)), are all found to be monotonic functions (either increasing or decreasing) of the savings ratios; however, there are changes in the ranking of commodities-industries by IPEI. For instance, the graphs in Figure 1 display, on the one hand, the IPEI of commodities-industries i = 7, 9, 23 and 27, as well as the economy's 'average IPEI', which is defined as $\bar{\delta}_1^i \equiv \bar{\Delta}_G^i/\bar{\Delta}_y^i$, where $\bar{\Delta}_G^i \equiv [\boldsymbol{\pi}^g]^T(\boldsymbol{e}/n)$ (average PE multiplier), $\bar{\Delta}_y^i \equiv \boldsymbol{p}^T\boldsymbol{\Pi}^y(\boldsymbol{e}/n)$ (average income multiplier) and $\boldsymbol{e} \equiv [1,1,\ldots,1]^T$ (summation vector), and therefore reflects the relevant multiplier effects induced by a hypothetical, simultaneous increase of $1/n$ units in autonomous demand for every domestically produced commodity i. On the other hand, they display the actual pollutant emission intensity of the economy, $APEI$, which was found to be approximately equal to 0.19 (kt CO_2/Million US$), and the IPEI associated with the 'actual total autonomous demand', $ATAD$, for domestically produced commodities, as well as with its components, i.e. domestic 'Final consumption expenditure of general government' ($GGFC$), domestic 'Gross Fixed Capital Formation and Changes in inventories' (FC–In), and 'Direct purchases by non-residents (exports) and Exports (cross border)' (Ex), which are obtained directly from the aggregated NIOT: $\delta_1^d \equiv [\boldsymbol{\pi}^g]^T\boldsymbol{d}/\boldsymbol{p}^T\boldsymbol{\Pi}^y\boldsymbol{d}$, where $\boldsymbol{d}$ is the $n \times 1$ vector denoting a component of actual autonomous demand. Relation $\delta_1^i > \bar{\delta}_1^i$ implies that the pollutant emission intensity effect of industry i is on average stronger than that of the other industries, while $\delta_1^d > APEI$ or $\delta_1^i > APEI$ imply an increase in the actual pollutant emission intensity of the economy.

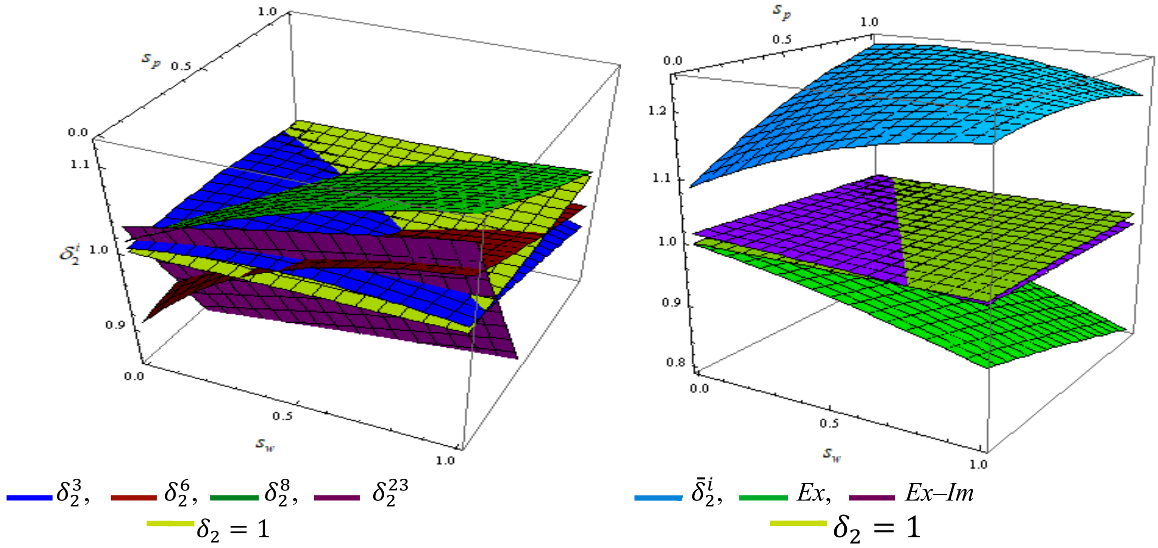
Figure 1: The actual pollutant emission intensity of the economy, and individual and aggregate incremental pollutant emission intensities as functions of the savings ratios.



Furthermore, there are individual IPE-S, δ_2^i (defined by equation (2)), that are non-monotonic functions of the savings ratios, as well as δ_2^i (either monotonic or non-monotonic) that change from less than unity to greater than unity. For instance, the graphs in Figure 2 display the notional surface

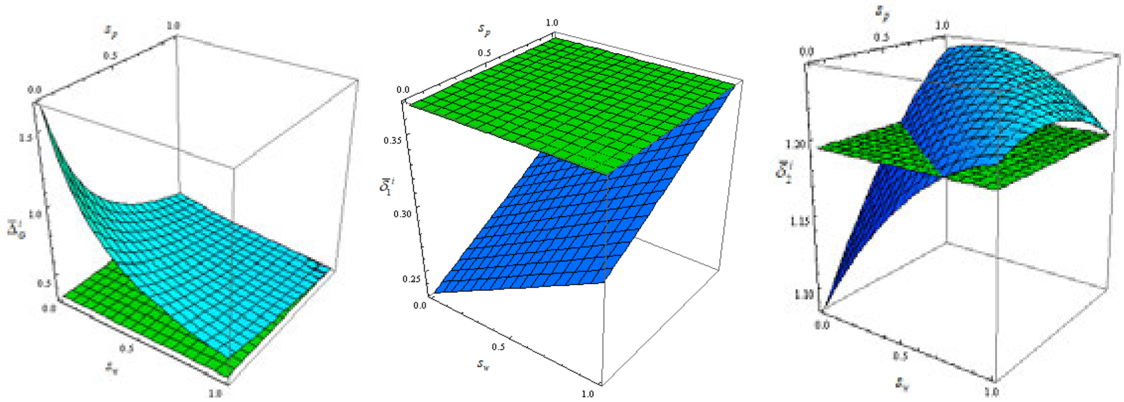
$\delta_2 = 1$ and, on the one hand, δ_2^i, where $i = 3$, 6, 8 and 23. On the other hand, they display (i) the economy's 'average IPE-S', which is defined as $\bar{\delta}_2^i \equiv \bar{\Delta}_G^i / \{[\boldsymbol{\pi}^g]^T \boldsymbol{\Pi}^{Im} [\mathbf{p}^T(\mathbf{e}/n)/\bar{\Delta}_{Im}^i](\mathbf{e}/n)\}$ where $\bar{\Delta}_{Im}^i \equiv \mathbf{p}^T \boldsymbol{\Pi}^{Im}(\mathbf{e}/n)$ (average import multiplier), and therefore reflects the relevant multiplier effects induced by a hypothetical, simultaneous increase of $1/n$ units in exports of every domestically produced commodity i; (ii) the IPE-S associated with the actual total exports (*Ex*); and (iii) the IPE-S associated with the actual total exports and total imports (*Ex–Im*), which is given by $[\boldsymbol{\pi}^g]^T \mathbf{Ex}^* / [\boldsymbol{\pi}^g]^T (\mathbf{p}^T \mathbf{Ex}^* / \mathbf{p}^T \mathbf{Im}^*) \mathbf{Im}^*$, where $\mathbf{Ex}^*$, $\mathbf{Im}^*$ denote the vectors of actual total exports and total imports, respectively, and reflects the actual composition of trade. The observed fact that, for *each* possible value of the savings ratios, $\bar{\delta}_2^i$ is greater than unity (see the right-hand graph in Figure 2) is due to industry 15 ('Electricity, gas, steam and air conditioning supply'), which is characterised by the highest values of the IPE-S, i.e. $3.53 < \delta_2^{15} < 11.46$, IPEI, i.e. $0.74 < \delta_1^{15} < 4.41$, and PE multiplier, i.e. $4.06 < \Delta_G^{15} < 5.43$ (versus $0.33 < \bar{\Delta}_G^i < 1.66$) and, at the same time, by a low 'openness ratio' (actual exports and imports to gross output) of 1.4%.

Figure 2: Individual and aggregate incremental pollutant emission-savings/uses from balanced trade as functions of the savings ratios.



Finally, the graphs in Figure 3 display the average PE multiplier, IPEI and IPE-S of traditional input–output analysis, i.e. $(\bar{\Delta}_G^i)^{\mathrm{Tr}} \equiv \mathbf{g}^T[\mathbf{I}_n - \mathbf{D}]^{-1}(\mathbf{e}/n) \cong 0.33$, $(\bar{\delta}_1^i)^{\mathrm{Tr}} \cong 0.37$, and $(\bar{\delta}_2^i)^{\mathrm{Tr}} \cong 1.20$, respectively, versus their Kurz counterparts.

Figure 3: The average pollutant emission multiplier and environmental indices: traditional input–output analysis (green colour) versus Kurz's analysis.



3.2. Distributive variables and environmental taxation

In what follows we set $\bar{\mathbf{w}}^T \equiv (min\{w_j\})^{-1}\mathbf{w}^T$, $\hat{\bar{\mathbf{r}}} \equiv (min\{r_j\})^{-1}\hat{\mathbf{r}}$ and $\mathbf{p}^T\boldsymbol{\gamma}^* = 1$ (*numéraire* equation), where $min\{w_j\} = w_1 \cong 0.025$, $min\{r_j\} = r_3 \cong 0.186$, which implies that $R \cong 0.378$, and $\boldsymbol{\gamma}^* \equiv (\mathbf{p}^T\boldsymbol{\gamma})^{-1}\boldsymbol{\gamma}$.

3.2.1. Distributive variables

For $0 \leq s_w < s_p < 1$, there are individual PE multipliers, which are non-monotonic or strictly increasing functions of 'the' profit rate; for instance, the graphs in Figure 4 correspond to the case where $s_w = 0.05$ and $s_p = 0.2$, and display the non-decreasing individual PE multipliers. Moreover, as the – sufficiently representative – graphs in Figure 5 suggest, there are δ_1^i and δ_2^i which are non-monotonic functions of the profit rate.

Figure 4: The individual pollutant emission multipliers that are non-decreasing functions of the profit rate: $s_w = 0.05$, $s_p = 0.2$ and $0 \leq r < R \cong 0.378$.

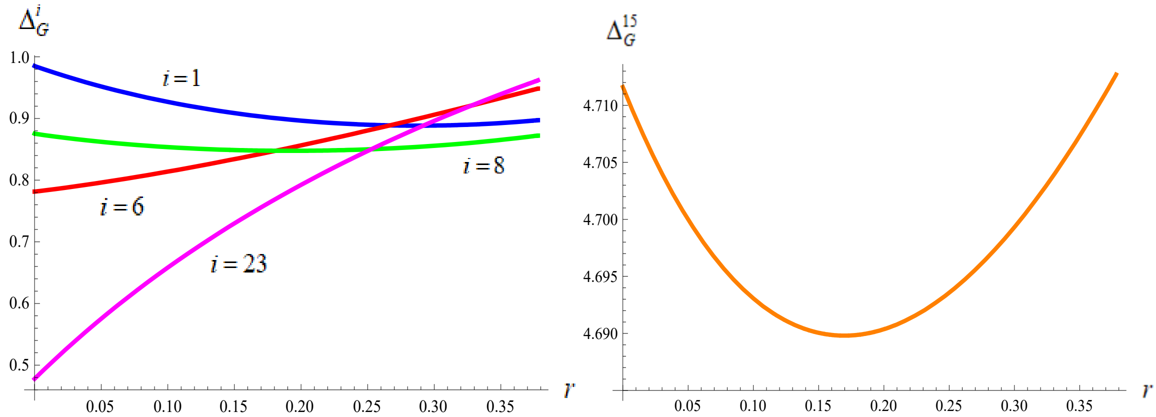
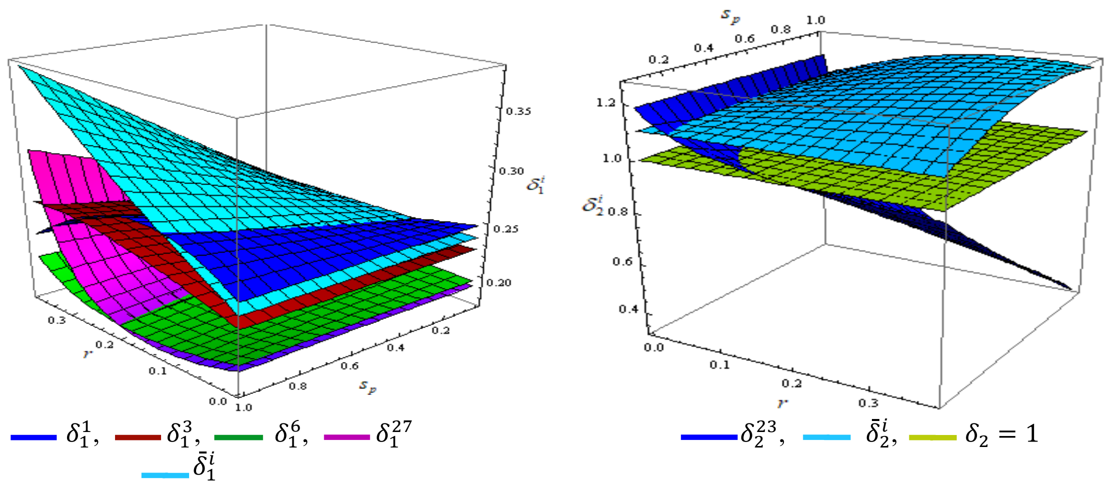


Figure 5: Individual and average incremental pollutant emission intensities and pollutant emission-savings/uses from balanced trade as functions of the savings ratio out of profits and the profit rate: $s_w = 0.05 < s_p \leq 1$ and $0 \leq r < R \cong 0.378$.



3.2.2. Environmental taxation

The curves in Figure 6 correspond to condition (6) and suggest that an increase in the environmental tax rate does not necessarily imply an increase in the relative prices of relatively 'PE-intensive' commodities. Finally, as the graphs in Figure 7 suggest, at a given level of the profit rate, the IPEI may change non-monotonically as the environmental tax rate changes (in this figure, all but one of the curves are non-monotonic).

Figure 6: Examples of graphical representation of the condition governing the direction of relative price movement: $0 \leq r < R \cong 0.378$.

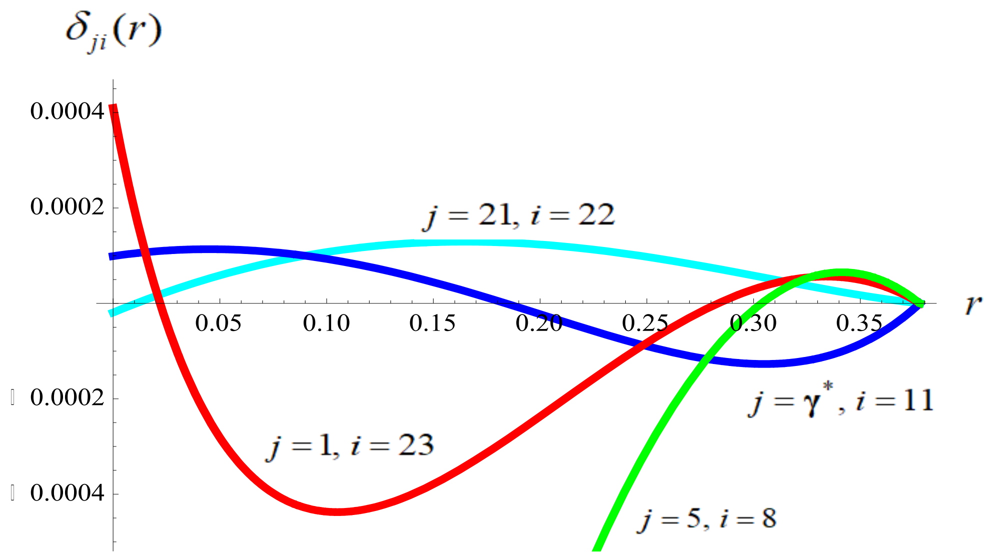
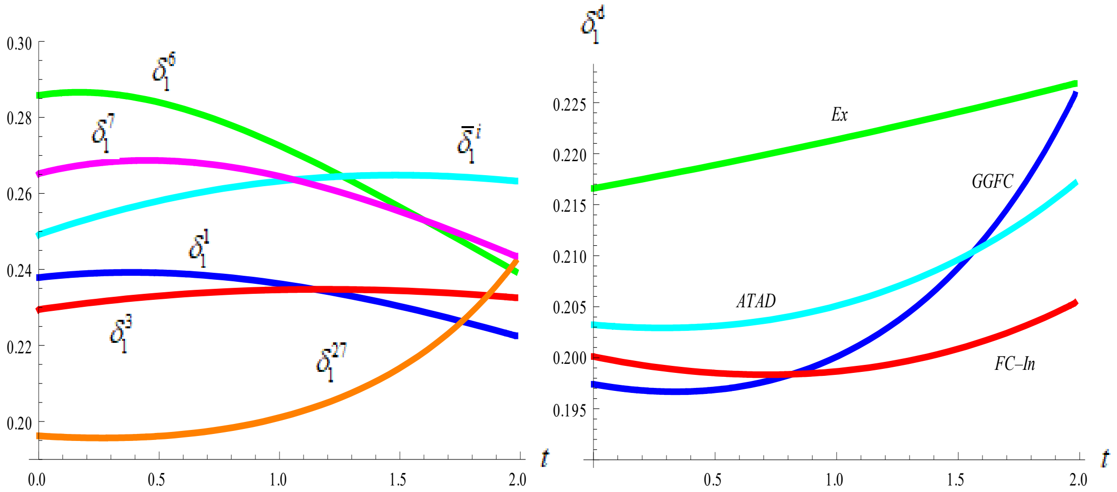


Figure 7: Individual and aggregate incremental pollutant emission intensities as functions of the environmental tax rate: $s_w = 0.05$, $s_p = 0.2$, $\bar{r} = min\{r_j\} \cong 0.186$ and $0 \leq t < t_{max}$.



4. Concluding Remarks

This paper formulated an environmental extension of the Kurz static matrix multipliers, where the multiplier effects of demand reflect , in complex and – often – interacting ways, socio-technical intra- and inter-national total backward linkages–leakages. It has thus been shown that: (i). Even when the savings ratios/direct tax rates and distributive variables are held constant, both the magnitude of the change in pollutant emissions/energy use and the direction of change in the actual pollutant emission/energy use intensity of the economy depend heavily on the physical composition of autonomous demand. (ii). The monotonicity of individual incremental pollutant emission intensities and pollutant emission-savings/uses from balanced trade with respect to the savings ratios/direct tax rates is a priori unknown and, in general, there are changes in the rankings of commodities-industries (and sectors) by these environmental indices. (iii). Environmental multipliers can change in unpredictable ways as the environmental tax rate and/or distributive variables change. In particular, an increase in the environmental tax rate does not necessarily imply an increase in the relative prices of relatively 'pollutant emission/energy-intensive' commodities and can cause non-monotonic changes in the incremental pollutant emission/energy intensities.

Taken together, these results generalise those obtained from traditional frameworks and, thus, set limits to their relevance for both research and policy-making. Since in the real economic world there is no "one-way avenue that leads from 'Factors of production' to 'Consumption goods'" (Sraffa, 1960, p. 93), but instead a circular flow system of production–consumption–pollutant emission, heterogeneous bad and capital goods–positive-profit frameworks appear to be more appropriate than traditional ones for studying the environmental multiplier effects of demand.

Author Contributions

TM designed the research, constructed and explored the model, performed the computations, and wrote the manuscript. **CT** collected and evaluated the empirical data, constructed the modelling variables, contributed to the literature selection, commented on the findings and the manuscript, and read and approved its final version.

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Appendix: Data Sources and Construction of Variables

Table A1. Industries after the aggregation process.

No.	Industries (ISIC codes)
1	A01–A02 ⊕ A03: Agriculture, hunting, forestry ⊕ Fishing and aquaculture
2	B05–B06 ⊕ B07–B08 ⊕ B09: Mining and quarrying, energy producing products ⊕ Mining and quarrying, non-energy producing products ⊕ Mining support service activities
3	C10–C12: Food products, beverages and tobacco
4	C13–C15: Textiles, textile products, leather and footwear
5	C16 ⊕ C17–C18 : Wood and products of wood and cork ⊕ Paper products and printing
6	C19: Coke and refined petroleum products
7	C20: Chemical and chemical products
8	C21: Pharmaceuticals, medicinal chemical and botanical products
9	C22 ⊕ C23: Rubber and plastics products ⊕ Other non-metallic mineral products
10	C24: Basic metals
11	C25: Fabricated metal products
12	C26 ⊕ C27 ⊕ C28: Computer, electronic and optical equipment ⊕ Electrical equipment ⊕ Machinery and equipment, nec
13	C29 ⊕ C30: Motor vehicles, trailers and semi-trailers ⊕ Other transport equipment
14	C31–C33: Manufacturing nec; repair and installation of machinery and equipment
15	D35: Electricity, gas, steam and air conditioning supply
16	E36–E39: Water supply; sewerage, waste management and remediation activities
17	F41–F43: Construction
18	G45–G47: Wholesale and retail trade; repair of motor vehicles
19	H49 ⊕ H50 ⊕ H51 ⊕ H52 ⊕ H53: Land transport and transport via pipelines ⊕ Water transport ⊕ Air transport ⊕ Warehousing and support activities for transportation ⊕ Postal and courier activities
20	I55–I56: Accommodation and food service activities
21	J58–J60 ⊕ J61 ⊕ J62–J63: Publishing, audiovisual and broadcasting activities ⊕ Telecommunications ⊕ IT and other information services
22	K64–K66: Financial and insurance activities
23	L68: Real estate activities
24	M69–M75: Professional, scientific and technical activities
25	N77–N82: Administrative and support services
26	O84: Public administration and defence; compulsory social security
27	P85: Education
28	Q86–Q88: Human health and social work activities
29	R90–R93: Arts, entertainment and recreation
30	S94–S96: Other service activities

Note: The symbol "⊕" denotes industry aggregation.

The used National Input–Output Table (NIOT) for the US economy (and the year 2018) is available via the OECD website, https://data.oecd.org/ (2021 edition), and describes 45 industries classified according to the International Standard Industrial Classification (ISIC Rev. 4); https://www.oecd.org/sti/ind/input-outputtables.htm. Because the 'OECD Air Emissions Accounts' provide no data on the USA, we use data on 'Carbon dioxide emissions based on production (PROD_CO_2)' (measured in million tons; 2021 edition) from the OECD 'Trade in embodied CO_2 (TECO2)' database (http://oe.cd/io-co2; for the underlying concepts, construction methods and data sources, see Yamano and Guilhoto, 2020). However, CO_2 emissions from industry T ('Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use') equal zero, while the only non-zero NIOT elements associated with this industry are 'Output at basic prices' and 'Final consumption expenditure of households' for domestically produced commodities (which are equal to each other). It is also observed that several industries (especially in the service sector) are characterised by significantly low CO_2 emissions. Therefore, we remove industry T and aggregate (based on ISIC codes) the data into 30 industries (see Table A1).

The construction of the modelling variables is as follows: (i). The price vector, $\boldsymbol{p}^T$, is identified with $\boldsymbol{e}^T \equiv [1,1,\ldots,1]$, i.e. the physical unit of measurement of each commodity is that unit which is worth of a monetary unit (in the present NIOT, the unit is set to 1 million US dollars). Our individual commodity-industry multipliers are all independent of the choice of physical units in which commodities are measured (see Mariolis and Ntemiroglou, 2023, p. 665). (ii). The matrices of input–output coefficients, $\boldsymbol{D} \equiv [d_{ij}]$ and $\boldsymbol{M} \equiv [m_{ij}]$, are obtained by dividing, element-by-element, the domestic and imported inputs, respectively, in each industry by its gross output (i.e. by its 'Output at basic prices', which is obtained directly from the aggregated NIOT). (iii). The industry-level data on employment, $EMPN_j$, are obtained from the OECD STAN database (https://www.oecd.org/industry/ind/stanstructuralanalysisdatabase. htm; 2020 edition), and are measured in thousands of persons engaged in production. Therefore, the element l_j of the diagonal matrix of direct labour coefficients, $\hat{\boldsymbol{l}}$, is obtained by dividing employment in industry j by its gross output, x_j, i.e. $l_j = EMPN_j/x_j$. (iv). The money wage rates, w_j, are estimated from $w_j = LABR_j/EMPN_j$, where $LABR_j$ represents the labour compensation in industry j; $LABR_j$ are also obtained from the OECD STAN database and are measured in million US dollars. (v). The profit rates, r_j, are estimated from $r_j = [(1 - w_j l_j)/\sum_{i=1}^{n} a_{ij}] - 1$, where $a_{ij} \equiv d_{ij} + m_{ij}$. (vi). Given that 'Non-profit institutions serving households' (e.g. churches and religious societies, sports and other clubs, trade unions and political parties) are private, non-market producers that provide goods or services to households for free or at prices that are not economically significant (see Eurostat, 2013, Chaps. 2 and 9), while, in the present NIOT, total 'Final consumption expenditure of non-profit institutions serving households (NPISH)' as a percentage of total 'Final consumption expenditure of households (HFCE)' equals 3.54% for domestically produced commodities and 0.27% for imported commodities, we chose not to take into account the 'Final consumption expenditure of non-profit institutions serving households'. Thus, the vectors of 'Final consumption expenditure of households' for domestically produced and imported commodities are considered as the empirical counterparts of $\boldsymbol{\gamma}_d$ and $\boldsymbol{\gamma}_m$, respectively. (vii). The vector of direct CO_2 emission coefficients, $\boldsymbol{g}^T$, is obtained by dividing the CO_2 emissions from each industry (expressed in kilotons) by its gross output.

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Evaluation of Indoor Environmental Quality (IEQ) of Transport Cabins Using an Optical Particle Counter

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Abstract
Africa is experiencing an unprecedented demographic growth since few decades. It is followed by an increasing rate of urbanization in almost all countries. In parallel, we are witnessing a deterioration in air quality, especially in urban areas. Road traffic contributes significantly to atmospheric pollution through unregulated traffic, poor roads' design, and poor fuel quality. The surge in vehicle imports appears as an aggravating factor, as these vehicles are old and use low quality fuels. Roads' densities are very low, most roads unpaved or poorly maintained. Congestion has become frequent in new megacities such as Dar-es-Salam, Lagos, Douala, Abidjan, etc. Literature review shows a focus on outdoors dispersion and impacts and points out exhaust fumes, tyres degradation, and roads condition as main sources of pollutants while studies focusing on in-cabin pollution are still scarce. In this study, we present results of an ongoing evaluation of air pollutants concentration in minibuses in the city of Thiès (Senegal) using a Particle Plus 8301-AQM2 Series handled optical particle counter (OPC). Three different types of sources are identified, as the outdoor air, the vehicle itself and the occupants. Fine particles concentrations, carbon dioxide (CO_2), temperature and relative humidity were recorded in several routes at different periods of the day (morning, afternoon, and evening) and for several days. Recorded data show high concentration of fine particles which increases over time (from 25 up to 300 µg/m3) depending on outdoor conditions and the areas crossed by the bus. CO_2 concentration (300-900 ppm) varies with the number of passengers during the trip. The temperature was in the range 30-40 °C and the relative humidity, 40-70%. The speed analysis shows frequent variations and was found low, ~2.5 m/s. Keeping doors and windows open help in eliminating excess CO_2 but ends in high level of dust concentration in the cabin.

Keywords: African cities; air sensors; OPC, air quality.

JEL Codes: I15; O29; R00

Session 11

Sustainable Water Management – Social and Natural Capital

Impact of Fuel Costs on Fish Prices: An Econometric Analysis in the Ionian Sea

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Abstract
This study, conducted under the SEAwise project, which is funded by the European Union's Horizon 2020 research and innovation programme (grant agreement No 101000318), explores the relationship between fuel costs and fish prices in the GSA20 region, specifically the Ionian Sea in Greece. The paper presents a detailed econometric analysis of four key fish species: Hake, Shrimp, Striped Red Mullet, and Red Mullet. Utilizing comprehensive datasets encompassing catch quantities, average market prices, and fuel prices, the study employs regression analyses and other statistical tools to uncover patterns and correlations. Our findings reveal a complex picture: while Hake and Shrimp prices exhibit a small sensitivity to fuel cost fluctuations, Striped Red Mullet and Red Mullet prices are significantly impacted by changes in fuel costs. These results suggest a nuanced interplay between operational costs and market dynamics in the fisheries sector. The study contributes insights to environmental economics, particularly in understanding how external economic factors, such as fuel prices, can influence marine resource economics. This work not only informs policymaking in sustainable fisheries management but also adds a significant dimension to the ongoing dialogue on the economic sustainability of marine ecosystems under the SEAwise project.

Keywords: Fisheries Economics, Fuel Costs, Fish Prices, Ionian Sea, Market Dynamics

JEL Codes: Q22; Q41; Q56; R11; C51.

1. Introduction

The fishing industry, a vital aspect of many coastal communities, faces many challenges, including several environmental and economic factors. This paper, developed under the SEAwise project, funded by the European Union's Horizon 2020 research and innovation programme (grant agreement No 101000318), aims to explore one such critical economic factor: the impact of fuel costs on fish prices. Our study area is the Ionian Sea in Greece, known for its diverse and economically significant fisheries.

Our investigation is relevant in the context of the rising global concerns around sustainable fisheries management and environmental conservation. The interplay between fuel prices and fish prices not only has implications for the economic viability of fisheries but also poses environmental impacts, given the potential influence on fishing practices and intensity.

The primary objective of our study is to quantitatively analyze the relationship between fuel costs and the prices of four key fish species in the GSA20 region: Hake, Shrimp, Striped Red Mullet, and Red Mullet.

In contributing to the existing literature, this paper fills a gap by offering a focused econometric analysis within the context of the Ionian Sea's fisheries. While previous studies have explored various aspects of fisheries economics, the specific investigation of fuel cost impacts on fish prices, particularly in this region, remains underexplored. Our study thus adds a significant dimension to the dialigue on the economic and environmental sustainability of marine ecosystems, aligned with the overarching goals of the SEAwise project.

2. Literature Review

Our paper builds upon existing literature in the field of fisheries economics and environmental economics.

Mavromatti et al. (2021) and Voulgaris et al. (2013) provide insights into the profitability and efficiency of the Greek fish farming sector. Their findings emphasize the importance of liquidity, working capital management, productivity, and industry growth in influencing firm profitability, which are key considerations in our study of fuel costs and fish prices. The studies by Carvalho et al. (2021), Guillen et al. (2016), and Arnason (2007) highlight the critical role of fuel as a major expense in fishing fleets and suggest that fuel price increases are a major factor affecting the economic performance of fishing fleets.

Studies by Klonaris (2014), Batzios et al. (2005), and Arvanitoyannis et al. (2004) shed light on the consumer attitudes towards fish and the limited substitution possibilities among fish categories. These insights into consumer behavior and market dynamics provide a broader context for interpreting the impact of fuel costs on fish prices. The work of Cheilari et al. (2013) and Parker et al. (2015) highlights the sensitivity of fishing fleet profitability to fuel price variations and the wide range of fuel inputs in fisheries.

Our study contributes to this field by providing a focused analysis of this relationship in the GSA20 region, adding valuable insights specific to the context of the Ionian Sea fisheries. We address the gap in the existing literature by focusing on the specific impact of fuel costs on the prices of key target species particularly the Ionian Sea in Greece. While previous research has broadly investigated the economic dynamics of fisheries and the general influence of fuel costs on fishing fleet profitability and operational efficiency, there is a lack of detailed analysis on how these factors affect individual fish species in this specific geographic context. By focusing on Hake, Shrimp, Striped Red Mullet, and Red Mullet, our research offers a granular perspective on the economic interplay between fuel prices and fish market dynamics. This species-specific and region-focused approach fills a gap in fisheries economics literature specifically for the economic conditions of the Ionian Sea.

3. Methods and Data

The methodology of this study is designed to analyze the relationship between fuel costs and the prices of four key fish species (Hake, Shrimp, Striped Red Mullet, and Red Mullet) in the GSA20 region (Ionian Sea) in Greece.

3.1 Data Collection

The data used for estimating fish prices and total catches are sourced from the website of the Central Market and Fishery Organizations of Greece (OKAA, https://www.okaa.gr/gr/statistika-alieumaton-okaa-ae/?rid=5). Our dataset includes information on all landings of all species at the fishing ports within the GSA20 region (Ionian Sea) in Greece, as well as the fishing port of Piraeus — the largest fishing port in the country. The time frame covered by this data spans from January 2013 to December 2022 and the frequency is monthly.

For the fuel price data, we retrieved information from the European Market Observatory for fisheries and aquaculture (EUMOFA, https://www.eumofa.eu/data), aligning with the same period as the fish price and catch data. The EUMOFA provides reliable and up-to-date market data.

3.2 Econometric Models

Our methodology involves mainly regression analysis to explore the relationship between fuel prices and fish prices. Separate models were developed for each fish species to account for species-specific market dynamics. Prior to regression analysis, descriptive statistics (mean, standard deviation, minimum, maximum) were computed for all variables to understand their basic distribution and trends.

3.3. Statistical Analysis

To initially identify the degree of association between fuel prices and fish prices, correlation analysis was conducted. Next, Autoregressive Conditional Heteroskedasticity (ARCH) tests were performed to examine the stability of variances in our regression models. Finally, to ensure the reliability of our regression models, unit root tests were employed to check the stationarity of the time series data.

4. Empirical Results

The results of the study provide insightful revelations into the dynamics between fuel costs and fish prices in the GSA20 region, particularly for Hake, Shrimp, Striped Red Mullet, and Red Mullet. The findings are presented as follows:

Table 11: Descriptive Statistics of catch quantities, average and fuel prices for hake, shrimp, striped red mullet and red mullet

	count	mean	std	min	25%	Median	75%	max
Hake_Total_Catch	120	80.162,65	39.958,09	12.470,70	47.655,60	76.586,50	107.396,38	175.884,90
Shrimp_Total_Catch	120	50.711,94	23.572,88	671,10	40.483,33	52.877,40	66.937,93	104.946,70
StrRedMullet_Total_Catch	120	35.410,74	22.461,42	904,40	8.858,13	41.172,95	52.056,38	74.293,00
RedMullet_Total_Catch	120	19.119,76	12.041,84	1.849,20	6.623,53	19.696,85	27.402,73	47.937,50
Hake_Avg_Price	120	6,67	1,22	4,13	5,83	6,63	7,51	10,40
Shrimp_Avg_Price	120	3,30	2,61	1,55	2,10	2,60	3,11	13,90
StrRedMullet_Avg_Price	120	7,01	1,35	5,00	6,16	6,68	7,71	12,38
RedMullet_Avg_Price	120	10,74	2,48	6,60	8,89	10,08	12,73	16,30
Fuel price	120	0,49	0,18	0,20	0,37	0,46	0,58	1,12

Table 11 provides the Descriptive Statistics for 120 observations. Specifically, it presents a comprehensive breakdown of catch quantities (in kg), average prices (in €), and the associated fuel prices (in €/lt) for the above-mentioned species. This preliminary data forms the foundation upon which we model the price determinants and analyze the influencing factors, offering insights into the economic interplay of supply, demand, and operational costs in the region.

Table 12: Basic regression results of the variables of interest

Regression Results	Hake price_ Fuel price	Shrimp price_ Fuel price	StrRed Mullet price_ Fuel price	Red Mullet price_ Fuel price
Intercept	6,8611	2,784	6,323	9,0556
Slope for Fuel Price	-0,3795	1,054	1,4017	3,4231
P-value for Intercept	1,24E-41	0,00012	5,96E-35	7,62E-27
P-value for Fuel Price	0,5457	0,4331	0,043	0,0066
R-square	0,0031	0,0052	0,0343	0,0608
R-square adjusted	-0,0053	-0,0032	0,0261	0,0528
F-statistic (P-value)	0,5457	0,4331	0,043	0,0066

Before proceeding with our econometric analysis, it is useful to visually the relationships at hand. The following scatterplots offer a preliminary glance into how the independent variables relate to the price of each target species. These visualizations serve as a foundation, setting the stage for the in-depth analysis that follows.

Figure 1: Relationship between Hake Average Price and Fuel Price

Figure 2: Relationship between Shrimp Average Price and Fuel Price

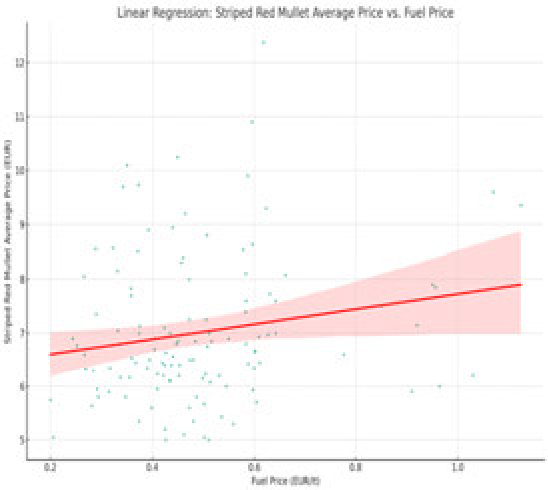

Figure 3: Relationship between Striped Red Mullet Average Price and Fuel Price

Figure 4: Relationship between Red Mullet Average Price and Fuel Price

Looking at Figure 1, there seems to be a negative relationship between the fuel price and the average price of hake. However, relying on **Table 12** the relationship is not statistically significant. This suggests that other factors, not considered in this simple regression, might play a more dominant role in influencing the Hake's average price. In Figure 2, there appears to be a positive relationship between the fuel price and the average price of Shrimp. However, from Table 12 this relationship is statistically insignificant. This implies that other factors not considered in this simple regression might be more influential in determining the Shrimp's average price.

Moving on and observing Figure 3, there is a statistically significant positive relationship between the fuel price and the average price of Striped Red Mullet. This is confirmed in Table 12 whereas fuel prices rise, the average price of Striped Red Mullet also tends to increase. This relationship might be due to increased operational costs associated with higher fuel prices, which could be passed onto consumers in the form of higher fish prices. Finally, there is a statistically significant positive relationship between the fuel price and the average price of Red Mullet as shown in Figure 4 and Table 12. As with the Striped Red Mullet, this can be attributed to the increased operational costs due to higher fuel prices being passed onto consumers. The effect appears stronger for Red Mullet compared to the other species, suggesting its price might be more sensitive to changes in fuel price.

4.1 Model specifications

The general form of the model is:

$$\text{Hake\_Avg\_Price} = \beta_0 + \beta_1 \times \text{Hake\_Total\_Catch} + \beta_2 \times \text{Fuel price} + \epsilon \quad (1)$$

4.1.1 Hake

Table 13 presents the estimated results of the proposed specification. The constant term represents the expected average price of Hake when both the total catch and fuel price are zero. The slope of hake's total catch is statistically significant with a p-value close to zero and it suggests that for every additional kilogram of Hake caught, the average price decreases by approximately 0.0000245. Similarly, the slope of fuel price implies that for every €1 increase in the fuel price, the average price of Hake increases by approximately €0.0972. However, its P-value is 0.797, indicating it is not statistically significant in this model. Based on the coefficient of determination (R-sq), the model explains 64.4% of the behaviour in the Hake average price.

Table 13: Regression analysis results for Hake average price

Dependent Variable: HAKE_AVG_PRICE
Method: Least Squares
Sample: 2013M01 2022M12
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.589474	0.229701	37.39409	0.0000
HAKE_TOTAL_CATCH	-2.45E-05	1.69E-06	-14.49978	0.0000
FUEL_PRICE	0.097215	0.377453	0.257556	0.7972
R-squared	0.643578	Adjusted R-squared		0.637485
F-statistic	105.6311	Prob(F-statistic)		0.000000

Next, we test for ARCH effect that refers to the assumption of constant variance of the error term across observations. It is a common problem in cross-sectional regression analysis but it could be an issue when analyzing time series data too leading to inefficiency and bias estimated coefficients. The results are shown in Table 4, where there is no indication of ARCH effect problem. Both the F-statistic and the Obs*R-squared suggest that there is not sufficient statistical evidence to reject the null hypothesis of no ARCH effects, given the high p-values (0.4596 and 0.4554, respectively). This means that based on this test, the series does not exhibit signs of conditional heteroskedasticity, at least not in the manner of an ARCH(1) model.

Table 4: Heteroskedasticity Test: ARCH

F-statistic	0.550421	Prob. F(1,117)	0.4596
Obs*R-squared	0.557209	Prob. Chi-Square(1)	0.4554

Therefore, the model for Hake price is specified as:

$$\text{Hake\_Avg\_Price} = 8.5895 - 0{,}00002448 \times \text{Hake\_Total\_Catch} + 0.0972 \times \text{Fuel price} \tag{2}$$

4.1.2 Shrimp

Table 5 presents the estimated results of the proposed specification. The constant term again represents the expected average price of Shrimp when both the total catch and fuel price are zero. The slope if total catch suggests that for every additional kilogram of Shrimp caught, the average price decreases by approximately 0.00007. It is statistically significant with a zero p-value. Similarly, the fuel price coefficient implies that for every €1 increase in the fuel price, the average price of Shrimp increases by approximately €0.33. However, its p-value is 0.756, indicating it's not statistically significant in this model. Based on R-squared value, the model explains 40.1% of the behaviour in the Shrimp average price.

Table 5: Regression analysis results for shrimp average price

Dependent Variable: SHRIMP_AVG_PRICE
Method: Least Squares
Sample: 2013M01 2022M12
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.682925	0.702822	9.508703	0.0000
SHRIMP_TOTAL_CATCH	-6.98E-05	7.94E-06	-8.793095	0.0000
FUEL_PRICE	0.326111	1.047529	0.311315	0.7561
R-squared	0.401036	Adjusted R-squared		0.390797
F-statistic	39.16861	Prob(F-statistic)		0.000000

Testing for ARCH effect, the results are shown in Table 5, where again there is no indication of any problem. Both the F-statistic and the Obs*R-squared suggest that there isn't sufficient statistical evidence to reject the null hypothesis of no ARCH effects. This is evident from the high p-values (0.5031 and 0.4989, respectively). In practical terms, the model doesn't seem to suffer from ARCH-type heteroskedasticity.

Table 6: Heteroskedasticity Test: ARCH

F-statistic	0.451247	Prob. F(1,117)	0.5031
Obs*R-squared	0.457197	Prob. Chi-Square(1)	0.4989

Therefore, the model for Shrimp price is specified as:

$$Shrimp\_Avg\_Price = 6.682925 - 0{,}06984 \times Shrimp\_Total\_Catch + 0.3261 \times Fuel\ price \quad (3)$$

4.1.3 Striped Red Mullet

Table 7 presents the estimated results of the proposed specification. The constant term represents the expected average price of Striped Red Mullet when both the total catch and fuel price are zero. The first slope suggests that for every additional kilogram of Striped Red Mullet caught, the average price decreases by almost 0.00005. It is statistically significant with a zero P-value. The second slope concerning the fuel price implies that for every €1 increase in the fuel price, the average price of Striped Red Mullet increases by approximately €1.0124. It's statistically significant with a p-value of 0.018. Based on R-squared value, the model explains 63.6% of the behavior in the Striped Red Mullet average price.

Table 7: Regression analysis results for shriped average price

Dependent Variable: STRREDMULLET_AVG_PRICE
Method: Least Squares
Sample: 2013M01 2022M12
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.173333	0.257455	31.74668	0.0000
STRREDMULLET_TOTAL_CATCH	-4.69E-05	3.37E-06	-13.91682	0.0000
FUEL_PRICE	1.012386	0.423124	2.392644	0.0183
R-squared	0.636307	Adjusted R-squared		0.630091
F-statistic	102.3502	Prob(F-statistic)		0.000000

Testing again for ARCH effect, it can be seen from Table 8 that there is not any indication of such problem. Both the F-statistic and the Obs*R-squared suggest that there isn't sufficient statistical evidence to reject the null hypothesis of no ARCH effects, given the high p-values (0.6590 and 0.6557, respectively). This implies that, based on this test, the series doesn't show signs of conditional heteroskedasticity in the form that the ARCH(1) model tests for.

Table 8: Heteroskedasticity Test: ARCH

F-statistic	0.195738	Prob. F(1,117)	0.6590
Obs*R-squared	0.198752	Prob. Chi-Square(1)	0.6557

Therefore, the model for Striped Red Mullet price is specified as:

$$StrRedMullet\_Avg\_Price = 8.1733 - 0{,}00004686 \times StrRedMullet\_Total\_Catch + 1.0124 \times Fuel\ price \quad (4)$$

4.1.4 Red Mullet

Table 9 presents the estimated results of the proposed specification. The intercept represents the expected average price of Red Mullet when both the total catch and fuel price are zero. The slope of the total catch suggests that for every additional kilogram of Red Mullet caught, the average price decreases by almost 0.0002. It's statistically significant with a zero P-value. The slope of fuel price implies that for every €1 increase in the fuel price, the average price of Red Mullet increases by approximately €1.5. However, its p-value is 0.075, indicating that it is significant at the 10% level. Based on R-squared value, the model predicts 59.2% of the behavior in the Red Mullet average price.

Table 9: Regression analysis results for red mullet average price
Dependent Variable: REDMULLET_AVG_PRICE
Method: Least Squares
Sample: 2013M01 2022M12
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.92241	0.530387	24.36411	0.0000
REDMULLET_TOTAL_CATCH	-0.000153	1.24E-05	-12.34493	0.0000
FUEL_PRICE	1.500470	0.834331	1.798412	0.0747
R-squared	0.592105	Adjusted R-squared		0.585132
F-statistic	84.91911	Prob(F-statistic)		0.000000

Moving on to the ARCH effect test, then from Table 10 there is gain not any indication of such a problem. Both the F-statistic and the Obs*R-squared suggest that there isn't sufficient statistical evidence to reject the null hypothesis of no ARCH effects, given their very high p-values (0.9197 and 0.9189, respectively). This implies that, based on this test, the series doesn't show signs of conditional heteroskedasticity in the form that the ARCH(1) model tests for.

Table 10: Heteroskedasticity Test: ARCH

F-statistic	0.010201	Prob. F(1,117)	0.9197
Obs*R-squared	0.010375	Prob. Chi-Square(1)	0.9189

Therefore, the model for Red Mullet price is specified as:

$$RedMullet\_Avg\_Price = 12.9224 - 0{,}0001973 \times RedMullet\_Total\_Catch + 1.5005 \times Fuel\ price \quad (5)$$

4.2 Unit Root Tests

The unit root tests (detailed results are in the Appendix) confirmed the stationarity of the time series data for both catch quantities and average prices for each species, ensuring the robustness of the regression analysis.

These results highlight the nuanced impact of fuel costs on different fish species. While Hake and Shrimp prices appear to be less sensitive to changes in fuel costs, Striped Red Mullet and Red Mullet prices demonstrate a clear dependency on fuel price fluctuations. This differentiation underscores the importance of species-specific analysis in fisheries economics and points towards the complex interplay of various factors influencing market prices.

5. Discussion

Our findings shed light on the relationship between fuel costs and fish prices in the GSA20 region, revealing several insights relevant to environmental economics and fisheries management. The lack of a significant relationship between fuel prices and the prices of Hake and Shrimp suggests that these species' market dynamics are influenced more by factors other than operational costs, such as catch size, demand, and possibly ecological factors. Conversely, the significant positive relationship observed for Striped Red Mullet and Red Mullet with fuel prices indicates that operational costs, particularly fuel, are a more dominant factor in their pricing. This could be attributed to the specific fishing techniques or the geographical areas where these species are harvested, which might be more fuel intensive.

These findings are useful for policymakers. For species like Striped Red Mullet and Red Mullet, strategies to mitigate the impact of fuel price fluctuations may needed, mightly including advocating for more fuel-efficient fishing practices or providing financial support mechanisms during periods of high fuel prices. For species like Hake and Shrimp, where fuel costs are less of a pricing factor, management efforts might focus more on sustainable catch limits and demand-side factors to stabilize prices. The study highlights the environmental implications of fuel use in fisheries. Fuel-efficient practices not only reduce operational costs but also minimize the carbon footprint of fishing activities, contributing to broader environmental sustainability goals. Understanding the economic drivers, like fuel costs, in fisheries can lead to more environmentally conscious decisions that align economic viability with ecological preservation.

6. Limitations and Future Research

One limitation of the study is its regional focus, which may not be generalizable to other fishing areas or species. Additionally, the study did not extensively explore other potential factors influencing fish prices. Future research could expand to other regions and include more diverse species. It would also be beneficial to investigate other influencing factors, such as market demand, ecological changes, and global economic trends.

6. Conclusions

This study, conducted under the SEAwise project and supported by the European Union's Horizon 2020 research and innovation programme, has provided insights into the relationship between fuel costs and fish prices in the GSA20 region, specifically focusing on Hake, Shrimp, Striped Red Mullet, and Red Mullet. Our findings reveal a complex and species-specific dynamic where the impact of fuel costs on fish prices varies considerably across different species.

For Hake and Shrimp, our analysis indicated that fuel costs do not significantly influence market prices, suggesting that these species are more affected by other factors such as catch size and market demand. On the other hand, the prices of Striped Red Mullet and Red Mullet showed a significant sensitivity to changes in fuel prices, highlighting the importance of fuel costs in their market pricing dynamics.

The implications of these findings are broad. They underscore the need for tailored approaches in fisheries management and policymaking, particularly in addressing the challenges posed by fluctuating fuel costs. For species sensitive to fuel price changes, implementing strategies to mitigate this impact could be crucial for ensuring economic and environmental sustainability. For those less affected, focus might be more appropriately placed on other aspects of fisheries management. Moreover, this study contributes to the broader dialogue on sustainable fisheries management within the context of environmental economics, highlighting the importance of considering a range of economic factors, including operational costs like fuel, in managing fishery resources effectively and sustainably.

In conclusion, while this study provides valuable insights, it also sets a foundation for further research, particularly in exploring the impacts of other economic factors on fisheries and extending the analysis to other regions and species.

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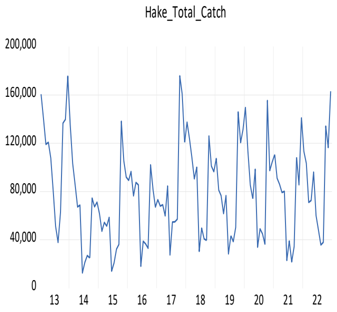
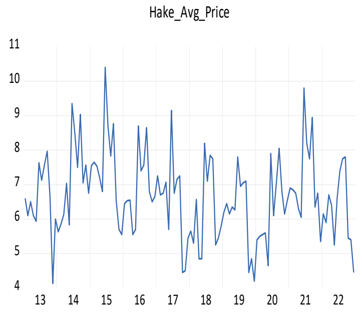
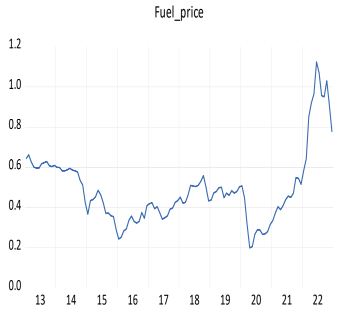
Appendix - UNIT ROOT TESTS

HAKE







Null Hypothesis: HAKE_TOTAL_CATCH has a unit root
Exogenous: None
Lag Length: 12 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.568404	0.4689
Test critical values:	1% level	-2.586753	
	5% level	-1.943853	
	10% level	-1.614749	

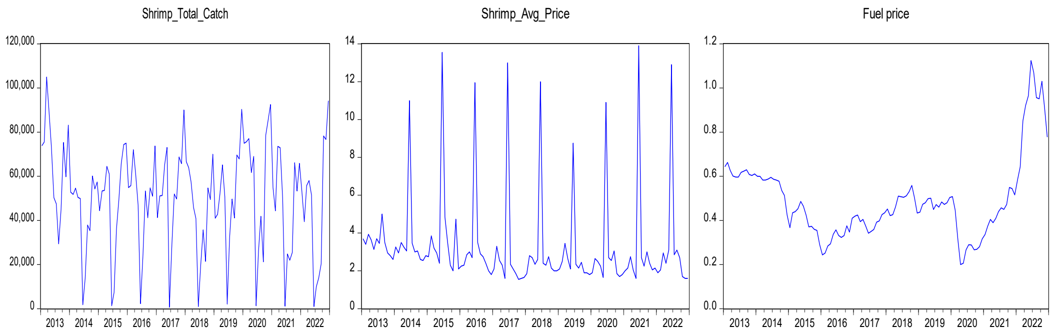
Null Hypothesis: HAKE_AVG_PRICE has a unit root
Exogenous: None
Lag Length: 12 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.249637	0.5941
Test critical values:	1% level	-2.586753	
	5% level	-1.943853	
	10% level	-1.614749	

Null Hypothesis: FUEL_PRICE has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.656970	0.4306
Test critical values:	1% level	-2.584707	
	5% level	-1.943563	
	10% level	-1.614927	

SHRIMP



Null Hypothesis: SHRIMP_TOTAL_CATCH has a unit root
Exogenous: None
Lag Length: 12 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.684204	0.4184
Test critical values:	1% level	-2.586753	
	5% level	-1.943853	
	10% level	-1.614749	

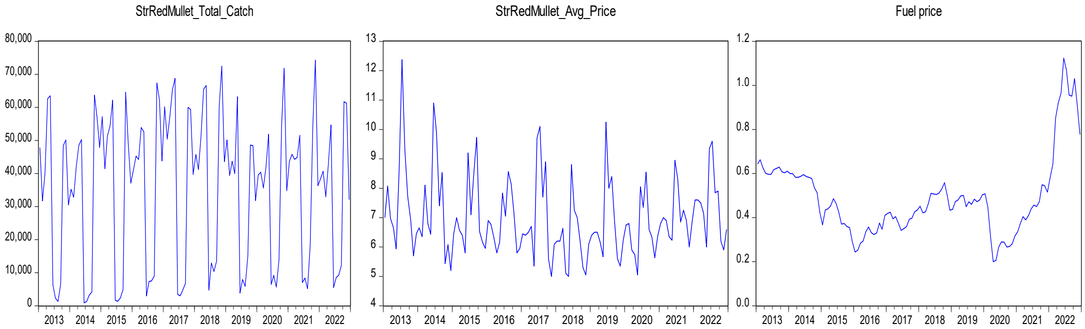
Null Hypothesis: SHRIMP_AVG_PRICE has a unit root
Exogenous: None
Lag Length: 11 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.382629	0.5442
Test critical values:	1% level	-2.586550	
	5% level	-1.943824	
	10% level	-1.614767	

Null Hypothesis: FUEL_PRICE has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.656970	0.4306
Test critical values:	1% level	-2.584707	
	5% level	-1.943563	
	10% level	-1.614927	

STRIPPED RED MULLET



Null Hypothesis: STRREDMULLET_TOTAL_CATCH has a unit root
Exogenous: None
Lag Length: 12 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.065332	0.6588
Test critical values:	1% level	-2.586753	
	5% level	-1.943853	
	10% level	-1.614749	

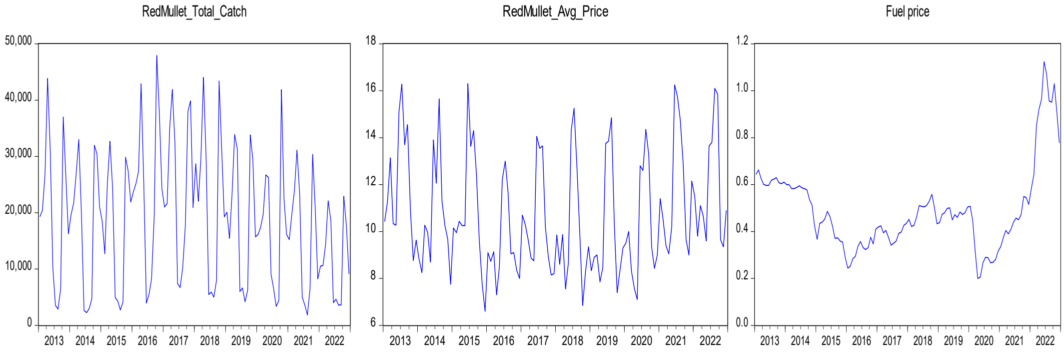
Null Hypothesis: STRREDMULLET_AVG_PRICE has a unit root
Exogenous: None
Lag Length: 11 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.319768	0.5681
Test critical values:	1% level	-2.586550	
	5% level	-1.943824	
	10% level	-1.614767	

Null Hypothesis: FUEL_PRICE has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.656970	0.4306
Test critical values:	1% level	-2.584707	
	5% level	-1.943563	
	10% level	-1.614927	

RED MULLET



Null Hypothesis: REDMULLET_TOTAL_CATCH has a unit root
Exogenous: None
Lag Length: 12 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.063032	0.2585
Test critical values:	1% level	-2.586753	
	5% level	-1.943853	
	10% level	-1.614749	

Null Hypothesis: REDMULLET_AVG_PRICE has a unit root
Exogenous: None
Lag Length: 11 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.108243	0.6442
Test critical values:	1% level	-2.586550	
	5% level	-1.943824	
	10% level	-1.614767	

Null Hypothesis: FUEL_PRICE has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.656970	0.4306
Test critical values:	1% level	-2.584707	
	5% level	-1.943563	
	10% level	-1.614927	

The dependence of the industries of the Greek economy from the fisheries and aquaculture sector

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Abstract
The present study investigates the relationships between the productive industries of the Greek economy and the fisheries and aquaculture sector. Specifically, through the Leontief demand-driven and Ghosh supply-driven input-output models, both backward and forward linkages of the fisheries and aquaculture sector in terms of output and employment are estimated. Consequently, the industries on which the fisheries and aquaculture sector relies for the purchases and sales of intermediate inputs are identified. Moreover, the sector's contribution to the Greek economy's efforts to increase employment is emphasized. The main empirical findings of our analysis are as follows: (i) the primary industries on which the fisheries and aquaculture sector depends for its demand of intermediate inputs are the 'Wholesale & Retail Trade' and the 'Coal & Petroleum Refining Products', (ii) the main industries from which the fisheries and aquaculture sector sources the supply of its intermediate inputs are the 'Hotels & Restaurants' and the 'Food, Beverages & Tobacco', and (iii) the fisheries and aquaculture sector has relatively significant backward and forward interindustry employment linkages, indicating that the sector's contribution to the effort to increase total employment is relatively high. The results of our study provide valuable insights into the intricate interindustry dynamics of the Greek fisheries and aquaculture sector, serving as a foundation for formulating effective policies aimed at enhancing the sector's sustainability, fostering economic resilience, and promoting employment growth.

Keywords: Fisheries and aquaculture, input-output analysis, interindustry linkages, employment, Greek economy

JEL Codes: C67, Q22, Q28

Η Εξάρτηση των Κλάδων της Ελληνικής Οικονομίας από τον Τομέα της Αλιείας και των Υδατοκαλλιεργειών

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Περίληψη
Η παρούσα μελέτη διερευνά τις διακλαδικές σχέσεις που δημιουργούνται μεταξύ των παραγωγικών κλάδων της ελληνικής οικονομίας με τον τομέα της αλιείας και των υδατοκαλλιεργειών. Ειδικότερα, μέσω των υποδειγμάτων ζήτησης και προσφοράς εισροών-εκροών, εκτιμώνται τόσο οι προς τα πίσω όσο και οι προς τα εμπρός διακλαδικές συνδέσεις του τομέα της αλιείας και των υδατοκαλλιεργειών ως προς τα μεγέθη της παραγωγής και της απασχόλησης. Έτσι, ανιχνεύονται οι κυριότεροι κλάδοι από τους οποίους ο τομέας της αλιείας και των υδατοκαλλιεργειών εξαρτάται για την αγορά και την πώληση των ενδιάμεσων εισροών, ενώ αναδεικνύεται η συμβολή του τομέα στην προσπάθεια της ελληνικής οικονομίας για αύξηση της απασχόλησης. Τα βασικά ευρήματα της ανάλυσης μας είναι τα εξής: (i) οι κυριότεροι κλάδοι από τους οποίους ο τομέας της αλιείας και των υδατοκαλλιεργειών εξαρτάται για τη ζήτηση των ενδιάμεσων εισροών του, είναι ο κλάδος «Χονδρικό & λιανικό εμπόριο» και ο κλάδος «Οπτάνθρακας & προϊόντα διύλισης πετρελαίου», (ii) οι κυριότεροι κλάδοι προς τους οποίους ο τομέας της αλιείας και των υδατοκαλλιεργειών εξαρτάται για την προσφορά των ενδιάμεσων εισροών του, είναι ο κλάδος «Εστίαση & ξενοδοχεία» και ο κλάδος «Τρόφιμα, ποτά & καπνός», και (iii) ο τομέας της αλιείας και των υδατοκαλλιεργειών παρουσιάζει σχετικά μεγάλες προς τα πίσω και προς τα εμπρός διακλαδικές συνδέσεις της απασχόλησης, με αποτέλεσμα η συνεισφορά του τομέα στην προσπάθεια της αύξησης της συνολικής απασχόλησης της ελληνικής οικονομίας να θεωρείται ιδιαίτερα σημαντική. Τα εμπειρικά ευρήματα της παρούσας μελέτης δύναται να αποτελέσουν τη βάση για τη διαμόρφωση ορθολογικότερων πολιτικών με στόχο την ενίσχυση της βιωσιμότητας του τομέα της αλιείας και των υδατοκαλλιεργειών, την ενίσχυση της οικονομικής ανθεκτικότητας και την προώθηση της αύξησης της συνολικής απασχόλησης.

Λέξεις Κλειδιά: *Αλιεία και υδατοκαλλιέργειες, ανάλυση εισροών-εκροών, διακλαδικές συνδέσεις, απασχόληση, ελληνική οικονομία*

JEL Κωδικοί: C67, Q22, Q28

1. Introduction

The sector of fisheries and aquaculture is considered a critical pillar of the Greek economy. Despite its limited contribution to the Gross Production Value (0.17%), it represents a primary production sector of considerable socio-economic importance, especially for coastal areas[1]. In particular, the fisheries sector has a relatively large number of employees. According to data from the 2020 reporting year, the number of employees in the fisheries sector (18,693 jobs) ranks Greece as the third highest among EU Member States, following Spain and Italy (STECF, 2022).

In recent decades, substantial endeavours have been undertaken to gather data and insights regarding the impact of the fisheries and aquaculture sector on GDP globally (World Bank, 2012; FAO, 2018), regionally (De Graaf and Garibaldi, 2014; Hofherr et al., 2012; Gillett, 2009), and nationally (CFSY, 2021).[2] Consequently, the utilization of input-output analysis to examine the contribution of the fisheries and aquaculture sector to economies is becoming more widespread, establishing it as a valuable tool for formulating more rational economic and/or environmental policies. The assessment of intersectoral relations between the fisheries and aquaculture sector and other productive sectors, can highlight the importance of the sector concerning key economic and environmental indicators.

In the context of input-output analysis, an exogenous increase in the final demand (e.g., household consumption expenditure, investment, etc.) of a sector *j* of the economy causes an increase in its output, so that this sector increases its demand for intermediate inputs from other sectors of the economy.[3] The latter, in turn, increase their production to meet the increased demand, causing corresponding effects on the inputs of the sectors of the economy. The intersectoral effects/ linkages of an industry can be divided into:

(i) direct, which consists of the fact of the change in inputs due to changes in the output of industry *j* and

(ii) indirect, which refers to the change in the inputs of those industries that allocate their output to the industry *j*.[4]

Similar to the process described above, a change in the final demand of an industry will create additional demand for important production factors, such as employment, which ultimately leads to an increase in employment in the total economy.

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[1] For a detailed analysis of the sector's importance over time in the Greek society and economy, see, AGRERI (2023).

[2] Despite the strong interest and major efforts made by various international organisations to effectively assess the contribution of fisheries and aquaculture sector to GDP and to design measures and policies for a more sustainable development of the sector, there is no consensus on the assessment methodology to be adopted. In this context, the FAO study (Cai et. al., 2019) provides a modern and comprehensive guide for estimating the contribution of fisheries and aquaculture to GDP, by using input-output techniques.

[3] Similarly, there is the case of an increase in the output of an industry due to an exogenous increase in its primary inputs (e.g., imports, wages, etc.). For the space economy we focus our example only on the effects caused by changes in the final demand of the industry.

[4] There are also induced effects which are due to the change in inputs as a consequence of changes in income caused by the direct and indirect effects of the production of the examined industry.

Focusing on the fishery industry, when there is a rise in fish production due to changes in its final demand, it implies that the sector must utilize more products from other industries as intermediate inputs. These products require the use of a variety of intermediate inputs. For example, the increase in the production of the fishery industry led to a significant rise in demand for fishing equipment, such as the manufacturing of fishing nets. This leads to an increase in their production, thus affecting their respective industries. Fishing vessels also utilize electronic navigation systems. The increased demand for these technologies influences their production, impacting the technology industry and the electronics market. Finally, increased fishing activity is leading to a significant rise in the demand for fuel. Consequently, this increased demand for fuel affects the production and processing of oil and other energy-related products. We can, therefore, see that increased fishing activity due to exogenous changes has a broader impact on various industries of the economy, making fisheries an important industry interacting with other industries of the economy.

The main objective of this research is to evaluate the interindustry relationships of the fisheries and aquaculture sector of the Greek economy for the year 2018, focusing on production and employment by highlighting the primary industries on which the sector depends for the purchase and sale of intermediate inputs. For this purpose, input-output analysis models are used, both on the demand and supply side.

The study is structured as follows: In Section 2, a brief presentation of the methodology applied to measure the interindustry relationships of the fisheries and aquaculture sector is presented. In Section 3, the main empirical findings of the study are illustrated, while Section 4 presents the study's concluding remarks.

2. Estimation of the Interindustry Relationships

2.1. Interindustry linkages of production

Each sector of the economy is linked to the other sectors both backward (or vertically) and forward (or horizontally). The backward interindustry relationships in an economy pertain to the connections between the domestic output of industries and the demand for intermediate inputs. These inputs can either be domestically produced or imported. Conversely, the relationships existing between sectoral output and the supply of intermediate inputs –whether domestically produced or imported– are referred to as forward relationships.

In particular, on the demand side, each element *ij* of matrix **L** of equation (I.7) in Annex I expresses the degree of change in output of industry *i* due to the unit change in final demand for the domestically produced product of industry *j*. Therefore, the total - direct and indirect - backward linkages of output of industry *j* will be given by the sum of the elements in column *j* of matrix **L** expressing the change in output of all industries of the economy.[1] Based on the above, we can derive the industries from which industry *j* most significantly demands or purchases inputs from other industries, representing the backward production dependence of industry *j*.

On the supply side, each element *ij* of matrix **G** in equation (I.14) shows the change in domestic output of industry *j* resulting from a unit change in the primary inputs of industry *i*. Thus, the total forward linkages of production of the industry *i* will be given by the sum of the elements of row *i* of

[1] This type of linkages is also referred to as an input multiplier.

the matrix **G**, indicating the degree to which domestic output changes across all industries in the economy.[1] This allows for the identification of the most important industries in which industry *i* provides or sells inputs to them, indicating the forward production dependence of industry *i*.

2.2. Interindustry linkages of employment

Let $\hat{\boldsymbol{\lambda}}$ be the diagonal matrix of the sectoral direct employment coefficients of the economy. These coefficients are defined as the ratio of the number of persons employed in the industries to the domestic production, expressing the change in the employment of the industries when their gross output changes by one unit.[2] On the demand side, each element *ij* of the matrix $\hat{\boldsymbol{\lambda}}\mathbf{L}$ expresses the degree of change in employment of industry *i* due to the unit change in final demand for the domestically produced product of industry *j*. This allows for the estimation of the backward dependence of industry *j* on other industries in terms of employment. The total -direct and indirect- backward employment linkages of the industry will be given by the sum of the elements in column *j* of this matrix, expressing the change in employment of all industries of the economy. On the supply side, each element *ij* of the matrix $\mathbf{G}\hat{\boldsymbol{\lambda}}$ represents the degree of change in the employment of industry *j* resulting from a unit change in the primary inputs of industry *i*. This allows for tracing the forward dependence of industry *i* on other industries in terms of employment. Therefore, the total forward linkages of employment of the industry will be given by the sum of the elements in row *i* of this matrix, indicating the change in employment across all industries in the economy.[3]

3. Empirical Findings

This section presents the main empirical findings of the assessment of relationships existing in the Greek economy for the year 2018 between the fisheries and aquaculture sector and the other industries.[4]

3.1. Interindustry Production Linkages of the Fisheries and Aquaculture Sector

Figures 1 and 2 give an overview of the position of the interindustry production relationships of the fisheries and aquaculture sector in the Greek economy. The backward and forward interindustry linkages of the sector are below the corresponding averages of the overall economy, as well as the corresponding averages of the three main sectors of the economy. In other words, the rise in the value of the total output of the economy resulting from a unit change in either final demand or the sector's primary inputs is less than the increase that would occur with a corresponding change in any other sector. It therefore appears that the fisheries and aquaculture sector is not a key-sector of the Greek economy.[5]

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[1] This type of linkages is also referred to as an output multiplier.

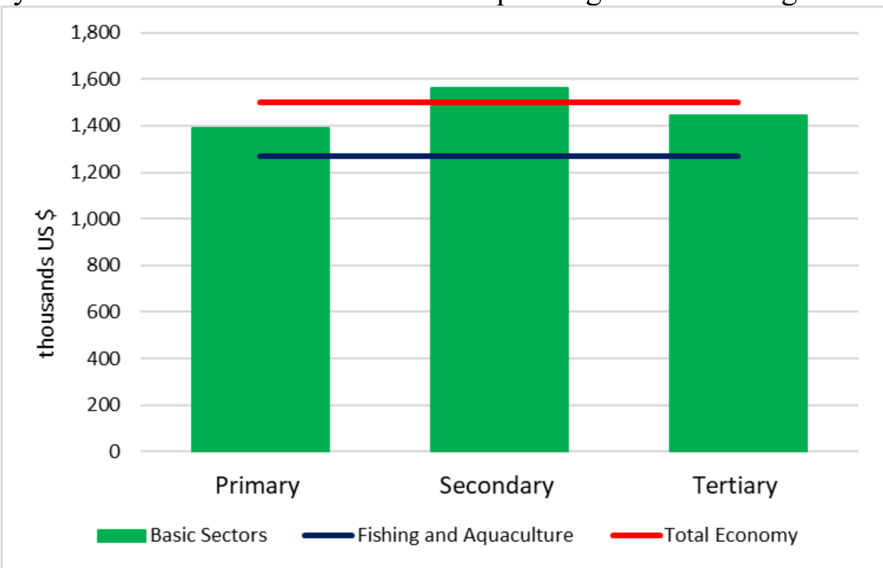
[2] The direct employment coefficient is considered the most representative indicator of labour intensity in the productive sectors of the economy.

[3] The persons employed in the industries of the economy on the demand and supply side will be given respectively by $\boldsymbol{\Lambda} = \hat{\boldsymbol{\lambda}}\,\mathbf{L}\,\mathbf{y}^d$ και $\boldsymbol{\Lambda} = \mathbf{v}^{\mathrm{T}}\mathbf{G}\,\hat{\boldsymbol{\lambda}}$.

[4] The numerical results are available upon request.

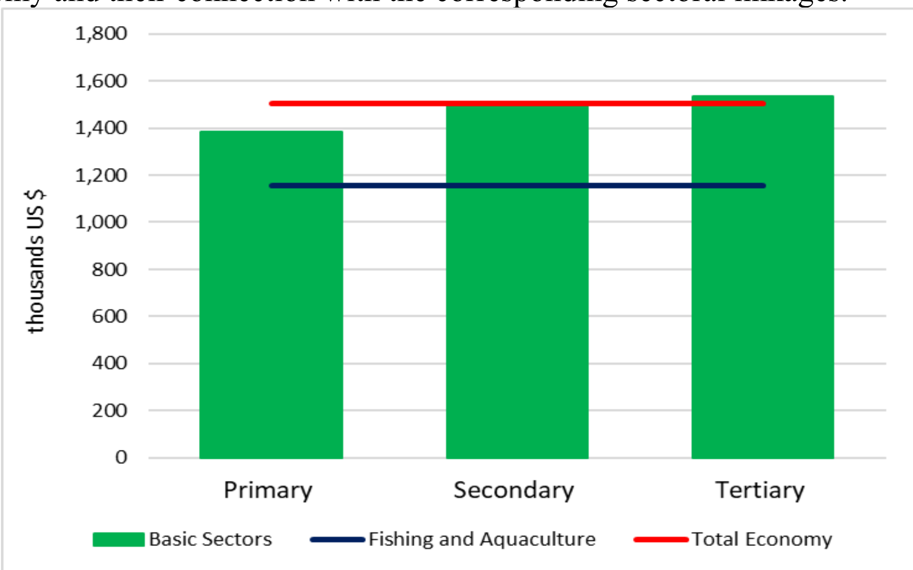
[5] The primary objective of assessing the interindustry linkages in the economy is to compare and prioritize them, aiming to identify sectors with the highest growth potential. For example, if the backward linkages of industry *r* are larger than those of industry *s*, then it can be assumed that an

Figure 1: The position of the backward production linkages of the fisheries and aquaculture sector in the total economy and their connection with the corresponding sectoral linkages.



Source: Authors' own elaboration and calculation.

Figure 2: The position of the forward production linkages of the fisheries and aquaculture sector in the total economy and their connection with the corresponding sectoral linkages.

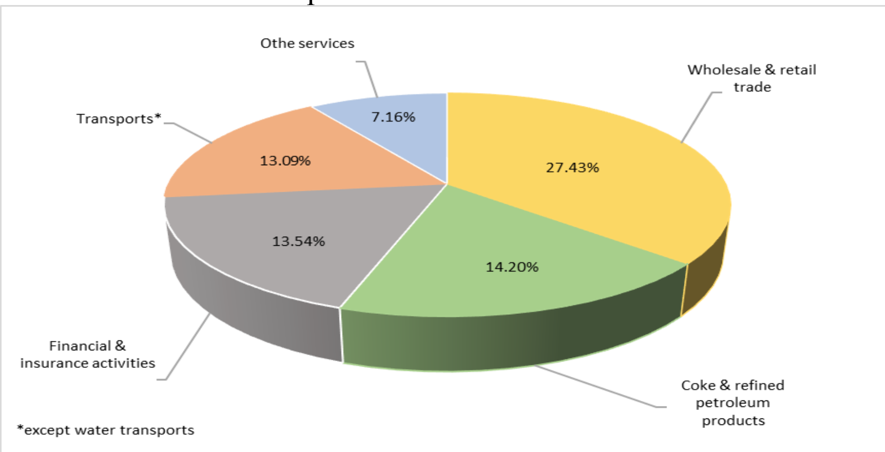


Source: Authors' own elaboration and calculation.

increase in the final demand of industry *r* would more effectively stimulate the growth dynamics of the economy than an equivalent increase in the final demand of industry *s*. Similarly, if the forward linkages of industry *r* are higher than those of industry *s*, then it could be argued that an increase in the primary inputs of industry *r* benefits the economy more than an equivalent increase in the primary inputs of industry *s*. Hence, policymakers should concentrate on key-sectors. These sectors, exhibit, on average, higher backward and, at the same time, forward linkages.

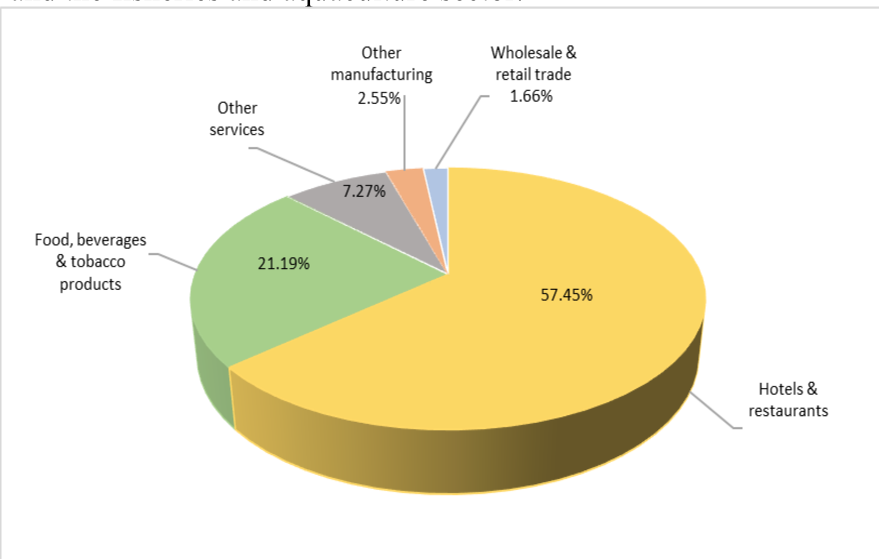
The backward and forward production dependence of the fisheries and aquaculture sector on other industries within the Greek economy is illustrated in Figures 3 and 4 respectively. These figures highlight the most significant industries upon which the sector relies for the purchase of its intermediate inputs. In more detail, the primary sectors from which the fisheries and aquaculture sector derives its domestically produced inputs include 'Wholesale & retail trade' (27.43%), 'Coke & refined petroleum products' (14.20%), 'Financial & insurance activities' (13.54%), 'Transport' (13.09%), and 'Other services' (7%). The primary industries where the fisheries and aquaculture sector supply its domestically produced inputs include 'Hotels & restaurants' (57.45%), 'Food, beverages & tobacco' (21.19%), 'Other services' (7.27%), 'Other manufacturing industries' (2.55%), and 'Wholesale & retail trade' (13.09%).

Figure 3: The top five most significant backward production linkages between the industries of the Greek economy and the fisheries and aquaculture sector.



Source: Authors' own elaboration and calculation.

Figure 4: The top five most significant forward production linkages between the industries of the Greek economy and the fisheries and aquaculture sector.

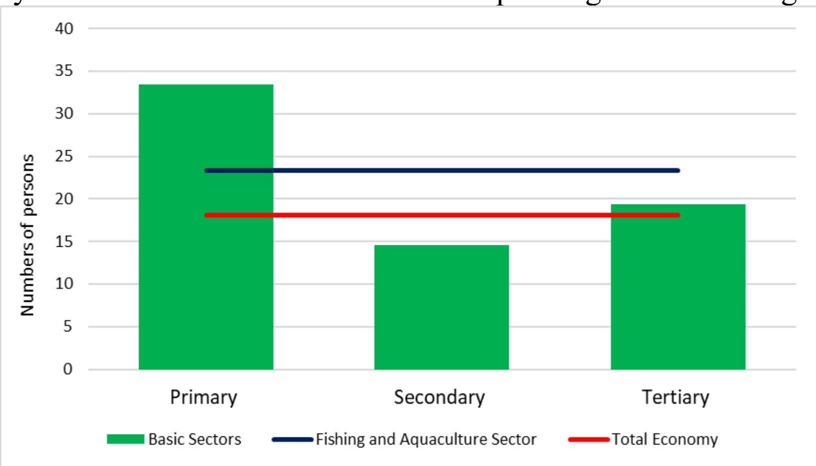


Source: Authors' own elaboration and calculation.

3.2. Interindustry Employment Linkages of the Fisheries and Aquaculture Sector

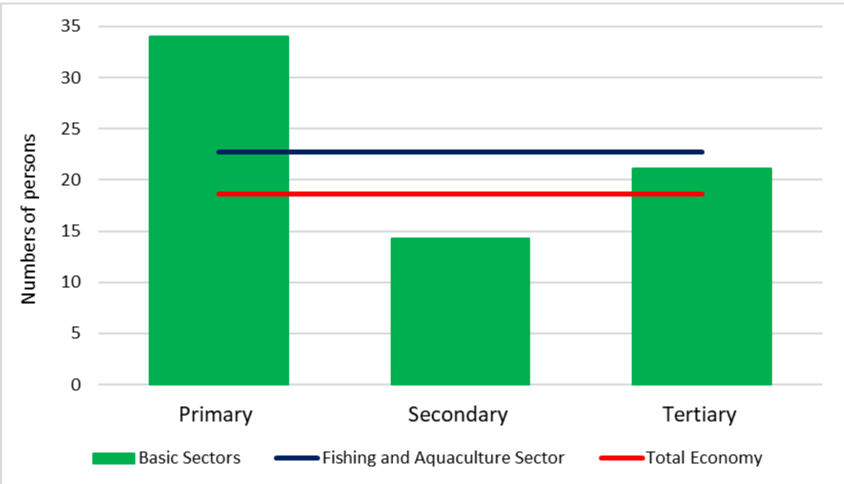
Figures 5 and 6 provide an overview of the position of the interindustry employment linkages of the fisheries and aquaculture sector in the Greek economy. The sector's linkages are greater than the corresponding averages of the total economy as well as the averages of the secondary and tertiary production sectors. However, compared to the average linkages of the primary sector, the linkages of the fisheries and aquaculture sector are lower. Thus, the increase in employment in the overall economy resulting from unitary changes in final demand and/or primary sector inputs will be more than the increase that would be caused by a corresponding change in any other sector (excluding the industries of the primary sector). Therefore, the sector's contribution to the endeavour to boost employment in the economy is particularly significant.

Figure 5: The position of the backward employment linkages of the fisheries and aquaculture sector in the total economy and their connection with the corresponding sectoral linkages.



Source: Authors' own elaboration and calculation.

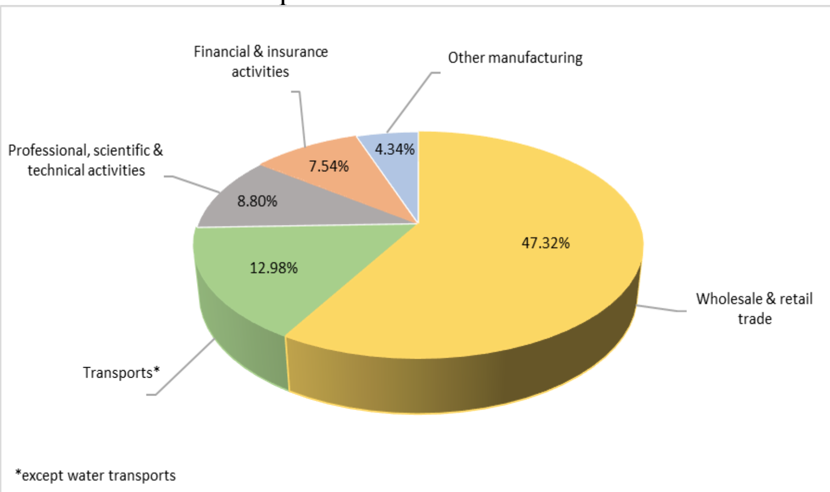
Figure 6: The position of the forward employment linkages of the fisheries and aquaculture sector in the total economy and their connection with the corresponding sectoral linkages.



Source: Authors' own elaboration and calculation.

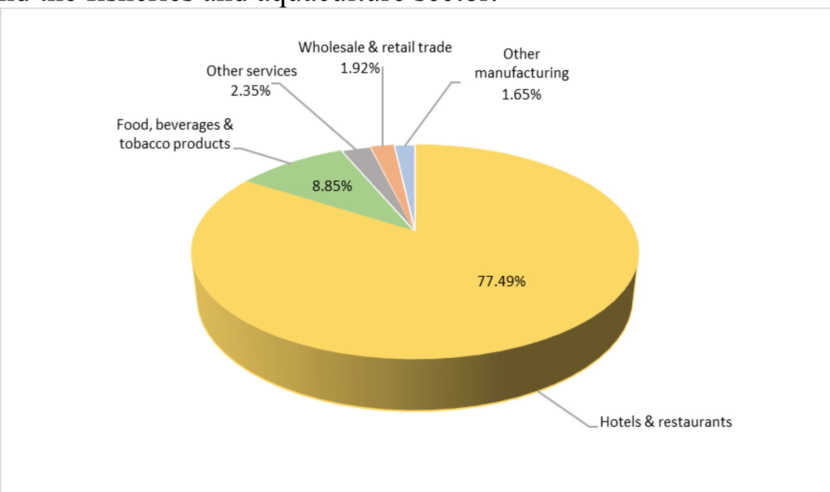
Figures 7 and 8, illustrate the dependence of the fisheries and aquaculture sector on the other industries of the Greek economy in terms of the size of employment. Based on Figure 7, the main sectors contributing to the increase in total employment in the economy after a unit change in final demand in the fisheries and aquaculture sector are 'Wholesale & retail trade' (47. 32%), 'Transport' (12.98%), 'Professional, scientific & technical activities', (8.80%), 'Financial & insurance activities' (7.54%) and 'Other manufacturing industries' (4.34%). On the other hand, the industries that contribute most to employment growth in the economy due to the unit change in the sector's primary inputs (Figure 8) are 'Hotels & restaurants' (77.49%), 'Food, beverages & tobacco' (8.85%), 'Other services' (2.35%), 'Wholesale & retail trade' (1.92%) and 'Other manufacturing' (1.65%).

Figure 7: The top five most significant backward employment linkages between the industries of the Greek economy and the fisheries and aquaculture sector.



Source: Authors' own elaboration and calculation.

Figure 8: The top five most significant forward employment linkages between the industries of the Greek economy and the fisheries and aquaculture sector.



Source: Authors' own elaboration and calculation.

5. Concluding Remarks

In the present study, we evaluated the interindustry relationships of the fisheries and aquaculture sector in the Greek economy using input-output analysis for the year 2018. Our analysis revealed the following:

(i). An increase in the final demand of the sector by 1,000 USD results in an overall -direct and indirect- increase in the Greek economy:

- of the gross value of domestic production equal to 1,270 USD, with 85% (1,075 USD) of this value corresponding to an indirect increase and 15% (196 USD) to a direct increase,
- of employment by 23.38 persons, with 16% (3.41 persons) corresponding to an indirect increase and 84% (19.97 persons) to a direct increase, and

(ii). An increase in the primary inputs of the sector by 1,000 USD results in an overall -direct and indirect- increase in the Greek economy:

- of the gross value of domestic production equal to 1,155 USD, with 89% (1,022 USD) of this value corresponding to an indirect increase and 11% (132 USD) to a direct increase,
- of employment by 22.67 persons, with 12% (2.70 persons) corresponding to an indirect increase and 88% (19.97 persons) to a direct increase, and

Based on the above empirical results, we conclude that:

(i). The fisheries and aquaculture sector exhibits relatively modest backward and forward interindustry production linkages. Consequently, it does not appear to generate significant demand for domestically produced goods from other industries in the economy. Simultaneously, its products are not extensively utilized as intermediate inputs in the production processes of other industries.

(ii). The fisheries and aquaculture sector demonstrates relatively substantial backward and forward interindustry employment linkages. As a result, the sector's contribution to the endeavour to enhance overall employment in the Greek economy is considered to be particularly significant.

(iii). The primary sectors on which the fisheries and aquaculture sector relies for the purchase-demand of its intermediate inputs are 'Wholesale & retail trade' and 'Coke & refined petroleum products' while the main sectors to which the fisheries and aquaculture sector depends for the sale-supply of its intermediate inputs are 'Hotels & restaurants' and 'Food, beverages & tobacco'.

(iv). The most significant increase in employment in the Greek economy stemming from the demand for intermediate inputs by the fishing and aquaculture sector is attributed to its purchases from the 'Wholesale & retail trade' sector. Conversely, the most substantial increase in employment resulting from the supply of intermediate inputs by the sector is associated with its sales to the 'Hotels & restaurants' sector.

The empirical findings of this study can form the basis for the formulation of more rational policies aimed at enhancing the sustainability of the fisheries and aquaculture sector, strengthening economic resilience and promoting overall employment growth. To this end, estimating the environmentally interindustry linkages of the sector by employing the hypothetical extraction method (Tsirimokos, 2022, 2023) could be a focus of future research. Moreover, the quantitative estimation of the sraffian autonomous demand multipliers (Mariolis and Ntemiroglou, 2023), along with the development of alternatives policy scenarios of demand variations in the fisheries and aquaculture sector, is expected to reveal important information about the sector's dynamics in the formation of national product-income and employment for the Greek economy, providing a framework for the implementation of targeted policies that ensure the sustainable development of the sector.

Annexes

Annex I: The Basic Equations of the Input-Output Models for the Assessment of the Interindustry Relationships of the Economy

Based on the Input-Output Tables (IOTs), two fundamental models are formulated: the Leontief (1936) and the Ghosh (1958) models. These models detail the interindustry transactions in domestically produced and imported products, both on the demand side (Leontief model) and on the supply side (Ghosh model) of the economy. Specifically, in the Leontief model, the exogenous variable is the final demand, whereas in the Ghosh model, the exogenous variable is the primary inputs.

On the demand side, the following relationship hold:[1]

$$\mathbf{x} = \mathbf{Z}^d\,\mathbf{i} + \mathbf{y}^d \tag{I.1}$$

and,

$$\mathbf{m} = \mathbf{Z}^m\,\mathbf{i} + \mathbf{y}^m \tag{I.2}$$

where $\mathbf{x}$ is the vector of gross domestic output, $\mathbf{Z}^d$ and "$\mathbf{Z}^m$ are respectively the matrices of interindustry transactions in domestically produced and imported intermediate inputs, "$\mathbf{y}^d$ and $\mathbf{y}^m$ are respectively the vectors of final demand for domestically produced and imported goods, and finally, $\mathbf{m}$ is the vector of total imports.

The matrices of direct input coefficients are defined as follows:

$$\mathbf{A}^d \equiv \mathbf{Z}^d\,\hat{\mathbf{x}}^{-1} \tag{I.3}$$

and,

$$\mathbf{A}^m \equiv \mathbf{Z}^m\,\hat{\mathbf{x}}^{-1} \tag{I.4}$$

where $\mathbf{A}^d$ and $\mathbf{A}^m$ are the matrices of direct input coefficients for domestically produced and imported products, respectively.

Multiplying equations (I.3) and (I.4) from the right by the vector $\mathbf{x}$, gives the equations:

$$\mathbf{A}^d\,\mathbf{x} = \mathbf{Z}^d\,\mathbf{i} \tag{I.5}$$

and,

$$\mathbf{A}^m\,\mathbf{x} = \mathbf{Z}^m\,\mathbf{i} \tag{I.6}$$

Substituting equation (I.5) into equation (I.1) and then solving for $\mathbf{x}$, we obtain:

$$\mathbf{x} = \mathbf{L}\mathbf{y}^d \tag{I.7}$$

where $\mathbf{L} \equiv [\mathbf{I} - \mathbf{A}^d]^{-1}$ is the Leontief inverse matrix for domestically produced products. Similarly, by substituting equation (I.6) into equation (I.2), we obtain, via equation (I.7), the equation:

$$\mathbf{m} = \mathbf{A}^m\,\mathbf{L}\mathbf{y}^d + \mathbf{y}^m \tag{I.8}$$

On the supply side, the following relationship holds:

$$\mathbf{x}^{\mathrm{T}} = \mathbf{i}^{\mathrm{T}}\mathbf{Z}^d + \mathbf{i}^{\mathrm{T}}\mathbf{Z}^m + \mathbf{v}^{\mathrm{T}} \tag{I.9}$$

where $\mathbf{v}^{\mathrm{T}}$ is the vector of primary inputs.

The direct output coefficients matrices are defined as follows:

$$\mathbf{B}^d \equiv \hat{\mathbf{x}}^{-1}\mathbf{Z}^d \tag{I.10}$$

and,

$$\mathbf{B}^m \equiv \hat{\mathbf{x}}^{-1}\mathbf{Z}^m \tag{I.11}$$

where $\mathbf{B}^d$ και $\mathbf{B}^m$ are the matrices of direct output coefficients for domestically produced and imported products, respectively.

Multiplying equations (I.10) and (I.11) from the left by the vector "$\mathbf{x}^{\mathrm{T}}$ gives the equations:

[1] Letter "T" indicates transposition of a vector (e.g., $\mathbf{x}^{\mathrm{T}}$).

$$\mathbf{x}^{\mathrm{T}}\mathbf{B}^{d} = \mathbf{i}^{\mathrm{T}}\mathbf{Z}^{d} \tag{I.12}$$

and,

$$\mathbf{x}^{\mathrm{T}}\mathbf{B}^{m} = \mathbf{i}^{\mathrm{T}}\mathbf{Z}^{m} \tag{I.13}$$

Finally, equation (I.9) through equations (I.12) and (I.13) can be formulated as follows:

$$\mathbf{x}^{\mathrm{T}} = (\mathbf{x}^{\mathrm{T}}\mathbf{B}^{m} + \mathbf{v}^{\mathrm{T}})\,\mathbf{G} \tag{I.14}$$

where $\mathbf{G} \equiv [\mathbf{I} - \mathbf{B}^{d}]^{-1}$ is the Ghosh inverse matrix for domestically produced products.

Annex II: Data Sources and Processing

For the analysis of the interindustry relations in the fisheries and aquaculture sector, the most recent available statistical data from the following sources were used:
(i). IOTs data were sourced from the Organisation for Economic Co-operation and Development (OECD) Input-Output Database (OECD, 2021). The IOTs included information on domestic and imported intermediate consumption, final demand, gross output, and gross value added for the year 2018. All data from the IOTs were expressed in thousands of United States dollars (USD).
(ii). The OECD Structural Analysis Database (STAN Database) (OECD, 2020) was used for the variable "EMPN" (Number of persons engaged, total employment), which records the number of persons employed by the industries for the year 2018.

Table A.II.1 presents the classification of the 23 sectors of the Greek economy used in our analysis.[1] Industries 1 and 2 belong to the primary production, industries 3 to 14 belong to the industrial sector, while industries 15 to 23 belong to the services sector. Industry 11 ('Other manufacturing') includes various activities related to the production and processing of a variety of products, including but not limited to non-metallic components, computers, electronic and optical products, electrical equipment, machinery and equipment, motor vehicles, trailers, semi-trailers and other means of transport, as well as furniture, jewellery, musical instruments, toys, and the repair and installation of machinery and equipment. Industry 22 ('Other services') includes various services not included in other major categories, including information and communication, computer and personal and household goods repair, and various other personal services. It also includes activities in the real estate sector, as well as services in the arts, entertainment and recreation sector. Industry 23 ('Other services') includes various public services and activities, such as public administration and defence, compulsory social security, education and human health and social work. It is noted that the industry 'Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use' has zero intermediate consumption and has therefore been excluded from our analysis.

[1] IOTs consists of 45 industries. However, for a more precise representation of the results, we decided to merge some of these industries. This process led to a reduction of the total number of industries to 23, as shown in Table A.II.1.

Table A.II.1: Industry Classification

No.	Industry
1	Agriculture, hunting and forestry
2	Fishing and aquaculture
3	Mining and quarrying
4	Food, beverages and tobacco products
5	Textiles
6	Paper and printing
7	Coke and refined petroleum products
8	Chemical and pharmaceutical products
9	Rubber and plastic products
10	Basic metals and fabricated metal products
11	Other manufacturing
12	Electricity
13	Water supply and wastewater management
14	Constructions
15	Wholesale & retail trade
16	Transport (except water transport)
17	Water transport
18	Hotels and restaurants
19	Financial and insurance activities
20	Professional, scientific and technical activities
21	Administrative and support services
22	Othe services
23	Public sector

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The economic aspects of water management practices in Classical Athens

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Abstract
In this paper, we present the water management practices that were implemented by the Athenian city-state of the Classical times (508 – 323 BC) under an economics perspective. They were based on the diptych: investing on water management infrastructure and introducing effective relative institutions. Infrastructure included extensive public works such as the building of public wells, aqueducts, fountains, springs and cisterns, the building of an underground water supply network and the building of a sewage underground network for wastewater management. Institutions included the introduction of three categories of public magistrates who were assigned to implement the city-states' water management strategy. We further argue that the success of the Athenian water management institutions was based on a combination of motives and disincentives; one the one hand, satisfactory salaries and public honors for the public magistrates who were assigned by the city-state to exercise these institutions, and on the other hand, the imposition of heavy fines and / or dismissal from public office to any of the above magistrates if they provided subpar services. We finally discuss if and how the Athenian water management strategies may be seen as an inspiration for our modern societies on relative environmental issues.

Key words: Classical Athens; water supply infrastructure, public goods; water management institutions; economic institutions

JEL Codes: H41; H76; K20; N43; N53; Q28, Q58

1. Introduction

This paper contributes to the ongoing global discussion on sustainable water management which has become imperative nowadays. Increased demand and increased usage of water resources globally, which is not always characterized by optimization and efficiency, has led to environmental degradation both quantitatively and qualitatively. This is one of the most important and pending global problems nowadays, others including, among others, pandemics (such as Covid-19), and energy shortages (which have been culminated due to situations such as the Russian invasion to Ukraine).

It has been estimated that by 2050 more than 40 percent of the world's population will be living in water stressed regions, which is around 1 billion more people than live in such regions nowadays. Growing water scarcity will, in turn, magnify the economic and environmental impacts of climate change. This will of course undermine the quality of life of all living beings on earth. Water crisis, which is a sub-category of the wider global environmental crisis, is largely due to poor water management. If unchecked, water scarcity could increase the likelihood of civil unrest and conflicts (Barbier 2019, ix, 3, 15).

Of course, so far economists, environmental scientists and researchers from other disciplines have dealt with the issue of water shortages, since this is an intertemporal phenomenon. Studies such as the recent ones of Kroetz et al (2022) and Tang and Leng (2022) among others, have tried to find the optimal point of exploitation of water resources through researching for the ideal water management techniques and practices. In more general this discussion is related to the contemplation of the world's disappearing supplies of minerals, forests, and other exhaustible assets that has led to demands for regulation of their exploitation (Solow 1974). Hotelling's (1931) seminal paper with the title: The Economics of Exhaustible Resources has given impetus to a plethora of later authors such as Dasgupta and Heal (1974) and Dasgupta (1979), for further research on relative topics.

Having taken all the above into account, this paper attempts to contribute to the global discussion of managing water resources by analyzing a historical case, the city-state of Athens during the Classical times (508 – 323 BC). We choose this case study for three main reasons.

Firstly, because we wish to see how an ancient society dealt with water management problems, and if there are any lessons or ideas from the past that could inspire us for nowadays in dealing more efficiently with the current situation. After all, eminent scholars such as the economist J. Schumpeter ([1954], 2006, 10-11) believed that in order to better understand the economies of today, we also need to study carefully those of the past due to the experience that we can potentially gain for nowadays. Lyttkens (2013, x) who has extensively studied the economic organization of Classical Athens adds that, through a series of specific conditions we can use the ancient experience as a historical laboratory to gain insights of a general nature that can be applicable to contemporary societies.

Secondly, Athens, was not just a typical city-state of the times, but, like the USA nowadays, was the leader of the Delian League, an alliance of more than 300 members-city-states, and authors such as Figueira and Jensen (2019) and Bitros et al (2020) argue among others, that Athens 'exported' its political and economic model of organization, to a larger or a lesser extent, to its more than 300 allies. Due to this, it will not be an exaggeration to argue that, to some extent, by analyzing Classical Athens, we can have a relatively good image of the structure of the institutions of the median ancient Greek city-state of the times.

Thirdly, there is evidence that the Greeks developed advanced infrastructures for the management of their scarce water resources since even the prehistoric times, such as the Cycladic, Minoan and Mycenaean civilizations period during approximately 3000 – 1100 BC onwards

(Angelakis, and Koutsoyiannis 2003, 999-1004; Koutsoyiannis et al. 2008, 45-47; Angelakis 2017; Krasilnikoff and Angelakis 2019).

But in this paper, we focus on the case of Athens during the Classical times because much more reliable and tangible evidence is available in comparison to other historical case studies of the antiquity, and thus our deductions can be much more reliable.

The paper is organized as follows: in Section 2 we explain in brief the political and economic organization of Classical Athens. We think that this Section is necessary since it helps the reader to understand that behind the infrastructure and institutions that are described in the Sections 3 and 4 respectively, there is an economic reasoning in the mentality of the Athenians. In particular Section 3 describes the public works and infrastructure that the Athenians developed so as to efficiently implement a focused water management policy and Section 4 describes the institutions that were introduced by the Athenian policymakers for supporting a water management policy. Section 5 concludes by also providing some thoughts - proposals that could potentially be beneficial for our societies nowadays, based on the experience and the wisdom that the Athenians gained through implementing in practice their own water management institutions and practices.

2. The Athenian political and economic institutions in brief

The Athenian society, was the first ever democracy where a set of sophisticated political and economic institutions were implemented in practice.

Regarding the first, it was organized upon *direct* (or participatory) *democracy* principles.[1] The most important political institutions included the Athenian Assembly of citizens (known as *Ecclesia*), the Council of the Five Hundred (known as *Boule*) and the popular courts (known as *Heliaia*). The Assembly was gathered approximately 40 times a year and was open to all citizens. There decisions on policy and law-making were taken. The Council prepared the agenda of the discussions of the Assembly and was the also the main supervisory institution of the Athenian public administration. The popular courts were exercising the law in practice so as to ensure that the Athenian regime was functioning under the principles of the rule of law (Hansen 1991; Ober 2008; Cartledge 2018; Bitros et al. 2020).

Regarding the second, contrary to earlier though influential views of *primitivist* (mainly Marxist – oriented) historians such as Finley (1973) who argued that the ancient Greek (mainly the Athenian) and the Roman economies were based on very primitive economic structures, in the last 30 years there is a strikingly rising trend in the bibliography which has significantly refuted such views. Now we know that the Athenians during the Classical times had established a primitive version of a market type of an economy where the basic principles of the demand and supply mechanism were practiced (O' Halloran 2018; Bitros et al. 2020) and where various sophisticated institutions were implemented in practice such as public magistrates, who protected the market against profiteering, known as the *agoranomoi* (Bitros et al. 2020; Economou et al. 2021; Halkos et al. 2021). Bitros and Karayiannis (2008) further analyzed the related issue of entrepreneurship in Athens, under free market economy principles.[2]

In his seminal book the *Athenian Economy and Society: A Banking Perspective*, Cohen (1992) thoroughly analyzed the sophisticated way in which banks functioned in Classical Athens. They performed a plethora of activities such as: i) exchanging coins and foreign currencies ii) accepting deposits and carrying out payments on behalf of their customers iii) providing loans under interest to

[1] In contrast to democracy nowadays, which is based on the representative model of governance.

[2] For the relative developments in the Roman economy, which was also characterized by a sophisticated economic organization for the times, see among others, Temin (2012) and Verboven (2021).

various business operations, including bottomry loans in shipping iv) providing sureties, negotiating claims, and offering guarantees and personal advice to important customers v) accepting documents and valuables for safekeeping vi) facilitating export–import activities by settling payments among importers from, and ex-porters to, merchants abroad.

More than 30 bankers are attested in Athens such as the famous Pasion (Cohen 1992, 31). Amemiya (2007) and Acton (2014) also provided evidence regarding insurance services that were linked to the loans provided by these banks, for performing efficient international commercial transactions. Sophisticated ways of handling various state economic affairs in an efficient way are analyzed by authors such as Hansen (1991) and Pritchard (2015), related to the functioning of the Athenian public administration. Furthermore, Economou and Kyriazis (2017) provide evidence on property rights protection, Lyttkens (2013) focused on taxation and rationality in decision making on economic matters and Kyriazis (2009), Pritchard (2015) and Bitros et al (2020) regarding the management of state expenses and the shaping of the annual state budget (public revenues and expenditures). Economou et al. (2021) and Halkos et al. (2021) have further focused on the reliability of the Athenian currency, the *drachma*, which became the most widely used international currency of the times due to the purity of its silver content.

Due to such institutions the Athenian state achieved economic growth at least for specific sub-periods during the Classical times as Ober (2015) and Harris and Lewis (2016) have convincingly argued among others, and according to Bitros et al. (2020) this was also related to the provision of public goods such as defense and police services, education (partially) and health care. In this paper we argue that, in actuality, a water management policy was also implemented in Classical Athens, and should be also seen as a public good.

3. The Public infrastructure for establishing a water management policy

Thucydides (*The Peloponnesian War*, 1.2.3-6) informs us that Athens and the region of Attica in general was much less fertile in comparison to other areas of Greece such as the districts of Thessaly and Boeotia (Central Greece) and most of the Peloponnese (South Greece). Plutarch (*Solon*, 23.5) adds that in general the area of Athens was inadequately supplied with water, either by flowing rivers, lakes or rich springs and Angelakis and Koutsoyiannis (2003, 999) write that unlike civilizations such as those in Mesopotamia and Egypt, which were based on the exploitation of water of the large rivers such as Tigres, Euphrates, and Nile, the Greek civilization has been characterized by limited and often inadequate natural water resources.

The above description made mandatory for the Athenians to find ways to optimize the use of their available water resources, through establishing an effective water management system so as to ensure a basic level of quality of life and the well-being of citizens. To achieve this, they implemented a twofold system based on both infrastructure and institutions. In this Section we focus on the former while the later are analyzed in the next Session

3.1.1. Using public and private wells

Athenians put great efforts into the water supply of their city-state which was characterized as a dry region. Most of the inhabitants used wells which had been dug, but this was not enough. To face the water shortage problem, which was related to the very existence of the city-state itself, the great law-giver Solon from the beginning of the 6th c. BC instituted a law where there was a public well that everyone among the residents could use as a collective good. But if their homes were far away from the wells, they should have tried to obtain their own water by digging deep into the ground in their land properties. If they could not find water, they then had the right to use a jug of the size of almost 20 liters and twice a day to draw water from a neighbor's well. Krasilnikoff and Angelakis (2019), based on Plutarch (*Solon* 23.4) argue that Solon reformed the so-called 'Draconian Constitution'.[1] According to our view, this information is important because it describes an established primitive version of a water management procedure backed by law.

3.1.2. Building aqueducts

Except the existence of pools and springs, Aristotle (*Politics*, 7.1330b) recognized also the importance of constructing aqueducts so as to achieve an effective water supply system of the city-state. He writes:

> (…and [the polis] must possess if possible a plentiful natural supply of pools and springs, but failing this, a mode has been invented of supplying water by means of constructing an abundance of large reservoirs for rainwater, so that a supply may never fail the citizens when they are debarred from their territory by war.

A highly important public work of such a kind was built in the time of the tyrant Peisistratus and his sons, a large aqueduct, the exact location of which is still not known to date.[2] It is known, however, that it carried water from the Hymettus Mountain, at a distance around 7.5km to the center of the city, very close near Acropolis. Angelakis and Koutsoyiannis (2003, 1005) add that the greater part of this aqueduct was carved as a tunnel at a depth reaching 14m. In other parts it was constructed as a channel, either carved in rock or made of stone masonry, with depth 1.30m–1.50m and width 0.65 m. In the bottom of the channel, a pipe made of ceramic sections was placed. Other aqueducts were also constructed in several phases forming a network of pipelines; one of them, the Hymettus aqueduct, followed a route parallel to that made of Peisistratus (Koutsoyiannis and Mamassis (2017). Meton, famous mathematician and engineer of the times, built another aqueduct to Piraeus.

In fact, aqueducts already existed from the Archaic Period (750-509 BCE), the completion of which had been undertaken by various tyrants, such as Periandros in Corinth, Theagenis in Megara, Peisistratus in Athens, and Polycrates in Samos with the famous Eupalinian trench. Drainage elements known within Greek city-states included eaves troughs for individual buildings, drain pipes piercing the walls or foundations of individual houses, water-collector channels in neighborhoods such as those in a district in the city-state of Akragas during the Hellenistic times (323 – 146 BC) and the great drains in public areas such as the Agora at Argos. Koutsoyiannis and Mamassis (2017) conclude that using and maintaining large-scale aqueducts provided more water at lower cost.

3.1.3. Building wells, fountains, springs and cisterns

Archeological evidence has proven that during the tyrant Peisistratus and his sons Athens had developed an important public water supply network consisting of wells, fountains, and springs and there were also a number of private springs and wells (Crouch 1993, 314; Koutsoyiannis and Mamassis 2017; Stroszeck 2021, 113-115). In particular, Koutsoyiannis et al. (2008, 49) and Krasilnikoff and Angelakis (2019, 9) have argued that 400 wells were found, constructed either from public or private projects. There was a great variation in depth among them, which ranges from 2.5

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[1] The lawgiver Draco wrote the first Athenian laws handed down to us in ca. 621-620 BC. Draco's laws maintained till 594 BC, when Solon undertook the leadership of Athens and he instituted a new set of laws.

[2] Peisistratus ruled the city-state of Athens during the 561, 559–556, and 546–527 BC periods respectively. His son Hippias ruled the city from 527 to 510.

to 37 m, with an average of about 10 m. This infrastructure was further developed during the Classical Period.

Koutsoyiannis and Mamassis (2017) argue that in addition to wells and large-scale aqueducts, Athenians developed a technology of storing rainwater from roofs in underground cisterns. Cisterns were large tanks that stored rainwater collected from impervious surfaces for domestic uses or for consumption. A large portion of them were constructed below the ground surface and were waterproofed (Crouch 1993, 24). Thompson (1940) writes that a system of interconnected cisterns has been found near the Hephaisteion in Athenian Agora. In several cases, small-scale constructions, i.e. wells and cisterns, were interconnected forming complex systems storing ground and rain water.

Angelakis and Koutsoyiannis (2003, 1006) add that as Athens's water supply system was expanded and aqueducts transferred water to public fountains, private installations like wells and cisterns tended to be abandoned. But, the latter would be necessary in times of war because the public water system could stop functioning temporarily, therefore, the owners were forced by decree to maintain their private facilities in good condition and ready to use.

3.1.4. Building an underground water supply network

Angelakis and Koutsoyiannis (2003, 1005) argue that the Athenians used both groundwater, by practicing the art of drilling of wells, and stormwater, by constructing cisterns. Furthermore, the water from the two main rivers of Attica, Kephisos and Ilissos, whose flow was very limited in summer, was mainly used for irrigation.

What is also of great importance is that archaeological evidence has proved that the Athenian water supply system was also supported by a gutters network that reached a depth of up to 14 meters. Crouch (1993) and Koutsoyiannis, and Mamassis (2017) describe in detail the technical parameters of such a water supply system. Angelakis and Koutsoyiannis (2003, 1004) add that this primitive water distribution system was in place underneath the city, consisting of underground connections of wells and this was progressively expanded all around the city to the outskirts.

The gutter system was constructed in sections, in various phases. This sounds logical as it was a very big project. It is enough to consider how much time and effort it takes when changes need to be made to the water pipes system in a modern town due to age, which means closing roads and entire urban complexes to traffic, etc. Although there are not statistical data available, we consider the construction of a gutters system by the Athenians as a costly expenditure for providing a public good.

3.1.5. Building a sewage underground network for wastewater management

Water is an essential element of our lives, while modern medicine practices claim that the frequent use of clean water can improve our health, our physical condition, and even our appearance. So, did the Athenians who had understood that water is of fundamental importance and central to the natural health and well-being of citizens. Aristotle (*Politics*, 7.1330b) for example writes on the importance of clean and drinkable water:

> '……And since we have to consider the health of the inhabitants….. and the influence of the water-supply and of the air is of this nature. Hence in wise cities if all the sources of water are not equally pure and there is not an abundance of suitable springs, the water-supplies for drinking must be kept separate from those for other requirements……'

Aristotle raised various issues as mentioned with the above passage, but we focus on two of them: water resources are not unlimited, and that is essential that the water quality that is consumed in organized cities such as Athens, to be of the highest quality. Similar views are referred in his *Metaphysics* (1.983b) where Aristotle writes that water is the origin of nature.

Having understood this, the Athenians introduced laws and regulations which protected surface waters from pollution as will be further analyzed in Subsection 4.3 below. The Athenians went into a step further by establishing an underground sewage system so as to completely separate drinking water from water used for other purposes. Similar pipes to those being used for channeling fresh water throughout the city-state were also used for sewers. Sewers of large cross section, were built. These sewers were either carefully constructed with stone walls and tiles or flat slab covers or were simply made of inverted roof tiles with the presence of manholes for cleaning and maintenance (Angelakis and Koutsoyiannis 2003, 1005; Angelakis et al. 2023, 6).

Stroszeck (2021, 120-121) adds that the earliest recorded wastewater management policy of the city of Athens can be found in the Agora during the 5th century BC, when a monumental drain was installed. It was an 1 x 1m square in section, the side walls were made from polygonal conglomerate blocks, the floor consisted of limestone, and the cover slabs of yellow limestone. This channel collected drainage water from the southwestern entrance area and led it north along the western side of the Agora. Near the northwestern entrance, it was connected to a massive channel built for the river Eridanos, which carried the water farther westwards through the so-called Sacred Gate. Over the centuries, this main drainage system was supplemented and enlarged by many other wastewater channels. These channels were laid below the streets, either on the side or under the middle of the road, and manholes were built at regular intervals for their maintenance. Like a certain type of well, these were constructed from clay cylinders equipped with foot holes. Hughes (1996, 101) adds that Athens had a sewer system that provided fertilizer for her own fields, but not every house was connected; many had their own cesspools.

As a final comment, according to Krasilnikoff and Angelakis (2019, 8) establishing a water management policy was based on a twofold system which involved both large-scale (e.g. the aqueduct of Peisistratus of 6th century Athens) and small-scale (wells and cisterns) projects. It has also to be mentioned that water management infrastructure is not only attested regarding our case study, Athens, but applies also for many other city-states throughout the known Greek world of the times, such as Akragas, Argos, Corinth, Delos, Delphi, Gela, Gortys, Byzantium, Olynthos, Pella, Pergamon, Syracuse. Crouch's (1993) research is indicative of this.

4. Establishing the institutions for supporting a water management policy

Except investing in public infrastructure so as to create a water supply network, the Athenians also created a series of institutions so as to achieve an efficient water management policy. We believe that they had understood the basic logic of the famous motto of D. North (1990, 12) encapsulated in the phrase: 'institutions matter'. Thus they took care to shield their water management policy not only with the proper infrastructure, but also with effective institutions, as analyzed below, in order to optimize the use of water, seeing it above all, as a public good. In this section we are focusing on these institutions.

4.1. The epimeletes epi ton ydaton kai ton krunon

To start with, the Athenians, during the Classical times, instituted the post of *epilemetes epi ton ydaton kai ton krunon* (superintendent of fountains), a magistrate who required special knowledge with the duty to supervise the fair distribution of water and the cleanliness of the springs (Hughes 1996, 101; Thommen 2012: 57; Bitros et al. 2020, 91, 93). According to Krasilnikoff and Angelakis (2019, 9-10), this magistrate was instituted in the early 5th century BC, known as *krounon epimeletes*. His duties further included, to secure the operation and maintenance of the city's water supply system and to monitor enforcement of the regulations regarding water management (Angelakis and Koutsoyiannis 2003, 1006; Koutsoyiannis and Mamassis 2017).

It is important to note that according to Aristotle, (*Athenian Constitution*, 43.1) and the orator Aeschines (*Against Ctesiphon*, 3.29) the majority of public offices in the Athenian public administration were filled in through election by lot, but there were also some very few where public officials were appointed by the Athenian *demos* (the people) instead of being elected. According to Aeschines, all these magistrates were subjected to auditing. Aristotle (*Politics*, 6.1317.b15-1318.a3) adds that some posts required experience and skill, thus they could not be filled in by common people. According to Aristotle (*Athenian Constitution*, 42.2, 43.1) these included special posts such as the *ten strategoi* (ten generals) who were leading the Athenian armed forces, as well as the *epimeletes epi ton hydaton kai ton krounon*[1] among others. Krasilnikoff and Angelakis (2019, 10) add that suitable candidates for this magistracy would require special skills in order to be successful candidates to this important job of overseeing the water supply of the city.

Thus, the fact that the post of the *epilemetes* was filled in by an expert indicates how important such a post was considered by the Athenians. This is because they had understood that filling this post with the most competent men, was directly related to their prosperity as a whole. The high importance of this particular post, is also certified by three specific incidents, among others: Firstly, according to Plutarch (*Themistocles*, 31.1), Themistocles, the great Athenian statesman had served in this post at some time. Secondly, according to a survived Athenian decree (*IG* I^3 49) concerning the Athenian water supply, this post was also related to the involvement of Pericles' family in this process.[2] Thirdly, in 333 BCE the Athenians awarded publicly a gold wreath to Pytheus, an *epilemetes*, because he restored and maintained several fountains and aqueducts (Angelakis and Koutsoyiannis 2003, 1006; Koutsoyiannis and Mamassis 2017). Honoring someone publicly in the *direct democratic* regime of Athens, was something special. It was an extraordinary honor on the part of the state and a way of morally rewarding a citizen for his loyal deeds.

4.2. The guardians of the water supply and the astynomoi

It is logical to assume that it would have been almost impossible for the *epimeletes* to supervise and ensure only by himself the fair distribution of water for all wells, fountains and springs throughout the city-state. The post of *epimeletes* was primarily related to ensure the technical perfection and functionality of the fountains.

From Angelakis and Koutsoyiannis (2003, 1006) and Thommen (2012, 58) we further learn that a number of guards were responsible for ensuring the proper daily use and the proper maintenance of the public wells, fountains, springs and cisterns. It is not known how many they were, but what

[1] For reasons of ease from this point onwards, we will refer to this post as, the *epimeletes*.

[2] Themistocles, among other great deeds he made during his turbulent life, was the mastermind behind the Battle of Salamis, who according to various authors, saved Greece and the western world from the mighty Persian Empire (Strauss 2004). Pericles was a forerunner of Themistocles. He was also an important statesman who strengthened Athens, by introducing further democratic reforms and by making it the economic, military and geopolitical leader of the Delian League (Figueira and Jensen (2019). Perhaps his most characteristic act is the construction of the Parthenon Temple at the Acropolis. We notice that, in principle, water management duties were assigned to capable and highly recognized political figures of Athens, Themistocles and Pericles being two of the most well-known cases among them.

has been extracted by the ancient primary sources is that they were supervised about the effectiveness of their work by a special state service, known as the *ten astynomoi*. Plato (*Laws*, 6.763d) writes characteristically that:

> '…..[the *astynomoi*] shall also have charge of all the water-supplies conveyed and passed on to them by the guards in good condition, to ensure that they shall be both pure and plentiful as they pour into the cisterns, and may thus both beautify and benefit the city. Thus it is needful that these men also should have both the ability and the leisure to attend to public affairs…'

In general, the *astynomoi* had a series of important duties to accomplish, regarding cleanliness and maintaining order on the streets, such as the removal of any dead body from the streets, the supervision of road maintenance, they were in charge of street repairs and repairs of the temples of the city-state, they had to ensure that the rubbish that was collected properly by the dung collectors of the city-state, was thrown outside the city walls at a distance of approximately 1.85 km, and they were also entrusted to water management duties. Regarding water management issues they were overseeing the supply of water within the city with the duty to ensure that water will be pure and plentiful. This was a primitive regulation for water management (Aristotle, *Athenian Constitution*, 50; Plato, *Laws*, 6.759 a, 6.763d; Hansen 1991: 387; Cox 2007; Thommen, 2012: 58; Bitros et al 2020, 92). Each one of the *ten astynomoi* was elected by lot for an annual service (Hansen, 1991: 387). Half of them served in the city of Athens and the rest in the port of Piraeus.

A very illuminating information regarding the duties of astynomoi is also provided by the so-called 'Law of Astynomoi', or 'Astynomic Law' of Pergamon found by German archaeologists in 1901, in Pergamon in Asia Minor (today's Western Turkey)

in a limestone slab, in a house at the southeast of Pergamon's Agora. It describes legislation based on written laws as far as the responsibilities, the powers and the duties of the *astynomoi*. Saba (2012) who has focused on this particular law argues that the duties of the *astynomoi* were, among others, to check on the condition and maintenance of buildings, thoroughfares and waterworks. The law further defines who was responsible for the work and costs involved in maintaining infrastructure such as public roads, streets and paths, water cisterns, springs, conduits, sewers, fountains, toilets, rubbish collection and public and private boundary walls. The law specifically forbade clothes to be washed or animals to drink from public fountains. Each *astynomos* (in singular) was responsible for a particular area within the city-state, in which he was to record and report on cisterns in private houses, and ensure that owners kept them clean and covered. He imposed fines on trespassers and hand the money either to the state treasurers or to those who suffered damage due to a neighbor's negligence. Officials who failed to charge the fine were fined by the state authorities.

Obviously, the duties of the *astynomoi* of Pergamon were similar to those of Athens and many other Greek city-states of the times. What is also important to be mentioned, based on the above and other evidence, is that the *astynomoi* had also the power to issue penalties for noncompliance. Cox (2007: 772) has retrieved evidence provided by Plato's *Laws* (6.764c, 6.779c) where the philosopher states that the *astynomoi* were authorized to impose fines of up to 100 drachmae and punishment to anyone disobeying the law. Loomis (1998, 32-61) who has focused on wages in Classical Athens, argues that during the 5th century BCE, the average worker was paid 1 drachma per day during the 5th century and 1.5 drachmae during the 4th, thus a 100 drachmae penalty should be seen as a large sum of money. The Athenians had understood that the heavier the penalty the more efficient would be the compliance of the citizens, the *metics* and the slaves[1] who participated in the Athenian economy.

As a final comment, Pritchard (2015, 84-85) provides analytical details regarding the wages that the Athenian public magistrates were receiving at a daily basis. Most of the at least 700 of these public servants of the Athenian state were receiving 4 *obols* at a daily basis, that is, 2/3 of a drachma, including the *epimeletes* and the *astynomoi*. This means that these two groups were receiving a satisfactory salary in a permanent basis, and it logical to argue that they should have been quite satisfied with this, since till the completion of their duties, they never faced the threats and the side-effects of unemployment.

4.3. Environmental laws and regulations

In this sub-section we refer on evidence regarding environmental laws and regulations that functioned as supportive to the success of the overall Athenian water management policy. To start with, we refer to an inscription found known as *IG* I[3] 257 of ca. 440 BC which contains the 'law for tanners,' which demanded that tanners were forbidden to dispose their wastes to Ilissos river. In fact, this could be seen as one of the first ever environmental laws. It is worthy to be mentioned that the Athenians of the times had introduced many environmental protection laws such as laws protecting the preservation of trees: For example, Demosthenes in *Against Macartatus* (43.71), describes severe penalties to those citizens and *metics* who damaged trees throughout Attica:

> 'If anyone shall dig up an olive tree at Athens, except it be for a sanctuary of the Athenian state or of one of its demes[2], or for his own use to the number of two olive trees each year, or except it be needful to use it for the service of one who is dead, he shall be fined one hundred drachmae, to be paid into the public treasury, for each tree, and the tenth part of this sum shall belong to the goddess. Furthermore, he shall be obligated to pay to the private individual who prosecutes him one hundred drachmae for each olive tree. And suits concerning these matters shall be brought before the archons[3], according as they severally have jurisdiction….'

Further relative evidence has also been secured by ancient authors such as Lysias (*On the Olive Stump*) and Julius Pollux (*Onomasticon*, 7.146.1-4).

Another law, *IG* I[3] 49, reproduced by Krasilnikoff and Angelakis (2019, 10-11), regarding water management is related to the so-called 'Springhouse Decree', probably issued no later than 430 BC, and was related to Pericles and his family.

Furthermore, it is worthy to be mentioned the view of Crouch (1993, 623) who has argued that the close cultural and economic relations between the Greek city-states throughout the Hellenic world of the times[4], such as mother-cities and their colonies resulted to the transfer of water management and other kind of techniques and technologies outside mainland Greece. A typical example is the case of the city-state of Corinth and its colony Syracuse in today's South Italy. However, due to space

[1] *Metics* were alien residents of Athens, mostly originating from other Greek city-states. They relocated in Athens for work purposes.

[2] The municipalities of the Athenian state.

[3] The *nine archons* were high-ranking officials, mostly originating either from high income citizens or the nobility class who was originating from the aristocratic period of Athens (750 – 510 BC) before the advent of democracy. Their duties, during the democratic era were limited to judicial matters.

[4] In the East Mediterranean, the Balkans and the Black Sea region.

limitations we have chosen to focus only on the case of Athens of the Classical times. But it is worthy to be mentioned to this point that laws on water management have survived from many other Greek city-states aswell.

For example, laws designed to preserve the scarcity of resources originate from 5th century Gortyn, Crete. In particular, a regulation instructs individuals – probably farmers engaged in irrigation – not to extract water from the river Litheos, so as to prevent the water level from going below the mark set on the bridge. Two additional inscriptions from Gortyn reflect the other concern of ancient Greek lawmakers, which was to prevent damage caused by farmers channeling drainage water into neighboring fields causing damage to construction works and crops (ICret IV 73 A, ICret IV 52A and 52B, 1-6; Krasilnikoff and Angelakis 2019, 12-13).

5. Conclusions

In this paper we link some aspects of the Athenian economy in Classical times to a series of water management policies that were implemented through a specific set of institutions, in particular, the *epimeletes* and the *guardians & astynomoi* respectively. These were reinforced by building the proper water supply infrastructure through state expenses, thus, in a wider sense, the Athenian state provided to its citizens with integrated water supply services as a public good.

Crouch (1993, 30) summarizes our findings in a vivid way:

'This society knew how to find water, to save it or drain it away as circumstances required, to transport it by sophisticated long-distance water supply lines, to make public display in fountains and pools that contributed amenity as well as nourishment, to use it both at home, in the public baths, and in sanctuaries, and to drain it away afterward, cleverly reusing it to maintain other necessary resources such as food, fuel, and building materials, and indeed the water table itself….'

Our findings indicate that the success of the Athenian water management practices should not only be attributed to the creation of the proper infrastructure and institutions but also to the techniques that the Athenians introduced so as to make these institutions effective. In particular, they imposed fines to the above groups of public officials in the event they provided subpar services. As our game theory analysis further indicated, due to this threat these officials had every reason to behave efficiently and professionally since otherwise, they would not only lose their wages but also face penalties and fines.

One could argue that the above findings are well-known and commonly acceptable assumptions regarding how environmental policies nowadays are perceived around the world. On the other hand, it can be said that with the case study of Athens during Classical times we confirm that the above findings have an intertemporal character that lasts through time and space.

Potential avenues for further research that this paper opens up are, first, to further focus on Environmental Economics issues regarding ancient economies (such as Classical Athens as well as other historical cases) through methodological approaches of an interdisciplinary nature which link an environmental issue, for example, water management, to disciplines such as Institutional Economics, Economic History and Game Theory, as this research does.

Another potential avenue is to link decisions on environmental issues to governance regarding modern societies. It is well-known that decisions regarding introducing or abolishing new laws or decisions (e.g. war or peace, or building a sewage underground network etc.) in Classical Athens were taken and decided by the Athenian Assembly of citizens through *direct democracy* procedures.

If the Athenian paradigm of direct democracy can inspire modern policymakers on environmental issues, this could be related to the introduction of referendums on environmental issues, both at the level of municipalities and regions, or at the state level, such as, for example, ex ante consultation between the local authorities and the local community / citizens before reaching a decision, for example, on the construction (or not) of more parks and green areas that can create *positive externalities* under the definition of Baumol (1972) and others. Another paradigm through referendums decisions on a popular basis could have been, for example, the introduction (or not) of more wind turbines or solar panel parks to replace lignite or other older pollutant types of energy production.

At present, environmental policy issues are at the forefront of international interest. The most current ones are climate change and climate crisis. Solving these issues requires effective international cooperation. We believe that the Athenian paradigm on water management can serve as a source of inspiration regarding such discussions, that is, improving the quality of decision-making on environmental issues for the present and the future, at the global level.

There are, of course, also some limitations regarding our research, the most noticeable is the absence of cliometric data so as to test our hypotheses. But this applies not only for Classical Athens, but also for every other ancient economy in general. In this case, we can only rely on the findings of historical research by using them cautiously.

We hope that this paper will further stimulate further the interest of the academic community on related issues.

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Exploring links between local social capital and social effectiveness of protected areas

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Abstract
Protected Areas (PAs) are the most widely used tool for biodiversity conservation globally. In the European Union there are plans to protect 30% of land and 30% of water by 2030. Although PAs were initially proposed as a polity tool with a key aim to protect and restore biodiversity it is now widely recognised that they can also promote local socio-economic priorities. Despite this recognition, there are very limited studies exploring the social effectiveness of PAs and how these areas may deliver benefits for local communities living near them. In this paper I will present results from a European study assessing the benefits of PAs for local communities while also exploring how local social capital interacts with people's perceptions regarding these benefits. The results of the study show that there is a strong link between local social capital and perceived social impacts, revealing the importance of assessing effectiveness of PAs both with ecological and social criteria, and for the latter using subjective and objective indicators. These findings provide a useful and operational framework for PA practitioners and researchers illuminating pathways to increase the level of effectiveness of PAs.

Keywords: EU Biodiversity Strategy; ecosystem restoration; biodiversity, Europe, social capital, governance

JEL Codes: Q24; Q25; Q26; Q28

The geography of environmental migration.
Greece: Case studies and affected areas

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Abstract
The purpose of the present research was to investigate the phenomenon of environmental migration in Greece. Its objectives related to the identification of the main factors driving migration or displacement in Greece, the identification of the affected areas with the highest number of internal displacements due to disasters in the years 2018-2022 and the cartographic performance of the above areas for the aforementioned period. In order to provide answers, the method of multiple case studies was chosen, the cartographic rendering of these studies - using the analog symbols in the ArcGIS 10.4.1 software environment – and the circular frequency diagram in the spreadsheets of the Microsoft Excel application. The main source of data was the data provided by the Internal Displacement Monitoring Centre (IDMC). More specifically, 15 case studies were carried out in affected areas of Greece between 2018-2022, and in which internal displacements were equal to or greater than 500. Thus, with the two criteria (time period and number of internal displacements), the affected areas of the country were identified as case studies. A map was then created with the standards of ArcGIS 10.4.1 software to represent the affected areas as well as the size of the displacements which correspond to each area. The pie chart determined the percentage distribution of the type of disaster in the affected areas. The research showed that environmental migration in Greece exists in the form of internal displacement and the main factors that cause this phenomenon are wildfires, earthquakes, cyclones, and floods. Also, the regions most affected in the years 2018-2022 by the phenomenon were Attica and Evia. Finally, the research demonstrated that internal displacements in Greece may increase in the future.

Keywords: environmental migration, climate change, internal displacement, Greece, GIS

JEL Codes: Q5; Q54

Session 12

Quantitative Methods
– Environmental Efficiency

Dynamic Modeling of Environmental Quality with Embodied Technological Progress

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Abstract

In this paper, we make two assumptions according to which the environment offers at large two distinct services each of a different kind. The first assumption considers that environmental resources may serve as inputs to the production of conventional goods.For example the exploitation of an oil source from which, one firm extracts the oil which in turn is used as a fossil fuel for an industry. The second service provided is the environment itself which offers amenities (i.e. clean air, blue coasts, natural creeks, clean rivers and lakes etc.). Therefore in both cases, environmental quality plays a crucial role in the economic activities of any nation. In this paper, we combine technology adoption with environmental quality taking into account technological progress. To do this combination we set an optimal control model with the multi–stage property, therefore more complicated than a simple optimal control model. The model with a linear function can be solved analytically, otherwise is solved numerically. We obtain that the abatement process jumps upwards right at the moment that adopted the enhanced new technology. Moreover, we found that the social planner cuts down on the abatement process before the enhanced new technology is adopted.

Keywords: Optimal control, Multistage maximum principle, Environmental quality, Technology adoption.

JEL Codes: O44, Q56, Q58

Περίληψη
Σε αυτό το άρθρο, κάνουμε δύο υποθέσεις σύμφωνα με τις οποίες το περιβάλλον προσφέρει γενικά δύο ξεχωριστές υπηρεσίες, η καθεμία διαφορετικού είδους. Η πρώτη υπόθεση θεωρεί ότι οι περιβαλλοντικοί πόροι μπορούν να χρησιμεύσουν ως εισροές για την παραγωγή συμβατικών αγαθών. Για παράδειγμα, η εκμετάλλευση μιας πηγής πετρελαίου από την οποία, μια επιχείρηση εξάγει το πετρέλαιο το οποίο με τη σειρά του χρησιμοποιείται ως ορυκτό καύσιμο για μια βιομηχανία. Η δεύτερη υπηρεσία που παρέχεται είναι το ίδιο το περιβάλλον που προσφέρει ανέσεις (δηλαδή καθαρό αέρα, γαλάζιες ακτές, φυσικούς κολπίσκους, καθαρά ποτάμια και λίμνες κ.λπ.). Επομένως και στις δύο περιπτώσεις, η ποιότητα του περιβάλλοντος διαδραματίζει κρίσιμο ρόλο στις οικονομικές δραστηριότητες οποιασδήποτε χώρας. Σε αυτή την εργασία, συνδυάζουμε την υιοθέτηση τεχνολογίας με την περιβαλλοντική ποιότητα λαμβάνοντας υπόψη την τεχνολογική πρόοδο. Για να κάνουμε αυτόν τον συνδυασμό ορίζουμε ένα μοντέλο βέλτιστου ελέγχου με την ιδιότητα πολλαπλών σταδίων, επομένως πιο περίπλοκο από ένα απλό μοντέλο βέλτιστου ελέγχου. Το μοντέλο με γραμμική συνάρτηση μπορεί να λυθεί αναλυτικά, διαφορετικά λύνεται αριθμητικά. Διαπιστώνουμε ότι το γράφημα της διαδικασίας μετριασμού των ρύπων κάνει άλματα προς τα πάνω ακριβώς τη στιγμή που υιοθετείται η βελτιωμένη νέα τεχνολογία. Επιπλέον, διαπιστώνουμε ότι ο κοινωνικός σχεδιαστής περιορίζει τη διαδικασία μετριασμού των ρύπων προτού υιοθετηθεί η βελτιωμένη νέα τεχνολογία.

1. Introduction

In this study, we deal with the environment as a resource capital that belongs to a nation or country. The first use is that the environment as a capital offers its resources to the production of goods that are consumed, the second use of the environment is itself which offers its amenities (Halkos, Papageorgiou, 2016)

The paper concerns the time of the new technology adoption during the abatement process in order to improve the quality of the natural resources. For this purpose, we employ a multi-stage optimal control model and we take into account the oncoming innovations that will happen in the process of the pollutant abatement. With the same model, we are able to decide about the length of the time interval at which the benevolent social planner would invest in the technology that improves abatement of pollutants, and moreover how this technology interacts with the national capital of environmental resources.

Our model approach is close to Guo and Zhu (2016) technology adoption approach for the firms, in which a firm gives great importance to the evaluation of economic profits between the adoption of advanced abatement technologies against the traditional methods. To do that they employ an optimal control model in which abatement of the pollutants is an accumulated capital while the costs faced by the representative firm are a combination of production, abatement, and taxation costs. Another interesting paper, related to our approach, is that of Farzin and Kort (2000) in which a risk-neutral competitive firm can lower its pollution emissions by building up abatement capital stock. The authors examine the effect of a higher pollution tax rate on abatement investment both under full uncertainty and when the timing or the size of the tax increase is uncertain.

This work continues the optimal control theory applied in environmental economics management as proposed by Halkos and Papageorgiou (2022), but in the easier case of one stage.

Furthermore, as it is pointed out in literature, in economics it is important to find and analyze the optimal timing between two or more alternative regimes. The examples are many and are not limited to situations like the optimal timing of privatizations of firms, optimal timing of a new technology introduction, optimal timing to join in an EMU–like union, optimal timing of investment, and so on (Makris M., 2001). Concerning the modeling of such situations alternating between two or more regimes the proposed models are at large optimal control models of infinite periods but reduced in two or more stages, and therefore more difficult, with respect to its solutions, than those of one stage. As it is mentioned, in many cases in Economics, it seems more appropriate to consider a problem with an infinite horizon. In our case we suppose that the social planner apart from choosing its usual policies can also change the technics of the pollutants abatement process from an instant t_1^* and on for which instant time holds that $0 \leq t_1^* < \infty$ and therefore we have two distinguished regimes. The first stage defined in the time interval $[0, t_1^*]$ and is characterized by a trivial technique of abatement. Second situation takes place in time interval $[t_1^*, \infty[$ at which applies the augmented technology on pollutants abatement. As it becomes clear, equilibrium allocations and social utility will depend on the actual choice of the switch time t_1^* and moreover the goal of the social planner is to find the optimal time at which the government accepts the new technology. The rest of the paper is organized as follows: In section 2 we present the basic model and the results with a simple welfare function, section 3 proceeds with the model analysis, section 4 extends the model introducing a concave welfare function, while section 5 concludes the paper.

2. The model

Let us consider a country that implements a pollution abatement policy to reduce the concentration of pollutants that degrade the quality of environmental resources. Environmental resources are the natural capital of any country and the concentration of pollutants reduces the efficiency of these resources; on the other hand, any pollution abatement process undertaken obviously increases the quality of the above resources. In our model, we allow the decision maker to adopt a new technology in order to improve the efficiency of natural resources.

We denote by T the time of adoption of the new technology, i.e. the decision variable, and with $E(t)$ we denote the capital stock of the total natural resources. We assume that prior to any technology change, a unit of abatement leads to an increase of one unit in the stock of natural resources. After the time $t \geq T$, when the new technology is adopted, the same one unit of abatement increases the capital of natural resources by $\alpha(t)$ (instead of one unit). Here by $\alpha(t)$ denotes the productivity of the improved technology in the abatement process which is as an immediate effect on the economy of the natural resources. Due to the technological progress and according to the linearity improvement of the productivity of machines, as argued by Feichtinger et al (2006), the following restrictions apply:

$$\alpha(0) = 1,\ \alpha'(t) > 0\,,\, \alpha(t) = 1 + bt \tag{1}$$

a is a positive constant.

Assuming that all costs associated with the adoption of the new technology are zero, the social planner will always choose the technology with the higher abatement results. Then at time T, for $t \geq T$, the improved abatement would be $a(T)$. Therefore the accumulation equations of the natural resources before and after the new technology adoption are respectively

$\dot{E}$=$A - \delta E$ for $t < T$

$\dot{E} = a(T)A - \delta E$ for $T \leq t < \infty$

δE is the depreciation of the environmental quality due to pollution.

The cost of the abatement of pollutants process $C(A)$, consists of acquisition and adjustment costs and is assumed to be quadratic, i.e.

$$C(A) = A + \tfrac{c}{2}A^2 \tag{2}$$

for $c > 0$ (a positive constant).

he social planner maximizes discounted utility, which is a function of the welfare derived from good environmental quality (the existence of many natural resources) minus the cost of abatement.

In summary, the two-stage optimal control becomes:

First the optimal control problem with one technology adoption

$$max_{A,T} U(A,T) = \int_0^\infty e^{-rt}\left(W(E) - A - \tfrac{c}{2}A^2\right)dt \tag{3}$$

$$\dot{E}=A - \delta E \quad \text{for } t < T \tag{4}$$

$$\dot{E} = a(T)A - \delta E \quad \text{for } T \leq t < \infty \tag{5}$$

$$E(0) = E_0 > 0 \tag{6}$$

Therefore, the Stage 1 problem, which determines abatement prior to technology deployment, is

$$max_{A,T}U(A,T) = \int_0^T e^{-rt}\left(W(E) - A - \tfrac{c}{2}A^2\right)dt + e^{-rT}W_2^*(E(T),T) \tag{7}$$

$\dot{E}$=$A - \delta E$, $E(0) = E_0 > 0$

And the stage 2 problem after the technology adoption becomes

$$U_2^*(E_T,T) = max_A U_2(E_T,A,T) = \int_T^\infty e^{-r(t-T)}\left(W(E) - A - \tfrac{c}{2}A^2\right)dt \tag{8}$$

$\dot{E} = a(T)A - \delta E \quad E(T) = E_T > 0$

3. Model analysis

3.1. Amount of abatement

Here we analyse the proposed model in order to draw some conclusions. An attractive specification for the welfare function would be the linear case, i.e. a welfare function linear in environmental quality, thus

$$W(E) = wE \tag{9}$$

$w > 0$, and moreover we assume that the marginal welfare exceeds the initial cost of environmental resources capital, i.e.

$$w > \delta \tag{10}$$

The latter assumption was made to ensure that the use of abatement processes is optimal from the outset.

We start the analysis of the model with the finite planning horizon. As argued in the literature (Dockner et al., 2000), it is necessary to introduce the welfare function at the end time (the well known salvage function in the optimal control theory). This could be, in our case, the total welfare of the country that can be obtained by using the capital of natural resources $E(\tau)$ from the time horizon date until infinity time.

Therefore, the value of the social welfare at date τ equals to $\frac{wE(t)}{\delta}$.

We now consider the case where the social planner introduces a new technology into the abatement process only once.

<u>The model with one technology introduced</u>

The resulting model for a finite planning horizon with one technology is the following

$$max_{A,T}U(A,T) = \int_0^\tau \left(wE - A - \tfrac{c}{2}A^2\right)dt + \frac{wE(t)}{\delta}$$

Subject to $\dot{E}{=}A-\delta E$ for $t<T$

$\dot{E}=a(T)A-\delta E$ for $T\le t<\infty$

$$E(0)=E_0>0$$

The analysis of the above model with an adopted technology has the following parts. First we consider the time interval after the introduction, secondly the time before the introduction and thirdly the starting time of the abatement process.

Stage 2 (after adoption of the new technology – time interval $[T,\tau]$)
The social planner has the following objective maximization (according to (8) for finite horizon)

$$max_A U_2(E_T,A)=\int_T^{\tau} e^{-r(t-T)}\left(wE-A-\tfrac{c}{2}A^2\right)dt+\frac{wE(t)}{\delta}$$

$\dot{E}=a(T)A-\delta E \quad E(T)=E_T>0$

Applying Pontryagin's maximum principle Dockner et al (2000) we take the following Hamiltonian

$H_2=wE-\left(A+\frac{c}{2}A^2\right)+\lambda_2(\alpha(T)A-\delta E)$

λ_i, $i=1{,}2$ are the adjoint variables for the stages $i=1{,}2$.

Taking the necessary optimality conditions we have

$\frac{\partial H_2}{\partial A}=0\rightarrow 1+cA=\lambda_2\alpha(T)$ (11)

$\frac{\partial H_2}{\partial A}=0\rightarrow 1+cA=\lambda_2\alpha(T)$ (12)

$\lambda_2(\tau)=\frac{w}{\delta}$ (13)

From (11) - (13) it is obvious that

$\lambda_2(t)=\widetilde{\lambda_2}=\frac{w}{\delta}>0$ (14)

$A(t)=\widetilde{A_2}=\frac{\alpha(T)w-\delta}{c\delta}$

Combining equation (14) with the constraint (5) $\dot{E}=\alpha(T)A-\delta E$ we found the expression of the natural resources capital as:

$$E(t)=\left(E(T)-\widetilde{E_2}\right)e^{-\delta(t-T)}+\widetilde{E_2}$$

$\widetilde{E_2}=\alpha(T)\frac{\alpha(T)w-\delta}{c\delta^2}$

Stage 1 (before the new technology adoption – time interval $[0,T]$)

In this time interval we have the following finite time maximization problem (7)

$$max_{A,T}U(A,T)=\int_0^T e^{-rt}\left(W(E)-A-\tfrac{c}{2}A^2\right)dt+e^{-rT}W_2^*(E(T),T)$$

under the constraint $\dot{E}{=}A-\delta E$, $E(0)=E_0>0$

Given the specification (9) $W(E)=wE$ the Hamiltonian is the following

$$H_1=wE-\left(A+\frac{c}{2}A^2\right)+\lambda_1(A-\delta E)$$

and the conditions of optimality are

$$1 + cA = \lambda_1 \quad (15)$$

$$\dot{\lambda}_1 = \delta\lambda_1 - \mathrm{w} \quad (16)$$

The costate variable is continuous at the time of technology adoption T, therefore the transversality condition is the following

$\lambda_1(T) = \frac{w}{\delta}$

In the stage 1 the costate and the abatement rates are constant and are given from the following

$$\lambda_1(t) = \widetilde{\lambda_1} = \frac{w}{\delta}$$

$$A_1(t) = \widetilde{A_1} = \frac{w - \delta}{c\delta} \quad (17)$$

Comparing the two quantities of the abatement (after and before technology adoption) we get the following result.

Proposition 1.

With the adoption of the new technology, the amount of abatement of the pollutants increases (otherwise jumps up) by a positive quantity which is exactly the following expression $\frac{bwT}{c\delta}$ >0,

Proof

The result follows immediately taking the difference

$$\widetilde{A_2} — \widetilde{A_1} = [\alpha(T) - 1]\frac{w}{c\delta} = \frac{wbT}{c\delta} \quad (18)$$

and combining with (1) (since it is supposed that $\alpha(T) = 1 + bT$ and $b > 0$).

3.2. Adoption time

It is obvious that adopting a new technology at time zero or at time τ has the same objective value as not adopting a new technology at all, which is clearly not optimal. Therefore, the adoption time T should satisfies the inequality: $0 < T < \tau$. The next proposition clarifies the optimal time of the adoption of the new technology.

Proposition 2.

The optimal adoption time of the new technology is determined by the following expression

$$T = \frac{1}{3wb}\left(wb\tau - 2(w - \delta) + \sqrt{4(w - \delta)^2 + 2wb\tau(w - \delta) + w^2b^2\tau^2}\right) \quad (19)$$

Proof
In the Appendix
Corollary 1.
The country invests in the less efficient technology during a longer time interval than it invests in the more efficient, i.e.,

$$0 < \tau - T < \frac{\tau}{2} < T \tag{20}$$

Proof in the Appendix.

The result of corollary 1 seems somehow strange, as an earlier switch would allow the social planner to use a more efficient technology sooner. Nevertheless, by waiting longer, the social planner of the country can adopt a more efficient abatement technology in order to abate the pollutants productively. At time $\tau/_2$ the adoption of the technology is more effective.

The worthiness of the proposition 1 is that the adoption time is dependent only on the model parameters with the exception of the initial environmental quality level E, which hinges on the linearity of the utility function $W(E) = wE$. In the following we make some comparative statics for the time of adoption T with respect to some parameters of the model.

Corollary 2.

The more efficient the capital of the natural resources the more worthiness the earlier adoption of the new technology is. In other words, the higher the marginal utility of the natural resources capital, the greater the gain of the new technology adoption.

Proof

The result is easily obtained, taking the first derivative of the adoption time (19) w.r.t. the marginal utility gained by the capital.

Therefore the dependence of the adoption time on marginal utility w, would be:

$$\frac{\partial T}{\partial w} = \frac{\delta}{3w^2 b}\left(\frac{4(w-\delta) + wb\tau}{\sqrt{w^2b^2\tau^2 + 2w^2b\tau + 4w^2 - 2wb\tau\delta - 8w\delta + 4\delta^2}} - 2\right) < 0 \tag{19.1}$$

The derivative is a negative quantity, which means that:
This dependence of the adoption time on marginal utility (19.1) says that the more efficient the environmental quality the earlier the country adopts the new technology. The reason for this is that the higher the marginal utility is, the greater the gain from adopting a technology. So if the social planner of the country waits to adopt a new technology while the marginal utility w is high, the opportunity cost of waiting is high too.

Corollary 3.
As progress goes faster, the country pays to wait longer with adopting a new technology.

Proof

We inspect the effect of the positive constant of productivity b to the adoption time T, therefore taking the partial derivative of the adoption time we have:

$$\frac{\partial T}{\partial b}=\frac{(\alpha-\delta)}{3wb^2}\left(2-\frac{4(w-\delta)+wb\tau}{\sqrt{w^2b^2\tau^2+2w^2b\tau+4w^2-2wb\tau\delta-8w\delta+4\delta^2}}\right)>0 \tag{19.2}$$

The dependence of the adoption time T with respect to the technological progress (19.2) obeys that as the progress goes faster, the decision for waiting for the adoption is more expensive.

Corollary 4

When the depreciation rate of the environmental quality due to pollution is higher the country adopts the new technology later.

Proof

We take the partial derivative of the adoption time w.r.t. depreciation rate

$$\frac{\partial T}{\partial \delta}=\frac{1}{3wb}\left(2-\frac{4(w-\delta)+wb\tau}{\sqrt{w^2b^2\tau^2+2w^2b\tau+4w^2-2wb\tau\delta-8w\delta+4\delta^2}}\right)>0 \tag{19.3}$$

The rigorous reasoning of that fact is that when the depreciation rate of environmental quality or the depreciation rate of the capital of natural resources is bigger, then the net value of the abatement of pollution is smaller, therefore in order to make the adoption of the incoming technology more profitable the social planner of the country under consideration has to decide for a better technology. To make this more applicable the social planner of the country employs technological progress by delaying the new technology adoption time.

4. Concave welfare function

We continue our analysis assuming a concave utility function with the following quadratic specification w.r.t. environmental quality.

$$W(E)=wE-\frac{m}{2}E^2$$

As in the usual practice we take care about future discount of welfare and costs.
As in the previous section, we leave the sequence of moves unchanged, i.e. firstly Stage 2 after the adoption of the new technology and secondly Stage 1 before the adoption. Finally, we take the expression of adoption time.

Stage 2 (after adoption of the new technology)
The Hamiltonian for $t\in[T,\infty)$ is the following

$$H_2=wE-\frac{m}{2}E^2-\left(A+\frac{c}{2}A^2\right)+\lambda_2(a(T)A-\delta E) \tag{21}$$

with the optimality conditions

$$1+cA=\lambda_2 a(T) \tag{22}$$

$$\dot{\lambda}_2=(r+\delta)\lambda_2-w+mE \tag{23}$$

Hence we deal with the following dynamical system

$$\dot{E} = -\delta E + a(T)A \tag{24}$$

$$\dot{A} = \frac{a(T)}{c}mE + (r+\delta)A + \frac{r+\delta}{c} - \frac{a(T)}{c}w \tag{25}$$

The steady state solution is

$$\widetilde{E_2} = \frac{a(T)w-(r+\delta)}{a(T)m+\frac{\delta(r+\delta)c}{a(T)}} \tag{26}$$

$$\widetilde{A_2} = \frac{\delta w-\frac{\delta(r+\delta)}{a(T)}}{a(T)m+\frac{\delta(r+\delta)c}{a(T)}}$$

$$\widetilde{\lambda_2} = \frac{m+\frac{\delta wc}{a(T)}}{a(T)m+\frac{\delta(r+\delta)c}{a(T)}}$$

An equilibrium exists (with positive environmental stock and abatement rate) in the case the inequality $a(T) > \frac{r+\delta}{w}$ holds true.
The following result follows from the above discussion

Proposition 3
The steady state equilibrium of the evolution of environmental quality and evolution of the abatement process, i.e. the system (24) - (25), is saddle point stable.

Proof
We take the Jacobian matrix of the system (24), (25) in order to check the stability
Hence,

$$J = \begin{vmatrix} -\delta & a(T) \\ \frac{a(T)}{c}m & r+\delta \end{vmatrix} = -\delta(r+\delta) - \frac{a^2(T)}{c}m < 0 \tag{27}$$

The negativity of the Jacobian matrix ensures the saddle point stability.

Stage 1 (before the technology adoption)
For this stage 1 the similar analysis leads to the following dynamical system

$$\dot{E} = -\delta E + A$$

$$\dot{A} = \frac{1}{c}mE + (r+\delta)A + \frac{r+\delta}{c} - \frac{1}{c}w$$

And the steady state of the finite time optimal control problem is

$$\widetilde{E_1} = \frac{w-(r+\delta)}{m+c\delta(r+\delta)} \tag{28}$$

$$\widetilde{A_1} = \frac{\delta w-\delta(r+\delta)}{m+\delta c(r+\delta)}$$

$$\widetilde{\lambda_1} = \frac{m+\delta wc}{m+\delta(r+\delta)c}$$

The above discussion implies the following result.

Proposition 4
A steady state solution for the stage 1, before the adoption time of the new technology, exists only if the inequality of the model parameters, $w > r + \delta$, holds true. Moreover, the steady state solution is saddle point stable.

Proof
Inspecting (28), both environmental quality and abatement haves positive values if and only if $w > r + \delta$.
As a continuation we check whether the solution is stable. Therefore, we construct the Jacobian matrix of the above dynamical system, hence

$$J = \begin{vmatrix} -\delta & 1 \\ \frac{m}{c} & r+\delta \end{vmatrix} = -\delta(r+\delta) - \frac{m}{c} < 0$$

The negativity of the Jacobian ensures the saddle point stability of the steady state solutions.

5. Conclusions

This study tackles with the problem of the environmental capital of a country and specifically examines how the abatement of the pollutants can improved through the adoption of better technology. Starting with the hypothesis that environmental resources can serve as inputs into the production of conventional goods and at the same time the environment itself provides amenities to the people of a country, it is obvious that a good environmental quality becomes a vital priority for the economy of any nation. Therefore the abatement of the pollutants concentration is the main process - tool for the environmental quality restoration. In this work we propose and analyze a two stages optimal control model in continuous time for which the adoption time of the improved technology in the abatement process plays a crucial role. The model we propose maximizes the infinite time discounted social utility minus the costs of abatement process under the constraint of pollutants accumulation, which constraint splits in two equations also depending on the adoption time. First using a linear welfare function we found that the amount of abatement of the pollutants increases (otherwise jumps up) by an exact positive quantity (Proposition 1) and with the same linear social utility function we found the exact expression of the improved technology adoption time (Proposition 2). Continuing the analysis of the model we provide four corollaries connecting the

adoption time with the parameters of the model. In the next section of the paper we analyze the extended model assuming a concave social utility function for which we found the steady state equilibrium (Proposition 3) and we discover the conditions of the model's parameters under which the equilibrium is stable (Proposition 4). All the propositions are proved with the rigorous mathematics expressions.

Appendix

Proof of Proposition 2

According to Tomiyama K. Rossana R. (1989) it is known that at the technology adoption time T we have the following condition

$$H_1(T) = H_2(T) - b\int_T^\tau \lambda_2(t)A(t)dt = H_2(T) - wb\frac{q(T)w-\delta}{c\delta^2}(\tau - T) \qquad (A.1)$$

Substituting the expressions of H_1, H_2 from the main text the we have

$$\begin{aligned} wb\frac{(1+bT)w-\delta}{c\delta^2}(\tau - T) = \\ = \frac{w}{c\delta} - \frac{(1+bT)w}{c\delta} + \frac{c}{2}\left(\frac{w-\delta}{c\delta}\right)^2 - \frac{c}{2}\left(\frac{(1+bT)w-\delta}{c\delta}\right)^2 + \\ + \frac{w}{\delta}\left((1+bT)\frac{(1+bT)w-\delta}{c\delta} - \frac{w-\delta}{c\delta}\right) \end{aligned}$$

and after rearrangement

$$p(T) = 3wbT^2 + (4(w-\delta) - 2wb\tau)T - 2\tau(w-\delta) = 0$$

Since $w > \delta$ the above second order polynomial in T has as unique positive root the expression (19) of Proposition 2.

Proof of Corollary 1

The result (20) follows from the next inequalities

$$p(0) = -2\tau(w-\delta) < 0$$

$$p\left(\frac{\tau}{2}\right) = \frac{3}{4}wb\tau^2 + 2(w-\delta)\tau - wb\tau^2 - 2\tau(w-\delta) = -\frac{1}{4}wb\tau^2 < 0$$

$$p(\tau) = 3wb\tau^2 - 4(w-\delta)\tau - 2wb\tau^2 - 2\tau(w-\delta) = wb\tau^2 + 2(w-\delta)\tau > 0$$

and the fact that the polynomial $p(T)$ is strictly concave

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European firms productivity growth and environmental regulation. Re-examining the Porter hypothesis

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Abstract

European manufacturing firms have to cope with the new regulations that advocate a greener and more sustainable future with less emissions and at the same time enhance or at least maintain their productivity levels. Thus, it is imperative for economic science to study the effects that newly imposed regulations have on economic growth and suggest any appropriate modifications. We follow a non radial directional distance function where each firm uses a vector of inputs and produces a vector of desirable and also a vector of undesirable outputs. We adopt a non-radial efficiency estimation, which assumes that inputs and undesirable outputs decrease at a different rate as desirable outputs increase. We compute a regulatory impact indicator that provides information about the loss of outputs resulting from new policies. Moreover, we compute environmental productivity growth and its components based on Oh (2010). Environmental productivity growth has the advantage that takes into consideration the incorporation of emissions in the production function (known as Malmquist-Luenberger index) and also addresses the existing problem of heterogeneity by adopting the concept of metafrontier. Finally, we explore the impact of regulatory impact indicator on environmental productivity growth using a panel vector autoregression method. Our findings showcase that the average value of environmental productivity has increased by 0.7% and 0.2% for heavy metals and greenhouse gases respectively, during the 2011- 2017 period. On the contrary, environmental productivity for other gases indicates that neither a catch up nor lagging behind took place. The component of best practice change is the main reason that environmental productivity growth increased on average, since it increased for all pollutant groups on average. Finally, we compute the impact that environmental regulations exert on environmental productivity and find that increasing the index of regulations by 1%, causes an increase of environmental productivity by 0.24% and 0.44% for heavy metals and greenhouse gases groups, respectively. The other gases group does not provide a statistically significant result. We support the "weak" Porter Hypothesis, which attests that well-designed environmental regulations can exert a positive effect on environmental innovation.

Keywords: Metafrontier Malmquist–Luenberger index; Environmental Productivity; Environmental regulations; Technological heterogeneity

JEL Codes: C14, C44, C67, L20, Q53.

Testing the Environmental Kuznets Curve hypothesis in the case of tourism in the Eurozone member states

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Abstract
The process of tourism development always constitutes a demanding research subject regarding its impacts on environmental performance, for instance, when investigating the Environmental Kuznets Curve (EKC) hypothesis. Particularly, this is the case in our modern reality, which is characterized by severe changes in v environmental quality levels. From this perspective, the present study investigates the role of tourism spending concerning domestic and international visitors on greenhouse gases (GHGs) and carbon dioxide emissions. In regression models, we include spending for business and leisure purposes as tested variables to confirm or not the EKC hypothesis. Furthermore, we examine if and how renewable energy decreases these environmental quality indicators. We apply panel data analysis for Eurozone member states between 1996 and 2019 by using the Driscoll-Kraay standard errors with fixed effects regression. Research findings evidence the inverted U-shape curve. As a result, the EKC hypothesis is confirmed in both cases of visitor spending and domestic spending for business and leisure purposes. Granger non-causality tests confirm feedback hypotheses for all tested pairs of variables. Practical implications reveal the crucial role of renewables in limiting air degradation levels, whereas they highlight the role of sustainable tourism spending in maintaining a clean and safe environment.

Keywords: Environmental Kuznets Curve, tourism growth, air pollution.

JEL Codes: Q56; Z32; Q5.

Are climate change policy instruments the sword of Damocles on fostering green technology independence to achieve green growth and sustainability in Europe?

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Abstract

The long-term commitment of the European Union to environmental protection materializing via numerous directives echoes in the European Green Deal. Green growth acts as the means to sustainability transition, despite technological and climate change policy implementation discrepancies exist. We introduce a conceptual framework bringing together the policy framework and country capabilities. Our aim is to explore the effects of climate change policy instruments, environmental policy effectiveness and eco-innovation performance on the relative advantage of the EU-28 in developing green technologies to foster green transition. We compile a unique dataset on the EU-28 from 2010 through 2019, including the climate change mitigation policy rate and environmental policy effectiveness for the first time. Findings from panel quantile robust instrumental regressions show that environmental policy instruments have a differential effect on the relative advantage of the country to develop green technologies while a non-linear effect of eco-innovation performance is documented. Evidence indicates that climate change policy tools influence in an asymmetric way the technology aspect of green growth, hindering environment-related technological independence. Environmental policy effectiveness affects the high technology-dependent countries while green fiscal policy behaves as a mitigator of green technological advantage creation. This study contributes to SDGs 7, 9, 12 and 13.

Keywords: Green Growth & Sustainability Transition; Advantage in Developing Green Technologies; Environmental & Climate Change mitigation policy instruments; Eco-innovation.

JEL Codes: C50, O52, Q55, Q56, Q58.

Suitability evaluation of broadleaved wood for multiple uses with the application of PROMETHEE IImethod

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Abstract

The contribution of forests to Greece's Gross National Product is one of the smallest among the countries of the European Union. Furthermore, Greece imports large quantities of sawn wood timber from abroad. The right choice of tree species in primary and secondary wood processing forestry enterprises, based on specific criteria, could have essential economic benefits for the timber industry in Greece. The aim of this paper was to evaluate the suitability of the most common species of broadleaved trees used in the Greek timber industry, with the use of a Multiple Criteria Decision Analysis approach, considering qualitative and economic criteria. The method PROMETHEE II was used, and five tree species were investigated: beech, chestnut, oak, poplar, and walnut in selected criteria which affect the wood quality and determine the final uses of timber, such as pricing, density, resilience to insects, etc. According to the results, the most suitable tree species was walnut, having the highest ranking (highest net flow) among the alternatives under the specific criteria. Chestnut and oak also had a positive net flow and were ranked as optimal solutions. On the other hand, beech and poplar had negative net flows and were not ranked as optimal solutions. Poplar, in particular, achieved the highest negative flow among the examined tree species and, hence, was unsuitable for the production of technical or sawn timber. Therefore, walnut, chestnut and oak were the proposed species for furniture manufacturing and production of sawn timber, in contrast with beech and poplar.

Keywords: sawn timber;forest products; sustainability; economic benefits;multiple criteria decision analysis.

JEL Codes: Q23;L73;Q01;Q56; D81.

1. Introduction

In the sustainable management framework, Greece aims to exploit forests more sustainably by applying forest policies and providing knowledge to forest managers to operate more efficiently and make good use of wood as raw material (Koulelis et al., 2022). The contribution of forests to Greece's Gross National Product (GNP) is one of the smallest among the countries of the European Union, even though one of the main goals of the National Forest Strategy of Greece was the significant increase of the forest sector in the GNP of the country (Tsiaras et al., 2021). Greece has significantly low productivity in terms of wood output and wood removals (Koulelis, 2012) and, therefore, imports large quantities of wood and wood products from abroad (Koulelis, 2019). The global financial crisis in 2008 deteriorated this deficit (Koulelis, 2016), and the production decline, especially in roundwood and sawnwood, was continuous from that period, followed by a substantial increase in imports (Koulelis et al., 2023). Therefore, the right choice of tree species based on specific criteria in primary and secondary wood processing forestry enterprises could have economic benefits for the Greek timber industry.

Access to knowledge of the theoretical background of wood related to wood structure and mechanical and physical properties is essential since they are strongly connected with wood's behavior and, by extension, its utilization. Furthermore, the availability of raw material and pricing are important factors determining the final suitability of the wood (Tsoumis,1991; Šuhajdová et al., 2018). A tool to accomplish tests related to finding the optimum solution for specific end uses is MCDA. Multiple Criteria Decision Analysis (MCDA) methods are broadly used for complex problems with multiple conflicting criteria in order to provide a ranking of the alternatives from best to worst, helping the decision maker to select the best alternative (Behzadian et al., 2010).

More than 70.000 different wood species are known, and almost 400 are used internationally, having a wide range of applications. Some of these are only exploited in the countries where they grow without being exported abroad. Proper utilization of wood demands a good knowledge of its identification, anatomical characteristics, properties, and behavior during mechanical processing since they are connected (Kakaras, 2008; Mantanis, 2008).

The mainly used wood species which are native to Greece and are utilized for various products and constructions are pine (*Pinus sp.*), fir (*Abies sp.*), spruce (*Picea sp.*), beech (*Fagus sp.*), oak (*Quercus sp.*), poplar (*Populus sp.*), and chestnut (*Castanea sp.*). Moreover, a smaller amount of timber is produced from other species, such as cypress (*Cupressus sp.*), juniper (*Juniperus sp.*), yew (*Taxus sp.*), walnut (*Juglans sp.*), plane tree (*Platanus sp.*), elm (*Ulmus sp.*), olive tree (*Olea sp.*), ash (*Fraxinus sp.*), etc. Besides the domestic wood species, foreign species are imported as roundwood or sawn timber for the production of many final products and uses. Imports include species such as *Quercus sp.*, *Fagus sp.*, *Populus sp.*, *Pinus sp.*, *Abies sp.*, *Picea sp.*, etc from Europe and North America, as well as tropical species such as Teak, Iroko, Zebrano, Palissander, Sapele, Tiama, Padouk, Kosipo, etc. Finally, large quantities are imported as wood pulp to produce paper (Voulgaridis, 1995; Mantanis, 2008; Voulgaridis, 2015).

The aim of this paper was to evaluate the suitability of the most common species of broadleaved trees used in the Greek timber industry, such as sawn (construction) timber, plywood, and furniture, using a Multiple-Criteria Decision Analysis approach, considering qualitative and economic criteria.

2. Materials and Methods

The Multiple-Criteria Decision Analysis (MCDA) method used in the present paper was the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), and more specifically, PROMETHEE II, an MCDA method presented by Brans (1982) providing a complete ranking of the alternatives (Brans and De Smet, 2016). PROMETHEE II is based on a pairwise comparison of alternatives along each criterion. Alternatives are evaluated according to different criteria, which have to be maximized or minimized (Behzadian et al., 2010). The complete ranking of the alternatives is provided by the net outranking flow, which is the balance between the positive and the negative outranking flows. The higher the net flow, the better the alternative (Brans and De Smet, 2016).

Net outranking flow (phi) = positive outranking flow (phi+) – negative outranking flow (phi-).

$$\varphi\ (\alpha) = \varphi^{+}(\alpha) - \varphi^{-}(\alpha)$$

When $\phi(a) > 0$, a is more outranking all the alternatives on all the criteria, when $\phi(a) < 0$ it is more outranked (Brans and De Smet, 2016).

PROMETHEE II was used to select the optimal broadleaved tree species among the examined alternatives under specific criteria that affect wood quality and determine the final uses of timber, such as pricing, wood density, shrinkage, mechanical properties, dry weight, resilience to insects, workability, etc. The data used in the present paper were collected from other researchers (Kantay & Ünsal, 2000; Kakaras 2008; Skarvelis & Mantanis 2013; Voulgaridis, 2015; Kakavas et al. 2018a; Kakavas et al., 2022) the Forest Products Pricing Table of Greece for the management year 2023, and the wood database (https://www.wood-database.com/), a database from 2007 specialized in wood species from all over the world, their structural characteristics and basic physical and mechanical properties, according to Forest Products Laboratory (US, 1987)

Five broadleaved species (hardwood) commonly used in wood processing forestry enterprises of Greece were examined: chestnut (*Castanea sativa*), beech (*Fagus sylvatica*), walnut (*Juglans regia*), poplar (*Populus nigra*), and oak (*Quercus petraea*). The species mentioned above have significant value to the national and international timber market.

The preference functions and the thresholds of indifference (q) and preference (p) were calculated with the assistance of the "Help me" wizard of Visual PROMETHEE Academic Edition (Mareschal, 2013). The data of the study were analyzed with the software Visual PROMETHEE Academic Edition (Figure 1). The criteria were selected based on their importance for selecting wood for multiple uses, and they were given the same weight in the scenario presented in this paper. In future publications with more scenarios examined, the weight of the criteria will be properly modified.

The under-consideration criteria were specific gravity, Janka hardness, modulus of rupture, modulus of elasticity, crushing strength, shrinkage ratio (tangential/radial), natural durability, resistance to fungi, bacteria and insect attack, workability and pricing. Table 1 presents the selected criteria, their scale (numerical, qualitative, currency) and their unit.

Specific gravity measures the mass contained in a given volume. It is based on weight when oven-dried and volume when green or at 12% moisture content. Some researchers believe wood density is strongly connected with the resilience of constructions since timber has greater strength and less possibility of trunk breakage than other construction materials (Tsoumis, 1991; Larjavaara & Muller-Landau, 2010). Gravity is a criterion that needs to be maximized.

Figure 1: The data of the study

Evaluations

Scenario: Scenario1 (active)

	Active	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Active	**Scenario1**	**Density**	**Hardness**	**Rupture**	**Elasticity**	**Strength**	**Shrinkage**	**Durability**	**Workability**	**Resistance**	**Pricing**
yes	**Castanea sativa**	545	3,00	71,4	8,61	43,8	1,6	5	5	2	81,00
yes	**Fagus sylvatica**	715	6,46	110,1	14,31	57,0	2,0	1	5	1	60,90
yes	**Populus nigra**	385	2,02	63,7	7,21	36,0	2,3	2	4	2	56,20
yes	**Juglans regia**	640	5,41	111,5	10,81	50,2	1,4	3	4	2	97,33
yes	**Quercus petraea**	710	4,99	97,1	10,47	47,3	2,2	5	3	5	65,10

Statistics

Scenario: Scenario1 (active)

Active	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Density	**Hardness**	**Rupture**	**Elasticity**	**Strength**	**Shrinkage**	**Durability**	**Workability**	**Resistance**	**Pricing**
Minimum	385	2,02	63,7	7,21	36,0	1,4	1	3	1	56,20
Maximum	715	6,46	111,5	14,31	57,0	2,3	5	5	5	97,33
Average	599	4,38	90,8	10,28	46,9	1,9	3	4	2	72,11
Standard Dev.	123	1,63	19,8	2,40	6,9	0,3	2	1	1	15,12

Preference parameters

Scenario: Scenario1 (active)

Active	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Density	**Hardness**	**Rupture**	**Elasticity**	**Strength**	**Shrinkage**	**Durability**	**Workability**	**Resistance**	**Pricing**
Min/Max	max	max	max	max	max	min	max	max	max	max
Weight	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Preference Fn.	Linear	Linear	Linear	Linear	Linear	Linear	Usual	Usual	Usual	Linear
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
Q: Indifference	159	1,42	23,7	2,61	11,4	0,2	n/a	n/a	n/a	12,35
P: Preference	355	3,95	60,9	7,02	27,2	0,6	n/a	n/a	n/a	32,82
S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 1: Criteria of the study, scale, and unit

A/A	**Criterion**	**Scale**	**Unit**
1	Specific gravity	numerical	Kg/m^3
2	Janka hardness	numerical	Newton
3	Modulus of rupture	numerical	MPa
4	Modulus of elasticity	numerical	GPa
5	Crushing strength	numerical	MPa
6	Shrinkage ratio (tangential/radial)	numerical	TR ratio
7	Natural durability	qualitative	5-point Likert scale
8	Resistance to fungi, bacteria, and insect attack	qualitative	5-point Likert scale
9	Workability	qualitative	5-point Likert scale
10	Pricing	currency	Euro (€)

Wood is a natural polymer consisting of cellulose, hemicellulose, and lignin. The above polymers create a net supporting the material and providing resistance to fungi, bacteria, or insect attacks. Some species contain large amounts of extractives, concentrated mainly in heartwood, and have a natural durability to decay and ageing. Each species shows a different degree of durability based on the proportion of cellulose, hemicellulose and lignin and the percentage of extractives. Furthermore, the percentage of the extractives is connected with the dimensional stability of wood (Scheffer and Morrell, 1998; Tsoumis, 1991; Grigoriou, 1992; Filippou, 2014; Kakavas et al., 2018b). Resistance and durability are two criteria to be maximized.

Mechanical properties, such as modulus of rupture and elasticity, hardness, and resistance to breakage, define wood's behavior and final uses since they are related to more stable constructions. Wood is an anisotropic material; therefore, it performs differently in three directions: axial, radial and tangential. The orientation of the material defines the strength of the final use. These properties are also affected by the shrinkage and swelling of wood since wood is a hygroscopic material that tends to absorb water and change its dimensions anisotropically (Tsoumis, 1991; Kretschmann, 2010). The properties mentioned above are criteria that need to be maximized.

Wood shrinkage, reduction, swelling, and increased dimensions due to water loss and absorption are important properties that affect its utilization. Dimensional variation may cause severe defects in wood constructions, such as warping, change of shape, opening and tightening of joints, or even collapse. An important factor affecting this property is the presence of extractives, which reduces the percentages of water loss or absorption (Tsoumis, 1991; Kakavas et al., 2018b). Thus, this criterion needs to be minimized.

Wood's processing properties and workability define the time and effort required for the construction configuration. Furthermore, wood behavior while being processed with machines (for example, drilling, cutting, planning, etc) is connected with wood density, anatomical structure, chemical composition, and quality. The resistance during the process can cause blunting of tools in different degrees, depending on the wood species. As a result, workability is a criterion that needs to be maximized. (Kakaras 2008; Voulgaridis, 2015).

Finally, pricing is a factor that defines wood's value in the market. According to the pricing table of forest products (2023), the goal is to produce high-value timber. So, pricing is a criterion that needs to be maximized.

3. Results and Discussion

According to the PROMETHEE II complete ranking, walnut (*Juglans regia*) was the tree species with the best performance under the examined criteria (Net Flow, Phi = 0,2028), followed by chestnut (*Castanea sativa*, Net Flow, Phi = 0,1562). An acceptable alternative was also oak (*Quercus petraea*, Net Flow, Phi = 0,0434), while beech (*Fagus sylvatica*) and poplar (*Populus nigra*) were not acceptable alternatives since they had negative net flows. Specifically, poplar showed the worst performance among all alternatives, having the lowest score (Net Flow, Phi = - 0,3785). Acceptable solutions are presented in Figure 1 on the green bar (Phi > 0), while non-acceptable solutions are shown on the red bar (Phi < 0).

The results showed that walnut was the most suitable tree species, having the highest ranking (highest net flow) among the alternatives under the specific criteria. Conversely, poplar achieved the worst performance (lowest net flow) among the examined tree species. Beech achieved the third highest score in Phi+, higher than oak, but on the other hand scored the second highest score in Phi-, having as a result that its net flow was negative, although very close to zero (-0,0239). Figure 3 shows the PROMETHEE Flow Table displaying the Phi, Phi+ and Phi- scores, while the alternatives are ranked according to the PROMETHEE II complete ranking.

Figure 2. Optimal solution (Source: Produced by Visual PROMETHEE)

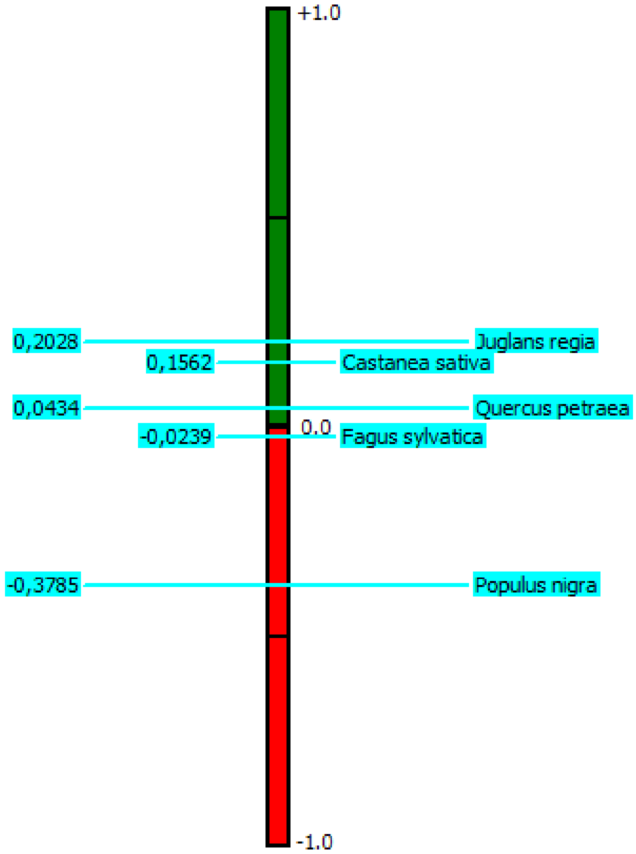

Figure 3: PROMETHEE Flow Table

PROMETHEE Flow Table

Rank	action	Phi	Phi+	Phi-
1	Juglans regia	0,2028	0,3329	0,1300
2	Castanea sativa	0,1562	0,2666	0,1104
3	Quercus petraea	0,0434	0,2294	0,1861
4	Fagus sylvatica	-0,0239	0,2480	0,2720
5	Populus nigra	-0,3785	0,0750	0,4535

(Source: Produced by Visual PROMETHEE)

Figure 4 shows the Unicriterion preference flows, the scoring for every alternative in each criterion. We observe that poplar (*Populus nigra*) achieved the worst score in seven criteria and negative net flow in nine criteria, a performance that fully justifies its selection as the worst alternative among the examined broadleaved species. On the other hand, walnut (*Juglans regia*) achieved the best performance in four criteria (rupture, shrinkage, durability, and pricing). Moreover, it had positive net flow in nine criteria, justifying its selection as the best alternative among the examined hardwood. Beech scored best in five criteria (density, hardness, elasticity, strength, and workability). However, it also had the worst score in two criteria and a negative net flow in four criteria, resulting in poor overall performance. Beech's unicriterion preference flows could be a matter of concern for the design of future studies, especially regarding the weight of the criteria.

Figure 4. Unicriterion preference flows

Φ Preference Flows

	Density	Hardness	Rupture	Elasticity	Strength	Shrinkage	Durability	Workability	Resistance	Pricing
Castanea sativa	-0,0204	-0,3557	-0,2245	-0,1752	-0,0285	0,6250	0,7500	0,7500	0,0000	0,2415
Fagus sylvatica	0,2321	0,4565	0,2534	0,5454	0,1804	-0,3125	-1,0000	0,7500	-1,0000	-0,3447
Populus nigra	-0,5536	-0,5978	-0,3797	-0,3430	-0,1962	-0,5625	-0,5000	-0,2500	0,0000	-0,4021
Juglans regia	0,1224	0,2925	0,2722	0,0057	0,0443	0,7500	0,0000	-0,2500	0,0000	0,7914
Quercus petraea	0,2194	0,2045	0,0786	-0,0329	0,0000	-0,5000	0,7500	-1,0000	1,0000	-0,2862

(Source: Produced by Visual PROMETHEE)

4. Conclusions

The present paper examined the suitability of five of the most common species of broadleaved trees used in the Greek timber industry, and according to the findings, walnut was the optimal alternative that outranked the other examined species. Chestnut and oak also achieved positive scores, and therefore, they are also acceptable alternatives as broadleaved species suitable for furniture manufacturing and sawn timber production. On the other hand, beech had an overall poor performance, and at the same time, poplar achieved the lowest score in the selected criteria among the alternatives; therefore, beech and poplar are considered as non-acceptable hardwood for wood processing forestry enterprises in Greece.

It is evident that the right choice of tree species in primary and secondary wood processing forestry enterprises, based on specific criteria, is a typical Multiple Criteria Decision Analysis problem. The PROMETHEE II method provided a complete ranking of the examined alternatives, and the findings could have essential economic benefits for the timber industry in Greece.

A limitation of the present study is that only five of the most common species of broadleaved trees used in the Greek timber industry were examined. In future research, more tree species, including coniferous species and tropical species, could be assessed for their suitability to be processed by the Greek timber industry. Moreover, the research could include more criteria such as axial compression, radial and tangential swelling, proportion of juvenile wood, defects presence etc, more scenarios with different weights of the selected criteria, including a sensitivity analysis.

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Modeling counter pollution policies: Defensive or aggressive? which one is more effective

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Abstract
This work examines how much the counter pollution policies affect the volume of the pollutants in a country and tries to give answers to the question of which one is the more effective. The research takes place using an optimal control model, where the state variable is the volume of the pollutants and the control variables are two types of counter–pollution actions, the one is that which encourages the entrance of new polluting firms, therefore incrementing the volume, (defensive) and the other that doesn't increment the volume of pollutants (aggressive). The proposed model is nonlinear and doesn't find analytical solutions, but the sensitivity analysis takes place with the use of numerical implementation of Pontryagin's maximum principle. In general, the proposed model admits two steady states (two different volumes of pollutants), one in which the volume of pollutants vanishes and the second in which there is a high volume of pollutants in a country. Whereas the defensive strategy is used at any time, it is not optimal not to use aggressive strategies if the volume of pollutants is below a certain limit.

Keywords: *Optimal dynamic control; Counter-pollution; Pollution modeling*

1. Introduction

This paper deals dynamically with the question of how pollution concentration is influenced by counter-pollution policies. One concern expressed about aggressive counter-pollution is that might turn firms' opinions against counter-pollution actions, with the sense that the latter considers that it is worth undertaking the risk of engaging in pollution activities, provided they don't catch. It does not seem credible that the best counter-pollution policy is to do nothing proactive. On the other hand, it also does not seem prudent to ignore entirely the possibility that offensive counter-pollution operations might be a doubled-edged, stocking new pollutants even as some volume is removed from the current stock. Presumably, there may be some optimal intensity of counter-pollution efforts that balance their obvious benefits with potential negative effects on stocking volume and/or some optimal mix of tactics that are more or less prone to deposit new pollutants.

There is a wide range of counter-pollution tactics that might be arrayed along a continuum in terms of their likelihood of deposition, but the model abstracts these into two discrete categories.

"Aggressive" strategies result in the potential deposition of pollutants to the existing stock, therefore are enough to make it easier for candidate polluters to enter provided that they are still non-arrested. These tactics might include the imposition of taxes, firms' locking and even imprisoned of the entrepreneur, or other tactics that involve significant collateral damage or inconvenience to innocent third parties.

"Defensive" strategies facilitate potential entrants to the pollution landscape enough to make the pollutants problem more difficult to manage. The defensive strategies might include the reduction in the degree or intensity of pollution in soil, rivers, lakes, seas, atmosphere, and so on. Pollution abatement refers to technology applied or measures are taken to reduce pollution and/or its impacts on the environment. The most commonly used technologies are scrubbers, noise mufflers, filters, incinerators, waste—water treatment facilities, and composting of wastes.

The rest of the paper is organized as follows. Section 2 describes the model formulation, section 3 and its subsections deal with the equilibrium and stability of the main model and its variations of it, and section 4 concludes.

2. Model formulation

We denote the above available control strategies, employed by the regulator, by $u(t)$ for the defensive and by $v(t)$ for the aggressive. Hereafter we'll denote the control strategies omitting the time variable t.

The regulator is concerned with the state variable x(t) of the model which is the volume of pollutants concentration. For this purpose, we normalize the volume of pollutants with the number of polluting firms in a country, making the simplified, but rather a rational assumption that every polluting firm deposits one volume unit of pollutants, i.e. everyone polluting firm corresponds to one unit of pollutants. This assumption is made for the ease of exposition of the model and especially in order to connect the volume of pollutants with population models, which are easier for conclusions extraction due to existing functional specifications of the population models. Therefore the volume of pollutants stock evolves over time depending on various inflows and outflows occurring during that time. To form the equation of motion of the stock of pollutants accumulation, we begin with an initiation term δ, which is a rather small constant quantity and represents the initial volume of pollutants at the setup of the model. We take the initial value term δ as a relatively small volume compared with the new volumes of pollutants that could be added during the time. Concerning the growth of the stock of pollutants, we adopt the perspective of the diffusion modeling at which the augment onto the stock occurs according to the word of mouth rule, i.e., the more polluting firms act in a market the more new polluting firms will enter, therefore the more pollutants would be added onto the existing stock. The growth of the polluting firms, therefore the growth of the pollution stock, is not unbounded (the stock is not grown exponentially) due to specific factors that reduce the evolution of the pollutants stock. The main premise of the paper is that the taxation and fine imposition operations, which are aggressive policies, make a higher equity risk premium as it is known (Leibowitz M.2003), a fact that is a serious incentive for more firms to engage in polluting activities. As consequence, the growth of the pollutants can be a function of the control variable which represents the aggressive strategy, i.e. the growth function could be noted as $G(x,v)$. For the growth function $G(x,v)$ it is assumed that is increasing with respect to the stock of pollutants with diminishing returns and increasing to the aggressive control variable as well, i.e. $G_x > 0, G_{xx} < 0, G_v > 0$. Moreover, the aggressive policy is not necessarily an obstacle for the firms to pollute, i.e. without any policy measures there exists a reasonable stock of pollutants, a fact represented by the expression $G(x,0) > 0$.

Concerning the factors that decelerate the growth of pollutants evolution, we distinguish three factors that act to lessen the pollutant augmentation. One reducing factor could be the polluters' abandonment of the market due to the burden stemming from taxation measures and fine imposition operations, hence the more the polluting firms abandon the market the more the pollutants stock decrease. Therefore the first decrement is a function of the stock of pollutants, i.e. $F_1(x)$, with $F_1(x) > 0$. Another term that reduces the growth of the concentration of the pollutants is related to the defensive policy i.e. $F_2(x,u)$ and the third is related to the aggressive policy, thus $F_3(x,v)$.

In what follows we formulate the objective functional of the regulator over the infinite planning horizon and it consists of his costs stemming from the stock of pollutants as well as from the aggressive and defensive activities as well. The cost functional needs to be minimized, i.e. the optimal control model under consideration seems to be the following:

$$min_{u,v>0} \int_0^\infty e^{-rt} \left(C_1(x) + C_2(u,v)\right) dx$$

subject to $\quad \frac{dx}{dt} = \dot{x} = \delta + G(x,v) - F_1(x) - F_2(x,u) - F_3(x,v) \quad$ **(1)**

and $\quad x(0) = x_0$

In the next we will try to give specific forms to the cost functions as well as the functions involved in the differential equation which describes the evolution of the stock of pollutants as well, taking into account that there is no data that would probably support specific functional forms. Therefore, we choose simple functional forms focusing, at the same time, on the qualitative behavior of solutions, and not finding the analytical expressions of the model's solutions.

Considering the cost function stemming from the pollution stock we assume that is linear to its argument, i.e. $C_1(x) = cx$. The linearity of the cost function ensures an easy analysis, but the most important is that, in the model's analysis that follows, the linear form doesn't influence the threshold results obtained (which results are rather stemming from system dynamics). For the policy control costs now, one could assume that these costs have an adverse interaction, i.e. $C_{uv} > 0$. The latter assumption means that using a defensive policy could make it more expensive to use an aggressive strategy. In order to avoid these interactions among costs it is convenient to model the cost function, which stems from the policies under consideration, in separable form, i.e. $C(u,v) = C_2(u) + C_3(v)$. Exactly the above policy costs are presumed to be convex and with diminishing returns, therefore an appropriate functional form is the quadratic, i.e. $C_2(u) = u^2$ and $C_3(v) = v^2$.

Considering now the augmenting function $G(x, v)$ we follow the modeling of growth for drug and crime models. Adapting the latter growth in our model the assumption is that the new entries in the landscape of pollution are encouraged by the existing polluting firms. According to that approach (Grass et al, 2008) the growth rate ought to be increasing approximately in proportion to the current number of polluting firms, say kx with $k > 0$. The growth couldn't be exponential or unbounded, but should slow down because of limits on the number of potential entries, limits on the capacity of the set of polluting firms to absorb new members. The degree of slowing down is modeled by the parameter $\alpha \leq 1$. Moreover, the aggressive use of counter pollution measures $v(t)$ increases the new entries. Putting all together and remembering the initial one to one normalization, i.e. every polluting firm deposits one unit of pollutants, the augmenting function could be in the following form

$$G(x, v) = (1 + \rho v)kx^{a}$$

The first of the three types of outflows represent withdrawals from the pollution situation, therefore could be in a linear to the stock form, i.e. $F_1(x) = \zeta x,\ \zeta > 0$. The second and the third terms that reduce the augment of the volume of pollutants are related to the two types of policies the regulator exerts. The more aggressive the counter-pollution effort the more pollutants are removed. The above factors are modeled as products of a function of the control policies u, v multiplied by a function of the pollution stock x, i.e. for the defensive policy $F_2(x, u) = f_1(x)\beta(x)$ and $F_3(x, v) = f_2(x)\gamma(v)$ for the aggressive control policy. We have serious predictions for the existence of diminishing returns if more specialized skills are needed, and so there is a limited number of units that conduct defensive policies. In our model, the concavity is modeled by a power function $f_1(x) = x^{\theta}, \theta \leq 1$. The factor $f_2(x)$ which defines the decrement due to aggressive policy is modeled as being linear in the stock of pollutants parameter because the methods are perceived to be "shotgun" or "undirected" methods and hence $f_2(x) = x$. The more pollutants are deposited the more aggressive measures, e.g. the more taxes will be levied.

Now it remains to give specific concave functional forms to the expressions $\beta(u)$ and $\gamma(v)$. We choose the logarithmic functional concave form, so any differences in the resulting policies (defensive or aggressive) should stem from the differences in character, but not from the selected functional forms. Both functions include a leading constant, representing the efficiency of the policies. Since defensive-type policies are more expensive in the sense that for any given level of spending $z, \beta(z) < \gamma(z)$ the constant for defensive-type interventions $\beta > 0$ is smaller than the constant $\gamma > 0$ used by aggressive policies.

After all, the analytic forms are: $\beta(x) = \beta ln(1 + u)x^{\theta}$ and $\gamma(x) = \gamma ln(1 + v)x$.

Putting all together the optimal control problem (1) makes the following form

$$min_{u,v>0} \int_0^{\infty} e^{-rt}\,(cx + u^2 + v^2)dt$$

subject to $\quad \frac{dx}{dt} = \dot{x} = \delta + (1 + \rho v)kx^{a} - \zeta x - \beta ln(1 + u)x^{\theta} - \gamma ln(1 + v)x \quad$ **(2)**

and $\quad x(0) = x_0$

with the new variables $\zeta, \beta, \gamma > 0, \beta < \gamma$ and $0 < \theta < 1$

3. Equilibrium of the model

3.1. Reduced form model

For convenience, we make the following normalization to the volume of the pollutants to be equal to one. That is, the normalization is such that in the absence of the initial volume of pollutants $\delta = 0$ and no counter pollution measures $(u = 0, v = 0)$ the long-run size of the volume of pollutants equals one, therefore

$$\dot{x} = kx^{a} - \zeta\chi$$

which yields $k = \zeta$ at $x = 1$

We formulate the model presented so far bearing in mind the optimal control framework. Therefore, the two policies aggressive and defensive are assumed to be dependent on time, i.e., $u(t), v(t)$, but allow a situational reaction in the form of anti—pollution measures that depends on the current stock of pollutants. After all, the controls $u(t), v(t)$ should be feedbacks of the state variable, i.e. in the form $u(x,t),\ v(x,t)$. In order to obtain a first insight as a preliminary step about the model's complexity, at the early stage we may consider the model where the controls are held fixed, i.e. $u(.) \equiv u,\ v(.) \equiv v$. The determination of the dynamical behavior and the computation of the equilibrium of the system could be done by reformulating the differential equation of motion of the pollutants accumulation and setting certain values for the parameters a, θ. With parameter values $= 1, \theta = 1/2$, together with the assumption $k = \zeta$ the equation of motion becomes

$$\frac{dx}{dt} = \dot{x} = \delta + \zeta\rho v x - \beta ln(1+u)x^{1/2} - \gamma ln(1+v)x \qquad \mathbf{(3)}$$

We can find the equilibrium of equation (3) by solving the following equation

$$\big(\zeta\rho v - \gamma ln(1+v)\big)x - \beta ln(1+u)\sqrt{x} + \delta = 0\ \mathbf{(4)}$$

3.1.1. Equilibrium solutions for the reduced model

In order to solve $(\mathbf{4})$ and to find the analytical forms of the stock of pollutants, we separate the following two cases.

Case 1:

$$\zeta\rho v - \gamma ln(1+v) \neq 0$$

Equation (4) is quadratic in $\sqrt{x}$ with the two solutions

$$\sqrt{x_{1,2}} = \frac{\beta ln(1+u) \pm \sqrt{\beta^{2} ln^{2}(1+u) - 4\delta\big(\zeta\rho v - \gamma ln(1+v)\big)}}{2\big(\zeta\rho v - \gamma ln(1+v)\big)}$$

$$\sqrt{x_{1,2}} = \frac{\beta ln(1+u)}{2(\zeta\rho v - \gamma ln(1+v))}\big(1 \pm \sqrt{1-\Xi}\big) \qquad \mathbf{(5)}$$

with $\quad \Xi = \frac{4\delta(\zeta\rho v - \gamma ln(1+v))}{\beta^{2} ln^{2}(1+u)}$

Case 2:

$$\zeta\rho v - \gamma ln(1+v) = 0$$

The equilibrium is given by the solution

$$x_1 = \left(\frac{\delta}{\beta\big(1 + ln(1+u)\big)}\right)^2$$

3.1.2. *Stability of equilibrium of the reduced model*

In order to determine the stability of equilibrium we consider the Jacobian matrix, which is

$$J(x) = \frac{d\dot{x}}{dx} = \zeta\rho v - \gamma ln(1+v) - \frac{\beta ln(1+u)}{2\sqrt{x}}$$

And applying into the two above cases we have

$$J(x) = \begin{cases} \frac{-\beta^2 ln^2(1+u)}{2\delta} & \zeta\rho v - \gamma ln(1+v) = 0 \\ \left(\zeta\rho v - \gamma ln(1+v)\frac{\pm\sqrt{1-\Xi}}{1\pm\sqrt{1-\Xi}}\right) & \zeta\rho v - \gamma ln(1+v) \neq 0 \end{cases} \quad \textbf{(6)}$$

The careful inspection of the Jacobian (6) is recorded as in the following proposition 1.

Proposition 1
The stability of equilibrium for the reduced model is given by the following values

Values of Ξ	x_1	x_2
$\Xi \leq 0$	Asymptotically stable	Undetermined
$0 < \Xi < 1$	Repelling	Asymptotically stable
$\Xi = 1$	Semistable	Semistable
$\Xi > 1$	Undetermined	Undetermined

Remarks on proposition 1
For the values of the quantity $\Xi \in (0,1)$ for which both equilibrium exists $x_1 > x_2$, whereas for $\Xi = 1$ both equilibrium values constitute a semistable equilibrium.
The stability and existence results will also hold true for parameter values α and θ near 1 and $1/2$.
The solution is depicted in figure 1 for parameter values given in the table 1.

Table 1. Parameter values specified for numerical calculation of the ODE (3)

β	ζ	γ	ρ	δ	u	v
1.00	3.00	1.00	0.10	0.12	1.00	10.00

Figure 1.a: Phase portrait of equation (3)

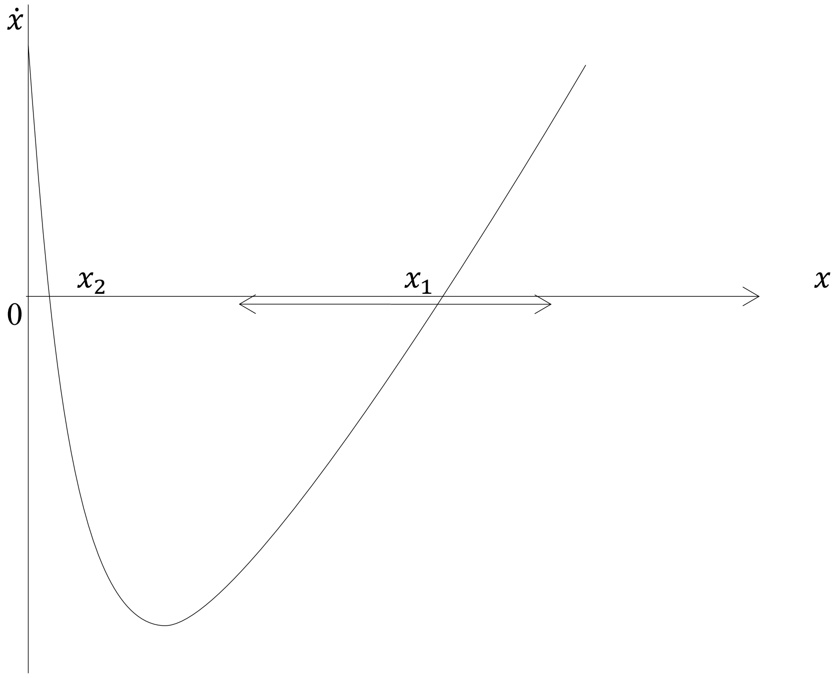
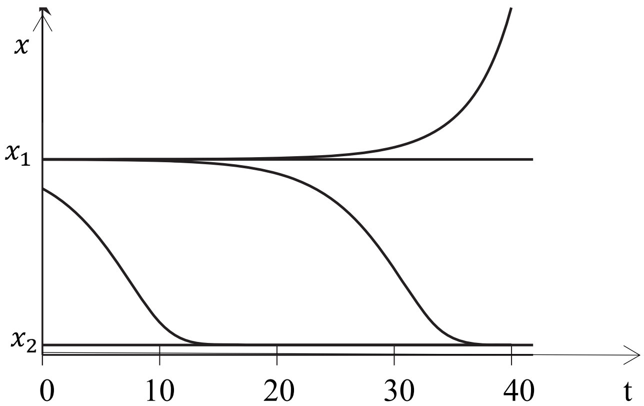


Figure 1.b: Some solutions trajectories of the equation (**3**)



3.2. The aggressive policy version of the model

In order to include some specific cases of the model we relax many assumptions made in the original version. First of all, we omit the control named defensive strategy in the simplified version, and second by making the outflow related to that control linear with respect to the control variable, instead of concave. Moreover, we modify the objective functional making it linear to the stock and control. After all the optimal control problem is the following.

$$max_{v(.)>0} \int_0^\infty e^{-rt} (-cx(t) - v(t))dt$$

subject to $\frac{dx(t)}{dt} = \dot{x}(t) = \delta + \big(k + \varepsilon v(t)\big)x(t)^{a} - \zeta x(t) - \eta v(t)x(t)$ $\quad(\boldsymbol{P.1})$
with $k, \varepsilon, a, \zeta, \eta > 0$ and $k > \zeta$.

We also include explicit bounds concerning the control, therefore the aggressive policy is constrained in a closed interval, i.e. $v(.) \in [0, \overline{v}]$.

Further simplification reveals the special case at which $\alpha = 1, \delta = 0$, and the equation of motion collapses into the following

$$\frac{dx}{dt} = \dot{x} = gx + \theta v x$$

Where $g = k - \zeta > 0$ and $\theta = \varepsilon - \eta$. It is worth noting that for $\theta \geq 0$, the existing aggressive policy has no effective action because not only it costs money but at the same time increases the volume of pollutants, due to its positive sign. Therefore it is reasonable to choose $\theta < 0$ together with $g + \theta\overline{v} < 0$, where $\overline{v}$ is the upper bound of the aggressive policy v.
We consider the following functions

$$M(x) = -cx + \frac{g}{\theta}$$
$$N(x) = -\frac{1}{x\theta}$$
$$I(x) = -\frac{r}{x\theta} - c$$
$$\Omega(x) = gx + \theta v x$$

It can be shown that the following result holds true.

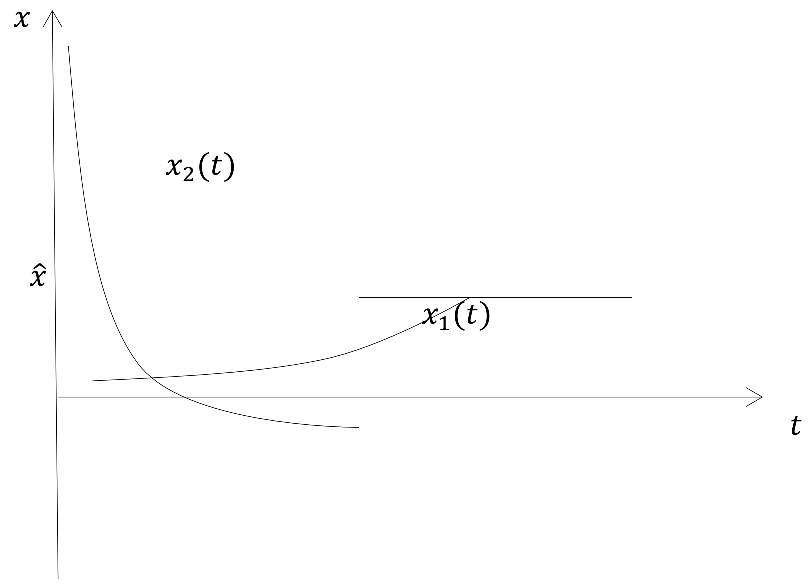
Proposition 2
For the aggressive policy model, the optimal solution is the Most Rapid Approach Path (MRAP) to the singular value of the pollutants stock given by: $\hat{x} = -\frac{r}{c\theta}$

Proof
Upon request

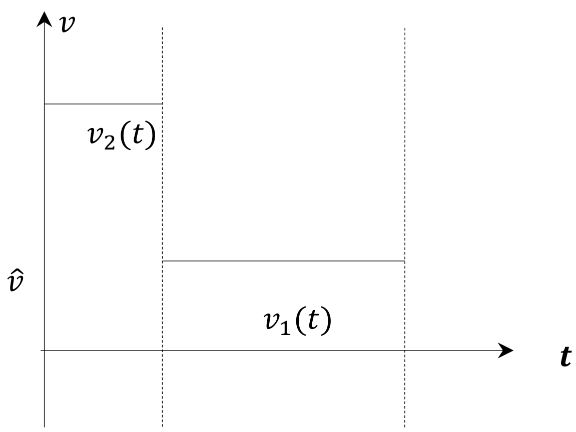
Remark 1.
For $x(0) < \hat{x}$, the optimal aggressive strategy v is "do nothing", i.e. $v = 0$ until the stock of pollutants reaches the value $\hat{x}$, then the optimal policy should switch to the control $v^{*} = -\frac{g}{\theta}$. Conversely, if $x(0) > \hat{x}$ the regulator applies full aggressive control $v^{*} = \overline{v}$ and switches at $x = \hat{x}$ to the aggressive policy $v^{*} = -\frac{g}{\theta}$
The following figure depicts the two MRAP solutions $x_1(t), x_2(t)$ of the slack form model for which the initial stock of pollutants lies either beneath or above the current stock $\hat{x}$. Panel (b) shows the corresponding aggressive policies $v_1(t), v_2(t)$.

Figure 1

(a)



(b)



Remark 2

The long run value of the pollutants $\hat{x} = -\frac{r}{c\theta}$ in Proposition 2, in terms of the parameters c, θ has the following interpretation. An increase/decrease in the costs for every unit of pollutants or an increase/decrease in the efficiency of the counter pollution measures leads to a decrease/increase in the long-run volume of the pollutants. Concerning the discount factor r, Proposition 2 says that a myopic regulator is more willing to tolerate the long-run augmentation of the volume of pollutants than a farsighted regulator.

3.3. *The improved original model*

3.3.1. *Optimality conditions*

In order to solve the optimal control model we apply Pontryagin's maximum principle. Thus, the current value Hamiltonian is

$H = \lambda_0(cx + u^2 + v^2) + \lambda\big(\delta + (1+\rho v)kx^a - \zeta x - \beta ln(1+u)x^\theta - \gamma ln(1+v)x\big)$ **(7)**

$\lambda_0 \in R$ and λ the costate variable in current values.

First, we consider the degenerate case $\lambda_0 = 0$ in order to exclude. Therefore, we assume $\lambda_0 = 0$ to derive a contradiction. First order condition for the Hamiltonian **(7)** is

$H_u = -\frac{\beta x^\theta}{1+\theta} < 0$ and the Hamiltonian is minimized only for $u = \infty$, which contradicts optimality. Therefore, hereafter we consider only the case $\lambda_0 = 1$, i.e. $\lambda_0 > 0$ normalized to one.

Continuing we derive the necessary condition $u^* = \arg\min_{u\geq 0} H$, by setting

$H_u = 2u - \frac{\lambda\beta x^\theta}{1+\theta} = 0$ which yields

$$u^* = \frac{1}{2}\left(\sqrt{1+2\lambda\beta x^\theta} - 1\right) \quad \textbf{(8)}$$

While for the other policy, we have to solve $H_v = 2v + \lambda\left(\rho\kappa x^a - \frac{\gamma x}{1+v}\right) = 0$ which in turn yields the optimal control

$$v^* = \frac{1}{2}\left(-\rho k x^2 - 2\sqrt{(\rho\lambda k x^2 - 2)^2 + 8\lambda\gamma\beta x}\right) \quad \textbf{(9)}$$

And the derivative of the Hamiltonian w.r.t. the state variable equals to

$$H_x = c + \lambda\left(k(1+\rho v^*)ax^{a-1} - \zeta - \beta ln(1+u^*)\theta x^{\theta-1} - gln(1+v^*)\right) \quad \textbf{(10)}$$

And the canonical system is written as:

$$\dot{x} = \delta + (1+\rho v^*)kx^a - \zeta x - \beta ln(1+u^*)x^\theta - \gamma ln(1+v^*)x \quad \textbf{(11)}$$

$$\dot{\lambda} = \lambda\left(r - k(1+\rho v^*)ax^{a-1} + \zeta + \beta ln(1+u^*)\theta x^{\theta-1} + \gamma ln(1+v^*)\right) - c \quad \textbf{(12)}$$

u^* and v^* are given by **(8)** and **(9)**.

The variable λ the so–called costate is the shadow price of the state variable denoted by x . This shadow price measures the increase in the objective (cost) functional stemming from a very small increase in the volume of pollutants x. Therefore, the shadow price is a very important variable in an optimal control model. From the economic perspective, only the positive long–run values of the shadow price have a meaning (this is because of the minimization of the total costs), i.e., the condition $\lim_{t\to\infty}\lambda(t) > 0$ has to hold. After all the positivity of the state and costate variables can be derived from **(11)** and **(12)**. Equation **(11)** for $x = 0$ yields $\dot{x} = \delta$, therefore the stock of pollutants x remains positive for every initial value $x_0 > 0$. The same occurs for the shadow price of the stock of pollutants. As one can see, from equation **(12)** $\dot{\lambda} = -c$ if $\lambda = 0$. Yet, if there exists a time instant t_0 at which $\lambda(t_0) \leq 0$, then $\lambda(t)$ would be negative from this time instant t_0 and then. But, as we stated $\lim_{t\to\infty}\lambda(t) > 0$, i.e. only the positive long run values of the shadow price $\lambda(t)$ have an economic meaning, there is no exists such a time instant t_0, consequently the shadow price $\lambda(t)$ of the stock of pollutants is positive at every time instant.

The above discussion follows into the next results, which are rather corollaries of the correctness of the model's assumptions and setup.

Proposition 3.
In the original model of pollutants accumulation, the optimal defensive policy, on behalf of the regulator, has always a positive value, i.e. $u^* > 0$.
Proof
Considering the optimal value for the defensive policy: $u^* = \frac{1}{2}\left(\sqrt{1+2\lambda\beta x^\theta} - 1\right)$ the quantity under the root, $1+2\lambda\beta x^\theta$, has always a value greater than 1 ($1+2\lambda\beta x^\theta > 1$), stemming from the positivity of the values of the state and costate variables x and λ, therefore always will be $u^* > 0$.

Proposition 4
In the model under consideration, it is profitable to invest in every control policy which stamps out more pollutants than those accumulated over expected, due to the increasing pollution, regardless of the intervention's costs, so long as costs are positive.
Proof
It is obvious that, since the shadow price of the stock of pollutants is always positive, $\lambda(t) > 0$, then an increase in the stock of pollutants due to the overloading of pollutants is a bad policy and no one regulator would invest in that policy.

4. Conclusions

In this paper, we consider two wide categories of counter-pollution policies, i.e. the aggressive and the defensive. For the comparison purposes of the policies we set up a very simple optimal control model and we solve it in a variety of its aspects.

First of all, we present the generalized model with the two above policies and we raise the constraints under which the cost minimization process takes place. Next, we reformulate the differential equation of pollutants concentration of the main model, making the control policies feedback of the state variable, which is the stock of pollutants. We found the exact expression of the equilibrium solution for the stock of pollutants. As the next step, we consider the stability properties of the equilibrium solution of the stock inspecting the Jacobian matrix of the solutions and we record the findings of the stability investigation as proposition 1. Two figures in the next depict the phase portrait and the trajectories of the equilibrium solutions.

Next, we remove the defensive policy of the model and for the resulting aggressive policy model we found the Most Rapid Approach Path optimal value of the stock of pollutants and this finding is recorded as proposition 2. The two figures that follow depict the two MRAP solutions $x_1(t), x_2(t)$ of the optimal value of the stock of pollutants for the aggressive policy model as well as the corresponding policies $v_1(t), v_2(t)$.

In the last step, we examine the optimality conditions of the original model and we record as proposition 3 the result which says that the optimal defensive policy has always a positive value. Examining the shadow price of the state variable we extract the conclusion that, "an increase in the stock of pollutants due to the overloading is a bad policy", therefore no one regulator would invest in that bad policy..

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Session 13

Sustainable Tourism
– Circular Economy II

Exploring the role of tourism in environmental degradation

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Abstract
The tourism industry always seeks ways to expand its potential and market share in terms of economic gains. In this course, many environmental problems occur, which should be investigated to advance viable solutions in the long term. To this effort, the present study explores the role of the total contribution of tourism to the Gross Domestic Product (GDP) in the context of the Environmental Kuznets Curve hypothesis (EKC). To conceptualize environmental degradation, we use carbon dioxide emissions and energy-related methane emissions. We also use renewable energy sources and internal travel and tourism consumption as explanatory variables. We put into the process panel data analysis between 1996 and 2019 for the Eurozone countries. We apply the Driscoll-Kraay standard errors with fixed effects regression. Results indicate that the EKC is confirmed concerning tourism's contribution to GDP, whereas renewables limit air pollution. Internal travel and tourism consumption has a negative impact on energy-related methane emissions. Additionally, Granger non-causality tests show that feedback hypotheses are present for all tested variables with the exception of tourism's contribution to GDP that evidence the growth hypothesis. Practical implications stress the importance of advancing the concept of sustainable tourism and becoming more responsible when spending for tourism purposes.

Keywords: Environmental Kuznets Curve, tourism, economic growth, energy, air pollution.

JEL Codes : Q56; Z32; N1; Q42; Q5

Tourism Local Development and Destination Management – The sustainability of small and medium-sized tourism enterprises and the environment in which they are based

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Abstract

Until recently, natural resources were considered to be inexhaustible in the tourism industry, automatically renewable and offered for free exploitation aiming at economic growth. Nowadays, with catastrophic fires, floods and climatic change, the notion of sustainability of a place is essential. Businesses based on tourism destinations, like big hotels (the most important members of the worldwide tourism chain value) have burdening effects on the environment. Thus, international hotel chains are committed to implement sustainability policies nowadays by incorporating them in their strategic plan and by implementing environmental practices like energy efficiency measures that reduce water consumption, waste and carbon emissions, in order to protect and preserve the flora and fauna and promote the value of unique nature. But what happens with the small and medium-sized enterprises? We investigate the way the employees of those enterprises behave in order to promote the sustainability of the environment they are based on. The conclusions of the research showed that the regional administrations of tourism destinations and local development should educate workers about the environment. That would be a very valuable tool for achieving a positive impact both to the businesses and the environment. Therefore, sustainable goals would come into effect if they are based on professional morale and functional practices.

Keywords: tourism destinations, small and medium tourism enterprises, sustainability, environmental education, tourism destination management

JEL Codes: Q56, Z32, I26, Q00, Z39

Local Tourism Development and Destination-The buying behavior of the consumer-tourist based on the organizational culture for the environmental footprint of the enterprise

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Abstract

Sustainable development meets the needs of the present without compromising the ability of the future generations to meet their own needs. The first wave of the most popular "green" thinking in the developed countries goes back to the 1960's, when a minority of citizens became interested in the state and degree of use of the natural environment at a local, national and global level. Nowadays, the citizens' awareness about this issue is increasing year after year, especially with regard to the practices and the organizational culture of tourist units about the protection and preservation of the natural environment in which they operate. The choices of many tourism business customers today are based on the profile of the area, its natural features, the activities offered and the nature protection programs implemented in the area. Therefore, we investigated the extent that the potential customers-tourists make their choices based on the environmental footprint of the business. The results about the consumers' behavior are important for the local tourism development and the tourism destination management agencies. That happens because a greater percentage of consumers, compared to previous surveys, refuse to buy the offered tourism product, if the business does not display environmental awareness.

Keywords: Sustainable development, consumer behavior, tourism businesses, tourism development management, environmental footprint

JEL Codes: Q01, P46, Z32, R11

Developing and implementing Corporate Social Responsibility and Circular Economy strategies in the Hotel Industry.

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Abstract
Corporate social responsibility (CSR) and Circular Economy (CE) is a policy priority both at national and EU level. Furthermore, these have been promoted by both policy makers and consultants on the basis of a number of benefits that are associating their integration. The aim of this research is to assess the challenges and opportunities for implementing CSR and CE in the hotel industry. A case study focusing on Mediterranean SPA hotel in Katerini is being disucssed. Furthermore, the development and implementation of a certified management system on CE is discussed and the challenges and opportunities from its adoption in the hotel are also highlighted. It appears that very significant benefits can be gained from the implementation of CSR and CE strategies. Furthermore, the certified management system provides a structured and an effective approach to implement CSR and CE strategies.

Keywords: Corporate Social Responsibility, Circular Economy, Certified Management System, Hotel industry

JEL Codes: Q52; Q53, Q56

A Methodological Framework and Typology to classify the regulatory- or proactive-driven corporate environmental and social behavior

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Abstract

Different economic and social actors ask firms to protect natural environment and minimize their negative impacts on societies. In turn, firms have responded to these pressures, incorporating environmental and social management practices. So far, the literature has examined proactive and regulatory-driven motives behind firms' decisions to adopt environmental management practices with various typologies being suggested that intuitively classify firms into categories such as reactive, proactive, and first mover. Although the intuitive nature of such classifications has a great merit, these typologies have also drawbacks which can impact on decision making of interested parties. To enhance the effectiveness of these typologies, this paper develops a Typology Matrix to classify firms into four behavior types namely, reactive, proactive, innovative and progressive, in relation to various sustainbility criteria. It is based on scoring measurement systems to draw information from corporate social responsibility reports in order to identify the proactive or regulatory--driven strategy of firms. The proposed methodology was applied in a sample of top 25 chemical firms according to their sales. The results showed that 16% of the sampled firms were progressive firms since they achieved high score in the progressive financial, social and environmental topics, whereas the vast majority of the firms were classified as reactive (60%).

Keywords: Corporate Sustainability, Corporate Environmental Management, Corporate Environmental Innovation, Corporate Environmental Accounting, firm behavior

JEL Codes: D22, D25, F64, G18, G28, G38, J16, Q58

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No	Department	Institution
1	Dept. of Agribusiness and Supply Chain Management	Agricultural University of Athens
2	Dept. of Agricultural Economics and Development	Agricultural University of Athens
3	Dept. of Forestry & Natural Environment Management	Agricultural University of Athens
4	Dept. of Physics	Alioune Diop University of Bambey
5	Dept. of Civil Engineering, School of Engineering	Aristotle University of Thessaloniki
6	School of Primary Education, Faculty of Education	Aristotle University of Thessaloniki
7	Dept. of Spatial Planning and Development Engineering / Polytechnic School	Aristotle University of Thessaloniki
8	Faculty of Engineering, School of Civil Engineering	Aristotle University of Thessaloniki
9	Lab. of Forest Economics, School of Forestry and Natural Environment	Aristotle University of Thessaloniki
10	Lab. of Forest Informatics Faculty of Forestry and Natural Environment, School of Agriculture, Forestry & Natural Environment	Aristotle University of Thessaloniki
11	Lab. of Environmental Engineering and Planning, Division of Hydraulics and Environmental Engineering, Dept. of Civil Engineering, School of Engineering	Aristotle University of Thessaloniki
12	Lab. of Forest Engineering and Topography, School of Forestry and Natural Environment	Aristotle University of Thessaloniki
13	School of Agriculture, Forestry & Natural Environment	Aristotle University of Thessaloniki
14	School of Civil Engineering	Aristotle University of Thessaloniki
15	School of Physical Education and Sports Science	Aristotle University of Thessaloniki
16	Sustainable Development Unit	ATHENA RC
17	Research Lab. on Socio-Economic and Environmental Sustainability (ReSEES)	Athens University of Economics and Business
18	School of Business	Athens University of Economics and Business
19	School of Economics and ReSEES Research Lab.	Athens University of Economics and Business
20		Avaris Transport Engineers LLC
21	CINAV, Center of Naval Research, Portuguese Naval Academy	Base Naval de Lisboa
22	Dept. of Digital Transition and Climate Policies	Cluster of Bioeconomy and Environment of Western Macedonia
23		CSEF, University of Naples Parthenope
24	Dept. of Civil Engineering	Democritus University of Thrace
25	Section of Transportation, Dept. of Civil Engineering	Democritus University of Thrace
26	Department of Environmetnal Engineering	Democritus University of Thrace
27		General Directorate of Planning and Infrastructure Prefecture of Central Macedonia
28	Directorate of Primary Education of Zakynthos	Greek Ministry of Education and Religious Affairs
29	Dept. of Economics and Sustainable Development	Harokopio University of Athens
30	Dept. of Economics and Sustainable Development,School of Environment, Geography and Applied Economics	Harokopio University of Athens
31	Agriculture Economics Research Institute (AGRERI)	Hellenic Agricultural Organization – DEMETER
32	Institute of Mediterranean Forest Ecosystems	Hellenic Agricultural Organization – DIMITRA
33	Institute of Marine Biological Resources and Inland Waters	Hellenic Centre for Marine Research
34	College of Economics and Management	Huazhong Agricultural University
35		Institute for Studies on the Mediterranean (ISMed)
36		Institute for Systems Engineering and Computers at Coimbra
37		Instituto Superior de Engenharia de Coimbra
38	Dept. of Civil Engineering	International Hellenic University
39	Dept. of Organisation Management, Marketing and Tourism	International Hellenic University

No	Department	Institution
40	Dept. of Surveying and Geoinformatics Engineering	International Hellenic University
41		KDC Consulting and Engineering P.C
42		Koubaras Ltd
43	Institute for Environmental Economics and World Trade	Leibniz University Hannover
44	CEMAT, Center for Computational and Stochastic Mathematics, Instituto Superior Técnico	Lisbon University
45	Dept. of Economics	National and Kapodistrian University of Athens
46	Faculty of Social Theology and Religious Studies, Theology School	National and Kapodistrian University of Athens
47	Dept. of Geography and Environmental Sciences	Northumbria University
48	NOVA Information Management School (NOVA IMS)	Nova University Lisbon
49	Dept. of Public Administration	Panteion University
50		Particles Plus, Stoughton, MA - USA
51		Paul Watkiss Associates
52	Dept. of Technology, Management and Economics	Technical University of Denmark
53	Global Climate Hub, European Hub, Greek Hub	UN SDSN
54		United Nations Industrial Development Organization (UNIDO)
55	DCeT-UAb, Dept. of Sciences and Technology	Universidade Aberta
56	UAb, Dept. of Sciences and Technology	Universidade Aberta
57	Departamento de Ciências e Tecnologia	Universidade Aberta
58		Universidade da Beira Interior
59	Deparment of Economy	Universidade da Coruña
60	Departamento de Engenharia Civil	Universidade de Coimbra
61	CEAUL – Centro de Estatística e Aplicações	Universidade de Lisboa
62	UDESC	Universidade do Estado de Santa Catarina
63	Faculdade de Medicina Dentária	Universidade do Porto
64	Dept. of Economics, Business School	University of Aberdeen
65	Dept. of Environment	University of Aegean
66	Dept. of Economics	University of Patras
67	Dep. of Environment	University of the Aegean
68	Dep. of Environment	University of the Aegean
69	Dept. of Ichthyology and Aquatic Environment and Dept. of Special Education, Joint Postgraduate Programme "Education for Sustainability and the Environment"	University of Thessaly
70	Dept. of Economics	University of Thessaly
71	Dept. of Finance and Accounting	University of Thessaly
72	Dept. of Ichthyology and Aquatic Environment and Dept. of Special Education, Joint Postgraduate Programme "Education for Sustainability and the Environment"	University of Thessaly
73	Dept. of Planning and Regional Development, School of Engineering	University of Thessaly
74	Lab. of Operations Research, Dept. of Economics	University of Thessaly
75	Global Sustainable Development, School for Cross-Faculty Studies	University of Warwick
76	Dept. of Wine, Vine and Beverage Sciences	University of West Attica
77	Dept. of Informatics and Computer Engineering	University of West Attica
78	Dept. of Public and Community Health	University of West Attica

#ENVECON9

Thank you very much

The Scientific & Organizing Committees