Laboratory of Operations Research
Department of Economics
School of Humanities and Social Sciences
University of Thessaly

5th Conference

"Economics of Natural Resources & the Environment"

Conference Proceedings

Thursday 1 - Saturday 3 November 2018

http://envecon.econ.uth.gr/main/


ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ
ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΩΝ ΕΠΙΣΤΗΜΩΝ

The Laboratory of Operations Research of the Department of Economics, School of Humanities and Social Sciences, University of Thessaly, organized the 5th Conference "Economics of Natural Resources and the Environment" for the 5th time in a raw. This scientific meeting follows the successful organization of the first two scientific conferences in the framework of the COOPERATION 2011 research program and the project entitled "Greenhouse gas emission scenarios and policies to combat them by the year 2030 in the fields of energy, transport and environment Industry in Greece ". The first two Pan-Hellenic Conferences on the Economics of Natural Resources and the Environment: Climate Change took place successfully on the 1st of March 26-27, 2014 and 2nd on 31st October and 1st of November 2014. The successful organization of the 3rd Panhellenic and the 4th Conferences on Economic Natural Resources and the Environment on October 30-31, 2015 and November 4-5, 2016 respectively, which was expanded to present the key themes of today's Economy of Natural Resources and the Environment.

Similarly, this conference aimed to present the main issues that are of concern to the Economic of Natural Resources and the Environment, focusing on the various environmental problems and their management and resolution policies both at the level of Greece and globally. Its aim is to highlight the interdisciplinary nature of environmental research by exchanging views and experiences of researchers from different scientific fields and finding common components of research approaches.

The presence of the scientific activities of scientists and researchers who participated in this conference also rewarded and further strengthened this effort. Interesting scientific studies and constructive discussions in crowded lecture rooms by academics, researchers, research teams and students can only satisfy us and encourage us to continue this effort.

Conference Scientific Coordinator
Professor George E. Halkos

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Conference Site: http://envecon.econ.uth.gr/main/

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CONFERENCE COMMITTEES

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Conference Website

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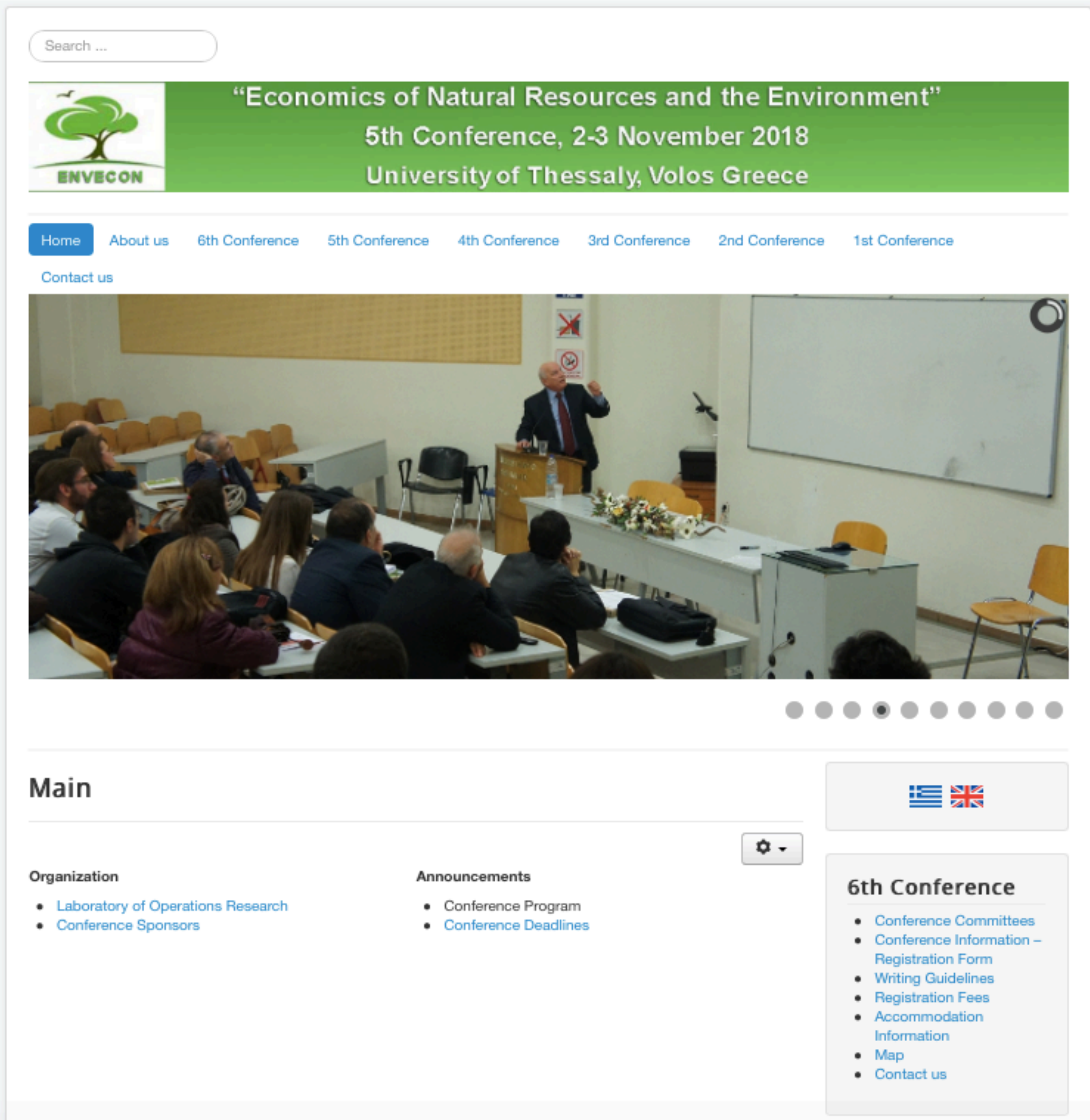

Concise Conference Schedule		
Day	**Time**	**Sessions-Topics**
Thursday 01/11/2018	**12:00-14:00 Domotel Xenia Venue**	**Round Table:** **Presentation of the Activities of the Laboratory of Operations Research Members**
	19:00-19:30	**Opening Ceremony**
	19:30-19:45	**Welcome Speech** *Aims, Scopes and Structure of the 5th ENVECON Conference* *Professor George Halkos*
	19:45-21:00 Saratsis Auditorium	**Keynote Speakers** *Professor Charles Perrings* *Professor Ann Kinzig*

Friday 02/11/2018	**08:30-09:30**	**Registrations**
	09:30-11:30 Room B1	**Session 1:** **Quantitative Methods in Environmental and Resource Economics: Econometrics**
	09:30-11:30 Room I2	**Session 2:** **Socio-economic Environmental Assessment**
	11:30-12:00 Room A1	Coffee Break
	12:00-13:00 Room B1	**Keynote Speaker** *Professor Anil Markandya*
	13:00-14:00 Room A1	Lunch Break
	14:00-16:00 Room B1	**Session 3:** **Waste Management/Cyclical Economy**
	14:00-16:00 Room I2	**Session 4:** **Environmental Issues & Concerns**
	16:00-17:00 Room B1	**Keynote Speaker** *Professor Shunsuke Managi*
	17:00-17:30 Room A1	Coffee Break
		Session 5: **Environmental Policies and Assessment**

	17:30-19:30 Room B1	
	17:30-19:30 Room I2	**Session 6:** **Sustainable Transport**
	19:30-20:30 Room A1	Dinner Break

Saturday 03/11/2018	**09:30-11:30 Room B1**	**Session 7:** **Quantitative Methods in Environmental and Resource Economics: Mathematics**
	09:30-11:30 Room I2	**Session 8:** **Energy Issues & Policies**
	11:30-12:00 Room A1	Coffee Break
	12:00-13:00 Room B1	**Keynote Speaker** *Professor Clevo Wilson*
	13:00-14:00 Room A1	Lunch Break
	14:00-16:00 Room B1	**Session 9:** **Environmental Valuation**
	14:00-16:00 Room I2	**Session 10:** **Sustainable Tourism**
	16:00-16:30 Room A1	Coffee Break
	16:30-18:30 Room B1	**Session 11:** **Environmental Efficiency & Performance**
	16:30-18:30 Room I2	**Session 12:** **Sustainable Development**
	18:30-19:00 Room B1	**Closing & Giveaways**
	20:30	Formal Conference Dinner

CONFERENCE SCHEDULE

Thursday 1 November 2018

Round Table **12:00-14:00** **Domotel Xenia Venue**

Topic: Presentation of the Research Occupations of the Laboratory of Operations Research

Chairperson: Professor George Halkos

12:00-12:20	*Environmental behavior in a private-sphere context: Integrating theories of planned behavior and value belief norm, self-identity and habit* Anastasia Gkargkavouzi[1], George Halkos[2] & Steriani Matsiori[1] [1]University of Thessaly, Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences [2] University of Thessaly, Department of Economics, Faculty of Humanities and Social Sciences, Laboratory of Operations Research
12:20-12:40	*Environmental regulation and economic cycles* Halkos Emm. George – Halkos G. Emmanuel - Papageorgiou J.George – Papageorgiou G. John University of Thessaly, Laboratory of Operations Research
12:40-13:00	*Analyzing the energy market's most effective risk management tools and strategies* George Halkos and Apostolos S. Tsirivis *Laboratory of Operation Research, Department of Economics, University of Thessaly*
13:00-13:20	*Exploring the EMEP Input Output model of Air Pollution* George Halkos, Kyriaki Barboudaki, George Voulagkas & Kyriaki Tsilika *Laboratory of Operations Research, Department of Economics, School of Humanities and Social Sciences, University of Thessaly*
13:20-14:00	Discussion

Opening Ceremony **19:00-19:30** **Saratsis Auditorium**

Keynote Speakers **19:30-21:00** **Saratsis Auditorium**

Topic: Ecology and economics in the science of anthropogenic biosphere change

Professor Charles Perrings

Professor Ann Kinzig

School of Life Sciences, Arizona State University

Friday 2 November 2018

1st Session **09:30-11:30** **Room B1**

Topic: Quantitative Methods in Environmental & Resource Economics: Econometrics

Chairperson: Professor George Halkos

09:30-09:50	*Climate-friendly interventions by central banks: the inclusion of green assets in Quantitative Easing purchases* Stephanos Papadamou & Nikolaos A. Kyriazis Department of Economics, University of Thessaly, 28th October 78 Street,
09:50-10:10	*Econometric assessment of market competition in electricity markets* Olivér Hortay & Tamás Szőke Department of Environmental Economics, Budapest University of Technology and Economics, Budapest
10:10-10:30	*Revisiting the environmental Kuznets curve hypothesis: A dynamic panel VAR analysis* Michael L. Polemis Department of Economics, University of Piraeus, Piraeus,
10:10-10:50	*Revisiting the relationship between economic growth and forested areas: A cross-country assessment* George Halkos[1] & Antonis Skouloudis[2] [1] *Department of Environment, University of Thessaly, Volos* [2] *Department of Environment, University of the Aegean, Lesvos*
10:50-11:10	The impact of market competition on CEO compensation in the US energy sector (1992-2015) Konstantinos N. Konstantakis & Panayotis G. Michaelides & Efthymios M. Tsionas *National Technical University of Athens, Greece* *Lancaster University Management School, UK*
11:10-11:30	Discussion

2nd Session 09:30-11:30 Room I1

Topic: Socio-economic Environmental Assessment

Chairperson: Associate Professor Steriani matsiori

09:30-09:50	*Critical application of NEP scale in Greece* Steriani Matsiori Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences University of Thessaly
09:50-10:10	*The spatial-economic dimension of aquaculture in Greece* Sophoclis E. Dritsas (PhD) Special Teaching Staff, Grade A' Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences University of Thessaly
10:10-10:30	*A bilevel scheduling algorithm for maximizing NPV in forests with different rotation ages* Konstantinos Petridis[1] Angelo Sifaleras[1] Garyfallos Arabatzis[2] Department of Applied Informatics, School of Information Sciences University of Macedonia
10:10-10:50	*Why people care about climate change*
10:50-11:30	Discussion

Keynote Speaker 12:00-13:00 Room B1

Topic: Evaluating Agro-food Systems in a Sustainable Context
Professor Anil Markandya
Basque Centre For Climate Change (Klima Aldaketa Ikergai)

3rd Session **14:00-16:00** **Room B1**

Topic:	**Waste Management – Circular Economy**
Chairperson:	**Associate Professor Konstantinos Evangelinos**
14:00-14:20	*Evaluating 22 EU Member States' 'waste culture' using Hofstede's and Schwartz's cultural dimensions* George Halkos & Kleoniki Natalia Petrou Laboratory of Operation Research, Department of Economics, University of Thessaly
14:20-14:40	*The added value of the cement industry in the circular economy* Eric Waeyenbergh Advocacy Manager and Health Geocycle Europe
14:40-15:00	*Circular economy aspects in sustainability reports: A critical overview of Greek market* Konstantinos Evangelinos, Stefanos Fotiadis, Panagiotis Vouros, Christina Mpitsori, Antonis Skouloudis, Ioannis Nikolaou *Environmental Policy and Corporate Environmental Management Research Group, Department of Environment, University of the Aegean, Mytilini,* *School of Economics, Business Administration & Legal Studies, International Hellenic University, Thessaloniki,* *Democritus University of Thrace, Department of Environmental Engineering, Komotini,*
15:00-15:20	*Circular economy in Greece: Evidence from Central Macedonia* Sofia-Natalia Boemi[1], Chrysanthi Kiskini[1], Konstantinos Tertivanidis[1] and Konstantinos Befas[2] [1]Regional Development Fund of Central Macedonia
15:20-16:00	Discussion

4th Session **14:00-16:00** **Room I1**

Topic: Environmental Issues & Concerns

Chairperson: Professor Christos Kitsos

14:00-14:20	*Measurement of green industrial performance: an enhanced GIP index* Jaime Moll de Alba & Valentin Todorov United Nations Industrial Development Organisation (UNIDO), Vienna International Centre
14:20-14:40	*Investigating the impact of wellbeing on economic performance: Evidence from European Union countries and regions.* George Ekonomou & Dimitris Kallioras Department of Planning and Regional Development, School of Engineering, National University of Thessaly
14:40-15:00	*The Relationship between Environmental Degradation, Economic Development and Corruption: A Panel Data Cointegration Analysis of Asian Emerging and Developing Countries* Anam Shehzadi[a]and Heike Wetzel[a] [a]Institute of Economics, University of Kassel
15:00-15:20	*Can we hedge an investment against a potential unexpected environmental disaster?* Halkos George and Zisiadou Argyro Laboratory of Operation Research, Department of Economics, University of Thessaly
15:20-16:00	Discussion

Invited Speakers Speech **16:00-17:00** **Room B1**

Topic: Inclusive Growth for Sustainability: Measurement from Inclusive Wealth Report 2018

Professor Shunsuke Managi

Urban Institute, Kyushu University, Japan

5th Session 17:30-19:30 Room B1

Topic:	**Environmental Policies & Assessment**
Chairperson:	**Professor Anil Markandya**
17:30-17:50	*Assessing the impact of a climate change adaptation intervention: Evidence from Central Highlands of Afghanistan* Asadullah Jawid & Menusch Khadjavi Department of Economics, Christian Albrechts University of Kiel
17:50-18:10	*What drives responsible business? Examining the links between reputation risk, non-government organization (NGO) pressure and responsible business performance* James Wallace & Dr. George Iatridis Department of Economics, University of Thessaly, Group Communications and Corporate Responsibility, Allianz SE
18:10-18:30	*Prediction of Global Warming impacts using Fuzzy Cognitive Maps and Semantic Web techniques* Athanasios Tsadiras[1] , Maria Pempetzoglou[2] & Iosif Viktoratos[1] [1]School of Economics, Aristotle University of Thessaloniki, [2]School of Social Administration and Political Science, Democritus University of Thrace
18:30-18:50	*Towards better tools for effective environmental policy* George E. Halkos & Kyriaki D. Tsilika Laboratory of Operations Research, Department of Economics, School of Humanities and Social Sciences, University of Thessaly
18:50-19:10	*Identification of regimes in river behavior using nonlinear timeseries analysis* Athanasios Fragkou, Theodoros Karakasidis, Antonios Liakopoulos Laboratory of Hydromechanics and Environmental Engineering, Department of Civil Engineering, University of Thessaly
19:10-19:30	Discussion

6th Session 17:30-19:30 Room I1

Topic:	**Sustainable Transport**
Chairperson:	**Professor Vassilios Profillidis**
17:30-17:50	*Real-time road traffic forecasts – a hybrid approach using artificial intelligence and Singular Spectrum Analysis* Stylianos Kolidakis[1], George Botzoris[1], Vassilios Profillidis[1], Panagiotis Lemonakis[2] [1]School of Civil Engineering, Democritus University of Thrace [2]University of Thessaly, Department of Civil Engineering
17:50-18:10	*Examining the determinants of CO2 emissions caused by the transportation sector activity: Empirical evidence from 12 European countries* Vasiliki V. Georgatzi, Apostolos Vetsikas, and Yeoryios Stamboulis Department of Economics, University of Thessaly
18:10-18:30	*Artificial Neural Networks: A Modern Tool for Empirical Modeling of Transport Demand* Vassilios Profillidis, George Botzoris, Stylianos Kolidakis School of Civil Engineering, Democritus University of Thrace
18:30-18:50	*The contribution of the road transport projects of the NSRF 2007-2013 to the development of a Greek region* Christina Mavraki[1], Garyfallos Arabatzis[1], Apostolos Kantartzis[1] & Chrisovalantis Malesios[2] [1]Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace [2]Operations & Information Management Department, Aston Business School, Aston University
18:50-19:10	*Investigation of bicyclists' riding behaviour under normal traffic conditions in the road network of a mid-sized Greek city* Konstantinos Zavitsanos[1], Athanasios Galanis[2], Panagiotis Lemonakis[1], George Botzoris[3] & Nikolaos Eliou[1] [1]University of Thessaly, Department of Civil Engineering [2]Technological Educational Institute of Central Macedonia, Department of Civil Engineering and Surveying Engineering and Geoinformatic [3]Democritus University of Thrace, Department of Civil Engineering
19:10-19:30	Discussion

Saturday 3 November 2018

7th Session **09:30-11:30** **Room B1**

Topic: Quantitative Methods in Environmental & Resource Economics: Mathematics

Chairperson: Professor Charles Perrings

09:30-09:50	*Budget and environmental subsidies: Optimal management and a dynamic game* George Emm. Halkos and George J. Papageorgiou University of Thessaly, Department of Economics, Laboratory of Operations Research
09:50-10:10	*Modeling a closed economy by a lattice Hamiltonian* Founta Konstantina, Benos Christos, Zachilas Loukas University of Thessaly, Department of Economics
10:10-10:30	*Adopting Tolerance Intervals in Environmental Economics* Christos P. Kitsos Thomas T. Toulias University of West Attika
10:30-10:50	*Wind energy potential based on Visibility Complex Network and Recurrence Plot time series analysis* Avraam Charakopoulos[1], Theodoros Karakasidis[1], Ioannis Sarris[2] [1] Laboratory of Hydromechanics and Environmental Engineering, Department of Civil Engineering, University of Thessaly [2] Department of Mechanical Engineering, University of West Attica
10:50-11:10	*The economy of packed products' oxidation process* Antonios Kanavouras[1] & Frank A. Coutelieris [1] Department of Food Science and Human Nutrition, Agricultural University of Athens [2] Department of Environmental & Natural Resources Management, University of Patras
11:10-11:30	Discussion

8th Session **09:30-11:30** **Room I1**

Topic: Energy Issues & Policies

Chairperson: Professor Shunsuke Managi

09:30-09:50	*Energy transition, poverty and inequality: Insights from panel data for Vietnam from 2004 to 2016* Trung Thanh Nguyen[a*], Thanh-Tung Nguyen[a], Vincent Hoang[b], Clevo Wilson[b], Shunsuke Managi[c] [a] School of Economics and Management, Leibniz University Hannover, Germany; [b] School of Economics and Finance, Queensland University of Technology, Australia; [c] Urban Institute, Kyushu University, Japan
09:50-10:10	*Assessing the sustainability of renewable energy sources with the combination of life cycle and SWOT analyses* Demetrios N. Papadopoulos University of Patras, Department of Environmental and Natural Resources Management
10:10-10:30	*Energy policy establishment for off-grid small isolated settlements* Evangelos Tsiaras & Frank A. Coutelieris Department of Environmental and Natural Resources Management, University of Patras
10:30-10:50	*Selection of optimal on shore wind farm sitting locations in Greece, using Multi criteria Decision Analysis* Ioannou Konstantinos[1] Tsantopoulos Georgios[2] Arabatzis Garyfalos[3] [1]Researcher, National Agricultural Organization – "DEMETER", Forest Research Institute [2]Associate Professor, Democritus University of Thrace, Department of Forestry and Management of the Environment and Natural Resources [3]Professor, Democritus University of Thrace, Department of Forestry and Management of the Environment and Natural Resources
10:50-11:10	*Determinants of household electricity consumption in Greece: A statistical analysis* Dimitra Kotsila & Persefoni Polychronidoy Hellenic Open University, Patras
11:10-11:30	Discussion

Keynote Speaker 12:00-13:00 **Room B1**

Topic: Could Revealed and Stated Preference Techniques Produce Similar Outcomes for Policy Decision-making?

Professor Clevo Wilson

School of Economics and Finance, Queensland University of Technology, Australia

9th Session 14:00-16:00 Room B1

Topic:	**Environmental Valuation**
Chairperson:	**Professor Clevo Wilson**
14:00-14:20	*Understanding people's perception about biodiversity importance, management and conservation* George Halkos[1] and Steriani Matsiori[2] [1] Laboratory of Operations Research, Department of Economics, University of Thessaly [2] Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences University of Thessaly
14:20-14:40	*Valuation of ecosystem services and assessment of their social impacts* Nikoleta Jones[1], James McGinlay[1], Kostantinos Evangelinos[2] [1]Global Sustainability Institute, Anglia Ruskin University [2]Department of Environment, University of the Aegean
14:40-15:00	*Psychological and contextual barriers to recycling, energy and water conservation behaviors: The role of personal and social factors* Anastasia Gkargkavouzi[1], George Halkos[2] & Steriani Matsiori[1] [1]University of Thessaly, Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences [2] University of Thessaly, Department of Economics, Faculty of Humanities and Social Sciences, Laboratory of Operations Research
15:00-15:20	*Preferences and willingness to pay for protecting the marine and coastal environment from plastic waste: a case study of Syros Island, Greece* Charalampos Mentis[1], Dionysis Latinopoulos[2], Kostas Bithas[1] [1]Research Team on Economics of the Environment and Sustainable Development, Institute of Urban Environment and Human Resources (UEHR), Department of Economic and Regional Development, Panteion University of Social and Political Sciences [2]School of Urban-Regional Planning and Development Engineering, Aristotle University of Thessaloniki
15:20-15:40	*Implementing Hedonic Pricing Models for valuing the visual impact of wind farms in Greece* Konstantinos Skenteris[a], Sevastianos Mirasgedis[a] & Christos Tourkolias[b] [a] Institute for Environmental Research & Sustainable Development, National Observatory of Athens [b] Center for Renewable Energy Sources & Saving
15:40-16:00	Discussion

10th Session **14:00-16:00** **Room I1**

Topic:	**Sustainable Tourism**
Chairperson: Professor Ann Kinzig	
14:00-14:20	*Shark aggregation and tourism: Opportunities and challenges of an emerging phenomenon* Ziv Zemah Shamir , Shiri Zemah Shamir, Dan Tchernov, Aviad Scheinin and Nir Becker [a]Department of Economics and Management, Tel-Hai College [b]Marine Biology Department, M. Kahn Marine Research Station, University of Haifa [c]School of Sustainability, Interdisciplinary Center Herzliya
14:20-14:40	*Alternative forms of sustainable development: The case of thermal tourism* Delitheou Vasiliki & Georgakopoulou Stavroula Panteion University of Social and Political Sciences, Department of Economic and Regional Development
14:40-15:00	*Integrating sustainable supply chain management (SSCM) amongst Greek supermarkets* Eleni Sardianou* & Efthalia Christou** *Harokopio University, School of Environment, Geography and Applied Economics, Department of Home Economics and Ecology, Graduate Program of Sustainable Development **NATO Office of Resources (NOR)
15:00-15:20	*The use of carbon shadow pricing as a tool to drive the decarbonization of the Greek hotels operations* Benjamin Karatzoglou Department of Economics, University of Macedonia
15:20-15:40	*Wind energy, an energy solution for hospitality businesses* Amalia Karabekou[1], Dimitrios Kovos [2], Stephanos Karagiannis [1] & Vasiliki Delitheou[1] [1] Department of Economic and Regional DEevelopment, Panteion University [2] Mechanical Engineer Design and Draftin, Sheridan College, Brampton, Ontario
15:40-16:00	Discussion

11th Session **16:30-18:30** **Room B1**

Topic: Environmental Efficiency & Performance

Chairperson: Professor George Halkos

16:30-16:50	*Two stage DEA & marginal effects of environmental variables to TE index* George Halkos[1] & Christina Bampatsou[1,2] [1]Laboratory of Operations Research, Department of Economics, University of Thessaly [2]Ionian University, Faculty of Economic Sciences
16:50-17:10	*Research Intensities and R&D Input-Output Multipliers: An Examination of their Intertemporal Stability Using Data on the US Economy* Lampros Nikolaos Maros[1], Christos T. Papadas[2], and Penelope Gouta[2] [1] CIHEAM IAM Chania [2]Agricultural University of Athens, Department of Agricultural Economics and Rural Development
17:10-17:30	*A merry triangle or a heavy cross? Environmental Efficiency, Productive Performance & Competitiveness under Technological Heterogeneity* Nikos Chatzistamoulou[ab], Kostas Kounetas[b] [a]School of Economics, University of Surrey, UK [b]Department of Economics, University of Patras
17:30-17:50	*Measuring efficiency in forestry section using Network DEA approach: An application to EU countries* Konstantinos Petridis[1] Ioannis Kyritsis[2] [1]Department of Applied Informatics, School of Information Sciences, University of Macedonia [2]School of Economic Sciences, Aristotle University of Thessaloniki
17:50-18:10	*European Industries' Energy Efficiency Performance Under Different Technology Regimes. The Role of Heterogeneity, Path Dependence and Energy Mix.* Kostas Kounetas and Eirini Stergiou Department of Economics, University of Patras
18:10-18:30	Discussion

12th Session **16:30-18:30** **Room B1**

Topic:	**Sustainable Development**
Chairperson:	**Professor Michael Zouboulakis**
16:30-16:50	*Assessing the independence of NRA in controlling the competition in Iranian energy market* Tayebeh Saheb & Hassan Ganji Yahyazadeh Tarbiat Modares University, Tehran University, School of Law
16:50-17:10	*Just how Smart is [Smart] Regulation? Achieving Sustainable Development with Regulation-induced Innovation* Nicholas A. Ashford[a] & Abdelfeteh Bitat[b] [a]Massacusetts Institute of Technology [b]Université Saint-Louis Bruxelles
17:10-17:30	*Assessing Safety in Public Areas with Space Syntax Application; Case Study of Tarbiat Pedestrian Area, Tabriz-Iran* Kübra Cihangir Çamur[1] & Mehdi Roshani[2] [1] Gazi University, Faculty of Architecture, City and Regional Planning Department [2]Gazi University, Graduate School of Natural and Applied Sciences, City and Regional Planning Department
17:30-17:50	*The effect of growth-CO_2 emission relationship on sustainable development: Application of the Wavelet Transform Technique* Ammouri Bilel (1), Issaoui Fakhri (2) & Zitouna Habib (3) (1)Laboratoire DEFI, Ecole Supérieure de Sciences Economiques et Commerciales, Université de Tunis. (2)Le Laboratoire de Recherche « Prospective, Stratégies et Développement Durable » Université Tunis EL-Manar, Faculté des Sciences Economiques et de Gestion de Tunis (3) Faculté des Sciences économiques et de gestion de Nabeul
17:50-18:10	*Economic and environmental impact of low carbon technologies in German energy system* Subhash Kumar and Reinhard Madlener RWTH Aachen University, Germany Department: FCN, E.ON Energy Research Center
18:10-18:30	Discussion

Closing & Giveaways **18:30-19:00** **Room B1**

Topic: Closing & Final Giveaways

Professor George Halkos

Department of Economics, School of Humanities and Social Sciences, University of Thessaly

ABSTRACTS

Environmental behavior in a private-sphere context: Integrating theories of planned behavior and value belief norm, self-identity and habit

Anastasia Gkargkavouzi[1], George Halkos[2] & Steriani Matsiori[1]

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Abstract

This study explores the determinants of environmental behavior in a private-sphere context and proposes an integrative model that includes the constructs from two theoretical frameworks, the theory of planned behavior (TPB) and the value belief norm theory (VBN), along with two additional variables, habits and self-identity. A questionnaire survey method was used to collect the survey data and statistical analysis relied on application of structural equation modeling (SEM). The results show that intention is the best predictor of environmental behavior followed by habits and subjective norm is the main attendant of intention. Awareness of consequences has a positive impact on personal and subjective norms, attitudes and perceived behavioral control, while these constructs have in turn a significant influence on behavioral intention. Self-identity moderates the relationships between biospheric values and personal norm, attitudes, subjective norm, and perceived behavioral control. The proposed model exhibit superior predictive ability compared to the original TPB and VBN models verifying its utility and effectiveness in explaining environmental behavior. The results of this work can be used by governments and policymakers to design and implement conservation programs to promote a more sustainable lifestyle. Recommendations for future research are discussed in the last section of this paper.

Keywords: Theory of planned behavior; value-belief-norm theory; habit; self-identity; private-sphere environmental behavior.

JEL Codes: A14; C38; Q00; Q51; Q56; Q59.

ROUND TABLE: ***Presentation of the Research Occupations of the Laboratory of Operations Research***

Environmental regulation and economic cycles

Halkos Emm. George – Halkos G. Emmanuel - Papageorgiou J.George – Papageorgiou G. John

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Abstract

This paper considers economic cycles that do not depend on the exogenous economic actions. More precisely, the paper develops a positive model of government behavior in order to define the intertemporal fiscal policies that are optimal for a country, determining the optimal level of the budget and the optimal level of the rate of environmental quality, as well. For this purpose, we setup an optimal control model involving the intertemporal subsidy strategies for an authoritarian (like a central European) government. It will be shown - applying the Hopf bifurcation theorem - that cyclical strategy, i.e. waves of regulation, environmental subsidies alternating with deregulation, cuts in social programmes, etc., may be optimal strategies.
In this paper we propose an extremely simple optimal control model concerning budget surplus and environmental subsidies. We investigate the cyclical environmental policies applying one bifurcation theorem. A number of propositions are stated during the solution process.

Keywords: Budget, environmental resources, subsidies, Hopf bifurcation, optimal control

JEL Codes: E62, C61, H61, H23, Q50, C02,

ROUND TABLE: ***Presentation of the Research Occupations of the Laboratory of Operations Research***

Analyzing the energy market's most effective risk management tools and strategies

Apostolos S. Tsirivis

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Abstract

The current review emphasizes on the importance of the development of an effective price risk management strategy regarding energy products, as a result of the high volatility of that particular market. The study provides a thorough investigation of the numerous risk management methodologies and econometric techniques that were presented in the most representative academic researches, trying to shed light to the advantages, as well as the weaknesses of each approach. After a comprehensive examination of the relative literature, it is evident that although being able to predict the future variance through the advanced developments of the basic ARCH and GARCH models is essential to manage risk, however it fails to provide a clear view on the specific amount of money that is at risk on behalf of the investor or any party directly affected by the price fluctuations of a specific or multiple energy products. Thus, it is necessary for risk managers to make one more step trying to select the most appropriate and effective approach that will make possible an accurate forecast of the relative Value-at-Risk, which by definition provides a good measure of the total amount that is at stake. Nevertheless, despite the variety of the variance models that have been developed and the relative VaR methodologies, the vast majority of the researchers conclude that there is no model or specific methodology that outperforms all the others. On the contrary, the best approach to minimize risk and accurately forecast the future potential losses is to adopt that specific methodology that will be able to take into consideration the particular characteristic features regarding the trade of a specific or a certain group of energy products.

Keywords: Energy commodities, risk management, volatility modeling, ARCH-GARCH, Value-at-Risk (VaR), Extreme Value Theory (EVT)

JEL Codes: Q40;Q48;Q58

ROUND TABLE: ***Presentation of the Research Occupations of the Laboratory of Operations Research***

Exploring the EMEP Input Output model of Air Pollution

George Halkos, Kyriaki Barboudaki, George Voulagkas & Kyriaki Tsilika

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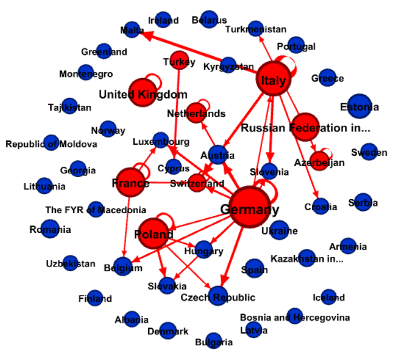
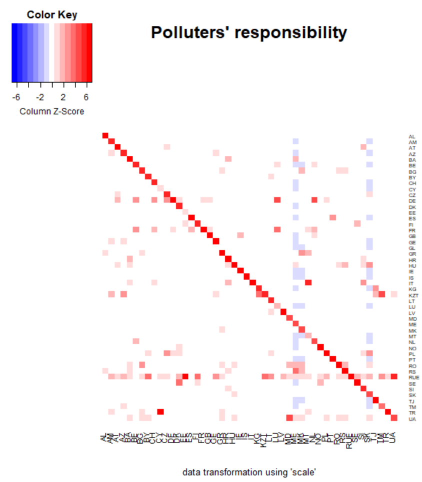
Abstract

The primary objective of this paper is the structural analysis of source-receptor air pollution problems in the EU region. Two views are provided for the analysis: an emission-driven view and a deposition-driven view. Different visualization modules are used to reproduce the global pollution network and identify the biggest sources and sinks of pollution. Visual modelling helps to understand the linkages and interconnections in the transboundary pollution network. Our interactive outputs give the options to zoom in specific areas of the global source-receptor air pollution scheme and highlight the top emitters or receptors of pollution. Ranking of countries in decreasing order of pollution responsibility and/or vulnerability using graph metrics is a main result. Data sources are emissions-depositions (or source-receptor) tables of air pollutants, available online from the data repository of the European Monitoring and Evaluation Program (EMEP) of the Long-Range Transmission of Air Pollutants in Europe. In our computer-based visual analysis, we employ solely open software.



Computer-based design and analysis of pollution networks in Gephi – receptors' view



Exploring linkages and interdependencies in source receptor air pollution problems with heat maps in R package – emitters' view

Keywords: source-receptor air pollution; network analysis; heatmaps.

JEL Codes: C63; C88; Q53; Q58.

KEYNOTE SPEAKERS:

Ecology and economics in the science of anthropogenic biosphere change

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Abstract

We examine the consequences of a forty-year experiment in interdisciplinary collaboration between ecologists and economists to understand anthropogenic impacts on the biosphere. Research on the linkages between biodiversity and ecosystem function has, for example, established the scientific basis for the valuation of many important natural assets, and has deepened our understanding of the stability and sustainability of natural resource systems. Focusing on biodiversity, we consider how the experiment has strengthened the science of biosphere change, but also how it has raised new challenges for both disciplines.

Climate-friendly interventions by central banks: the inclusion of green assets in Quantitative Easing purchases

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Abstract

This study investigates how unconventional monetary policies exercised by major economies hit by the Global Financial Crisis and the Eurozone sovereign debt crisis could render environmental-friendlier. The inclusion of ‘‘green assets’’, such as equities, bonds, infrastructure and real-estate loans as well as structured and securitized products could replace assets of emission-intensive sectors in the balance sheet of monetary authorities. We look into the possibility that the ‘‘green investment gap’’ may be lowered by high-level policy coordination and how this could be strengthened by coordination with fiscal policy and financial regulation. Therefore, we cast light on an innovative aspect of central bank policymaking by taking into consideration climate-related risks.

Keywords: unconventional monetary policy; green assets; emission-intensive sectors

JEL Codes: E52; E58; Q43; Q48

Econometric assessment of market competition in electricity markets

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Abstract

In this paper I present an econometric modeling technique of asymmetric price transmission (APT) to measure the market power of traders in the electricity market. The focus of my work is to analyze the theoretical and practical applicability of this modeling technique. The intuition behind the method is the assumption that partial or asymmetric price transmission refers to deviations from the perfect competition. In the course of the research, I show that the increase in competition which happened as a result of the liberalization of the Hungarian electricity market can be detected by applying the APT approach. The main purpose of the study is therefore not to explore the market conditions but to present the possibilities and limitations of the application of the proposed methodology in the electricity market.

Keywords: Market competition, energy, econometrics.

JEL Codes: C52, C54, L11, L81, Q41

1st SESSION: *Quantitative Methods in Environmental & Resource Economics: Econometrics*

Revisiting the environmental Kuznets curve hypothesis: A dynamic panel VAR analysis

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Abstract

This study is based on a balanced panel of pollutants (CO_2, SO_2 and NOx emissions per capita) drawn from the electricity sector of 51 U.S. regions covering the period 1990-2012. The empirical findings indicate a strong evidence of nonlinear cointegrated relationships between local (SO_2 and NO_x) and global (CO_2) emissions generated in the electricity sector with the level of economic growth. The dynamic Panel-VAR results using impulse response functions and variance decomposition support the validity of these findings further. These results call for the need to strengthen the effectiveness of environmental degradation policies by ensuring sustainability of the electricity sector in order to drastically reduce global and local pollutants.

Keywords: EKC hypothesis; Pollutants; Sustainability; Environmental degradation; Panel VAR.

JEL Codes: C11; C23; Q4.

1st SESSION: *Quantitative Methods in Environmental & Resource Economics: Econometrics*

Revisiting the relationship between economic growth and forested areas: A cross-country assessment

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Abstract

A critical challenge for sustainability is to preserve forested areas, along with the ecosystem services they provide, while enhancing enabling conditions towards economic development. In this study, the relationship between growth and forested areas is examined across 23 countries where the vast majority of primary forests occurs. Macroeconomic and institutional characteristics as well as population dynamics are hypothesized to have an impact on forested areas. By employing panel data appropriate methods we test the validity of the Environmental Kuznets Curve (EKC) hypothesis concerning the relationship between GDP/c and forest area. Likewise, we examine whether institutional and macroeconomic conditions affect forest area and if dynamics have any effect on forested areas in all assessed countries.

Keywords: Forested area; growth; economic development; panel data analysis, Environmental Kuznets Curve.

JEL Codes: O44; O57; Q01; Q23; Q56

The impact of market competition on CEO compensation in the US energy sector (1992-2015)

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Abstract

In this paper, we examine the impact of market competition on CEO compensation by analyzing a sample of all American firms in the energy sector in the 1992 - 2015 time span, and measuring market competition by means of the Herfindhal-Hirschman-Index. We divide industries into three sub-groups based on small, medium and high market concentration and try to expand our research by exploring the impact of the recent financial crisis. The paper investigates how CEO salaries are affected by firm-level determinants, e.g. firm size, returns on assets, returns on equity, capital expenditure, market concentration, Tobin's Q etc. as well as by the individual characteristics of each CEO, e.g. CEOs age, gender. Based on our findings, the market concentration index in the US energy sector has a negative and statistically significant impact on CEO compensation for all firms that operate in either a highly monopolistic or a purely competitive environment. The results of this empirical work are robust after examining for different alternative high order effects specifications. Our study could inspire future research in the hot heated field of energy economics.

Keywords: Energy sector; USA; Competition; CEO; Panel Data.

JEL Codes: Q40; Q49; L22; D22

Critical application of NEP scale in Greece

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Abstract

One of the most known measures of an environmental belief system is the NEP scale. The new NEP scale, according consists of fifteen items and has five sub-scales (limits to growth, antianthropocentrism, the fragility of nature's balance, rejection of exemptionalism, and the possibility of an eco-crisis). The NEP scale has been used in many countries, for different groups of people for measuring environmental attitude, beliefs and worldviews. Researchers have expressed their doubts about the validity of NEP scale and a lot of studies was carried out to explore them. Thus, there is a need to test the applicability and validity of NEP scale from the point of view of Greek people. The present study attempts to refine and validate NEP scale keeping in mind the Greek people. With this objective, data were collected using self-administered structured questionnaire from 1000 respondents from different cities. The approach combines of applied methodological research like Principal Component and Cluster Analyses together with logistic regression was used. Significant relationships are found between NEP scale factors and socioeconomic characteristics respondents.

Keywords: Biodiversity, People opinion, Natural environment management

JEL Codes: Q29; Q50; Q51; Q57

The spatial-economic dimension of aquaculture in Greece

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Abstract

Aquaculture is one of the fastest growing food industries worldwide as demand for fishery products is constantly increasing. The first units were established in our country in the early 1980s, and since then this sector is one of the most important branches of agricultural production and the most important branch of animal production. This activity has evolved into one of the most competitive sectors of our country's primary production and maintains one of the first positions in the production of Mediterranean species not only at European but also at international level. The aim of this research is to analyze the possible contribution of aquaculture enterprises to the development of coastal areas of Greece and especially to those municipal units where the specific production units have been installed and operated. In this context, the proposed methodology is based on the mapping of the municipalities of coastal areas in mainland and island Greece where aquaculture enterprises were established as recorded in the Register of Aquaculture Products Producers of the Veterinary Code for Pisces (Ministry of Rural Development and Food). An attempt is then made to systematically assess the socio-economic characteristics of the aforementioned municipalities through a comparative analysis with the corresponding features of the rest of the coastal area of Greece where aquaculture enterprises do not operate.

Keywords: Aquaculture, economic demography, coastal area, Greece.

JEL Codes: J10, Q22

A bilevel scheduling algorithm for maximizing NPV in forests with different rotation ages

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Abstract

The forest harvest scheduling problem constitutes an important problem category of the forest management problems. Especially, when multiple forests are available with different forests with not the same rotation age, then the sustainability must be guaranteed in the end of the planning horizon. The present paper studies the maximization of the Net Present Value (NPV) under forest scheduling constraints. Specifically, a bilevel scheduling algorithm is proposed, for maximizing NPV in forests with different rotation ages. Furthermore, some preliminary computational results are also shown in order to assess the benefits of the proposed Bilevel Non Linear Programming (BLNLP) model. Finally, a discussion of the results of a scenario analysis is also presented.

Keywords: Bilevel optimization; linear programming; forest harvest scheduling problem; environmental economics.

JEL Codes: C61; C63; Q23; Q51.

Why people care about climate change

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Abstract

There is an increasing debate among many people about the existence of climate change. This debate has often focused. This debate often focuses on peoples' opinion about the causes of climate change, its consequences and the responsibilities. Climate change is an important issue facing the world today, but some think that is an overstatement. This research tries to contribute to the public debate aimed at a sample of 250 respondents of Cyprus. The research attempts to explore people's knowledge for climate change and segment the sample into groups according to whether people accept or reject the climate change. For data analysis a combination of applied methodological research techniques like Correspondence analysis and Principal Component Analysis was used. Using a significant amount of data, we examined the impact of direct experience with changes in weather conditions, beliefs, hierarchy of environmental issues, people information in order to justify their attitude towards the environment.

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Keywords: Carbon emissions; decomposition analysis; growth, energy; European Union.

JEL Codes: O44; O47; O52; Q43; Q56.

KEYNOTE SPEAKER:

Evaluating Agro-food Systems in a Sustainable Context

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Abstract

The paper presents an overview of evaluation and valuation methods used to assess the dependence and impacts of agricultural and food (AGRIFOOD) production, processing, distribution and consumption activities on supporting ecosystems and their services, and on human wellbeing. The selection of evaluation criteria and valuation methods appropriate for various decision making processes along the AGRIFOOD value chain is illustrated with examples. Typical applications where evaluation and valuation could help would be in addressing the following questions:

1) To what extent can food security be improved through agricultural intensification, as opposed to expanding the area devoted to agricultural production, and in both cases what are the external costs and benefits?

2) Organic farming and low external input agriculture are presented as alternatives to conventional farm management systems, which proponents claim will better protect the health of soils, plants and wildlife. What are the impacts of these practices on society?

3) Food production has multiple environmental impacts and ecological dependencies. What farm management systems and practices can ensure food security while reducing adverse environmental impacts? What are the synergies and trade-offs involved?

3rd SESSION: *Waste Management - Circular Economy*

Evaluating 22 EU Member States' 'waste culture' using Hofstede's and Schwartz's cultural dimensions

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Abstract

The issue of municipal solid waste (MSW) arisings has received great attention recently as it is a by-product of economic activity but also serves as an input to the economy through material or energy recovery. In relation to that, the main focus of this study is cultural formation and especially the current picture of waste culture and public perception across European Union (EU) Member States. Thus this study will first evaluate environmental efficiency with Data Envelopment Analysis (DEA) based on five parameters: waste, gross domestic product (GDP), labour, capital, and population density for 22 EU Member States and for the years 2005, 2010 and 2015 in order to evaluate which Member States are more efficient. Then the results from the efficiency analysis are contrasted to Hofstede's and Schwartz's cultural dimensions on STATA with the use of regression modelling. Results show that for year 2005 no significant relationship is noticed between the efficiency scores and the cultural dimensions' data from both researchers, whereas for years 2010 and 2015 there appears to be a significant connection with changes in the predictors also affecting the response variable. Among Hofstede's dimensions, individualism, uncertainty avoidance, long term orientation and indulgence were positively associated with the efficiency scores regarding waste arisings for 2010 and 2015. The relationship between Schwartz's cultural values and the DEA efficiency scores was not found to be significant. Findings suggest that Hofstede's cultural dimensions would be best to be considered when developing national level strategies and campaigns to manage waste arisings. The above mentioned findings can be associated with the financial crisis that has hit Europe after 2008 making people more sceptical on environmental issues and how waste is best to be managed making sense financially but also environmentally. At the same time EU legislations have laid out some important Directives in the field of waste management. Finally, along with the factors above, EU has been faced with severe environmental challenges due to waste arisings, as well as accidents and injuries for people working in this sector. All these factors have widely modified waste culture and public's approach towards waste as represented by the study's results as well.

Keywords: Environmental efficiency; waste culture; EU Member States; DEA; environmental policy; regression analysis; cultural dimensions

JEL Codes: O44; Q53, Q56; Z1.

The added value of the cement industry in the circular economy

Eric Waeyenbergh

Advocacy Manager and Health Geocycle Europe

Abstract

The production and recycling of concrete is of upmost importance in the context of the circular economy. Waste resulting from the treatment of construction and demolition waste can be recycled in the concrete production. But waste can also be recycled in the production of cement; participating to the implementation of the circular economy. The presentation covers the safety and health aspects related to the recycling of waste in the cement production, climate change and energy saving, environmental impacts and the potential of applying the principle of the circular economy, with the recycling of post-consumer waste, considering the social impact and responsibility of the recycling of waste.

Keywords: Cement industry; circular economy; recycling; waste treatment

JEL Codes: Q53; Q56

Circular economy aspects in sustainability reports: A critical overview of Greek market

Konstantinos Evangelinos, Stefanos Fotiadis, Panagiotis Vouros, Christina Mpitsori, Antonis Skouloudis, Ioannis Nikolaou

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Abstract

The concept of Circular Economy (CE) comprises a unique sector of interest for businesses, governments and local communities as several opportunities and challenges stem from its implementation. This paper aims to emerge CE aspects distracted from forty sustainability reports published in 2016 as well as their application in Greek Market. A compound disclosure index was drawn reckoning on five Environmental Category indicators close to the CE concept. Findings show that only a small number of sample firms present a leniently good performance and comply with the proposed CE indicators. The general trends indicate that the absence of communal or national law over CE's matters in combination with the unawareness of the benefits from its implementation, contributes to low integration. In contrast, a recognized definition of CE protected by the proper legislative framework should be set up inciting the whole Greek business sector to adhere to the suggested indicators while preparing annual Corporate Social Responsibility (CSR) Reports.

Keywords: Circular Economy; CSR Reports; Sustainable Development.

JEL Codes: Q56; Q57

Circular economy in Greece: Evidence from Central Macedonia

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Abstract

Sustainability, in terms of economic models, is defined as the achievement of current needs without directly or indirectly compromising the needs of future generations. This is closely linked to circular economy (CE). Circular economy represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits. At EU level, circular economy concept is receiving increasing attention not only in the enterprise sector but also at the academic. In fact, the European Environmental Agency, recorded that the annual net benefits for EU-27 businesses from implementing resource-efficiency/CE measures, such as waste prevention, the recovery of materials, changing procurement practices and the re-design of products are estimated to range from EUR 245 billion to EUR 604 billion, representing an average of 3–8% of annual turnover for 2016.
In the aforementioned framework, this study analyses regional policies that should be introduced in order to force Greek enterprises to take advantage of the recirculation of resources and energy and the recovery of value from waste and the current challenges. Finally, the study briefly examines the integration opportunities between SMEs with other companies and industry associations or clusters to develop industrial symbiosis and close their materials loop.

Keywords: Circular economy; economic growth; policies; Central Macedonia.

JEL Codes: Q01, O44, O47, E32, E21

Measurement of green industrial performance: an enhanced GIP index

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Abstract

The green industrial performance (GIP) index provides policy-makers and development specialists with a sound tool to analyse and compare the performance of economies in terms of green manufacturing. The development of such an index responds to the demands for an environmentally-respectful industrial development process as per the 2030 Sustainable Development Agenda. The demand for sustainable development seems not be matched with the existence of an analytical framework to measure to how green the change of an economy is. Building on our earlier research, the article introduces methodological improvements to the green industrial performance (GIP) index.

In previous research, we identified and constructed a set of indicators covering the various facets of the green industrial performance of economies. We also introduced a composite index to rank economies according to their green industrial performance. In this article we address some of the limitations of the index and how it is calculated. To improve the non-satisfactory data coverage, we investigate alternative imputation methods; refine our list of "green" products; and test new outlier detection methods.
Using the enhanced GIP index, we carry out an analysis of green industrial performance covering a large set of economies.

Keywords: Green manufacturing; structural change; sustainable development; composite index.

JEL Codes: O14; Q01; Q56.

Investigating the impact of wellbeing on economic performance: Evidence from European Union countries and regions.

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Abstract

Every society seeks to achieve an advanced level concerning the status of well-being both in social and economic level. Gross Domestic Product (GDP) indicates a primary measure of determining economic development between regions, within countries, across nations. Hence, it is considered a fundamental statistical measure the level of which might be crucial to make decisions and choose a direction concerning the course and level of development within a territory unit. In this perspective, the purpose of this study lies in investigating potential impacts that a wide range of well-being and world governance composite indicators exert on regional GDP per capita for the year 2016 (cross-sectional approach). Regressors found to positively impact regional GDP per capita implying that even non-material conditions might become crucial to achieve regional economic development. Significant practical implications have been derived based on research findings which in turn can be incorporated in relevant regional policies.

Keywords: regional economics, development

JEL Codes: I31 , R10 , O10

4th SESSION: *Environmental Issues & Concerns*

The Relationship between Environmental Degradation, Economic Development and Corruption: A Panel Data Cointegration Analysis of Asian Emerging and Developing Countries

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Abstract

According to the International Monetary Fund (IMF, 2017), the share of Asian emerging and developing countries in the world's gross domestic product (GDP) doubled from about 16% in 1998 to about 32% in 2017. Within the same period the annual average growth in real GDP of Asian emerging and developing countries amounted to about 7.43 %, whereas the world's average growth in GDP was only about 3.78% (IMF, 2017). These numbers show that within the last 20 years the economic development in emerging and developing Asia significantly increased. Projections suggest that this trend will hold at least for the next five years (IMF, 2017).Unfortunately, in line with this development, the amount of climate-damaging carbon dioxide (CO2) emissions also increased. While in 1998, CO2 emissions from burning of fossil fuels and the manufacture of cement in emerging and developing Asia amounted to about 4.91 million kilotons, this number increased to about 13.67 million kilotons in 2014. Overall, Asian emerging and developing countries were responsible for about 38 % of the world's CO2 emissions in 2017 (World Bank, 2017).

A potential solution to this problem is given by the theoretical concept of the so called Environmental Kuznets Curve (EKC) hypothesis. The hypothesis states an inverted U-shaped relationship between environmental degradation and economic development. That is, initially environmental degradation increases with economic development, but after a certain level of economic development environmental degradation turns to decrease (Grossman and Krueger, 1991). Numerous studies in the area of developing and environmental economies have studied the relationship between economic growth and environmental degradation in the context of the EKC hypothesis (see e.g. Stern (2004), Dinda (2004) and Kaika and Zervas (2013)) for extensive reviews). However, only a few have empirically analyzed the impact of corruption on this relationship (see e.g. Welsch (2004), Cole (2007) and Leitao (2010)).

Overall, previous research indicates a three dimensional relationship between environmental degradation, economic growth and corruption. However, findings for the indirect and direct effects within this nexus are mixed. Our study contributes to the empirical literature by analyzing the long-run relationship betweenCO2 emissions, gross domestic product (GDP) and control of corruption for 25 Asian emerging and developing countries in the period from 1998 to 2014. In order to do so, we apply recently developed second generation panel data cointegration methods that account for a number of estimation problems such as unobserved heterogeneity, cross-sectional dependence and endogenous regressors. Thereby, we are able to provide state-of-the-art research results that account for several limitations in previous studies. Furthermore, by focusing on Asian emerging and developing countries we aim to shed light on the importance of good institutional quality for a sustainable growth path in one of the fastest growing regions in the world.

Keywords: Economic development; degradation; corruption; panel data analysis; Asian emerging countries; developing countries

JEL Codes: C23;Q50;Q56

Can we hedge an investment against a potential unexpected environmental disaster?

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Abstract

The purpose of this paper is to approach the way investors perceive the risk associated with unexpected environmental disasters. More specifically, the paper examines certain types of natural and technological disasters, which tend to be associated. The literature describes these types of disasters as "na-tech", wishing to emphasize the fact that a natural disaster can lead to successive natural or technological disasters. Based on literature and historical sources, the most common types of such disasters are geophysical and industrial environmental disasters. All the unexpected events that have occurred since the beginning of the new millennium and belong to these sub-categories are examined in an attempt to determine whether an unexpected event may affect the investor's point of view of the risk associated with the event and consequently his investment psychology. In order to study the investment response to the potential risk of a natural disaster, the prices of country bonds are used, and in the case of technological disasters, the share prices of the enterprise which is responsible for the disaster are used. The methodology proposed by the literature for field inquiries is being applied with purpose to obtain results that will allow us to accept or reject the hypothesis regarding the possible market reactions. The results of the survey can be used by investment advisors to provide investors with a-priori information to avoid volatility and instability after a devastating event. They can also be used by governments, especially of those countries who are more susceptible to these catastrophes or countries that tend to invest on those countries, in order to compensate and hedge for their potential risk in advance.

Keywords: natural, technological, disaster, market reaction, investor's phycology

JEL Codes: C58; C59; F21; Q50: Q54.

KEYNOTE SPEAKER:

Inclusive Growth for Sustainability: Measurement from Inclusive Wealth Report 2018

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Abstract

The Inclusive Wealth Index is a new way of measuring a nation's wealth, taking into account human capital (education, skills, earning potential, life expectancy, and population) and natural capital (fossil fuels, minerals, forest resources, fishery, and land), as well as produced capital (roads, railroad tracks, buildings, vehicles, machineries, etc.). This is a more comprehensive index than previous ones such as GDP, which measures income, and HDI, which incorporates education and life expectancy in addition to income. In our new UN published report, as a director of the report on 140 countries from 1990, I provide the valuable insights into investment strategies of countries on nature, health, education and demonstrates the use of the Inclusive Wealth Index as a key indicator for sustainable, stronger, and more peaceful development. This provides message to inclusive growth discussion on SDGs framework.

Assessing the impact of a climate change adaptation intervention: Evidence from Central Highlands of Afghanistan

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Abstract

This paper evaluates the impacts of the first climate change adaptation project in Afghanistan, supported under the Least Developed Countries Fund (LDCF). Using a novel dataset of 169 farmers, we employ propensity score and regression-based methods to estimate the community level impacts of the treatment in Bamiyan Province. The findings suggest positive impacts of the intervention on female engagement in farming, risk of drought, on-farm employment, and use of improved types of seeds and crop varieties. Our results, however, do not show any significant project effects on the risk of flood. The results are robust to a number of different specifications and existence of mild unobserved covariates. We conclude that while the project has been a successful demonstration of adaptation interventions; in order to fully address the existing and expected climate-related risks, however, a long-term, full-size intervention should follow.

Keywords: Climate change, adaptation, Least Developed Countries Fund, Afghanistan.

JEL Codes: C21, Q25, Q54, Q58;

What drives responsible business? Examining the links between reputation risk, non-government organization (NGO) pressure and responsible business performance

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Abstract

This paper investigates the comparative influence of reputation risk and NGO pressure on corporate activity in the field of environmental responsibility. The paper revisits research to test if there is a perverse incentive between environmentally damaging industries and perceived environmental performance, reputation and disclosure. Access to industry leading database sources are also utilized to test the hypotheses more rigourously and improve on original data. Through new research, the role of NGO's is tested to understand the comparative strength of this relationship. The finance sector is also incorporated into a second set of samples to test in view of the increasing focus by campaign groups on the sector as a facilitator of damaging sectors. The sample sets are derived from the Newsweek Green 500 published annually by Forbes. A regression analysis is conducted on all metrics along with various forms of correlation testing on all relationships. Testing indicates the role of NGO's being more significant than reputation risk metrics or alignment to responsible investor ratings. Within the sample set the role of finance companies is also more pronounced than the traditionally supposed environmentally damaging issues. A negative correlation between financial performance and one of the disclosure metrics is also found.

Keywords: Environmental; NGOs; Ratings & Ratings Agencies; Reputation; Social Responsibility.

JEL Codes: G24; L14; L31; M14; Q56.

Prediction of Global Warming impacts using Fuzzy Cognitive Maps and Semantic Web techniques

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Abstract

One of the most important problems of our era is Global Warming. Both the ecological-economic impacts of Global Warming and also the mechanisms that cause the Greenhouse Effect are thoroughly studied and reported. In this paper, a model of the causal relationships that exist in the field of global warming is created, using the well-established Artificial Intelligence technique of Fuzzy Cognitive Maps (FCMs). The FCM technique incorporates ideas from Artificial Neural Networks and Fuzzy Logic. Various scenarios are imposed to the FCM model and predictions are made on these, by simulating FCM dynamic behavior and studying the equilibrium that the FCM dynamic system reaches. For making these simulations, a semantic web software tool was created that also makes the results and various models easily accessible to other users or systems, through the Internet. Policy makers can use this technique and tool to make predictions by viewing dynamically the consequences that the system predicts to their imposed scenarios.

Keywords: Global Warming; Computational Techniques, Simulation Modeling; Neural Networks and Related Topics; Forecasting and Prediction Methods, Simulation Methods.

JEL Codes: Q54; C63; C45; C53.

Towards better tools for effective environmental policy

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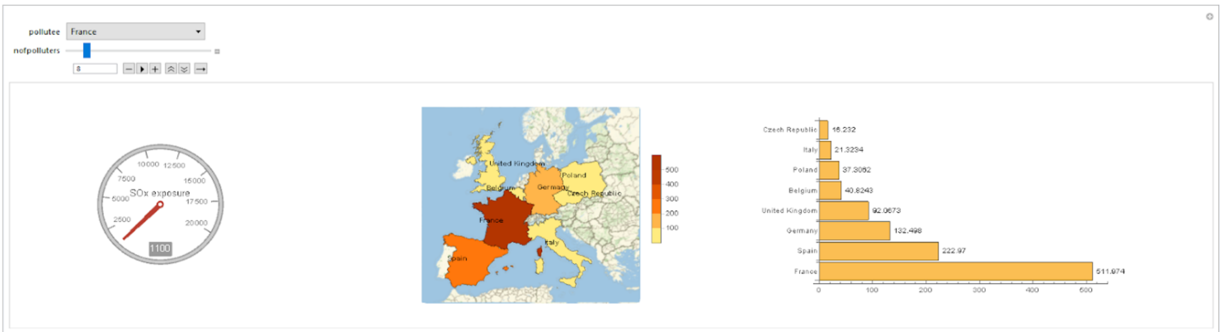
Abstract

Effective environmental policy should be based on robust information on trends. Our objective in this paper is to make data-driven decisions: we aim at policies that are built on officially reported emission data and we make use of intuitive tools and interfaces to guide environmental policy with completeness and consistency.
Transboundary air pollution is a two-sided problem involving a polluter and a pollutee. The visualizations we have created allow a user to conceive the transboundary air pollution scheme from either the polluters' or pollutees' perspective.
Based on the European Monitoring and Evaluation Program (EMEP) source-receptor records during 2004 to 2014, we develop comprehensive pollution monitoring systems. Our systems are created in visualization software in order to bring out the status, attributes and dynamics of transboundary air pollution. Our monitoring applications consist of different visualization modules. All of these modules carry their own information, which can be used separately or together to serve specific visualization tasks: either the polluters' responsibility or the pollutee's vulnerability. Several interactive interventions are integrated into each module to achieve particular visualization goals. Controls are added for the number of polluters, the year of study, the level of pollution, the geographical zone, all within the extended EMEP area.



Environmental damage on the EMEP scale of SOx pollution in France (left), localization of SOx pollution responsibility (center) and raking of pollution responsibility (right) for SOx pollution in France, 2010.

Keywords: Visual analytics; pollution monitoring system; geographical heat maps.

JEL Codes: C63; C88; Q53; Q58.

Identification of regimes in river behavior using nonlinear timeseries analysis

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Abstract

Non linear timeseries analysis covers a wide field of applications with methods based on phase space reconstruction which are giving useful results for understanding the system's dynamics. In the present work we apply nonlinear time series methods and more specifically the method of Recurrence Plots (RP) and Recurrence Quantification Analysis (RQA on 16 year of daily values of the Nestos river water level recorded at the Temenos measurement station. From this analysis important parameters such as "%Recurrence", "Determinism", "Laminarity" and "Tapping Time" are extracted giving important information about system's periodicities and phase transitions which help us to locate seasonal changes and extract useful conclusions about possible changes of the behavior of the environmental dynamical system as years passing by (climate changes).

Keywords: Non Linear Timeseries Analysis; Recurrence Plots; Recurrence Quantification Analysis; Climate Change.

JEL Codes: C02; C22.

6th SESSION: ***Sustainable Transport***

Real-time road traffic forecasts – a hybrid approach using artificial intelligence and Singular Spectrum Analysis

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Abstract

The paper presents a hybrid methodology of time series analysis and forecasting, applied on road traffic data, which leverages from Singular Spectrum Analysis (SSA) and Artificial Neural Network (ANN). The main objective of the research was to develop a short–term forecast of daily traffic of toll roads across Greek National Highway Network. The proposed methodology was implemented and evaluated upon an integrated software, based on Mathworks MatLab, which was developed by the authors. Experimental outcomes on daily data, from specific tolls, show a superior prediction accuracy of hybrid SSA–ANN forecasting methodology, when compared to performance of statistical criteria such as root mean squared error (RMSE), mean absolute error, MAE) and coefficient of determination R^2. Results comparison reveals that the hybrid SSA–ANN improve the forecasting accuracy of an ANN model in daily traffic load forecasting. An Intelligent Transport Systems (ITS) with embedded hybrid SSA–ANN forecasting methodology can enable proactive decisions to mitigate the economic and environmental impacts of transport infrastructure congestion.

Keywords: Singular spectrum analysis; artificial neural network; traffic load; forecasting; transportation

JEL Codes: C45, C53, C55, R41.

6th SESSION: *Sustainable Transport*

Examining the determinants of CO2 emissions caused by the transportation sector activity: Empirical evidence from 12 European countries

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Abstract

The transportation sector consists the second most important sector that contributes in the production of the CO2 emissions worldwide, while it consumes more that the one third of total energy consumption within the country-members of the EEA. Towards climate change mitigation, policies and regulations, and new infrastructure investments are employed so as to facilitate the route to a low carbon economy. In this paper we investigate possible determinants of CO2 emissions caused by the transportation sector activity for 12 European countries over the period 1994 to 2014. We examine the effects of Environmental Policy Stringency, Climate Change Mitigation Technologies related to transportation, share of value added by the transport sector and infrastructure investments (rail, inland and road). We employ panel data analysis; panel unit root tests, panel cointegration tests, the Fully-Modified OLS (FMOLS) approach, the Dynamic OLS (DOLS) approach and Granger causality test are employed in order to examine the relationship between CO2 emissions caused by the transportation sector activity and their statistically significant determinants.

Keywords: transportation sector, climate change mitigation, CO2 emissions, European countries

JEL Codes: C23, C33, O33, Q56, Q58

6th SESSION: *Sustainable Transport*

Artificial Neural Networks: A Modern Tool for Empirical Modeling of Transport Demand

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Abstract

In the present paper it is analyzed how modelling and forecast of future transport demand can be conducted with application of artificial intelligence and particularly of the method of artificial neural networks (ANN). This method permits to derive conclusions for the evolution of a phenomenon for which a set of input – output data are available, without any requirement to know how input data are transformed to output data. ANN is an empirical method inspired from the way of operation of biological neurons, how and under what conditions are biological neurons activated, operating and learning. The method of ANN is used in the paper to model and forecast future transport demand in relation to the evolution of GDP and other driving forces of the problem, for mature and developing air transport markets.

Keywords: Empirical models, artificial intelligence; artificial neural network; forecasting, transport demand

JEL Codes: R41; C45, C52; C53; R15

6th SESSION: *Sustainable Transport*

The contribution of the road transport projects of the NSRF 2007-2013 to the development of a Greek region

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Abstract

The purpose of the present paper is to study how the actions of the road projects of National Strategic Reference Framework (NSRF) 2007-2013 contributed to the development of the Region of Eastern Macedonia and Thrace, as these actions were included in the respective Operational Program of Eastern Macedonia and Thrace 2007-2013. It analyzes the European regional policy, examines the cohesion policy of the European Union, which aims to reduce regional inequalities and ensure the social, economic and territorial cohesion. In Greece, the cohesion policy implementation for the period 2007-2013 was achieved through the NSRF 2007-2013, where the present study presents its training philosophy and the priorities set. The study area concerns the Region of Eastern Macedonia and Thrace, followed by the analysis, characteristics and results of the Operational Program of the Region of the same period, through which 87 road projects were implemented. Data are collected for each of these projects and, through the presented research methodology, conclusions are drawn on the contribution of these actions to the development of the Region.

Keywords: Regional Development; Regional Policy; Regional Inequalities; European Cohesion Policy; Operational Program for East Macedonia and Thrace.

JEL Codes: O18; R50; R58.

Investigation of bicyclists' riding behaviour under normal traffic conditions in the road network of a mid-sized Greek city

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Abstract

This study examines the bicyclists' riding behavior under normal traffic conditions in the urban road network of Volos which is a mid-sized Greek city. In order to conduct this study, a new methodology was developed based on the use of GPS technology embedded in instrumented vehicles for the acquisition of behavioral and performance data parameters such as speed, position and lateral/longitudinal accelerations. All these parameters are crucial for 2-wheeler road users compared to the 4-wheeler ones. Although extensive literature review refers to naturalistic driving studies, no relevant research of naturalistic riding studies for bicyclists has been conducted so far. This study proposes a practical, low cost and time effective process to evaluate the perception of traffic conditions under the bicyclist's point of view. This study concludes that it is feasible to record bicyclists' speed and acceleration profiles with accuracy and speed. Moreover, supports that there is a strong indication that bicycle is a rather controllable and predictable transport mode. However, in order to generalize the conclusions drawn in a wider proportion of road users, more experiments including a greater number of participants and road sections should be conducted.

Keywords: Bicycle; road safety; speed; acceleration; naturalistic study.

JEL Codes: O18; O33; R41.

Budget and environmental subsidies: Optimal management and a dynamic game

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Abstract

This paper is concerned with a classic topic of intertemporal environmental economics: the optimal management of environmental quality over time by the environmental regulator and the dynamic conflict between two groups of economic agents involved in environmental quality. The traditional management model with subsidies is extended towards a two–state model in which any taken environmental subsidy is treated as a result of historical adjustments, i.e. as a stock variable. As a consequence of this extension, an equilibrium dynamics with bifurcations and limit cycles occur. In the next step we discuss conflicts as a game with two types of players involved: the enjoyers of the good environmental quality and the heavy equipped exploiters of the environmental quality. Both players have a common interest to consume: the subsidy function, thought as a budget harvesting function, which is dependent both on utility enjoyed by the citizens and on the intensity of the extractors effort.

Keywords: Budget, subsidies, environmental quality, optimal control, differential games.

JEL Codes: H61, H23, Q50, C60, C72

Modeling a closed economy by a lattice Hamiltonian

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Abstract

This research uses a physics model, i.e. particles in lattice, in order to study a closed economy of an isolated place (e.g. planet or island). The 3−particle Toda model is Hamiltonian and thus fully conservative. We reproduce an economy of three populations (human, fauna, flora), instead of a lattice of three particles. Higher populations lead to higher positive energies (that represent their effect on environment), up to infinity. But, incomplete information, imperfect technology and adaptation make this idea unrealistic. Instead, odd order truncations have pretty realistic properties, applicable on environment: for low positive populations, their effect on environment is positive and increasing. After a level of maximum benefit, effects become decreasing and, inevitably, negative. These (over)populations might destroy their environment. In parallel, higher populations create chaotic trajectories. Higher order of truncation have similar properties, but higher populations can survive, since they are closer Toda approximations, representing technological developments, macrocultural evolution and better adaptation to environment. Overpopulation and disaster point exist, no matter how high the odd−order truncation is. In a perfect world, infinite odd order truncation can be achieved and can eliminate overpopulation limits.

Keywords: Hamiltonian dynamics, Closed economy, Overpopulation, Ecosystem, Sustainability.

JEL Codes: Q56, Q57, C61

Adopting Tolerance Intervals in Environmental Economics

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Abstract

When limited knowledge is associated with the underground problem under investigation we are not certain on the process we have to follow, therefore there is uncertainty. The measure of uncertainty is associated with the Fisher's information. Notice that uncertainty in practice is related with the physical problem under investigation. A typical example can be the Environmental Economics system under study. There is a number of model specifications estimating eventually the Benefit Area, as the intersection of the given marginal abatement function, with the marginal damage cost function. The point of their intersection is known as the optimal level of pollution. The corresponding in damage reduction axis point is known as the optimal level of reduction pollution. For the optimal level of pollution we can evaluate the corresponding tolerance region – either the classical or the expected tolerance interval – and therefore we obtain four possible optimal level of pollution and the corresponding tolerance interval for the reduction pollution point. The associated four Benefit Areas can be evaluated, due to the adopted Tolerance Region procedure, rather than a Confidence Interval approach.

Keywords: Uncertainty; Environmental Economics; Mathematics; Statistics

JEL Codes: C02; C60; Q00; Q50

Wind energy potential based on Visibility Complex Network and Recurrence Plot time series analysis

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Abstract

Renewable energy sources where wind power is an important part are increasingly participating in developing economy and environmental benefits. The present work approaches the problem of identification of the underlying dynamic characteristics and patterns through the Complex Network and the Recurrence Plots (RP) time series analysis of velocity and angle wind time series. The data were collected by cup anemometers located in a measurement tower installed in the mountains of the region Achaia, Peloponnesus, Greece. We have demonstrated that the proposed analysis provides useful information which can characterize distinct regions of the time series and also identify and detect dynamical transitions in the system's behavior. The results will be useful for the prediction of the produced wind energy.

Keywords: Non Linear Time series Analysis; Recurrence Plots; Recurrence, Quantification Analysis Complex Networks, Visibility algorithm, Wind time series

JEL Codes: C02; C22.

7th SESSION: *Quantitative Methods in Environmental & Resource Economics: Mathematics*

The economy of packed products' oxidation process

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Abstract

This present work introduces an illustration of natural phenomena and quantification of the natural factors involved, based on a direct analogy between their evolution processes to an oligopolistic competitive environment. In particular, the authors aim to deal with "oxidation processes" as such production sites that use ("consume") the "raw materials" (oxygen molecules) according to their incoming production capacity (oxidation potential): the imported commodity (oxygen), the recipient companies operating in a limited market (oxidation substrate) and the determinant factor that resembles borders, affecting the size of the productive activities of the overall market (packaging as a the controller of the incoming goods) and the related by-products, such as the cost of production resources, that are directly related to the activation energy requirements of these reactions occurring positions and the availability of the raw materials. Therefore, describing natural phenomena in a stochastic mathematical way will allow the use of those fundamental elements of statistical physics to integrate deterministic processes (and quantities) into a micro-scale. It is the opinion of the writers, that the innovation of this work is the use of economic laws for the world of natural phenomena, against the, commonly used and generally accepted, inverse process.

Keywords: natural phenomena, oligopolistic competition, stochastic mathematical modeling, statistical physics.

JEL Codes: E220; E230; E250; E270; F120; F140; F170; F410.

Energy transition, poverty and inequality: Insights from panel data for Vietnam from 2004 to 2016

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Abstract

We use panel data of a nationally representative household survey on energy consumption expenditure of more than 9,000 households to investigate the changes in household energy use, energy poverty and energy inequality in Vietnam over the period 2004 to 2016. Results show that households tend to move from biomass based to cleaner energy sources of gas, petroleum and electricity. However, this transition is different across regions, between ethnicities and welfare groups. This progress is more clearly seen in the Red River Delta region where households reduce significantly their expense on coal and biomass, and increase the consumption of gas and electricity. By comparison, poor and ethnic minority households in the Northern Mountainous region still heavily rely on coal and biomass to meet their energy demands. Regarding energy poverty incidence, rural households of the minority ethnic groups in the Northern Mountainous region are the poorest in most of poverty indicators. During this period, the electricity – based energy poverty has decreased, but in terms of the burden of energy cost, this poverty indicator has experienced a significant increase. Regarding inequality indicators, energy consumption inequality tends to decrease more than household income and consumption inequalities. Among energy sources, gas, oil and electricity inequalities tend to decrease whereas coal inequality has increased.

Keywords: Energy transition; poverty; inequality, panel data; Vietnam.

JEL Codes: O13; P25; O53.

Assessing the sustainability of renewable energy sources with the combination of life cycle and SWOT analyses

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Abstract

The production and consumption of energy, as well as the environmental problems that arise, occupy a prime interest for all states on a global scale. The adoption of a policy towards green energy has been greatly improved, but it has to become more concrete. This study will assess various renewable energy sources using life cycle analysis (LCA) and SWOT. Applying life cycle analysis to a product enables the optimization of raw materials, energy and environmental impacts. Similarly, implementing a life cycle analysis on renewable energy sources can highlight the most environmentally friendly source of energy. Simultaneously, the SWOT analysis shows positive and negative elements and as a result, it helps in preventing strategic planning errors for energy production. The combination of these two analyses helps decision-making, strategic planning and environmental management as regards the choice of the most appropriate renewable energy source.

Keywords: Life cycle analysis, SWOT analysis, energy sustainability, renewable energy, energy policy.

JEL Codes: O13, P18, Q28, Q48, Q58, Q01, Q29, Q42.

Energy policy establishment for off-grid small isolated settlements

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Abstract

This work presents a methodology for identifying the most appropriate location(s) for installing low-scale RES-based hybrid electricity production systems to cover the local energy demands without grid connection. The selection is initially based on geographical, geospatial and demographical data, while the proposed method is based on the optimal combination of the meteorological data (solar and wind potential), the available resources (in terms of free space and of investment costs) and the desired load. On top of that, optimization of both the size and the operation of the hybrid system is also performed. To efficiently match the produced energy with the demands, a potential interconnection with one nearby settlement with the same characteristics is also considered. Finally, the economic balance of costs (installation, operation & maintenance, replacement) and benefits is presented, and the proposed system is judged against it. In conclusion, this study could act as a policy tool for off-grid power production in national level.

Keywords: Off-grid power production; Renewables.

JEL Codes: Q28; Q42; Q48; Q56.

Selection of optimal on shore wind farm sitting locations in Greece, using Multi criteria Decision Analysis

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Abstract

The usage of Renewable Energy Sources (RES) is increasing throughout the world as there is a global effort to reduce the dependence from fossil fuels which are considered as a main cause for climate change. Wind Farms currently are rated among the most common forms of RES applications especially in countries like Greece. The optimization of spatial planning in order to identify the most suitable places for the installation of wind farms is one of the most difficult problems because there is a need to identify and calculate the effect of a variety of both qualitative and quantitative parameters. Multi Criteria Decision Making Methods (MCDM) are commonly used in order to solve this problem and are combined with Geographic Information Systems (GIS) to spatially represent the results from the application of the MCDM methodology. In this paper we demonstrate a methodology which applies the current legislation and uses an MCDM methodology called Analytical Hierarchy Process (AHP) and GIS in order to determine the most suitable locations for wind farms installation.

Keywords: MCDM, AHP, GIS, DSS

JEL Codes: Q01, Q20, Q28, Q47, Q48

Determinants of household electricity consumption in Greece: A statistical analysis

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Abstract

Over the last decades, the contemporary way of living, as well as, the technology development have increased the household electricity consumption. However, the excessive use of electricity consumption has an impact on the environment increasing the carbon footprint and contributing to the climate change. Governments are concerned about the way that our societies consume energy and are committed to reduce the greenhouse emissions. As the residential sector contributes to electricity consumption, it is crucial to investigate the socio-economic parameters, dwellings' characteristics and climate conditions that determine the electricity consumption in households. The data of this study are collected from 1,801 dwellings from all Greece regions. In the statistical analysis two models are built, agreeing that the most significant determinants that influence the electricity consumption are the number of occupants, the size of the dwelling, the number of bedrooms, the heating type, the heating and cooling hours, the weather conditions and the fact of occupants not going on winter holidays.

Keywords: Electricity, consumption, determinants, socio-economic, statistical analysis.

JEL Codes: P18; P28; Q4; C1.

KEYNOTE SPEAKER:

Could Revealed and Stated Preference Techniques Produce Similar Outcomes for Policy Decision-making?

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Abstract

Most green spaces have amenity values. However, during certain months of the year green spaces turn into dis-amenities. Bushfires are a case in point. In this presentation we attempt to show that residents on average are willing to pay more to live closer to green space than farther away thus discounting the possibility of bushfires. Where recent bushfires have occurred the process is reversed. Our initial research findings suggest that it is possible to validate results of a revealed preference approach with a stated preference approach. Selected suburbs from Brisbane and Rockhampton, Australia are selected for this work. The potential implications of this study are discussed.

Understanding people's perception about biodiversity importance, management and conservation

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Abstract

The aim of present study is to contribute to a better understanding of the ways of the wider public reason about issues of biodiversity change and management, and more to determine the factors that influence people support for biodiversity management measures due to climate changes. For this reason a face-to-face survey of 468 respondents randomly selected was carried out. The sample was stratified to ensure adequate sample sizes to compare results from three geographical areas: 48.7% of the sample was from Pagasetic Gulf area, 26.1% from the Crete-Rethymno area, and 25.2% from the Lesbos (Mytilini). For this purpose, a combination of applied methodological research techniques like Correspondence analysis and Principal Component Analysis was used. The results indicated the relative importance of region to respondents' perceptions knowledge and concern about biodiversity. According to the results biodiversity loss will mainly influence our country due to consequences to environment quality, heritage and financial wealth, following the impacts to world economy, knowledge and inspiration.

Keywords: Biodiversity, People opinion, Natural environment management

JEL Codes: Q54; Q57; Q58

Valuation of ecosystem services and assessment of their social impacts

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Abstract

In the past decade there has been an increasing discussion regarding the links between ecosystem services and their impacts on human well-being. This is an important research field, especially in the context of designated Protected Areas, as the provision of ecosystem services is closely linked with the level of public acceptability for such policy initiatives. Numerous techniques have been proposed in order to measure and value ecosystem services. However, a gap remains in the literature in regards to the most appropriate ways to assess their impacts. The present article proposes new links between valuation techniques for ecosystem services and assessment of social impacts taking into consideration the complexities of the socio-ecological systems of Protected Areas. In particular, the authors of the paper propose that the assessment of social impacts needs to be part of the scientific process of valuing ecosystem services in order to have a more holistic understanding of the services provided from an ecosystem and how these impacts acceptability for conservation initiatives.

Keywords: Ecosystem Services, Social impact assessment, economic valuation techniques, well-being

JEL Codes: Q57

Psychological and contextual barriers to recycling, energy and water conservation behaviors: The role of personal and social factors

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Abstract

The present study shed light on the psychological and contextual barriers that affect recycling, energy and water conservation behaviors considering the role of a series of personal and social factors. We applied a questionnaire survey method and used Confirmatory Factor Analysis (CFA) and structural equation modeling (SEM) to analyze the data. We expect that social norms, self-efficacy feelings, sunk costs, and perceived risks inhibit eco-friendly behaviors. The results show that both personal and social variables have a significant influence on recycling, energy and water saving behaviors. However, each type of action have different determinants. The findings of this work can be used by policymakers to design and implement interventions to effectively promote environmental behavior taking into account the various barriers to these types of behaviors.

Keywords: Psychological barriers; contextual barriers; recycling; energy conservation behavior; water conservation behavior; personal factors; social factors.

JEL Codes: A14; C38; Q00; Q51; Q56; Q59.

Preferences and willingness to pay for protecting the marine and coastal environment from plastic waste: a case study of Syros Island, Greece

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Abstract

The presence of plastic waste in the coastal/marine environment poses a high economic burden and is closely associated with social costs in terms of pollution and waste. Thus, in order to preserve the healthy functioning of ecosystem services and ensure environmental sustainability it is deemed critical to reduce all forms of plastic waste at once. This study aims to explore citizens' and stakeholders' preferences and willingness to pay (WTP) for the reduction of plastic waste and especially plastic bags in the coastal/marine environment of Syros Island (Greece). In this framework, two separate surveys were conducted during May-June 2016 and May 2017. In the first survey a choice experiment method was used to assess the values of several ecosystem services most likely to be affected by the accumulation of plastic litter in the coastal/marine environment. A total of 341 completed and useful questionnaires were collected from Syros' Island citizens. In the second survey a contingent valuation technique was used, focusing on a specific target group (hotel/room rental facilities owners), resulting in the collection of 40 useful questionnaires. According to the valuation results of both surveys a significant percentage of both residents and hotel owners of Syros are supporting policies for the protection and conservation of the local coastal/marine environment.

Keywords: marine/coastal environment; plastic waste; willingness to pay; ecosystem services valuation; choice experiment method.

JEL Codes: Q51; Q53; Q57; C25; Q25.

9th SESSION: *Environmental Valuation*

Implementing Hedonic Pricing Models for valuing the visual impact of wind farms in Greece

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Abstract

Even though wind energy is a pollution-free and in finitely sustainable form of energy, there is considerable concern over some environmental effects resulting from wind power development. Criticism focuses primarily on the visual impact due to the installation of wind turbines and transmission lines, which results in the deterioration of the landscape and may harm the associated economic activities, namely tourism, real estate, etc. This study presents an application of the Hedonic Pricing Method for valuing the landscape externalities associated with the large-scale exploitation of wind power at the local level. Specifically, the presented research investigates roughly 1,800 sales of single-family homes surrounding 17 existing wind facilities in two Greek islands, namely Evia and Kefalonia. Developing four different hedonic models in the two areas, the results derived diverge. In Evia case study we found that the value of the dwellings per unit area increases with the distance from the nearest wind farm. On the other hand, in Kefalonia case study, neither the view of the wind facilities nor the distance of the home to those facilities is found to have a statistically significant effect on sales prices.

Keywords: Visual impact; wind energy; hedonic pricing; energy externalities.

JEL Codes: Q42, Q51.

Shark aggregation and tourism: Opportunities and challenges of an emerging phenomenon

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Abstract

In the last few winters, sharks have been aggregating near the Israeli Mediterranean coast, at a specific point, near Hadera power station. This unusual phenomenon has fascinated residents, visitors, kayakers, divers and swimmers. We analyse the effects of this intense human interest on the sharks, using contingent behaviour, in Hadera and in Ashkelon, where sharks are present but not the infrastructure for their observation. We also report on changes in shark behaviour due to change in tourism intensity. We find a change of about ILS 4.1 million annually for both sites but a larger individual consumer surplus in Hadera, where sharks are currently observable. Touristic intensity crosses the threshold level by about 12% and making the socio-equilibrium sustainable for both humans and sharks would have a social cost of ILS 0.157 million.

Keywords: Shark aggregation, shark behaviour, human-wildlife conflict, Mediterranean, Travel cost, tourism.

JEL Codes: Q26; Q51; Q57

Alternative forms of sustainable development: The case of thermal tourism

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Abstract

Thermal tourism is a special form of providing tourist services at special facilities that use recognized thermal natural resources. Thermal tourism blooms in Europe with pioneer country Germany. There are 1,400 developed bathing sites in Europe, visited by millions of patients from all over the world. This industry employs about 750,000 people and has an annual turnover of approximately 45 billion euros.
In Greece, thermal tourism is an important part of our cultural heritage and not only because Greece is one of the richest countries in natural sources with excellent quality water. Despite the fact that Greece is the first country in Europe in the quality and uniqueness of natural thermal resources, its thermal tourism is declining. Furthermore, in this article, efforts will be made to identify the causes that contribute to the reduction of thermal tourism, as well as to draw some conclusions with a view to improving and sustaining the thermal tourism.

Keywords: alternative tourism, thermal tourism, sustainable development.

JEL Codes: Q01, Z32.

Integrating sustainable supply chain management (SSCM) amongst Greek supermarkets

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Abstract
The retail supermarket sector has been affected by the recession experienced in recent years in Greece. That is why, supermarkets targeted to increase their performances, achieve reduction to operating costs employing sustainable supply chain management (SSCM). The purpose of the present paper is to analyze green logistics decisions within the retail supermarket sector by using economic, social, operational and environmental metrics. The research problem of this study is to examine the barriers and drivers that affect manager's perceptions on relation to sustainable supply chain management (SSCM), employing data from supermarket managers in Athens, Greece. Managers adopted several sustainable supply chain practices in order to increase the performance of the super market stores, such as material handling, waste management and reverse logistic. Results indicate that managers' decision to adopt green supply chain practices combined both organizational and economic criteria.

Keywords: Retail businesses, Supply chain management, Sustainability

JEL Codes: M59, Q01, Q55

The use of carbon shadow pricing as a tool to drive the de-carbonization of the Greek hotels operations

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Abstract

Nations regard tourism as a low-impact development option and massively invest in tourist-drawing infrastructure. However, recent research has shown that tourism is a carbon intensive activity, accounting for almost 8% of global GHG emissions. The accommodation sector in particular accounts for approximately 20% of tourism emissions resulting from ventilation, heating, air-conditioning and facility operations with data varying according to the location, type, size, occupancy and category of the establishments. The average carbon footprint of an overnight stay aggravates heavily if a life cycle perspective is used. The hospitality sector's target for carbon reduction to mitigate global warming and meet the Paris-set 2° Celsius cap requires that hotels reduce their absolute carbon emissions by 66% by 2030 and by 90% by 2050, against a 2010 baseline. These figures are significant but technically achievable and demanded if the industry commits to decoupling its strong growth from emissions escalation. A number of actions, tools, and innovative approaches must be adopted by hotels to decarbonise their activities. Carbon shadow-pricing is such a tool which, if effectively applied, may accelerate the available solutions. This paper suggests the use of internal (shadow) pricing by Greek hotels as an instrument to appraise the sustainable profitability of a hotel project, de-risk business, identify energy inefficiencies, and incentivize low carbon innovation within departments; it also proposes a methodology on how to set an internal carbon price in the Greek hospitality domain and how to make the most out of this initiative.

Keywords: Carbon emissions; hotel operations decarbonization; carbon internal pricing; carbon shadow pricing.

JEL Codes: O44; O47; O52; Q43; Q56.

10th SESSION: ***Sustainable Tourism***

Wind energy, an energy solution for hospitality businesses

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Abstract

Energy is a driving force for everyday human activities, both in the economy and in the technology. Many countries worldwide have realized the urgent need for clean, non-polluting power generation and are trying to be the main driver for electricity, renewable energy. (Kaplanis, 2003).
According to recent studies, the most economical and affordable renewable energy source has become the wind power. Wind systems are widely used in our time, and in this study we would like to present you the proposal of a team of Sheridan college engineers in Ontario, Canada, where they created a small wind turbine that promises to meet the electrical needs of a small hospitality unit, ie to produce energy reliably and at low cost.
Greece has an extremely rich wind potential and the wind power is practically an inexhaustible source of energy. The exploitation of its high potential in our country, coupled with the rapid development of technologies embedded in small, modern, efficient wind turbines, is of paramount importance for sustainable development, saving energy resources, protecting the environment and tackling climate change.

Keywords: Wind power, small wind turbines, hospitality units, sustainable development

JEL Codes: Q01, L83, O13, P28, Q42

Two stage DEA & marginal effects of environmental variables to TE index

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Abstract

In the present study, the non-parametric method of Data Envelopment Analysis (DEA) is applied, in order to determine the technical efficiency (TE) index of G7 countries when variable returns to scale (VRS) hold for the entire period under consideration, 1993 to 2012. As inputs labor and capital are used while we utilize GDP as output. In the second stage of our analysis the DEA bootstrap approach along the line of Simar and Wilson (2007) is applied, as a way to deal with the disadvantages of the non-parametric DEA method. The bootstrap provides a convenient way to simulate repeatedly the data generating process using resampling method so that the resulting DEA efficiency indices, of each simulated sample, mimic the sampling distribution of the original DEA efficiency indices. Through the procedure proposed by Simar-Wilson, we investigate the relationship between the efficiency evaluation of DMUs as calculated by the DEA method, in the first stage of our analysis, and the variables of arable land, total greenhouse gas emissions and total primary energy consumption. In addition, for these variables and through the estimated regression coefficients, elasticities and marginal effects to both TE and GDP index are calculated.

Keywords: Data envelopment analysis; Environmental Economics; Carbon emissions; Eco-Efficiency; Total factor productivity index.

JEL Codes: O11; O57; Q01; Q40; Q43; Q48; Q50; Q58; R15.

Research Intensities and R&D Input-Output Multipliers: An Examination of their Intertemporal Stability Using Data on the US Economy

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Abstract

Input-Output (IO) Analysis methods and their expansion to cover Research and Development (R&D) issues, resulted in the adoption of extended IO R&D multipliers. The latter show how changes in one or more sectors' final demands affect R&D expenditures in all sectors of the economy. The concept of sectoral research intensity defined as the R&D expenditures of a sector per unit of its own production value, is a necessary tool for the estimation of IO R&D multipliers. These intensities and multipliers are particularly useful for the quantitative analysis of the relationships between economic growth with R&D activities at a detailed sectoral level and for the whole economy as well. Knowledge of such relationships is particularly useful in order to device R&D policies and incentives. In order to achieve such a goal and make safe predictions, the stability of multipliers and intensities is a prerequisite. Using OECD data on the US economy, i.e. US IO tables and sectoral R&D expenditures for a series of years, we estimate sectoral research intensities and multipliers. Subsequently, their stability is evaluated using several established criteria in the literature with encouraging results which are presented and discussed.

Keywords: Input-Output Multipliers; Research and Development; Research Intensities.

JEL Codes: C67; D57; 031.

A merry triangle or a heavy cross? Environmental Efficiency, Productive Performance & Competitiveness under Technological Heterogeneity

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Abstract

We investigate the relationship between environmental efficiency, competitiveness and productive performance by adopting the country frontiers approach under a DEA meta-frontier framework. The interest is placed on 9 industries of Manufacturing and 4 of the transportation sector in 17 European countries from 1999 through 2006. Using a directional distance function we estimate environmental efficiency while at the second stage, we explore the potential of the latent instrumental variables approach to alleviate endogeneity concerns between the measures of performance. To cope with the case where sufficient instruments are not readily available, we attempt to identify the model through heteroscedasticity-based instruments. Findings under the no-endogeneity assumption indicate that the influence of competitiveness on environmental efficiency is weaker when productive performance is considered. Relaxing that assumption, we estimate the model constructing instruments as simple functions of the model's data while afterwards we augment the generated instruments using foreign direct investments as an instrument to find that competitiveness is not a sufficient condition for environmental performance improvement. Productive performance affects negatively and significantly environmental efficiency while its combined effect with competitiveness exerts no influence on the latter. Preliminary findings indicate that the particular triangle does not work, at least in the case examined herein.

Keywords: Environmental Efficiency; Competitiveness; Heterogeneity; Latent Instrumental Variables Approach

JEL Codes: C36; Q50; D20.

Measuring efficiency in forestry section using Network DEA approach: An application to EU countries

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Abstract

Forest production has become one of the most researched topics due to climate change and increased trend in demand for forest products (namely wood and paper). To measure the efficiency of forest production, the operations are de-composed into two stages. The first stage approximates the management of raw material which will be fed into the second stage, decomposed into two sub-processes; manufacturing of paper and wood final products. Since the efficiency of the proposed problem is decomposed into different stages, a Network DEA model is formulated and applied to EU countries based on data from EUROSTAT.

Keywords: Resource Economics, Forestry, Network DEA, Performance Measurement

JEL Codes: C61; C63; Q23; Q51.

European Industries' Energy Efficiency Performance Under Different Technology Regimes. The Role of Heterogeneity, Path Dependence and Energy Mix.

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Abstract

Energy consists an indispendable input into production function and plays a crucial role on countries' growth. Because of the strong and sustained economic growth that exists in the last decades, the demand for energy has been increased massively. Thus, European Commision has devoted sizable resources towards energy efficient and saving policies through the adoption of social and physical infrastructures to support the long term mitigation of global warming and encourage global sustainable dependence. We model the productive and energy efficiency performance of European industries taking into account both desirable and undesirable outputs in the production process under a metafrontier framework. This allows for a detailed consideration of the efficiency improvements made possible via technological spillovers within a given class of membership. Our dataset consists of 27 European countries and 14 industrial sectors of manufacturing which are studied for the period 1995 to 2011. In a first stage, DEA and DDF approaches were used for the estimation of productive performance, energy efficiency and technology gaps. In a second stage, Tobit and fractional model estimators are employed in order to investigate possible factors that affect energy efficiency and the role of the implied technology as it is conveyed by the level of each country.

Keywords: Energy efficiency, Directional Distance Functions, European, Industries, Metafrontier analysis, Energy mix

JEL Codes: Q40; D24; D22; C30

Assessing the independence of NRA in controlling the competition in Iranian energy market

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Abstract

Energy regulators play a major role in the development of a competitive market for energy production and supply. Recently, according to the law of "Amendment on the law of the General Policies of the Principle 44 of Constitution law) 2018)" in Iran, the Competition Council in Iran has been authorized to foresee and establish regulators in various areas, including energy sector. This paper tries to investigate whether the recent reform leads to the independence of the National Regulatory Authority (NRA) from the three dimensions of decision-making, budget and staff. The result of this study shows that although, compared to the former situation, the recent reform is a step forward, this reform was also unsuccessful in the realization of the full independence of the NRAs especially in the energy sector which the major players of the industry are state-dependent. Therefore, in order to achieve the full independence of the NRAs especially in the energy sector in Iran, it is suggested to consider the European Union's Third Energy Package to make the most effective amendments in the regulatory of the energy market in Iran.

Keywords: NRA, Competition, Energy Market, Monopoly Goods, Independence and Responsibility

JEL Codes: K00;K2;K21;K23;K32;D42;L4;L43

Just how Smart is [Smart] Regulation? Achieving Sustainable Development with Regulation-induced Innovation

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Abstract

Endogenous technological change theory provides a framework that enables to understand how firms' dynamic respond to policies. It also allows to model the interplay between sustaining innovation by incumbents and radical innovation by new entrants as well as imitation through the diffusion of innovations. In this paper, we show how stringent regulation can affect market dynamics, and economic growth, by stimulating the entry of fringe players that are more likely to rise to the challenge (Schumpeter creative destruction) instead of regulated firms that are more likely to respond through incremental changes to existing technology (Arrow's replacement effect). As such, we distinguish between weak and strong regulation-induced technological change. We also distinguish between regulations that will stimulate radical entrants that introduce new technologies as opposed to the ones that stimulate imitative entrants through knowledge spillovers. Lastly, we argue that stringent regulation might be beneficial for both incumbents and new entrants when the diffusion deficit is addressed.

Keywords: sustainable development; innovation; policy; environmental regulation; endogenous technological change

JEL Codes: Q01; Q55; Q58.

Assessing Safety in Public Areas with Space Syntax Application; Case Study of Tarbiat Pedestrian Area, Tabriz-Iran

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Abstract

In studying the urban complex issues, simulation and modelling of public space use considerably helps in determining and measuring factors such as urban safety. Depth map software for determining parameters of the spatial layout techniques; and Statistical Package for Social Sciences (SPSS) software for analysing and evaluating the views of the pedestrians on public safety were used in this study. Connectivity, integration, and depth of the area in the Tarbiat city blocks were measured using the Space Syntax Method, and these parameters are presented as graphical and mathematical data. The combination of the results obtained from the questionnaire and statistical analysis with the results of spatial arrangement technique represents the appropriate and inappropriate spaces for pedestrians. This method provides a useful and effective instrument for decision makers, planners, urban designers and programmers in order to evaluate public spaces in the city. Prior to physical modification of urban public spaces, space syntax simulates the pedestrian safety to be used as an analytical tool by the city management. Finally, regarding the modelled parameters and identification of different characteristics of the case, this study represents the strategies and policies in order to increase the safety of the pedestrians of Tarbiat in Tabriz.

Keywords: Pedestrian Safety, Urban Public Space, Space Syntax, Tarbiat, Tabriz, Iran.

JEL Codes: Q01;R00;R40;R52

The effect of growth-CO_2 emission relationship on sustainable development: Application of the Wavelet Transform Technique

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Abstract

Despite the relative abundance of works that has attempted to identify the relationship between economic growth and CO2 emissions, they have not been able to answer many questions, most of which is the effect of this relationship on sustainable development. Also, the techniques used to know the nature of this relationship suffers from several problems because they only inform about the existence of causality and its nature (unidirectional, bidirectional). To overcome its shortcomings we have opted for the application of wavelet technique (over several countries) to know both the nature of the causality and the phase difference that can take place between the economic growth of countries and CO2 emissions.

Keywords: Carbon emissions; Growth, Sustainable development, Wavelet transform.

JEL Codes: Q01; Q2; Q28; Q34.

Economic and environmental impact of low carbon technologies in German energy system

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Department: FCN, E.ON Energy Research Center

Abstract

The Federal Government of Germany sets ambitious targets for energy and climate policy with the introduction of an Energy Concept in 2010. In this concept, greenhouse gas emissions are to be reduced by 80% by 2050 as compared to 1990 levels and renewable are to supply 80% of electricity. In addition, due to the Fukushima disaster, Germany decided to phase-out nuclear energy by 2022 from energy mix. In order to enable the implementation of large scale renewable energy supply, smart grids are needed to manage the high intermittency of renewable energy sources. This study investigates the possible components, design and prospects of creating a sustainable renewable energy system with such a smart grid. This investigation is conducted by using the EnergyPlan model. The analysis is based on hour-by-hour computer simulations leading to the structure of a smart grid capable of balancing energy supply and demand in Germany. Three different renewable energy scenarios are developed to project the state of the German energy grid up to 2050. The simulation results indicate that the proposed renewable energy systems will even be associated with fewer costs than today's energy system. In a heavy renewable scenario, CO2 reduced by 94.2% while electricity supply is almost completely by renewable i.e. RES share of 92.3%. Results of this study show that decarbonisation of the German energy system is indeed technically and economically possible and worthwhile, if this transition is supported by political and public willingness.

Keywords: Low carbon Technology; Germany; Energy sector; Environmental mitigation; Energy Plan model

JEL Codes: Q41; Q42; Q47; Q51.

CONFERENCE PROCEEDINGS

Proceedings Summary

The 5th Conference program consisted of 12 sessions and 5 Keynote speakers, held in the lecture rooms in the Department of Economics in the University of Thessaly. The 12 thematic sections presented concerned quantitative methods in environmental and resource economics both econometrically and mathematically, socioeconomic environmental assessments, waste management, cyclical economy, environmental issues and concerns, environmental policies and assessments, sustainable transport, energy issues and policies, environmental valuation, sustainable tourism, environmental efficiency and performance and sustainable development. In total, 30 studies were included in the conference proceedings, however, it is important to mentions that a number of papers has not been included in the book of proceedings due to the fact that they have already been submitted to the conference special issues journals.

The 1st work by Halkos, Barmpoudaki, Voulangas and Tsilika, presents the explorations of the EMEP Input Output model of Air pollution, while their main outcome is the ranking of countries in decreasing order of pollution responsibility and/or vulnerability using graph metrics. The 2nd work by Matsiori, presents the critical application of NEP scale in Greece, where the outcome gives significant relationship between NEP scale factors and socioeconomic characteristics respondents. The 3rd work by Dritsas, presents the spatio-economic dimension of aquaculture in Greece. An attempt is made to systematically assess the socio-economic characteristics of the aforementioned municipalities through a comparative analysis with the corresponding features of the rest of the coastal area of Greece where aquaculture enterprises do not operate.

The 4th work by Ekonomou and Kallioras, presents the investigations of the impact of wellbeing on economic performance, giving evidence from the European Union countries and regions. As a main outcome, regressors found to positively impact regional GDP per capita implying that even non-material conditions might become crucial to achieve regional economic development. Significant practical implications have been derived based on research findings which in turn can be incorporated in relevant regional policies. The 5th work by Wallace and Iatridis, presents the factor that drives responsible businesses by examining the links between reputation risk, non-government organizations (NGO) pressure and responsible business performance. As they mention, within the sample set the role of finance companies is also more pronounced than the traditionally supposed environmentally damaging issues. The outcome underlines a negative correlation between financial performance and one of the disclosure metrics. The 6th work by Tsadiras, Pempetzoglou and Viktoratos, presents the prediction of Global Warming impacts using Fuzzy Cognitive Maps and Semantic Web techniques. As they conclude, policy makers can use this technique and tool to make predictions by viewing dynamically the consequences that the system predicts to their imposed scenarios.

The 7th work by Fragkou, Karakasidis and Liakopoulos, presents the identification of regimes in river behavior using nonlinear timeseries analysis. From this analysis important parameters such as “%Recurrence”, “Determinism”, “Laminarity” and “Tapping Time” are extracted giving important information about system’s periodicities and phase transitions which help us to locate seasonal changes and extract useful conclusions about possible changes of the behavior of the environmental dynamical system as years passing by (climate changes). The 8th work by Kolidakis, Botzoris, Profillidis and Lemonakis, presents the Real-time road traffic forecasts by a hybrid approach using artificial intelligence and Singular Spectrum Analysis. Their results provide evidence that An Intelligent Transport Systems (ITS) with embedded hybrid SSA–ANN forecasting methodology can enable proactive decisions to mitigate the economic and environmental impacts of transport infrastructure congestion. The 9th work by Georgatzi, Vetsikas and Stamboulis, present the examination of the determinants of CO2 emissions caused by the transportation sector activity: empirical evidence from 12 European Countries. They employ panel data analysis; panel unit root tests, panel cointegration tests, the Fully-Modified OLS (FMOLS) approach, the Dynamic OLS (DOLS) approach and Granger causality test are employed in order to examine the relationship between CO2 emissions caused by the transportation sector activity and their statistically significant determinants.

The 10th work by Profillidis, Botzoris and Kolidakis, presents the artificial neural network: a model tool for empirical modeling of transport demand. As they mantion, the method of ANN is used in the paper to model and forecast future transport demand in relation to the evolution of GDP and other driving forces of the problem, for mature and developing air transport markets. The 11th work by Mavraki, Arabatzis, Kantartzis and Malesios, presents the contribution of the road transport projects of the NSRF 2007-2013 to the development of a Greek region. The study area concerns the Region of Eastern Macedonia and Thrace, followed by the analysis, characteristics and results of the Operational Program of the Region of the same period, through which 87 road projects were implemented. The 12th work by Zavitsanos, Galanis, Lemonakis, Botzoris and Eliou, presents the investigation of bicyclists' riding behavior under normal traffic conditions in the road network of mid-sized Greek city. This study concludes that it is feasible to record bicyclists' speed and acceleration profiles with accuracy and speed. Moreover, supports that there is a strong indication that bicycle is a rather controllable and predictable transport mode. However, in order to generalize the conclusions drawn in a wider proportion of road users, more experiments including a greater number of participants and road sections should be conducted.

The 13th work by Founta, Benos and Zachilas, presents the model of a close evonomy by a lattice Hamiltonian. As they conclude, the (over)populations might destroy their environment. In parallel, higher populations create chaotic trajectories. Higher order of truncation have similar properties, but higher populations can survive, since they are closer Toda approximations, representing technological developments, macrocultural evolution and better adaptation to environment. Overpopulation and disaster point exist, no matter how high the odd−order truncation is. In a perfect world, infinite odd order truncation can be achieved and can eliminate overpopulation limits. The 14th work by Kitsos and Toulias, present the adopting tolerance intervals in environmental economics. They mention that for the optimal level of pollution they can evaluate the corresponding tolerance region – either the classical or the expected tolerance interval – and therefore we obtain four possible optimal level of pollution and the corresponding tolerance interval for the reduction pollution point. The associated four Benefit Areas can be evaluated, due to the adopted Tolerance Region procedure, rather than a Confidence Interval approach. The 15th work by Charakopoulos, Karakasidis and Sarris, present the wind energy potentials based on visibility complex network and recurrence plot time series analysis. They have demonstrated that the proposed analysis provides useful information which can characterize distinct regions of the time series and also identify and detect dynamical transitions in the system's behavior. The results will be useful for the prediction of the produced wind energy.

The 16th work by Kanavouras and Coutelieris, presents an economic approach of physical phenomena. By describing natural phenomena in a stochastic mathematical way will allow the use of those fundamental elements of statistical physics to integrate deterministic processes (and quantities) into a micro-scale. It is the opinion of the writers, that the innovation of this work is the use of economic laws for the world of natural phenomena, against the, commonly used and generally accepted, inverse process. The 17th work by Papadopoulos, presents an attempt on assessing the sustainability of renewable energy sources, with the combination of life cycle and SWOT analysis. The combination of these two analyses helps decision-making, strategic planning and environmental management as regards the choice of the most appropriate renewable energy source. The 18th work by Tsiaras and Coutelieris, presents the energy policy establishment for off-grid small isolated settlements, mentioning that their study could act as a policy tool for off-grid power production in national level.

The 19th work by Ioannou, Tsantopoulos and Arabatzis, presents the selection of optimal on shore wind farm sitting locations in Greece, using multi criteria decision analysis. In the paper they demonstrate a methodology which applies the current legislation and uses an MCDM methodology called Analytical Hierarch Process (AHP) and GIS in order to determine the most suitable locations for wind farms installation. The 20th work by Kotsila and Polychronidoy, presents the determinants of household electricity consumption in Greece. In their statistical analysis two models are built, both concluding that the most significant determinants that influence the electricity consumption are the number of occupants, the size of the dwelling, the number of bedrooms, the heating type, the heating and cooling hours, the weather conditions and the fact of occupants not going on winter holidays. The 21st work by Halkos and Matsiori, presents the understanding people's perception about biodiversity importance, management and conservation. Their results indicated the relative importance of region to respondents' perceptions knowledge and concern about biodiversity. According to the results biodiversity loss will mainly influence our country due to consequences to environment quality, heritage and financial wealth, following the impacts to world economy, knowledge and inspiration.

The 22nd work by Mentis, Latinopoulos and Bithas, presents the preferences and willingness to pay for protecting the marine and coastal environment from plastic waste by analyzing the case of Syros Island in Greece. According to their valuation results of both surveys a significant percentage of both residents and hotel owners of Syros are supporting policies for the protection and conservation of the local coastal/marine environment. The 23rd work by Skenteris, Mirasgedis and Tourkolias, presents the implementation of hedonic pricing models for valuating the visual impact of wind farms in Greece. By developing four different hedonic models in the two areas, the results derived diverge. In Evia case study we found that the value of the dwellings per unit area increases with the distance from the nearest wind farm. On the other hand, in Kefalonia case study, neither the view of the wind facilities nor the distance of the home to those facilities is found to have a statistically significant effect on sales prices. The 24th work by Becker, Shamir and Shamir, presents the shark aggregation and tourism as well as the opportunities and challenges of an emerging phenomenon. As they underline, touristic intensity crosses the threshold level by about 12% and making the socio-equilibrium sustainable for both humans and sharks would have a social cost of ILS 0.157 million.

The 25th work by Dellitheou and Georgakopoulou, presents the alternative forms of sustainable development by analyzing the case of thermal tourism. As they mention, in Greece, thermal tourism is an important part of our cultural heritage and not only because Greece is one of the richest countries in natural sources with excellent quality water. Despite the fact that Greece is the first country in Europe in the quality and uniqueness of natural thermal resources, its thermal tourism is declining. The 26th work by Sardianou and Christou, presents the integrated sustainable supply chain management (SSCM) amongst Greek supermarkets. They conclude that managers adopted several sustainable supply chain practices in order to increase the performance of the super market stores, such as material handling, waste management and reverse logistic. Results indicate that managers' decision to adopt green supply chain practices combined both organizational and economic criteria. The 27th work by Karatzoglou, presents the use of carbon shadow pricing as a tool to drive the decarbonization of the Greek hotels operations. His paper suggests the use of internal (shadow) pricing by Greek hotels as an instrument to appraise the sustainable profitability of a hotel project, de-risk business, identify energy inefficiencies, and incentivize low carbon innovation within departments; it also proposes a methodology on how to set an internal carbon price in the Greek hospitality domain and how to make the most out of this initiative.

The 28th work by Karabekou, Kovos, Karagiannis and Delitheou, presents the wind energy as an energy solution for hospitality businesses. They underline that Greece has an extremely rich wind potential and the wind power is practically an inexhaustible source of energy. The exploitation of its high potential in our country, coupled with the rapid development of technologies embedded in small, modern, efficient wind turbines, is of paramount importance for sustainable development, saving energy resources, protecting the environment and tackling climate change. The 29th work by Maros, Papadas and Gouta, presents the research intensities and R&D Input-Output multiples throught the examination of their intertemporal stability using data on the US economy. Using OECD data on the US economy, i.e. US IO tables and sectoral R&D expenditures for a series of years, we estimate sectoral research intensities and multipliers. Subsequently, their stability is evaluated using several established criteria in the literature with encouraging results which are presented and discussed. The 30th work by Dritsas, presents the population projections at potential risk of rising sea level (2025-2050) by examining the case of Gironde (Estuaire de la Gironde). He drives attention to the fact that local-regional bodies should focus on the fact that the group of municipalities that currently have a low level of vulnerability is potentially able to cope with rising population pressures over a 2050-time horizon. Some municipalities currently showing low risk, may face a heightened risk in the future because not only it is not excluded that new coastal areas and estuaries of the rivers could be flooded, but also possible population growth can cause additional human pressures.

As a conclusion, I would like to mention that in this conference we also had interesting presentations and in-depth discussions both by the invited speakers and by the participating academics and researchers. The publication of these practices is based on the responsibility of the research teams and any mistakes, omissions, ambiguities and any similarities with other scientific work are the responsibility of the authors alone.

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Conference Papers

Exploring the EMEP Input-Output model of Air Pollution

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Abstract
The primary objective of this paper is the structural analysis of source-receptor air pollution problems in the EU region. Two views are provided for the analysis: an emission-driven view and a deposition-driven view. Different visual schemes are used to reproduce the global pollution network and identify the biggest sources and sinks of pollution. Visual modelling helps to understand the linkages and interconnections in the transboundary pollution network. Our interactive outputs give the options to zoom in to specific areas of the global source-receptor air pollution scheme and highlight the top emitters or receptors of pollution. Ranking of countries in decreasing order of pollution responsibility and/or vulnerability using graph metrics is a main result. Data sources are emissions-depositions (or source-receptor) tables of air pollutants, available online from the data repository of the European Monitoring and Evaluation Program (EMEP) of the Long-Range Transmission of Air Pollutants in Europe. In our computer-based visual analysis, we employ solely open software.

Keywords: source-receptor air pollution; network analysis; heatmaps; free open-source software.

JEL Classification: C63; C88; Q53; Q58.

1. Introduction

The awareness of the pollution responsibility and the pollution dispersion is the first step to combat damage and social costs associated with air pollution (Halkos 1992; 1993; 1994; Hutton and Halkos 1995, Anaman and Looi, 2000; Halkos and Tsilika, 2014; Halkos and Tsilika, 2017; Fujii and Managi 2016; Halkos et al., 2018). In this paper, we introduce a visual framework that explores linkages and interdependencies in source-receptor (hereafter SR) air pollution. The calculation of pollution indicators and ratios along with the visualization of the source-receptor air pollution scheme are sine qua non conditions to estimate the environmental impact of major polluters and their severe consequences. These tasks are integrated in network analysis software Gephi (v. 0.9.2) and in several free visual interfaces. The computer input consists of yearly country-to-country source-receptor (SR) pollution data over the extended EU area, as reported in the source-receptor tabular information in the EMEP/MSC-W website. The main contributions of this paper are:
A computer-based design and analysis of transboundary air pollution networks and
Mapping the pollution interactions among countries of the EMEP extended domain
In the first part of the paper, we build graph models of pollutants exchange. By employing graph measures and metrics, pollution indicators are estimated in order to quantify 1) the responsibility of polluters and 2) the degree of exposure for pollution victims, in annual basis. Ranking of countries in decreasing order of pollution responsibility and /or vulnerability is a main result of network analysis.
We aspire to illustrate the relevance of our results with respect to policy making and potential economic consequences. Our computational approach provides useful information on air pollution mapping in the EMEP area, early warning, risk awareness in an eco-framework, in order to set the

directions for pollution control policies. Moreover, policies that reduce the associated social costs, damage costs, climate change costs.
This paper is organized as follows. Section 2 briefly presents the software and the data overview. The visualization tasks are described in section 3 followed by a detailed discussion of our structural analysis of transboundary pollution data in Section 4. Section 5 concludes the paper.

2. Software and data availability

Gephi is a cross-platform application, as it is developed in Java (Bastian et al., 2009). It is successfully tested on many different architecture, OS and graphical configuration. Gephi requires Java version 7 and later (https://gephi.org/). Gephi can import several standard file formats of data files (among them CSV and spreadsheets).
Data sources are emissions-depositions (or source-receptor) tables of air pollutants (see table 1), available online from the data repository of the European Monitoring and Evaluation Program (EMEP) of the Long-Range Transmission of Air Pollutants in Europe. Access to the source-receptor relationships by country of sulphur and nitrogen, ozone and particulate matter (PM) for period 2004-2016 is possible through the EMEP database[1]. The data are generated by source-receptor calculations, where emissions for each emitter of one or more precursors are reduced by 15%. For oxidized sulphur, oxidised nitrogen and reduced nitrogen, the results have been scaled up to represent the entire emission from an emitter. The calculations are based on a consistent series of model runs, all using the EMEP/MSC-W model version rv4. The data files are given in a semicolon separated CSV format. Data used throughout this paper concern 49 land areas from the extended EMEP domain.

3. Visualization Tasks

There are different visualization tasks for SR data analysis, which can be classified into four categories:
Pinpoint air pollution emitters and receptors,
Report the variation of rankings for polluters and pollutees according to 13 different pollutants.
Compare different regional pollution blocks (e,g, in different geographical zones). Similarities and differences between different regions are always of great interest.
Reveal the blame and/or damage of a country to another, in terms of transboundary air pollution. This is a way of assessing distributional impacts of transboundary air pollution.

4. Visualization Modules

In the existing literature and the EMEP reports, transboundary air pollution data are presented in the form of maps, pies and bar charts (EMEP report, 2016). Here we exploit two popular graphic methods for visualizing high dimensional data: networks and heatmaps. Other innovative visualizations for air quality data have been reported in (Orudjevet al., 2016; Qu et al., 2007; Kanemoto et al., 2014; Carslawa et al., 2012).

Table 1: Data Attributes included in SR table, all in the extended EMEP domain

Pollutant / indicator	Unit
Deposition of OXS (oxidised sulphur)	100Mg of S
Deposition of OXN (oxidised nitrogen)	100Mg of N
Deposition of RDN (reduced nitrogen)	100Mg of N
PM2.5 Effect of a 15% reduction in PPM emissions	ng/m^3
PM2.5 Effect of a 15% reduction in SOx emissions	ng/m^3
PM2.5 Effect of a 15% reduction in NOx emissions	ng/m^3

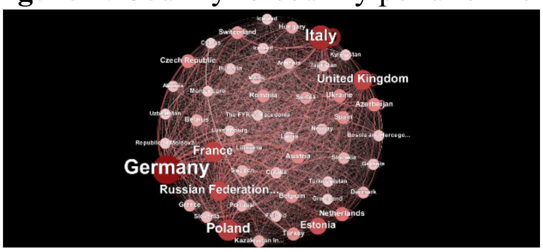
[1] http://emep.int/mscw/index_mscw.html

PM2.5 Effect of a 15% reduction in NH3 emissions	ng/m^3
PM2.5 Effect of a 15% reduction in VOC	ng/m^3
AOT40$_f^{uc}$[2]. Effect of a 15% reduction in NOx emissions	ppb.h
AOT40$_f^{uc}$. Effect of a 15% reduction in VOC emissions	ppb.h
SOMO35[3]. Effect of a 15% reduction in NOx emissions	ppb.d
SOMO35. Effect of a 15% reduction in VOC emissions	ppb.d

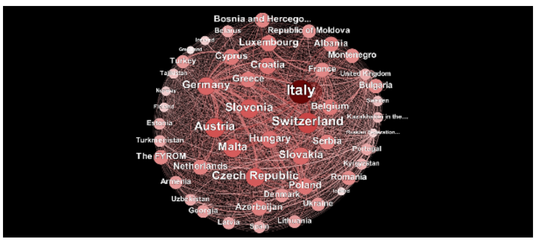
4.1 Graph modelling

Our visualization module is based on graph theory. The countries can be interpreted as nodes and pollution relationships among them as edges in the network, thus to have the whole system transferred into an Input-Output network, which could quantify the interdependency among differed countries. The network visualization and exploration software is good at revealing the underlying structures of associations between EMEP countries (known also as "link analysis"). It permits the user to estimate and visualize the degree of responsibility of polluters and create the country-to-country blame network (figure 1 a,c). The user can also estimate and visualize the degree of exposure of pollution victims (figure 1b,d). By considering the strength of the interrelations, we indicate air pollution hotspots. Outcoming edges represent emitters' output and incoming edges represent receptors' input. The edge weights used are the levels of pollutants. The weighted degree and the weighted in- and out-degree (Barrat et al., 2004; Newman, 2001; Opsahl et al., 2010; Jiang et al., 2019) is calculated to investigate the structure of the network. Countries responsibility for pollution is measured by weighted-out degree of each node. Countries exposure in pollution is measured by weighted-in degree of the pollution network. The possibility to rank countries in order of increasing responsibility (in terms of their weighted-out degree) or vulnerability (in terms of their weighted-in degree) to air pollution is always an option (figures 5-6).
Gephi provides an interface for filtering nodes and edges (Heymann, 2015). The degree filter matches nodes with a degree that falls within the given minimum and maximum values, inclusive. A user can choose whether the filter operates on the in-degree, out-degree or overall (in + out) degree (see indicatively figure 2). Narrowing filters are applied to the entire network (figure 3b), and are used to select a subset of nodes or edges in a network based on user-specified constraints (figure 4a-f). Filtering options in figure 4 bring out the distribution of the top 9 pollutees per geographical zone.

Figure 1: Country-to-country pollution network (pollutant: AOT40NMVOC, 2013)

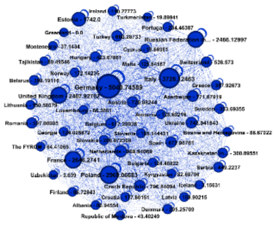


Size of node, name and color intensity is analogous to emitters' responsibility



Size of node, name and color intensity is analogous to receptors' exposure

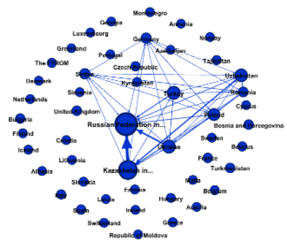
[2] Accumulated amount of ozone over the threshold value of 40 ppb
[3] Sum of Ozone Means Over 35 ppb



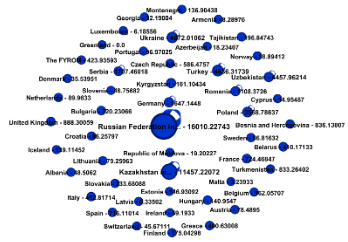
Emitters' responsibility in numbers

Receptors' exposure in numbers

Figure 2: Filtered pollution network (pollutant: SOx, 2013, metric: weighted-out degree). Size of node and name is analogous to polluters' responsibility

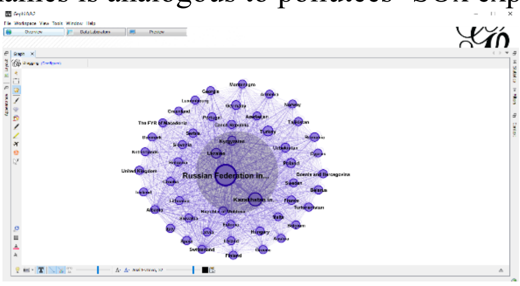


(a) Pollution interactions among top 9 polluters in the global pollution network

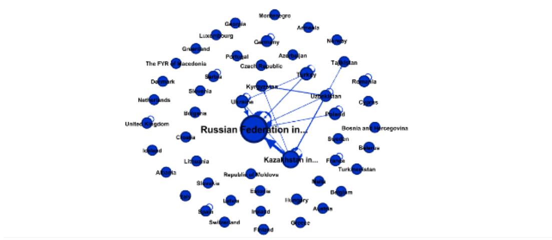


(b) Self-loops are used to depict the amount of pollution emitted by top 9 polluters. Numbers denote oxidised sulphur depositions in 100 Mg of S

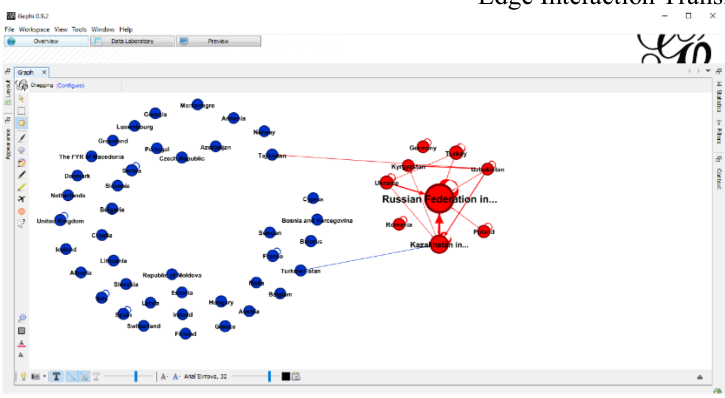
Figure 3: Gephi options to make the global pollution network more manageable. Size of node and names is analogous to pollutees' SOx exposure.



Focusing on a certain area of the global source-receptor SOx pollution scheme

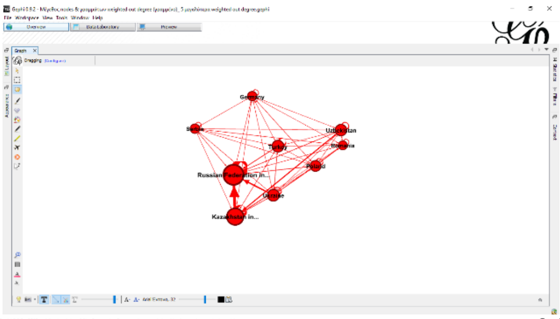


Filtering the SOx pollution network: selecting edges with weight≥300 (units: 100 Mg of S) with Edge Interaction Transformer

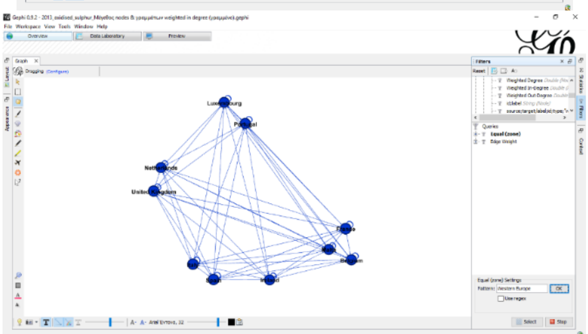


Isolating a subset of nodes based on user-specified constraints (here the top 9 pollutees)

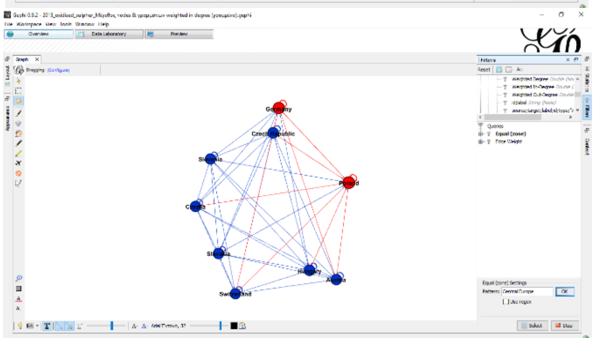
Figure 4: Disconnecting the global pollution network. Size of node and name is analogous to pollutees' SOx exposure for 2013



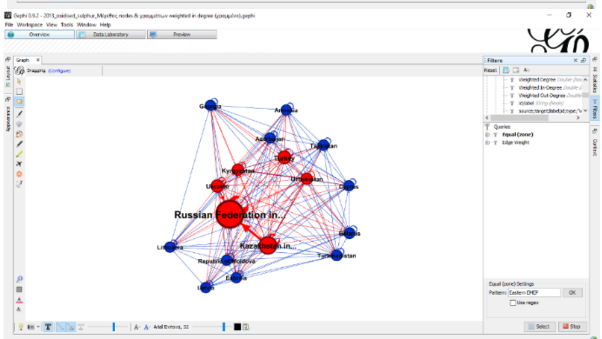
(a) top 9 pollutees in red



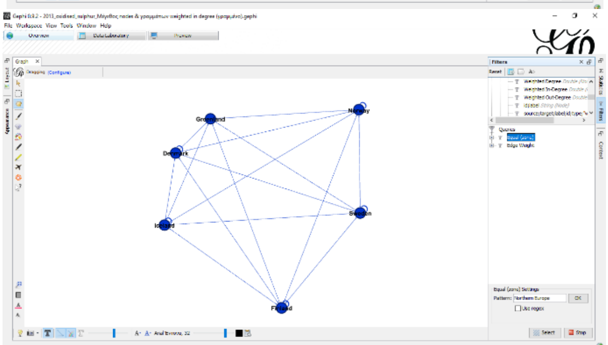
(b) Western Europe



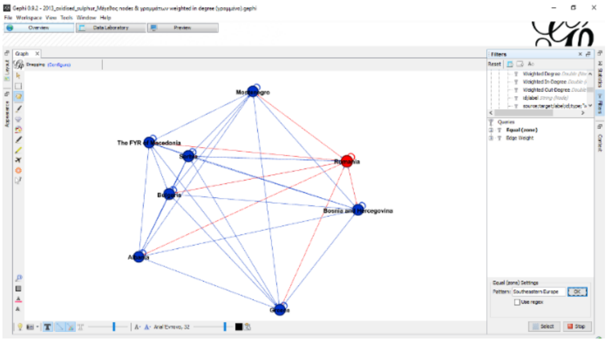
(c) Central Europe



(d) Eastern EMEP area



(e) Northern Europe



(f) Southeastern Europe network

Figure 5: Ranking the emitters of the extended EMEP area (metric: weighted-out degree). Horizontal bars chart was obtained using Tableau (Tableau, 2014)

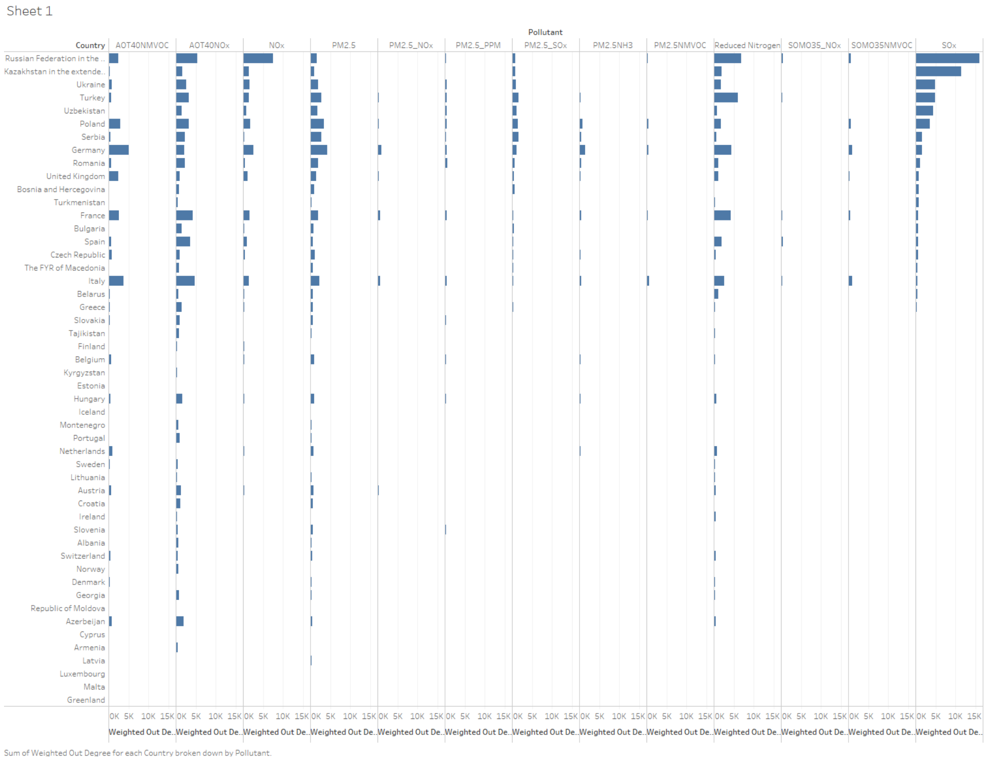
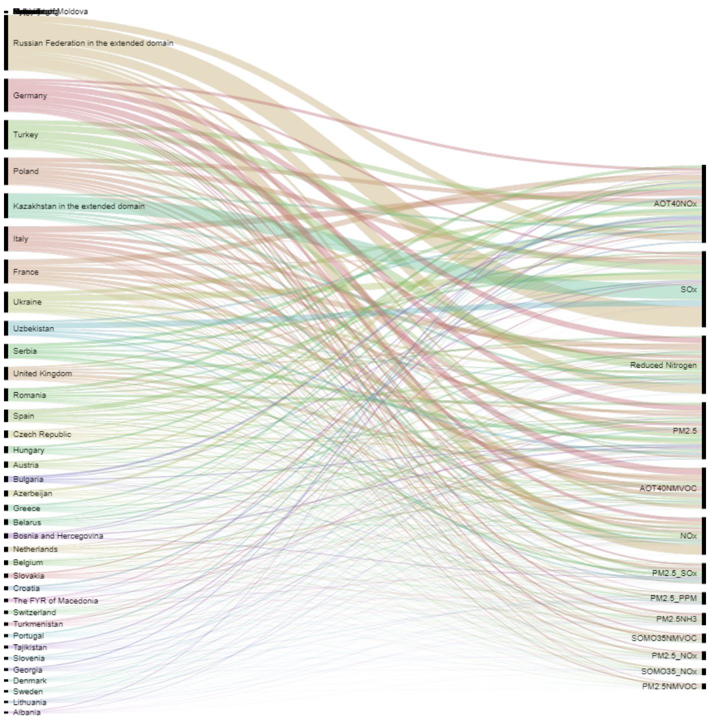


Figure 6: Ranking polluters and pollutants of the extended EMEP area (metric: weighted-out degree). Alluvial diagram was obtained using RAWGraphs (Mauri et al., 2017)



5. Conclusions

This paper mainly focuses on how countries interact within the SR pollution scheme and how the pollution providers spread their pollution. EMEP data are adopted to establish inter-country input–output tables and create graph models and tabular representations. The SR transboundary air pollution system for any pollutant are so interconnected that the polluters affect almost all countries. The SR tables are presented in a way to indicate the major pollution effects in the global pollution tabular scheme. For central planners, graph modelling could be a tool for policymaking. For governments and regional planners, ranking lists provide concise directions on which countries to blame and which to protect.

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Critical application of NEP scale in Greece

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Abstract

One of the most known measures of an environmental belief system is the NEP scale. The new NEP scale, according consists of fifteen items and has five sub-scales (limits to growth, antianthropocentrism, the fragility of nature's balance, rejection of exemptionalism, and the possibility of an eco-crisis). The NEP scale has been used in many countries, for different groups of people for measuring environmental attitude, beliefs and worldviews. Researchers have expressed their doubts about the validity of NEP scale and a lot of studies was carried out to explore them. Thus, there is a need to test the applicability and validity of NEP scale from the point of view of Greek people. The present study attempts to refine and validate NEP scale keeping in mind the Greek people. With this objective, data were collected using self-administered structured questionnaire from 1000 respondents from different cities. The approach combines of applied methodological research like Principal Component and Cluster Analyses together with logistic regression was used. Significant relationships are found between NEP scale factors and socioeconomic characteristics respondents.

Keywords: NEP scale, Peoples' attitudes, environmental management

JEL Classification codes: Q29; Q50; Q51; Q57

1. Introduction

Recently, a great number of surveys aimed at enhancing people environmental attitudes and a number of them suggest that pro-environmental behavior is related with positive attitudes (Kaiser et al. 1999; Fielding et al. 2008). Therefore exploring and understanding people environmental attitudes it is very important for essential for the promotion of pro-environmentalism (Milfont and Duckitt 2004). People Environmental attitudes is the essence of moral and social values (Clayton and Myers 2009) and encapsulate people beliefs, affective responses, and behavioral intentions toward environmental issues and activities (Schultz et al. 2004). Therefore the measurement of environmental attitude has emerged as an important issue and a rather difficult task.

One of the most used and general acceptance measurements of environmental attitude is the New Environmental/Ecological Paradigm (NEP) scale (Dunlap and Van Liere 1978; Dunlap et al. 2000). The original NEP scale was published in 1978 using 12 items with a 4-point Likert scale response system. Then, in 2000 NEP scale revised to include 15 items with a 5-point Likert response scale. The revised scale based on five dimensions of people environmental attitude: beliefs about humanity's ability to upset nature, the existence of limits to human economic growth and development, and humanity's right to rule over the rest of nature (Dunlap and Van Liere 1978; Dunlap et al. 2000). Since NEP scale was used widely in many countries to measure environmental attitudes, beliefs, and worldviews (Ogunbode, 2013). Also multiple studies which apply NEP scale in different group of people (Schultz and Zelezny 1999; Schultz et al. 2000; Johnson et al. 2004;

Pahl et al. 2005) trying to explore the factors that influence people attitudes against natural environment.

Since its construction NEP scale has been applied to different with different samples: students, general population different nationalities and specific groups of people (Schultz and Zelezny 1999; Cordano et al., 2003; Johnson et al., 2004; Pahl et al. 2005; Noblet et al., 2013; Ogunbode, 2013; Denis and Pereira, 2014; Moyano and Palomo, 2014; Pienaar et al., 2015; Vozmediano and Guillén, 2005). According of the results of many studies NEP scale is related to people' behavioral intentions or self-reported and observed pro-environmental behaviors (Scott and Willits 1994; Stern et al. 1995; Tarrant and Cordell 1997; Ebreo et al. 1999; Rauwald and Moore 2002; Casey and Scott 2006).

In addition, there is a number of researches that relate the NEP scale with a number of socio-economic variables (age, education, gender etc.) by looking for the factors that affect people' score in scale dimensions (Halkos and Matsiori 2015; Harraway et al. 2012; Denis and Pereira, 2014; Ogunbode, 2013).

Despite the acceptance of the NEP scale a number of objections and problems have led to disagreement among its users (Hawcroft and Milfont 2010) mainly relates to the dimensionality of the scale, many researchers face the NEP items as a single measure of environmental attitudes even when the scale is not unidimensional (Dunlap et al. 2000; Lopez and Cuervo-Arango 2008; Hawcroft and Milfont 2010).

In Greece there are studies that use NEP scale in order to provide information on the nature of environmental worldviews and test the NEP scale. Halkos and Matsiori (201??) using a sample of general public apply NEP scale to analyze people behavior against marine biodiversity at the same time they investigate the dimensionally of the scale. The results of the study did not confirm the four dimensions of the scale. Also Halkos and Matsiori (2015) found that women scored higher than men in the antianthropocentric dimension. Another study that tried to determine the social economic characteristics that distribute to people environmental concern and test dimensions of the scale is Halkos et al. (2019), the results is in line with previous study and did not carmine the dimensionally of the scale analyzing the role of various socio-demographic, cultural, attitudinal and behavioral variables. In other studies NEP scale were used to investigate people pro-environmental behaviors (Gkargkavouzi et al…). Ntanos et al. (2019) evaluate Greek people environmental awareness based on the NEP in order to locate the most important facets of the NEP Scale.

This study tries to test the dimensionality and reliability of the revised NEP scale among the population of Greece. The primary aim of this study was to investigate if NEP scale could be used to explain in environmental beliefs and worldviews among Greek people. In so doing, a) we will contribute to research aimed at constricting a reliable measurement tool of environmental attitude and b) the results of present study will help to understand people ecological attitudes and the way they feel, think, and act or support for environmental politics which are in line with environmental protection.

2. Materials and Methods

The study population of this research consisted of 1265 persons from Greece (convenient sample). A self-filled questionnaire were used, which consisted of 2 parts The first part of the questionnaire consisted of questions aimed at gathering sociodemographic and socioeconomic data about the respondents (age, gender, education, field of education, income, religious beliefs, etc.). The second part was comprised of questions to determine participant's environmental attitudes by the use of the New Ecological Paradigm Scale (Dunlap et al. 2000). In this part of the questionnaire respondents were asked to specify their level of agreement or disagreement with a series of statements using a Likert scale. In the third and the fourth parts, questions were provided to examine respondents' environmentally friendly behavioral intentions and their actual performance of behavior. Intentions were evaluated by indicating the agreement or disagreement with given statements (e.g. "I iUnder this study revised NEP scale, in a modified translation, was used as a tool to measure environmental orientation, attitudes and behavior.

3. Empirical results and discussion

Table 1 presents the descriptive statistics of the respondents' socioeconomic characteristics.

Table 1: Descriptive statistics of respondents' basic socioeconomic characteristics

	Mean/Precedence	Standard Deviation
Gender (%)	51.7% (Female)	
Age (years)	33.01	13.71
Education level (years)	27.2 (Secondary Scholl)	3.065
Marital Status (%)	50.7 (Single)	
Monthly Personal Income (€)	727.17	477.70

3.1 Analysis of responses to the NEP Scale items

Table 2 summarizes the responses to the 15 items of the NEP Scale. NEP scale consisting of 15 items with a 5-point Likert scale response system as "strongly agree" (**SA)**, "Agree" (A), "neither agree nor disagree" (N), "disagree" (D) and "strongly disagree" (SD) and are coded as 5, 4, 3, 2 and 1 respectively. According to Dunlap et al. (2000) agreement with the odd numbered items and disagreement with the even numbered items indicate pro-NEP responses. For the calculation of NEP score the seven even-numbered items are reverse coded.

Individuals total NEP score is an indication of an ecological worldview and it ranged (Figure 1) from 15 to 75 with mean score 51.88 ($\pm$ 7.20). According to the Rideout *et al.* (2005) a NEP score above of 45 indicates a pro-ecological attitude.

An individual's score which indicates the degree of endorsement of an ecological world-view is the sum of the scores on the 15 items and has a range of 15 to 75 with higher scores indicating pro-NEP. The items' mean ranged from 1.86 (item: "*The earth has plenty of natural resources if we just learn how to develop them*") to 4.33 (item: "*Plants and animals do not have equal rights as humans to exist*"). Individuals mean score range from 1 to 5 with an average of 3.46 ($\pm$0.48). NEP scores were calculated as an average of all scores on the individual scale items. For many researchers a NEP score of 3 indicates a behavior between an anthropocentric and a pro-ecological worldview (Rideout *et al.* 2005; Van Petegem and Blieck 2006). The mean score for all items of NEP scale in this study was 3.46 (+) so closed to previous research from Halkos and Matsiori (????) who calculate mean NEP score equal to 3.56.

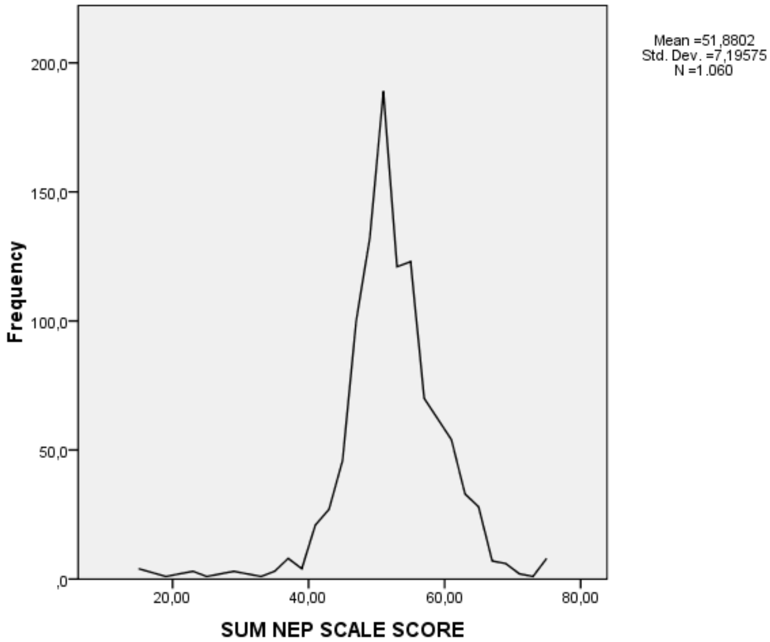


Figure 1: Total NEP scale score

The mean scores for eight pro-NEP items range from 3.41 to 4.33, whereas, the mean score on the seven pro-DSP items ranged from 1.86 to 3.59 (lower values due to reverse coding).

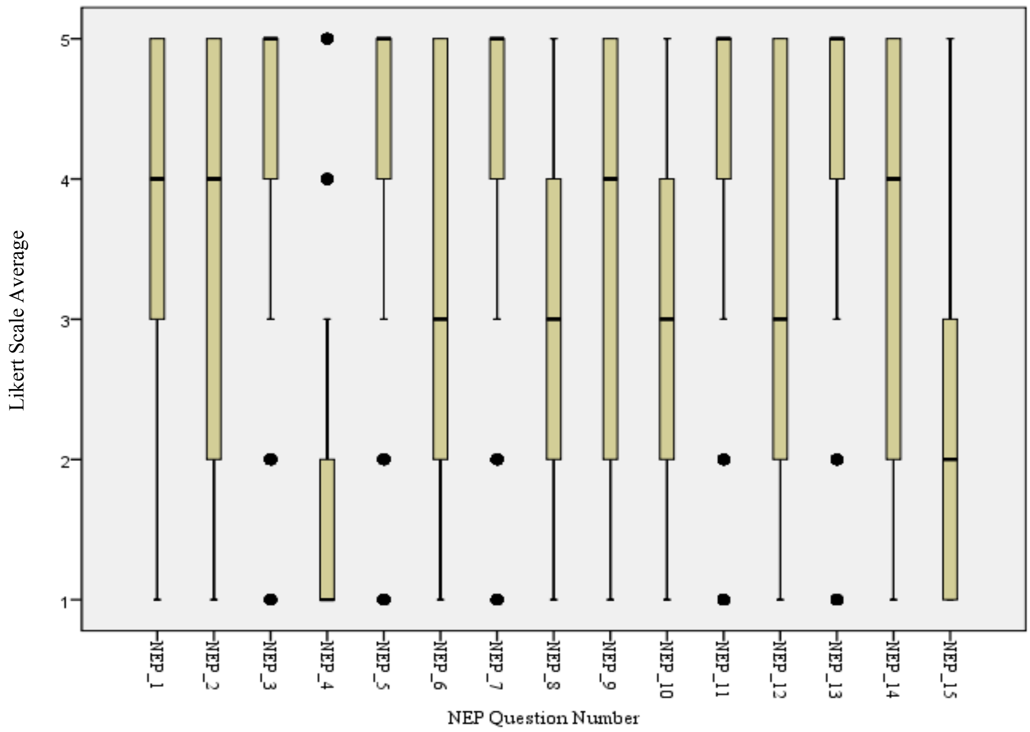
Table 2. Frequency and mean distribution of the NEP scale items

NEP facets	Scale items	Responses (%)					NEP facets mean	Mean	SD
		SD	D	N	A	SA			
Reality of limits to growth	We are approaching the limit of the number of people the earth can support	7.1	13.5	15.8	24.3	30.8	2.92	3.41	1.4
	The earth has plenty of natural resources if we just learn how to develop them	3.6	6.1	15.0	23.7	51.5		1.86	1.1
	The earth has only limited room and resources	17.6	10.0	14.3	23.6	34.3		3.47	1.5
Antianthro-pocentrism	Humans have a right to modify the natural environment to suit their needs	31.3	24.2	24.1	13.3	7.1	3.58	3.59	1.2
	Humans were meant to rule over the rest of the nature	21.4	11.7	17.4	24.8	24.4		2.81	1.3
	Plants and animals do not have equal rights as humans to exist	22.3	60.8	9.8	3.7	3.5		4.33	1.0
Fragility of nature' s balance	When humans interfere with nature, it often produces disastrous consequences	20.4	4.8	7.5	23.0	44.2	3.66	3.66	1.5
	The balance of nature is strong enough to cope with the impacts of modern industrial development	27.5	19.4	15.5	14.5	22.9		3.02	1.4
	The balance of nature is very delicate and easily upset	3.8	4.6	13.0	26.7	51.7		4.19	1.0
Rejection of human exceptiona-lism	Human intelligence will ensure that we don't make the earth unlivable	8.8	13.3	23.5	26.9	27.5	3.65	4.36	1.0
	Despite our special abilities, humans are still subject to the laws of nature	3.6	6.4	13.9	25.4	50.7		4.04	1.5
	Humans will eventually learn enough about how nature works to be able to control it	28.1	16.2	21.3	17.4	16.7		3.70	1.4
Pos	Humans are severely abusing the environment	2.8	6.3	9.2	27.5	54.2	3.89	3.46	1.3

	Human destruction of the environment has been greatly exaggerated	24.8	20.9	18.4	14.7	21.1		3.41	1.2
	If things continue going as they presently are, we will soon experience a major ecological disaster	2.9	4.4	10.4	26.2	56.0		2.52	1.5
	Overall frequency	15.1	14.8	15.3	21.0	33.1	Mean score 3.46		

According to our results the 40.7% of respondents strong agree with Pro-NEP items, whereas only 10.1% disagreed. Moreover, a significant amount of students (15.3%) have ambivalent views on the environmental issues (Figure 2). Overall according of the percentage distribution of responses to the NEP Scale items allows us to draw the conclusion that participants tend to have pro-NEP attitude on most scale issues (Table 2).

The goal of present research was to test the reliability of the NEP scale and determine the dimensionality in order to be used in Greece as a tool for measuring the environmental consciousness of people. The internal consistency of the NEP constructs was tested with the use of



corrected item-total correlation[4] (r_{i-t}), the Cronbach's coefficient alpha (α), and principal components analysis (PCA) (Aldrich *et al*. 2007; Clark *et al*. 2003; Dunlap *et al*. 2000). Cronbach's coefficient alpha is 0.578, the value of Cronbach's alpha is not very satisfactory according Sekaran (2005), Hair et al. (2006) and Kaiser (1974) it is marginally acceptable. Similarly, the findings on the corrected item-total correlations for each item show very low to low correlations, ranging from .045 to .364 (Table 2).

Figure 2. Responses to the NEP statements s

The value of corrected item-total correlation (Table 3) ranges from a low 0.011 for "*The earth has only limited room and resources*" to a high of 0. .360 for "*The balance of nature is very delicate and easily upset*". In the literature the accepted level of ri-t, is higher of 0.3 (Aldrich *et al.* 2007; Clark *et al*. 2003; Dunlap *et al*. 2000). According the values of "Cronbach's Alpha if Item

[4] The corrected item-total correlation is the correlation coefficient between each item's score and the sum of the scores of the other 14 items (Ndebele and Marsh 2014)

Deleted" shows that Cronbach's alpha is not sensitive to exclusion of any item. This result indicates that the NEP scale has low consistency in Greek case.

Table 3. Item-total statistics

NEP facets	Scale items	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted	NEP facets Cronbach's Alpha
Reality of limits to growth	We are approaching the limit of the number of people the earth can support	.154	.441	.536	0.015
	The earth has plenty of natural resources if we just learn how to develop them	.050	.,257	.551	
	The earth has only limited room and resources	.011	.369	.573	
Antianthro-pocentrism	Humans have a right to modify the natural environment to suit their needs	.300	.237	.506	0.134
	Humans were meant to rule over the rest of the nature	.192	.354	.528	
	Plants and animals do not have equal rights as humans to exist	.337	.371	.505	
Fragility of nature balance	When humans interfere with nature, it often produces disastrous consequences	.185	.628	.530	0.556
	The balance of nature is strong enough to cope with the impacts of modern industrial development	.330	.553	.494	
	The balance of nature is very delicate and easily upset	.360	.347	.499	
Rejection of human exceptiona-lism	Human intelligence will ensure that we don't make the earth unlivable	.240	.306	.518	0.168
	Despite our special abilities, humans are still subject to the laws of nature	.220	.242	.523	
	Humans will eventually learn enough about how nature works to be able to control it	.070	.421	.554	
Possibility of an ecocrisis	Humans are severely abusing the environment	.358	.371	.500	0.265
	Human destruction of the environment has been greatly exaggerated	.051	.380	.559	
	If things continue going as they presently are, we will soon experience a major ecological disaster	.339	.408	.504	

All dimensions have positive correlation with the NEP scale, three of them strong, two moderate expect from dimensions "*Ecocrisis*" and "*Limits to growth*", "Limits to growth" and "Anti-Exemprionalism" and "*Ecocrisis*" and "*Balance of nature*" which have negative correlation (Table 4).

Table 4. Correlations among dimensions and NEP

	Balance of nature	Ecocrisis	Anti-exemprionalism	Limits to growth	Anti-antrophocentrism	NEP

Balance of nature	1.000	-.099**	.009	.110**	-.001	.280**
Ecocrisis	-.099**	1.000	.475**	.196**	.264**	.677**
Anti-exemprionalism	.009	.475**	1.000	-.024	.055	.652**
Limits to growth	.110**	.196**	-.024	1.000	.279**	.474**
Anti-antrophocentrism	-.001	.264**	.055	.279**	1.000	.505**
NEP	.280**	.677**	.652**	.474**	.505**	1.000
**. Correlation is significant at the 0.01 level (2-tailed).						

While of respondents' tendency for pro-NEP attitude the allowance of theirs across responses categories suggests an heterogeneity in environmental attitude, the results are in in line with others studies using NEP scale to measure people environmental attitude Aldrich, Grimsrud, Thacher, and Kotchen (2007), Clark et al. (2003), Cooper et al. (2004), Dunlap et al. (2000), Ek and Soderholm (2008), and Kotchen and Reiling (2000).

Mann – Whitney test shows significant difference between female (M = 251081.50) and male (M = 208238.50) respondents (U= 101655.5, P=0.021) in total NEP scores. Research findings agree with the general view that women are more environmentally sensitive than men and they score higher on the NEP scale (Halkos and Matsiori 2018; 2017; Diamantopoulos *et al.* 2003; Zelenzy *et al.* 2002; Mohai 1992).

The Kruskal-Wallis test found that environmental attitude scores in six different education levels did differ significantly (x^2 =16.606, df = 5, p = 0.174). Education is a factor influencing the ecological behavior of citizens and surveys have shown that that younger people are more likely to hold environmental beliefs than older respondents (Halkos and Matsiori 2018; 2017; Arcury *et al.* 1987; Arcury and Christianson 1990; Edelstein 1988; Mohai and Twight 1987).

Also Mann – Whitney test did not show a statistically significant relationship between mean NEP scale score and other variables as member of non-government organizations etc. Respondents' age and income did not make a considerable impact on their environmental attitudes.

On the contrary non parametric test revealed a high relation between mean NEP scores and individuals' opinions about marine biodiversity utility (Table 2).

Table 3: Descriptive statistics of respondents' basic socioeconomic characteristics

	Grouping variable	p	Decision
Mean NEP scale score	Recognition of marine biodiversity direct use value (supply goods and services)	.000	Reject the null hypothesis
	Recognition of marine biodiversity indirect use value (suppor our life, ecological balance etc)	.000	Reject the null hypothesis
	Recognition of marine biodiversity bequest value	.393	Reject the null hypothesis
	Recognition of marine biodiversity existent value	.000	Reject the null hypothesis
	Recognition of marine biodiversity option value	.014	Reject the null hypothesis
	Recognition of marine biodiversity quasi option value	.199	Accept the null hypothesis

3.2 Principal Components Analysis

A principal component analysis with varimax rotation was performed to check the NEP scale's dimensionality. In this way we tried to investigate if people perceive the dimensions of NEP scale as described in its construction. Specifically, with the use of NEP scale, consisting of 15 items with a 5-point Likert scale response system, we explore people's beliefs about humanity's ability to upset nature, the existence of limits to human economic growth and development, and humanity's right to rule over the rest of nature (Dunlap and Van Liere 1978; Dunlap *et al.* 2000; Hunter and Rinner, 2004). All items of revised NEP scale were translated without any other major changes. Each of the five facets of an ecological worldview (recognition of limits to growth, antianthropocentrism belief in a delicate balance of nature, anti-exemptionalism, and recognition of the possibility of an Eco-crisis) was addressed by three items.

The PCA of the NEP scale (KMO = 0.746; Bartlett $\chi 2$ (105) = 4556.190, p =0.000) indicated four eigenvalues greater than one (3.151, 2.711, 1.969 and 1.143). However, the Kaisers' criterion (eigenvalue >1) tends to overestimate the number of factors (Damásio 2012; Fabrigar et al. 1999).

Four factors are derived (according the criteria of Eigenvalue) from the NEP scale, which explains 60.21% of total variance (Table 4). The results confirm the grouping of the 15 items into four value orientations; namely: "*Eco-crises*", "*Criticism of human attitude*", "*Human abilities*" and "*Limits of Nature*". Many researchers have analyzed the dimensionality of the adult NEP scale with the number of dimension to fluctuate from one dimension to up to four dimensions (Dunlap *et al.* 2000).

The first one of these four factors contains six items related with "eco-crises" and human responsibilities for the ecological problems we face, but also for the consequences of their actions in nature. Specifically, to the first factor loaded two items on the possibility of eco-crisis (item 15 and 5), also two anti-anthropocentrism items (items 7 and 2), one item of fragility of nature's balance (item 13) and one item of rejection of exceptionalism (item 9).

All items to second factor make a Criticism of human attitude against the environment. In particular this factor has four items and includes one item on the limits to growth (items 1), one item on the fragility of nature's balance (item 3), one item on the possibility of eco-crisis (item 10) and one of the Rejection of exceptionalism (item 14).

Table 4: Results of PCA analysis on NEP scale items

Factor name		NEP Items	Component F_i				Commu-nalities
			F1	F2	F3	F4	
Eco-crises	Eco-crisis	If things continue going as they presently are, we will soon experience a major ecological disaster	0.76				0.60
	Anti-Anthro	Plants and animals have equal rights as humans to exist	0.75				0.58
	Balance	The balance of nature is very delicate and easily upset	0.71				0.54
	Anti-Exempt	Despite our special abilities, humans are still subject to the laws of nature	0.62				0.42
	Eco-crisis	Humans are severely abusing the environment	0.59				0.51
	Anti-Anthro	Humans have a right to modify the natural environment to suit their needs	0.42				0.31
Critic ism of	Limits	We are approaching the limit of the number of people the earth can support		0.78			0.65

	Eco-crisis	Human destruction of the environment has been greatly exaggerated		0.78			0.71
	Anti-Exempt	Humans will eventually learn enough about how nature works to be able to control it		0.70			0.66
	Balance	When humans interfere with nature, it often produces disastrous consequences		0.66			0.74
Human abilities	Balance	The balance of nature is strong enough to cope with the impacts of modern industrial development			0.81		0.75
	Anti-Anthro	Humans were meant to rule over the rest of the nature			0.76		0.62
	Anti-Exempt	Human intelligence will ensure that we don't make the earth unlivable			0.51		0.62
Limits of Nature	Limits	The earth has only limited room and resources				0.80	0.68
	Limits	The earth has plenty of natural resources if we just learn how to develop them				0.54	0.60
	Eigenvalue		3.151	2.711	1.969	1.143	
	Variance		21.0	18.1	13.1	7.6	
	Total Variance		59.825				
	Cronbach' s a		0.515	0.515	0.758	0.429	
	Total Cronbach's a						
	K.M.O. : 0.746 Bartlett's Test of Sphericity: Approx. χ^2=4556.190 df = 105 Sig.= 000						

In the third factor they highlight issues related to human abilities and how they affect nature The third factor includes one item on the fragility of nature's balance (item 8), on the antiexemptionalism (item 4) and one item on the anti-anthropocentrism (item 12).

The fourth factor refers to reality of limits to growth and it consists of two items on the limits to growth (item 6 and 11).

Table 3: Descriptive statistics of respondents' basic socioeconomic characteristics

	Grouping variable	p	Decision		Grouping variable	p	Decision
Direct Use Value	Eco-crises	.000	Reject the null hypothesis	Existen Value	Eco-crises	.000	Reject the null hypothesis
	Criticism of human attitude	.000	Reject the null hypothesis		Criticism of human attitude	.155	Retain the null hypothesis
	Human abilities	.000	Reject the null hypothesis		Human abilities	.000	Reject the null hypothesis
	Limits of Nature	.000	Reject the null hypothesis		Limits of Nature	.000	Reject the null hypothesis
Indirect Use Value	Eco-crises	.000	Reject the null hypothesis	Option Value	Eco-crises	.000	Reject the null hypothesis
	Criticism of human attitude	.000	Reject the null hypothesis		Criticism of human attitude	.076	Retain the null hypothesis
	Human abilities	.000	Reject the null hypothesis		Human abilities	.000	Reject the null hypothesis

	Limits of Nature	.000	Reject the null hypothesis		Limits of Nature	.071	Retain the null hypothesis
Bequest value	Eco-crises	.000	Reject the null hypothesis	Quasi Option Value	Eco-crises	.021	Reject the null hypothesis
	Criticism of human attitude	.052	Retain the null hypothesis		Criticism of human attitude	.000	Reject the null hypothesis
	Human abilities	.000	Reject the null hypothesis		Human abilities	.000	Reject the null hypothesis
	Limits of Nature	.062	Retain the null hypothesis		Limits of Nature	.000	Reject the null hypothesis

4. Conclusion

The present study tries to test the consistency and dimensionality of the NEP scale assessing the environmental worldviews of Greek people. According to the results Greek people are concern for the environment depending on their knowledge and their socioeconomic characteristics.

Therefore, there is a need for further systematic study of the deeper ideological roots of the ecological beliefs that predominate in this context and the specific ways in which individuals' rationalizations of nature and environmental issues are shaped by their personal, social, and economic circumstances.

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The spatio-economic dimension of aquaculture in Greece

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Abstract

Aquaculture is one of the fastest growing food industries worldwide as demand for fishery products is constantly increasing. The first units were established in our country in the early 1980s, and since then this sector is one of the most important branches of agricultural production and the most important branch of animal production. This activity has evolved into one of the most competitive sectors of our country's primary production and maintains one of the first positions in the production of Mediterranean species not only at European but also at international level. The aim of this research is to analyze the potential contribution of aquaculture enterprises to the development of coastal areas in Greece and especially to those municipal units where the specific production units have been installed and operated. In this context, the proposed methodology is based on the mapping of the municipalities of coastal areas in mainland and island Greece where aquaculture enterprises were established as recorded in the Register of Aquaculture Products Producers of the Veterinary Code for Pisces (Ministry of Rural Development and Food). An attempt is then made to systematically assess the socio-economic characteristics of the aforementioned municipalities through a comparative analysis with the corresponding features of the rest of the coastal area of Greece where aquaculture enterprises do not operate.

Keywords: Aquaculture, economic demography, coastal area, Greece.

JEL Codes: J10, Q22

1. INTRODUCTION

Aquaculture is one of the fastest growing food industries worldwide as demand for fishery products is constantly increasing. Since 1980, the production of capture fisheries has largely stabilized and therefore the increase in the world fish supply is mainly due to the aquaculture sector with farming finfish providing about 50% of the fish consumed in the world (FAO, 2018:2). Although the growth rate of the sector has somewhat slowed in the recent years, it remains more intense than those of other major food production sectors. In Europe, aquaculture is also a sector in expansion, representing about 20% of fish and shellfish supply (STECF, 2016) while around 80% of the production is concentrated in only 6 countries (Spain, U.K., France, Italy, Greece and Netherlands). Europe is one of the largest market for fish in the world with a sea food consumption that has continually increased during the past two decades so that its self-sufficiency is relatively low (less than 50%). This evolution of fish and shellfish demand offers real opportunities for the sector, and more particularly for the most disadvantaged rural coastal regions, provided that the extension of this type of activity takes place in the context of sustainable development that is the conservation of the natural resources (Haylor et al., 2001).

As regards Greece, the aquaculture sector is a quite recent activity with the first units created in the early 1980s and since then, this sector is one of the most important branches of agricultural production and the most dynamic branch of animal production. The sector is diverse, encompassing artisanal and family enterprises as well medium and large size enterprises.

This activity has evolved into one of the most competitive sectors of the primary production of our country and maintains one of the first places in the production of Mediterranean species not only at European but

also at international level. Aquaculture in Greece is composed of around 800 units of marine aquaculture (fish and mussels) and 120 freshwater units (Anagnopoulos, 2016) .
At the local level, the aquaculture units undoubtedly contribute to the diversification of the economic system, creating jobs directly and indirectly while it can partially compensate in different regions, the reduction of catches from wild fisheries. However, the implantation of new plants often generates negative reactions from the local population due to both risks of environmental pollution and risks of conflict with other economic activities, especially those directly related to tourism.
In this context, the aim of the present paper is to analyze and evaluate the potential contribution of aquaculture enterprises to the development of coastal areas in Greece. The analysis refers more particularly to the coastal municipalities in which aquaculture units are located. The specific question to which we will try to provide answers can be summarized in these terms: to what extent these municipalities with aquaculture activities are characterized by stronger resilience capacities comparatively to the other rural coastal regions?

2. METHODOLOGY

Initially, it was necessary to spatially locate the marine aquaculture production units in order to specify the municipalities concerned by the analysis. It is necessary to point out that the present work is focusing on the marine fish aquaculture. This mapping was based on the combination of two sources of information: (i) the existing map of aquaculture units in Greece produced by the APC Advances Planning Consulting in 2014 and (ii) the Register of Aquaculture Production Businesses from the Greek Ministry of Rural Development and Food, offering useful complementary data. For each one of the production units, the register contains information about their location (municipalities). Consequently, it was possible to select the coastal municipalities in which aquacultures have been implanted and to produce the relevant map.
In a second phase, a Municipality Scoreboard concerning demographic and socioeconomic characteristics was produced in order to assess the performance of the two groups of rural coastal municipalities: those with aquaculture production and the other ones. Most of the data have been extracted from the last two population censuses (2001-2011, ELSTAT), unique data sources available at such a small spatial scale. Despite the difficulty to obtain detailed information, the local scale was considered necessary to better analyze the potential impacts of aquaculture units on the coastal area.
Given that demographic and economic data are produced on the basis of the administrative division of the country (Region, Departments, Municipalities etc), the coastal area of Greece was delimited through the smallest scale, that is the local community which a subdivision of the Municipalities. Before the last administrative reform (2010), the country had 1033 municipalities and communes. Nowadays, municipalities are among 325, generally comprising several subdivisions which in most cases correspond to the former municipalities and communes. It is necessary to underline that the analysis at “settlement” level (villages) could be considered as more reliable, but the lack of data at such a scale would greatly weaken the analysis.

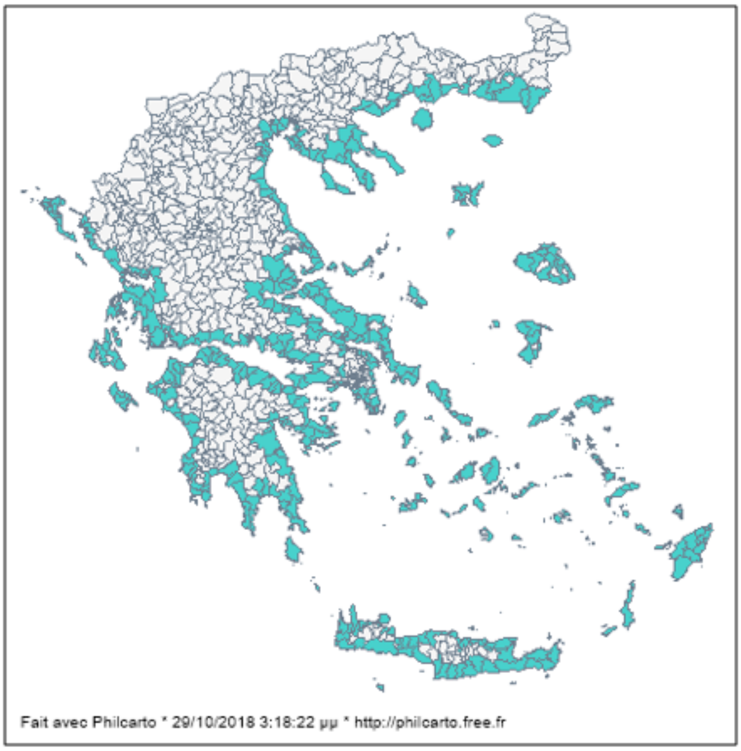
3. DELIMITATION OF THE COASTAL AREA OF GREECE

On a total of 1.044 local communities[5], the coastal area includes 442 corresponding to 42% of the country’s surface (Map 1). With about 4.8 million residents, it concentrates 44% of the population living in Greece and the majority of the biggest urban centers: Five of the nine municipalities with more than 100.000 inhabitants are located in this area. Greek coastal area is a dynamic space concentrating most of the economic activities of the countries, justifying finally a population’s growth during the last two decades (+9,1%) clearly higher than the country, limited to +5,9%. The attractiveness of the coast board, especially for young people and

[5] Local communities are municipal subdivisions of the new municipalities as defined by the last administrative reform implemented in 2010 which reduced the number of local administrative entities (municipalities and communes) from 1033 to 325.

retirees was particularly intense during the first decade 1991-2001 while the movement slowed down during the second decade. After 2001, the population living in coastal areas remained quite stable unless the rest of the country: the population living in the Hinterland decreased by 2,5% and for the first time since the 1950s, the total number of residents in Greece also decreased by 1,1%.

Map 1. The coastal areas of Greece: 442 municipalities



If the coastal area retains its population, this is due to a positive natural balance (more births than deaths), confirming its demographic dynamics while the migratory balance[6] is slightly negative comparatively to the hinterland (Table 1).

Table 1. Population dynamics of coastal areas

	Population		Total variation	Natural Balance	Migratory Balance	‰ NB(*)	‰ MB(*)
	2001	2011					
Coastal Area	4.787.092	4.801.598	14.506	28.959	-14.453	+6.0	-3.0
Hinterland	6.144.116	6.010.550	-133.566	8.717	-142.283	+1.4	-23.4
GREECE	10.931.208	10.812.148	-119.060	37.676	-156.736	+3.5	-14.4

(*) The rate of Natural Balance (NB) and the rate of Migratory Balance (MB) are calculated for 1000 inhabitants at the middle of the period 2001-2011

Examining the migratory balance by main classes of ages, it appears that coastal areas of Greece reveal an attractiveness for young population (20-29 years old) as well as for retirees, phenomenon also observed in several other European countries. Nevertheless, the coastal area is far from homogeneous, as it includes highly urbanized zones, tourist-oriented island areas as well as more or less disadvantaged rural areas. Over the last two decades, some coastal municipalities (8%) have effectively lost more than one-fifth of their population while a quarter of them have experienced a strong population growth (over 30%). Most of the last ones are touristic places (islands) or located at relatively close proximity from urban centers. In such a

[6] Migratory balance is the difference between the number of persons entering and leaving the coastal area during the period 2001-2011.

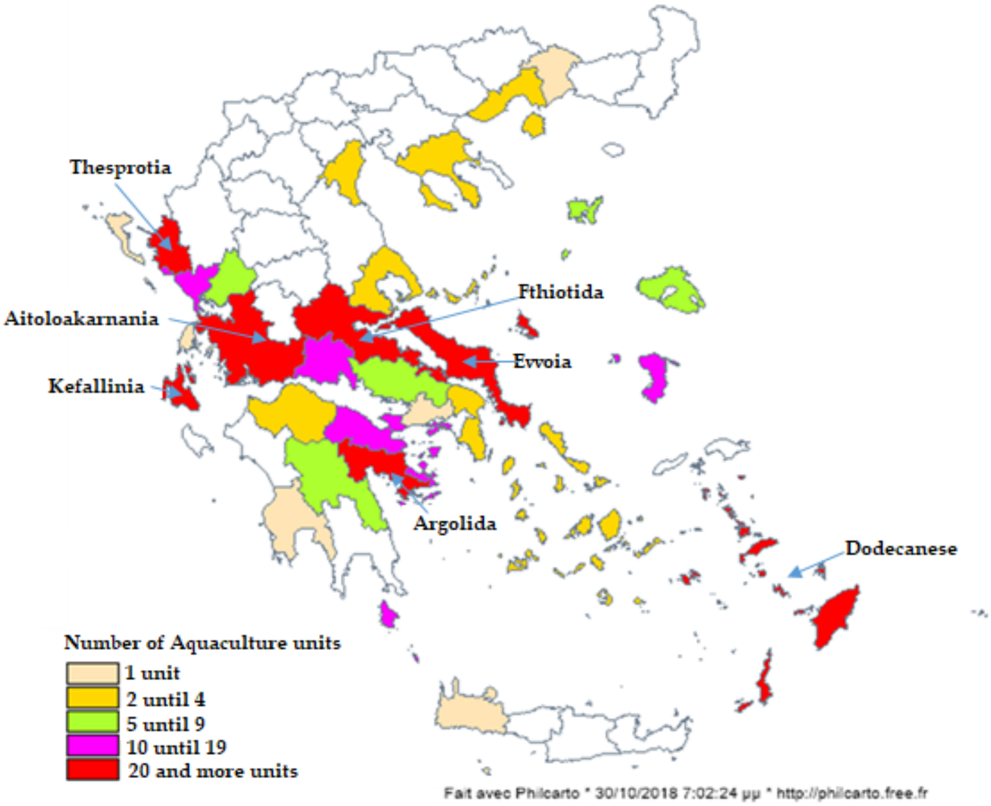
context, it is interesting to examine in what extent aquaculture production businesses is contributing to the capacity to maintain and/or attract new population and to participate to the local development process of the coastal areas directly concerned by this activity.

4. THE DEVELOPMENT AND DISTRIBUTION OF AQUACULTURE FARMS IN GREECE

Modern aquaculture is a quite recent activity in Greece. Through strong European Union support, the first marine fish farms were created in the early 1980s, importing technology mainly from France and Spain (FAO, 2016). Despite several crises mainly due to imbalance between demand and supply, inducing low prices periods in 1999-2002 and 2007-2008 (Theodorou et al. 2015) as well as the recent Greek economic crisis, the sector remains the first Greek exported animal product, representing more than 10% of the total agricultural exports of the Country. According to the Register of Aquaculture Production Businesses, the number of fish farms is 331, spread around the country but mainly located in 29 of the 51 regions of Greece (NUTS 3[7]). The spatial distribution reflects a significant concentration of farms (60%) in seven regions: Evvoia (33 farms), Argolida (28), Aitoloakarnania (27), Thesprotia (27), Kefallinia (26), Dodecanese (23) and Fthiotida (22).

[7] In accordance with Eurostat Classification (2013), NUTS 3 are the 3rd level of the "hierarchical system for dividing up the economic territory of the EU" in regions.

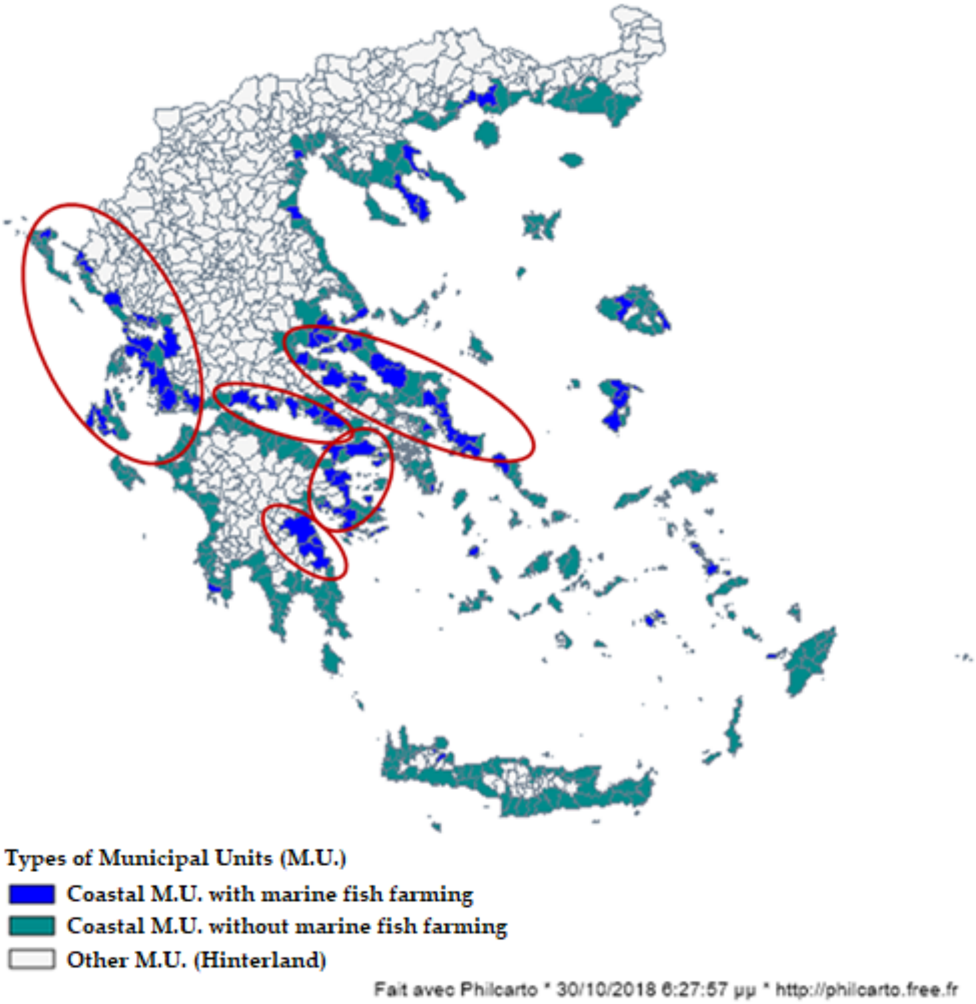
Map 2. Regional concentration of aquaculture farms



About the 331 aquaculture units, 309 are marine and located in 87 coastal municipal units (approximately 20% of all coastal municipal units), confirming the particularly high spatial concentration of the activity in 5 geographic zones of the country (Map 3). These 87 localities cover 26% of the Greek coastal area but comprise only 13,3% of the coastal population, a share that remained stable over the past two decades. Consequently the population density is quite low, about 47 inhabitants per km^2 against 109 for the other coastal units, confirming that most localities involved in this activity are rural and in a way, this can avoid some conflicts with other traditional activities of coastal areas, as it is the cas with tourism. Fom another point of view, by examining their location, it appears that they are generally not far from commercial infrastructures which is a necessary precondition for the fish farming's viability (Anagnopoulos, 2016).

The existence of even a limited number of marine fish farming especially in the remote areas and islands is of particular importance for such local communities because these farms contribute to the diversification of the local economy, offering employment's opportunities (F.G.M., 2017: 15). According to the STECF (2016), this activity provides directly or indirectly around 12.000 jobs. Moreover, despite the deep economic crisis facing the country, the decline in employment was relatively small compared to the rest of the economy.

Map 3. Main zones of marine fish farming – 87 coastal municipal units



During the last two decades (1991-2011), when aquaculture experienced rapid growth (3,550 tonnes of production in 1990, more than 110,000 in 2010), the population of the 87 municipal units involved in marine fish farming increased from 606.000 to 641.000 (5,8%), highlighting a relative population dynamics, certainly less intense than the other coastal units (9,6%) but clearly higher than hinterland units (3,4%). More important is the fact that during the period 2001-2011, most of the localities with marine fish farming have maintained their population: overall the 87 localities have lost less than 1000 residents. The retention of the population when the country is facing an important external migration (especially young people), is due to a positive net apparent migratory balance, reflecting the net establishment of new groups of population in these municipal units, unlike the other coastal localities whose population's growth is solely due to the positive natural balance (Table 2). Effectively, for the first group of localities, the rate of net apparent migration[8] is about + 13,8‰ while the other coastal localities as the whole country present a negative migratory balance. These positive flows concern mainly the persons aged between 30 and 59, corresponding to the potentially economically active population. This group of ages represents 63% of the total of new residents and its rate of apparent migration is particularly high (+ 18‰).

Table 2. Population dynamics of coastal localities with Marine Fish Farming

[8] The rate of net apparent migration is the difference between the number of persons entering and leaving a territory (locality) per 1000 residents at the middle of the period. The calculation of apparent migration during the period 2001-2011 is based on the following formula: Population in 2011 = Population in 2001 + Natural Balance + Apparent Migration Balance.

	Population		Total variation	Natural Balance	Migratory Balance	‰ NB(*)	‰ MB(*)
	2001	2011					
Coastal Area with Marine Fish Farming	641.881	640.910	-971	-9.799	8.828	-15,3	**+13,8**
Other Coastal Areas	4.145.211	4.160.688	15.477	38.758	-23.281	+9,3	-5,6
GREECE	10.931.208	10.812.148	-119.060	37.676	-156.736	+3.5	-14.4

(*) The rate of Natural Balance (NB) and the rate of Migratory Balance (MB) are calculated for 1000 inhabitants at the middle of the period 2001-2011

Finally, at the dawn of the crisis when the first austerity measures were implemented, the above mentioned trends can be interpreted as a capacity of resilience as regards the coastal localities with marine fish farming.

6. CONCLUSION

Despite the recent adverse demographic evolution at Country level (Kotzamanis et al., 2016), the coastal area and especially those with aquaculture activity present a relative dynamics or at least resilience capacity.
Comparatively to the rest of the coastal area, the 87 localities in which are located marine fish farming are characterized by a relatively higher population attractiveness: During the period 2001-2011 (period including the early years of the economic crisis), these localities have benefited from the installation of new populations while the remaining 355 coastal localities - as a whole - are characterized by a negative apparent migratory balance.
The above evolution can be interpreted at least as an indication of the relative socio-economic dynamics of the localities with marine fish farming, since population's retention or even more captation is one of the main characteristics of the economic attractiveness in itself (Servillo et al., 2011). This attractiveness can be considered even stronger given the fact that the new residents settling in these localities during the last decade were mainly working-age individuals and not only retirees as it is often the case for coastal zones.
Obviously the lake of recent data as regards the population growth at local level limits the scope of the present results. The analysis of the results of the next census (planned for 2021) will help to deepen the above approach and to evaluate more precisely in what extent the aquaculture sector will have strengthened the resilience capacity of the above examined municipal units.
After four (4) years of adverse evolution for the aquaculture sector, it is estimated that the sector is again in a "phase" of development and will therefore gradually have the capacity to create new jobs at the local level (FGM, 2017). At the same time, the Framework for Common Spatial Planning for Aquaculture (2011) and the new law for the Development of Aquaculture (2014) provide directives and criteria for the expansion and the competitiveness of the sector while the recent creation of the Hellenic Aquaculture Producers' Organization (2016) is expected to play a central role in order to develop a more effective cooperation between all stakeholders and finally to ensure the 'future resilience' of Greek aquaculture in an increasingly competitive environment both within Europe and globally.
Finally, based on the available data (though limited), the current analysis has shown that the coastal localities with aquaculture activity – even if they are in rural and relatively isolated areas – present a relatively dynamic demographic profile with enough margins of improvement. The very recent evolutions that is: (i) the production recovery (with 120.000 tonnes of aquaculture production in 2016, Greece has exceeded its maximum level of 2009) and (ii) the above mentioned institutional interventions, can therefore contribute to the future "resilience" of the sector as well as the coastal areas concerned by the activities directly and indirectly related to the aquaculture sector.

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Investigating the impact of wellbeing on economic performance: Evidence from European Union countries and regions.

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Abstract
Every society seeks to achieve an advanced level concerning the status of well-being both in social and economic level. Gross Domestic Product (GDP) indicates a primary measure of determining economic development between regions, within countries, across nations. Hence, it is considered a fundamental statistical measure the level of which might be crucial to make decisions and choose a direction concerning the course and level of development within a territory unit. In this perspective, the purpose of this study lies in investigating potential impacts that a wide range of well-being and world governance composite indicators exert on regional GDP per capita for the year 2016 (cross-sectional approach). Regressors found to positively impact regional GDP per capita implying that even non-material conditions might become crucial to achieve regional economic development. Significant practical implications have been derived based on research findings which in turn can be incorporated in relevant regional policies.

Keywords: well-being, regional economics, economic development

JEL Codes: I31 , R10 , O10

Ερευνώντας τον αντίκτυπο των δεικτών ευημερίας στην οικονομική απόδοση: ενδείξεις από περιφέρειες και κράτη της Ευρωπαϊκής Ένωσης

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Περίληψη
Κάθε κοινωνία επιδιώκει να κατακτήσει μια ιδανική κατάσταση ευημερίας τόσο σε κοινωνικό όσο και σε οικονομικό επίπεδο. Το Ακαθάριστο Εγχώριο Προϊόν (ΑΕΠ) αποτελεί το κύριο μέτρο που καθορίζει την οικονομική ανάπτυξη μεταξύ περιφερειών και κρατών. Κατά συνέπεια, πρόκειται για ένα σημαντικό στατιστικό μέγεθος, το επίπεδο του οποίου καθορίζει σε κρίσιμο βαθμό τη λήψη αποφάσεων και την κατεύθυνση σχετικά με την πορεία και το επίπεδο της ανάπτυξης μιας περιοχής. Στο πλαίσιο αυτό, ο σκοπός της παρούσας εργασίας έγκειται στη διερεύνηση του πιθανού αντίκτυπου που επιφέρει μια ευρεία σειρά δεικτών ευημερίας και δεικτών παγκόσμιας διακυβέρνησης στο περιφερειακό κατά κεφαλήν ΑΕΠ για το έτος 2016. Οι διερευνητικές μεταβλητές των παλινδρομήσεων βρέθηκε ότι επηρεάζουν θετικά το περιφερειακό κατά κεφαλήν ΑΕΠ με σαφείς ενδείξεις ότι οι μη-υλικοί παράγοντες μπορούν να επηρεάσουν σε σημαντικό βαθμό το επίπεδο της περιφερειακής οικονομικής ανάπτυξης. Τα αποτελέσματα της έρευνας μπορούν να χρησιμοποιηθούν σε πρακτικό επίπεδο για τη διαμόρφωση αντίστοιχης περιφερειακής πολιτικής.

Λέξεις Κλειδιά: ευημερία, περιφερειακή οικονομία, οικονομική ανάπτυξη

JEL Κωδικοί: I31 , R10 , O10

Introduction

Wellbeing has been a philosophical and sociological concern since the beginning of time, and research has extended over time to disciplines such as psychology, health sciences and economics (Smith and Diekmann 2017). Well-being might be considered as an outcome situation that defines the human (individual) perception and society status concerning living and standard conditions of living. Well-being is a valid population outcome measure beyond morbidity, mortality, and economic status that tells us how people perceive their life is going from their own perspective (Diener and Seligman 2004; Diener, 2009; Diener et al., 2009; Frey and Stutzer, 2002; Diener, 2009). In general terms, Gross Domestic Product (GDP) measures the value of a country's production of goods and services. GDP represents the total monetary value of all goods and services produced over a specific time period. In essence, GDP indicates a primary measure of economic development between regions, within countries, across nations. But, to what extent does this measure adequately reflect the level of well-being interpreted in non-monetary values? Does this measure always define the status of living, high or low, for intangible, but, substantial, non-material conditions? Does this number mirror any aspect of quality of life beyond financial terms? Does the current socio-economic status allow for resting only in economic dimensions of well-being? D'Acci (2010) argues that research is intensively put into practice so as to study measurements of well-being, including a more holistic vision of the development and welfare of a country. Human-centric approaches seem to be in the centre of the relevant debate for finding answers and provide relevant feedback when planning strategies. Scientists struggle for putting into practice policies and regional development plans that are highly connected with well-being status. In this perspective, the purpose of this study lies in investigating potential influences e.g. connection, relationship, strength, direction that a wide range of well-being and world governance composite indicators exert on regional GDP per capita for the year 2016 (cross-sectional approach). In essence, the aim of this paper is to look critically at the different concepts of wellbeing and investigate how they inform economic research across regions of European Union (EU) and Organization for Economic Co-operation and Development (OECD). Tracking and quantifying research evidence might shed light on the realization of potential and capacity (lessons learned, continuous improvement) to becoming better and achieving higher levels of human and society satisfaction. What it might be valued most, is the relationship and strength reported among such well-being factors and the most acknowledgeable measure for economic performance in terms of development and growth, namely regional Gross Domestic Product per capita.

Methodology

This study aims at investigating the potential impact of well-being indicators derived from OECD on regional GDP per capita among European Union (EU) member states. Such member states are simultaneously members of OECD. In addition, two World Governance Indicators (WGI) obtained from World Bank datasets as defined by Kauffman et al. (2010) were used to investigate potential effects on GDP per capita. The conceptual framework to measure regional well-being builds on over ten years of OECD work focusing on measures of people's well-being and societal progress which led to the creation of the Better Life Initiative. The nature of the indented analyses as well as the purpose of this study required the construction of two econometric models so as to process the data with the help of multiple linear regression. Multiple regression is widely used to estimate the size and significance of the effects of a number of independent variables on a dependent variable (Neale et al., 1994). Two datasets were used to perform the analyses. The first concerns data derived from OECD (2016). Such data are directly related with three well-being indicators used as composite variables (predictors) in multiple linear regression. Thirteen indicators compose eleven well-being topics which in turn give the three 'broader' composite indicators: Material Conditions (mat), Quality of Life (qual), Subjective Well-being (sub). More specifically, Material Conditions predictor is composed by income, jobs, and housing well-big topics. Quality of Life encompasses health, education, environment, safety, civic engagement and accessibility of services whereas Subjective well-being consists of two well-being topics, namely community and life satisfaction. The most recent values of all indicators were released in 2016. Two new dimensions have been added compared to previous relevant datasets (e.g. 2014): Community and Life satisfaction. Both compose the Subjective Well-being which was used in multiple linear regression as a predictor variable. Region of Åland in Finland (FI20) was excluded from the analysis due to lack of data on Perceived social network support (Community well-being topic) and Self-assessment of life satisfaction indicators (Life satisfaction). As a result, 192 regions for further analyses were finally used. Eurostat database was the source to obtain regional Gross Domestic Product per capita (PPS) by NUTSII regions for the year 2016. PPS stands for Purchasing Power Standards and is a common currency that eliminates the differences in price levels between countries allowing meaningful volume comparisons of GDP between countries. For analytical purposes, we assume that exchange rate between USD dollars ($) and EURO (€) is 1:1. Two World Governance Indicators (WGI) were used to perform multiple linear regression as well: voice and accountability and regulatory quality. Voice and accountability indicator reflect perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Regulatory quality reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Kaufmann et al. (2010) state the definition and methodology used so as to arrive at safe calculations.

Results

Two econometric models as a function of multiple linear regression were constructed so as to serve the purpose of this study. The mean value for regional GDP per capita within the regions under consideration was 27,619€. Luxemburg has the highest value of regional GDP per capita for the year 2016 (71,500€) whereas Northern Great Plain in Hungary has the lowest value (12,500€). Well-being composite indicators have a measurement scale between 0 and 10. For mat well-being composite variable, the highest value was reported in Bavaria region in Germany (7.7) while the lowest value was found in both West Macedonia (1.6) and West Greece (1.6) regions in Greece. For qual well-being composite variable, the highest value was reported in Sweden, and specifically in Upper Norrland region (8.8) whereas its lowest value was found in Lubuskie region in Poland (4.2). For sub well-being composite variable, the highest value was found in both Northern Jutland (9.8) and Capital (DK, Hovedstaden) (9.8) regions in Denmark while the lowest value was reported in region of Central Greece (Sterea Ellada) (1.2). For voice Worldwide Governance Indicator, the highest value was reported in Portugal in North region (Norte) (1.77) whereas the lowest value was found in region of Central Hungary (Közép-Magyarország) (0.37). For regulat WGI, the highest value was reported in Grinigen in Netherlands (1.98) whereas the lowest value was found in region of East Macedonia in Greece (0.15). For the first econometric model, and in view of meeting the assumption of normality concerning the dependent variable, a mathematical transformation was applied and the dependent variable took the form of its natural logarithm. After the transformation the dependent variable ln_GDPpc found to be normally distributed. Furthermore, by examining the relevant boxplot no extreme outliers seem to exist. The results show that the values of the dependent variable ln_pcGDP16 are normally distributed with a skewness coefficient of 0.237. Also, Kolmogorov – Smirnov test for normality gave a sig. value of 0.200 whereas Shapiro – Wilk test gave a sig. value of 0.190. As a result, an equation with $F(3,188) = 90.071$, $p < 0.05$, and an R^2 of 0.59 was found, meaning that 59% of the variance of the dependent variable (ln_GDPpc) is explained by the regressor variables included in the model. The value of such strength of relationship among the natural logarithm (ln) of GDPpc and the three predictors is acceptable, meaning that the model fits the data well at a considerable and significant level (goodness-of-fit). Analysis of Variance table (ANOVA) shows that at least one of the regression coefficients is significantly different from zero. The value of R^2 is considered high. The level of multicollinearity can be judged by examining Tolerance, Variance Inflation Rates (VIF) and Condition Index (CI) values. Menard (1995) states "A tolerance of less than 0.20 is cause for concern; a tolerance of less than 0.10 almost certainly indicates a serious collinearity problem." Since VIF is the inverse of tolerance a tolerance of 0.20 corresponds to the rule of 5 and a tolerance of 0.10 to the rule of 10. Neter et al. (1989) state "A maximum VIF value in excess of 10 is often taken as an indication that multi-collinearity may be unduly influencing the least square estimates". For high values of VIF we expect low values of TOL. A value of 10 has been recommended as the maximum level of VIF (Hair et al 1995; Kennedy 1992). Notwithstanding, Rogerson (2001) suggests a maximum value of 5 whereas Pan and Jackson (2008) recommend a maximum value of 4. Furthermore, all CI values equal or larger than 30 are critical whereas values between 10 and 30 indicate weak multicollinearity (Belsley, 1991). Concerning that first econometric model, Tolerance and VIF values for mat predictor are 0.406 and 2.464 respectively. For qual predictor Tolerance and VIF values are 0.378 and 2.646 respectively. For sub predictor, Tolerance and VIF values are 0.443 and 2.259 respectively. In addition, all CI values for the first econometric model are lower than 30. Consequently, all relevant values for detecting the level of multicollinearity are within acceptable ranges as indicated in the bibliography. One of the basic assumptions that should be tested in multiple linear regression is the presence of homoscedasticity which means that regression residuals must have a constant variance (same variance, equal variability). When this assumption is violated (heteroscedasticity) then the calculation of the standard errors is unreliable which in turn leads to unreliable conclusions concerning the significance of the regression coefficients. Based on the Figure below (Fig. 1), it is visually judged that the values of regression standardized residuals are not normally distributed. Such evidence shows lack of homoscedasticity which in turns does not allow for achieving dependable results and damages the robustness of the constructed model. As a result, the assumption of homoscedasticity is violated and corrective action should be taken. Otherwise, the model will not perform well and misleading conclusions will be drawn. After applying the White test for detecting and correcting the model (removing heteroscedasticity) we received the following results (Table 1).

Fgure 1. Normal probability plot for ln_GDP per capita (2016) dependent variable.

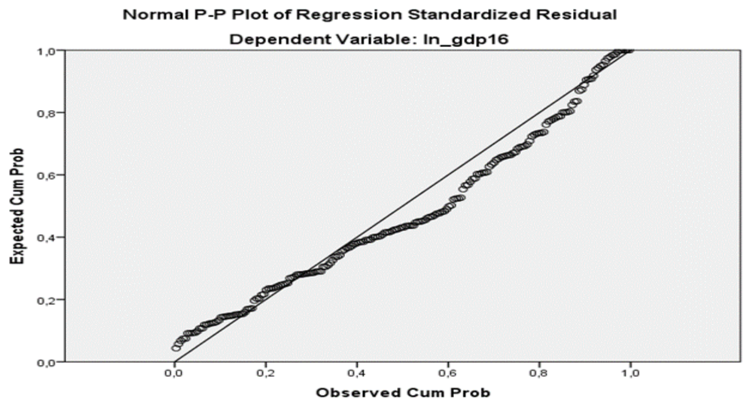

Table 1. Regression results having applied White test for removing heteroscedasticity

	B	SE	WHITE_SE	WT_VAL	SIG_WT
Constant	9.172	0.099	0.095	96.466	0.000*
mat	0.119	0.016	0.013	9.001	0.000*
qual	0.047	0.022	0.023	2.093	0.038*
sub	0.019	0.012	0.010	1.783	**0.076****
* Significant at a 95% Confidence Interval, **Significant at a 90% Confidence Interval					

If we increase mat by one unit we expect (predict) regional GDPpc to increase by 12.63% by keeping all other predictors constant. Accordingly, if we increase qual by one unit we expect regional GDPpc to increase by 4.9% by keeping all other predictors constant. Within the same logic, if we increase predictor variable sub by one unit we expect regional GDPpc to increase by 1.9% by keeping all other predictors constant. Based on its scale measurement all three predictors can take values between [0,10]. All regression coefficients are statistically significant (p value<0.05) and have the expected signs (positive). We can conclude that our model is robust.
The second econometric model was constructed so as to investigate potential effects of two Worldwide Governance Indicators (WGI) on regional Gross Domestic Product (GDP) per capita for the year 2016 (dependent variable) among countries that are simultaneously members of EU and OECD. An equation with $F(3,188) = 54.071$, $p < 0.05$, and an R^2 of 0.36 was found, meaning that 36% of the variance of the dependent variable (ln_GPDpc16) is explained by the predictors included in the model. Analysis of Variance table (ANOVA) shows that at least one of the regression coefficients is significantly different from zero. No multicollinearity exists since values of TOL (0.513) and VIF (1.948) are within the acceptable range of values. The same assumption can be made concerning CI and Variance Proportion Values. Both CI values are less than 15 whereas none of each CI is associated with more than two coefficients the variance of which is greater than 0.90. Normal probability plot (Fig. 2) shows in a graphical manner if the values of a variable, in our case regression standardized residuals, fit a normal distribution. By examining the relevant plot, we conclude that regression standardized residuals are not normally distributed. After applying the White test for detecting and correcting the model (removing heteroscedasticity) we received the following results (Table 2).

Figure. 2. Normal probability plot for regression standardised residuals for ln_GDPpc values (second econometric model).

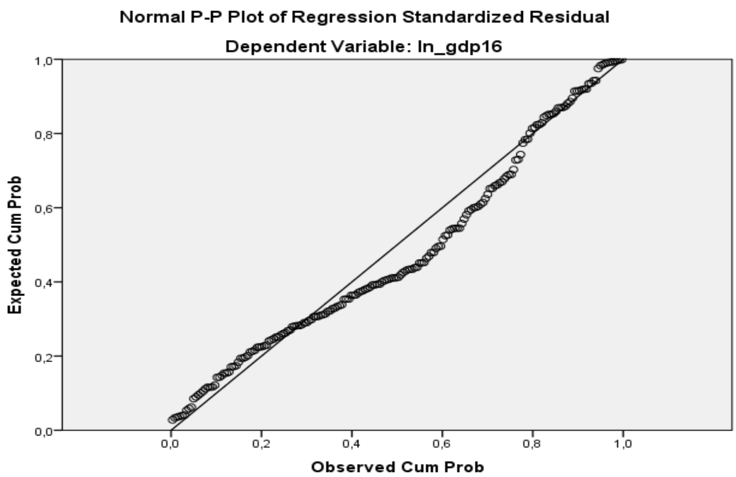

Table 2. Regression results after applying White test for the second econometric model.

	B	SE	WHITE_SE	WT_VAL	SIG_WT
Constant	10.131	0.21	0.021	476.765	0.000
ln_voice	0.402	0.089	0.100	4.025	0.000
ln_regulat	0.159	0.044	0.041	3.883	0.000

Judging from the results of the second econometric model it can be argued that if voice is increased by one percent, we expect GDP per capita to increase by 0.4%, ceteris paribus. If regulat is increased by one percent, we expect pc GDP to increase by 0.16%, ceteris paribus. Voice and regulat predictors take values within [-2.5, 2.5]. All regression coefficients are statistically significant (p value<0.05) and have the expected signs (positive). We can conclude that the model is robust.

Discussion and Conclusions

Central is the effect of mat predictor on GDP per capita. Results showed that the greater change (increase) in the regional GDP per capita is caused by the mat predictor. Interestingly, such indicators give a material dimension to the concept of well-being which in turn seems to positively affect the GDP per capita at a high degree. Mat composite variable has its lowest value (1.6) in Greece in both Regions of West Greece and West Macedonia. Based on research findings if we increase mat composite variable thus, fix unemployment issues by establishing a friendly business environment for private sector and take advantage of all region's advantages concerning geographical position and inherent characteristics, GDP per capita will increase at a considerable level from the present value (17,200€). Therefore, Regional Smart Specialization Strategy for Western Macedonia should be put in practise (RIS3). The same issues come evident concerning Region of West Greece. Low values of mat composite variable indicate that corrective action should be taken so as to revitalize, reboot, regional and local economy at once. Well-structured regional policies and well-organized development plans must be aligned with the potential and capacity of the Region. Smart and effective exploitation of financial instruments from EU seems to be a good solution to start with. Quality of life concept (qual) seems to be complementary to this argument. More specifically, for one unit increase in the scale measurement of the composite variable qual, [0-10], GDP per capita will increase by 4.7% (ceteris paribus). Quality of life is composed by several dimensions, namely health, education, environment, safety, civic engagement and accessibility of services. In essence, positive changes in GDP per capita are supported by the fact that well-educated individuals, for instance, might receive private returns with regard to employment rates, research and development initiatives, high levels of productivity and social benefits. Subjective well-being is associated with social cohesion and social connectedness which in turn help people to trust organizations and institutions. As a direct consequence, social networks and interpersonal relations will be built resulting in achieving individual well-being and satisfaction within the overall socio-economic system. That said, GDP per capita will evidently be increased given the importance of education in creating better and gaining more. Quality in life means developing in a sustainable and cost-effective manner its fundamental components e.g. environment. Green and blue economy, cycling economy and relevant aspects of every economic activity encompass superior level of quality not only within its theoretical background but, also, within its practical implication with respect to the total economic outcome in a given region. Not to mention the significance of physical and mental health in producing and enjoying goods and services due to better health and labour participation. All aspects have to offer in a positive manner so as to produce better and consume smarter by, simultaneously, experiencing the added value to regional economic status. Supportively, civic engagement in terms of governance, trust in institutions and political stability as well as consultation on rule-making are fundamental elements to achieve superior economic performance in terms of actively participating in determining the regulatory framework and the business environment where organizations and institutions deploy its management and marketing plans. Such participation of citizens in the political process seemed to affect in a positive manner the GDP per capita. Since environmental quality contributes to the notion of quality of life, great attention should be paid on biodiversity and geodiversity issues since rising GDP per capita might have finally adverse effects on regions with a high degree of pollution. Intense industrialization and severe economic activity might damage ecosystem services and benefits received. Environmental changes might have long term devastating effects on citizens and affect in a negative manner the quality of life within a region. Furtherly, quality of life interrelates citizens (individuals that have preferences, make decisions and demonstrate environmental behaviour, are economically active), society (host communities which seek for social integrity and cohesion), ecosystems (supply goods and services, tangible and intangible) and economy (demand forecasts, revenues, return on investment).

Arguably, within a safe, clean, well-functioning and welcoming living environment the value of quality raise awareness of the economic and social impacts associated with development and growth. Consequently, there is emerging evidence of how such measures can lead to longer-term business and economic gains with a positive impact on GDP per capita. A wide array of thinking is being brought between GDP per capita and subjective well-being to describe how a region progress in economic terms and how social indicators affect, signal, such relationship. In this perspective, Davies (2014) argues that indicators of social aspects that have a dominant role in determining citizens' well-being are increasingly being used to supplement economic measures whereas subjective evaluations of well-being can also be used as a measure of progress. Subjective well-being reflects the notion of measuring how people experience and evaluate their lives (OECD, 2016). In addition, it can be argued that subjective well-being is defined as 'a person's cognitive and affective evaluations of his or her life' (Diener et al., 2003). In this perspective, subjective well-being represents a useful measurement for assessing progress and determining levels of satisfaction within the regional socio-economic system. It would be vital to mention that the lowest subjective well-being might be reported by unemployed individuals and thus, 'leakages' or reduced economic activity might be experienced in regions with low employment rates. In essence, higher values of subjective well-being will find GDP per capita to increase. In the same wavelength, the second econometric model indicates that voice and regulat predictors affect positively and significantly regional GDP per capita (2016). More specifically, voice predictor variable reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Regulat predictor variable reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Results mirror to a large degree the need and necessity to actively participate, substantially contribute and firmly decide about the public policy that best serves common good and advances social cohesion. Such conclusion is highly associated with the ability to objectively judge public policies that have as a central premise regional growth in terms of sustainable development. Regulat predictor shows that when policies are designed to promote in a lawful and dependable manner private sector development then the relevant economic activity will create benefits for regional units. It goes without saying that public policies should facilitate investments and business extrovert character so as to experience growth year by year. If this is not the case, then opportunities of development will become less by simultaneously narrowing the margins for further exploitation of well-educated individuals (brain drain phenomena). Individuals will have less disposable amount of money to spent, unemployment will reach high levels and housing conditions will not become better. Consequently, they should act against such phenomena by participating to public processes whereas officials should make appropriate reforms and set comprehensive regulatory framework characterized by flexibility and fairness to let entrepreneurs execute their business plans. Attention for further research should be paid since there is strong empirical and ethical arguments for degrowth (Buchs and Koch, 2018). The term is defined as a voluntary, democratically negotiated, equitable downscaling of societies' physical throughput until it reaches a sustainable steady-state (Alexander 2012; Schneider et al., 2010; Latouche, 2010). Human-centric well-being aspects is what policy makers should value most. Such an effort requires great attention since each region is unique and must act as a 'learning organization' that continually seeks improvement. Nevertheless, the study results demonstrate the potential of the multiple linear regression for analysing data and make projections that profoundly enhance our understanding of the role these projections play in motivating and directing spatial planning, investments and public policies.

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What drives Responsible Business? Examining the links between Reputation Risk, Non-Government Organization (NGO) Pressure and Responsible Business Performance

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Abstract
This paper investigates the comparative influence of reputation risk and NGO pressure on corporate activity in the field of environmental responsibility. The paper revisits research to test quantitatively if there is a perverse incentive between environmentally damaging industries and perceived environmental performance, reputation and disclosure. Access to industry leading database sources is also utilized to test the hypotheses more rigourously and improve on original data. Through new research, the role of NGO's is tested to understand the comparative strength of this relationship. The finance sector is also incorporated into a second set of samples to test in view of the increasing focus by campaign groups on the sector as a facilitator of damaging sectors. The sample sets are derived from the Newsweek Green 500 published annually by Forbes. A regression analysis is conducted on all metrics along with various forms of correlation testing on all relationships. Testing indicates the role of NGO's being more significant than reputation risk metrics or alignment to responsible investor ratings. Within the sample set the role of finance companies is also more pronounced than the traditionally supposed environmentally damaging issues. A negative correlation between financial performance and one of the disclosure metrics is also found.

Keywords: Environmental; NGOs; Ratings & Ratings Agencies; Reputation; Social Responsibility.

JEL Codes: G24; L14; L31; M14; Q56.

1. Introduction (Εισαγωγή)

This paper investigates the comparative influence of reputation risk and NGO pressure on corporations and environmental responsibility. The paper revisits research to test if there is a perverse incentive between environmentally damaging industries and perceived environmental performance, reputation and disclosure.

In recent years there has been a rapid increase in the focus on corporations and their environmental impact. This focus has been from competing stakeholders such as NGO's, responsible investors and consultancies all with differing agendas. Corporations are faced with a range of non-legislative demands to comply or support these initiatives to mitigate reputation impact, be more attractive to investors and benefit from any potential business advantage.

Through this research we seek to understand, building on previous methodology, the varying roles of these stakeholders utilizing NGO data sets not commonly used and updating obsolete metrics previously used. We hope to articulate what are the real drivers of reputation for companies and if there are actual or perceived benefits.

2. Literature Review (Ανασκόπηση Βιβλιογραφίας)

The concept of responsible business is one which is constantly evolving and developing. A wealth of terminology has been developed to describe differing approaches and labelling of how companies can be more responsible. Definitions vary significantly ranging from the traditional 'corporate social responsibility (CSR)' to more visionary 'creating shared value (CSV)' or the investment focused 'environmental, social & governance' (ESG) categorization. In the absence of a single global formal standard, ISO26000 provides guidance collating a range of existing guidelines and clarifying the definition of 'social responsibility' and the role in contributing to sustainable development: "Social responsibility: responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behavior…".

Many definitions of CSR focus on it being a voluntary activity. This is enshrined in the definition by the European Commission (2011), as " a concept whereby companies integrate social and environmental concerns in their business operations and in their interactions with their stakeholders on a voluntary basis."

Critics of CSR and other forms of responsible business highlight this voluntary nature as a major weakness. According to the European Commission (2014), only 10% of the largest companies in the EU currently disclose non-financial information, e.g. environmental and social aspects.

Visser (2010) highlights three key areas as the reason why CSR has failed to meaningfully address major societal issues such as ecological decline or world poverty. These consist of incremental improvements in management which are not significant enough, CSR functions/resources being peripheral to the short-term shareholder driven structure of companies and that true corporate shifts to responsibility costs a significant investment or loss of revenue in the short-term.

The OECD (2001) draws attention to the fact that it is not down just to the actual private or voluntary initiative, but there is a need for other aspects of the economy and society to function properly (e.g. regulation), "…the effectiveness of these initiatives is closely linked to the effectiveness of the broader systems of private and public governance from which they emerge – private initiatives cannot work well if other parts of the system work poorly".

There is a growing trend in trying to value or demonstrate responsible business approaches which tend to be driven by superior (non) financial performance and engagement of stakeholders. This is a debate often summarized as defining 'the business case' for CSR / Sustainability activity. Advocates of this approach are often looking at this from an 'opportunity' perspective and not necessarily reacting to negative circumstances. There are a multitude of reasons why a company might wish to be responsible, Carrol et al (2010) categorize four key example areas defining why a company might wish to focus on CSR: "Reducing costs/risks, competitive advantage, reputation/legitimacy and seeking win-win outcomes".

Responsible business initiatives can range from employee wellbeing programs delivering better staff performance to effective corporate governance measures improving corporate decision making. This in turn, can have indirect effects on operational performance, cost of debt or share price performance. Clark et al (2014), in their meta-analysis on sustainability and financial performance indicate that over 80% of their reviewed articles indicate a positive correlation on stock price performance, operational performance and cost of capital.

Business today is exposed to a far wider range of stakeholders than the traditional shareholder, customer and employee dynamic. The advent of social media has inevitably given a voice to campaigners, concerned employees and contributes to the rapid dissemination of information. In order to manage, both the traditional and social media channels, being able to back up the claims of responsible business can give weight to company communications, i.e. being able to prove what is being said.

Due to the wide-ranging nature of non-financial issues being considered under the broad umbrella of responsible business, being able to demonstrate aggregate performance is challenging. It is highly likely that the definition of responsibility will vary depending upon the stakeholder who is interested, e.g. an environmental campaigner will be interested in different information from a human rights activist.

There are already a wealth of benchmarks operated by organizations aiming to support responsible investment and demonstrate superior sustainability performance. Two of the major semi-

quantitative indices, FTSE4Good and Dow Jones Sustainability Index, aim to support investors wishing to take a more proactive ESG approach. These ready-made indices allow an investor or other stakeholder to make a quick judgment on which companies are more responsible. Naturally, this requires trust to be placed into the analysis and interpretation of the index provider. Each index utilizes their own methodology assessing numerous company criteria.
KPMG, (2014) highlights the need to monetize the externalities of companies for more accurate company valuations. By valuing externalities they highlight the negative impacts on the environment/society (e.g. non-regulated pollution or labor abuses) which are beyond conventional financial valuation, but also the positive ones not represented on balance sheets (e.g. wealth creation, positive product impacts).
The International Integrated Reporting Council, (IIRC) (2014) believes the concept of integrated reporting will provide a solution. By replacing various disconnected forms of corporate reporting, they believe it will encourage companies to think and demonstrate the creation of value in the short, medium and long term. It highlights reporting against a number of 'capitals'(financial, manufactured, intellectual, human, social and relationship) but do not intend to provide metrics. But the International Integrated Reporting Council (2013) highlight that the Framework should not, "… define value from any one particular perspective because what constitutes value depends on an individual's own circumstances and perspective…".
This suggests that whilst the IIRC might provide a framework for communicating, the intent is not to measure or value responsible business. This differs from the Sustainability Accounting Standards Board (SASB) (2013) who focus on American based companies recognizing that, "…accounting for non-financial assets of performance in financial terms has inherent limitations in the absence of robust markets or proper valuation techniques".
SASB highlights that although environmental and social capitals can be accounted for in terms of assets and liabilities, they cannot be accurately priced, either historically or marked to market. What is certain, is that there is no shortage of initiatives in trying to monetize responsible business for different stakeholders, a few examples include The Economics of Environment and Biodiversity initiative (Sukhdev, P et al 2014) focusing on how the environment can be valued in decision making, the Environmental Profit and Loss (EP&L) accounting technique utilized by Puma and Novo Nordisk, developed in association with Trucost (2014), and the Climate Disclosure Standards Board (2013), a sub-project of the Carbon Disclosure Project focuses on the disclosure of carbon impact values.
All these advanced methodologies attempt to formulate a route for organizations to express their responsibility. But, many NGO's would simply state that showing business being refused with a poor environmental and social record is the most clear demonstration of responsibility beyond the traditional shareholder. A number of organizations are increasingly taking this route in financial services.
As Cho et al (2012) suggest, there are clear linkages between external disclosure and poor environmental performance. In turn, measures of performance, in this case the DJSI positively influences perception, based on increased disclosure due to poor performance. Cho et al (2012) examine to what extent there is a correlation between perceived reputation risk, performance and disclosure using proxy sources.
Several key statistical formulae are utilized to test their theories. Although these are not specified in the paper, from the description they are assumed as follows (values for x, y defined in section 3):
Correlations based on a path analysis- Eq (1)

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (1)$$

Regression derived from Brown at al (1994) and used by Cho et al (2012) – Eq (2)
Rating = Bo + B1 + B2 + B3 + B4 + B5 + e. (2)

T-test – Eq (3)

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{S_1{}^2}{N_1} + \frac{S_2{}^2}{N_2}}} \quad (3)$$

Pearson Product-Moment calculation Eq (4)

$$\rho_{X,Y} = \frac{E(XY) - E(X)E(Y)}{\sqrt{E(X^2) - E(X)^2}\sqrt{E(Y^2) - E(Y)^2}} \quad (4)$$

Whilst it is logical that companies are more likely to proactively disclose their response, position or activity in relation to controversial environmental activities it may not be down to negative media exposure. The present paper builds on the work of Cho et al (2012) and introduces an additional value to understand if specific NGO pressure on companies is a greater driver. It is also highly likely that the two factors work in tandem and that there may be a time lag between the NGO pressure on a company, additional disclosure and then improved performance.
The key controversy of the work by Cho et al (2012) examines if the DJSI is incentivizing un-environmentally friendly activity. It's suggested that the desire for transparency and increased disclosure results in viewing corporations in a more positive light and that the limitations of non-financial information facilitates this.

3. Methods and Data (Μέθοδοι και Δεδομένα)

The methods of analysis are statistical with multivariate analysis due to the number of parameters than come into play.

3.1 Data

The research initially seeks to test the hypothesis of Cho et al (2012). A baseline of 2015 data is used as being most complete across all the sources. A number of improvements are made on the original data sources and some substitutions where they were no longer used in 2015. Two internationally respected data providers agreed to allow use of their information for academic purposes. Firstly, RepRiskAG – the Zurich based assessor of ESG risk which delivers a consolidated reputation risk score for 55,304 companies globally. Secondly, SigWatch – a global NGO tracking database assessing the activity of 6,000 NGO's globally and their corporate targets.

Table 1: Data sources

	Cho et al (2012) sources	Updated sources (2015)
Sample	Newsweek Green 500	Newsweek Green 500
Finance Metrics	Unspecified	Morningstar

Reputation	Newsweek Green 500 Reputation Sub-Score	Reputation score demised by Newsweek. RepRisk replacement
Performance	Newsweek Green 500 Score	Newsweek Green 500 Score
Disclosure	Clarkson et al (2008) scale for GRI ---------------------------------- Not applicable	GRI official disclosure ratings scaled to Clarkson et al (2008) -- CDP official ratings scaled to Clarkson et al (2008) range
DJSI	DJSI binary indicator of membership	DJSI performance rankings (improvement on binary limitations)
NGO	Not applicable	SigWatch tracking database

The sample utilized by Cho et al (2012) follows a similar path to other studies in that they select three sectors which they consider to be the most environmentally damaging. The focus was limited to basic materials, utilities and energy for the likelihood of greater political focus. In recent years, the political focus has increased with regard to financial services and their facilitating impact on environmentally damaging activities. We therefore incorporate financial services into the sample set.

3.2 Methods

H1a: Perceptions of corporate environmental reputation are positively associated with firm environmental performance – Eq. (1) is employed (Where x = individual RepRisk score of company and y = ranking within Top 500 Green Companies).

In addition to the first hypothesis, Cho et al (2012) utilize a regression analysis (Brown et al, 1994) against the reputation scores to confirm there is no undue perception influence. As their original data was partly based on opinions, this was a relevant concern. With the utilization of RepRisk as the substitute, their methodology is not based on opinions and takes into account a deeper analysis of reputation avoiding this bias. The only available financial metric across all companies in the data set was Return on Assets (ROA) which is used along with other data sources based on Eq (2). These values are provided in a matrix with summary statistics and correlations. They include testing against new NGO data sources and improved data sets. A principal components analysis is also undertaken to check which elements are most responsible for variance.

In recreating the analysis of Cho et al (2012), a t-test of means is conducted to check if the selected industry sectors are lower than the overall Newsweek sample to indicate worse performance in the form of Eq (3). These values along with the other results are extracted to recreate the correlation matrix table used by Cho et al (2012), and is a result of a series of Pearson product-moment correlations Eq (4).

H1b: Perceptions of corporate environmental reputation are positively associated with firm environmental disclosure - Eq. (1) is employ*ed* (Where x = individual RepRisk score of company and y = GRI score / CDP score)

The methodology of Clarkson et al (2008) was used by Cho et al (2012) in assessing GRI compliance. Since 2012, GRI introduced an official scoring method, this is utilized and the scale is rationalized to the same 0-100 score.

The original intent of Cho et al (2012) was to test the quality of disclosure within their research. GRI remains a self-disclosure rating with no independent test of quality. The Carbon Disclosure Project is an alternative disclosure metric which focuses on environmental issues but is checked by the organization, we use their rating rationalized to the same scale, to see if this is a better indicator of disclosure quality.

H2a: Perceptions of corporate environmental reputation are positively associated with firm membership of the DJSI - Eq. (1) is employed (Where x = DJSI performance scores and y = individual RepRisk score of company)

Cho et al (2012) utilized a binary measure of whether a company was a member of the DJSI. They were not aware that RobecoSAM release a report later in the year of more granular performance rankings. These are utilized on a scale of 0-5 relative to the company performance improving on the previous issue of a binary data source.
H2b: Firm membership of the DJSI is positively associated with firm environmental performance - Eq. (1) is employed (Where x = DJSI performance scores and y = ranking within Top 500 Green Companies).
H2c: Firm membership in the DJSI is positively associated with firm environmental disclosure - Eq. (1) is employed (Where x = DJSI performance scores and y = GRI score / CDP score).
H3: Firm environmental disclosure is negatively associated with firm environmental performance - Eq. (1) is employed (Where x = GRI score / CDP score and y = ranking within Top 500 Green Companies).
H4a: Perceptions of corporate environmental reputation are positively associated with the high frequency of NGO campaigns targeting the firm - Eq. (1) is employed (Where x = number of times targeted by NGO activists and y = individual RepRisk score of company).
H4b: High frequency of NGO campaigns is positively associated with firm environmental performance - Eq. (1) is employed (Where x = number of times targeted by NGO activists and y = ranking within Top 500 Green Companies).
H4c: High frequency of NGO campaigns are positively associated with firm environmental disclosure - Eq. (1) is employed (Where x = number of times targeted by NGO activists and y = GRI score / CDP score).

4. Empirical Results (ή Εμπειρικά Αποτελέσματα)
The updated 2015 sample set for the three damaging sectors reputation score is higher and due to methodological changes significantly higher than the 2012 means. By incorporating financial services into the sample set the mean is reduced to the average value of a Green 500 participant which is to be expected as the sample set is nearly half of the participants.

Table 2: Sample set means and medians

	2012	2015	
Total Green 500	*500 firms*	*500 firms*	
Reputation mean (median)	34 (33)	43 (42)	
Range	1-100	0-78	
Sample of sectors	*92 firms*	*79 firms (i)*	*210 firms (ii)*
Reputation mean (median)	36 (35)	48 (52)	43 (42)
Range	9-64	0-76	0-76

Equivalent sectors as 2012 (materials, utilities and oil & gas
Includes finance sector

In testing the hypotheses based on Cho et al (2012) and new NGO based hypotheses, a series of T-test of means were conducted (see table 3). Only two hypotheses (H1a and H1b – GRI) were found to have statistically similar sets of means, which is to be expected when considering the underlying data. The remaining hypotheses were found not to be supported via the T-tests, but significant relationships were found via the regression analysis and pearson product moment test.

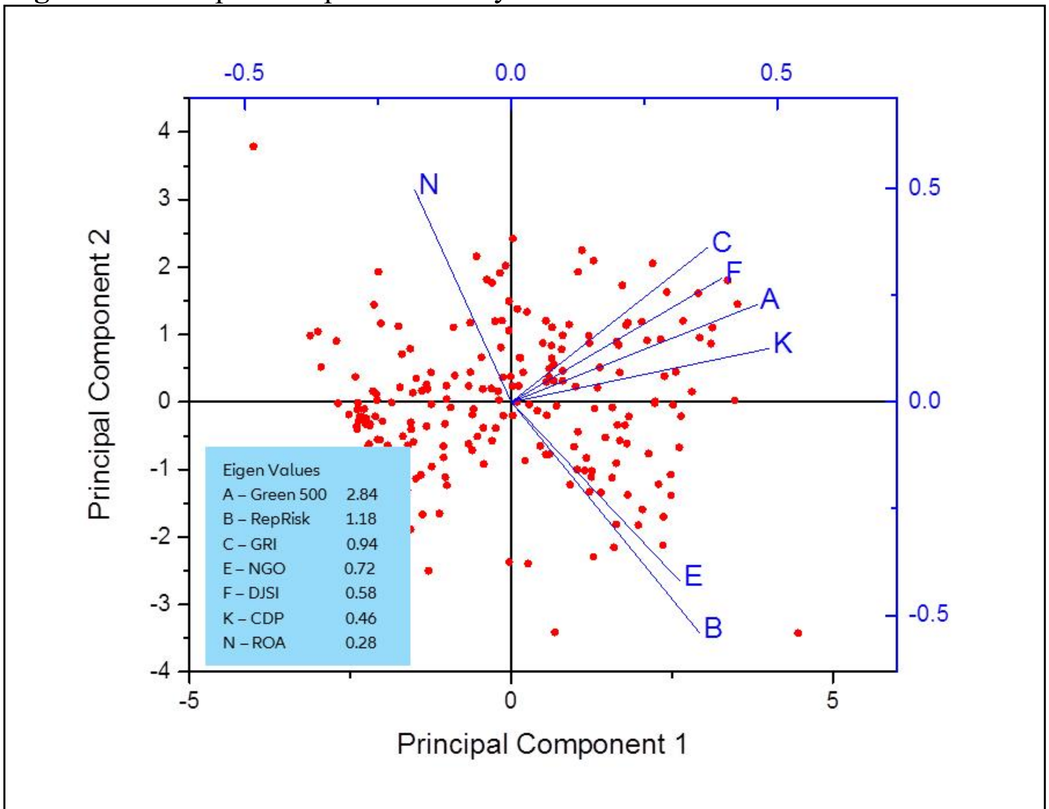
Table 3: T-test of means

Relationship	95% CI mean diff.	T-test mean diff.	T-value	P-value
H1a	Not different	0	-1,89	0,061
H1b (GRI)	Not different	0	-1.73	0,086
H1b (CDP)	Significantly different	0	-2.19	0,029

H2a	Significantly different	0	34.78	7,247
H2b	Significantly different	0	29.73	5.194E-77
H2c (GRI)	Significantly different	0	20	1.898E-50
H2c (CDP)	Significantly different	0	-21	2.161E-53
H3 (GRI)	Significantly different	0	-3.32	0,001
H3 (CDP)	Significantly different	0	-4.72	4.278E-6
H4a	Significantly different	0	30.69	2.236R-79
H4b	Significantly different	0	-22.78	1.512E-58
H4c (GRI)	Significantly different	0	16.67	3.040E-40
H4c (CDP)	Significantly different	0	18.35	1.897E-45

A principal components analysis was undertaken on the various metrics involved in the research. We see an inverse relationship between ROA and two indicators (Rep Risk performance score and NGO campaigns). We see a clustering of the other metrics indicating their similar disclosure nature. The main reasons for variance are indicated by the Eigenvalues relating to the performance score and reputation scores.

Figure 1: Principal Components Analysis



In the regression and Pearson product moment tests, we see correlations which are significant. The largest correlation with reputation is NGO's, potentially reflecting links between NGO actions being reflected in the RepRisk score. Disclosure has the lowest correlation suggesting that it is not an indicator of a worse reputation.

When considering performance within the Green 500, we see positive correlations with GRI disclosure, but especially for strong performers in the CDP. This highlights the greater effectiveness of CDP as a measure of performance.

A key point of note is that there is no significant relation between DJSI membership and NGO activity. This suggests that NGO targets are not necessarily high performing DJSI members.

We see two statistically significant correlations for ROA, the strongest being a negative relationship with an increased RepRisk score. Secondly, we see also a significant negative relationship between good performance within the CDP and a ROA value for companies. This potentially suggests that companies adhering to best practice environmental/climate activities have worse return on their assets, potentially reflecting a short-term loss for having greater environmental standards in this metric.

Table 4: Regression analysis

	Reputation	Performance	Disclosure	DJSI	NGO	CDP	ROA
Reputation	1						
Performance	0,239	1					
Disclosure	0,208	0,429	1				
DJSI	0,242	0,394	0,429	1			
NGO	0,472	0,284	0,173	0,170	1		
CDP	0,342	0,693	0,363	0,473	0,289	1	
ROA	-0,291	-0,134	-0,032	-0,098	-0,070	-0,196	1

Table 5: Pearson product moment test

	Reputation	Performance	Disclosure	DJSI	NGO	CDP	ROA
Reputation	1						
Performance	0,233*	1					
Disclosure	0,208*	0,429*	1				
DJSI	0,236*	0,399*	0,429*	1			
NGO	0,472*	0,281*	0,173*	0,168	1		
CDP	0,339*	0,693*	0,363*	0,474*	0,289*	1	
ROA	-0,29*	-0,134	-0,032	-0,099	-0,070	-0,197*	1

2-tailed test of signficiance is used
* Correlation is significant at the 0.05 level

5. Conclusions (ή Συμπεράσματα)

The original suggestions in the work of Cho et al (2012) suggested that there is a link between DJSI membership and improved reputation. Companies which have better disclosure have enhanced reputation are DJSI members and that worse performers in the Green 500 disclose more. Whilst we find a positive correlation between DJSI and reputation, we actually find the NGO data set having a much stronger correlation and suggests that NGO's are a much greater driver of reputation than DJSI. Our results also support the conclusion that DJSI performance is also significantly associated with increased disclosure. Our testing contradicts the work of Cho et al (2012) in that we do not find that worse performers disclose more in the Green 500..

A key controversial finding of Cho et al (2012) was that they suggested that the DJSI was more closely associated with disclosure metrics (what organizations say) than performance (what they do). We also see this link to disclosure (GRI) we see a stronger relationship with CDP which includes performance aspects and therefore a more accurate disclosure metric.

The principal components analysis indicates that the biggest determinants of variance in the ratings are the performance and ratings. We also see a directly inverse relationship between ROA and Reputation/NGO measures. The relationship of ROA and the significant negative correlations are very interesting. The most logical explanation being that companies most reputationally exposed have a poorer ROA which is a positive financial message to avoid activities which can harm reputation and secondly that high performing CDP companies have a worse ROA. This could potentially be due to a focus on avoiding environmentally damaging assets.

Further investigation will be undertaken in assessing the links between NGO activity and the same metrics over time.

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Prediction of Global Warming Impacts using Fuzzy Cognitive Maps and Semantic Web techniques

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Abstract
One of the most important problems of our era is Global Warming. Both the ecological-economic impacts of Global Warming and also the mechanisms that cause the Greenhouse Effect are thoroughly studied and reported. In this paper, a model of the causal relationships that exist in the field of global warming is created, using the well-established Artificial Intelligence technique of Fuzzy Cognitive Maps (FCMs). The FCM technique incorporates ideas from Artificial Neural Networks and Fuzzy Logic. Various scenarios are imposed to the FCM model and predictions are made on these, by simulating FCM dynamic behavior and studying the equilibrium that the FCM dynamic system reaches. For making these simulations, a semantic web software tool was created that also makes the results and various models easily accessible to other users or systems, through the Internet. Policy makers can use this technique and tool to make predictions by viewing dynamically the consequences that the system predicts to their imposed scenarios.

Keywords: Global Warming; Computational Techniques, Simulation Modeling; Neural Networks and Related Topics; Forecasting and Prediction Methods, Simulation Methods.

JEL Codes: Q54; C63; C45; C53.

Πρόβλεψη Επιπτώσεων της Υπερθέρμανσης του Πλανήτη με τη χρήση Ασαφών Γνωστικών Απεικονίσεων και Τεχνικών Σημασιολογικού Ιστού

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Περίληψη
Ένα από τα σημαντικότερα προβλήματα της εποχής μας είναι η υπερθέρμανση του πλανήτη. Τόσο οι οικολογικές/οικονομικές επιπτώσεις της υπερθέρμανσης του πλανήτη, όσο και οι μηχανισμοί που προκαλούν το φαινόμενο του θερμοκηπίου, έχουν μελετηθεί και αναλυθεί διεξοδικά. Σε αυτή την εργασία κατασκευάζεται ένα μοντέλο των σχέσεων αιτίας-αποτελέσματος που υπάρχουν στο αντικείμενο της υπερθέρμανσης του πλανήτη, χρησιμοποιώντας την καθιερωμένη τεχνική της Τεχνητή Νοημοσύνη, αυτή των Ασαφών Γνωστικών Απεικονίσεων (Fuzzy Cognitive Maps - FCMs). Η τεχνική FCM ενσωματώνει ιδέες από τα Τεχνητά Νευρωνικά Δίκτυα και την Ασαφή Λογική. Διάφορα σενάρια επιβάλλονται στο μοντέλο FCM και γίνονται προβλέψεις σε αυτά, μέσω της προσομοίωση της δυναμικής συμπεριφοράς του FCM μοντέλου και μελετώντας την ισορροπία

που επιτυγχάνει το δυναμικό σύστημα του FCM μοντέλου. Για την πραγματοποίηση αυτών των προσομοιώσεων, δημιουργήθηκε ένα εργαλείο λογισμικού του σημασιολογικού ιστού το οποίο καθιστά επίσης εύκολα προσβάσιμα τα αποτελέσματα και τα διάφορα μοντέλα, τόσο σε άλλους χρήστες όσο άλλα συστήματα, μέσω του Διαδικτύου. Οι υπεύθυνοι χάραξης πολιτικής μπορούν να χρησιμοποιήσουν αυτήν την τεχνική και το εργαλείο, για να κάνουν προβλέψεις παρακολουθώντας δυναμικά τις συνέπειες που προβλέπει το σύστημα, στα σενάρια τα οποία υποβάλουν σε αυτό.

Λέξεις Κλειδιά: Υπερθέρμανση του Πλανήτη; Υπολογιστικές Τεχνικές, Μοντελοποίηση Προσομοίωσης; Νευρωνικά Δίκτυα και σχετικά θέματα; Μέθοδοι Πρόβλεψης, Μέθοδοι Προσομοίωσης.

JEL Κωδικοί: O44, O47, O52, Q43, Q56.

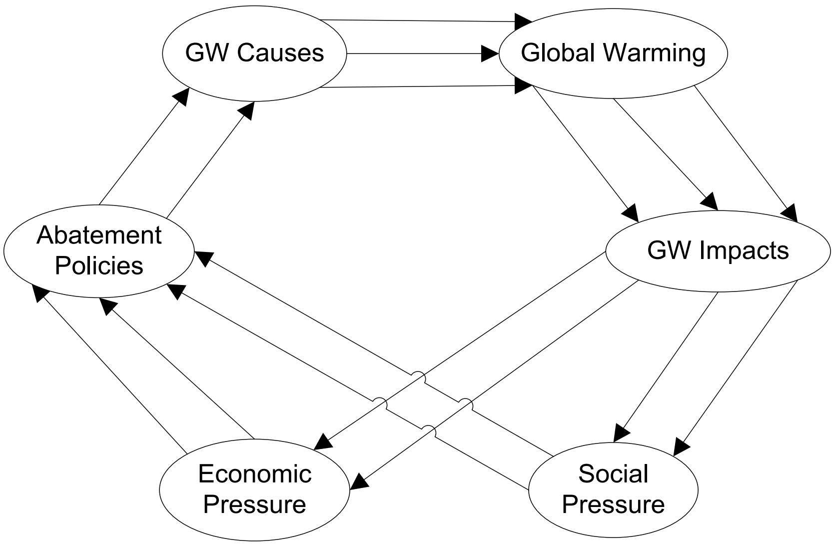
1. Introduction

One of the most important environmental problems of our planet is Global Warming (GW). Primary causes of GW have been identified to be certain human activities. The increase of temperature will affect earth's climate and the impacts will be enormous. GW should be treated as an international and not a regional problem because no country by itself can solve this problem. A solution should be attempted by the cooperation of developed and under developing countries. Developed countries should take the initiatives to provide financial assistance to scientists so as to a) find the causes of GW, b) identify the impacts of GW and finally c) propose solutions for the problem, taking care not to affect, or at least have limited effects to the economic development of the countries. In order to find solutions that are achievable both from economic & social point of view, various studies has been contacted in the area of "Global Environmental Economic" (Uzawa 2008, Stern 2007, Nordhaus 2003, Hanley et.al 2006, Chichilnisky & Rezai 2017). Feasible from economic point of view solutions should lead to corresponding political decisions. Various such political responses have been proposed (Helm & Hepburn 2011, FitzRoy & Papyrakis 2016, Hertel et.al. 2009).

2. A Causal Graph regarding GW

Any attempt to provide solutions for the GW problem, needs to take into consideration the causal relationships that exists among the elements that interact in this problem. A causal graph that regards the elements that interact in GW problem can be found in Figure 1.

Figure 1: A causal graph regarding the reduction of GW



According to the causal graph of Figure 1, the various causes of GW leads to an increase to GW, which in turn leads to increase to the GW impacts. These impacts sequentially affect both a) the Social Pressure to Act against GW and b) the Economic Pressure to Act against GW. These two types of pressure definitely influence GW abatement policies and by their imposition they lead to decreases of GW causes. Causes of GW, impacts of GW and GW abatement policies are presented in the following subsections.

2.1 Causes of GW

GW is the result of Earth's enhanced greenhouse effect. The emissions of greenhouse gases from human activities enhanced the greenhouse effect. In Table I the greenhouse gases are presented accompanied by the main human activities that cause the emissions of the corresponding gases. Intergovernmental bodies like the United Nations Intergovernmental Panel on Climate Change (IPCC) make great effort to provide the world with an objective, scientific view of GW and climate change by collecting data and make estimations of emissions based on the type of greenhouse gas. The main causes of GW can be identified to be: Energy Industries, Manufacturing Industries, Construction, Transport, Chemical Industry, Metal Production and Agriculture.

TABLE I

Gas	Main anthropogenic sources
CO_2	Fuel Combustion, deforestation and land use change, cement production
CH_4	Energy production and use, animal, rice paddies, sewage, organic waste in landfills
N_2O	Fertilizers, land clearing, adipic and nitric acid production, biomass burning, combustion of fossil fuels
HFCs	Refrigerators, airconditioners, chemical industry
PFCs	Aluminium production
SF_6	Electricity distribution

2.2. GW impacts
The impacts of GW have been studied by various scientists (Uzawa 2008, Stern 2007, Chichilnisky & Rezai 2017). Below, the most important impacts are listed.
Sea-level rise. GW will cause the rise of sea level because of the land-based glaciers and ice sheets but also because of the thermal expansion of water.
Forrest loss. It is expected that GW will cause migration of forests towards the poles and also change their composition.
Electricity. GW will affect some countries by increasing the demand of airconditioning and some others by reducing the need for heating. The total impact will depend on the geographical position of the developed and less developed countries.
Agriculture. Surface temperature increase will affect crops. Side effects such as complementary water will appear.
Water supply. GW will lead snow to melt sooner in winter, leading to less water flow in autumn and summer.
Species loss. GW will cause changes to inhabitant & predator-prey relationship and would increase the risks of extinction of many species. The problem is bigger for species that will be affected by the intrusion of salt water into wetland, because of the sea-level rise.
Human Life and Morbidity. Many human diseases are affected by weather and become more severe with the increase of temperature. Human deaths are expected to increase because of GW.
Hurricanes. The climate change will also cause more hurricanes and other extreme weather phenomena, leading to disasters.
Leisure Activities. The increase of the temperature will affect tourism and leisure activities e.g. ski industry.

2.3 GW Abatement policies
A number of GW abatement policies have been proposed and many of them have already been used in certain countries. Some of the most effective GW abatement policies are: a) Renewable Energy, b) Improved Energy Efficiency, c) Measures in Manufacturing Industry, d) Reduced emissions from vehicles, e) Carbon Taxes, f) Tradable Emission Permits, g) Subsidies, i) Better Means of Transportation.

3. Fuzzy Cognitive Maps
Axelrod (1976) introduced Cognitive Maps (CMs) while the introduction of Fuzzy Logic gave new representing capabilities to CMs and led to the development of Fuzzy Cognitive Maps (FCMs), by Kosko (1986, 1992). The FCM approach is consider a combination of Fuzzy Logic and Artificial Neural Networks. FCMs are created as collections of concepts and the various causal relationships that exist between these concepts. The concepts are represented by nodes and the causal relationships by directed arcs between the nodes. Each arc is accompanied by a weight w_{ij} that defines the degree of the causal relation between the two nodes-concepts C_i and C_j. The sign of the weight determines the positive or negative causal relation between the two nodes-concepts. Positive (negative) causal relation between two concepts C_i and C_j means that an increase of concept C_i will increase (decrease) C_j and also a decrease of concept C_i will decrease (increase) C_j.

In FCMs, although the degree of the causal relationships could be represented by a number in the interval [-1,1], each concept, in a binary manner, could be either activated or not activated. Certainty Neuron Fuzzy Cognitive Maps (CNFCMs) are introduced (Tsadiras and Margaritis, 1995 & Tsadiras and Margaritis, 1997), to provide additional representing capabilities to FCMs, by allowing each concept's activation to be activated just to a degree. Function $f_M()$ that was used in MYCIN Expert System (Buchanan and Shortliffe, 1984) for certainty factors' handling is used for the aggregation of the influences that each concept receives from other concepts. The dynamical behaviour and the characteristics of this function are studied in (Tsadiras and Margaritis, 1998). Certainty Neurons are defined as artificial neurons that use this function as their threshold function (Tsadiras and Margaritis, 1996). Using such neurons, the updating function of CNFCMs as a dynamic evolving system is the following:

$$A_i^{t+1} = f_M(A_i^t, S_i^t) - d_i\, A_i^t$$

where, A_i^{t+1} is the activation level of concept C_i at time step t+1,

$S_i^t = \sum_j w_{ji} A_j^t$ is the sum of the weighted influences that concept C_i receives at time step t from all other concepts,

d_i is a decay factor and

$$f_M(A_i^t, S_i^t) = \begin{cases} A_i^t + S_i^t(1 - A_i^t) = A_i^t + S_i^t - S_i^t A_i^t & if\, A_i^t \geq 0,\, S_i^t \geq 0 \\ A_i^t + S_i^t(1 + A_i^t) = A_i^t + S_i^t + S_i^t A_i^t & if\, A_i^t < 0,\, S_i^t < 0 \quad \left|A_i^t\right|, \left|S_i^t\right| \leq 1 \\ (A_i^t + S_i^t) \big/ \left(1 - \min(\left|A_i^t\right|, \left|S_i^t\right|)\right) & otherwise \end{cases}$$

is the function that was used for the aggregation of certainty factors to the MYCIN expert system.

4. A Semantic Web based Application to Simulate FCMs

To examine the dynamical behavior of FCMs, a Semantic Web based software tool/application was developed in order to simulate the behavior of FCMs.

The main purpose of Semantic Web is to provide a general framework to connect different heterogeneous systems on the web. Semantic web standards such as RDF/S and OWL technologies (usually referred as ontologies) are used consistently the past few years for this purpose. These standards provide formal data formats and exchange protocols so as to allow data to be shared and reused among different systems on the Web. By providing formal and general knowledge representation, they allow unified communication between different systems (Bassiliades, 2005).

As a result, using Semantic Web technologies to simulate FCMs offers the following advantages (Tryfona & Pfoser 2005, Tsadiras & Bassiliades 2013, Karmacharya et al. 2016):
Knowledge sharing and interoperability. Data concerning one specific FCM model (nodes regarding entities/concepts, edges, data/results etc.) can be easily used by other related FCM models.
Semantic web standards such as ontologies offer the ability to represent the structure of physical entities and the associations between them (e.g. representing related concepts and their connections). In addition, because they support logic and reasoning capabilities, more complex concepts and associations can be represented.
Apart from the above, they provide flexibility, since they can be reused and extended easily, saving a lot of time and effort for developers.

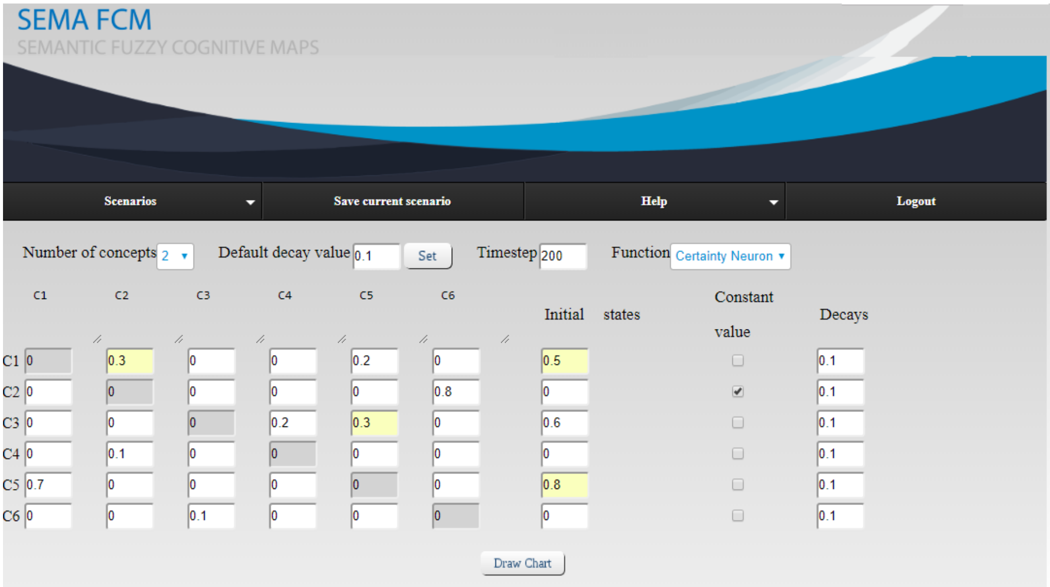
Therefore, a system which incorporates the above technologies and possesses their advantages was developed . The system[9] enables users to create their own account and start adding their FCMs. In the main screen the user is able to impose a scenario, being able to customize related attributes such as (Figure 2):
The number of concepts.
The names of the concepts.
The values of the weights w_{ij} (range from -1 to 1).
The default decay value of the FCM.
The number of time steps for simulation.

[9] http://platon.econ.auth.gr/examples/jsp/jsp2/fcm/logismiko.jsp

The transfer function to be used.
The initial states of each concept (range from -1 to 1).
Whether some of the concepts will have constant values.
The values of the decay factor (range from -1 to 1).

It should be noticed that the user can save the current scenario so as to be able to use it again in the future or modify it easily. It's worth mentioning that all the data are stored in the server in the form of RDF triples using sesame[10] repository. The user can first save the scenario, and then easily load it by selecting the corresponding choices in the related menu. The user can load existing FCMs, created by other users, by following a similar process.

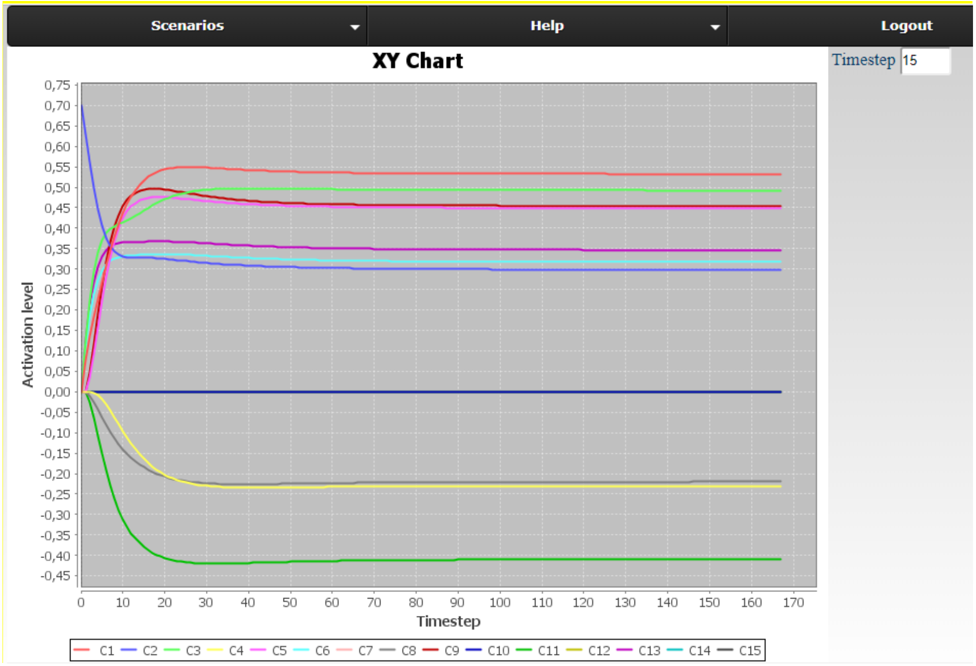
Figure 2. Parameterizing and Imposing an FCM Scenario



After imposing the scenario, the user can click on the corresponding button and draw the chart. The chart contains the activation levels of all concepts C_{ij} in every timestep. The user can view the simulation chart (Figure 3) and also download a text file which contains all the simulation data.

[10] http://rdf4j.org/

Figure 3. FCM Simulation Chart.



5. An FCM Model for Global Warming

In this study, an FCM model is created that regards GW. The FCM is based on the causal graph presented in Figure 1, and the Causes, Impacts and Abatement Policies that have discussed in Section 2, above. Choosing the most important of the causes, impacts and abatement policies, the FCM of Figure 4 is created. The weights of the arcs that connect the nodes are empirically and qualitatively proposed and they are presented in Table II.

Figure 4: A Fuzzy Cognitive Map for Global Warming

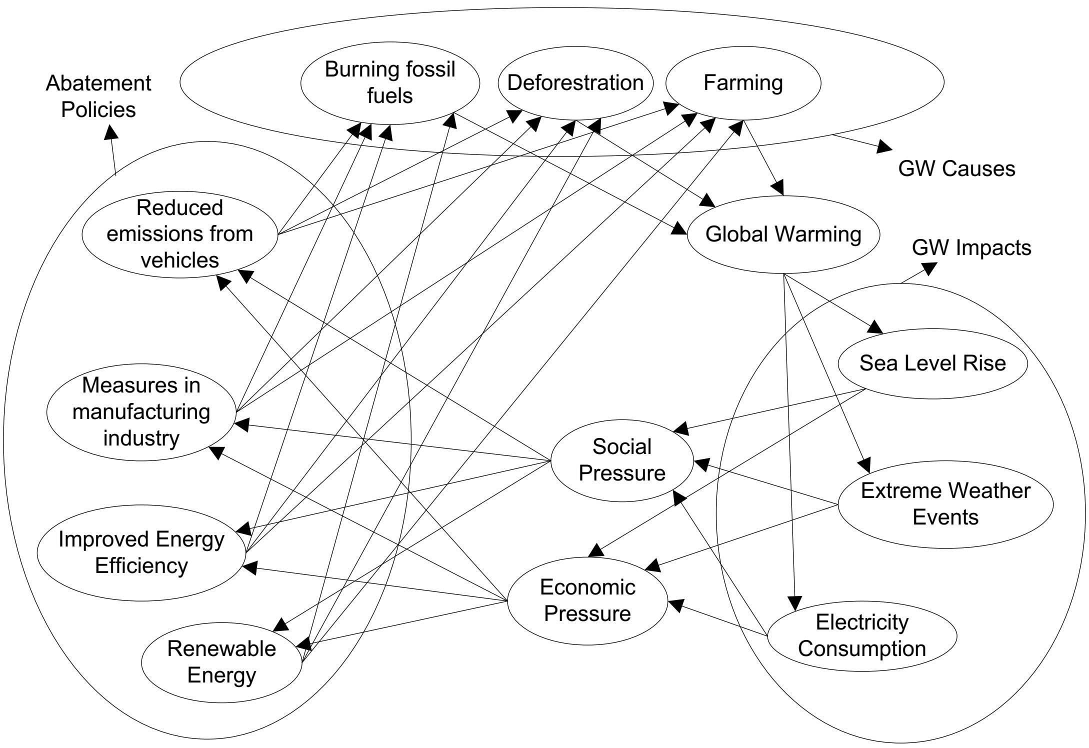


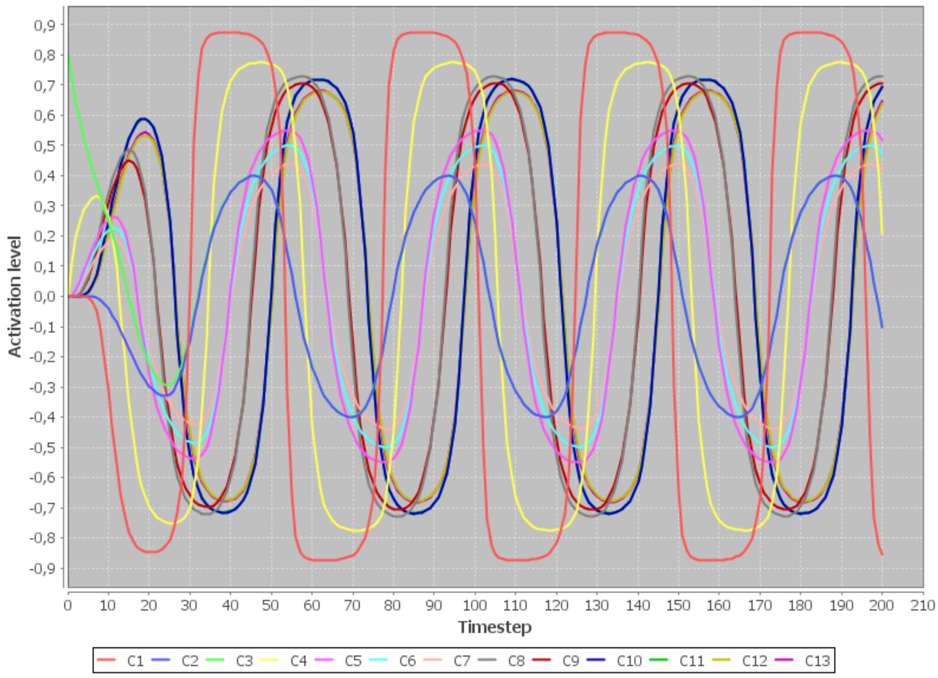
TABLE II

Weight Matrix (C:Concept)	C#1	C#2	C#3	C#4	C#5	C#6	C#7	C#8	C#9	C#10	C#11	C#12	C#13
C#1: Burning fossil fuels				0.9									
C#2 : Deforestration				0,6									
C#3 : Farming				0,5									
C#4 : Global Warming					0,6	0.5	0,4						
C#5 : Sea Level Rise								0.8	0.5				
C#6 : Extreme Weather Events								0,8	0,6				
C#7 : Electricity Consumption								0,3	0,7				
C#8 : Social Pressure										0,7	0,6	0,3	0.7
C#9 : Economic Pressure										0,6	0,7	0,8	0,4
C#10 : Renewable Energy	-0,9	-0,1	-0,1										
C#11 : Improved Energy Efficiency	-0,8	-0,1	-0,1										
C#12 : Measures in manufacturing industry	-0,9	-0,1	-0,2										
C#13 : Reduced vehicle emissions	-0,9	-0,1	0										

6. Simulating the FCM Model for Global Warming

Using the CNFCM technique discussed in Section 3, the FCM of Figure 4 was simulated. Initially all the concepts of the FCM were set free to interact and the system reached the dynamical behaviour of a limit cycle, showing that the system exhibits a periodical behaviour. The limit cycle is shown in Figure 5.

Figure 5: Dynamical behaviour of FCM when every concept is free to interact.

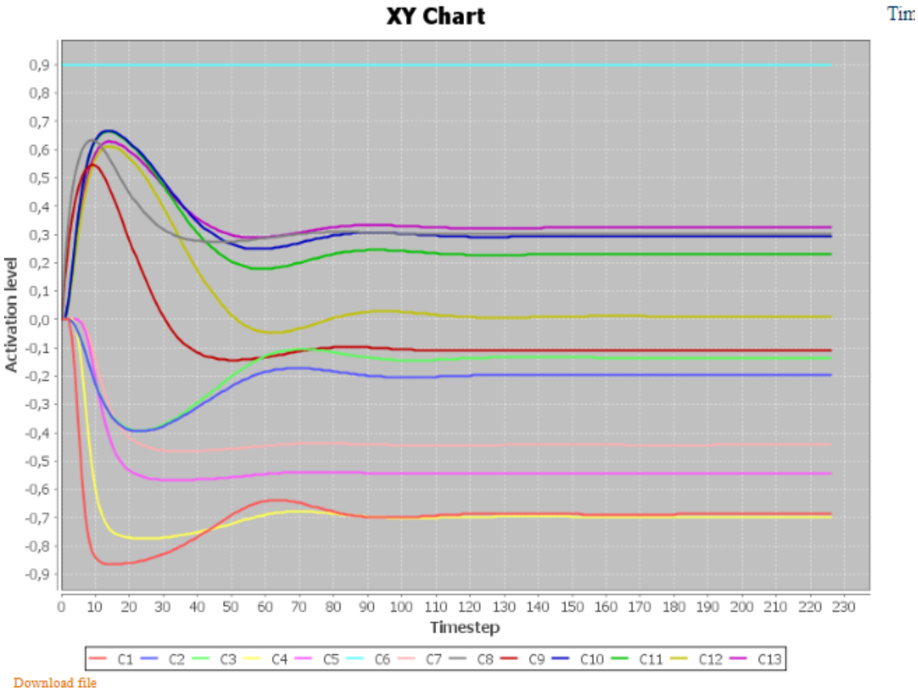


Another scenario that was imposed was that of GW causing the constant high increase in "Extreme Weather Events"(C6=0.9). As shown in Figure 6, the system after an oscillation reached an equilibrium point at the following values:

Burning fossil fuels	Deforestration	Farming	Global Warming	Sea Level Rise	Extreme Weather Events	Electricity Consumption
-0,688	-0,197	-0,135	-0.697	-0.544	0,9	-0,443
Social Pressure	Economic Pressure	Renewable Energy	Improved Energy Efficiency	Measures in manufacturing industry	Reduced vehicle emissions	
0,302	-0,109	0,295	0,231	0,01	0,324	

It can be concluded that the high increase of "Extreme Weather Events" caused mainly social pressure, that lead to increase of the use of Renewable Energy, Improved Energy Efficiency and Reduced emissions from vehicles. These caused the decrease of Global Warming and also its impacts on sea level rise and electricity consumption.

Figure 6: Dynamical behaviour of FCM when concept "Extreme Weather Events" is set constantly to high (=0.9)

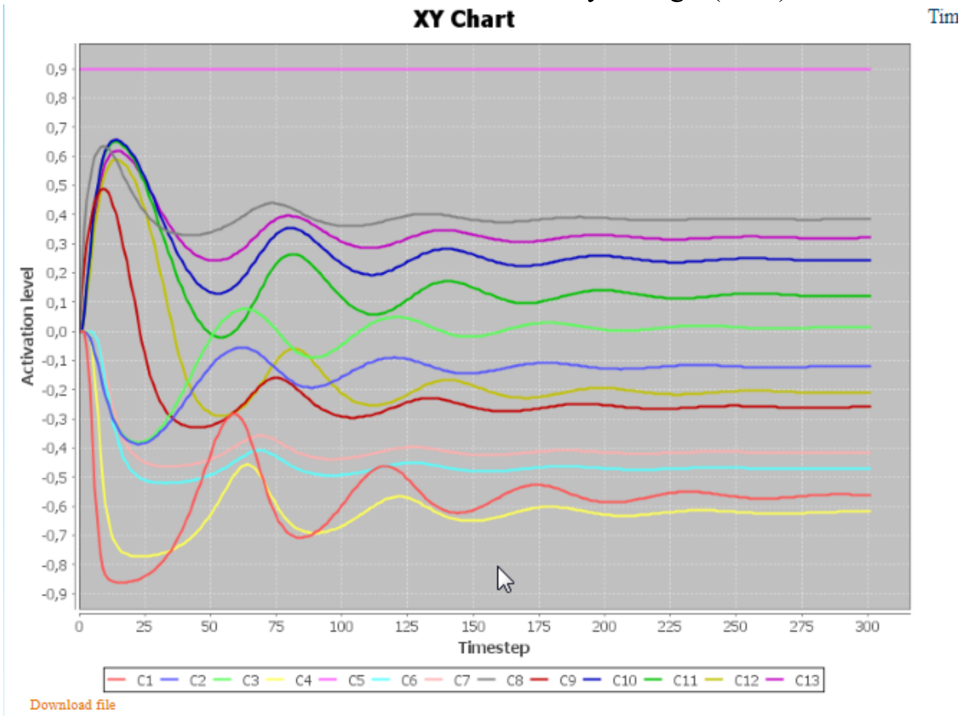


Another similar scenario is that of GW causing the constant high increase in "Sea Lever Rise"(C5=0.9) in which case, in a similar way, the system reached an equilibrium point after an oscillation (Figure 7) the following values. Other such scenarios can be imposed to the system and conclusions can be drawn in an analogous manner.

7. Conclusions

An FCM model of GW has been developed based on the causes, impacts and abatement policies of GW. A Semantic web software tool was used to simulate FCM. Various scenarios are imposed to the model and the consequences are predicted. More scenarios can be imposed, to assist policy making. Of course the FCM model developed can be extended to capture more causes-impacts, something that can be supported by the flexibility of the developed Sematic Web software tool.

Figure 7: Dynamical behaviour of FCM when concept "Sea Level Rise" is set constantly to high (=0.9)



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Identification of regimes in river behavior using nonlinear timeseries analysis

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Abstract
Nonlinear time series analysis covers a wide field of applications with methods based on phase space reconstruction which are giving useful results for understanding the system's dynamics. In the present work we apply nonlinear time series methods and more specifically the method of Recurrence Plots (RP) and Recurrence Quantification Analysis (RQA on 16 year of daily values of the Nestos river water level recorded at the Temenos measurement station. From this analysis important Recurrence Quantification parameters are extracted giving important information about system's periodicities and phase transitions which help us to locate seasonal changes and extract useful conclusions about possible changes of the behavior of the environmental dynamical system as years passing by (climate changes).

Keywords: Non Linear Timeseries Analysis; Recurrence Plots; Recurrence Quantification Analysis; Climate Change.

JEL Codes: C02; C22.

Ανίχνευση καταστάσεων στη συμπεριφορά ποταμού με τη χρήση μη γραμμικών μεθόδων ανάλυσης χρονοσειρών

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Περίληψη

Η μη γραμμική ανάλυση χρονοσειρών καλύπτει ένα μεγάλο πεδίο εφαρμογών με μεθόδους που βασίζονται στην ανακατασκευή του χώρου των φάσεων οι οποίοι δίνουν χρήσιμα αποτελέσματα για την κατανόηση της δυναμικής διαφόρων συστημάτων. Στην παρούσα μελέτη εφαρμόζεται η μέθοδος των Recurrence Plots (RP) και η Ποσοτική του ανάλυση Recurrence Quantification Analysis (RQA) σε ημερήσιες μετρήσεις κατά τη διάρκεια 16 ετών της στάθμης του ποταμού Νέστου από καταγραφές σταθμού στην περιοχή Τέμενος. Από την ανάλυση αυτή μελετήθηκαν σημαντικές παράμετροι από τους οποίους αποκομίσαμε σημαντικές πληροφορίες για περιοδικότητες καθώς και για διάφορες μεταβάσεις φάσεων του συστήματος που μας βοήθησαν να εντοπίσουμε αλλαγές εποχών και να εξάγουμε χρήσιμα συμπεράσματα για πιθανές αλλαγές στη

συμπεριφορά του περιβαλλοντικού δυναμικού συστήματος κατά το πέρασμα των ετών (κλιματικές αλλαγές).

Λέξεις Κλειδιά: Μη Γραμμική Ανάλυση Χρονοσειρών, Recurrence Plots, Recurrence Quantification Analysis, Κλιματική Αλλαγή.

JEL Κωδικοί: C02; C22.

1. Introduction

During recent years many changes in climate took place. Atmosphere becomes more unstable and phenomena like rainfalls become stronger and more powerful. These changes have various impacts on the environment including changes of river flows and resulting phenomena like floods (Booij, 2005). Thus it is important to detect such changes, understand their dynamics and use the results for better prediction of given events. Due to the complexity of the evolution of these dynamical systems it is necessary to apply nonlinear methods for the analysis. In recent years several tools taking into account the non-linarites have been developed (Kantz and Schreiber, 2003) for the study of dynamical systems through time series analysis. A tool that seem quite efficient in such processes is the Recurrence Plots (RP) and the corresponding Recurrence Quantification Analysis (RQA) (Zbilut and Webber, 1992, Marwan, 2003, Marwan et. al, 2007). This methodology has been successfully employed in e many applications on environmental (Aceves-Fernandez et. al, 2011), biological (Acharya et. al, 2013), financial (Addo et al., 2013), engineering (Karakasidis et al., 2009), Transportation (Fragkou et.al 2018) and many other dynamical systems.
In this study we discuss the environmental dynamical system of Nestos River through time series analysis of daily water level measurements, recorded over a period of 16 years and 4 months. Therefore, 6364 daily measurements extracted from Temenos station, during years 1980 to 1997 (01/01/1980 – 30/04/1997) (Greek Electric Company, DEH) and analyzed using Recurrence plots and Recurrence Quantification analysis methods. In section 2 we discuss the Recurrence Plots and Recurrence Quantification Analysis methodology and about the tools we use on the time series analysis. In section 3 we present the results from the application of RPs and RQA and finally some conclusions are presented.

2. Methodology

2.1 Recurrence Plots

Recurrence Plot is a graphical tool introduced in 1987 by Eckmann et al. (1987) in order to extract qualitative information on a dynamical system through study of its time series. One of its advantage is that it can be applied on non-stationary data. The first step in order to construct a Recurrence plot is to make a phase space reconstruction from the time series. For the phase space reconstruction we first estimate the time lag for the embedding. Fraser and Swinney (1986) suggested the Average Mutual Information (eqn.1) with the main advantage compared with autocorrelation function that takes into account nonlinear correlations.

$$I = -\sum_{ij}^{N} p_{ij}(t) ln \frac{p_{ij}(t)}{p_i(t)p_j(t)} \quad (1)$$

In this equation, $p_i(t)$ is the probability in the i-interval to exist a value of the time series and $p_{ij}(t)$ is the joint probability if in the i-th interval exist an observation, then in the j-th interval exists an observation in later time τ. Fraser an Swinney (1986) proved that if at a point τ the average mutual information falls at its first minimum value, then this

time lag is a reasonable choice of the proper time delay for the estimation of the embedding dimension. Taking this lag in mind False Nearest Neighbors is a method which one can estimate the optimal embedding dimension m by observing for false neighbors in the phase space (Kennel et al, 1992).

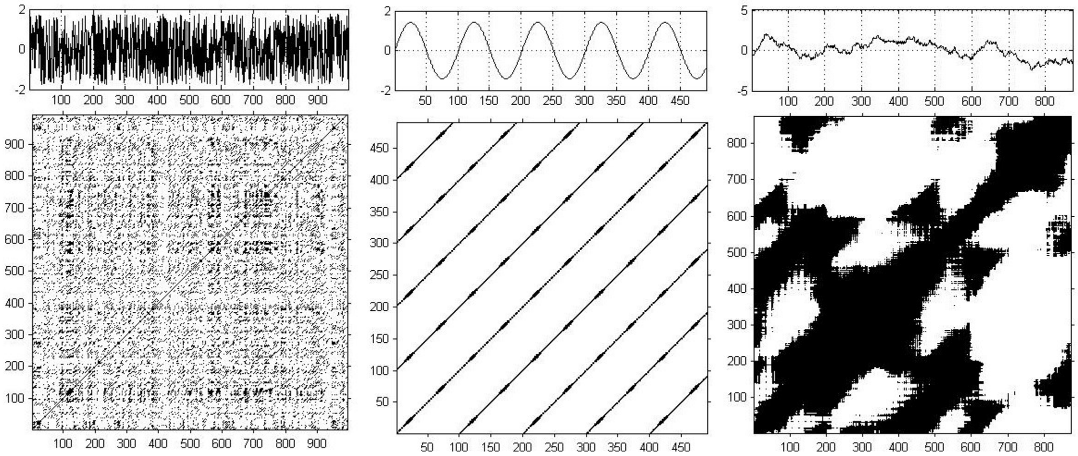
In the next step we embed the time series forming a sequence of vectors $\vec{x}_i = [x(t_i - (m-1)\tau_d), x(t_i - (m-2)\tau_d), \ldots, x(t_i)]$ (τ_d is the estimated time lag) and then we calculate distances $d_{i,j} = \|\vec{x}_i - \vec{x}_j\|$ between points i, j in the m-dimensional phase space. A matrix of distances called recurrence matrix is constructed then according to equation 2

$$R_{i,j} = \Theta(\varepsilon_\iota - \|\vec{x}_i - \vec{x}_j\|), \quad x_i \in R^m, \quad i,j = 1,2,\ldots.,N \tag{2}$$

where $R_{\boldsymbol{i,j}}$ is the recurrence matrix, m is the embedding dimension, ε the cutoff distance for the points considered to be recurrent and **Θ** is the Heaviside function. The Heaviside function takes the value of 1 when the points are located at smaller distances than the cut off distance ε otherwise **Θ**=0 (points are located at bigger distances than the cut off distance ε). On the texture of a Recurrence plot a black dot is placed at coordinates (i,j) if $R_{i,j} = 1$ and a white dot if $R_{i,j} = 0$. Recurrence Plots are symmetric with respect to the main diagonal ($R_{i,i} = 1$).When computing an RP a norm must be chosen. In the present study the Euclidean norm was used.

Recurrence Plot structure main contain lines parallel to the main diagonal (sign of deterministic processes), white regions (abrupt changes in the systems dynamics), isolated points (strong fluctuations). Recurrence plots of Deterministic processes may contain big diagonal lines, in contrast to Recurrence Plots of strongly fluctuating processes contain single isolated points. If during the evolution of the system there are states which are trapped in time then vertical and horizontal line appear on the RP's texture forming black regions (fig. 1). Such characteristic examples are recurrence plots from Gaussian noise (fig. 1a) (isolated points), sinus function (fig. 1b) (parallel lines to the main diagonal) and Brownian motion (fig. 1c) (abrupt changes in dynamics reflects to white bands on RP).

Figure 1. Recurrence pots of a) Gaussian noise, b) sinus function, c) Brownian motion



2.2 Recurrence Quantification Analysis

In order to quantify the visual information of the Recurrence plot Webber & Zbilut (1992) and Marwan (2003) introduced a number of quantities giving rise to the so called Recurrence Quantification Analysis (RQA). These quantifiers count the black dots on the recurrence Plot and quantify the lines forming those dots (diagonal and vertical). We present briefly some of the RQA indices that have been proposed and we use for the present work:

%Recurrence ή %REC : the ratio of the number of recurrence points to the total number of points of the plot

$$RR = \frac{1}{N^2}\sum_{i,j=1}^{N} R_{i,j} \qquad R_{i,j} = \begin{cases} 1, & (i,j)\ recurrent \\ 0, & otherwise \end{cases} \tag{3}$$

Average Line Length: The average length of the diagonal line segments in the plot, excluding the main diagonal.

Trapping Time, TT: It shows the average length of the vertical lines. Trapping Time represents the average time that the system has been trapped in the same state.

$$TT = \frac{\sum_{\upsilon=\upsilon_{min}}^{N} \upsilon P^{\varepsilon}(\upsilon)}{\sum_{\upsilon=\upsilon_{min}}^{N} P^{\varepsilon}(\upsilon)} \tag{4}$$

For the application of the Recurrence Plots method we need to embed the time series into an m-dimensional phase space (phase space reconstruction) with the False Nearest Neighbour method (FNN) (Kennel et.al, 1992) after finding the proper time lag with the function of the Average Mutual Information (AMI) (Fraser and Swinney, 1986). In order to perform the above calculations, we used the tool 'Command line Recurrence plots' (Marwan, 2006) and CRP toolbox ver. 5.12, Release 25 (Marwan, 2008) (for Recurrence Plots, RQA). For estimating time lag τ and embedding dimension m we used the toolbox "Time Series Analysis" (TI.SE.AN.) (Hegger et. al., 2007).
Studying the results of the visualization of the RP, we observed many parallel lines and interesting areas, which show the changes in the dynamics of the system. Then, for further understanding we applied the Recurrence Quantification Analysis with epoqs in order to locate the time periods in which those changes took place.

3. Results

Nestos is a river with total length 243 Km springs from Bulgaria and continues flowing in Greece (130 Km) at regions between Macedonia and Thrace. During period 01/01/1980 – 30/04/1997 (6364 observations) (fig. 2) water level data collected (Greek Electric Company, DEH) and analyzed with the nonlinear methods of Recurrence plots (RP) and Recurrence Quantification Analysis (RQA). Before applying the above nonlinear methods the time series was normalized to zero mean and standard deviation of one (i.e. the new normalized time series is given by $Y = \frac{X-\bar{X}}{\sigma}$) (fig.3). We used the False nearest Neighbors method and the embedding dimension was estimated to m=9 with time delay τ=35 which was found with the Average Mutual Information in order to perform the phase space reconstruction.

Figure 2. Timeseries of Nestos river water level.

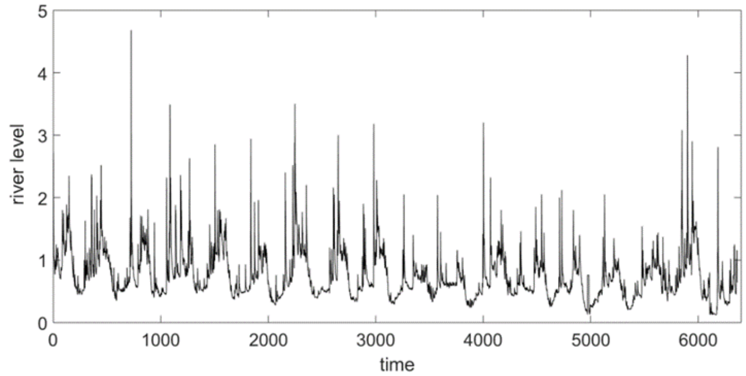
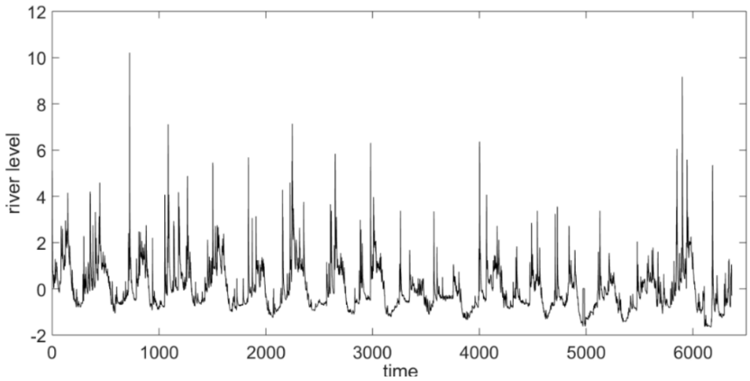


Figure 3. Normalized Timeseries with trend of Nestos river water level.



A main advantage of The Recurrence plots method is that it is able to give accurate results for time series with trend. Therefore the results obtained for the present study concern normalized time series with trend (fig 3).

3.1 Recurrence Plot and Recurrence Quantification Analysis

We construct the Recurrence plot (fig 4) with threshold ε=1.5 taking as the optimum rate of recurrences the value of 0.02 or Recurrence Rate = 2%. First of all by a visual inspection of the Recurrence plot (global inspection) we can separate 15 big diagonal segments forming lines parallel to the main diagonal. A closer inspection shows that the distance between these segments corresponds to the annual periodicity of the data. Moreover a "plane structure" on the RP can be distinguished in the region (2000-5500). Such a structure is indicative of a trend in the data.
Furthermore we can distinguish along the main diagonal of the RP a number of regions, indicated by squares in fig 5. Specifically seven regions can be observed. Those regions are A(1-1400), B(1400-1880), C(1880-2940), D(2940-3623), E(3623-4826), F(4826-5480), G(5480-6000). Regions A, C, E, contain big diagonal structures with small diagonal lines on each structure separated with small white areas (recurrent states in short characteristic times). Regions D, F contain more dense structures with diagonal and vertical lines revealing process that remain trapped in time. Region B and G contains white bands revealing abrupt change in the dynamics of the system. For better explanation and insight of the dynamics we proceed to Recurrence Quantification Analysis with epoqs.

Figure 4 The recurrence plot of Nestos river

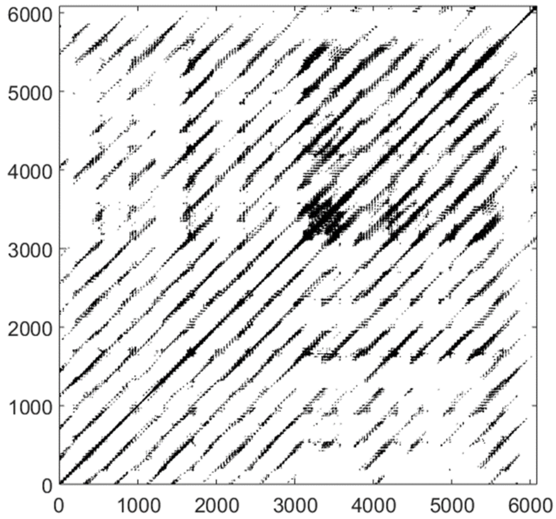
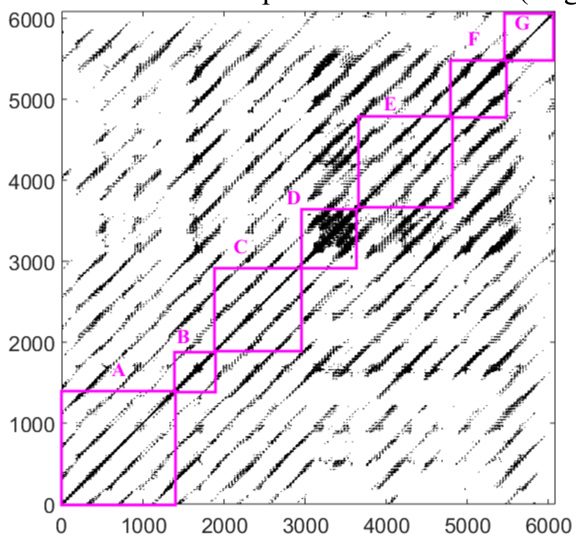


Figure 5 The recurrence plot of river Nestos (Regions)



Epoqs is an additional tool in the frame of recurrence quantification analysis with which we can detect phase transitions during the evolution of the system. For this, time windows are constructed sliding along the main diagonal. The length of each time window depends on the type of dynamical system under study. The evolution of environmental systems like Nestos River, depends on seasonal and monthly changes so we construct windows that covers 1 year time evolution of the system. In order to locate phase transitions with more accuracy during the evolution of the system, we set the windows to overlap over 1 day each. So 5999 epoqs are constructed and on each epoq Reoccurrence Quantification Analysis parameters were computed.

We focus on the diagrams of Recurrence Rate, Averaged Line Length and Trapping Time parameters. Averaged Line length counts points forming diagonal lines parallel to the main diagonal while Trapping time counts points forming vertical lines of the region. Recurrence Rate counts by definition all points of the considered region. A main advantage of Recurrence Quantification Analysis with epoqs is that we can reveal useful information about system transitions in time and locate regions of different dynamical behavior.

By examining the Recurrence Rate parameter (fig. 6a) first we observe small peaks where if we zoom out (fig.6b) we can see that we have an average distance between peaks corresponding to 35 days. This time interval corresponds to almost a month and it is equal to the time delay estimated from Average Mutual Information.

All three quantities extracted using RQA (figures 6,7,8) at regions A, C, E, have relatively small values. During these time periods as season changes, river level varies but in a normal usual way (river level is high during rainy months and low during dry months). At regions D, and F all three quantities have relatively large values. In this case river level do not change and stays for some time at a certain level (states trapped in time) so there are time periods when dry periods may last longer and the water level stays almost stable at low values or at high values if rainy periods lasts longer too. Dynamics of the system changes abruptly its normal behavior while the values of the three parameters in regions B and G change abruptly (weather conditions make the level of the river fluctuate strongly).

Figure 6. a) Recurrence Quantification Analysis of Nestos river water level (Recurrence Rate parameter), b) zoom out of the square region showing the distances between small peaks of fig 6a.

(b)

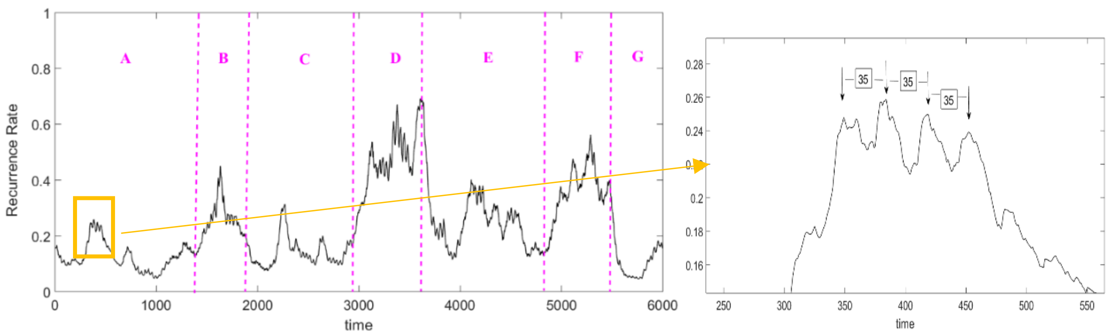


Figure 7. Recurrence Quantification Analysis of Nestos river water level (Averaged diagonal line length parameter).

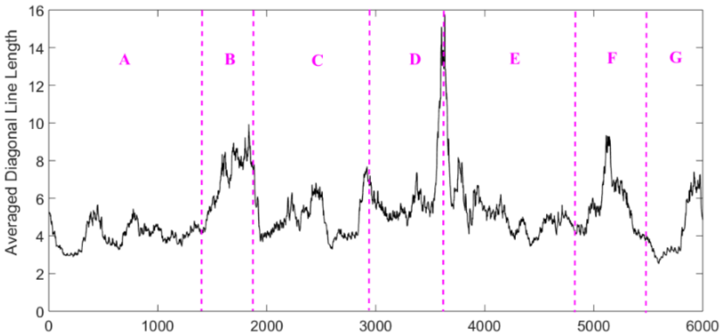
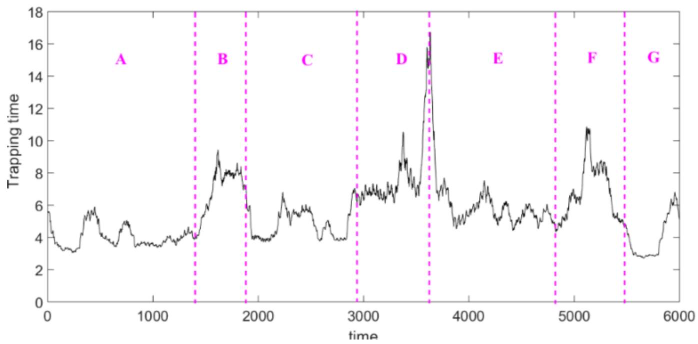


Figure 8. Recurrence Quantification Analysis of Nestos river water level (Trapping Time parameter)



4. Conclusions

In the present study we employed the nonlinear methods of Recurrence Plots and Recurrence Quantification Analysis with epoqs to analyze daily times series of water level of the Nestos River. Useful information was extracted firstly by observing structures on Recurrence plots and then by quantifying the Recurrence Plots structures.

Characteristic times of the dynamics of the system were revealed (essentially based on the power of human perception) as is the case of trend and monthly and annual variations. Moreover several characteristic regions in time were detected. Nonlinear methods show us the insight of the dynamics of the system and help us to understand through changes of the River level during time the impact of climate changes on the normal river flows. The results could be used as a tool for further analysis and prediction of possible changes in the river behavior and related it to climate changes.

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Real-time road traffic forecasts – a hybrid approach using artificial intelligence and Singular Spectrum Analysis

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Abstract
The paper presents a hybrid methodology of time series analysis and forecasting, applied on road traffic data, which leverages from Singular Spectrum Analysis (SSA) and Artificial Neural Network (ANN). The main objective of the research was to develop a short–term forecast of toll roads daily traffic across Greek National Highway Network. The proposed methodology was implemented and evaluated upon an integrated software, based on Mathworks MatLab, which was developed by the authors. Experimental outcomes on daily data, from specific tolls, show a superior prediction accuracy of hybrid SSA–ANN forecasting methodology, when compared to performance of statistical criteria such as root mean squared error (RMSE), mean absolute error, MAE) and coefficient of determination R^2. Results comparison reveals that the hybrid SSA–ANN improve the forecasting accuracy of an ANN model in daily traffic load forecasting. An Intelligent Transport Systems (ITS) with embedded hybrid SSA–ANN forecasting methodology can enable proactive decisions to mitigate the economic and environmental impacts of transport infrastructure congestion.

Keywords: Singular spectrum analysis; artificial neural network; traffic load; forecasting; transportation

JEL Codes: C45, C53, C55, R41.

Πρόβλεψη συγκοινωνιακού φόρτου σε πραγματικό χρόνο: Υβριδική προσέγγιση με χρήση τεχνητής νοημοσύνης και Ανάλυση Ιδιάζοντος Φάσματος

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Περίληψη
Στην παρούσα εργασία προτείνεται μια υβριδική μέθοδος ανάλυσης και πρόβλεψης χρονοσειρών κυκλοφοριακού φόρτου που συνδυάζει την Ανάλυση Ιδιάζοντος Φάσματος (SSA) και την αρχιτεκτονική των Τεχνητών Νευρωνικών Δικτύων (ANN). Κύριος σκοπός της εργασίας αποτελεί η ανάπτυξη υβριδικής μεθοδολογίας πρόβλεψης κυκλοφοριακού φόρτου, σε πραγματικό χρόνο, για το ελληνικό εθνικό οδικό δίκτυο αυτοκινητοδρόμων. Η προτεινόμενη υβριδική μέθοδος, που

υλοποιήθηκε και ελέγχθηκε με τη βοήθεια του λογισμικού MathworksMatLab, κάνοντας χρήση κατάλληλων στατιστικών κριτηρίων, όπως η τετραγωνική ρίζα του μέσου τετραγωνικού σφάλματος (RMSE), το μέσο απόλυτο σφάλμα (MAE) και ο συντελεστής προσδιορισμού (R^2). Τα πειραματικά αποτελέσματα επιβεβαιώνουν την υπεροχή της υβριδικής μεθόδου SSA – ANN έναντι των απλών τεχνητών νευρωνικών δικτύων και επαληθεύουν τη βελτίωση της ακρίβειας πρόβλεψης της προτεινόμενης μεθοδολογίας, σε πραγματικό χρόνο. Η ενσωμάτωση της προτεινόμενης μεθοδολογίας στη λειτουργία ενός Ευφυούς Συστήματος Μεταφορών (ITS) θα συμβάλλει στη βελτιστοποίηση της διαχείρισης οδικών υποδομών και στη μείωση των περιβαλλοντικών και οικονομικών επιπτώσεων που προκαλεί η κυκλοφοριακή συμφόρηση.

Keywords: Ανάλυση Ιδιάζοντος Φάσματος; ΤεχνητάΝευρωνικά Δίκτυα; Πρόβλεψη συγκοινωνιακού φόρτου; Μεταφορές; Οδικές υποδομές

JEL Codes: C45, C53, C55, R41.

1. Introduction– Literature Review

Forecasting is defined as the formulation of description for future traffic load of infrastructures. Prediction of traffic load is a procedure that defines the number of humans or vehicles that are going to use a specific transportation mean or transportation infrastructure for a specific time interval (Profillidis and Botzoris, 2006). Precise forecasting is very important since it defines the security and operational capacity of transportation infrastructure (Andersson et al., 2017). Traffic load forecasting is identified as complicated problem because of enormous and complex parameters that determines its functionality such as economic, social, technical and others (Bonsall 1997; Teodorović and Janić, 2016).

Research of basic transportation factors, such as velocity and density, that describes the traffic flow provide high level knowledge for transportation infrastructure understanding. The importance of traffic load is identified by the fact that influence the level of road security. Thus, traffic load analysis and forecasting can provide several benefits for transportation infrastructure functionality optimization (Adjenughwure et al., 2013).

One of the most popular quantitative traffic load forecasting methodology is time series analysis, which mainly uses data from the past to evaluate the future response of traffic load, without any qualitative analysis of the rest parameters that define traffic load. This means that research focus on the adequate transformation and decomposition of time series in order to extract information for the future response, taking into consideration the fact that, besides time, the rest factors that define traffic load will remains the same in the future (Profillidis and Botzoris, 2018).

The respective literature on time series analysis and forecasting based on the proposed hybrid SSA–ANN methodology describes successful implementation in many scientific sectors. Hybrid SSA–ANN characteristic properties make it attractive and promising to for addressing transportation, finance, industry, hydrology and energy forecasting challenges. This includes the non – linearity of their structure, their build – in capability to adapt to new information, as well as the universality of their design, being the same in all the domains that involves their application (Haykin S., 1994).

The importance of hybrid SSA–ANN methodology to provide models with forecasting accuracy and improved performance are underlined from a number of pervious researched (Table 1).

Table 1: Recent applications of artificial intelligence methods – Description and results

Research paper	Methodology	Criteria	Results
Statistical methods versus neural networks in transportation research: Differences, similarities and some insights (Karlaftis and Vlahogianni, 2006)	Statistical vs. computational intelligence	Similarities, differences and possible synergies	Both approaches have advantages and limitations

Singular Spectrum Analysis: Methodology and comparison (Hassani, 2007)	SSA	MAE, MRAE	-
Disaggregation and aggregation of time series components: A hybrid forecasting approach using generalized regression neural networks and the theta method (Theodossiou, 2010)	Hybrid ANN–Theta vs. other hybrid methods	MdAPE, MASE, sMAPE, MdRAE	Hybrid ANN–Theta
Short – term traffic flow forecasting method based on the data from video detectors using a Neural Network (Pamula, 2013)	Comparison of different ANN architectures 4-10-1, 6-18-1, 8-22-1)	RMSE, MAE, MAPE	Best ANN architecture 8-22-1
Short-term traffic forecasting: Where we are and where we are going (Vlahogianni et al., 2014)	Challenges in traffic forecasting	-	Combined models, advanced computing & Internet of Things
Traffic series forecasting by feedforward neural network: A case study based on traffic data of Monroe (Raeesi et al., 2014)	ANN 10-15-1, with 6 inputs (t, t-1, t-7, t-14, t-21, t-28)	MSE	t+1 forecast
Singular spectrum analysis: Hybrid forecasting methods with application to Air Transport demand (Adjenughwure et al., 2015)	Hybrid SSA–ANFIS vs. ANFIS	RMSE, MAE, MAPE, R^2	Hybrid SSA–ANFIS
Singular Spectrum Analysis and Neural Network to forecast demand in Industry (Lopes et al., 2016)	Hybrid SSA–ANN 10-4-1 vs. 15-4-1	MAPE, MSE, TPE	Hybrid SSA–ANN 10-4-1
Enhanced monthly precipitation forecasting using artificial neural networks and singular spectrum analysis conjunction models (Kalteh, 2017)	ANN vs. hybrid SSA–ANN	RMSE, R^2, CE	Hybrid SSA–ANN
A model to forecast wind speed through singular spectrum analysis and artificial neural networks (Lima et al., 2017)	Hybrid SSA–ANN vs. ANN	MAPE, MAE	Hybrid SSA–ANN
Precipitation analysis and forecasting using singular spectrum analysis with artificial neural networks (Sun et al., 2018)	Hybrid SSA–ANN, Hybrid SSA–LRF	RMSE, MAE, R^2	Hybrid SSA–ANN
A novel approach for predicting monthly water demand combining singular spectrum analysis with neural networks (Zubaidi et al., 2018)	Hybrid PSO–ANN vs. hybrid SSA-ANN	MAE, MSE, RMSE, R^2	Hybrid SSA–ANN

2. The proposed hybrid methodology

The proposed hybrid model for traffic load forecasting is based on the combination of Singular Spectrum Analysis, SSA (Golyandina et al., 2001; Hassani, 2007) and the use of Artificial Neural Networks, ANN (Dougherty, 1995; Karlaftis, and Vlahogianni, 2011). The aim of the development of proposed hybrid methodology is to optimize the forecasting ability through the:
decomposition, by using the SSA, of the initial time series,
elimination of noise component and (optionally) grouping of components with common characteristics,
response forecasting, by using ANN, of each main component of initial time series,
reconstruction of forecasting response of each main component,
enhanced results from hybrid model comparison.
The SSA technique is effective for analyzing time series and has been widely applied in many areas of research. The primary purpose of SSA is to decompose the original series into component series that can each be distinguished as a tendency component, a periodic or quasi-periodic component or a noise component. Our description of the SSA algorithm follows the methodology in (Golyandina, N. 2001). The SSA technique consists of four repeated steps in two stages: embedding and singular

value decomposition (SVD) belong to the decomposition stage; grouping and diagonal averaging belong to the reconstruction stage.
Decomposition is the first stage, which consists of two steps: embedding and singular value decomposition (SVD):
Embedding: The embedding procedure projects the original time series into a sequence of lagged vectors of size L by forming $K = T - L + 1$ lagged vectors $X_i = \{x_i, x_{i+1}, ..., x_{i+L-1}\}^T$, $i=1,...,K$. The trajectory matrix of the times series is:

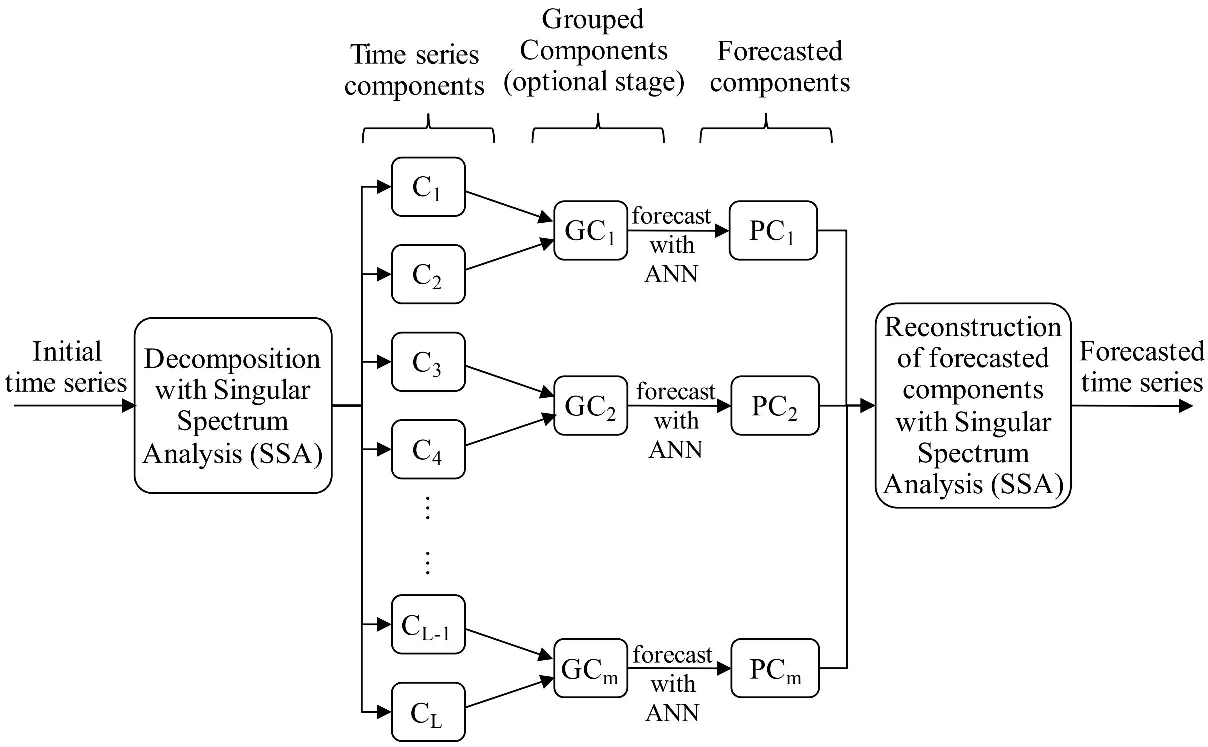
$$X = [X_1, X_2, ..., X_K] = (x_{ij})_{i,j=1}^{L,K} = \begin{pmatrix} x_1 & x_2 & x_3 & \cdots & x_K \\ x_2 & x_3 & x_4 & \cdots & x_{K+1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_L & x_{L+1} & x_{L+2} & \cdots & x_T \end{pmatrix} \tag{1}$$

The trajectory matrix is a Henkel matrix because ***X*** haw equal elements on anti-diagonals.
Singular value decomposition (SVD): From matrix ***X***, define the covariance matrix $\boldsymbol{XX^T}$. The SVD of $\boldsymbol{XX^T}$ provides a set of L eigenvalues in decreasing order of magnitude and the corresponding eigenvector $U_1, U_2, ..., U_L$. Then, the SVD of the trajectory matrix can be written as $X = [X_1, X_2, ..., X_L]$, where $X_i = \sqrt{\lambda_i} U_i V_i^T$. The triple $(\sqrt{\lambda_i}, U_i, V_i^T)$ is referred as the i-th eigentriple.

Second stage is *reconstruction*, which is subdivided into two steps: grouping and diagonal averaging:
Grouping: The grouping procedure partitions the set of indices $\{1, 2, ..., L\}$ into r disjoints subsets. Let $I = \{i1, i2, ..., ir\}$ be a group of r selected eigentriples and $X_I = X_{i1}, X_{i2}, ..., X_{ir}$, where X_I is the related to the signal, while the remaining (L–r) eigentriples denotes the time series related to the error.
Diagonal Averaging: Once the group of r components selected, the next step is to reconstruct the deterministic components of time series. The main principle to follow to transform each of the terms $X_I = X_{i1}, X_{i2}, ..., X_{ir}$ into reconstructed time series $F_{i1}, F_{i2}, ..., F_{ir}$ via the Hankelization process H( ) or diagonal averaging: assuming b_{ij} as an element of a generic matrix ***B***, the s-th term of the reconstructed time series could be obtained by b_{ij}, if $i + j = s + 1$. Once this step is completed, the reconstructed time series is an approximation of the original series, with removed noise components.

Research for Artificial Intelligence (AI) algorithms for analysis and forecasting of traffic load is an innovative application of gained knowledge in the field of transportation, which describes challenges and variety, depending on the differentiation of qualitative and quantitative characteristics that describe the time series. Proposed architecture of hybrid methodology SSA–ANN (Figure 1) is a modern approach for modeling of transportation infrastructure and traffic load forecasting.

Figure 1: The architecture of the proposed hybrid SSA–ANN methodology (Adjenughwure et al., 2015)



Artificial neural network functionality does not depend on deterministic rules. Instead, ANN is developed and trained through an iterative calculation process of error check, until the ANN reaches a local minimum error status, according to minimization of specific statistical criteria (Box et al., 2015), as described below:

Root MeanSquaredError (RMSE),
Mean Absolute Error (MAE),
Mean Absolute Percentage Error (MAPE),
Coefficient of determination (R^2).

In all cases that ANN is used, the selected architecture is described at Figure 3, where the ANN is developed in 2 levels, with the first level consisting from 6 neurons and the second level consisting of 3 neurons (Figure 2a). For ANN forecasting, ANN inputs are 8 and refer to daily traffic load from the 8 previous days. For SSA–ANN forecasting, ANN inputs are 11 main components from decomposition via SSA of initial time series (Figure 2b).

In order to verify the effectiveness and reliability of proposed hybrid methodology, an application is developed, using daily traffic load of passenger vehicles (with or without trailer and height until 2.2m)from the toll station of Moschohorion (route from Athens to Thessaloniki, Greece), which is located near the city of Larissa and belongs to Aegean Motorway S.A. and is located between the routes Athens–Thessaloniki. Time interval for data recording begins at 02/04/2008 and ends at 31/05/2014, which means that there are available 2.251 daily records (Figure 3).

Figure 2: Architecture of the single ANN method (a) and of the hybrid SSA-ANN method (b)

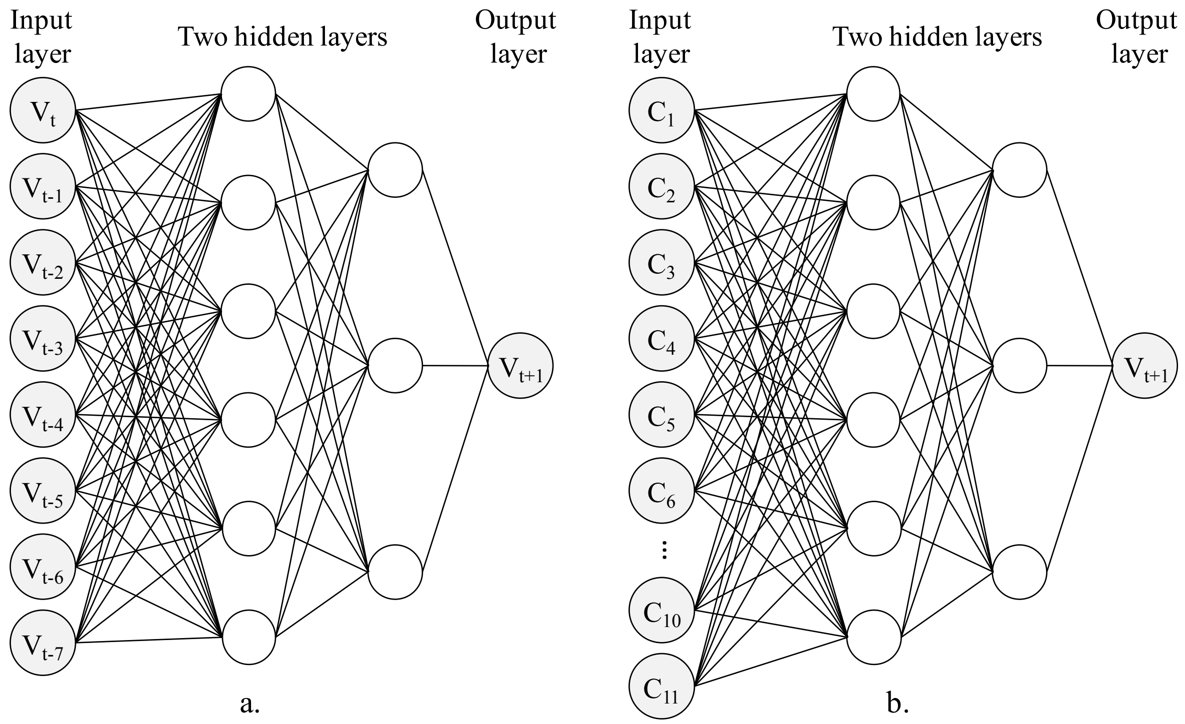
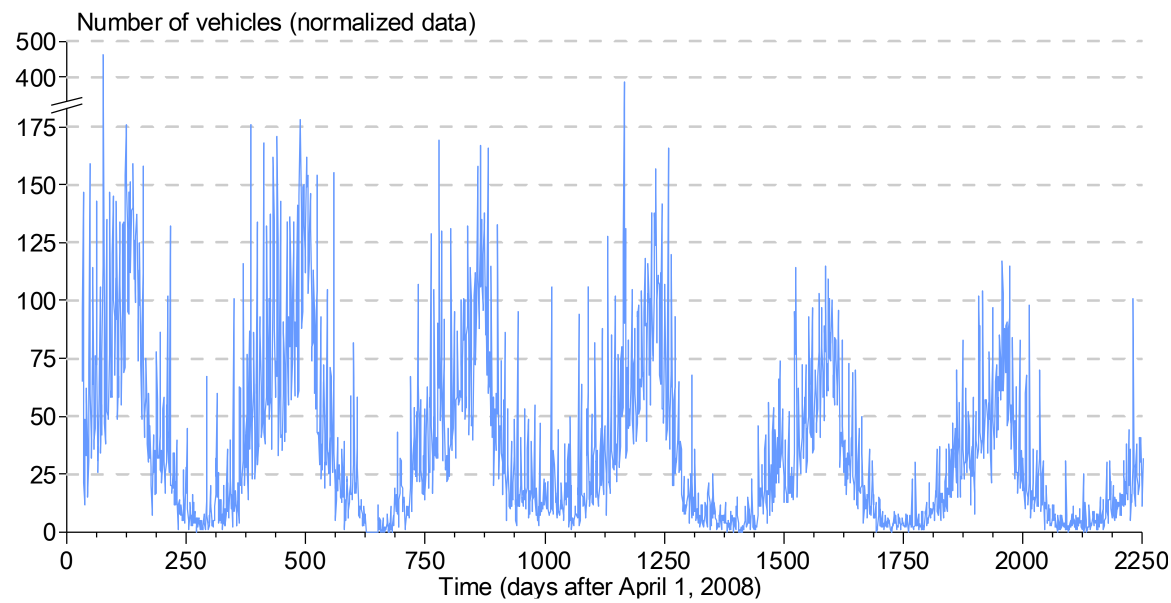


Figure 3: Normalized time series of the number of passenger vehicles from the toll station Moschohorion (direction from Athens to Thessaloniki)



3. Presentation and comparison of results

After initial time series decomposition with SSA, 11 components were used:primary component C1, which describes the trend of initial time series, and the components C2, C3, C4, …, C11 (Figure 4). Components after C12 (C12 included) are assumed to be noise components and will not be calculated when reconstructing time series. It is useful to notify that the components grouping is based to the component's frequency similarity.

Figure 4: Extracted principal time series components from the decomposition of the initial time series of daily data by using the Singular Spectrum Analysis (SSA)

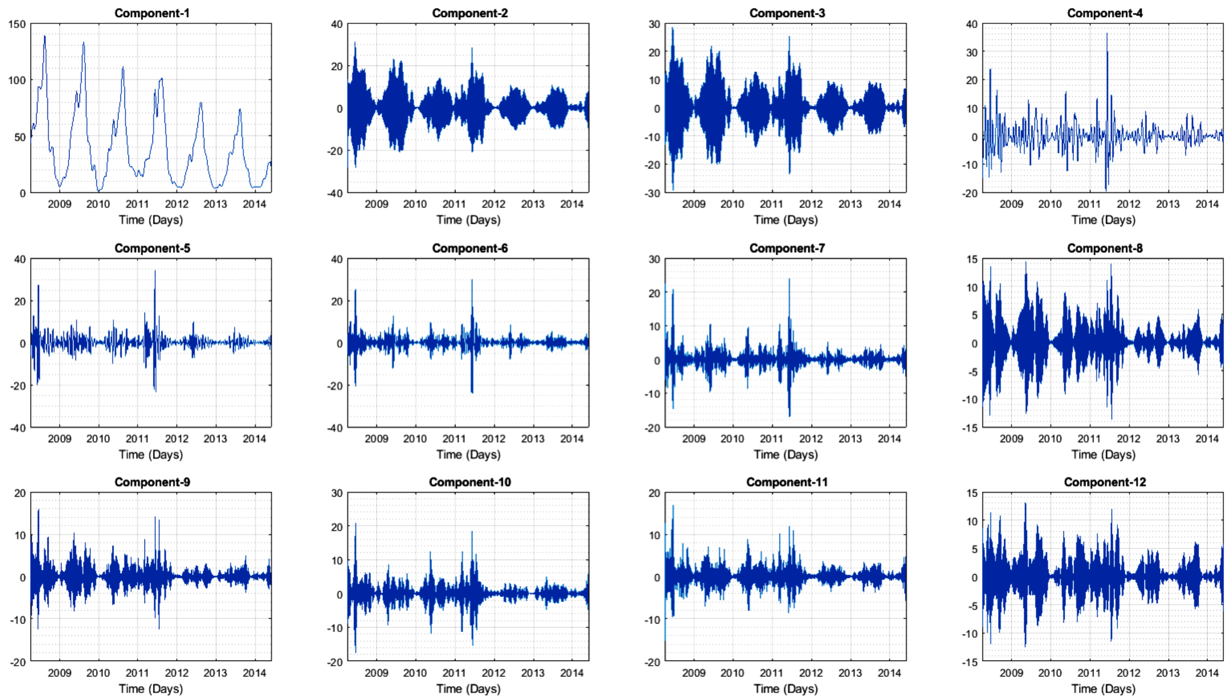


Figure 5 and 6 represent the initial time series of vehicle arrivalsat toll station of Moschohorion in the direction of Athens to Thessaloniki using ANN (Figure 5) and hybrid SSA–ANN (Figure 6). Table 2 presents results from comparison of ANN methodology and proposed hybrid SSA–ANN methodology, revealing a significant improvement of real time forecasting ability and accuracy, based on specific statistical criteria.

4. Conclusions

Accurate forecast of traffic load is essential for utilities, regulatory authorities, decision makers, local and national authorities, and transportation system engineers. The significance of a robust forecast of crucial parameters like traffic load demand, congestion time and others is evident for the decision-making strategy in short – term horizon. Traffic load demand forecasting is also essential in long – term planning towards supporting the decision makers for transportation systems maintenance and expanding.

In recent years, traffic load forecasting literature has witnessed an enormous growth of research papers. The aim of this paper is to test the robustness of a novel hybrid computational intelligence model in real – time day – ahead traffic load demand prediction. The proposed model combines Singular Spectrum Analysis (SSA) with Artificial Neural Networks (ANN). The SSA is used to decompose the original signal in a set of subseries and then an ANN is employed to optimize and upgrade the initial forecasting accuracy. The proposed methodology is characterized by high flexibility, comprehensive operation and low requirements for computational resources. Thus, it can be used by modern utilities, transportation operators and market participants while it can be embedded in Intelligent Transport Systems (ITS), enabling proactive decisions to mitigate the economic and environmental impacts of extended transport systems congestion.

Figure 5: Comparison between recorded data of vehicle traffic and forecasted traffic with the use of single ANN model.

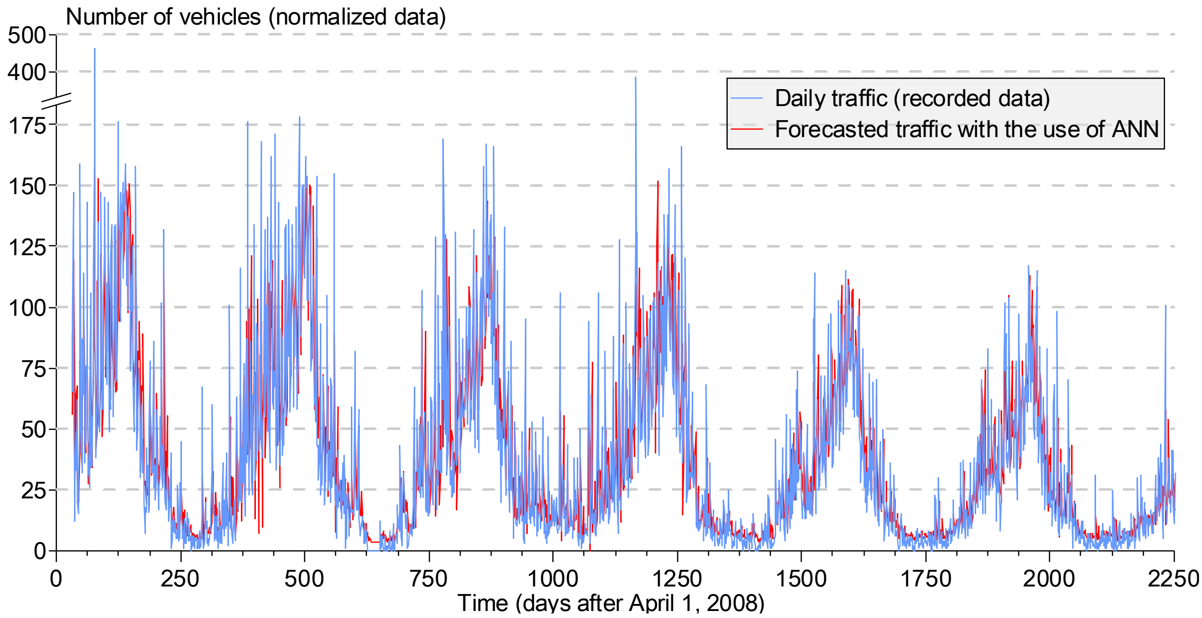


Figure 6: Comparison between recorded data of vehicle traffic and forecasted traffic with the use of the proposed SSA–ANN hybrid methodology

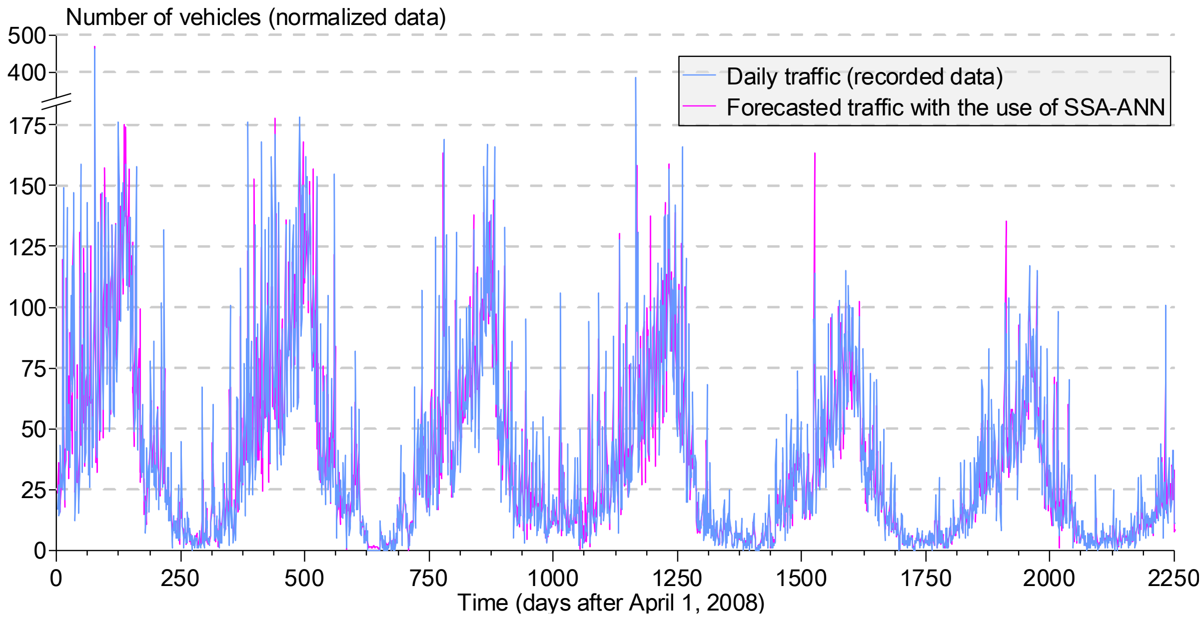


Table 2: Evaluation of the results of the proposed SSA–ANN hybrid methodology

Statistical criteria	Single ANN	Hybrid SSA–ANN	Percentage (%) improvement
Root MeanSquaredError (RMSE)	21.351	13.427	30.3%
Mean Absolute Error(MAE)	12.477	8.698	37.1%
Correlation coefficient R^2	0.854	0.945	10.6%

Use of proposed hybrid methodology for traffic load forecasting provides significant knowledge in integrated approach of transportation infrastructure while it offers optimization value to transportation infrastructure management in terms of traffic safety improvements and proactive mitigation of transport system congestion.In particular, when engaging with subject of road safety, identification of traffic load peaks and trends provide the capability to design transportation system extensions, manage extreme incidents and accident situations, schedule toll station operation in daily or monthly basis (Celikoglu, Cigizoglu, 2007).

Traffic load forecasting problem is a very challenging engineering task. Traffic load time series are volatile and can be influenced by a diverse group of variables. Therefore, more effort should be placed towards the goal of increasing the prediction accuracy. The future challenges can be summarized in the following:

Explore data – preprocessing techniques in terms of lowering both the forecasting error and processing time.

Construct new models within the concept of hybrid or combined methodologies.

Involve clustering tools that could extract transportation systems users' profiles and engage them in forecasting process.

Apply proposed hybrid methodology to national motorway system in order to identify similarities and differences of transport system characteristics, that can robust the forecasting ability and accuracy and propose applicable action for road safety.

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Examining the determinants of CO_2 emissions caused by the transportation sector activity: Empirical evidence from 12 European countries

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Abstract
The transportation sector consists the second most important sector that contributes in the production of the CO_2 emissions worldwide, while it consumes more than the one third of total energy consumption within the country-members of the EEA. Towards climate change mitigation, policies and regulations, and new infrastructure investments are employed so as to facilitate the route to a low carbon economy. In this paper we investigate possible determinants of CO_2 emissions caused by the transportation sector activity for 12 European countries over the period 1994 to 2014. We examine the effects of Environmental Policy Stringency, Climate Change Mitigation Technologies related to transportation, share of value added by the transport sector and infrastructure investments (rail, inland waterways and road). We employ panel data analysis; panel unit root tests, panel cointegration tests, the Fully-Modified OLS (FMOLS) approach, the Dynamic OLS (DOLS) approach and Granger causality test are employed in order to examine the relationship between CO_2 emissions caused by the transportation sector activity and their statistically significant determinants.

Keywords: transportation sector, climate change mitigation, CO_2 emissions, European countries

JEL Codes: C23, C33, O33, Q56, Q58

Εξετάζοντας τους παράγοντες που προκαλούν εκπομπές CO_2 που προέρχονται από τη δραστηριότητα του τομέα των μεταφορών: Εμπειρικά αποτελέσματα από 12 ευρωπαϊκές χώρες

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Περίληψη
Ο κλάδος των μεταφορών αποτελεί το δεύτερο πιο σημαντικό κλάδο όσον αφορά την παραγωγή εκπομπών διοξειδίου του άνθρακα, ενώ ταυτόχρονα καταναλώνει περισσότερο από το ένα τρίτο της συνολικής κατανάλωσης ενέργειας στις χώρες μέλη του ΕΟΠ. Προς την κατεύθυνση του περιορισμού της κλιματικής αλλαγής, πολιτικές, κανονισμοί και νέες επενδύσεις σε υποδομές επιστρατεύονται ώστε να διευκολύνουν την πορεία σε μια οικονομία χαμηλού άνθρακα. Στην παρούσα εργασία διερευνούμε πιθανούς προσδιοριστικούς παράγοντες που επηρεάζουν τις εκπομπές CO_2 που προκαλούνται από τη δραστηριότητα του τομέα των μεταφορών για 12 ευρωπαϊκές χώρες κατά την περίοδο 1994-2014. Εξετάζουμε τις επιπτώσεις της αυστηρότητας των περιβαλλοντικών πολιτικών, των τεχνολογιών μετριασμού της κλιματικής αλλαγής που σχετίζονται

με τις μεταφορές, του ποσοστού προστιθέμενης αξίας από τον τομέα των μεταφορών και των επενδύσεων σε υποδομές (σιδηροδρομικές, ηπειρωτικές θαλάσσιες και οδικές). Για την παρούσα μελέτη χρησιμοποιείται ανάλυση δεδομένων σε πάνελ· έλεγχοι μοναδιαίας ρίζας, έλεγχοι συνολοκλήρωσης, η πλήρης τροποποιημένη μέθοδος ελαχίστων τετραγώνων (FMOLS), η δυναμική μέθοδος ελαχίστων τετραγώνων (DOLS) και ο έλεγχος αιτιότητας κατά Granger, ώστε να εξεταστεί η σχέση μεταξύ των εκπομπών CO_2 που προκαλούνται από τη δραστηριότητα του τομέα των μεταφορών και των στατιστικά σημαντικών καθοριστικών τους παραγόντων.

Λέξεις Κλειδιά: κλάδος μεταφορών, περιορισμός κλιματικής αλλαγής, εκπομπές διοξειδίου του άνθρακα, ευρωπαϊκές χώρες

JEL Κωδικοί: C23, C33, O33, Q56, Q58

Introduction

Energy, manufacturing and transport are responsible for most fossil-fuel-related CO_2 emissions in the world. Since 1970 the transport sector has experienced the highest growth of GHG emissions (IEA, 2012). Transport accounted for around 23% of carbon emissions in 2013. Despite the policies addressing GHG emissions, the transport sector is the only main European economic sector in which GHG emissions have increased since 1990, while all other sectors have achieved reductions in emissions (EEA, 2015). As the global levels of urbanization and motorization are increasing, carbon emitted by the transport sector, and especially passenger traffic, is projected to keep growing the following years (Zhang et al.,(2018).

Transportation is perceived as a socio-technical system in transition to sustainability, where fundamental changes emerge in new technologies and new business models on the course to a low carbon economy. Rotmans et al. (2001) define transitions as transformation processes in which society changes in a fundamental way over a generation or more. It is a gradual, continuous process of change where the structure of a society or a subsystem of society transforms over time. According to Jin et al. (2012), transitions in the transportation sector may involve at least four modes: policy transitions, structural transitions, efficiency transitions, and technology transitions. In transportation we may see all of these modes coincide with varying intensities in different time periods.

Transitions in general, as well as transport sector transition to a low carbon economy, are multi-actor processes that take place in a multitude of interactions between social groups, commercial transactions, political negotiations, power struggles and coalitions (Geels, 2005). Transition to sustainability is a process that requires the integration of economic, environmental and social dimensions going beyond technological change to induce a transformation of society (Maccari, 2014).

Lah (2015) claims that the transportation sector is the hardest one to get decarbonized, as it is characterized by strong lock-in determinants, path-dependent processes and its infrastructure is characterized by high capital intensity. However, the necessity to move to a low carbon economy derives from the fact that the amounts of GHGs from the transportation sector have increased by almost 20% since 1990 and the global CO_2 emissions caused by the transportation sector are more than 20% of the total global CO_2 emissions (Chapman, 2007; EEA, 2015), while CO_2 emissions are GHG's most important factor for climate change.

In this paper we investigate the impact on the CO_2 emissions caused by the transportation sector from environmental policy stringency, new technologies related to transport sector having as aim to mitigate climate change, the share value of the transportation sector and the investments in road, rail and inland waterway infrastructures.

The paper is organized as follows. In section 2 we review relevant empirical studies which examine the effect of some determinants in the CO_2 emissions. In section 3 we present the data we used, and in section 4 the econometric methods used and the empirical findings of our research. Finally, in Section 5, we summarize, discuss and conclude.

Determinants affecting transportation CO_2 emissions

Most studies are focused on the decomposition of national CO_2 emissions and emission intensities, while the factors most examined as affecting the CO_2 vehicle emissions are vehicle ownership, population intensity, economic growth, changes in transport activity, modal structure, energy intensity (EI), fuel mix (FM), average traveling distance and number of vehicles (Wu et al., 2005; Lakshamanan and Han, 1997; Lu et al., 2007; Scholl et al., 1996; Schipper et al. 1997; Timilsina and Shrestha, 2009; Schipper et al., 2000).

Pereira and Pereira (2017) studied the effect of investments in municipal roads, highways, railroads and ports in Portugal and concluded that investments would not reduce emissions in absolute terms, but they affect only the average economy-wide emission intensity by reducing it. They argue that investments in national roads would leave the average emissions intensity unchanged. Fisch-Romito and Guivarch (2018) argue that transport infrastructures are an asset that creates lock-in on future carbon emissions because of their very long lifetimes. Therefore, infrastructures can either amplify the lock-in high-emitting transport patterns or otherwise facilitate decarbonization pathways.

One more relationship examined is the one between environmental policy stringency and the amount of CO_2 emissions caused. An increase in the degree of stringency of a country's GHG policy regime may cause reduction of its CO_2 emissions (Probst and Sauter, 2015; Sauter, 2014). In general, the policy imperative for a low carbon economy seems to be considered as a key driver of the socio-technical transitions, and more specifically in transportation and energy sectors (Lawhon and Murphy, 2012).

Technological innovation is supposed to enable a faster and less costly transition to a more efficient and sustainable transport system. This can be achieved by acting on three main factors: i) vehicles' efficiency through new engines, materials and design, ii) cleaner energy through new fuels and propulsion systems, iii) better use of networks and safer and more secure operations through information and communication systems (European Commission, 2011).

Data

We construct a panel data set that includes annual observations of CO_2 emissions from transportation, environmental policy stringency index, climate change mitigation technologies related to transportation, share of value added by the transport sector, and infrastructure investments for the sector. All data used are drawn from the OECD database and the estimation period is 1994–2014. The twelve European countries included in the sample are: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and the United Kingdom. The definitions of variables are presented in Table 1.

Table 1: Definition of model variables

Variable	Definition	Units of measurement
CO_2	CO_2 Emissions from transport	Tonnes per one million units of current US$ GDP
EPS	Environmental Policy Stringency Index	The index ranges from 0 (not stringent) to 6 (highest degree of stringency)

CCMTs	Climate change mitigation technologies related to transportation	Number of patent applications filled under the PCT, regarding the priority date in the inventor(s)'s country(ies) of residence
SVA	Share of value added by the transport sector	Share (%)
INLAND	Inland waterway infrastructure investment	Euro (current values)
RAIL	Rail infrastructure investment	Euro (current values)
ROAD	Road infrastructure investment	Euro (current values)
TOTINV	INLAND + RAIL + ROAD	Euro (current values)

Source: OECD Statistics database, https://stats.oecd.org/

Based on literature review, we expect that EPS and CCMTs related to transportation will have a positive impact (negative coefficients) on CO_2 emissions caused by the transportation sector (Probst and Sauter, 2015; Sauter, 2014). Also we expect that at least at the initiation of investments in infrastructures are going to have a negative impact (positive coefficient) in the CO_2 emissions caused by the transportation sector (Fisch-Romito and Guivarch, 2018). The effects of share of value added by the transportation sector on the CO_2 emissions caused by the transportation sector have not been investigated yet according to our literature review.

Methodology and Empirical Findings

We use panel data analysis to investigate possible determinants of CO_2 emissions caused by the transportation sector activity for 12 European countries over the period 1994 to 2014. These cross sections are chosen on the basis of longest data availability. In order to reduce the heterogeneity of the data among the examined countries, we transform the data in natural logarithms. According to our literature review, most of the studies are based only on time series or cross-sectional data. The reason why we use panel data set is that, compared with pure time-series and cross-sectional data, panel data set not only avoid multicollinearity but also identify and measure better the effects that time series and cross-sectional data cannot determine.

First, we use modern techniques for testing unit root such as those of Levin *et al.* (2002) (LLC), Im *et al.* (2003) W-test (IPS) and ADF-Fisher test (Maddala and Wu, 1999) to check for the presence of unit roots. Table 2 displays the panel unit root test results in the cases of intercept, and intercept and trend. Panel unit root tests indicate that the panel level series of the eight variables are non-stationary, but the eight panel first-difference series are stationary in both cases (intercept, and intercept and trend).

Table 2. Panel Unit Root Tests

	Levin-Lin-Chu (LLC)		Im-Pesaran-Shin (IPS)		Fisher-type ADF	
	C	C+T	C	C+T	C	C+T
LCO2	1,22	$-4,20^{**}$	4,16	$-2,56^{*}$	2,88	$40,51^{*}$
D(LCO2)	$-7,31^{**}$	$-5,60^{**}$	$-5,65^{**}$	$-3,35^{**}$	$75,57^{**}$	$48,87^{**}$
LEPS	-1,58	-0,64	1,99	0,13	9,91	24,53

D(LEPS)	-7,59**	-6,60**	-6,79**	-4,74**	91,18**	63,76**
LCCMTs	-3,74**	-0,22	-1,37	-0,54	32,43	36,29
D(LCCMTs)	-5,73**	-5,09**	-8,55**	-7,40**	117,20**	94,76**
LSVA	-0,92	2,85	0,51	2,42	18,77	11,51
D(LSVA)	-4,83**	-4,34**	-6,45**	-5,37**	89,54**	73,82**
LINLAND	0,29	-0,48	1,39	0,85	20,06	18,51
D(LINLAND)	-3,30**	-3,03**	-3,71**	-2,83**	55,53**	45,72**
LRAIL	-2,42*	-0,20	0,01	1,68	23,54	14,08
D(LRAIL)	-4,35**	-4,59**	-3,74**	-3,91**	54,67**	57,43**
LROAD	0,61	-0,13	1,27	0,34	16,33	24,99
D(LROAD)	-3,87**	-3,05**	-4,72**	-3,34**	65,86**	51,89**
LTOTINV	0,31	-0,54	1,41	0,86	19,74	18,48
D(LTOTINV)	-3,38**	-2,20*	-3,69**	-2,84**	55,25**	45,69**
* & ** denote significance at 5% and 1% respectively. This also applies to subsequent tables.						

In the second stage, we estimate the effects of EPS, CCMTs related to transportation, share of value added by the transport sector and infrastructure investments (inland, rail and road) on the CO_2 emissions caused by the transportation sector activity. We check the hypothesis that these factors may affect the volume of CO_2 emissions through the following three estimation models:

Model 1:

$$LCO2_{it} = \beta_0 + \beta_1 LEPS_{it} + \beta_2 LCCMTs_{it} + \beta_3 LSVA_{it} + e_{it} \quad \textbf{(1)}$$

Model 2:

$$LCO2_{it} = \beta_0 + \beta_1 LEPS_{it} + \beta_2 LCCMTs_{it} + \beta_3 LSVA_{it} + \beta_4 LTOTINV_{it} + e_{it} \quad \textbf{(2)}$$

Model 3:

$$LCO2_{it} = \beta_0 + \beta_1 LEPS_{it} + \beta_2 LCCMTs_{it} + \beta_3 LSVA_{it} + \beta_4 LINLAND_{it} + \beta_5 LRAIL_{it} + \beta_6 LROAD_{it} + e_{it} \quad \textbf{(3)}$$

where i and t stands for country and time respectively; e denotes normally distributed error term; $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, $\beta 5$, $\beta 6$ are the coefficient estimates on the relevant variables. In our analysis, we use both fixed effects (FE) and random effects (RE) models (see Table 3).

Table 3. Determinants of CO_2 emissions caused by the transportation sector activity

	Dependent Variable: LCO2					
	Model 1		**Model 2**		**Model 3**	
	FE	*RE*	*FE*	*RE*	*FE*	*RE*
C	3,32** (10,26)	3,86** (12,99)	5,62** (3,87)	3,35** (2,74)	5,48** (3,61)	3,14* (2,58)
LEPS	-0,42** (-9,47)	-0,46** (-11,61)	-0,41** (-9,16)	-0,47** (-11,48)	-0,41** (-9,12)	-0,47** (-11,67)
LCCMTs	-0,08** (-4,59)	-0,06** (-4,01)	-0,07** (-4,07)	-0,07** (-4,08)	-0,07** (-4,02)	-0,07** (-4,06)

LSVA	$0,82^{**}$ (4,36)	$0,48^{**}$ (2,87)	$0,63^{**}$ (2,96)	$0,53^{*}$ (2,58)	$0,64^{**}$ (2,92)	$0,52^{**}$ (2,49)
LTOTINV	-	-	-0,08 (-1,57)	0,02 (0,45)	-	-
LINLAND	-	-	-	-	-0,06 (-0,36)	-0,006 (-0,04)
LRAIL	-	-	-	-	-0,01 (-0,20)	0,006 (0,10)
LROAD	-	-	-	-	-0,01 (-0,13)	0,03 (0,40)
Adjusted R-squared	0,77	0,68	0,78	0,68	0,77	0,67
F-Statistic (prob.)	0,000	0,000	0,000	0,000	0,000	0,000
Jarque-Bera (prob.)	0,97	0,17	0,92	0,32	0,94	0,16
Hausman Test (prob.)	0,0001		0,0002		0,0001	
Obs.	218		212		212	
T-ratios are given in parentheses. This note also applies to the subsequent tables.						

In Table 3 we see that the EPS (LEPS) and the CCMTs related to transportation variable (LCCMTs) enter the estimations with negative and statistically significant coefficients at the conventional 1% level, while the coefficient of share of value added is positive and statistically significant at the 1% level[11]. Infrastructure investments (total or modal) do not seem to affect the dependent variable (see model 2 and model 3). We have to mention that, according to the Hausman test, FE models are more appropriate than RE models.

Third, we apply panel cointegration methodology using LCO_2 as dependent variable and their statistically significant determinants (LEPS, LCCMTs and LSVA). Three types of panel cointegration test are used. The first test - developed by Pedroni (1999, 2004) - consists of seven component tests: the panel v-test, panel rho-test, panel PP-test, panel ADF-test, group rho-test, group PP-test, and group ADF-test. The second test is the residual based panel cointegration test developed by Kao (1999). This test follows the same approach as the Pedroni tests, but specifies cross-section specific intercepts and homogeneous coefficients on the first stage regressors. The third panel cointegration test, developed by Maddala and Wu (1999), consists of two kinds of Johansen-type tests: the Fisher test from the trace test and the Fisher test from the maximum eigenvalue test. In Table 4 we present the results of the above panel cointegration tests (in the case of constant and without trend).

Table 4. Panel Cointegration Tests (LCO2, LEPS, LCCMTs and LSVA)

Pedroni Tests							**Kao Test**	**Johansen Fisher Tests**	
Panel v-Stat	Panel rho-Stat	Panel PP-Stat	Panel ADF-Stat	Group rho-Stat	Group PP-Stat	Group ADF-Stat	ADF	Trace test	Maximum Eigenvalue test

[11] We have to mention that the coefficient of LSVA is positive and statistically significant at the 5% level in the second model, in the case of RE model.

-0,49	1,21	-0,42	-0,60	2,67	-1,78*	-1,73*	-3,59**	None: 275,9** At most 1: 133,4** At most 2: 59,77** At most 3: 47,22**	None: 230,0** At most 1: 107,6** At most 2: 48,63** At most 3: 47,22**

We observe that, according to the group PP-statistic, group ADF-statistic, Kao test and Fisher tests, there is a long-run relationship among the four variables. Two of the seven Pedroni test statistics suggest evidence for panel cointegration at the 5% level. Kao test and Johansen Fisher tests indicate long-run relationship among the four variables at the 1% level.

Fourth, we use two cointegrating estimators to estimate the long-run elasticities of the innovation proxies: the Fully-Modified OLS (FMOLS)[12] as suggested by Phillips and Hansen (1990) and the Dynamic OLS (DOLS)[13] as developed by Stock and Watson (1993). Table 5 presents the empirical findings of the two approaches; the panel method is the pooled.

Table 5. Long-run elasticities with LCO_2 as dependent variable

	Dependent Variable: LCO2	
	FMOLS	***DOLS***
LEPS	-0,42** (-6,76)	-0,39** (-3,50)
LCCMTs	-0,11** (-4,51)	-0,18** (-3,31)
LSVA	0,83** (3,05)	0,67 (1,62)
Adjusted R-squared	0,78	0,82
Jarque-Bera (prob.)	0,85	0,90
Obs.	204	178

The results indicate that the Environmental Policy Stringency Index (LEPS) and the climate change mitigation technologies related to transportation variable (LCCMTs) affect CO_2 emissions in a constructive way; i.e. both variables have negative signs and are statistically significant at the 1% level. The coefficient of LEPS is in the range of -0,39 to -0,42, while the coefficient of LCCMTs is in the range -0,11 to -0,18; the relationships are inelastic for both methods, meaning that the magnitude of the impacts is small and less than 1%. The coefficient of LSVA enters the estimations with a positive sign but statistically significant at the 1% level only in the case of FMOLS method.

Finally, after determining that the selected variables are cointegrated, we proceed to the Granger-causality analysis (Granger, 1969) in order to examine possible causal links (Table 6).

Table 6. Panel Granger causality test results

Null Hypothesis	**F-Statistic**			
	1 LAG	2 LAGS	3 LAGS	**Results**
LEPS does not Granger cause LCO2	3,96*	5,84**	11,79**	LEPS ↔ LCO2

[12] The FMOLS procedure, apart from correcting for endogeneity and serial correlation, also asymptotically eliminates the sample bias.

[13] The DOLS has the advantage that it corrects for potential simultaneity bias among regressors. It entails regressing one of the I (1) variables on other I (1) variables, the I (0) variables, and lags and leads of the first difference of the I (1) variables. The rationale for incorporating the first difference variables and the associated lags and leads is to obviate simultaneity bias and small sample bias inherent among regressors.

LCO2 does not Granger cause LEPS	6,25*	3,99*	6,67**	
LCCMTs does not Granger cause LCO2	1,52	0,23	1,28	-
LCO2 does not Granger cause LCCMTs	0,39	2,42	2,32	
LSVA does not Granger cause LCO2	0,39	0,59	0,63	-
LCO2 does not Granger cause LSVA	0,03	0,74	0,52	

The empirical results show a strong bidirectional causal relationship between Environmental Policy Stringency Index and CO_2 emissions caused by the transportation sector activity (LEPS ↔ LCO2) for one to three time lags. The panel Granger causality results neither confirm any causal links between Climate Change Mitigation Technologies related to transportation and CO_2 emissions nor any causal links between the share of value added by the transport sector (LSVA) and CO_2 emissions.

Discussion and Conclusions

In this paper, we used annual data for 12 European countries for the period 1994 - 2014, in order to examine the effects of some important determinants on CO_2 emissions caused by the transportation sector. We used panel data analysis, an approach not used before on the issue of transport CO_2 emissions. Policies and technical innovations are supposed to be significant parameters when talking about transition, something that is confirmed in our study by the existence of a significant relationship between EPS and CO_2 emissions and CCMTs and CO2 emissions.
We found that the environmental policy stringency and the new innovations have positive policy outcome (negative signs) on CO_2 emissions; i.e. as policy stringency and innovation increase CO_2 emissions decrease, which confirms our literature review.
We also observe a bidirectional causal relationship amongst the EPS and the CO2 emissions caused by the transportation sector. Our econometric findings indicate that Environmental Policy Stringency Index is a decisive factor in reducing CO_2 emissions caused by the transportation sector activity, while the CCMTs related to transportation has not such a stronger power as EPS to CO_2 emissions caused by the transportation sector. EPS has a stronger long-run relationship with CO_2 emissions and may provoke lower emissions. In other words, our examination of policy and technical aspects has shown that the policy aspect has stronger influence on CO_2 emissions caused by the transportation sector.
From the examination of the causal relationship, we may also conclude that environmental policy stringency does not have immediate effects on the CO_2 emissions, but a time lag is required for the socio-technical system to adapt to policies.
It is important to take into consideration that the transportation sector is characterised by technological lock-ins, which means that a need for additional actions (e.g. subsidies, financial regulations) is also important, so as to move to new more sustainable technologies in a big scale. Identifying the key determinants that affect CO_2 emissions produced by the transport sector is essential for formulating more effective emission reduction policies. Authorities have to design stringent policies taking into account the time lag that policies need to take effect, as well as the different stages of economic development that the country of application experiences.
Our estimated models were instructive and useful to understand the impact of different determinants to the CO_2 emissions caused by the transportation sector, but future research is important, so as to examine the effects of aspects of economic growth to our dependent variable. Furthermore, we have

to check our findings in other countries that differ in terms of growth levels, in order to see if they are valid in countries with other characteristics.

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Artificial Neural Networks: A Modern Tool for Empirical Modeling of Transport Demand

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Abstract
In the present paper it is analyzed how modelling and forecast of future transport demand can be conducted with application of artificial intelligence and particularly of the method of artificial neural networks (ANN). This method permits to derive conclusions for the evolution of a phenomenon for which a set of input – output data are available, without any requirement to know how input data are transformed to output data. ANN is an empirical method inspired from the way of operation of biological neurons, how and under what conditions are biological neurons activated, operating and learning. The method of ANN is used in the paper to model and forecast future transport demand in relation to the evolution of GDP and other driving forces of the problem, for mature and developing air transport markets.

Keywords: Empirical models, artificial intelligence; artificial neural network; forecasting, transport demand.
JEL Classification: R41; C45, C52; C53; R15

Τεχνητά Νευρωνικά Δίκτυα: Ένα Σύγχρονο Εργαλείο Εμπειρικής Μοντελοποίησης της Ζήτησης των Μεταφορών

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Περίληψη
Στην εργασία περιγράφεται η μέθοδος της εμπειρικής μοντελοποίησης, μια τεχνική η οποία επιτρέπει την εξαγωγή αποτελεσμάτων από ένα σύνολο δεδομένων εισόδου-εξόδου δίχως να είναι απαραίτητα γνωστός ο μηχανισμός μετασχηματισμού των δεδομένων εισόδου σε αποτελέσματα. Ως μια σύγχρονη μέθοδος εμπειρικής μοντελοποίησης προτείνονται τα τεχνητά νευρωνικά δίκτυα (ΤΝΔ). Αναλύονται καταρχήν οι αρχές των βιολογικών νευρώνων και τα χαρακτηριστικά τους που επιτρέπουν τη διαδικασία εκμάθησης, καθώς και το αναλογικό ισοδύναμο των βιολογικών νευρώνων στη μοντελοποίηση, τα ΤΝΔ. Στη συνέχεια εφαρμόζονται ΤΝΔ απλής και επαναληπτικής τροφοδοσίας για τη μοντελοποίηση της αεροπορικής ζήτησης σε ανεπτυγμένες και αναπτυσσόμενες αεροπορικές αγορές παγκοσμίως και προσαρμόζονται μοντέλα στα οποία μαζί με το ΑΕΠ, την κλασσική μεταβλητή που εκφράζει την οικονομική μεγέθυνση, εισάγονται και άλλες μεταβλητές που εμπειρικά εκτιμάται ότι επιδρούν στη μεταφορική ζήτηση. Η εργασία ολοκληρώνεται με έλεγχο της προβλεπτικής ικανότητας των εκπαιδευμένων ΤΝΔ.

Λέξεις Κλειδιά: Εμπειρικά μοντέλα, τεχνητή νοημοσύνη, τεχνητά νευρωνικά δίκτυα, πρόβλεψη ζήτησης, μεταφορές.
JEL Κωδικοί: R41; R42; C52; C53; C67; R15

1. Empirical modelling of transport demand - Introduction

From a historical perspective, modelling has been characterized by two competing approaches. On the one hand, theory-driven approaches emphasize that calibrated models should be based on solid theoretical conceptions about the nature of the problem, the various dependent and independent variables that formulate the problem, a series of statistical tests concerning the functional form of the calibrated model. On the other hand, empirically-derived approaches, are mainly concerned with the research findings and the results of the modelling procedure, sometimes independent of the theory.

Empirical modelling is, therefore, one of the most commonly used methods in science, technology, engineering, and management. It refers to any kind of computer modelling based on empirical observations rather than on mathematically describable relationships of the system modelled. The evolutions in desktop computing and in open-source software, combined with recent advances in empirical modelling development algorithms (such as those of machine learning and artificial intelligence) have helped make this possible. A disadvantage of empirical modelling is that it is, more or less, a "black box" methodology which provides poor explanation concerning the transformation of inputs to outputs, and is therefore best used as a compromise in situations where a solid modelling framework is not available.

Modelling of a transport demand permits to estimate in real-time unknown variables of demand with a certain degree of rationality and reliability. Statistical and econometric methods, in spite of their apparent complexity, can nevertheless be overly simplistic. They possess a number of inherent flaws, for example (Profillidis and Botzoris, 2018):

transport demand is often considered as a linear problem; in most cases, however, it exhibits non-linear characteristics,

while trying to establish a causal relationship, statistical methods have usually only one independent variable (time), and econometric methods have a limited number of independent variables (the more important ones) but omit a number of less important variables,

both statistical and econometric methods are based on a set of assumptions, which limit the degrees of freedom and flexibility exhibited in real problems of transport demand.

Many of the above drawbacks can be dealt with the use of methods based on artificial intelligence (AI), which can be defined as the science of making machines or systems do things that would require human intelligence (Minsky, 1961). There are many types of AI systems, which however share some fundamental characteristics in common, as they are programmed to think like people, to act like people, and to think rationally and reasonably.

The method of artificial neural networks (ANN), called sometimes neural network method or simply neural method, is one of the techniques of AI. Other such techniques include Support Vector Machines, Genetic Algorithms, Autoassociative Networks, Incremental Learning, etc. ANN is a machine learning method which is inspired and tries to imitate (in a very simplistic manner) the way that biological neuronal systems, such as the human brain, work and process information.

Though there is still a great deal that is unknown about how the human brain works, the approximately 100 million neurons of the brain allow human beings to understand, remember, think, and apply previous experiences. An artificial neuron simulates these fundamental functions of a natural neuron, and thus imitates the basic operations of the human neuron network.

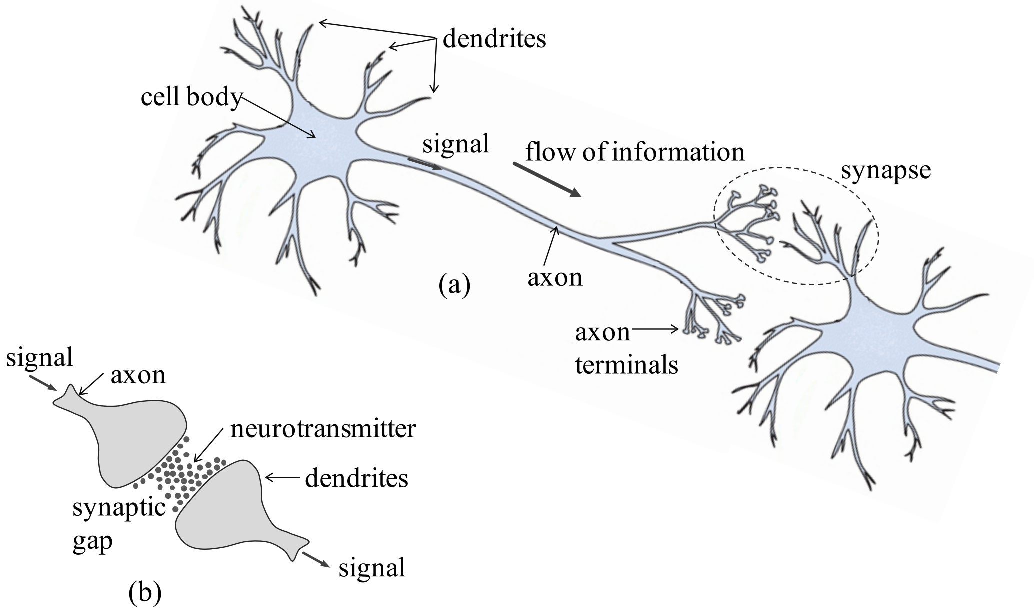
2. The basic characteristics of Neural Network Models

2.1 Structure and elements of a biological neuron

A biological neuron is the basic structural component of the neuron system. A simplified representation (Figure 1) of a biological neuron makes clear three fundamental functional units (Basheer and Hajmeer, 2000): the cell body (called soma), the dendrites, which receive signals from other neurons and pass them over the cell body, the axon, which receives signals of the cell body and transmits them to dendrites of neighbouring neurons.

The primary impulse to a neuron is a form of electric signal, which travels through a dendrite and before reaching the cell body goes through a small gap, called synapse or synaptic joint. This gap is full of substances that act as neurotransmitters, which either accelerate or decelerate the flow of electric signals. Each neuron has a threshold value of electric signals, below which the signal is not transmitted to the cell body and over which the signal is transmitted. In this latter case, the newly generated signal passes through the following neuron. Thus, a biological neuron receives external inputs, combines them and finally processes an output, usually in a non-linear way (Hopfield, 1982; Carpenter, 1989).

Figure 1: Constituent elements of a biological neuron (a) and mechanism of signal transfer between two biological neurons (b) (Source: Profillidis and Botzoris, 2018).



2.2 Structure of an artificial neuron and activation function

A clear analogy exists between a biological neuron and an artificial one (Figure 2). A biological neuron receives various signals of intensity x_i and synaptic strength w_i, and has a threshold value for activation b. In an artificial neuron, the connections between nodes simulate the axon and dendrites, the connection weights simulate the synapses, and the threshold value for activation has a similar operation (Cheng and Titterington, 1994; Basheer and Hajmeer, 2000). The artificial neuron receives many inputs x_i of a relative importance (weight) w_i, which result in a total input $\xi=\sum w_i \cdot x_i$. If this total input ξ is greater than the neuron's threshold limit value b, then the artificial neuron will be activated and the output y_i, a function of ξ ($y=f(\xi)$), will be transmitted to another neuron or to the environment. In successive calculations, an artificial neuron modifies the weights w_i in such a way that the calculated output y_i approaches the targeted output Y, if this is known. If Y is not known, successive calculations are terminated when values of y_i (calculated successively) are very close and the error is small compared to some fixed value. Thus, the key element of an artificial neuron consists in adjusting, during successive calculations, each weight w_i until the difference between the desired or expected output Y and the calculated actual output y_i is below a predetermined value.

All kinds of artificial neurons simulate the four basic functions of a biological neuron (Figure 3): i. reception of information from the external environment (the dendrites of a biological neuron), ii. decision whether this information will be activated and be taken into account or will be ignored as non-important (the synapses of a biological neuron), iii. processing of the information (the soma of a biological neuron), and iv. the output of the whole procedure (the axon of a biological neuron).

Figure 2: Analogies between a biological neuron (a) and an artificial neuron (b). (Source: Compiled by the authors, modified from Basheer and Hajmeer, 2000).

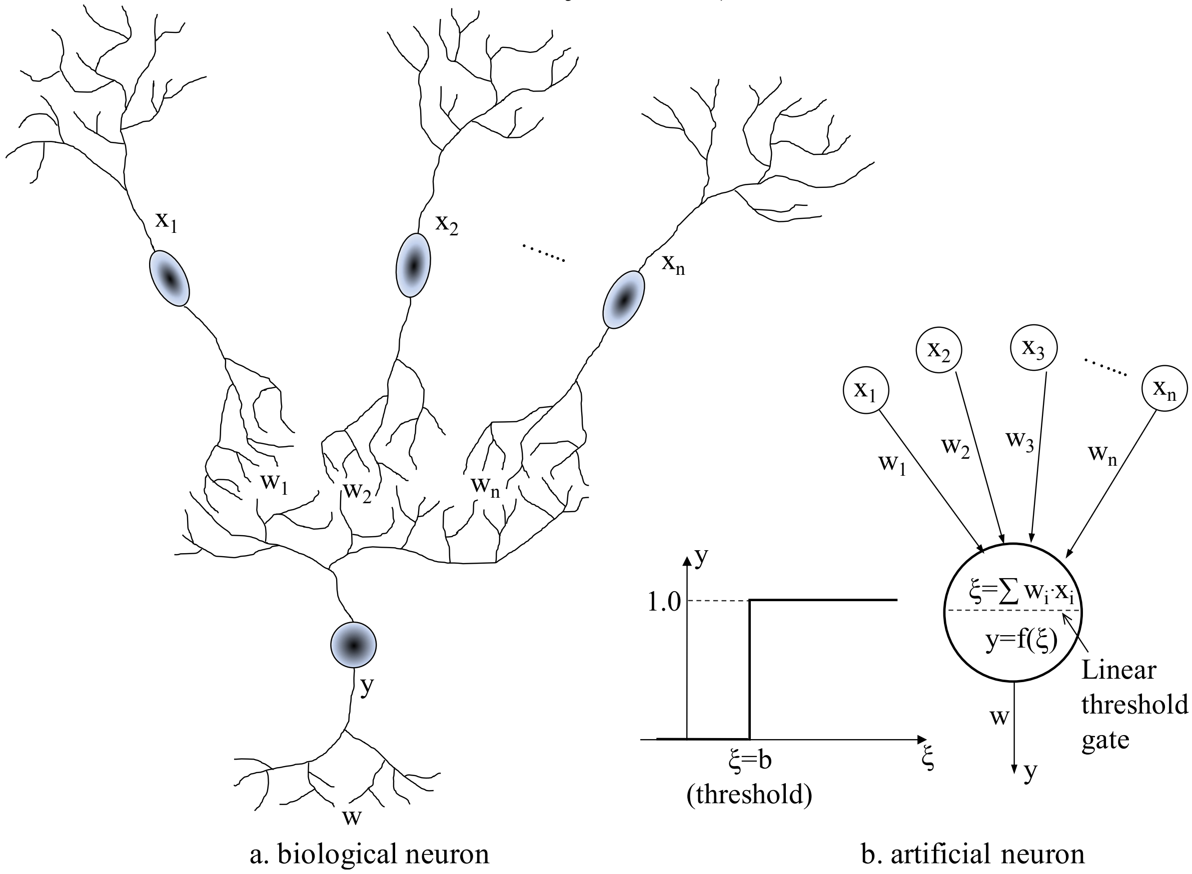
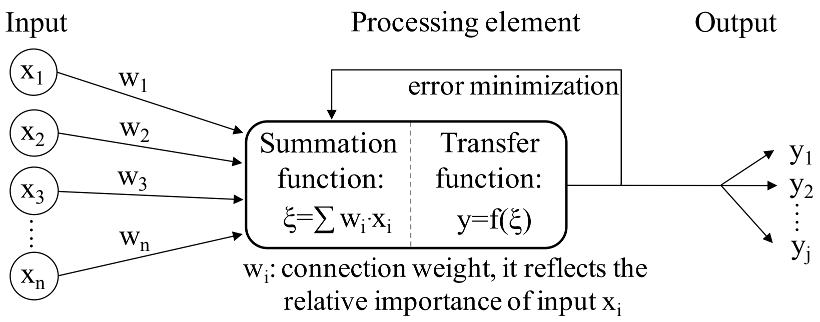


Figure 3: Fundamental operations in an artificial neuron (Source: Profillidis and Botzoris, 2018).



3. Transport problems for which artificial neural networks or other empirical models are more suitable

The study of a great number of applications of artificial neural networks (ANN) in transport problems highlight the nature of problems for which ANN or other empirically-derived models are more suitable, specifically when (Dougherty, 1995; Karlaftis and Vlahogianni, 2011):
we do not know or (even more so) are interested in the mechanisms and processes that follow our data,
there is no need to interpret the specific phenomenon,
assumptions and restrictions of statistical methods are not valid,
huge amounts of data (which may present fluctuations) should be taken into account.

On the other hand, theory-driven models are suitable when:
we know the mechanism and process of the problem, the variables that affect it, and the way and the degree of the effect of each variable,

we need to interpret the results,
assumptions and restrictions do not transform the problem under study to a different problem, compared to the surveyed one,
there are no missing data, which in addition do not present high fluctuations.

4. Application of ANN for transport: A long-term forecast of air transport demand

4.1 The problem, the dependent (output) and independent (input) variables

We will illustrate an application of ANN for the forecast of the number of air trips per inhabitant, which will be the dependent variable of the problem. We will examine a mature market (North America, including the USA and Canada, population: 0.357 billion inhabitants in 2015) and a developing market (South Asia, including, among others, India, Pakistan, Afghanistan, Bangladesh, etc., population: 1.744 billion inhabitants in 2015). Demand for air transport is principally affected by the GDP per capita of the considered area (Profillidis and Botzoris, 2015), which will be the single or one of the independent (input) variables of the problem. However, air transport is more and more affected by a number of other variables, such as (Oyewole, 2001; Lubbe, 2007; Coman and Ronen,2009; Suryani et al., 2010; IATA, 2011; Taxidis, 2016; Martin-Domingo and Martín, 2016):
percentage of population with easy access to the internet. An increasing number of customers of airlines (both low cost and full service airlines) collect information (about tariffs, departure and arrival times, etc.), buy their tickets, and check in for their flight with the use of the internet,
concentrations of populations in urban areas. In 2013, 20% of air trips worldwide had either as origin or destination 26 megacities, each one with a population of more than 10 million inhabitants, whereas 40% of air trips worldwide were between urban agglomerations with populations of 5 million or more.
population in the largest city.

Thus, the ANN model under study will have one output variable (annual number of air trips per 1,000 inhabitants) and four input variables (per capita GDP in purchasing power parity, users of internet as percentage of the whole population, degree of urbanization as percentage of the population living in urban areas, percentage of the whole population living in the largest city). Each of these four independent variables has a high value of Pearson correlation coefficient (r) in relation to the dependent variable (Table 1), a fact that testifies that each independent variable has a high correlation with the dependent one.

Table 1: Pearson correlation coefficient (r) between the dependent (output) variable and each one of the independent (input) variables (Source: Compiled by the authors).

Dependent variable (output variable to ANN)	Independent variables (input variables to ANN)	Pearson correlation coefficient (r)	
		North America	South Asia
Air trips per 1,000 inhabitants	Per capita GDP (in PPP)	0.97	0.95
	Users of internet	0.87	0.95
	Degree of urbanization	0.95	0.86
	Population living in the largest city	-0.95	0.82

4.2 Architecture and activation functions of the ANN models

We will try two well-known architectures of ANN: feedforward multiple input – single output (Figure 4) and recurrent. ANN models using the recurrent technique can be trained in two phases, open loop and closed loop (Figure 5).

Figure 4: Architecture of the feedforward multiple input – single output ANN model (Source: Profillidis and Botzoris, 2018).

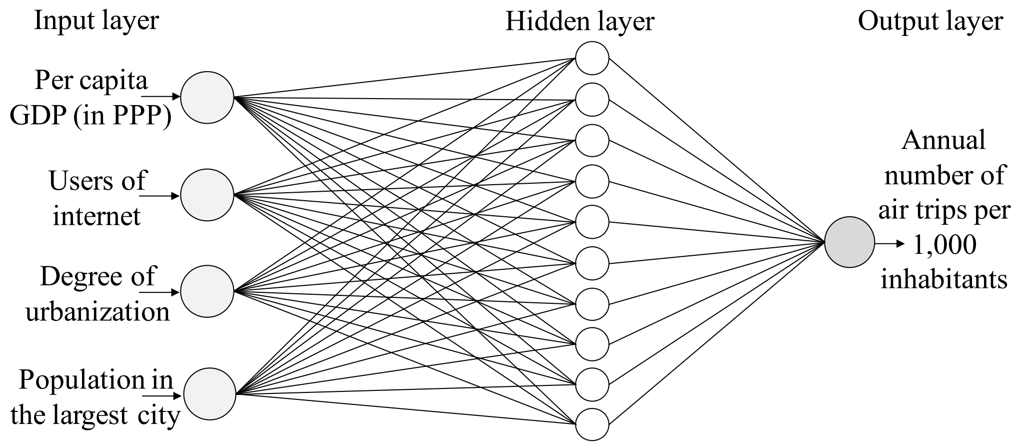
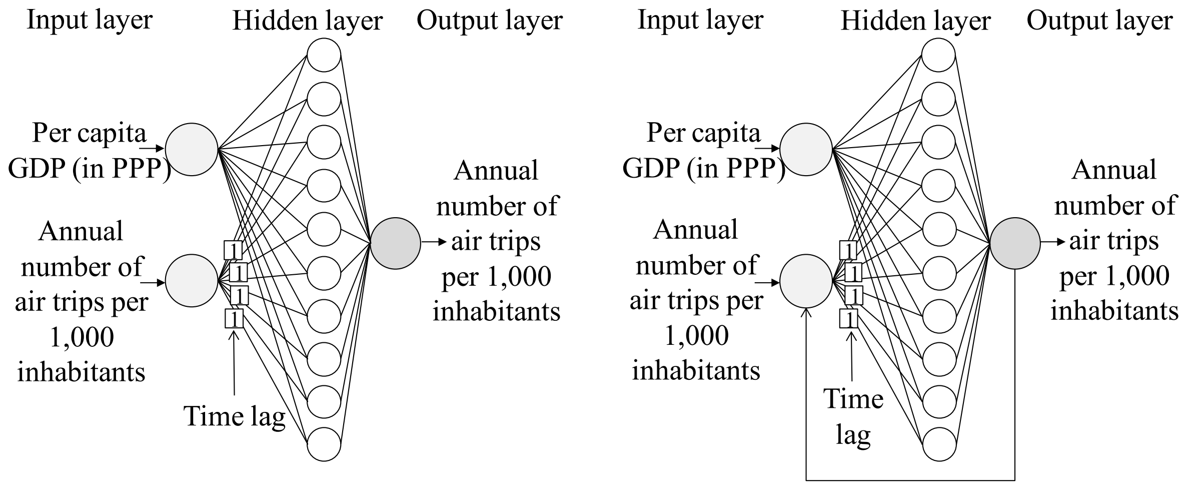


Figure 5: Architecture of the recurrent ANN model (Source: Profillidis and Botzoris, 2018).



a. Open-loop phase b. Closed-loop phase

Data were collected from the database of the World Bank (2017). The sample data will be randomly split into three sets, the training set, the validation set and the testing set, with the respective percentages of 75%, 15%, 15%. The training set will be used to train the ANN, the validation set will be used to inform the network when training will be stopped (when improvements between successive iterations have no significance differences), and finally the test set will provide a measure of the accuracy of the ANN.

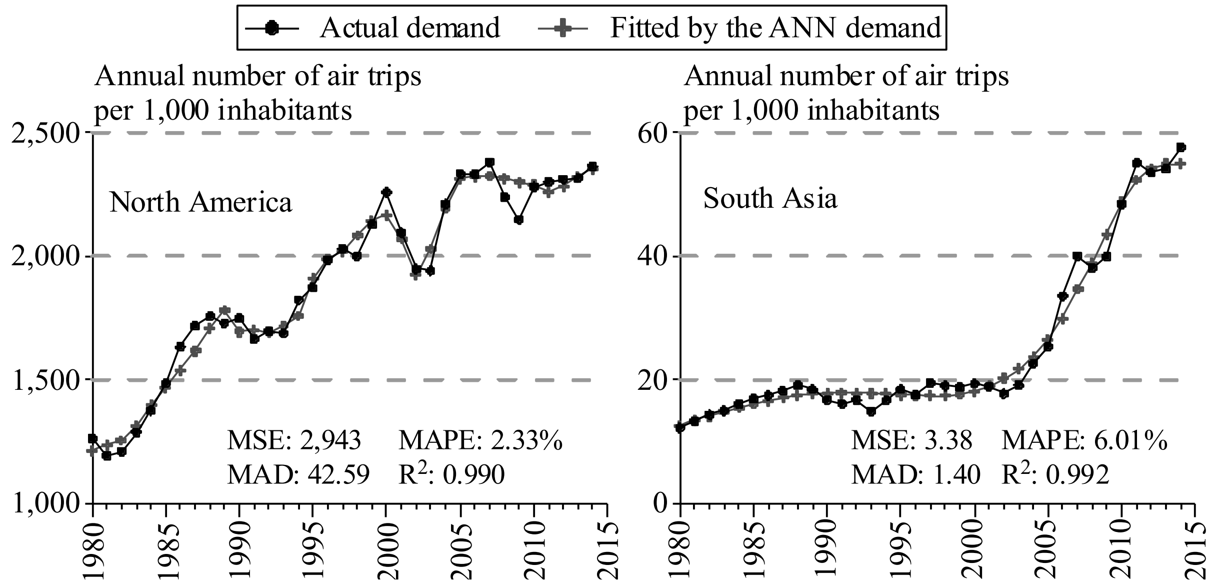
For the training procedure, the Levenberg-Marquardt algorithm will be used, since it is appropriate for solving non-linear least squares problems (Xiao et al., 2014). The activation function in the hidden layer is a sigmoid function and in the output layer is a linear function.

4.3 Results of the feedforward and the recurrent ANN models

The forecasting ability of the ANN models was checked on the basis of the values of the following statistical measures: mean squared error (MSE), mean absolute percentage error (MAPE), mean absolute deviation (MAD), and coefficient of determination (R^2).

Figure 6 illustrates results of the feedforward multiple input – single output ANN model and comparison with values of statistical data. The model has a high value of the coefficient of determination (R^2) and follows well the turning points of statistical data.

Figure 6: Results of the feedforward multiple input – single output ANN model and comparison with the actual values of air transport demand (Profillidis et al., 2017).



In a recurrent ANN model, the output variable is also an input lagged variable, in order to incorporate feedback over time. Thus, we will have two input variables (per capita GDP in purchasing power parity, lagged annual number of air trips per 1,000 inhabitants) and one output variable (annual number of air trips per 1,000 inhabitants). Recurrent ANN are particularly suitable for systems with a highly dynamic behaviour, strong fluctuations, and unpredictable changes in the course of time (Han et al., 2017).

We will train the recurrent ANN model in two phases (Figure 5):

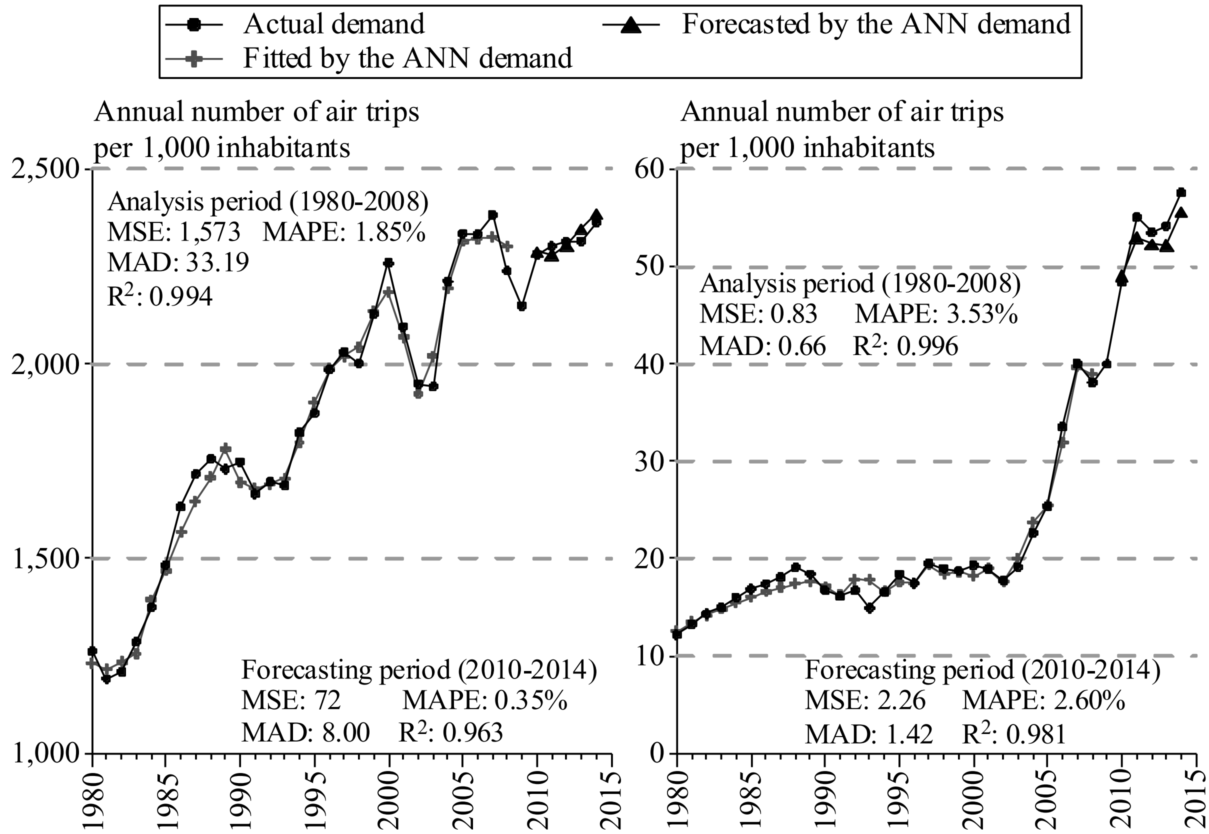
phase of open loop training: it permits the training of the model with the actual targeted values, thus minimizing the forecast error,

phase of recurrent closed loop feedback training: after the open loop training phase, the output of an iteration becomes input for the next iteration, thus providing the possibility for out of sample forecasting.

The appropriate time lags for the recurrent ANN can be estimated with the use of the correlograms of the autocorrelation function (ACF) and of the partial autocorrelation function (PACF) of the output variable (annual number of air trips per 1,000 inhabitants), which is also an input lagged variable. The plots of the correlograms of ACF and PACF are typical of a first-order autoregressive process: an exponentially declining ACF and statistically significant spikes, indicating the order of the autoregression, in the first lag of the PACF.

Figure 7 illustrates results of the recurrent ANN model for the 5-steps ahead forecast of passenger air transport demand. We can observe a high value of the coefficient of determination, which testifies the high forecasting ability of the model. The recurrent model is suitable for the forecast of future air transport demand, whereas the feedforward model is suitable for analyzing the evolution of demand in the past.

Figure 7: Results of the 5-steps ahead recurrent ANN model and comparison with the actual values of air transport demand (Profillidis et al., 2017).



5. Conclusions and further research

An ANN model of analysis and forecast of air transport demand is scrupulously studied and presented in this paper: architecture of the ANN model, single and multiple inputs, data and software, propagation rule (feedforward, recurrent), number of iterations, errors. The model was calibrated and applied for a mature and a developing air transport market and performed excellent forecasting abilities, as can be concluded from all statistical checks. The model can be used for the forecast of future air transport demand by incorporating the appropriate values of the independent variables.

ANN can constitute a mechanism of more or less automatic decision making procedure. In addition, ANN models can incorporate fuzzy logic and take into account human experience and lead to the so-called adaptive neuro-fuzzy inference system (ANFIS).

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The contribution of the road transport projects of the NSRF 2007-2013 to the development of a Greek Region

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Abstract
The purpose of the present paper is to study how the actions of the road projects of National Strategic Reference Framework (NSRF) 2007-2013 contributed to the development of the Region of Eastern Macedonia and Thrace, as these actions were included in the respective Operational Program of Eastern Macedonia and Thrace 2007-2013. It analyzes the European Regional policy, examines the cohesion policy of the European Union, which aims to reduce Regional inequalities and ensure the social, economic and territorial cohesion. In Greece, the cohesion policy implementation for the period 2007-2013 was achieved through the NSRF 2007-2013, where the present study presents its training philosophy and the priorities set. The study area concerns the Region of Eastern Macedonia and Thrace, followed by the analysis, characteristics and results of the Operational Program of the Region of the same period, through which 87 road projects were implemented. Data are collected for each of these projects and, through the presented research methodology, conclusions are drawn on the contribution of these actions to the development of the Region.
Keywords: Regional Development; Regional Policy; Regional Inequalities; European Cohesion Policy; Operational Program for East Macedonia and Thrace.

1. Introduction

Regional inequalities that appear mostly in the form of unequal social and economic opportunities, as well as strong differences in prosperity levels among the regions, is the main reason for the exercise of Regional policy, the key component of which is the cohesion policy. Through this, the European Union transfer resources from wealthier to poorer areas.

The ultimate goal is to modernize the backward regions. It is a vast expanse of budgetary expenditure amounted to 347 billion in the time frame 2007-2013 and was placed in the research and development sector and the transport sector. The creation of infrastructures is the most important policy that can contribute to the development of regions which are characterized by lagged performance in the specific sectors. Great emphasis is given to the creation of transport infrastructure connecting cities and regions with the development centers of the country, since it improves quality of life and economic efficiency. In addition to the importance of the development of road networks on the social and economic development of the country, the growth is directly related to the issues of regional convergence and lifting of isolation between regions of the country.

The aim of the current paper is to study how the actions of the NSRF 2007-2013 road transport programme contributed to the development of a Greek region which constitutes a typical example of a region well-distanced from the country's economic and governmental centers, namely the Region of Eastern Macedonia and Thrace, as these actions are incorporated into the corresponding Regional Operational programme of Eastern Macedonia and Thrace 2007 2013. The results of this research are presented in the form of tables and graphs. Furthermore we analyze the conclusions of the research and make suggestions for the better management of inputs of Regional finance Programs such as the NSRF 2007-2013.

2. Literature review

The goal of Regional development is to enhance convergence of different Regions of a country, towards the national average (Dontigney, 2017). In the European Union, Regional development promotes the balanced development of the latter. In addition, can assist in treating EU as an integral factor of government economic and social policy (Antonescu, 2014).

Dealing with Regional inequalities became very early an important issue of European policy. Although several studies show that there is evidence of the convergence of the European Union at the country level, this is not always the case at the regional level. The uneven development has a significant impact on the stability of countries, social relationships and the effective utilization of economic resources (Goletsis and Chletsos, 2011).

Analysis of Petrakos and Economou (2014), shows that southeastern Europe is characterized by growing regional imbalance, by increasing strengthening of metropolitan regions and by serious discontinuities at their borders, which, in most cases, produce isolated border areas and, finally, an urban system with serious deficiencies in the medium-sized cities.

Due to these considerable differences at the regional development, the EU has adopted a set of policy measures to promote the integration and convergence of less developed areas among the Member States, applying the so-called cohesion policy (Mikulic et al., 2013).

The EU constitutes a heterogeneous integration with major economic and social differences between the Member States and their regions. Therefore, the first challenge for EU cohesion policy is to acquire the required determinations and decisions towards increasing resources in order to combat inefficiency, gaps and exclusion in all European Regions (Petrakos, 2012).

However, the effectiveness of EU cohesion policy has been strongly criticized, especially by some wealthier Member States (Hoerner and Stephenso, 2012). Begg (2010) calls the cohesion policy as a "search policy objectives" and stresses the confusion generated by different, often competing and incompatible objectives. To be effective, the latter is need to encourage targeted interventions that will appropriately respond to identified Regional needs, and to have a coherent design based on coordination and balance of approaches from the top-down and bottom-up (Monastiriotis et al., 2017).

The existence of regional inequalities in a country remains an important theoretical and practical issue to be considered when planning and resource allocation and capital (Goletsis and Chletsos, 2011). What characterizes the growth in Greece during the last decades is the Metropolitan structure. In particular, the two largest urban centers, Athens and Thessaloniki, account for almost half of the country's population and productive activities that far exceed the proportion of their population ratio. This inequality in the distribution of the population resulted from strong internal migration flows and abandonment of the rural provinces for the greater part of the post-war period (Petrakos, 2004). In addition, new factors that exhibit an important effect on this type of Metropolitan concentration are those associated with the increasing globalization of economic activities and the integration of the European market, and the structural changes taking place in the production and economic cycles (Petrakos and Tsoukalas, 2004). A direct consequence is the unequal allocation of infrastructure, services and development opportunities (see, e.g., Polyzos, 2011). Another feature of the Regional problem in Greece is the depopulation of the rural Regions and the lack of medium-sized urban centers. Since the early 60's a large number of small and medium-sized cities have observed negative changes in their population.

3. The operational program of Eastern Macedonia and Thrace 2007 2013

The Regional Program of Eastern Macedonia and Thrace is part of the broader operational program of Macedonia and Thrace, which was approved by the "No. E (2007) 5337 26 10 2007 2007 CCI GR 161 PO 008" decision of the European Commission. The geographic area of implementation of the operational program of Macedonia-Thrace 2007-2013, includes three regions: "Western Macedonia", "Central Macedonia" and "East Macedonia and Thrace". The East Macedonia, and Thrace Region, presents greater developmental deficit so the strategy of operational programme focuses on options that will ensure high growth rate of the GDP to achieve convergence. The developmental vision of Eastern Macedonia and Thrace is divided in three specific objectives:

- Strengthening the competitiveness of the production system by utilizing the multiple possibilities offered by the transition to a knowledge-based economy.

- Utilization of its position in Southeast Europe and the Balkans in particular, as well as the proximity to the emerging markets of the Black Sea and the Eastern Mediterranean.

- The balanced economic and social development in the context of sustainability, with the aim of reducing inequality and greater participation in development results. (Special Management Service of Operational programme Region East Macedonia and Thrace, R.E.M. & T. 2008).

To achieve the strategic goal for the Region of Eastern Macedonia and Thrace three general development objectives have been proposed (Figure 1):

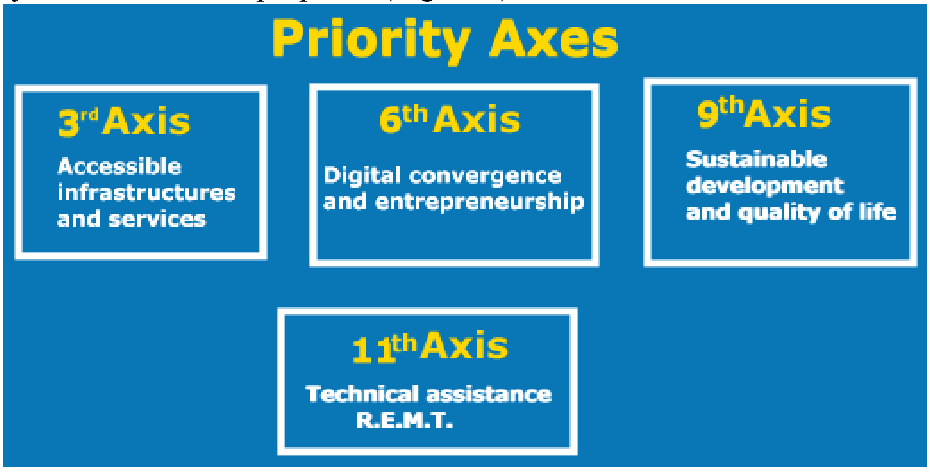

Figure 1: priority axes of the operational programme

Source: https://www.eydamth.gr/oldsite/2014-02-12-16-43-46/2014-02-12-16-44-08.html)

This paper focuses on priority axis 3: "infrastructure and service accessibility in REMT". The axis includes interventions in the region's road network to improve access to developed and developing sites of economic activities (industrial and ports) and in mountainous and remote areas. It also aimed to develop port infrastructure foremost in the cities of Alexandroupoli and Kavala and the completion of the railway network and its connection to sites of economic interest (i.e. the industrial areas and ports).

Finally, it indented to additionally complement the construction of the core national road network crossing the region, in parallel with the enhancement of the geographical growth of the region, transport routes and the upgrade and modernization of border stations. The former constitutes an important component for the specific region since they ensure the prospect of exploiting the country's northeastern land border, increased geopolitical importance in the context of EU enlargement to the East Balkans.

As planned, the total amount of public expenditure for the 3rd Axis amounts to 301.7 million Euro and the principal interventions relate to:

• Improvement/completion of National and Provincial Road Network and accessibility in mountainous and remote areas.

• Completion of sections of the Egnatia highway and connection with ports and airports.

• Strengthening of port infrastructure and their connection with the transport networks.

• Improvement/completion of the railway network and link to sites of economic interest (industrial area and harbors).

• Improvement/construction of new border stations.

The public expenditure for the co-financed Priority axis 3 is €166,574,500. Table 1 shows aggregate, stats from the implementation of the priority axis 3, per C.T.P.:

Table 1: Implementation of the priority axis 3, per Code Thematic Priority (C.T.P.)

THEMATIC PRIORITY	**NUMBER OF WORKS**	**INTEGRATION (€)**	**LEGAL COMMITMENTS (€)**	**EXPENDITURE (€)**
C.T.P. (16):Railways	2	15.542.818	15.542.818	14.891.105
C.T.P. (21): Highways (Trans European Transport Networks TEN-T)	2	45.849.633	45.849.633	36.026.947
C.T.P. (22): National roads	5	29.899.574	29.899.574	28.688.900
C.T.P. (23): Regional/local roads	60	80.558.033	80.558.033	79.473.575
C.T.P. (30): Ports	4	24.560.748	24.560.748	23.100.212
TOTAL (Axis Priority 3)	**73**	**196.410.808**	**196.410.808**	**182.180.740**

Source: http://www.makedonia-thrace.gr/el/Pages/NewsFS.aspx?item=125

4. Methods and data

4.1 Data collection - Data collection process

The sources of data used for the realization of this research consists mainly in data acquired from public services of the Region of Eastern Thrace, and in particular:

(a) The files of Directorates for technical works of Regional Units (R.U.) of Evros; Rodopi; Xanthi; Kavala and Drama.
(b) The files of Intermediate Managing Authority (IMA) of Operational programme of Eastern Macedonia - Thrace 2007-2013 R.E.M.& T.
(c) The files of Directorate of Planning and Development Region East Macedonia and Thrace.
(d) The Transparency Program.
(e) Central Electronic Public Procurement Registry (National Electronic Public Procurement System -NEPPS).

4.2 Area of research

The Region of Eastern Macedonia and Thrace occupies the northeastern extreme part of the country, bordering to the East by Turkey, Bulgaria to the North and West with the Region of Central Macedonia, while its southwest and southeast borders are the Aegean Sea and the Thracian sea, respectively. The total area of the region amounts to 14,157 square kilometers, which corresponds to 10.7% of the total area of the country. The permanent population of the region, according to the provisional results of the 2011 Census, stands at 608,182 inhabitants, thus covering the 5.62% of the total population of the country (Greek Statistical Authority ELSTAT, 2018). The population and spatial distribution by Regional Unit (R.U.) is described in the following table (Table 2).

Table 2: Area and population Region per Regional Unit and Municipality

REGIONAL UNIT / MUNICIPALITY	AREA (km^2)	% THE AREA IN THE WHOLE REGION R.E.M.& T.	POPULATION	% POPULATION IN THE WHOLE REGION R.E.M.& T.
R.U. EVROU	4.242	29.96%	147.947	24.33%
R.U. RODOPIS	2.543	17.96%	112.039	18.42%
R.U. XANTHI	1.793	12.67%	111.222	18.29%
R.U.KAVALA	2.111	14.91%	138.687	22.80%
R.U. DRAMA	3.468	24.50%	98.540	16.16%
TOTAL R.E.M.& T.	**14.157**	**100.00%**	**608.182**	**100.00%**

Source: Greek Statistical Authority (ELSTAT).

From the collected information acquired by the "Directorate for technical works" of each RU, it is found that the National road network of the region of Eastern Macedonia and Thrace, amounts to a length of 1,054.00 kilometers in total, while the Provincial road network is reaching the 2,252.80 kilometers i.e. approximately twice the size of the national road network. The allocation relating to the length of the provincial and the national road network, per RU, is given in Table 3.

Table 3: Length of provincial and national road network per Regional Unit

REGIONAL UNIT	PROVINCIAL ROAD NETWORK (Km.)	% PROVINCIAL ROAD NETWORK IN THE WHOLE REGION R.E.M.& T.	NATIONAL ROAD NETWORK (Km.)	% NATIONAL ROAD NETWORK IN THE WHOLE REGION R.E.M.& T.
EVROS	571,00	25,35%	366,00	34.72%
RODOPI	724,00	32,14%	73,00	6.93%
XANTHI	243,80	10,82%	144,00	13.66%
KAVALA	453,00	20,11%	226,00	21.44%
DRAMA	261,00	11,59%	245,00	23.24%
TOTAL R.E.M.& T.	**2.252,80**	**100,00%**	**1.054,00**	**100.00%**

According to data gathered from the Greek Statistical Authority (EL.STAT.) related to the gross domestic product (GDP), in the following table (table 4) the recorded GDP per RU is presented (calculated as a percentage of per capita GDP of the whole of the region), based on the data of year 2015:

Table 4: Gross domestic product of Regional Units of R.E.M.& T.

REGIONAL UNIT	GDP 2015 (EUR MIL.)	% IN THE WHOLE REGION R.E.M.& T.
EVROS	1,785	26.41%
RODOPI	1,070	15.82%
XANTHI	1,073	15.87%
KAVALA	1,798	26.60%
DRAMA	1,034	15.30%
TOTAL R.E.M.& T.	**6,760**	**100.00%**

In the Region of Eastern Macedonia and Thrace, within the framework of the operational programme of Eastern Macedonia and Thrace 2007-2013, a total of 87 road projects were integrated and financed, with a total public expenditure that amounts to €177,198,138.98.

4.3. Analysis

The outcomes of the current work are of particular interest as they show at a large degree the effect of road transport operations, the Regional operational programme of the Region of R.E.M. & T.2007-2013 on the development of the region. Further, examination of interactions between the program expenditures with other important factors such as the contractual public expenditure of road projects that were executed, the area covered, the length of the road network improved, the type of roads (National, Provincial or Municipal), the population and the gross domestic product (GDP) reveals important information. To export results, the IBM SPSS programme 21 (Released IBM Corp., 2012) has been utilized. For the visual representation of obtained results, scatter diagrams as well as the coefficient of linear correlation which gives us the size of linear correlation of two variables, have been used.

For drawing conclusions about the magnitude of the correlation of two variables then it is necessary to obtain a measure of their association. A simple way to get an initial idea of whether and how two variables correlate to each other, is to construct the scatter diagram. The relationship between the two variables is more powerful the closer to the ideal regression line are the points of the scatter diagram. One way to determine the relationship of the points of a diagram and dynamics of their correlation is the linear correlation coefficient. The correlation coefficient referred to as the Pearson's correlation coefficient, is defined on the basis of a sample of n pairs of observations (x_i , x_i) i = 1,2, ..., n, represented by r (X, Y) or simply by r. Pearson's r-correlation coefficient takes values from -1 to 1. As r approaches the value 1 (or -1), the stronger is the positive (negative) correlation between the two variables.

5. Empirical results

5.1 Correlation of Public Expenditure and Regional Units

The Regional Units that compose the research are: the R.U. of Evros, R.U. of Rodopi, R.U. of Xanthi, R.U. of Kavala and R.U. of Drama. The allocation of numbers of projects per R.U., for the total of eighty-seven projects are the following (See Figure 2):
R.U. Evros: 17 (19.54%) - R.U. Rodopi: 16 (18.39%) - R.U. Xanthi: 14 (16.09%) - R.U. Kavala: 21 (24.14%) - R.U. Drama: 19 (21.84%).

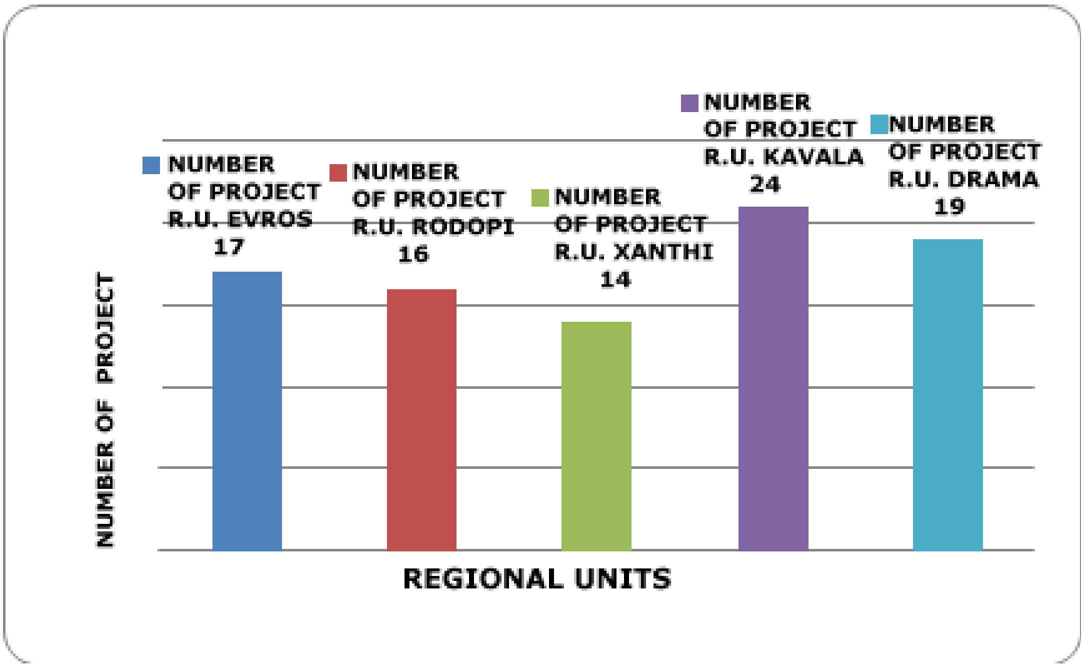

Figure 2: Number of projects per Regional Units

The total sum of contractual public expenditure of projects per RU is shown in the following Figure (Figure 3).

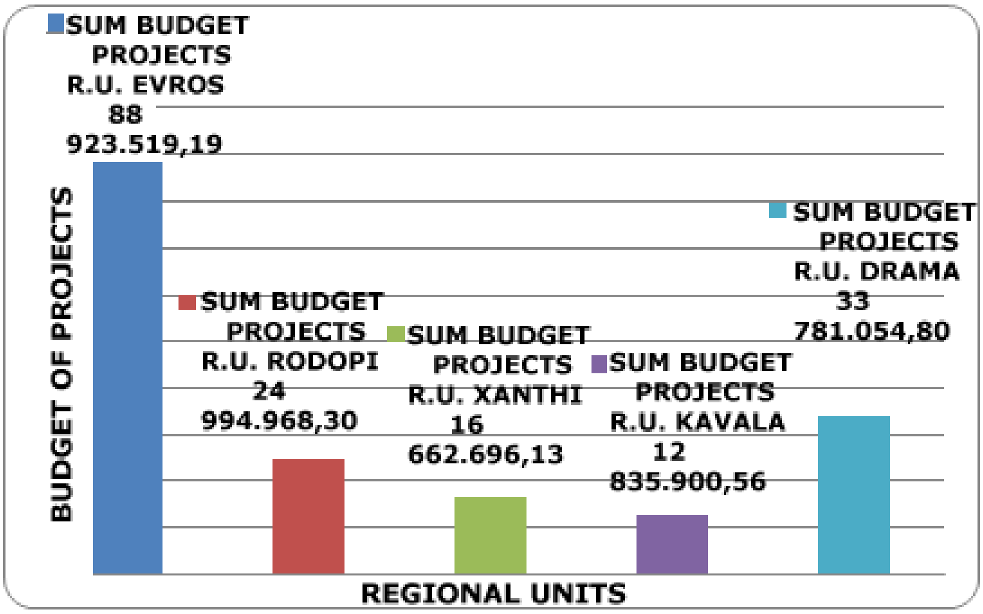

Figure 3: Project budgets per Regional Units

As one observes, despite the fact that the R.U. Evros and the R.U. Rodopi, have approximately the same number of projects (17 and 16, respectively), however the total budget of the roadwork for the R.U. Evros is nearly quadruple. Regarding the total budgets of projects, it is seen that in the 1st place is the R.U. of Evros, 2nd the R.U. of Drama, 3rd the R.U. of Rodopi, 4th the R.U. of Xanthi and 5th the R.U. of Kavala. Next, at the contractual expenditure level of all projects (being executed on every R.U. from all final beneficiaries from the region and the municipalities), it is noted that the amounts were allocated proportionally according to the size of the prefectures in terms of covered area. Thus, it is natural to expect a positive correlation between the public expenditure of projects and total covered area.

5.2 Correlation of Public Expenditure on Projects and Area of Municipalities

The 87 roadworks carried out in the Regional operational programme of Eastern Macedonia and Thrace spatially correspond to a total of 21 municipalities (Regional Units) (see Table A1 in the Appendix).

5.2.1 Correlation of total contractual public Expenditure projects per Municipality and area of the Municipality

The 87 road projects in our sample were allocated spatially in 21 Municipalities in the Region of R.E.M. & T. In table A1 of the Appendix the total of contractual public expenditure of projects executed per Municipality are reflected. In this sub-section, the two examined variables is the sum of the total contractual public expenditure of projects executed in each Municipality and the corresponding area of the Municipality. In the diagram below the horizontal axis shows the size of the Municipality and the vertical axis the amount of total public expenditure projects per Municipality.

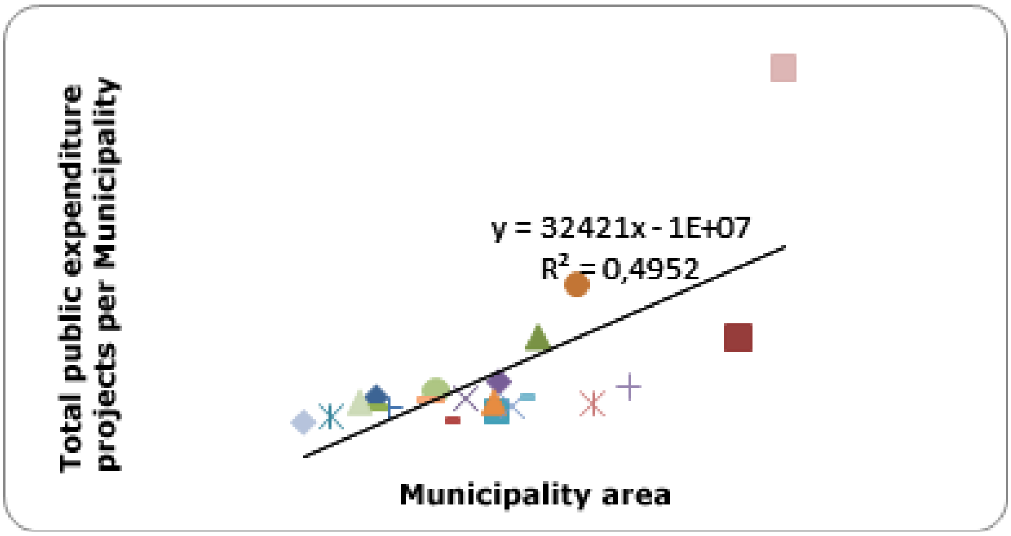

Figure 4: Amount of total contract public expenditure of projects per Municipality -area Municipality

By observing the scatter diagram it appears that there is a proportional relationship between the amount of the total public expenditure of projects per Municipality and the Municipality area. The Pearson's correlation coefficient, r, has a value of 0.704 (p-value< 0.001), so we have a positive correlation between the two variables, statistically significant at the 1% significance level.

5.2.2 Correlation of total contractual public expenditure projects and area levels of Municipalities (range 200 Km^2)

The following table 5 reflects all of the contractual public expenditure per municipal area classes (ranges: 200 km^2) as follows:

Table 5: Total contractual public expenditure per classes of Municipality area

AREA CLASSES (km^2)	NUMBER OF PROJECTS	CONTRACTUAL PUBLIC EXPENDITURE (€)
1st: 0-200	1	125.104,00
2nd: 201-400	12	14.593.069,15
3rd: 401-600	13	14.404.172,86
4 th: 601-800	34	35.867.255,39
5 th: 801-1000	18	34.321.770,04
6th: 1001 and up	9	77.886.767,54

A graphical representation of the table above is shown in Figure 5. By observing Figure 5, we can highlight the relatively good proportionality of contractual public expenditure from class to class. The two variables that are studied using Pearson coefficient, is the amount of public expenditure of the projects and classes of area of municipalities.

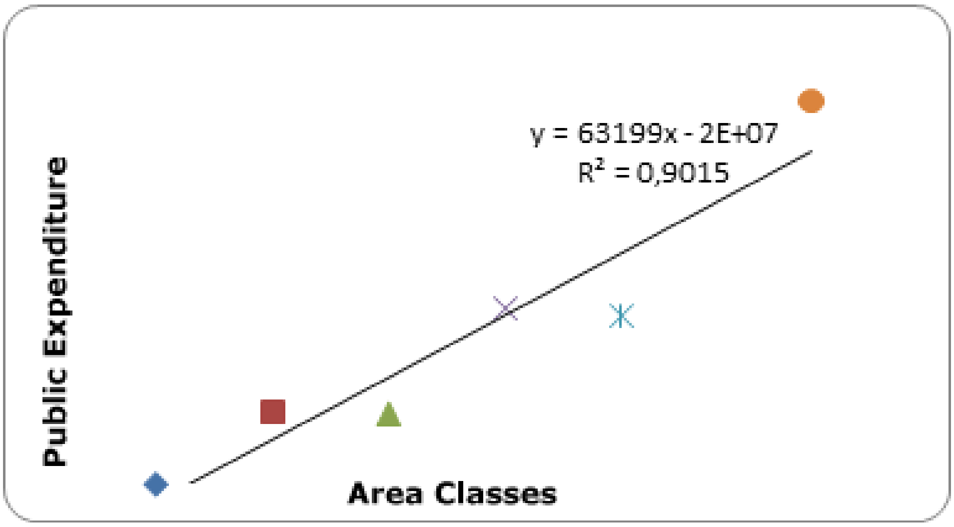

Figure 5: Total contract public expenditure of projects -area classes of Municipalities

From the scatter diagram it appears that there is a proportional correlation between the amount of the total public expenditure and the municipalities that are within a specific range limits of 200 km^2. The correlation coefficient has a value of 0.949 (p-value = 0.004<0.01) so we have very strong positive correlation between the two variables, statistically significant at the 1% significance level.

5.3 Correlation of public expenditure and road network length improved

5.3.1 Correlation of contractual public expenditure projects per Municipality and length of road network improved per Municipality

In table A2 in the appendix we present the total contractual public expenditure of roadwork per Municipality and the total (per Municipality), kilometers of roads that improved with their implementation, in alphabetical order of the name of the Municipality. In the diagram below (Figure 6) the horizontal axis shows the area of the Municipality and the vertical axis the amount of total public expenditure projects per Municipality.

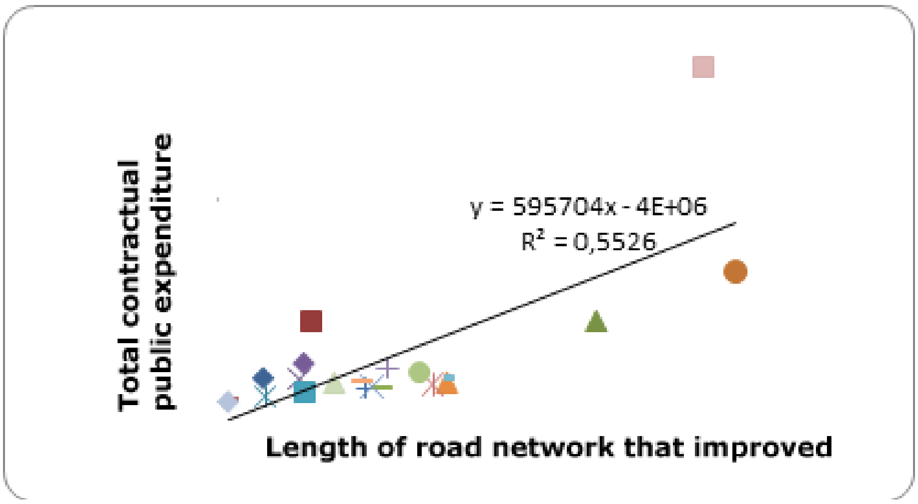

Figure 6: Contractual public expenditure projects - length of road network that improved with their implementation

The correlation coefficient r has a value of 0.743 (p value < 0.001), so we have a strong linear correlation between the two variables, statistically significant at a 1% significance level. Hence, it is found that there is a considerably strong correlation between the amount of contractual public expenditure between all roadwork of National Strategic Reference Framework (NSRF) 2007-2013 Eastern Macedonia and Thrace 2007 2013 executed in 21 municipalities and the total kilometers of roads that were improved in these municipalities.

5.3.2 Correlation of contractual public expenditure projects and municipal road network length that improved

In the diagram below (Figure 7) the horizontal axis shows the length of municipal roads improved and the vertical axis the amount of contractual public expenditure projects.

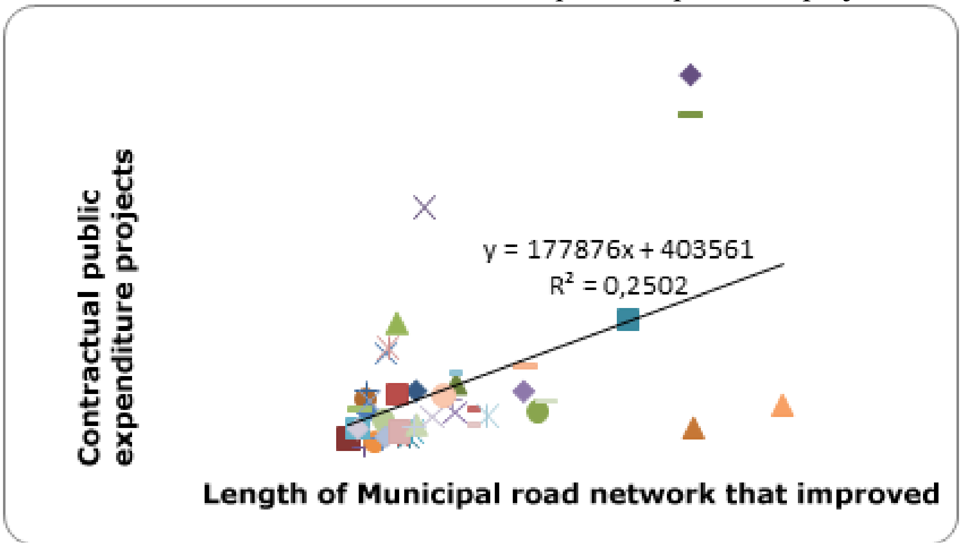

Figure 7: Contractual public project expenditure and length of a municipal road network that improved with their implementation

From the scatter diagram it appears that there is a proportionate relationship between the amount of conventional public expenditure on projects and the length of the municipal road network that is improving. The correlation coefficient r has a value of 0.5 (p-value < 0.001), indicating that a statistically significant correlation between the two variables exists.

5.3.3 Correlation of contractual public expenditure projects and provincial road network length improved

The two variables examined is the amount of contractual public expenditure of 33 projects and the length of the provincial road network that improves with their implementation. The aim is to identify a potential association between the two variables.

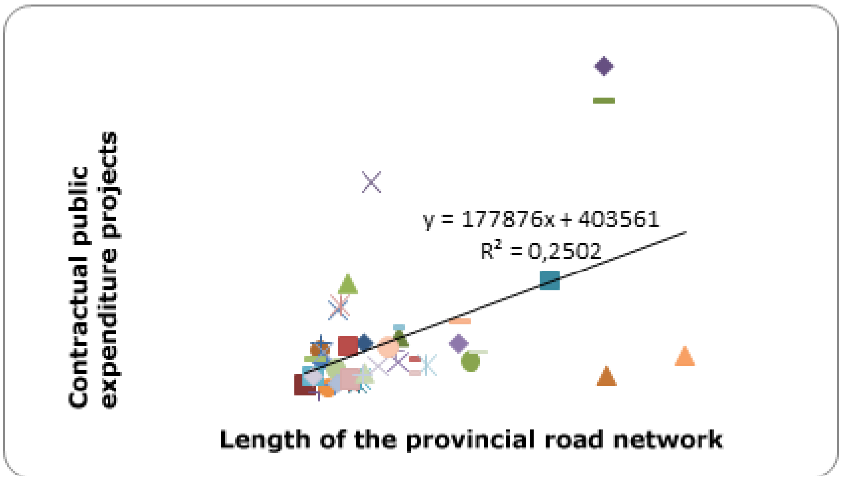

Figure 8: Contractual public project expenditure and length of a provincial road network that improved with their implementation

The correlation coefficient r is 0.708 (p-value < 0.001) which shows that we have a considerably strong correlation between the two variables. Hence, we have found that there is a strong and positive interaction between contractual public expenditure of the 33 projects relating to provincial road network and the corresponding length in kilometers of provincial roads that were improved.

5.3.4 Correlation of contractual public expenditure projects and a length of national road network that improved

From our sample, 8 projects are concerned with interventions to improve the national road network of the region. The two variables that this time will be studied are the amount of contractual public expenditure for the eight projects and the length of the national road network that improves with their execution.

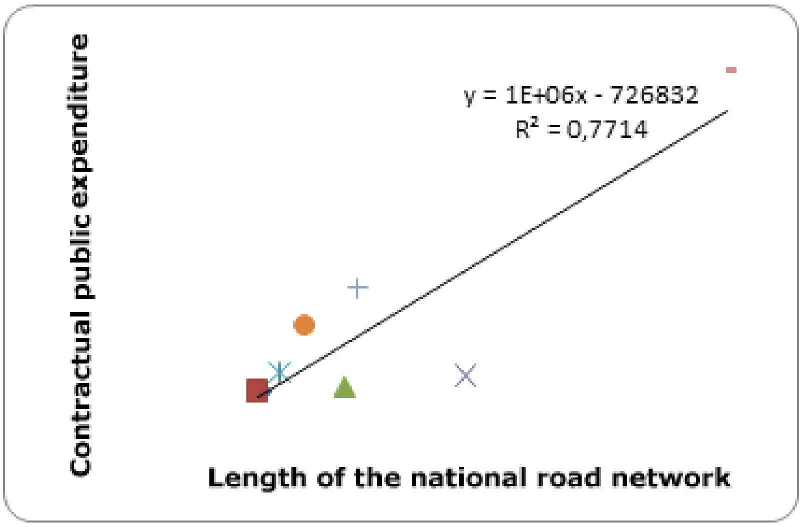

Figure 9: Contractual public project expenditure and length of a national road network that improved with their implementation

From the above scatter diagram (Figure 9) it appears that there is a proportional correlation between the amount of contractual public project expenditure and the length of the national road network that improved. The correlation coefficient r is 0.878 (p - value = 0.004 < 0.01) so we have very strong positive correlation between the two variables.

5.4 Correlation of public expenditure projects per Municipality and Population of the Municipality

In this section we examine the interaction of the two variables of contractual public expenditure of roadwork per Municipality, with the population of the Municipality (see Figure 10).

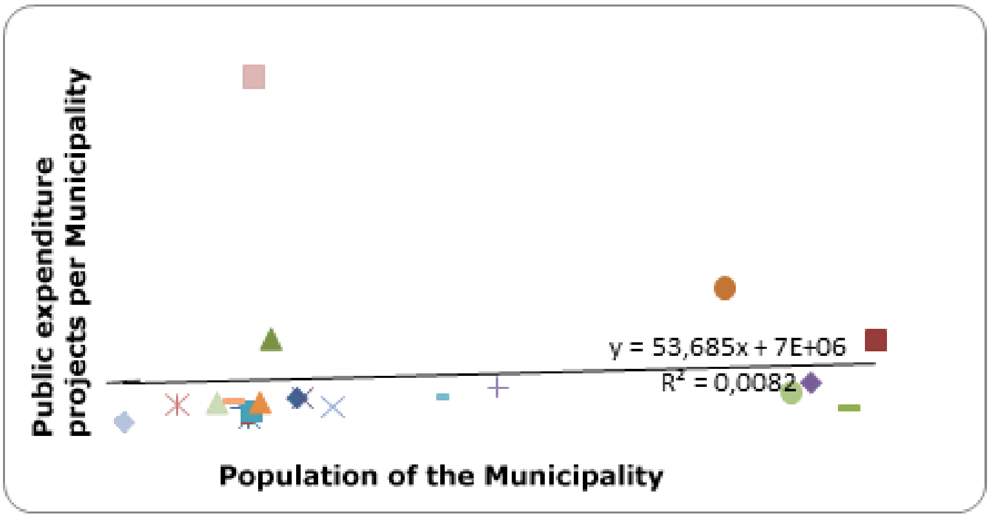

Figure 10: Contractual public project expenditure per Municipality and population of the Municipality

The correlation coefficient r for the association between the two variables is 0.090 (p- value = 0.697>0.05) so we have almost zero correlation between the two variables of contractual public project expenditure per Municipality and the Municipality population.

5.5 Correlation of public expenditure and gross domestic product (G.D.P.)

The two variables to be examined here, is the total contractual public expenditure of roadwork projects and the gross domestic product of each R.U. in Eastern Macedonia and Thrace. Table 6 below presents the total public expenditure of projects per R.U.:

Table 6: Total contractual public expenditure and G.D.P. per R.U.

REGIONAL UNIT	CONTRACTUAL PUBLIC EXPENDITURE (EUR MIL.)	G.D.P. PER REGIONAL UNIT R.U. (EUR MIL. 2015)
EVROS	88,92	1.785
RODOPI	24,99	1.070
XANTHI	16,66	1.073
KAVALA	12,84	1.798
DRAMA	33,78	1.310

In the diagram shown below (Figure 11), the horizontal axis represents the gross domestic product of each Regional Unit and the vertical axis the total amount of public contractual expenditure of projects per R.U.

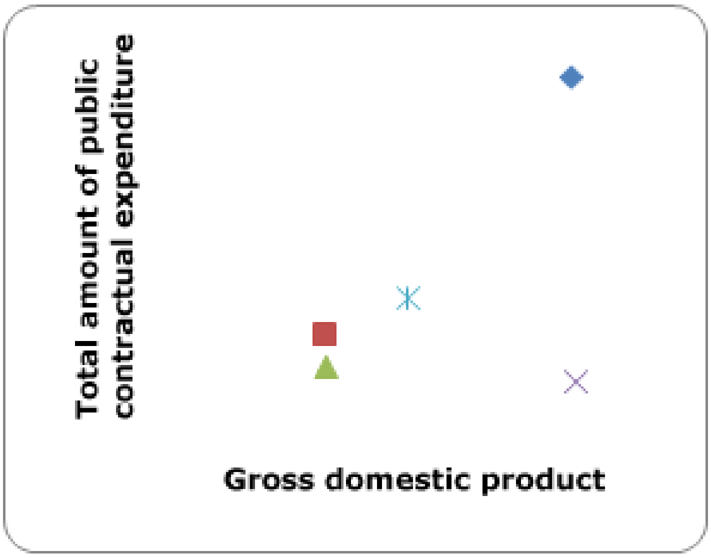

Figure 11: Contractual public project expenditure per RU and G.D.P. per R.U.

The correlation coefficient between the two variables is r = 0.473 (p - value = 0.421>0.05), and demonstrates that the association between "gross domestic product" and public expenditure is not statistically significant.

6. Conclusions

The aim of this work was to examine how and in which areas the activities of road transport of the NSRF 2007 2013 contributed to the development of a Greek region, specifically the Region of Eastern Macedonia and Thrace. The latter program implemented a total of 87 road projects with a total expenditure of €177,198,138.98. At the level of total public expenditure of roadwork program, 70% of this percentage corresponds to the Prefectures of Evros and Drama, with the public expenditure that corresponds to the Evros prefecture to amount to 50% of that budget. These two Prefectures geographically occupy the two ends (extreme parts) of the Region of Eastern Macedonia and Thrace, and the high financial contribution of contractual public expenditure of roadwork on these two regions, aimed to assist in their integration within the wider economic area of the region.

Of the main conclusions of the study is that the contractual public expenditure of the 87 projects, is in direct correlation with the area of the municipalities, and with the length of the road network improved, whereas no correlation with the population of municipalities and with the GDP of each regional Unit is detected. Therefore, the size of the area of each Municipality suggests the size of the road network constructed or improved. Hence, the largest the area of the Municipality, the greater need exists for improvement and modernization of road of infrastructure in this Region. It is characteristic that the largest Municipality of Soufli (1.326,00 km^2) absorbs up to 35% of the total rate of contractual public expenditure, while the smallest area of Municipality of Samothraki presents the less contractual public expenditure.

The length of the road network improved by the execution of 87 roadwork projects, also is in direct correlation with the public expenditure. In particular, 425.28km of road network have been improved. Of the above kilometers the 161,70km relate to improving the municipal road network, the 186.67km refer to provincial road network and the 76.76km to National road network, with the contractual public expenditure be calculated at a percentage of 27% for municipal roads, 30% for the Provincial roads and 43% for the National roads network.

The correlation between and the length of municipal roads, provincial roads and length of national road network and public contractual expenditure has been found to be positive and significant. Therefore, there is positive interaction between the contractual public expenditure and the factors of the length of Municipal Roads improved, the length of the provincial road network improved. Also, we have found a particularly strong positive interaction between expenditure and the length of the national road network being improved. Hence, it is found that emphasis has been attributed towards improving the national road network of the region.

With regard to contractual public expenditure and population, the 87 road projects of the programme, are not correlated with the population of the 21 municipalities within which were executed. This is an anticipated finding, since the allocation of projects is influenced by other factors such as urbanity or the mountainous landscape of the municipalities.

As a general conclusion based on the results of the current research, it is suggested that emphasis should be given on strengthening of road projects to enhance the attractiveness of the region, the regional and social cohesion, entrepreneurship and innovation. In this direction, the simplification of the institutional framework for the integration of road works may significantly assist. Strengthening of road projects may also contribute to further training in the institutional framework for the implementation of operations. The difficulties caused by lack of qualified personnel, the incomplete training of managers responsible for the projects' implementation, and lack of implementation experience observed for the already conducted co-financed operations, demonstrate the lack of familiarity of executives involved with the management and implementation of the NSRF program.

Among the basic interventions required is to strengthen the knowledge and skills of the human resources of the beneficiaries, in order to meet the structural and institutional changes, with emphasis based on the training of middle and senior officials. Emphasis should also be given to the revision of the program depending on the actual needs of the region and not only the absorption of funds. Greater emphasis needs to be placed on the transfer of resources towards transport infrastructure projects that can enhance regional attractiveness, social cohesion, entrepreneurship and innovation, especially under the current changes occurring nowadays in the economic environment. Finally, the modernization of the public sector by improving the structures of services and restriction of central bureaucratic procedures as well as the cooperation of local authorities – regions and ministries for better knowledge of local problems and specificities should contribute to strengthening of road works and the development of remote areas.

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APPENDIX

Table A1: Total amount of contractual public expenditure of roadwork projects per Municipality -area of Municipality

MUNICIPALITY	TOTAL AMOUNT OF CONTRACTUAL PUBLIC EXPENDITURE (€)	MUNICIPALITY AREA (KM^2)
AVDIRA	4.544.254,65	352,00
ALEXANDROUPOLI	15.112.468,47	1.217,00
ARIANNA	15.274.615,90	738,65
DIDYMOTECHO	4.461.463,67	565,40
DOXATO	1.073.872,40	244,10
DRAMAS	24.462.010,58	833,01
THASSOS	2.599.571,50	383,00
IASMOS	379.713,82	519,34
KAVALA	2.698.203,83	350,61
KOMOTINI	7.316.025,70	644,90
MARONIA SAPES	2.024.612,88	640,11
MYKIS	3.713.875,68	633,30
NESTOY	2.963.800,41	678,90
K.NEVROKOPI	3.409.575,48	870,00
XANTHI	5.577.991,12	495,10
ORESTIADA	6.450.183,98	955,60
PAGGAIO.	4.574.324,82	698,01
PROSOTSANIS	3.985.004,25	482,77
SAMOTHRAKI	125.104,00	178,00
SOUFLI	62.774.299,07	1.326,00
TOPEIRO	3.677.166,77	312,49

Table A2: Contractual public expenditure projects per Municipality and total length of road network improved

MUNICIPALITY	TOTAL CONTRACTUAL PUBLIC EXPENDITURE (€)	TOTAL LENGTH OF ROAD NETWORK IMPROVED (km)
AVDIRA	4.544.254,65	4,63
ALEXANDROUPOLI	15.112.468,47	10,66
ARIANNA	15.274.615,90	45,67
DIDYMOTECHO	4.461.463,67	9,13
DOXATO	1.073.872,40	4,90
DRAMAS	24.462.010,58	62,88
THASSOS	2.599.571,50	17,36
IASMOS	379.713,82	0,30
KAVALA	2.698.203,83	19,25
KOMOTINI	7.316.025,70	9,62
MARONIA SAPES	2.024.612,88	9,73
MYKIS	3.713.875,68	27,28
NESTOY	2.963.800,41	18,10
K.NEVROKOPI	3.409.575,48	25,53
XANTHI	5.577.991,12	23,98
ORESTIADA	6.450.183,98	19,98
PAGGAIO.	4.574.324,82	26,95
PROSOTSANIS	3.985.004,25	16,76
SAMOTHRAKI	125.104,00	0,30
SOUFLI	62.774.299,07	58,88
TOPEIRO	3.677.166,77	13,39

Investigation of bicyclists' riding behaviour under normal traffic conditions in the road network of a mid-sized Greek city

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Abstract
This study examines the bicyclists' riding behavior under normal traffic conditions in the urban road network of Volos which is a mid-sized Greek city. In order to conduct this study, a new methodology was developed based on the use of GPS technology embedded in instrumented vehicles for the acquisition of behavioral and performance data parameters such as speed, position and lateral/longitudinal accelerations. All these parameters are crucial for 2-wheeler road users compared to the 4-wheeler ones. Although extensive literature review refers to naturalistic driving studies, no relevant research of naturalistic riding studies for bicyclists has been conducted so far. This study proposes a practical, low cost and time effective process to evaluate the perception of traffic conditions under the bicyclist's point of view. This study concludes that it is feasible to record bicyclists' speed and acceleration profiles with accuracy and speed. Moreover, supports that there is a strong indication that bicycle is a rather controllable and predictable transport mode. However, in order to generalize the conclusions drawn in a wider proportion of road users, more experiments including a greater number of participants and road sections should be conducted.

Keywords: Bicycle; rider behavior; road safety; speed; acceleration; naturalistic study.

JEL Classification: O18; O33; R41.

Διερεύνηση της οδηγικής συμπεριφοράς ποδηλατών σε κανονικές συνθήκες κυκλοφορίας στο οδικό δίκτυο μεσαίου μεγέθους Ελληνικής πόλης

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Περίληψη

Η παρούσα εργασία διερευνά την οδηγική συμπεριφορά των ποδηλατών που κινούνται υπό κανονικές συνθήκες κυκλοφορίας στο αστικό οδικό δίκτυο της πόλης του Βόλου. Συγκεκριμένα, αναπτύχθηκε μια νέα μεθοδολογία που στηρίζεται στην τεχνολογία συσκευών GPS τοποθετημένων επί των ποδηλάτων, με σκοπό την απόκτηση σε πραγματικό χρόνο και υπό τις κρατούσες σε κάθε διαδρομή κυκλοφοριακές συνθήκες, δεδομένων συμπεριφοράς και απόδοσης των ποδηλατών, όπως είναι τα εξής: ταχύτητα, θέση και πλευρική/διαμήκης επιτάχυνση. Αυτές οι παράμετροι είναι χρήσιμοι για τη σύγκριση της κίνησης οχημάτων δυο και τεσσάρων τροχών. Αν και η διατιθέμενη διεθνής και ελληνική βιβλιογραφία εξετάζει εκτενώς την κίνηση μηχανοκίνητων οχημάτων, εντούτοις διαπιστώνεται μια σημαντική επιστημονική υστέρηση σε ό,τι αφορά τη μελέτη της συμπεριφοράς των ποδηλατών. Η παρούσα εργασία προτείνει μια πρακτική, χαμηλού κόστους και χρονικά αποδοτική διαδικασία για την καταγραφή και αξιολόγηση της αντίληψης των κρατουσών συνθηκών οδικής κυκλοφορίας από τους ποδηλάτες. Στην εργασία τεκμηριώνεται η άποψη ότι είναι εφικτό να καταγραφούν με ασφάλεια και ρεαλισμό οι παράμετροι κίνησης των ποδηλατών, ενώ διαπιστώνονται ισχυρές ενδείξεις ότι το ποδήλατο είναι ένα αρκετά ελέγξιμο και προβλέψιμο ως προς την κίνησή του μέσο μετακίνησης. Η γενίκευση των συμπερασμάτων απαιτεί τη διενέργεια επιπρόσθετων πειραμάτων με τη συμμετοχή μεγαλύτερου αριθμού ποδηλατών σε μεγαλύτερο πλήθος οδικών τμημάτων.

Λέξεις Κλειδιά: Ποδήλατο; συμπεριφορά αναβάτη, οδική ασφάλεια; ταχύτητα; επιτάχυνση; φυσιοκρατική μελέτη.

JEL Κωδικοί: O18; O33; R41.

1. Introduction

Bicycle is a sustainable transport mode but bicyclists are considered vulnerable road users due to their higher risk for their road safety. The safer and more convenient is the built environment for bicyclists more citizens will prefer to bike than using other transport modes mainly for short and medium distance urban trips. The bicycle built environment is not the same either for cities in the same country or for districts of an urban agglomeration. There are many differences related with economic, societal and geographical factors. The road environment differs between the central business district and neighborhoods of an urban area. A commuter should be able to ride his bike in order to reach his destination with safety and convenience in the entire urban area. Municipality officials should improve the bikeability level of their city if they want to promote bicycle use and sustainable transportation.

In order to promote bicycling, researchers worldwide have focused on route quality issues, such as traffic conditions, signalization, bicycle and vehicle lane design, curb and surface conditions, slope, weather, lighting, safety, accessibility to specific land uses, and also environmental factors associated with bicycling (Landis et al., 2001; Moritz, 1998). Furthermore, naturalistic driving studies have examined the driving behaviour of motorists (Laporte, 2010).

A number of instruments have been developed to identify the bikeability level of the urban road environment. Many of them provide measures of levels of service or similar indices, assessing the bicyclists' safety level based on route-related variables. Some methodologies examined the bicycling level of service on road segments in order to provide an index of how well urban and rural roads accommodate bicycle travel (Jensen, 2008). The validity and reliability of these instruments is not completely examined (Moudon and Lee, 2003). A limited number of studies examined environmental characteristics that are related with bikeability, like levels of stress, comfort and satisfaction (Landis et al., 1997). The most important barriers to bicycling include the insufficient or unsafe bicycling infrastructure, shortage of bicycling amenities, motorists' traffic flow and speed,

and undesirable land use conditions (Goldsmith, 1993; Litman, 2000; Eliou et al., 2009; Galanis and Eliou, 2014; Galanis et al., 2014).
The present study examines the bicyclists' riding behavior under normal traffic conditions in the road network in the city of Volos which is a mid-sized Greek city. For the successful implementation of the study, a new methodology was developed based on the use of GPS technology embedded in instrumented vehicles for the acquisition of behavioral and performance data parameters such as speed, position and lateral/longitudinal accelerations. All these parameters are more crucial for 2-wheeler road users compared to the 4-wheeler ones. This study proposes a practical, low cost and time effective process to evaluate the perception of traffic conditions under the bicyclist's point of view.

2. Methodology and Data Collection

2.1 Participants

The rider who performed the experiment had to be an experienced one, with low center of mass and enhanced sport adult profile. That was due to the additional load that he/she should stand (the equipment weights approximately 7 kg). The candidates were tested and their performances were compared to other typical riders in order to choose the one whose behavior was more similar to the typical rider as possible. For the same reason the gender of the participant was chosen to be male whilst in order to mitigate the accident risk during the implementation of the experiments, the candidate had to be no older than 50 years old, and in good physical condition, although it was unclear the correlation between age and accident risks.
Moreover the candidates should have blank accident record and they should consent to be equipped with the appropriate safety gear such as reflective vest and helmet. Another important issue was the successful operation of the data logging equipment and hence, the candidates should be familiar with its handling. That was achieved with a training process using the manuals of the equipment. Taking into account the above-mentioned, a male bicycle rider was chosen without impaired riding ability and place of residence close to the experiment routes.

2.2 Bicycle and Equipment

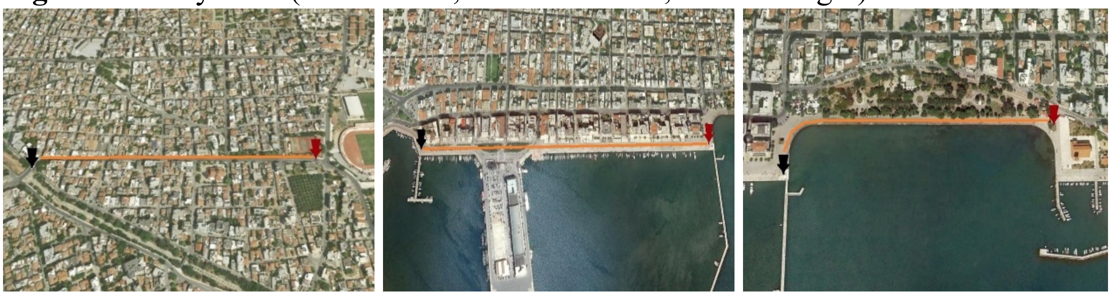
The common practice of obtaining driving performance data is the use of a radar gun as well as speed detectors. However many authors expressed the opinion that these recording equipment introduce either measuring errors or can affect road users' behavior who might perceive that equipment and consequently, adjust their speed and lateral position to the legal ones. In order to overcome these considerations, there is a new approach to record riding parameters, based on GPS technology.
Data loggers based on GPS technology are able to capture simultaneously video and vehicle data. Proper modifications to the instrumented 2-wheeler vehicle make their use ideal for motorsport experiments due to their small weight, size and increased accuracy. Thus, it is more feasible to measure speed, track position, distance, lap time, lateral acceleration, longitudinal acceleration and height. It has to be noted that the exploitation of such parameters can be very useful especially in circumstances where riding behavior is not approached exclusively in speed terms but also in terms of acceleration to the three dimensions. Apparently such approach is particularly crucial in 2-wheeled vehicles. In order to conduct the experiment we used equipment of the company Race Technology and specifically the Video4, DL1 and Speedbox devices (Race Technology website).
For this study, we selected a bike type which is appropriate to travel in the urban road network. The selection process was based on the fundamental idea of the naturalistic cycling studies which is to simulate the conditions of the experiment to be as close as possible to the typical transport standards for utilitarian trips. The first step was to select the type between a mountain or city bike, based on the most popular trends nowadays. Ultimately, a combination between those two options was

achieved with a bike equipped with 28-inch wheels and a suspension, providing a smoother riding. The use of a suspension was necessary, due to the maintenance level of the road pavements. The price range of the bike was based on the average amount of money that a Greek commuter could afford. There is no official data for this index therefore we had to make a hypothesis based on the average bike types presented in the city. The aluminum frame constitutes a popular option for city bicycles, because of its low weight, which is crucial as the steel frame and the measuring equipment significantly increase the total weight. This could lead to an inaccurate cycling profile because of distorted measurements. The hydraulic brakes used in this specific bicycle, provide sharp and accurate breaking, a common feature of mountain bikes.
The next step was the installation of the equipment on the bicycle. Specifically, we incorporated a large rack into the original design of the bicycle and we added metal bars with the welding technique. In this way we created a permanent stable base for the waterproof case that included the equipment and the necessary wiring. Outside of this case the antenna section was placed at a considerable distance from the bicycle rider in order to receive the GPS data unaffected. For equilibrium reasons (there was a significant increase in weight at the rear with the probability of concentrating the center of mass closer to the drive wheel, thus indirectly affecting the driving profile), a smaller rack was placed on the front of the bicycle with the optional choice for positioning the battery of the equipment. Finally, we continued to the final step of the equipment installation process that was the operational testing and calibration of the equipment on the field.

2.3 Study Area, Road Type, Weather Conditions and Time

The next step regarding the experimental design was the selection of the study area and specifically the study routes. They were chosen according to four criteria: location, road type, weather conditions and the date and time of data collection. The study routes should have ensured the continuous operation of the recording equipment. Additionally, for practical purpose, the study routes should have been close to the participant's residence. Taking into account the above-mentioned, the routes that could meet the standards of this research and the requirements of the experiment in the city of Volos are presented in Figure 1. In a more in-depth investigation, three routes were determined as most appropriate to conduct the measurements. The first one was a typical urban road shared by motorists and cyclists (Figure 1, left), (Agiou Dimitriou St), the second one was a road segment with a bikeway and a road segment where motorists are not permitted to drive through (Figure 1, center), (Argonauton St), and finally a pedestrian area (Figure 1, right) (in front of the Agios Konstantinos park). As it is marked in Figure 1, the red arrow represent the start point while the black one the end point for each route.

Figure 1: Study Area (Route1: left, Route 2: center, Route 3: right)



For safety reasons the measurements were stopped when the pavement was even slightly wet. The level of natural light had to be invariant and hence, during cloudy or foggy days the measurements were ceased as well. Generally, the instructions that were initially set, forbidden the conduction of the experiment in case any environmental or traffic conditions might divert the regular riding behavior. Totally, the bicycle rider conducted 9 measurements (3 repetitions for each route) for the needs of this study.

3. Data Analysis

The data analysis was based entirely on the Analysis V8.5.369 of Race Technology, the software that accompanies the recording and data collection devices. This selection was based after the rejection of the common way of analysis, which consists the data conversion into comma delimited files (extension *.csv).

The original data files recorded at the SD card (extension *.run) and opened using Analysis V8.5.369. The program analysis platform (layout) was modified after some customization in order to fit in the requirements of the cycling pattern. More specifically, we adjusted the vehicle weight, the powered wheel and smoothed over the values of the measurement variables, in order to avoid the unnecessary "noise" on the graphs. In some specific cases where the variable smoothing wasn't enough, the sample rate was reduced from 100 Hz to 10 Hz in order to achieve the desired effect.

In the presentation process, the tools we used to demonstrate the vehicle mobility patterns are common x, y graphs, single or multiple with the combination of different laps at the same area. Especially, the presentation of a specific variable was based on color changing bar imprinted on the cycling route of the experiment. The map where the routes were located was instantly downloaded from Google Earth into the Analysis program layout. Finally, the Analysis program calculates the summary statistics of the specific variables we used to approach the urban cycling pattern, such as maximum/minimum and average values of speed, longitudinal acceleration, yaw rate and roll rate.

4. Results

The trajectories of the first, second and third measurements for the three examined routes are presented in Figure 8 whilst the results of the measurements for the first route (Agiou Dimitriou St) are presented in the Figures 2-5.

Figure 2: 1st Route: Speed vs. Distance diagrams (Measurements: 1st left; 2nd right, 3rd center), (Race Technology).

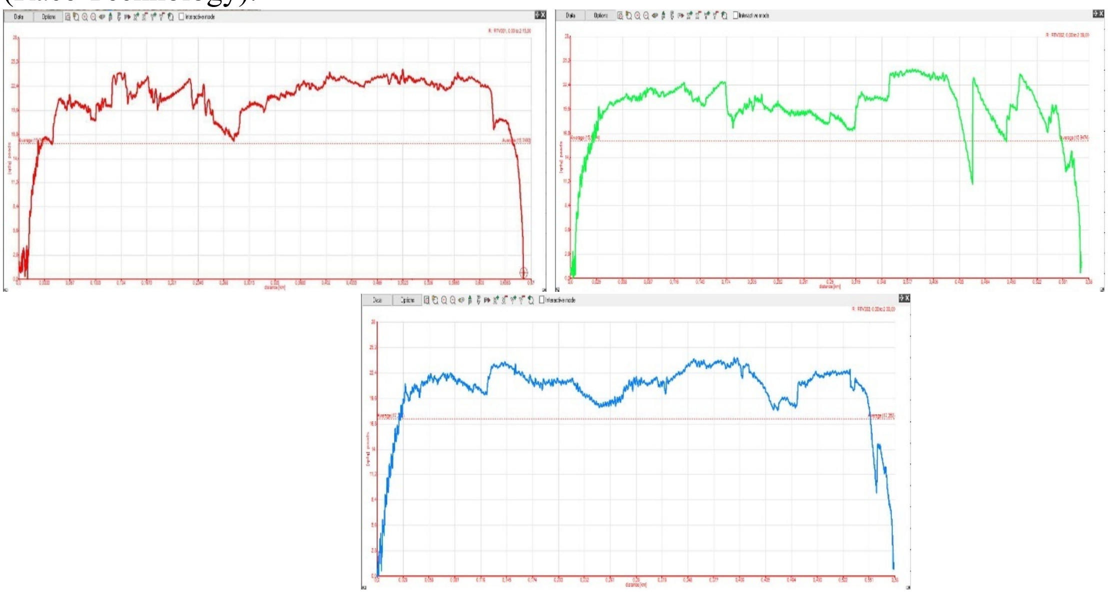
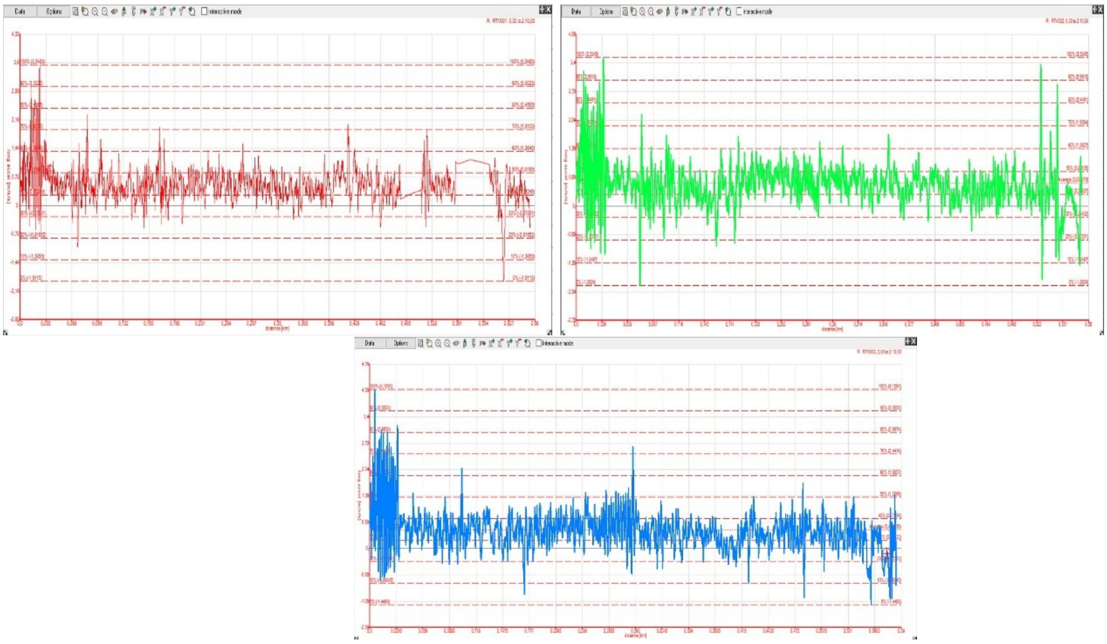
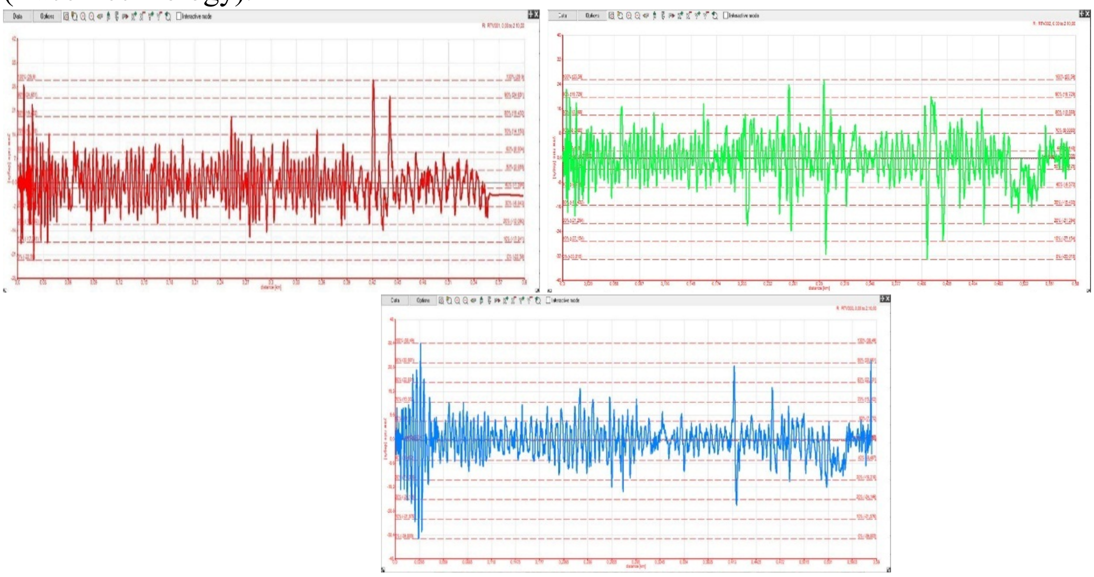


Figure 3: 1st Route: Longitudinal Acceleration vs. Distance diagrams (Measurements: 1st left; 2nd right, 3rd center), (Race Technology).



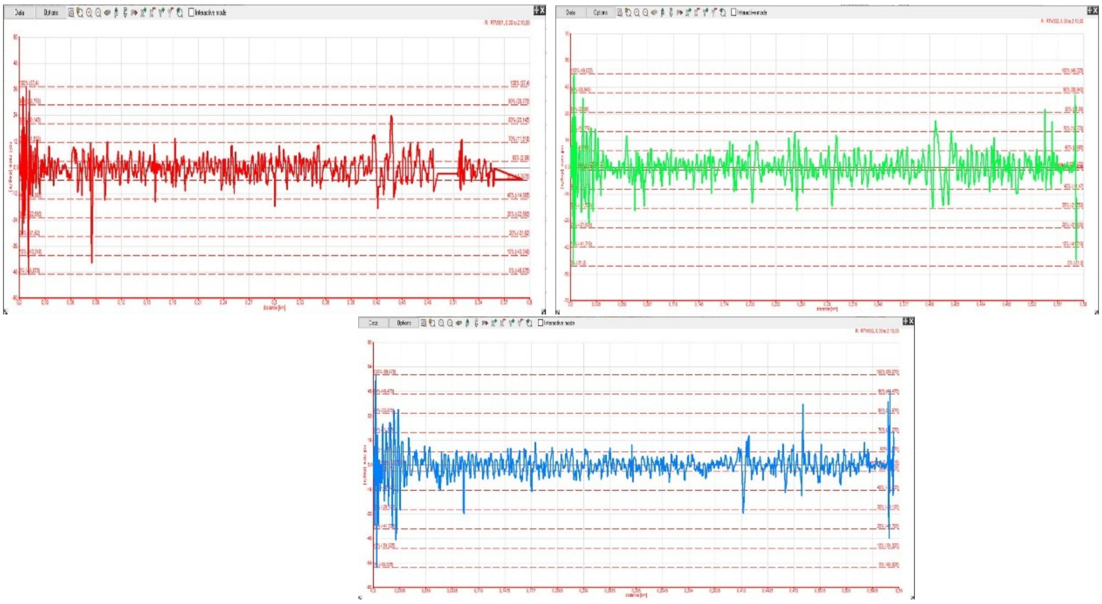
Except from the obvious homogeneity of the speed data at the three measurements, it is also clear the rider's wide speed range. This is probably due to the rider's effort to keep a safe speed in mixed traffic conditions which forced him to apply his brakes more often and pedal right after. The increase of the positive acceleration results the need for immediate regaining of the operational speed after braking. Such riding behaviors are similar in roads shared by motorists and cyclists.

Figure 4: 1st Route: Yaw Rate vs. Distance diagrams (Measurements: 1st left; 2nd right, 3rd center), (Race Technology).



The small yaw roll rate values indicate the cautious and stable riding behavior of the participant (Figure 4). The sense of fear for an eventual incident makes him ride very carefully choosing to decrease his speed, steer smoothly and avoid intense maneuvering and thus to roll the bike less intensively compared to the normal riding behavior which would result rapid change of the center of mass (Figure 5).

Figure 5: 1st Route: Roll Rate vs. Distance diagrams (Measurements: 1st left; 2nd right, 3rd center), (Race Technology).



The results of the measurements for the second and third route are presented in the Figures 6-7 (only the results of the first measurement for the 2nd and 3rd route).

Figure 6: 2nd Route diagrams: Speed vs. Distance (up left), Longitudinal Acceleration vs. Distance (up right), Yaw Rate vs. Distance (bottom left), and Roll Rate vs. Distance (bottom right), (First measurement), (Race Technology).

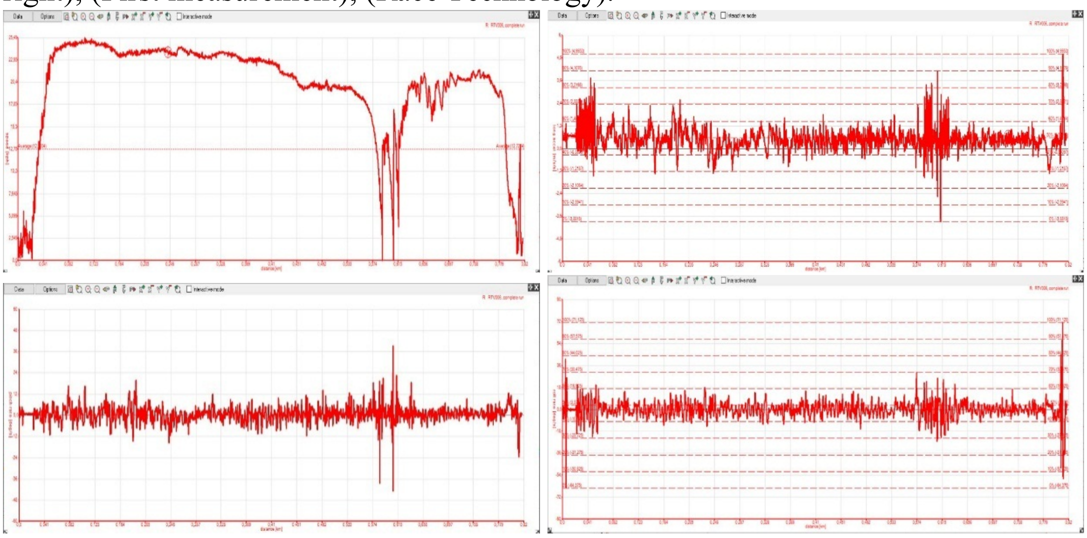
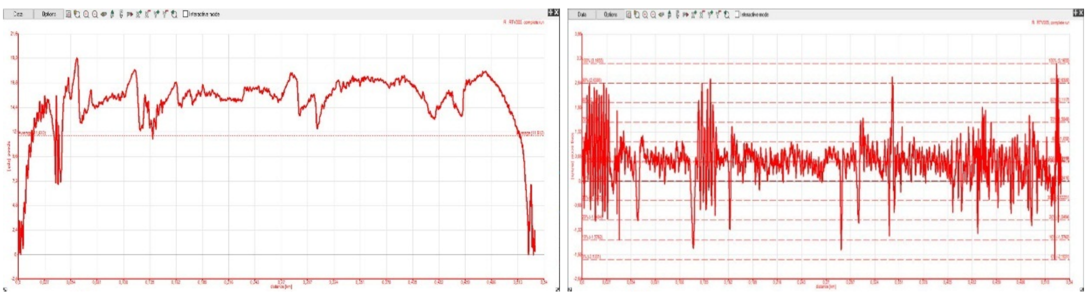
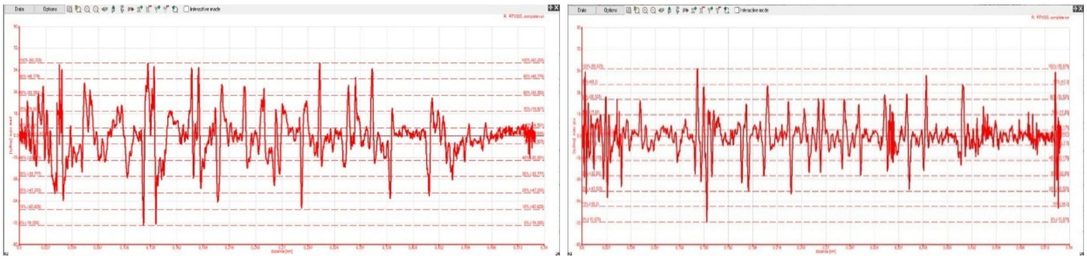


Figure 7: 3rd Route diagrams: Speed vs. Distance (up left), Longitudinal Acceleration vs. Distance (up right), Yaw Rate vs. Distance (bottom left), and Roll Rate vs. Distance (bottom right), (First measurement), (Race Technology).

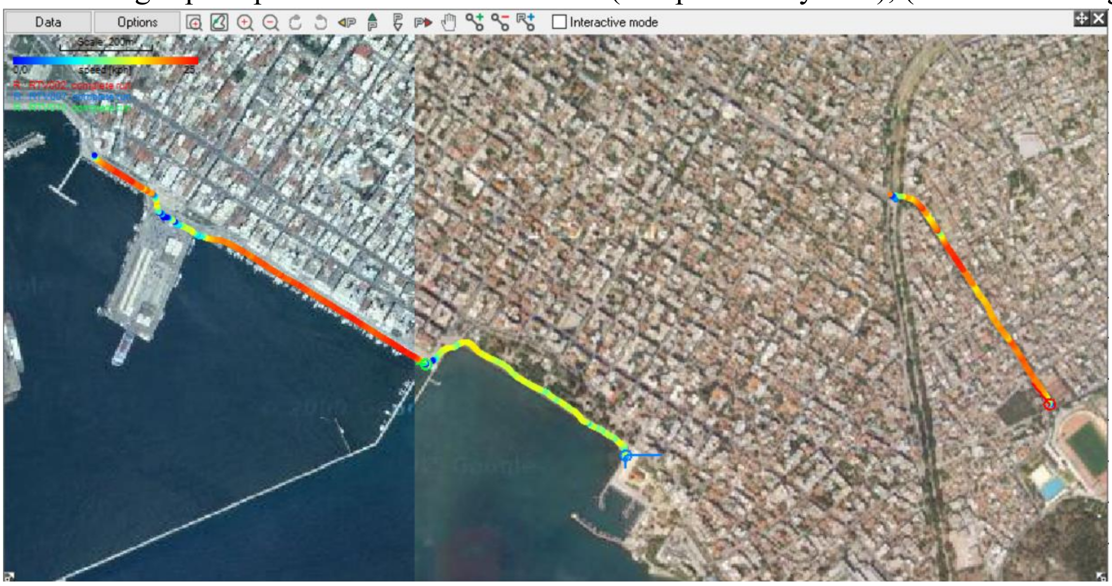




As presented in Figure 8, the trajectories of the bicycle rider are not identical for the three examined routes. In mixed traffic conditions the motorists forced him to adopt a stressed riding behavior. He is constantly checking backwards before any maneuver and slow down very often due to the presence of motorists ahead. Moreover, it is also noticeable the fact that the intense variation in his speed profile implies abnormal riding attitude. The average speed profile of the three routes is presented in Figure 9.

Figure 8: Trajectories of the first (red line), second (green line) and third (blue line) measurements for the three routes (Route 1, left; Route 2, center; Route 3, right), (Race Technology).

Figure 9: Average speed profiles for the three routes (complete study area), (Race Technology).



5. Conclusions

The aim of the present study is twofold; to provide a methodology in order to investigate cyclists behavior in urban roads and to trigger the execution of additional experiments including a greater sample of riders, road sections, weather conditions, equipment and vehicles in order to generalize the conclusions drawn. The conclusions that derived from the process of the behavioral cycling data of the participant who carried out the measurements, are the following:

The average speed at the pedestrians/cyclists area (3rd route) was the lowest one (12.12 km/hr) compared to the other two routes, whilst in the bikeway area (2nd route) was the medium one (15.05 km/hr). In the mixed traffic conditions (1rst route) the average speed was the highest one (17.35 km/hr).
All three routes present similar acceleration profiles. At the beginning of the route the bicycle rider strives to reach a certain speed (increased acceleration) and then he merely tries to maintain this speed (decreased acceleration).
Apparently, at the pedestrians/cyclists area (3rd route), the bicycle rider performs consecutive maneuvers and hence the raw/roll recordings are the highest of all the three routes. Furthermore, these values are reduced at the cyclists/motorists area (1rst route). That is probably because the bicycle rider is overwhelmed of fear and insecure and hence he is very cautious in performing maneuvers.
Bicycle is a sustainable transport mode widely used in the urban road network. Bicyclists can travel both in bikeways and in mixed traffic conditions together with motorists. This can result to uncertainties in terms of driving behavior and road safety. However, by analyzing the behavioral parameters of a rider, bicyclist is a rather predictable and consistent in terms of driving behavior. Indeed, the speed, acceleration and yaw/roll rate data are particularly homogenous and hence bicycle could be classified as a transport mode with controllable and predictive mobility pattern.

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Modeling a closed economy by a lattice Hamiltonian

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Abstract
This research uses a physics model, i.e. particles in lattice, in order to study a closed economy of an isolated place (e.g. planet or island). The 3−particle Toda model is Hamiltonian and thus fully conservative. We reproduce an economy of three populations (human, fauna, flora), instead of a lattice of three particles. Higher populations lead to higher positive energies (that represent their effect on environment), up to infinity. But, incomplete information, imperfect technology and adaptation make this idea unrealistic. Instead, odd order truncations have pretty realistic properties, applicable on environment: for low positive populations, their effect on environment is positive and increasing. After a level of maximum benefit, effects become decreasing and, inevitably, negative. These (over)populations might destroy their environment. In parallel, higher populations create chaotic trajectories. Higher order of truncation have similar properties, but higher populations can survive, since they are closer Toda approximations, representing technological developments, macrocultural evolution and better adaptation to environment. Overpopulation and disaster point exist, no matter how high the odd−order truncation is. In a perfect world, infinite odd order truncation can be achieved and can eliminate overpopulation limits.

Keywords: Hamiltonian dynamics, Closed economy, Overpopulation, Ecosystem, Sustainability.

JEL Classification: Q56, Q57, C61

Μοντελοποίηση μια κλειστής οικονομίας μέσω ενός Χαμιλτονιανού πλέγματος

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Περίληψη
Αυτή η έρευνα δανείζεται από τη Φυσική ένα μοντέλο σωματιδίων σε ένα πλέγμα, προκειμένου να μελετήσει μια κλειστή οικονομία, ενός απομονωμένου τόπου (π.χ. πλανήτη ή νησιού). Το μοντέλο 3−σωματιδίων του Toda είναι Χαμιλτονιανό και άρα πλήρως διατηρητικό. Αναπαράγουμε μια οικονομία τριών πληθυσμών (ανθρώπινου, χλωρίδας, πανίδας), στη θέση των τριών σωματιδίων ενός πλέγματος. Υψηλότεροι πληθυσμοί οδηγούν σε υψηλότερες θετικές ενέργειες (που αντιπροσωπεύουν την επίδρασή τους στο περιβάλλον), μέχρι το άπειρο. Ωστόσο, η ατελής πληροφόρηση, η ατελής τεχνολογία και προσαρμογή, καθιστούν αυτή την ιδέα μη ρεαλιστική. Αντίθετα, οι περιττής τάξης προσεγγίσεις έχουν πολύ ρεαλιστικές ιδιότητες, εφαρμόσιμες στο περιβάλλον: για χαμηλούς θετικούς πληθυσμούς, η επίδρασή τους στο περιβάλλον είναι θετική και αύξουσα. Μετά από ένα μέγιστο επίπεδο ωφέλειας, οι επιδράσεις γίνονται φθίνουσες και αρνητικές. Αυτοί οι (υπέρ)πληθυσμοί θα μπορούσαν να καταστρέψουν το περιβάλλον τους. Οι υψηλότεροι πληθυσμοί δημιουργούν χαοτικές τροχιές. Οι προσεγγίσεις υψηλότερης τάξης έχουν παρόμοιες ιδιότητες, αλλά επιβιώνουν υψηλότεροι πληθυσμοί, εφόσον είναι εγγύτερες προσεγγίσεις του Toda, αναπαριστώντας τεχνολογική ανάπτυξη, εξέλιξη της μακροκουλτούρας και καλύτερη προσαρμογή στο περιβάλλον. Ο υπερπληθυσμός και τα επίπεδα καταστροφής υπάρχουν, ανεξαρτήτως πόσο

υψηλή είναι η περιττής τάξης προσέγγιση. Σε έναν τέλειο κόσμο, η προσέγγιση άπειρης περιττής τάξης μπορεί να επιτευχθεί και μπορεί να εξαλείψει τον περιορισμό του υπερπληθυσμού.

Λέξεις Κλειδιά: Χαμιλτονιανή δυναμική, Κλειστή οικονομία, υπερπληθυσμός, οικοσύστημα, βιωσιμότητα.

JEL Κωδικοί: Q56, Q57, C61

1. Introduction

This paper attempts to achieve, through an interdisciplinary approach, the connection of two, seemingly, completely different closed systems. The first is a dynamical, non-linear, conservative system, that describes the motion of N interacting particles in lattice, while the second is a closed economic system that refers to a finite natural environment (such as an isolated island, planet or any other isolated place). The aim is to study the positive and negative impacts of the populations (and overpopulations) that constitute an economy, on the environment where they act.
On this basis, our research uses the Physics originated N-particle Toda lattice, for $N = 3$ (3pTL), which describes the energy, positions and velocities of a conservative system of a 3-particle lattice, through the following function, studied in Contopoulos & Polymilis (1987):

$$H = \frac{1}{2}\left(\dot{q}_1^2 + \dot{q}_2^2 + \dot{q}_3^2\right) + e^{(q_1 - q_2)} + e^{(q_2 - q_3)} + e^{(q_3 - q_1)} - 3 \qquad (1)$$

where $q_i, \dot{q}_i$, $i = 1, 2, 3$ are the positions and velocities of the three particles, respectively. This system is fully conservative for any energy level. Following the canonical transformation proposed by Lunsford & Ford (1972), the system becomes two-dimensional. Later, Contopoulos & Polymilis (1987) expanded the truncated Toda Hamiltonian, in Taylor series, for $3 \leq n \leq 10$ and Zachilas (2010a) and Zachilas (2010b) for $3 \leq n \leq 20$, for n being the order of expansion. Thus, the expanded Hamiltonian system forms as:

$$H = \frac{1}{2}\left(\dot{x}^2 + \dot{y}^2\right) + \Phi_i\left(x, y\right) = E \qquad (2)$$

where $\Phi_i(x, y)$,for $i = 1, \ldots, 20$, is the potential function, of each order Taylor approximation, and E is the integral of energy.
In particular, the third order expansion is identical to (and widely known as) the Hénon – Heiles model (HH) (1964). According to their conclusions, stochasticity increases, as energy increases. Similarly, the same results hold at higher energy levels for higher orders of Taylor truncations. Especially, in odd order truncations, the existence of escape energy is observable, that is, an energy level above which the zero-velocity curve (ZVC) opens. It is extremely interesting that, contrariwise, 3pTL is fully integrable (Zachilas, 2010a) and does not show escape energy at all. It is worth noting that, approximating 3pTL, the higher odd order approximations have less chaos at each energy level and the corresponding zero velocity curve opens at a higher energy level.
Using this context, we attempt to simplify a closed economy (or an ecosystem) with a very simple classification in three populations, indicatively: Fauna (x), Human (y) and Flora (z). These three populations coexist and interact with each other and with the natural environment (or wealth), which they transform through their activity. In fact, they compete for - but also co-formulate - the exploitation and development of a given (and finite) carrying capacity. This is an elementary closed economy of limited resources, which, therefore, has limited production capacity.

Our basic bridging assumption is that escape energy is identical to the sustainable production capacity of the economic model and, thus, higher order approximations represent better perception of and/or adaptation to the inhabiting environment.

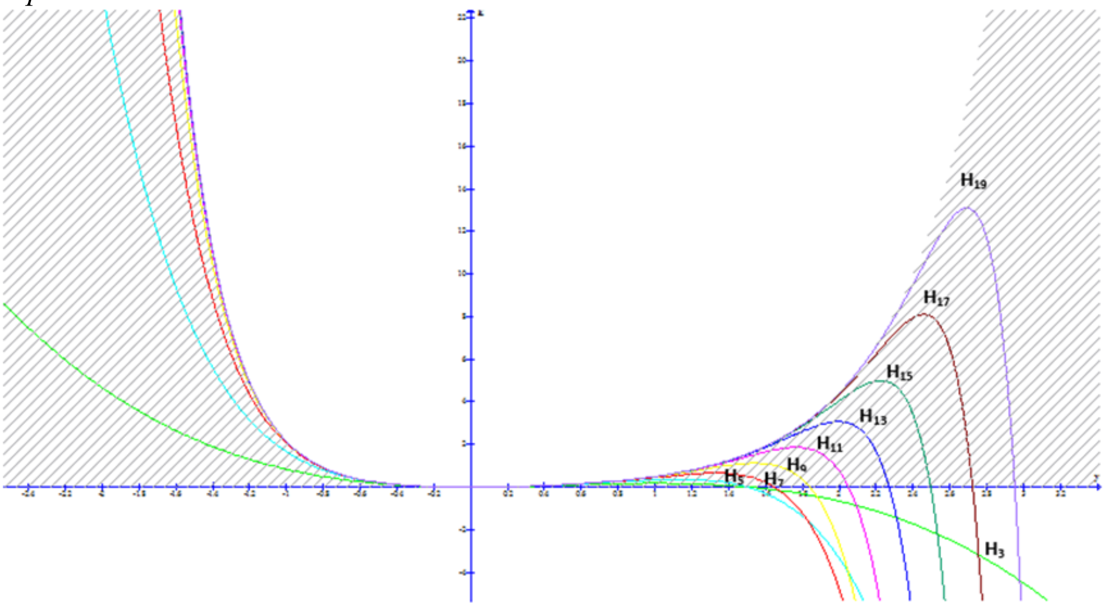
2. Population models and 3pTL

This research aspires to constitute a contribution to the scientific modeling of population interaction with environment. Applying a common dynamic model of Physics origin, both positive and negative effects of populations on a, restricted sourced, hosting environment are being approached. Most bibliography uses very complex models of numerous equations or extremely simple models that reduce reality and general applicability on more than specific cases.

This model is useful because it is simple enough, avoiding overspecification. It reproduces basic properties of reality and is applicable to any closed ecosystem having restricted capacity, independently of its exact situation. Populations of an isolated island, a lonely planet, or forgotten caves and even detached communities could be the subject of this approach. Otherwise, it is not built to reproduce any specific population or environment, so it is not restricted by the idea of fully modeling a complex environment using too many equations or to approach natural complexity using an unnaturally simple "environment" through one or very few structural equations.

A very common conception of populations' evolution is exponential growth (which is understandably believed to be a time restricted property, because of lack of resources or even disposability of waste (Meadows et al. 1972), as Malthus (1798) first proposed. According to Malthus' model, populations tend to reproduce and grow without important obstacles that would bound their ability to expand. Such an idea is completely compatible with 3pTL studied here, as shown in Figure 1. This unbounded growth of population and energy is represented by the shadowed surface, as the profile of the full exponential Toda.

Figure 7 A map of the E-y profiles of the first 9 potentials along with the profile of the full exponential TODA



Another approach considers that populations have an attractive upper bound, and they grow or shrink to reach it. This model is very important, since it introduces restricted capacity of environment (or social structure (Meadows et al. 1972). This constitutes a very important property of population dynamic models. Resources are not completely unrestricted and there should be a pick. What this model does not incorporate is a dynamic capacity. When populations are low enough, the seemingly abundant environment allows for, almost, exponential growth. In contrary, large populations tend to self-decrease, until they reach the capacity's steady state (Verhulst, 1838). Instead, reality seems to be different. (Over) populations can harm their environment, by decreasing its capacity. This means that populations and environmental quality react, since populations have the ability to degrade environment through pollution (temporal effect) and irreplaceable resources consumption (permanent effect). This dynamic relationship is clearly the core of the WORLD model (Meadows et al. 1972). This problem of irreplaceable resources can be managed, up to a limit, through technological development.

Additionally, an environment model approaches the subject in a concept very close to this paper concept (John et al. 1995). It constitutes a model in which human can become both harmful and beneficial to the environment. Consequently, environment variable without human is set to be equal to zero, and "disturbance" in a positive or negative way exists, because of human population and its specific habits. In that case, human consumption might reduce environmental quality, but government programs are believed to be able to reverse such effects. In the same way, as our model does, existence of human populations should not be a priori bad for a planet. According to them, it depends on our consumption habits and our environmental policies.

In order to provide a sufficient context, we should mention that Motesharrei et al. (2016) supported that technological advancement could help solve environmental sustainability problems, accordingly with the right policies required in developing and adopting the right technologies. Some important examples mentioned are the transition to renewable sources, increasing use efficiency, and behavioral changes to cut resource use and emissions. They also accept that carrying capacity is a useful analytical tool in order to study sustainability. Especially, when a population consumes more than a given system can replenish, collapse becomes a positive probability.

Moreover, as Brander and Taylor (1998) mention, collapses have occurred many times in human societies over the last 10,000 years. Their common hypothesis is that overpopulation caused a critical reduction in resource stocks. For example, Basener & Ross (2005) have modeled Easter Island's population.

Finally, the idea of modelling a non-specific environment and its populations is usually used in astrobiology. In Frank et al. (2018), sustainability, die-off, collapse or oscillation may hold. This model is a highly simplified representation of the true complexity inherent in the interactions between an energy consuming civilization (human or otherwise) and the host planetary systems.

Our model (3pTL) does not ignore environmental restrictions, even their dynamic attitude. It is different because it perceives population existence as both positive and negative to the environment, depending on its size and additionally on a technological/knowledge level. Moreover, there is the ability to reverse a collapse situation by upgrading knowledge/technology level. It is important to mention that we do not concentrate on human populations, or on a specific environment. In our opinion, inhabited environment might benefit by their hosted populations. As an example, fossil fuels are of organic origin, meaning that they exist because of fauna or flora. Therefore, a crucial energy resource for our population growth and civilization exists, because our planet has been inhabited for a long time.

Another contribution is that it considers three different categories of populations that interact with each other. Accordingly, "human is not alone". Additionally, through adjustment, we can observe those populations' effect on the environment quite easy. There are all the basic properties of a population – environment system and, interestingly, it is easy to observe the consequences of overpopulation, underpopulation and zero population on the environment and additionally on the complex behavior of the system. While we observe higher energies for higher populations, chaos is also increasing, and, consequently, the dynamics between populations become extremely difficult to predict.

3. Methodology

The basic assumption is that the escape energy of the physics' model is identical to the sustainable production capacity of the economic model, under any specific circumstances, whereas each energy (E) is maintained in contours, describing the change in the "value" and usability of natural environment, caused by the existing populations (x, y, z). Even if we only watch y, other populations are pretty important, since $\dot{y}$ is always the result of the relative "positions" of (x, y, z) particles, or in this metaphor, it is determined by the relative populations of fauna, human and flora.
In our model, for zero populations, there is zero energy (a lifeless island / planet with "inactive" natural wealth). This idea has been supported in John et al. (1995), where the environmental quality is modeled to be disturbed by human activity in both positive and negative components. Since no human (or other species) affect the environment, it is perceived as stable and equal to zero. This perception allows for both positive and negative energies, since zero is just a point and not a border situation for environment. On the other hand, negative populations are impossible in this model. The minimum acceptable population value is zero, which means either that the population has not existed yet, or that the population has already been extinct.
For positive populations, it is observed that the effect on the environment (energy) is initially positive. This concept has been ignored by Basener & Ross (2005), who describe the population evolution of an isolated island, where human has been disappeared, and Frank et al. (2018), who attempted to approach the survival or destruction of the technologically advanced population of a planet. In John et al. (1995), human disturbance could be both positive and negative, depending on assumptions on consumption and government supported environmental programs. This property is quite reasonable. In this paper, not only government supported environmental programs, but even the very existence of populations can benefit environmental quality. The initial energy of the system is zero and the existence of some populations on a planet or an island might be helpful and upgrade environmental quality.
Toda characterizes an economy that is totally applicable and adaptable to its environment. Populations' presence can only have positive effects on environmental quality. This appears to be a perfect utopia, an ideal situation to compare with. Odd order truncations are good approximations of this situation when population is low, but, when it grows enough, it exhausts environment and its quality decreases. These potential positive effects get higher along with populations adaptability and the same holds for the size of maintainable populations.
As we can observe in Figure 1, for positive populations (on the right-hand side) there exists a local maximum point. It shifts towards higher values of energy and population as approximation order increases ($H_3 \rightarrow E_{esc3} = 0.166666$, $H_5 \rightarrow E_{esc5} = 0.3586468$, $H_{13} \rightarrow E_{esc13} = 3.0650788$ and $H_{19} \rightarrow E_{esc19} = 13.087$) and tends to infinity[14]. Those (maximum) energies are called "*escape energies*". For higher populations, energy reduces gradually to zero and then below zero. We should mention that there is no specific border bounding positive populations, even if environment is harmed a lot. This is because our model aspires to be applicable in any case, whether the environment is fragile or stable enough. Although, if a limit is set, then collapse can be reproduced. Additionally, y populations, needed to reach escape, always increase. Toda profile is sufficiently approximated up to a point and then the maximum point bounds the approximation's applicability.
For higher populations, of course, this effect becomes consecutively less positive and then negative, a fact that implies damage of the planet, as seen in Figure 1 and consequently the elimination of the species that depend on it. This is not a linear relation between population and energy. While reasonably small populations cause positive energies, meaning environment improvement and population increases also increase energy, there is a maximum turning point for energy, above which the population increase burden the environment. Since populations are not internally determined by this model, energies could decrease and become negative, harming their own environment.

[14] In Appendix, we quote escape energies and populations up to H_{101}, and we try to determine their route as truncations increase.

Having those in mind, 3pTL is a closed system, such as a closed economy, which, however, has no escape energy. This means that the given "island" is inexhaustible and, thus, infinite populations can live there, always making a sustainable and beneficial use of it. It is about a society/economy that has solved its economic problem, as described by Robbins (1935). It is an economy of abundance. Thus, "unlimited" resources do not appear to be the key to sustaining growth in the world system. Apparently, the economic impetus such resource availability provides must be accompanied by curbs on pollution, if a collapse of the world system is to be avoided (Meadows et al. 1972).
On contrary, the approaches of higher and higher odd order truncations are able to maintain even higher energies and, consequently, even larger populations. However, the existence of escape energy is always the case. This shows that, when the approach of an unrestricted economy gets better (higher), it does not become accurate immediately, but it increases the limits imposed by the constraints. These transitions to higher odd order models can be interpreted as better adaptation to the environment or, more specifically, as an increase of accumulated knowledge. A technological development could be proposed (i.e. solar energy (Frank et al. 2018)) or a better applying "macroculture".
Thus, a perfect environment inhabited by perfect populations could be described by 3pTL. Imperfections in technology, knowledge, institutions or adaptation, which do exist, can be modelled by odd orders truncations. In order to understand the evolution as knowledge and adaptation improve, we are going to study:

$$H_3 = \frac{1}{2}\left(\dot{x}^2 + \dot{y}^2 + x^2 + y^2\right) + x^2 y - \frac{1}{3} y^3 \qquad (3)$$

known widely as Hénon – Heiles (HH).
Additionally, we study H_5, H_{13} *and* H_{19}, which are listed in Appendix. It is clear that increasing approximation orders stabilizes the system at previously chaotic or even crashing levels of energy, by adding some terms in the existing equation, explaining better adaptation to the inhabiting environment (knowledge, technology, culture) and ensuring viability to higher populations. This idea of building new blocks on the existing edifice has conceptual relevance to macrocultural emergence of new elements (Economou and Kyriazis, 2015). Diffusion process should be studied in following research, having in mind the impressive work of Udry and Martinet (1990)
The tools of dynamical analysis we are going to use for each of the above Hamiltonians are:

- Contour plots of the ZVC (Zero-Velocity Curves), in order to observe closed and open zero velocity curves, and the ZVC of the critical escape energy.
- Poincaré surface of section at several energies. They offer a useful presentation of chaos evolution, as energy increases.
- Our analysis uses the mathematic basis of Zachilas (2010a), but interpretations are innovative, since this specific model have never been used to describe an economic model of populations inhabiting a restricted environment.

4. Results

According to our study there exists an important linkage between the physics originated model and our economic – ecological model. Especially, 3pTL, when truncated shows some specific properties, such us a positive maximum point of energy for some positive population. Higher populations appear to decrease this energy – utility for the environment that is able to become 0 or even negative. This pattern is the case in any truncation, but it is shifted up and right.
In the following figures we can observe the Poincaré sections of four indicative truncations: H3 which is called Henon-Heiles, H_5, H_{13} *and* H_{19}. In Figure 2a we can observe the combinations of x and y populations, that correspond to escape energies in each truncation. It is clear that, as truncations increase, feasible populations increase for both *x* and *y*. Figure 2b shows the same ZVCs

on y-y' axes. Again, higher Taylor truncations lead to wider and smoother ZVCs. In the economic-environmental context these figures express the idea that higher applicability of populations to their environment can allow them grow a lot more.

Figure 8 a, b: ZVCs on x-y & y-y' (Poincaré)

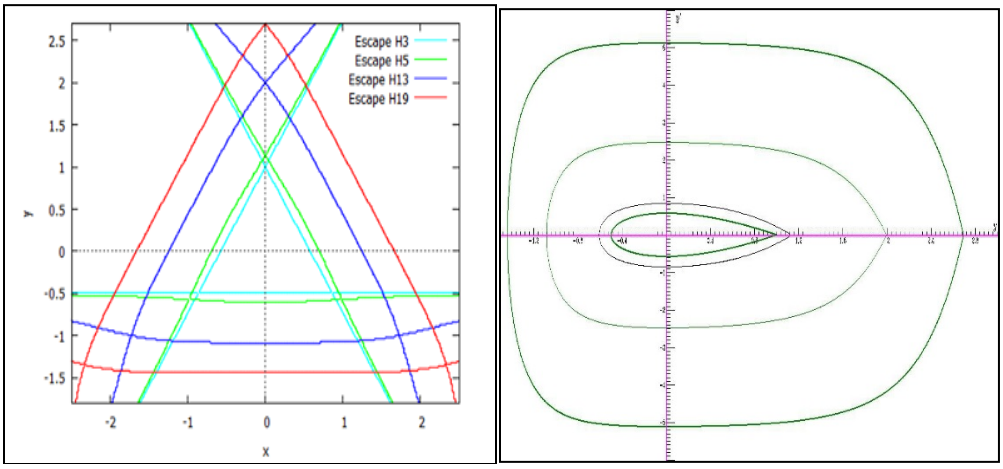
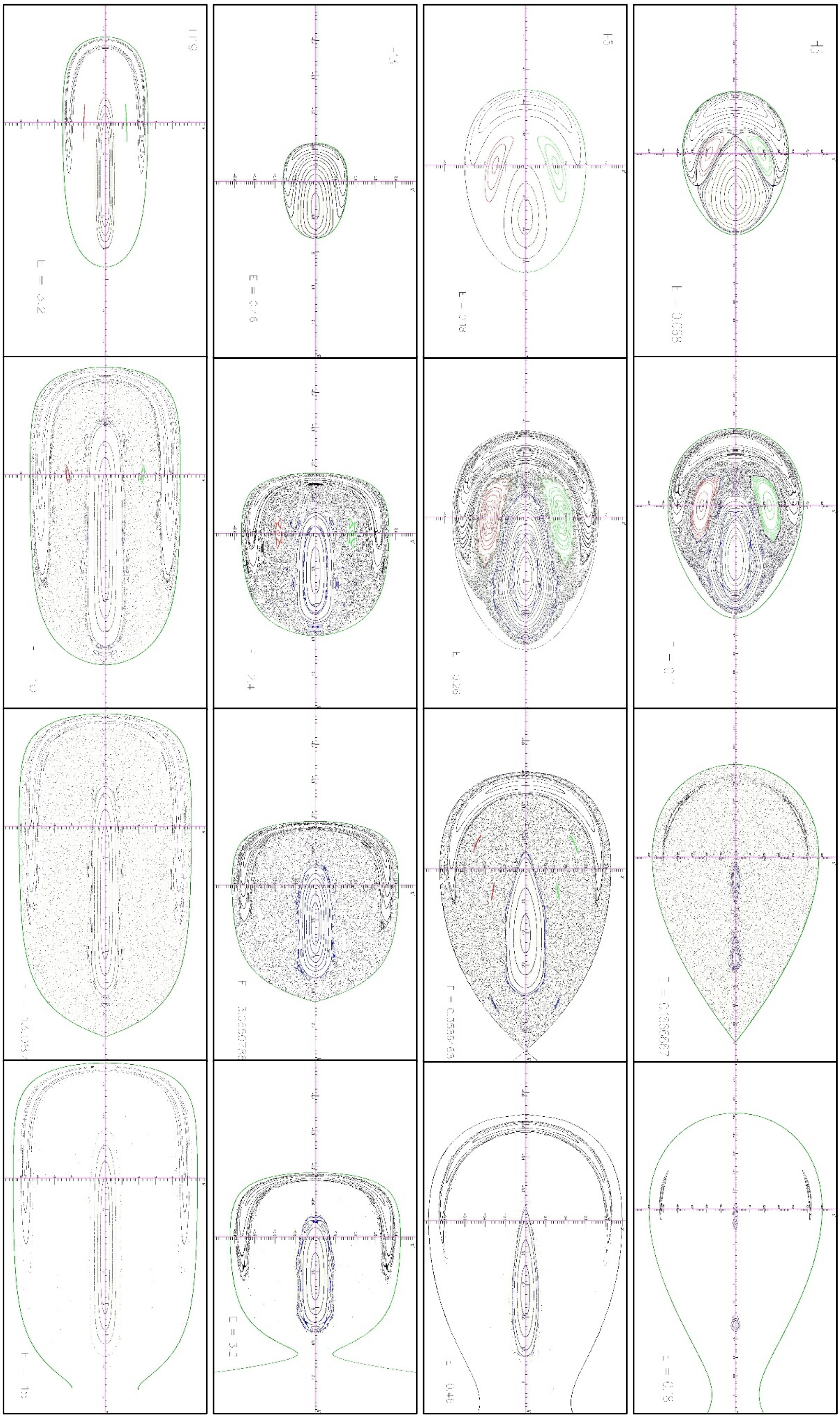


Figure 3 depicts various energies for all four truncations studied:
In the 1st column, for H_3 we choose the energy level at which the unstable invariant point (stochasticity) appears. The first column in higher orders represents the same energy as the fourth column of their previous odd order. ZVCs and invariant curves are closed and chaos is not present, while some bifurcations are obvious (especially in H_3 and H_{13}). Those economies survive.
In the 2nd column, stochastic seas occupy a wide surface of the figures. Four families still exist. Some (not-chaotic) islands of order can be observed in chaotic sea. Populations' behavior might be stochastic, but they survive.
In the 3rd column the escape energy of each truncation id depicted. After that point, ZVC opens and chaotic trajectories escape to infinity. This is the last point of sustainable populations. After that level, environment cannot sustain the populations inhabiting it. In order to achieve and make sure survival for higher energy levels, a new macroculture, a better adaptation to environment, is needed.
Finally, the 4th column includes energies higher than escape energy. Most initial values lead to chaotic trajectories that tend to infinity. Despite this danger, there are closed invariant curves that can survive at this combination of energy and truncation. Populations should apply better to their environment in order to become sustainable at higher levels. Otherwise, they could be lucky to stick on a closed invariant curve, or destroy their environment and disappear.
Consequently, except for perfect cases, environment and populations react both in a positive and in a negative way, while the specific turning point is determined by the ability of populations to adapt and avoid harming their specific hosting environment. This could be even a natural ability to adapt or the populations' ability to gain knowledge or improve technological levels and their habits, in general, in order to become friendly to their environment. As mentioned before, perfect adaptation and full information are represented by Toda model (or its infinite order approximation).

Figure 9 A panorama of Poincaré sections of the four indicative truncations: H_3, H_5, H_{13}, H_{19} in various energies.



5 Conclusions – Further research

In this research we used a widely known truncation of 3pTL physics model, in order to approach the behavior of an economic – ecological system of three populations hosted in an environment of restricted resources. Especially, we focus on the impact of such populations on their environment, based on their knowledge, adaptability and habits. Surprisingly, many reasonable properties can be reproduced, without any specification or data needed.

At first, the populations can be harmful and destructive to their environment/economy, if crowded, but they initially are beneficial and increase its value. Secondly, technological or cultural developments and adaptation have also been introduced and it has been observed that higher energy and population become possible in the ecosystem. Moreover, overpopulation and disaster point exist, no matter how high the odd-order of truncation is, while infinite odd order truncation should eliminate overpopulation limits. Overpopulation critical values are not absolute, but relative to knowledge and adaptation level. An adjustment should be applied at any specific case of planet, island or any closed environment, in order to make population levels and sustainable negative energies adaptable.

Although our model is under thorough investigation, it constitutes a model that can lead to conclusions. It demands a definition of populations, its differentials and an adaptation level. Using this information, it depicts the interaction of populations at every such level. Moreover, while there is no observable point of collapse, it can be extracted, if an applicable minimum (negative) barrier is set for energy. Finally, development steps might be infinite (if populations survive), widening the acceptable level of populations, which tend to infinity through this infinite path.

Further applications of this model on economics could perform as a whole field of research. In our opinion, initial steps should focus on population growth and their relationship to their environment, economic growth and institutional macroculture (Economou & Kyriazis, 2015), or even debt sustainable levels and the idea of graduation from default (Qian et al., 2011).

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Appendix

A. Toda truncations used (except for HH)

$$H_5 = \frac{x^2 + y^2}{2} + \frac{3yx^2 - y^3}{3} + \frac{x^4 + 2y^2x^2 + y^4}{2} + \frac{3yx^4 + 2y^3x^2 - y^5}{3}$$

$$\begin{aligned} H_{13} &= \frac{x^2 + y^2}{2} + \frac{3yx^2 - y^3}{3} + \frac{x^4 + 2y^2x^2 + y^4}{2} + \frac{3yx^4 + 2y^3x^2 - y^5}{3} \\ &+ \frac{9x^6 + 45y^2x^4 + 15y^4x^2 + 11y^6}{45} + \frac{6yx^6 + 10y^3x^4 + 2y^5x^2 - 2y^7}{15} \\ &+ \frac{27x^8 + 252y^2x^6 + 210y^4x^4 + 28y^6x^2 + 43y^8}{630} \\ &+ \frac{243yx^8 + 756y^3x^6 + 378y^5x^4 + 36y^7x^2 - 85y^9}{2835} \\ &+ \frac{9x^{10} + 135y^2x^8 + 210y^4x^6 + 70y^6x^4 + 5y^8x^2 + 19y^{10}}{1575} \\ &+ \frac{162yx^{10} + 810y^3x^8 + 756y^5x^6 + 180y^7x^4 + 10y^9x^2 - 62y^{11}}{14175} \\ &+ \frac{243x^{12} + 5346y^2x^{10} + 13365y^4x^8 + 8316y^6x^6 + 1485y^8x^4 + 66y^{10}x^2 + 683y^{12}}{467775} \\ &+ \frac{162yx^{12} + 1188y^3x^{10} + 1782y^5x^8 + 792y^7x^6 + 110y^9x^4 + 4y^{11}x^2 - 70y^{13}}{155925} \end{aligned}$$

$$\begin{aligned} H_{19} &= \frac{x^2 + y^2}{2} + \frac{3yx^2 - y^3}{3} + \frac{x^4 + 2y^2x^2 + y^4}{2} + \frac{3yx^4 + 2y^3x^2 - y^5}{3} + \frac{9x^6 + 45y^2x^4 + 15y^4x^2 + 11y^6}{45} + \frac{6yx^6 + 10y^3x^4 + 2y^5x^2 - 2y^7}{15} \\ &+ \frac{27x^8 + 252y^2x^6 + 210y^4x^4 + 28y^6x^2 + 43y^8}{630} + \frac{243yx^8 + 756y^3x^6 + 378y^5x^4 + 36y^7x^2 - 85y^9}{2835} \\ &+ \frac{9x^{10} + 135y^2x^8 + 210y^4x^6 + 70y^6x^4 + 5y^8x^2 + 19y^{10}}{1575} + \frac{162yx^{10} + 810y^3x^8 + 756y^5x^6 + 180y^7x^4 + 10y^9x^2 - 62y^{11}}{14175} \\ &+ \frac{243x^{12} + 5346y^2x^{10} + 13365y^4x^8 + 8316y^6x^6 + 1485y^8x^4 + 66y^{10}x^2 + 683y^{12}}{467775} \\ &+ \frac{162yx^{12} + 1188y^3x^{10} + 1782y^5x^8 + 792y^7x^6 + 110y^9x^4 + 4y^{11}x^2 - 70y^{13}}{155925} \\ &+ \frac{1458x^{14} + 44226y^2x^{12} + 162162y^4x^{10} + 162162y^6x^8 + 54054y^8x^6 + 6006y^{10}x^4 + 182y^{12}x^2 + 5462y^{14}}{42567525} \\ &+ \frac{43740yx^{14} + 442260y^3x^{12} + 972972y^5x^{10} + 694980y^7x^8 + 180180y^9x^6 + 16380y^{11}x^4 + 420y^{13}x^2 - 21844y^{15}}{638512875} \\ &+ \frac{729x^{16} + 29160y^2x^{14} + 147420y^4x^{12} + 216216y^6x^{10} + 115830y^8x^8 + 24024y^{10}x^6 + 1820y^{12}x^4 + 40y^{14}x^2 + 3641y^{16}}{425675250} \\ &+ \frac{2187yx^{16} + 29160y^3x^{14} + 88452y^5x^{12} + 92664y^7x^{10} + 38610y^9x^8 + 6552y^{11}x^6 + 420y^{13}x^4 + 8y^{15}x^2 - 1285y^{17}}{638512875} \\ &+ \frac{6561x^{18} + 334611y^2x^{16} + 2230740y^4x^{14} + 4511052y^6x^{12} + 3544398y^8x^{10} + 1181466y^{10}x^8 + 167076y^{12}x^6 + 9180y^{14}x^4 + 153y^{16}x^2 + 43691y^{18}}{97692469875} \\ &+ \frac{1458yx^{18} + 24786y^3x^{16} + 99144y^5x^{14} + 143208y^7x^{12} + 87516y^9x^{10} + 23868y^{11}x^8 + 2856y^{13}x^6 + 136y^{15}x^4 + 2y^{17}x^2 - 1022y^{19}}{10854718875} \end{aligned}$$

B. Escape energies and populations

Rate of escape energies change: [≈ 2.15] for E_3 to E_5 transition and [≈ 1.5945] for E_{99} to E_{101}. It may converge at some point around 1.59.

Change in maximum maintainable populations (Δy): ≈ 0.1366 for E_3 to E_5 transition and ≈0.2332 for E_{99} to E_{101}. Unexpectedly, $\Delta y_{27\to 29}$ is maximum Δy.

Table 1 Escape Energies and escape populations for successive truncations.

Order	Escape Energy	ratio	Escape y	Δy
3	0.166667		1	
5	0.35864	2.15188	1.13656	0.13656
7	0.64900	1.80961	1.32845	0.19188
9	1.11366	1.71595	1.54256	0.21410
11	1.86167	1.67167	1.76662	0.22406
13	3.06507	1.64641	1.99552	0.22889
15	4.99902	1.63096	2.22691	0.23139
17	8.10435	1.62119	2.45966	0.23274
19	13.08725	1.61484	2.69317	0.23351
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
27	87.29693	1.60424	3.63004	0.23439
29	139.94754	1.60312	3.86446	**0.23441**
31	224.22998	1.60224	4.09887	0.23441
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
99	$1.8 \cdot 10^9$	1.59459	12.04485	0.23319
101	$2.9 \cdot 10^9$	1.59451	12.27802	0.23317

Adopting tolerance regions in environmental economics

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Abstract

When limited knowledge is associated with the underground problem under investigation we are not certain on the process we have to follow, therefore there is uncertainty.Notice that uncertainty in practice is related with the physical problem under investigation and mainly concerns the involved parameters. A typical example can be the Environmental Economics system under study. There are many model specifications estimating, eventually, the Benefit Area. For the optimal level of pollution we can evaluate the corresponding tolerance region, in order to refer to this optimal level via the future observations rather via the parameters estimation. Tolerance regions can be either classical or expected tolerance regions. The associated four Benefit Areas can be evaluated through the suggested tolerance region procedure, rather than the confidence interval/region approach, and therefore four possible optimal levels of pollution can be obtained as well as the corresponding tolerance region for the reduction pollution point.

Keywords: Confidence interval/region;Tolerance region; Environmental Economics, General linear model.

JEL Classification: O4; O47; O52: Q43; Q56.

1. Introduction

Uncertainty is a key element for the description of physical problems under investigation, and the easiest way to measure it is, through an information-theoretic approach, by the adoption and study of certain measures of information (Kitsos and Toulias, 2017; Toulias and Kitsos, 2016; Toulias,2015). A typical example of physical problems is the study of the Environment and, in particular, the Environmental Economics. There are a number of model specifications estimating, eventually, the Benefit Area, which is the area covered by the intersection betweenthe marginal abatement function (MAD) and the marginal damage cost function (MD),restricted by the Cost or Benefits axis (Halkos and Kitsos, 2005, 2018).

In particular, research provides evidence that the Relative Risk (RR) differentiates under the gender factor (Pan-American Health Organization, 1998; Mitchell et al., 2007). Women seems to be more vulnerable to environmental disasters and climate change than men, mainly due to their social role and responsibilities. Therefore, different approaches are needed to analyze statistical parameters conserning environmental data, while model approach has been developed to Environmental Economics (Halkos and Kitsos, 2018a, 2018b) among others.

One question arising from the general study of models is "what is the percentage of the future observations that lie within a predefined interval/region with a given probability?". Such a request gives in fact the definition of the so-called tolerance region (TR), as it was defined by Wilks (1941). That is why, we believe, the adoption and study of the TRs is essential in environmental problems, as it would be shown in this research.

Uncertainty is hidden in Environmental Economics, either in the choice of the model or in other factors,have already been discussed (Halkos and Kitsos, 2005, 2018b; Halkos and Kitsou, 2014; Kitsou, 2015). Initially, the aim is to investigate and to produce relationships among the real-world events that we study so that the involved variance and Relative Risk (RR) to be expressed and analyzed; see for example Halkos and Kitsos (2012) among others. Environmental Economics is an important field that adopts such relationships and provides food for thought regarding Health and Economics.

Most of the work devoted on this subject is related to a confidence interval approach (Halkos and Kitsos, 2018b) which offers a solution towards the investigation of the involved uncertainty. The investigation of the future observations as well as the level of probability in order a future observation to be considered accepted or not, has its own importance which is equal if not greater than the important of some parameter estimations. This leads us to the concept of the tolerance interval/region (TR), roughly put: the interval/region in which a great percentage of future observations lies with a certain high probability. The above general idea of TR is discussed in Section 2. Interest is focused when the underlying model, with typical example being the General Linear Model (GLM) (Graybill, 1976), remains invariant to linear (affine) transformations. The δ-*expected tolerance region* is usually considered, which is the average TR, denoted with $\mathrm{ATR}(\delta)$. The gain in knowledge is then even more as we do not adoptjust a TR, but the expected TR which is asked to be at a certain probability level $\delta \in (0,1)$; see Section 3 for a brief discussion. We comment that, in bibliography, it is usually referred as the β-expectation tolerance region which (the β notation) is avoided in this study, not to be confused with the β parameter vector in the GLM.

In this paper, our interest is focused on the intersection point $I(x_0, k_0)$between the marginal abatement function (MAD) and the marginal damage cost (DC) function, known as the *optimal level of pollution*. The corresponding point x_0, in the Damage Reduction axis, is known as the *optimal level of reduction pollution*, while the value k_0 on the Cost axis is known as optimal cost. The area covered from those curves (see Fig. 1) is known as the *Benefit Area* (BA). Regarding the optimal level of pollution, we can evaluate the corresponding tolerance region, either the classical or the expected (invariant) tolerance interval $\mathrm{ATR}(\delta)$, and therefore we can obtain (from the intersection of the latter) four possible optimal levels of pollution and the corresponding tolerance interval for the reduction pollution point, as Halkos and Kitsos (2018a, 2018b)discussed for the confidence interval approach. The associated four Benefit Areas can be evaluated via to the adopted TR procedure, rather than a confidence interval approach.

But to what "amount" of pollution we are referring and we are planning to investigate, and what is the pollutants future behavior? It is known that the atmosphere influences the climate and, therefore, the knowledge of the pollution is crucial, while the restrictions on the factors polluted the environment are also important. Typical examples are the CO_2 and the CH_4factors, while CFC's (not existed before 1938) with construction similar to CH_4 have a larger duration and destroy O_3 layer, as it is known since 1985.Some researchers (Halkos, 2013) discussed different policies and taxation on SO_X, NO_X, CO_2, etc., while others (Kitsou, 2015) tackled the corresponding uncertainty problem. Moreover, Halkos and Kitsos(2018a)provided an extensive discussion on considering uncertainty, either through a mathematical or statistical point of view, by working on the theoretical identification of the Optimal Pollution Level, which was considered by Halkos and Kitsos (2005) and extended by Halkos and Kitsou (2014), with the adoption of different models describing the marginal abatement cost (MAC) and the marginal damage cost (MD) (Halkos, 2013).

2. Tolerance regions

Let $\Omega = \sim^n$ and $\mathrm{A} \subseteq \mathrm{B}$ with B being the Borel field $\mathrm{B} = \{[a,b),\, a,b \in \sim\}$. Consider the set function

$$Q:\ \Omega \to \mathrm{A}, \quad \sim^n \hat{\mathrm{A}}\mathbf{y} = (y_1, y_2, \ldots, y_n) \overset{Q}{\mapsto} Q(y_1, y_2, \ldots, y_n) \in \mathrm{A}\,.$$

We are restricted to statistical tolerance regions (TR) since $\Omega = \sim^n$ and A is in B. Hence, there exist two functions, say $L = L(\mathbf{y})$ and $U = U(\mathbf{y})$, such that

$$Q = [L, U), \quad L < U\,. \tag{2.1}$$

Wilks (1962), worked on a sample from a continuous distribution function (cdf) F, proved that a TR Q as in (2.1), with

$$L = L(\mathbf{y}) = Y_{(k_1)}, \quad U = U(\mathbf{y}) = Y_{(k_1+k_2)},$$

And where $Y_{(i)}$ is the i-th ordered statistic, defines a tolerance region. He also proved that

$$F(U) - F(L) = F\left(Y_{(k_1+k_2)}\right) - F\left(Y_{(k_1)}\right) \sim \mathrm{Beta}(k_2, n - k_2 + 1)\,.$$

The probability content of the tolerance region $Q = Q(\mathbf{y})$, based on independent observations from $\Pr_Y$, is called the *coverage* of Q, $C(Q) = \Pr_Y\left(Q(\mathbf{y})\right)$, i.e. in a function form

$$C:\ \mathrm{B} \to [0,1], \quad Q(\mathbf{y}) \overset{C}{\mapsto} C\left(Q(\mathbf{y})\right) = \Pr_Y\left(Q(\mathbf{y})\right). \tag{2.2}$$

The statistical tolerance region is a δ*-content tolerance region*, $\mathrm{CTR}(\delta)$, with probability γ if

$$\Pr\left(\Pr_Y\left(Q(\mathbf{y}) \geq \delta\right)\right) = \gamma \in [0,1]. \tag{2.3}$$

Recall the TR as the one considered above by Wilks (1962). Assuming $k_1 = r$, $k_2 = n - 2r + 1$ and $r < (n+1)/2$, it can then be proved (Kendal and Stuart, 1968), that

$$\gamma = \Pr\left(F\left(Y_{(n-r+1)}\right) - F\left(Y_{(r)}\right) \geq \delta\right) = 1 - \mathrm{IBeta}_\delta(n - 2r + 1, 2r),$$

where $\mathrm{IBeta}_\delta(p,q)$ denotes the incomplete beta distribution.

We imposed one criterion to assure that, on theaverage, the coverage would be δ and thus, the δ-expected TR, δ-eTR, is then defined as

$$\mathrm{E}\left\{\Pr_Y\left(Q\left(y_1, y_2, \ldots, y_n\right)\right)\right\} = \delta\,, \tag{2.4}$$

see (Muller and Kitsos, 2004 among others). Therefore, we create a region, a two-sided tolerance interval. Notice that the TR is not unique; see the integral equation (2.5) below. It is then clear that TR's can be proved very practical in industry and not only (Zarikas and Kitsos,2015).

Now, let us consider a future response $\mathbf{z} = (z_1, z_2, \ldots, z_n)$ and its corresponding tolerance region $Q(\mathbf{z})$. Then, the *affine tolerance region*, ATR, is a statistic $Q(\cdot)$ on $\sim^{n}$ over the space of future responses, based on the data such that

$$C\left[Q(\mathbf{z})\right] := \int_{Q(\mathbf{z})} H(\mathbf{z} \mid \mathbf{y})\, \mathrm{d}\mathbf{z} = \delta, \quad \delta \in [0,1]. \tag{2.5}$$

Moreover, we are asking the average of the probability coverage of the tolerance region to be δ for the future response, i.e.

$$\mathrm{E}_{\boldsymbol{\theta}}\left\{C\left[Q(\mathbf{z})\right]\right\} = \delta, \quad \boldsymbol{\theta} \in \Theta \subseteq \sim^{n},$$

and we are referring to it as $\mathrm{ATR}(\delta)$.

The density function $H(\mathbf{z} \mid \mathbf{y})$ in (2.5) is statistically well defined (see Appendix II) andcalled as the *prediction distribution* of the future response $\mathbf{z}$ (Fraser and Haq, 1969; Muller and Kitsos,2004).

We emphasize here that in practice the "invariant" property, i.e. to remain invariant under affine transformations, might not be applicable in all cases. Suppose there is a source of pollution in place M and suppose we transfer it in a distance d and rotate it by an angle ϑ, in a new position M'. Although, theoretically, the TR of M is equivalent to M' and is invariant under the affine transformation, the profile of the pollution (and hence the environmental analysis) might be completely different if M' is located near a river or a city, etc. This is an example where some mathematical concepts may not be always useful in practice.

The well-known $.95$ confidence interval $\hat{\mu} \pm 1.96\hat{\sigma}$, with $\hat{\mu}$ being the sample mean and $\hat{\sigma}$ the sample standard deviation may not necessarily include the 95% of the population as it depends on the variance of the estimates $\hat{\mu}$ and $\hat{\sigma}$. Therefore, a tolerance region is bounding this variance by requesting a certain percentage of the population (and not the parameters) to be included in tolerance interval.

The δ-expected TR for observations coming from the normal distribution can be evaluated due to the following Theorem 1. For the GLM, Theorem 2 is the appropriate one, while for the invariant case, Theorem 3 provides the corresponding $\mathrm{ATL}(\delta)$. That is, we provide the tolerance regions Q_0 as in (2.6) for the classical TR, Q_1 as in (2.11) for the simple linear model, and Q_1^* as in (2.15) for the invariant case of the simple linear model.

Theorem 1. *Let the error variable* ε *comes from the standard normal distribution* $\mathrm{N}\,(0,1)$. *Then, for the central TR,* 100δ *% of the normal distribution being sampled, the region*

$$Q_0 = \left[\bar{y} - ks, \bar{y} + ks\right), \tag{2.6}$$

is the δ*-expected region, with*

$$\bar{y} = n^{-1}\sum y_i, \quad s^2 = (n-1)^{-1}\sum\left(y_i - \bar{y}\right)^2, \quad k = \sqrt{1+n^{-1}}\; t_{n-1;(1-\delta)/2}, \tag{2.7}$$

where $t_{n-1;(1-\delta)/2}$ *being, as usual, the* t*-distribution with* $n-1$ *degrees of freedom, exceeding with probability* $(1-\delta)/2$.

In principle, two are the main families of models: Quantitative and Qualitative models. Typical examples for the former in Statistics are the General Linear Model (GLM) and the Regression Model, while for the latter is the Design Model. We shall focus on the GLM. Consider the matrix equation

$$\mathbf{y} = \mathbf{X\beta} + \boldsymbol{\varepsilon}, \tag{2.8}$$

where $\mathbf{y} \in \sim^{n\times 1}$ is an observable random vector, $\mathbf{X} \in \sim^{n\times p}$ is a matrix of fixed observable non-random variables, $\boldsymbol{\beta} \in \sim^{p\times 1}$ is a vector of unobservable parameters defined in a parameter space Θ and $\boldsymbol{\varepsilon} \in \sim^{n\times 1}$ is an unobservable random vector with mean $\mathrm{E}(\boldsymbol{\varepsilon}) = 0$ and covariance matrix $\mathrm{Cov}(\boldsymbol{\varepsilon}) = \boldsymbol{\Sigma}$. The only difference with the Regression Model is that the input variables $\mathbf{x}$ forming matrix $\mathbf{X}$ are random. The normality assumption for the errors is imposed when inference is asked, and the well-known OLS (Ordinary Least Squares) procedure is performed.

For the General Linear Model $\mathbf{y} = \mathbf{X\beta} + \boldsymbol{\sigma}$, the following holds (Graybill, 1976, Th. 8.3.1-2). In the following, Theorem 2 provides the classical TR for the GLM.

Theorem 2. *For the GLM as in (2.8), the interval*

$$Q_P = [L, U) \;\; with \;\; L = \hat{\boldsymbol{\beta}}'\mathbf{x}_0 - k_\delta \hat{\sigma} \;\; \text{and} \;\; U = \hat{\boldsymbol{\beta}}'\mathbf{x}_0 + k_\delta{}'\hat{\sigma}, \tag{2.9}$$

is a δ-tolerance interval at the point $\mathbf{x}_0 = (1, y_2, \ldots, y_p)$ with confidence coefficient $1-\gamma$, i.e. contains $100\delta\%$ of observations with confidence $1-\gamma$, and

$$k_\delta = -Kt_{1-\gamma;n-p;q}, \quad k_\delta' = Kt_{1-\gamma;n-p;-q}, \quad K^2 = \mathbf{x}_0'(\mathbf{X}'\mathbf{X})^{-1}\mathbf{x}_0, \quad k_\delta, k_\delta{}' \in \sim, \tag{2.10}$$

where $t_{1-\gamma;n-p;q}$ denotes the upper $1-\gamma$ probability point of the non-central t-distribution with $n-p$ degrees of freedom (df) and non-centrality parameter $q = -Z_\delta / K$.

Notice that $-t_{1-\gamma;n-p;q} = t_{\gamma;n-p;-q}$. We also emphasize that here that the evaluation of non-central t distribution needs special care.

Corollary 1. *For the simple linear regression model $y = \beta_0 + \beta_1 x + \varepsilon = \boldsymbol{\beta}'\mathbf{x} + \varepsilon, \quad \varepsilon \sim \mathrm{N}(0, \sigma^2)$ the δ-tolerance interval with confidence $1-\gamma$, is*

$$Q_1 = [l, u) = \left[\hat{\beta}_0 + \hat{\beta}_1 x_0 - k_\delta \hat{\sigma}, \hat{\beta}_0 + \hat{\beta}_1 x_0 + k_\delta{}'\hat{\sigma}\right), \tag{2.11}$$

with $n - p = n - 2$, $q = -Z_\delta / K$, k_δ, $k_\delta{}'$ as in (2.10) and

$$K^2 = \tfrac{1}{n} + \frac{(\mathbf{x} - \overline{\mathbf{x}}_0)^2}{\sum_{i=1}^{n}(x_i - \overline{\mathbf{x}})^2}.$$

Now, to construct a δ-expectation affine tolerance region, $\mathrm{ATL}(\delta)$, for the affine GLM, the prediction distribution is needed and the following holds (Muller and Kitsos, 2004).

Theorem 3.*Let the error variable ε follow the normal distribution with 0 mean and variance 1, i.e.*

$$f(\varepsilon_i)\,\mathrm{d}\varepsilon_i = \frac{1}{\sqrt{2\pi}}\exp\left\{-\tfrac{1}{2}\varepsilon_i^2\right\}\mathrm{d}\varepsilon_i, \quad i = 1, 2, \ldots, n.$$

Let also the matrix $\mathbf{X}_0$ of the GLM as in (2.8) corresponds to the matrix of n' future responses.

Then, for the central 100δ % normal distribution being sampled, the ellipsoidal region

$$Q_p^* = \left\{ \mathbf{y} \left| \left(\mathbf{y} - \mathbf{X}_0{}'\hat{\boldsymbol{\beta}}\right) \left(\frac{s}{n-p} \right)^{-1} \left(\mathbf{y} - \mathbf{X}_0{}'\hat{\boldsymbol{\beta}}\right) \le pF_{n',\, n-\mathrm{p}\,;\, n-\delta} \right. \right\}, \tag{2.12}$$

is the δ*-expectation* $\mathrm{ATR}(\delta)$*, i.e.*

$$ATR(\delta) = Q_p^* .$$

When $p = 1$, i.e. when we are referring to the simple linear model, the matrix $\mathbf{X}_0$ is reduced to the vector $\mathbf{x}_0$ and the following holds.

Corollary 2.*For the simple linear model*

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i, \quad \varepsilon_i \sim \mathrm{N}\,(0, \sigma^2), \quad i = 1, 2, \ldots, n,$$

the central δ*-expectation invariant TR,* $\mathrm{ATR}(\delta)$ *is*

$$Q_1^* = [L^*, U^*) \text{ with } L^* = \hat{\beta}_0 + \hat{\beta}_1 x_0 - k \frac{1}{(S_1^{-1})^{1/2}}, \; U^* = \hat{\beta}_0 + \hat{\beta}_1 x_0 + k \frac{1}{(S_1^{-1})^{1/2}}, \tag{2.13}$$

where $\hat{\beta}_0 + \hat{\beta}_1 x_1 = (1, x_1) \cdot (\hat{\beta}_0, \hat{\beta}_1)' = \mathbf{x}_0 \hat{\boldsymbol{\beta}}'$, $S_1^{-1} = 1 - \mathbf{x}_0{}'(\mathbf{X}'\mathbf{X} + \mathbf{x}_0{}'\mathbf{x}_0)^{-1}\mathbf{x}_0$*, and*

$$k = \frac{t_{n-p;\delta/2}}{\sqrt{n-2}} (RSS)^{1/2}. \tag{2.14}$$

Therefore, the interval $Q_1^* = [L^*, U^*)$as in (2.13) is the $\mathrm{ATR}(\delta)$. For the simple linear model, the corresponding TRs Q_1 and Q_1^*, as in (2.11) and (2.13) respectively, are the two candidates for the invariant TR-s in order to evaluate Q_1 or Q_1^*, so that a certain percentage of the future observations will lie, on average, within Q_1or Q_1^*, with certain given probability.

3. EnvironmentalEconomics

In Environmental Economics, the marginal abatement cost (MAC) as well as the marginal damage cost (MD)play an important role, as the optimal pollution level occurs at certain point for which $MAC = MD$. Although there is an uncertainty about the appropriate model choice for the description of MAC and MC, their typical presentation is given in Fig. 1 below (Halkos and Kitsou, 2005; Kitsou, 2014; Halkos and Kitsou, 2014).

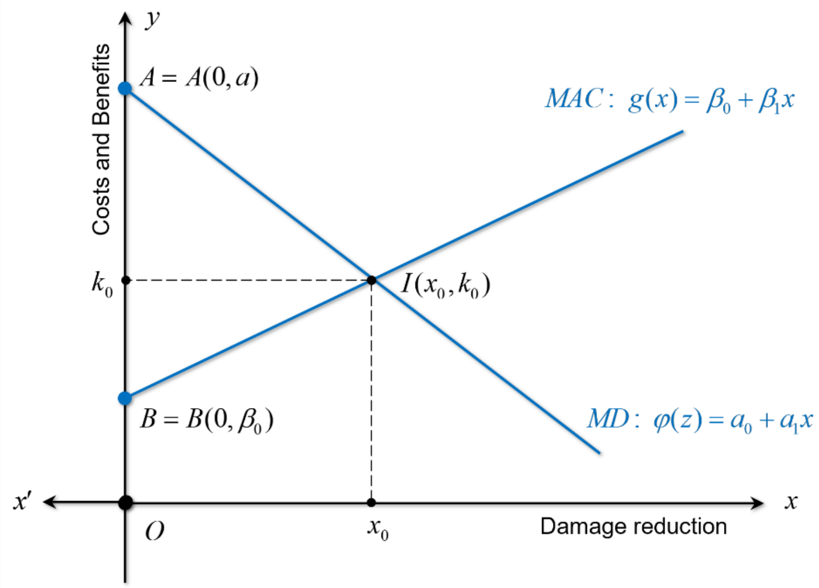

Figure 1. *Graphical presentation of the theoretical optimal level of pollution.*

Notice that the area of the triangle ABI corresponds to the Benefit Area (BA), where the curves $g = g(x)$ and $\varphi = \varphi(x)$ can be estimated only with the OLS methodology (Halkos and Kitsos, 2015).

For $\text{MAC} = g(x)$ linear, by the adoption of regression technics, we can evaluate $\hat{g}(x) = \hat{\beta}_0 + \hat{\beta}_1 x$ as well as for $\text{MD} = \varphi(x)$: $\hat{\varphi}(x) = \hat{\alpha}_0 + \hat{\alpha}_1 x$. Therefore, the TR, either Q_1 or Q_1^*, can be evaluated for $g(x)$ and $\varphi(x)$ respectively, say Q_{1g} or Q_{1g}^* and $Q_{1\varphi}$ or $Q_{1\varphi}^*$. In Fig. 2 the TR-s are presented together with the confidence intervals (CI-s) for both MAC and MD. The benefit area $\text{BA} = (AIB)$ has now different options, as the intersection I may vary but in any case it has to be $I(x_0, k_0)$ with $x_0, k_0 > 0$. This presentation is another way to tackle the concept of BA in Environmental Economics.

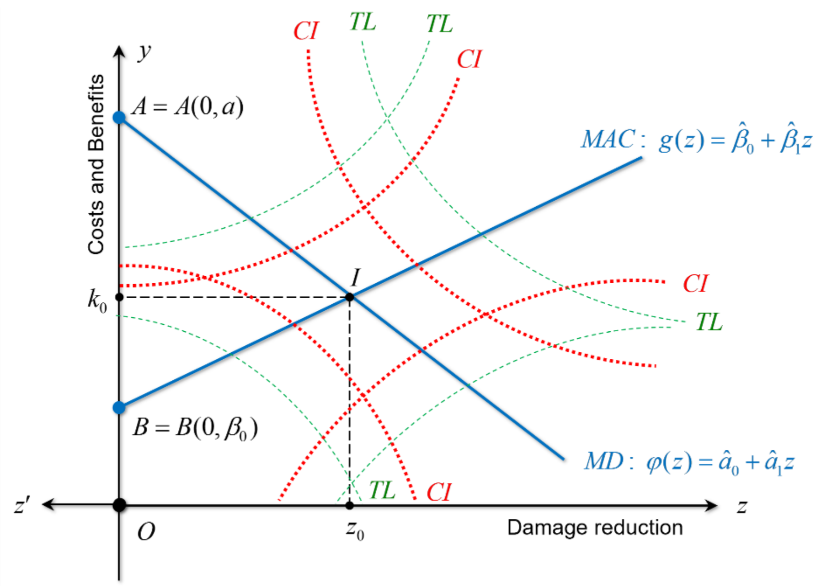

Figure 2. *Graphical presentation of the estimated level of pollution.*

We believe that there is a real need to work with the "future population" rather than the estimated measures of position or dispersion. The estimates of the mean, median, mode, and the percentiles, as well as the variance of the population, might offer information about the "center" and "scale" of the population, but does not provide information for the behavior of the future population coming from the source under study. Figure 2 provides evidence that, as the TRs are larger than CIs, TR might provide larger BAs and that could be a problem for the researcher who has then to decide what is the appropriate choice. We are working on this decision problem.

4. Discussion

We believe that, although a tolerance interval is less widely known than the confidence interval or the prediction interval, it is more useful in practical problems. While confidence intervals bounds the parameter estimates, such as mean, variance, proportion etc., tolerance interval bounds the range of the data that includes a specific proportion of the population.

Tolerance intervals are related to prediction intervals (Schervish, 1995) while Muller and Kitsos (2004) attempted to create bounds for the variance of the future response. In practice, the future response is of great importance. Practically speaking, a prediction interval is an estimate interval since future observations of some given data (analyzed in principle with the regression analysis) will fall in that interval with an assigned probability level.We emphasize that that a prediction interval bounds only a single future sample. The superiority of the tolerance interval is that it concerns the entire population while $\mathrm{ATR}(\delta)$ works on the average of future possible samples.This is the main reason that tolerance intervals are, we believe, more appropriate in practice.

Notice also that due to this simple relation,

$$1<\sqrt{n+1}\Rightarrow\frac{1}{\sqrt{n}}<\sqrt{1+\tfrac{1}{n}}\Rightarrow\frac{s}{\sqrt{n}}<s\sqrt{1+\tfrac{1}{n}}\Rightarrow\frac{ks}{\sqrt{n}}<k\sqrt{1+\tfrac{1}{n}},\quad k>0,$$

The tolerance region Q_0 is wider than a confidence interval. This is a simple heuristic proof of the fact that TR > CI, either as length, area, or volume. Keep in mind that TRs may be wider than CIs, however they are refer directly to the population rather than the sample parameters; see also Kitsos and Toulias (2012).

Appendix I (Invariance)

Let $\{(\Omega, \mathrm{A}, P), P\in \mathrm{P}\}$ be a probability space associated with points $\mathbf{y}\in{}^{\sim n}$. Let g be any one-to-one transformation of Ω onto itself. The collection of all sets gA with $A\in\mathrm{A}$, is a sigma-field $g\mathrm{A}$, and $g\mathrm{P}$ is the probability measure on $g\mathrm{A}$ induced by g such that

$$gP(gA)=P(A),\quad A\in\mathrm{A}. \tag{I.1}$$

Any function φ on Ω generates a new function $g\varphi$ such that

$$\varphi(x)=g\varphi(gx). \tag{I.2}$$

Then $(\Omega, \mathrm{A}, P)\overset{\text{is}}{\cong}(g\Omega, g\mathrm{A}, gP)$, i.e. g is an isomorphism in the sense that if $\mathrm{B}\subseteq\mathrm{A}$ then $g\mathrm{B}\subseteq g\mathrm{A}$, and if φ is any A-Π-integrable function on Ω, the $g\varphi$ is $g\mathrm{A}$ - $g\mathrm{P}$ -integrable on $g\Omega$ and

$$\mathrm{E}_{gp}\left(g\varphi \middle| g\mathrm{A}\right) \overset{\text{as}}{=} g\,\mathrm{E}_p\left(\varphi \middle| \mathrm{B}\right) \tag{I.3}$$

(i.e. except on a $g\mathrm{P}$ -null set). If we now let G be a group with element g such that

$$g\mathrm{A} = \mathrm{A}, \quad gP \in \mathrm{P}, \quad \text{with } P \in \mathrm{P}, \tag{I.4}$$

then the family $\left\{\left(\Omega, \mathrm{A}, P\right), P \in \mathrm{P}\right\}$ is said to be invariant under G.

The following lemma is essential for Section 3 and the analysis therein.

Lemma 1.(Kitsos (2011))*The set*

$$G = \left\{ g = \begin{pmatrix} \mathbf{I}_p & \mathbf{0} \\ \mathbf{h} & \lambda \end{pmatrix}, \quad \mathbf{I}_p \in \sim^{p\times p}, \quad \lambda > 0, \quad \mathbf{h} = (h_i) \in \sim^{p} \right\}, \tag{I.5}$$

is a group of transformations.

Let the GLM to be of the form (2.8). Notice that the transpose is then

$$\mathbf{y}' = \boldsymbol{\beta}'\mathbf{X}' + \sigma\boldsymbol{\varepsilon}',$$

and therefore, it is easy to prove that it holds

$$\begin{pmatrix} \mathbf{X}' \\ \mathbf{y}' \end{pmatrix} = \begin{pmatrix} \mathbf{I}_p & \mathbf{0} \\ \boldsymbol{\beta}' & \sigma \end{pmatrix} \begin{pmatrix} \mathbf{X}' \\ \boldsymbol{\varepsilon}' \end{pmatrix}, \tag{I.6}$$

With $\mathbf{0}' = (0,0,\ldots,0) \in \sim^{p}$, $\mathbf{I}_p \in \sim^{p\times p}$ denotes the identity matrix, i.e. $\mathbf{I}_p := \mathrm{diag}(1,1,\ldots,1)$. If we let

$$\mathbf{Y} := \begin{pmatrix} \mathbf{X}' \\ \mathbf{y} \end{pmatrix}, \quad \mathbf{g} := \begin{pmatrix} \mathbf{I}_p & \mathbf{0} \\ \boldsymbol{\beta}' & \sigma \end{pmatrix}, \quad \mathbf{E} := \begin{pmatrix} \mathbf{X}' \\ \boldsymbol{\varepsilon}' \end{pmatrix}, \tag{I.7}$$

then (I.6) forms an affine transformation with matrix $\mathbf{g}$ being an element g of a group of transformations, say G, and hence (I.6) is of the form $\mathbf{Y} = g\,\mathbf{E}$. So we can have an affine transformation for $\mathbf{E}$.

Appendix II

Let us consider the response $\mathbf{y} = (y_1, y_2, \ldots, y_n)$ and its corresponding tolerance region $Q(\mathbf{y})$. Then, the affine (invariant) tolerance region is a statistic $Q(\cdot)$ on $\sim^{n}$, and with space of future responses based on the data such that

$$\Pr\left(\mathrm{Q}\left(y_1, y_2, \ldots, y_n\right)\right) = \int_{\mathrm{Q}(.)} \Pr\left(\mathbf{y} \middle| \boldsymbol{\theta}\right) \mathrm{d}\mathbf{y}, \tag{II.1}$$

with $\boldsymbol{\theta}$ being an element or the parameter space $\Theta \subseteq \sim^{p}$. For the δ-expectation affine(invariant) equivalent tolerance region, it can be proved that is of the form

$$\mathrm{ATL}(\delta) = \mathrm{E}_{\boldsymbol{\theta}}\left\{\Pr_{\boldsymbol{\theta}}\left(Q\left(y_1, y_2, \ldots, y_n\right)\right)\right\} = \int_{\Theta}\left(\int_{\mathrm{Q}(.)} \Pr\left(\mathbf{y}\middle|\boldsymbol{\theta}\right) \mathrm{d}\mathbf{y}\right) h^*\left(\boldsymbol{\theta}\middle|\text{data}\right) \mathrm{d}\boldsymbol{\theta} = \delta, \tag{II.2}$$

with $h^*\left(\boldsymbol{\theta}\middle|\text{data}\right)$ being the structural distribution of parameters (Fraser and Haq, 1969; Muller and Kitsos, 2004). Under the assumption that Fubini's theorem hold and denoting

$$H\left(\mathbf{z}\middle|\mathbf{y}\right)=\int_{\Theta}\Pr\left(\mathbf{z}\middle|\boldsymbol{\theta}\right)h^{*}\left(\boldsymbol{\theta}\middle|\mathbf{z}\right)\mathrm{d}\boldsymbol{\theta},\quad \boldsymbol{\theta}\in\Theta\subseteq\sim^{n}, \tag{II.3}$$

then (II.2) is reduced to

$$\mathrm{ATL}(\delta):=\int_{Q}H\left(\mathbf{z}\middle|\mathbf{y}\right)\mathrm{d}\mathbf{y}=\delta. \tag{II.4}$$

The density function $H\left(\mathbf{z}\middle|\mathbf{y}\right)$ has been defined as the prediction distribution of the future response $\mathbf{z}$ (Fraser and Haq, 1969).

The prediction distribution (II.3) for the affine GLM is

$$H\left(\mathbf{z}\middle|\mathbf{y}\right)=\frac{\left|\mathbf{S}\right|^{-1/2}\Gamma\left(\dfrac{n+n'-p}{2}\right)}{\pi^{n'/2}\Gamma\left(\dfrac{n-p}{2}\right)}\left|\mathrm{I}+\left(\mathbf{y}-\mathbf{X}\hat{\boldsymbol{\beta}}\right)'\mathbf{S}^{-1}\left(\mathbf{y}-\mathbf{X}\hat{\boldsymbol{\beta}}\right)\right|^{-\frac{n+n'-\mathrm{p}}{2}}\mathrm{d}\mathbf{y}, \tag{II.5}$$

with $\hat{\boldsymbol{\beta}}$ and s^2 are being the usual OLS estimators for the parameter vector $\boldsymbol{\beta}$ and the variance s^2, as are stated below

$$\mathbf{S}^{-1}=s^{-2}\left(\mathbf{y}\right)\mathbf{S}_1^{-1},\quad \text{and it holds }\left|\mathbf{S}_1^{-1}\right|=\frac{\left|\mathbf{X}'\mathbf{X}\right|}{\left|\mathbf{X}'\mathbf{X}+\mathbf{X}_0{}'\mathbf{X}_0\right|},$$

$$s^2=s^2(\mathbf{y})=\left(\mathbf{y}-\mathbf{X}\hat{\boldsymbol{\beta}}\right)'\left(\mathbf{y}-\mathbf{X}\hat{\boldsymbol{\beta}}\right),\quad \hat{\boldsymbol{\beta}}=\left(\mathbf{X}'\,\mathbf{X}\right)^{-1}\mathbf{X}'\mathbf{y},$$

$$\mathbf{S}_1^{-1}=\mathrm{I}-\mathbf{X}_0\left(\mathbf{X}'\mathbf{X}+\mathbf{X}_0{}'\mathbf{X}_0\right)^{-1}\mathbf{X}_0{}',\quad \mathbf{X}_0\in\sim^{n'\times p},\quad n':\text{future responses.}$$

See for details Halkos (2007), Ellerton et al. (1986), and Muller and Kitsos (2004).

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Wind energy potential based on Visibility Complex Network and Recurrence Plot time series analysis

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Abstract
Renewable energy sources where wind power is an important part are increasingly participating in developing economy and environmental benefits. The present work approaches the problem of identification of the underlying dynamic characteristics and patterns through the Complex Network and the Recurrence Plots (RP) time series analysis of velocity and angle wind time series. The data were collected by cup anemometers located in a measurement tower installed in the mountains of the region Achaia, Peloponnesus, Greece. We have demonstrated that the proposed analysis provides useful information which can characterize distinct regions of the time series and also identify and detect dynamical transitions in the system's behavior. The results will be useful for the prediction of the produced wind energy.

Keywords: Non Linear Time series Analysis; Recurrence Plots; Recurrence, Quantification Analysis Complex Networks, Visibility algorithm, Wind time series

JEL Classification: C02; C22.

1. Introduction
For wind engineering the process of designing wind farms is based mainly on wind speed distribution. Site selection for the establishment of wind turbines is a complex process and it remains a challenging problem (Burton et al., 2011). The majority of research in the literature is focused on predicting and analyzing the wind speed using conventional weather prediction models (AR, ARAM, ARIMA, ANNs, SVM) (Soman, S. S. et al. 2010) which in general are characterized by the simplicity of model construction, reduced computational requirement, and accurate results for short-term prediction. In this study, the wind time series velocity has been analyzed via different time series techniques. Our analysis is based on, the recurrence plot (RP) [Marwan et al., 2007] technique and the recurrence quantification analysis (RQA) applied to the time series of wind speed (polar velocity) and direction (polar angle) treated as separated time series. Also, complex network analysis [Lacasa et al., 2008, Charakopoulos et al.,2014] is performed in an attempt to understand the wind velocity profile and to identify chracteristic regions during the evolution of the data with the same characteristics.

2. Data
The data consist of the average value every ten minutes collected by cup anemometers located in a measurement tower installed in the mountains of the region Achaia, Peloponnesus, Greece. The height of the tower is up to the hub height of the planned wind turbines. The length of the time series is 38540 values from months of March to December 2005 and stored as 10 minute averages. The wind speed time series and the mean polar speed are displayed in Fig. 1 (a,b).

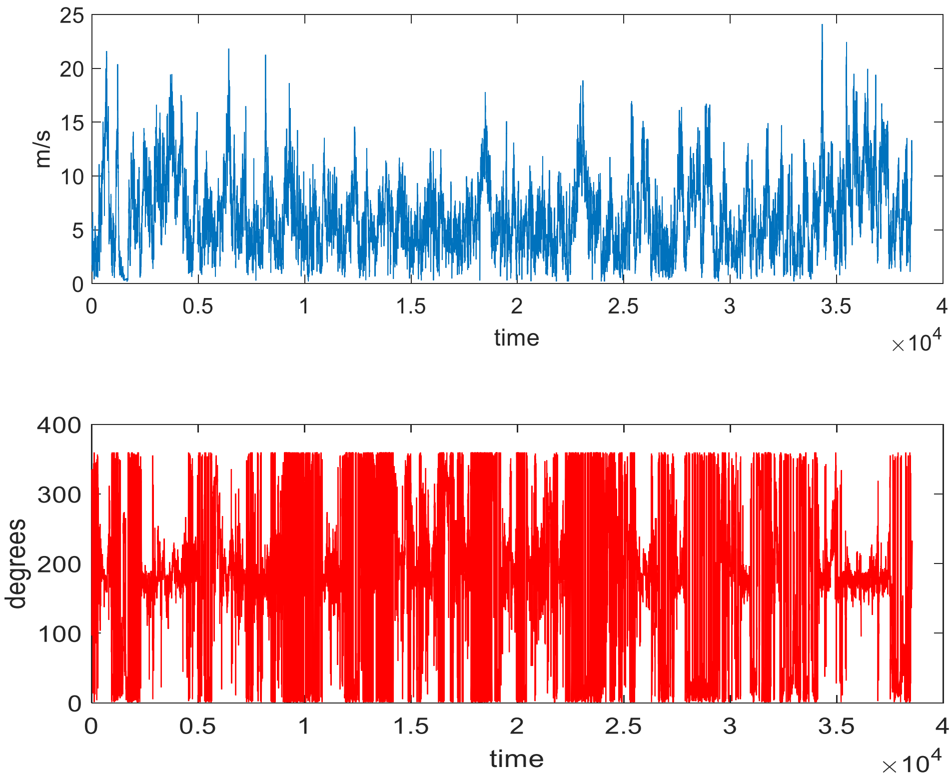


Figure 1: Time series of a) mean polar velocity in m/s and b) mean angle (degrees)

3. Recurrence Plot (RP) and Recurrence Quantification Analysis (RQA)

Recurrence analysis is an advanced graphical method for the detection of hidden correlations, patterns and to characterize the system behavior in phase space. Recurrence plot (RP) was introduced by Eckmann et al. (1987) to detect nonlinearities and chaotic dynamics in experimental data. In RP analysis, we calculate the symmetric NxN recurrence distance matrix using the following equation

$$R_{i,j} = \Theta\left(\varepsilon - \|x_i - x_j\|\right), i, j = 1,2, \ldots . N - (m-1)\tau \quad (1)$$

where ε is the cutoff distance, $\Theta(x)$ is the Heaviside function and $\|\cdot\|$ is the norm (e.g., the Euclidean norm), m is the embedding dimension, τ is the time delay and N is the length of the time series. The elements of distance matrix are the distances between all possible combinations of i-points and j-points. This means that if two phase space vectors x_i and x_j are sufficiently close, then $R_{i,j}=1$ otherwise $R_{i,j}=0$. If the distance between x_i and x_j is less than ε, then a dot is placed at (i,j) in the RP.

The patterns of the RP can identify periodic, chaotic and stochastic dynamic systems. Periodic systems are characterized by long and non-interrupted diagonals parallel lines related to period of oscillation. Chaotic systems are characterized by diametric lines with irregular distances. Stochastic systems are characterized by many individual dots with erratic distribution.

Although, the displays of distance plots are useful for improves the interpretation and exhibit distinct patterns from the system to be analyzed, however sometimes is difficult to interpret. The Recurrence Quantification Analysis (RQA) [Marwan et al., 2007, Webber et al., 1994] allows the quantification of the complex structure of the recurrence plot. The recurrence quantification analysis (RQA) measures the recurrence point density and the diagonal and vertical line structures of the RP. These features are possible to identify and quantify transitions between different states.

The recurrence variable *Determinism* (DET) measures the percentage of recurrent points forming line segments parallel to the main diagonal. The presence of these lines reveals the existence of a deterministic structure.

$$DET = \frac{\sum_{l=l_{min}}^{N} l \cdot P(l)}{\sum_{i,j}^{N} R_{i,j}} \tag{2}$$

where *P(l)* is the histogram of the lengths *l* of the diagonal lines. DET contains information about the duration of a stable interaction.

The second recurrence variable *Trapping time* (TT) is the average length of the vertical structures and contains information about the amount and the length of the laminar states.

$$TT = \frac{\sum_{v=v_{min}}^{N} v \cdot P(v)}{\sum_{v=v_{min}}^{N} P(v)} \tag{3}$$

Trapping time represents the average time that the system has been trapped in the same state.

4. Complex Network time series analysis

In the last decades, time series complex networks have gained considerable attention. The main idea is to analyze the dynamics of wind speed data through the analysis of the resulting complex networks. Time series are converted into complex networks by applying the transformation visibility graph method suggested by Lacasa et. al., (2008). We show that the network analysis provides a way to extract useful information about the underlying physical system.

In the Visibility algorithm, each value of time series is mapped to a node and each node is connected with all the other nodes that exists visibility between them. The visibility criterion can be mathematically defined as follows: two nodes $x(t_i)$ and $x(t_j)$ in the time series have visibility and consequently become two connected nodes in the associated graph, if any other data (t_k, $x(t_k)$) placed between them ($t_i<t_k<t_j$) fulfills the following constrain:

$$x(t_k) < x(t_i) + (x(t_j) - x(t_i))\frac{t_k - t_i}{t_j - t_i} \tag{4}$$

Hence, *i* and *j* are connected if one can draw a straight line in the time series joining the two points *i* and *j*, such that, at all intermediate points ($t_i<t_k<t_j$), $x(t_k)$ fall below this line. In a network mapped using the visibility algorithm each node is visible at least by its nearest neighbors (left and right). Besides that, the networks are connected and undirected. Once we have transformed the times series to a network we can calculate a number of measures for the network that can be related to the dynamical behavior of the system, for example see Charakopoulos et. al., (2014).

5. Hurst exponent

We also performed the Rescaled Range analysis (R/S) method [9], in order to calculate the Hurst exponent which is a measure of long range memory of time series. Hurst exponent of 0.5 indicates a random series, when a value of H lies within the interval 0.5<H<1 indicates persistent behavior, while a Hurst exponent value in the interval 0<H< 0.5 indicates an anti-persistent behavior.

6. Results and Discussion

6.1. Recurrence plot analysis

Fig. 2 (a) - (b) present the time series along with the corresponding RPs for the mean velocity and at Fig. 3 (a) – (b) the RP for the mean angle respectively. We can see that there are several distinct

RP pattern structures.

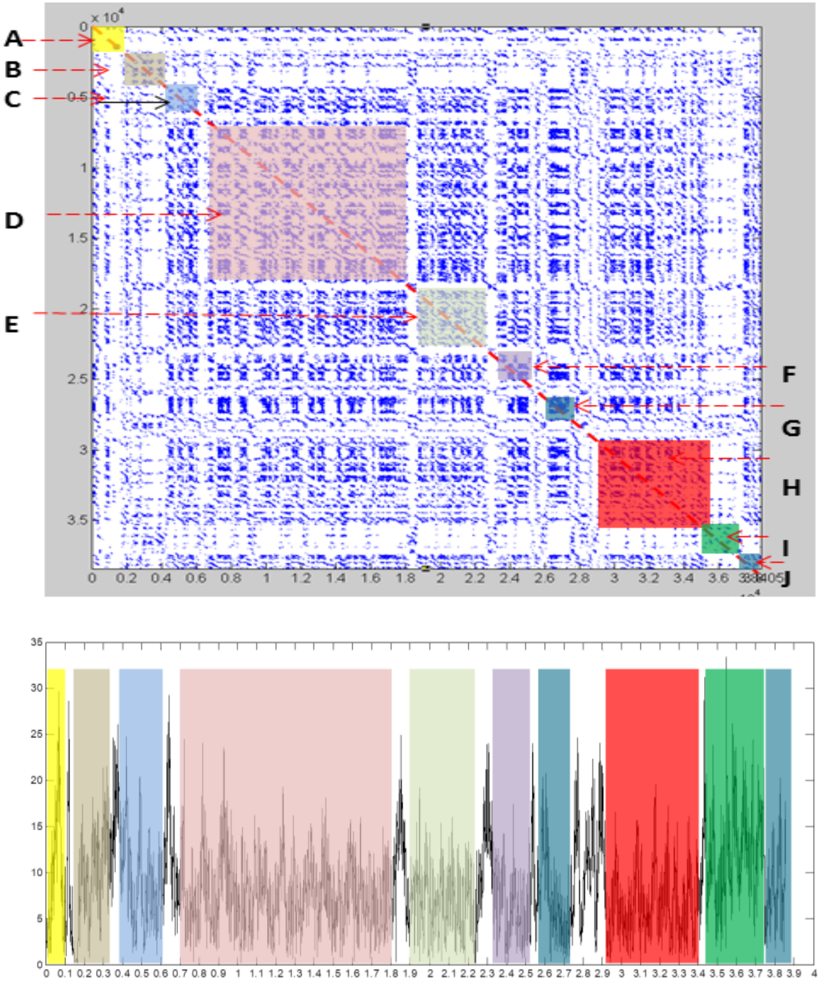


Figure 2: a) Global RP and b) time series of mean velocity

From Fig. 2 one can observe that the RP is characterized by successive blue and white rectangles, where some of these regions form regions which we call patterns. Generally we can see some small and some larger square-like patterns. More specifically between the coordinates 0 and 900 (times) the RP looks quite blue. This region corresponds to March and sketched with yellow color (A region). Next there is a white region corresponding to the peak value around 1000-1100 in time series. Then we can distinguish another pattern (B) with gray color which has almost the same statistical behavior in the time series domain. Next there appears again a white area corresponding to the peak value around 6000 to 6500.
Subsequently, we can distinguish areas (C, D, E, F, G, H, I, J) where they are separated by peak values of the time series. Each of these areas corresponds to regions almost with the same wind speed profile. Through a deep inspection of the RP we can select times at which transitions or other interesting events occur and to identify characteristic patterns.

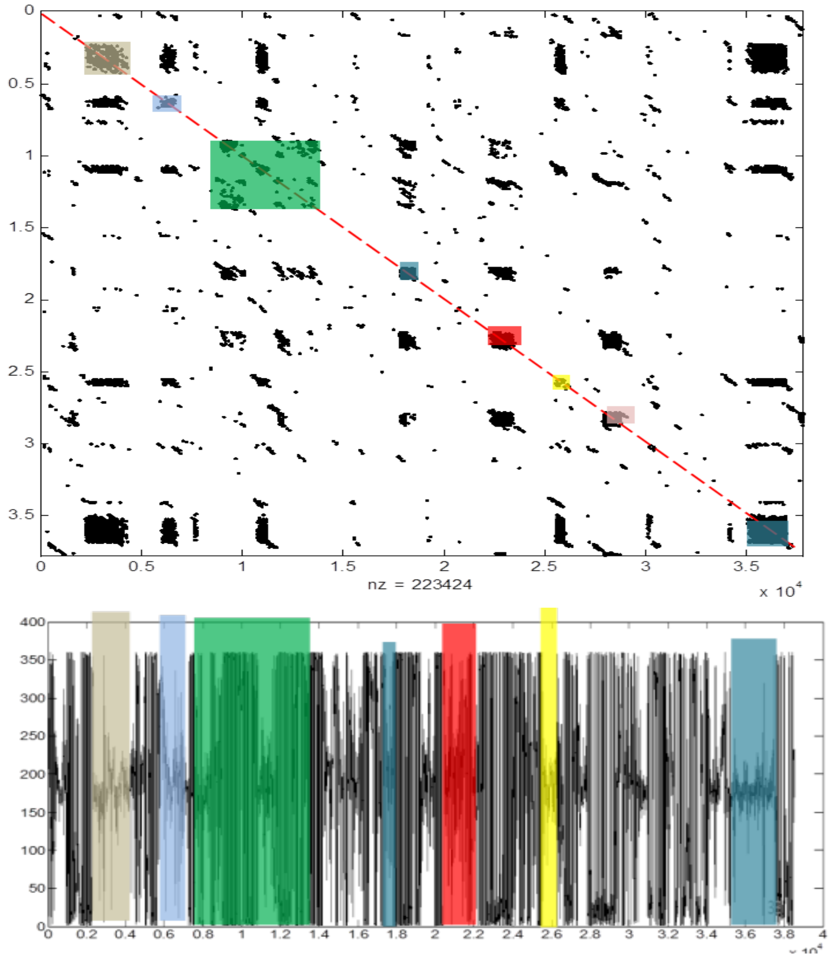


Figure 3: a) Global RP and b) time series of mean velocity

The RP of mean angle Fig. 3 (b) presents only small rectangles and is obviously less dense than that of mean angle indicating more frequent and larger fluctuations in the process.
Apart from the RPs we calculated the recurrence variable *Determinism* (DET) which measures the percentage of recurrent points forming line segments parallel to the main diagonal, and *Trapping time* (TT) which is the average length of the vertical structures and contains information about the amount and the length of the laminar states. DET contains information about the duration of a stable interaction and the Trapping time represents the average time that the system has been trapped in the same state. First we have divided the whole time series into subseries, using a fixed and a sliding window, and computed the variables in each subseries, called epoch. Each epoch consist of 288 values, corresponding to 2 days and shifted by 10 values (sliding window). In this approach DET and TT variables are computed for successive windows. Fig. 4 presents the results of the performance of Determinism and Trapping time measure. From a general point of view we can detect almost the same behavior of DET and TT. In the same figure the month's period are displayed with different colors.

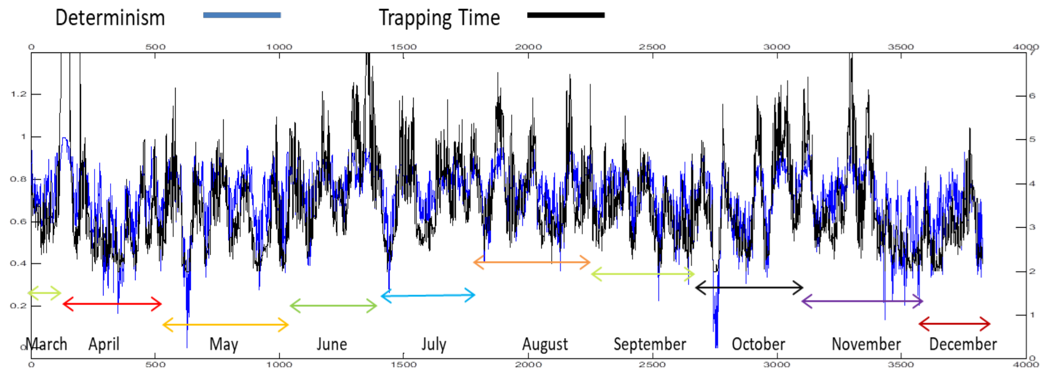


Figure 4: Determinism (blue line) and Trapping time (black line) measure of wind speed time series using RQA analysis.

A first overview of Figure 4 indicates that Determinism and Trapping Time present peaks at the same time recorded during evolution of the time series. Also we first calculated the exact position of the peaks, and then the time duration between the transitions from one state of the system to other using the determinism measure. In Fig. 5 we present the results of time intervals in days using Determinism measure and also the month's period. From this figure it can be seen that there exist two groups of time intervals. One with values in ranging from 2 to 4.5 days and another with values ranging from 5 to 8.5 days. The results indicate that the computation of recurrence features for each epoch reveals information about the changes in state inside the whole time series.

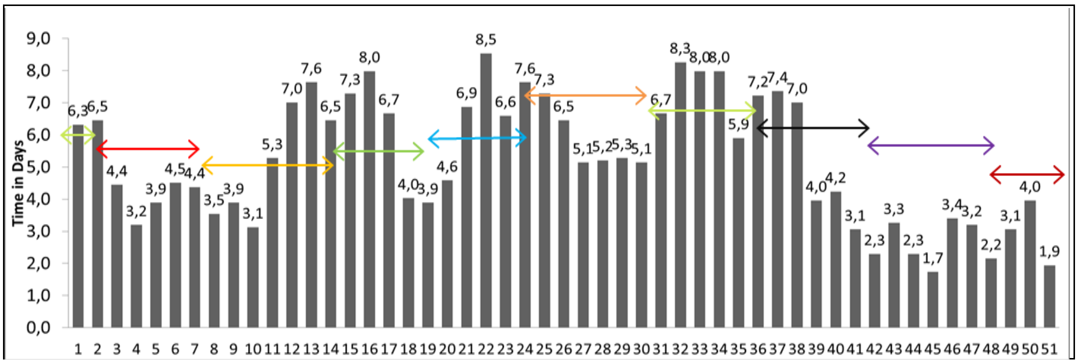


Figure 5: Time interval between peaks using Determinism measure of wind speed time series.

6.2. Complex network analysis

We divide the wind time series into segments (M1 to M9) with a period of one month and then each time series is transformed into network using the visibility algorithm and the degree distribution are evaluated. Each time series consists of 4275 values. The initial time series and the segments are displayed in Fig. 6.

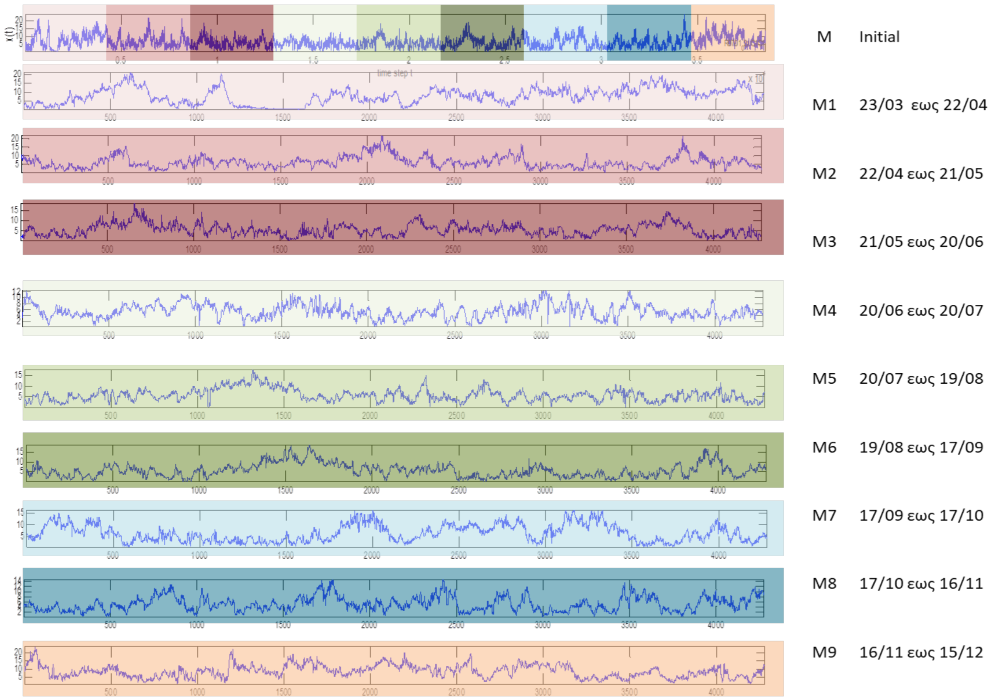
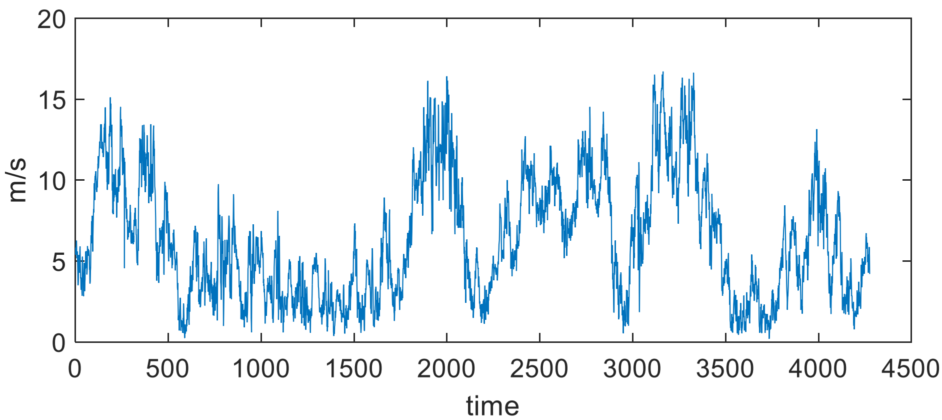


Figure 6: Initial and segment time series of wind speed data.

An example of representative constructed networks illustrated in Fig.7.



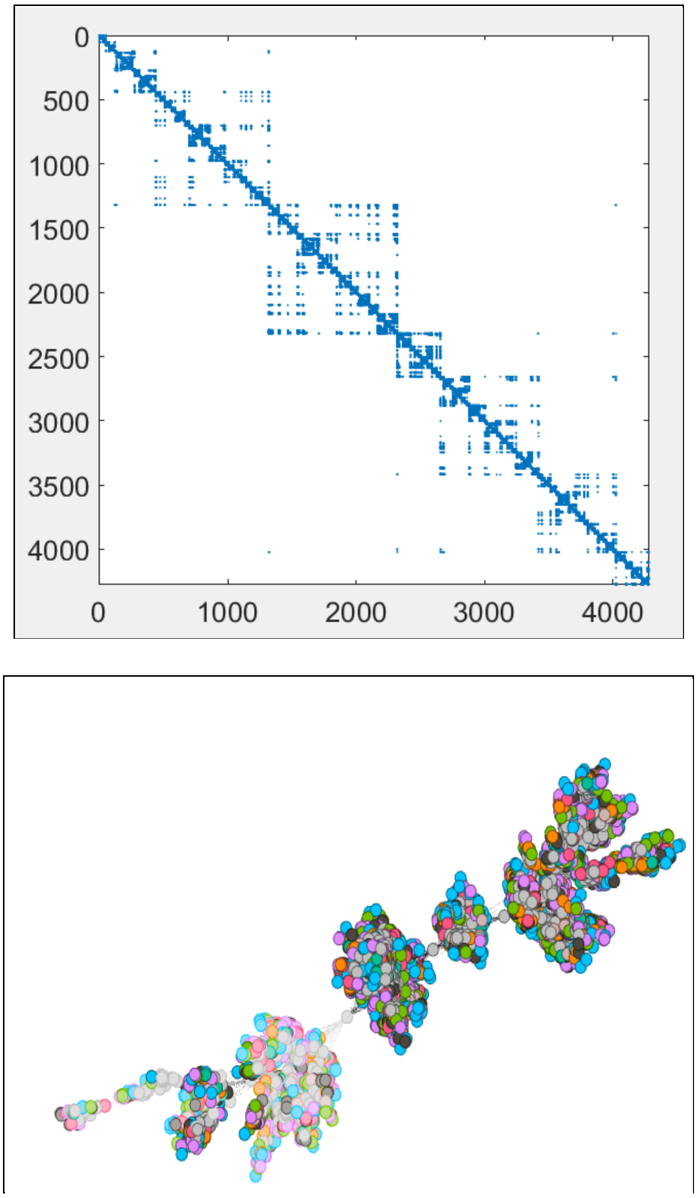


Figure 7: a) Time series b) adjacency matrix and c) network graph generated for a segment time series (M5).

We have estimated the degree distribution of each network generated from time series (segment) and we compared with the Hurst exponent *H*. The visibility graph network of a time series has a power law degree distribution $P(k)=k^{-\gamma}$ and is characterized as a scale-free network. Fig. 8 presents the degree distribution of M5 time series.

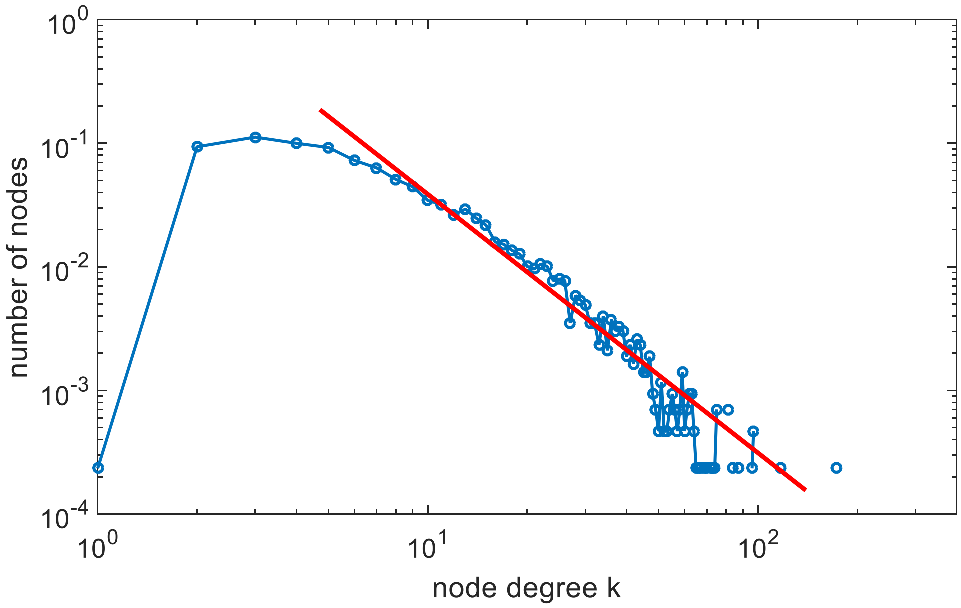


Figure 8: Degree distribution of network from M5 time series

We can observe that the network present a power law tail $P(k)=k^{-\gamma}$ distribution for k>100 with a power exponents γ~2.52. The results of power-law exponent γ and Hurst exponent for time series are summarized in Table 1.

Table 1 Power – law exponent γ and Hurst exponent

	M1	M2	M3	M4	M5	M6	M7	M8	M9
γ	2.19	2,22	2.52	2.68	2.43	2.36	2.31	2.48	2.39
H	0.93	0.9	0.89	0.85	0.89	0.93	0.95	0.86	0.93

In Fig. 9 the results of Power and Hurst exponent are shown for each time series.

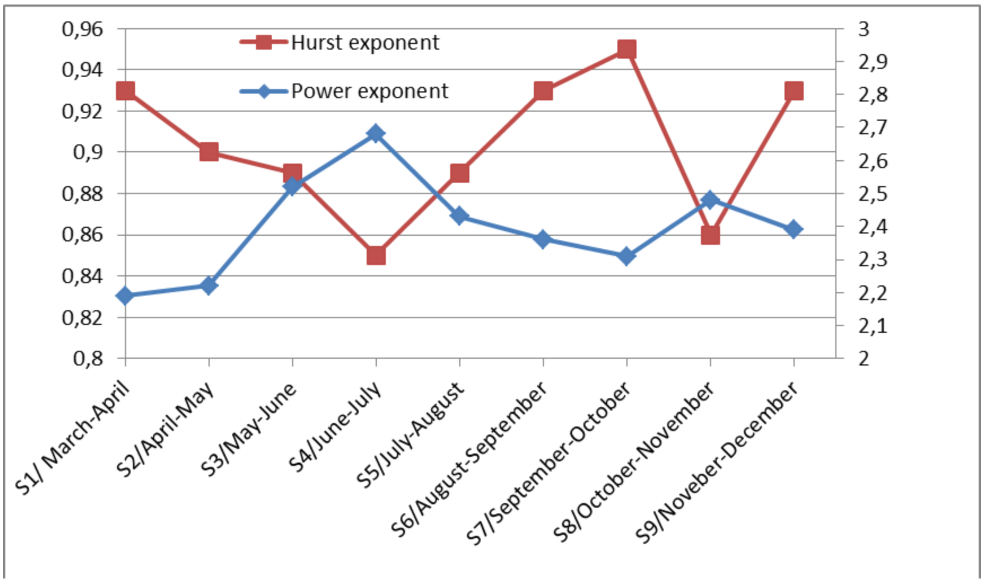


Figure 9: Hurst exponent H and power-law exponents γ for each time series (segment).

As we can see from Fig. 8, Hurst exponent H of time series the values are close to 1 indicating persistent behavior. We can also observe that the power-law exponent γ and the Hurst exponent are negative correlated which is in accordance with recent researches who present that there is a linear dependence between the above measures.

7. Conclusions

Since site selection for wind farm requires consideration analysis of wind profile, the present work approaches the problem of identifying different regions and pattern of wind speed data through the recurrence plot and complex network time series analysis. We have demonstrated that the structures of the RP contain useful information which can characterize distinct region to the time series. Also the results imply that quantification analysis reveals the underlying time series dynamics and we can exhibit characteristic time interval which are caused by the typical dynamical behavior. The complex network methodology has shown that the visibility graph analysis provides an alternative way to extract information from time series. The performance of combinations of the two main methodologies described could be promising for a better understanding of wind speed system complexity.

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The economy of the packed products' oxidation process

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Abstract
This present work introduces an illustration of natural phenomena and quantification of the natural factors involved, based on a direct analogy between their evolution processes to an oligopolistic competitive environment. In particular, the authors aim to deal with "oxidation processes" as such production sites that use ("consume") the "raw materials" (oxygen molecules) according to their incoming production capacity (oxidation potential): the imported commodity (oxygen), the recipient companies operating in a limited market (oxidation substrate) and the determinant factor that resembles borders, affecting the size of the productive activities of the overall market (packaging as a the controller of the incoming goods) and the related by-products, such as the cost of production resources, that are directly related to the activation energy requirements of these reactions occurring positions and the availability of the raw materials. Therefore, describing natural phenomena in a stochastic mathematical way will allow the use of those fundamental elements of statistical physics to integrate deterministic processes (and quantities) into a micro-scale. It is the opinion of the writers, that the innovation of this work is the use of economic laws for the world of natural phenomena, against the, commonly used and generally accepted, inverse process.
Keywords: natural phenomena, oligopolistic competition, stochastic mathematical modeling, statistical physics.
JEL Classification: E27; F12; C18.

1. Introduction

Within physical science, i.e. the process of studying, explaining and generalizing the physical laws of nature's phenomena, a great deal of interest is in defining those phenomena in question, as well as the broader, yet intermediate world or system, where the phenomena exist and evolve. By focusing on the system's principal properties, it would be possible, eventually, to build knowledge-based evidence in generalized universal terms, avoiding a rather incidental image of the momentarily presented inertia of the system's complexity. Issues related to the nature of determinism, such as how we understand that something is a cause of any phenomenon, the limits of determinism and the structure of scientific explanation, is what constitutes a scientific answer when we put the question "why" instead of "what" (Weber, 1904, Wittgenstein, 1953).

Usually, advanced mathematical models have been developed in parallel to experimentation methodology to establish a predictive behavior according to the experimental parameters. Either quantitative descriptions of the phenomena or general predictions may be applied using direct and simple or mechanistic models, respectively. In any case, modeling provides great opportunities as a powerful research tool.

This work aims to propose an approach regarding the description of phenomena occurring in the physical world in terms of economic terms. This analysis is based on an analogy, defined herein, between physico-chemical quantities and the economical ones. Furthermore, this analogy targets to a relative analogy between the fundamental principles governing the quantities in question. As a case study, this work uses oxidation of packaged olive oil to apply the idea and mathematically describes a methodology for predicting, hence, managing the behavior of the system, according to its natural economic trends.

2. System and Process: The olive-oil oxidation

The oxidation of oils has been among the most studied phenomena in the food science sector, mainly due to the significant impact of the oxidation byproducts on both sensorial and health status of goods and consumers. The process is initiated at the presence of oxygen, which, when reactive enough, interacts with a susceptible (based on the degree of unsaturation in the chemical chain) fatty acid on a triglyceride. As a consequence, a double or a triple bond of the fatty acid will break and the resulting two parts of the initial molecule will become free fatty acids, due to electrons availability in their structures. These primary oxidation products are (odorless and flavorless) mono-hydroperoxides that are precursors of unpleasant odors and flavors developing in oils, thus diminishing the quality of the olive oil. (Labuza, 1971, Kochhar, 1993, Morales et al., 1997, Crapiste et al., 1999).

Based on the oxidation conditions, i.e. oxygen energy level, reactivity with the free fatty acids, degree of unsaturation, temperature, light, etc., variety of hydroperoxides can derive from the corresponding fatty acids. These initially formed monohydroperoxides function as intermediate oxidation products. Mainly deriving from the mostly unsaturated fatty acids, they have a significant contribution to the overall oxidative degradation. Following that, oxidation reactions will progress towards the free fatty acids of the next saturation level, up to completely saturated fatty acids which seem to be oxidized more difficult, yet, potentially simultaneously to the previous ones.

A chemical rearrangement of the various unsaturated fatty acids, leads to a variety of off-flavor compounds, including volatile aldehydes and vinyl ketones of low sensory threshold, hence of high impact to products' sensorial quality. Such rearrangements follow either the so called "scission A" pathway, witch may result in the formation of an unsaturated aldehyde and an alkyl radical and a vinyl radical when reacting with a hydroxyl radical and a tautomerization of the deriving 1-enol to the corresponding aldehyde, or a "scission B" pathway that may yield a vinyl radical and a saturated aldehyde compound. Which pathway shall dominate depends on the oxidation state of the oil, temperature, oxygen pressure, the presence of pro- and antioxidative catalysts, and other factors. Additional volatile oxidation products arising during oxidation are susceptible to further oxidation that gives rise to additional off-flavor compounds. Furthermore, nonvolatile secondary oxidation products identified in oxidized oils, may decompose towards additional volatile products, influencing the flavors and odors of oils at later oxidation stages.

In the case of packaged products, the influence of the packaging material, the environmental conditions and the time of storage have a significant role in the retention of their quality. Besides the oxidation progress parameters related to the polymers' barrier properties should be taken into consideration in order to better estimate the impact of food-package interactions on the shelf-life of the product. Modeling, in this frame, may contribute in partly replacing a very time- and effort consuming experimental investigation, (Crapiste et al., 1999).

This work considers the food-packaging-environment system where there are three distinct areas of interest, including their overall interactions at the interphases of the system. Additionally, the food phase, being the most reactive and thus influential phase, due to the final impact on overall sustainability of quality, will be the major focus of applying the analysis.

The scope is to adopt the appropriate economy theory's relevant descriptors in favor of the oxidation process unveiling. We wish to target the physical phenomena of oxidation from an economic system operations' point of view for to assist, through the most justifiable correlation, towards a better understanding of the systemic behavior of oxidation susceptible packed perishable good.

3. Application of economy on physical phenomena

Within the food products, a particular food matrix, consisted of a number of constituents creates an oligopolistic competitive environment for those oxidation-susceptible components that may naturally, hence, unforced consume the oxygen sources in order to produce the oxidation by-products. That provides an added value for the available oxygen species, which leads to their unequal interchange among the system's participants. Similarly to any other commercial activity, there is a cost of transport, a demand vs. offer ratio and a commerce balance among either side of the packaging materials, for one or multiple resources involved.

Similarly to any economic system, in the case of the packed food system, we may also distinguish the steady and variable economy factors (Permeability), which, for simplification reasons may be defined by the demand and availability ratio (ΔP) and they may be limited to restrictions on raw materials in time (Oxygen flux – Q/t), as well as the restrictions on the cost of operations, i.e. the available energy (E_a) for producing the by-products, utilized via the corresponding exposure, temperature levels.

Then, these essential to production factors and their values' variability within each market possesses a strong determining role on the produced (by-)products distribution rate (defined as income restrictions). In specific, for the liquid oil matrices, the competition for oxygen among the oil's triglycerides shall define the oxidation rate, hence the oxidation (by-) products evolution according to the number and type (sensitivity to oxidation) of these triglycerides expressed via their "reaction cost value", (see, Kanavouras et al., 2004a, Kanavouras et al., 2004b, Kiritsakis et al. 2002, Coutelieris and Kanavouras, 2005, Kanavouras and Coutelieris, 2016).

In order to form our hypothesis, we shall consider the following systemic participants as economic participants:

Food phase: the overall economic area of interest.

Triglycerides: the particular "companies" forming an oligopoly state in the economic area, which are utilizing and competing for the same raw materials.

Free fatty acids: as the activities (type of production) within the production sites per market, utilizing the same raw materials.

Reactions' activation energy: the reciprocal of the price that companies are willing to pay in order to get the raw materials, i.e. the lower the activation energy the more the raw material they can get.

Oxidation potential: the overall production capacity of the market, per final product, at a given raw materials' availability.

Activation energy: the price payed per company for raw materials.

Oxidation rate: the overall production over time.

Shelf life: the time at which the production of products just exceeds their demand.

Hydro-peroxides: the various crude semi-final products deriving from free fatty acids.

Off-flavor compounds: final products produced for the overall economy.

Antioxidants: antagonists in same market, same raw materials.

Packaging: the borders (i.e. laws, regulations, logistics limitations, etc) between the oligopolistic environment's active sites and the external environment.

Packaging barrier properties: the imports restricting policy applied for the specific economy.

Permeation through packaging: the demand for raw materials.

Permeability coefficient: the amount of raw materials entering the economy per unit time, through certain borders, when demand is in equilibrium.

Equilibrium: the state at which, the amount of raw materials entering the borders equals the raw materials utilized by the economy, designating no accumulation of unused raw materials.

Oxygen flux: the rate of oxygen species entering through the packaging wall.

External environment: the raw material – oxygen – source, being in excess.
Oxygen species: the imported raw materials, needed by the production sites.
Temperature and light energy: production contributors.

In order to work towards this hypothesis, we need to set the following assumptions:
All types of triglycerides are constantly and simultaneously present within the food matrix.
The food matrix "collapses" when the first triglyceride is consumed.
The amount of the oxygen species in the external environment, possessing the potential to arrive at the food matrix, is unlimited.
The activation energy per triglyceride may differ among each other.
The packaging material remains unchanged in composition, shape and size.
The capability of the system to contain the final products is unlimited.

Through the above descriptive approach, the oxidation process is proposed to be perceived as a function of oxygen "commercialization"-"importation", from an excess environment towards a limited "market", through the "borders" of packaging. A committed to oxygen utilization "market" requires the imported "goods" so as to produce the semi-final products, as those shall be determined in space and time via productive capability of the particular sites within the food matrix. Semi-final products will be further "re-assembled" into the final products that shall determine the "quality" of the matrix based on justified consumers' perceptions.
Further down to this approach, in regards to the description of the overall matrix-economy, a food-pack system has a production capacity using either moveable or special production contributors, as they are defined by the income goods' distribution. In the case of oxidation that might be due to the oxygen's efficiency utilization contributors of temperature and light energy for a given specialization level represented in the structure of the matrix (e.g. free fatty acids saturation level/amounts, antioxidants).
Our working hypothesis, is based on treating the "reaction sites" as oxidation-production sites, which use and consume the "raw materials" (oxygen molecules) according to their incoming capacity (oxidation potential), being defined as the "cost of production resources", i.e., the oxidation activation energy requirements and the availability of raw materials.
On that base, the overall output is given by the following mathematical relationship against our hypothesis:

$$Q = S\left[\frac{1}{n} - b(P_i - P_m)\right]$$

where:
Q = the oxidation potential
S = the overall oxidation rate
n = the amounts of highly unsaturated triglycerides
b = a constant, representing the reaction of the oxidation rate against the changes of the P_i value
P_i = the activation energy of a particular triglyceride
P_m = the mean value of all the activation energies among all others' competitive triglycerides.

The demand function and the cost function are identical, though they produce or trade slightly different products. The overall product oxidation may then be defined by knowing the total amounts of triglycerides and the activation energy each one of those is demanding for to produce the oxidation by products.

If all the production sites charge the same "price" for their by-products, then each one will have a share of 1/n in the food matrix market. The one charging more will have the lower share and vice versa. The overall situation "S" remains unaffected by the average price.

In the end of the day, the overall oxidation level of the system, may be described, not necessarily on the detailed enumeration of the particular characteristics and trends of each and every production site. All we need to know is the number of the production sites and the price each one is charging per by-product.

Based on those production factors, an oxidation-by-products production capacity curve could be shaped, particular per system. In such representations, the minimum required "labor"/produced by-products shall define the productivity of the system, based on the fact that the products are produce where the "labor" required is cheaper, as a function of the relevant "technology" needed (reaction mechanisms according to the specialization structure). A prediction on the productivity reaction of one site may also be determined, based on the curve representing the amount of energy per by-product produced.

4. Conclusion

The present work hypothesis wishes to introduce a rather novel, for the natural sciences research, approach by engaging market economy theories into the field of physical processes' modeling. In order to do so, we have tried to establish the external similarity among a market and a physical phenomenon, given the natural trend for stable and more cost-efficiency systems. We have selected the food-packaging-environment system as a representative in-process-out evolution. We have also tried to establish certain boundaries within which we expect the similarity to by highly significant. Following our analysis, we have foreseen a rather significant similarity level among markets and oxidation. Therefore, we are placing a great trust towards exploring the strengths and benefits of transferring the economic theory rules into a physical phenomenon process, mainly for enriching the current points of view regarding the oxidation process.

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Assessing the sustainability of renewable energy sources with the combination of life cycle and SWOT analyses

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Abstract
The production and consumption of energy, as well as the environmental problems that arise, occupy a prime interest for all states on a global scale. The adoption of a policy towards green energy has been greatly improved, but it has to become more concrete. This study will assess various renewable energy sources using life cycle analysis (LCA) and SWOT. Applying life cycle analysis to a product enables the optimization of raw materials, energy and environmental impacts. Similarly, implementing a life cycle analysis on renewable energy sources can highlight the most environmentally friendly source of energy. Simultaneously, the SWOT analysis shows positive and negative elements and as a result, it helps in preventing strategic planning errors for energy production. The combination of these two analyses helps decision-making, strategic planning and environmental management as regards the choice of the most appropriate renewable energy source.

Keywords: Life cycle analysis, SWOT analysis, energy sustainability, renewable energy, energy policy.

JEL Codes: O13, P18, Q28, Q48, Q58, Q01, Q29, Q42.

Introduction

Due to global climate change and unstable economic growth, the energy production model has shifted from conventional sources to renewable energy sources (RES). The importance of a change in the policy strategy for energy policy, first emerged in the Kyoto Protocol negotiations (1997) and continues to date, at the last conference on climate change in Paris (2015), where the guidelines were laid down in the area of reducing the (CO_2) and the development of the green economy (*European Council*, 2018).
According to the REN21 annual energy report in 2017, the global Renewable Energy power approached its highest energy ever, which was estimated 178GW, increasing its global installed capacity by 9%. The installed capacity of renewable systems worldwide is 2,195 GW, with a total investment capacity of more than 300 trillion dollars (REN21, 2018). These goals could not be achieved, if there were no clear sustainability goals but also economic incentives that would provide guidelines for energy policy in the private sector (*Rahmatallah et al.*, 2018, *Mihaylov et al.*, 2019). Renewable energy is also beneficial by state governments, because through their perpetual energy production and abundance, they provide energy security and

independence (*Hannan et al.*, 2018, *Gao et al.*, 2018). The energy mix, as the quantity and choice of the right source of energy are selected by each state, shaping its national policy, which takes economic, technical, social and environmental impacts. Production and consumption of energy is the most important source of gas emissions (*IPCC*, 2014; *Eurostat*, 2017). Therefore, with resale in the business sector, products, which were produced by using renewable energy sources, offers to the commodity a sensitive component, which is presented in the form of an eco-label (*Prieto-Sandoval et al.*, 2016). The same comparison can be made to renewable electricity generation systems through life cycle analysis (LCA).

Life Cycle Analysis and SWOT Analysis

Life Cycle Analysis (LCA) is a technique that compares and analyzes the environmental impacts, which are generated by the construction of a product and the processes that accompany it. It is one of the most remarkable tools for assessing viability, since it counts energy loads, raw materials used and pollutants in every form of recipient. Finally, it can calculate the extra charge that a product may produce at the end of its useful life.
The study of the LCA focuses on the analysis of input and output elements and on the generation of mass and energy balances. Therefore, the LCA evaluates the environmental impact of a product or activity through energy, raw materials and waste generated. Based on the rational use of resources and energy, environmental improvements can be proposed. In order to fulfill the LCA, there is a framework of methodology, which consists of four stages that interact with each other and are the followings: (i) *Identification of purpose and object of study*, (ii) *Data recording*, (iii) *Impact assessment* and (iv) *Analysis of results* (*Mussiopoulos et al.*, 2015; *Rebitzer et al.*, 2004).
The first step determines the subject of the survey and the boundaries of the system. The second step is to analyze and measure the flows of energy, materials and pollutants throughout the life cycle. In the third stage, previous flows are presented and categorized on the basis of global environmental problems such as global warming potential or ozone depletion. In the fourth and final step, the concluding analysis and finding improvements is made (*ISO*, 2006).

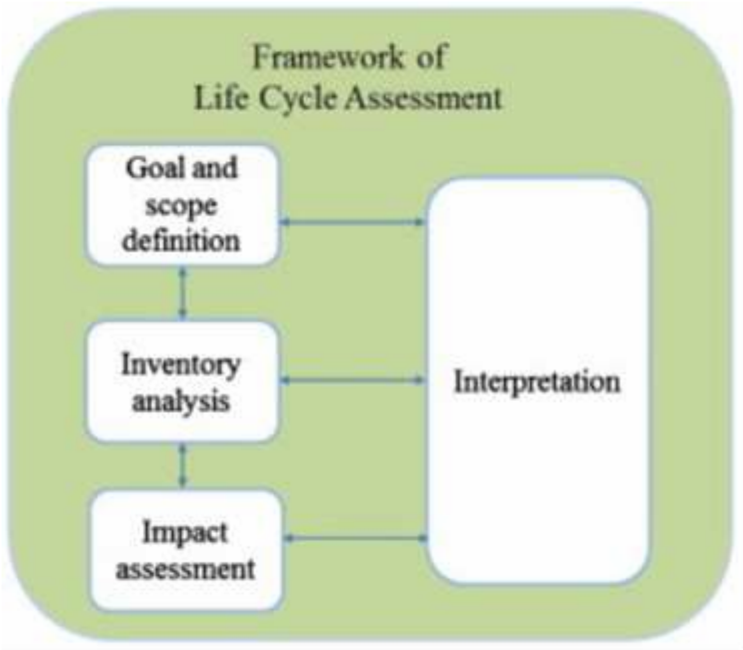

Figure 1. Life cycle analysis methodology framework (*Peng et al*., 2013)

In recent years, life cycle analysis has been used to compare the energy produced and the environmental performance of RES and new technologies. In order to make such a comparison, the terms (i) *energy payback time* (EPBT) and (ii) *greenhouse gas emission rate* (GHGe-rate) were used and defined by equations (1) and (2) (*Bhandari et al*., 2015).

$$\text{EPBT} = \frac{\text{Emanuf+ Eas+ Etran+ Einst+ Eope+Emaint+ Eend-of-life}}{\text{Eoutput}} = \frac{\text{Einput}}{\text{Eoutput}} \tag{1}$$

$$\text{GHGe-rates} = \frac{\text{GHGe-total}}{\text{Elca-output}} \tag{2}$$

Where E is the total energy required for the construction, assembly, transport, installation, operation, maintenance and management at the end of the useful life of the RES system being studied, in the order which is shown on the numerator equation (1). The term Einput refers to the sum of the previous terms and is measured in (MJ or kW), as opposed to Eoutput, which is the annual energy output and the unit of measurement is (MJ / year or kW / year). Also, the term GHGe-total refers to all emissions that have taken place throughout the life of the RES system and is measured in (g CO2-eq) and the term Elca-output is the energy produced during the lifetime of the RES system and is measured in (kWh). Although LCA is an excellent tool for measuring sustainability, it also has some drawbacks that are presented in the SWOT analysis (Strengths, Weaknesses Opportunities, Threats) of Table (1).

Table 1. SWOT Analysis for LCA

Strengths	Weaknesses
LCA production offers new jobs Reduction of environmental footprint in a process Reduce the cost during production Strengthening sustainability Enhance product competitiveness Enhance environmental diplomacy	High cost of LCA design Lack of attention to environmental impacts by businesses, while putting more weight on energy efficiency Lack of comprehensive databases The presence of gaps in databases Frequent use of hypotheses Time consuming process Databases are not approved
Opportunities	**Threats**
Important tool in decision making Participation in the strategic planning of a business Contribute to choosing appropriate policies Opportunities for training and education There is no need for infrastructure to produce LCA, such as laboratory instruments. Great prospects for research and education Conservation of natural ecosystems and effort to reduce negative impacts	Although LCA is an old technique, it has little impact on businesses Difficult financing in the current economic environment Limited data provision due to confidentiality issues LCA is usually done by large companies as the cost is great for a small business It does not lead to a single result and can be misinterpreted

Life Cycle Analysis on Renewable Energy Sources

Greenhouse gas emission rate

LCA can be applied to RES and give the environmental profile of each power generation system. The application of LCA to RES was discussed in the reviews by *Varun et al*. (2009), *Amponsah et al.* (2014) and *Turconi et al*. (2013) and are presented in Table 2. However, there are other reviews that individually review RES using LCA. For geothermal energy it is considered the work of *Tomasini et al*. (2017), which analyzes four geothermal energy systems with a range of 18.3 to 62 g-CO_2 / kWh. For photovoltaics, reviews that are considered are *Sherwani et al.* (2010), *Peng et al.* (2013) and *Wong et al.* (2016). As for the heat-concentrating systems, it is considered the work of *Lamnatou and Chemisana* (2017). Cumulative-thermal systems are parabolic mirrors or solar towers, which take advantage of the heat of the sun to produce electricity. Photovoltaics may range from 43 g-CO_2 / kWh for thin film photovoltaic to 671 g-CO_2 / kWh for monocrystals. In contrast, aggregate systems are less polluting, showing a range of 40 to 50 g-CO_2 / kWh.
Wind energy is extensively reported in the study of *Kaldellis and Apostolou* (2017), where there is a comparative assessment of wind systems between on and off shore. This study states that the emissions of onshore wind systems are less than the equivalent offshore of about 57%. The study data shows 15.6 g CO_2 / kWh for offshore wind systems and 9 g CO_2 / kWh for onshore wind systems.

For hydroelectric power, carbon dioxide (CO_2) emissions have a wide range of values, due to various scale and technical applications. In the work of *Raadal et al*. (2011), for the exploitation of hydroelectric power are reported projects with reservoirs and without, as well as projects with different scale. In conclusion, the projects with a reservoir ranged from 4.2 to 152 g-CO_2 / kWh, while the energy exploitation without a reservoir ranges from 0.3 to 13 g-CO_2 / kWh.
Exploiting energy from biomass, as suggested in the study by *Muench and Guenther* (2013), is more complex. By biomass, we refer to any kind of organic substance that burns and delivers energy. This includes combustible materials such as wood, residues from agricultural processes, lignocellulosic crops, crops containing oils, ears and even waste. Fuel type, combustion techniques - such as single-fuel or auxiliary – and as well as the type of burner, affect the emission of greenhouse gases. The worst emission scenario is calculated (after conversion of units) to 1084.94 g CO_2
/ kWh and best to 243.79 g CO_2 / kWh by the pyrolysis technique (*Sebastian et al*., 2007; *Faix et al*., 2010).

Table 2. LCA on RES

Writters	Solar (g-CO2/kWh)	Wind (g-CO2/kWh)	Geothermal (g-CO2/kWh)	Hydroelectric (g-CO2/kWh)	Biomass (g-CO2/kWh)
Amponsah et al. (2014)	9.4-300 91.1	1.7–123.7 34.2	11-78 31.9	2-60, 20	14.4-650 88
Varun et al. (2013)	53.4-250 146.3	9.7-123.7 36.4	-	3.7-237 65.8	35-178 80.16
Turconi et al. (2013)	13-190 122.5	3-41 27.5	-	2-20 9.5	8.5-310 69.25

Note: in the bottom right diagonal box, is the average of the values

Energy payback time (EPBT)

Another element that influences the environmental profile of an energy system is the energy payback time (EPBT). For photovoltaic systems, as reported in the study by *Bhandari et al*. (2015), it ranges from 1 to 4.1 years, with cadmium tellurium photovoltaic cells (CdTe) having the fastest energy payback time and monocrystalline photovoltaic cells are the slowest to pay off the energy required for their construction. The concentrator-heat systems have EPBT 1 to 1.4 years, superior to the photovoltaics (*Lamnatou and Chemisana*, 2017).
Wind energy is pioneering in the energy payback time of the investment. Offshore wind energy systems range from 10 to 11 months, while land-based systems from 5 to 6 months (*Haapala and Prempreeda,* 2014; *Bonou et al.*, 2016). Continuing with hydroelectricity, which is said to be able to exploit with or without barrier, it is likely to have an energy payback time of about 0.5 to 1 year with barrier and 1 to 1.3 years without barrier (*Varun et al.*, 2010).

Biomass energy systems and geothermal systems are significantly dependent on the

performance of its system and a relatively stable energy payback time figure cannot be readily available. Geothermy, among other things, depends greatly on the location. According with Gonzalez (2017) the energy that is needed for drilling the well can be paid back in 1,8 months. The state of biomass exploitation is, also, complex. The requirements for burning new biomass needs new crops and new means of transport to be created for the service itself. Also, the biomass combustion factory cannot have stable performance and neither stable fuel quality. Another drawback is at the end of its life, as biomass can either be recycled or exploited otherwise. All of these parameters hinder the calculation of the energy payback time. However, assuming some parameters such as constant supply, not considering the transport energy of the fuel at the point of production, etc., the EPBT is calculated in 9 to 12 days as they claim in the application studied by *Weissbach et al*. (2013). Another example is the exploitation of biomass in Mongolia returning the invested energy to
3.2 years (*Wang*, 2015).

Capital and operating costs

Capital and operating costs are another factor, perhaps the most important for choosing the most appropriate RES in strategic planning. The International Renewable Energy Agency (IRENA) report for 2017 quotes sales prices as well as market trends for all RES. Photovoltaics in Europe recorded a fall of 83% between 2010 and 2016. By mid-2017, the frame price reached USD 0,3 / W (*Exawatt*, 2017) (USD in 2016).
On the other hand, aggregated systems, due to their number of technologies and storage units, range from USD 2550 / kWh to USD 13150 / kWh. Maintenance costs are calculated at USD 0.04 / kWh. Subsequently, dealing with wind energy, it is observed that for an average wind turbine, the smallest value was observed in 2002 in the United States with USD 800 / kW. Data from 2017 indicates that a global wind turbine is sold at about USD 1000 / kW. Operating costs on contracts with maintenance companies between 2008 and 2017 ranged from USD 22 to 44 / kWh.
The next RES that is being discussed is hydroelectric power, whose fixed cost depends mainly on technical works by up to 90%. Fixed costs for the use of water were rising by 2016, and a steady course in 2017 at the price of 1558 USD / kW. The operating cost per year varies according to the capacity of the installation. The US Energy Information Agency calculates the operating cost of 0.06% of the fixed cost plus USD 0.003 / MW (*EIA*, 2017). An average operating cost for high capacity projects is USD 20 - 60 / kW / year (*IPCC*, 2011).
Bioenergy has a wide range of prices due to the different forms of marketable biomass. Fixed prices range from USD 500-2000 / kW for simple burners, while for fixed bed gasifiers the prices are between USD 2000 - 7000 / kW. The operating cost is relatively small with USD 0,005 / kWh. Lastly, reference is made to geothermal energy. A typical geothermal system ranges between USD 2000-5000 / kW and has an operating cost of about USD 110 / kW. These values can be supported in the study by *Dale* (2013), which compares the cost base of various RESs excluding geothermal, biomass and hydroelectric power.

SWOT Analysis on RES

Life cycle analysis shows the environmental profile, energy requirements and costs are the main factors for finding the most appropriate RES. However, there are parameters, that need to be emphasized, such as job creation, social support for a specific RES, etc. At the same time there are weaknesses, threats and failures in the realization of RES projects. The qualitative analysis of all these components can be achieved by SWOT analysis for the production of energy from each RES separately (Tables 2 to 6).

Table 2. SWOT Analysis for solar energy

Strengths	**Weaknesses**
Low dependence on topographic features The maximum daily photovoltaic electricity production is in line with the maximum daily electricity demand of the grid There is a variability in the capacity of a photovoltaic system, covering also individual household energy needs Low maintenance costs Ability to hybridize with other systems	Occupation of large area compared to another RES Higher cost compared to wind Long wait for economic achievement of the dead end Daily and seasonal production disproportion
Opportunities	**Threats**
Wide use of financial incentives Possibilities to increase the efficiency of photovoltaics Creation and development of new solar energy systems such as Parabolic mirrors with Stirling engine. Due to topographical independence they are used in a variety of applications (drilling, lighting, etc.) Development of energy storage technologies High interest from investors	High toxicity during the manufacture of photovoltaic cells Difficult management at the end of their life / difficulty in recycling If the photovoltaic cells are not of silicon origin, rare elements such as Gallium (G), Indium (In) Tellurium (Te) etc. are required.

Table 3. SWOT Analysis for wind energy

Strengths	**Weaknesses**
Low area requirement Low cost There are no genotoxic effects at any stage of the wind turbine life cycle Hybridization with other power generation systems is possible Simultaneous application with agriculture and livestock farming due to low area needs Low maintenance costs	High dependence on topographic features Large fluctuations in power generation that make the electrical stability of the network difficult High interconnection costs due to the distance between ideal wind points and part of the energy consumption High aesthetic nuisance High chance of an accident
Opportunities	**Threats**
Development of energy storage technologies High interest from investors Creating new jobs opportunities Easy recycling at the end of wind turbine life Development of new offshore wind farms	Causing death to migrating birds Minimal benefits for the local community, which leads to controversy for the realization of such projects Noise pollution

Table 4. SWOT Analysis for geothermal energy

Strengths	Weaknesses
High trust from the public Improve local tourism Stable power generation Low maintenance costs Ideal for home cooling and heating systems	High dependence on landscape for high entropy points for power generation Demand for large infrastructure High initial investment fund High cost of heat load distribution
Opportunities	**Threats**
Technological development of geothermal power, resulting in cost savings Development of geological risk minimization techniques Creation of thermal baths	A common lack of an effective policy to promote geothermal energy Surface instability may occur Possible release of toxic gases

Table 5. SWOT Analysis for hydroelectric energy

Strengths	Weaknesses
Greater lifetime of the project that leads to cheaper energy supply from other sources If a reservoir is hydroelectric, it offers stable production and can be used in the grid as a source of basic load energy Flexible power generation according to the permissible water flow	High dependence on the landscape High accident probability High initial cost Inability to operate during periods of drought It is almost essential to use a shutter
Opportunities	**Threats**
Increase tourism in the area due to the dam Creation of sports clubs for water sports Chances of creating a local irrigation and water supply system	Dams cause cessation of the transport of sediment downstream of the river Dams create reservoirs in their area of construction by burying natural and cultural heritage Limited interest from investors Vague legislation

Table 6. SWOT Analysis for biomass energy

Strengths	Weaknesses
It consists of areas with large rural potential Simple and easily applicable technology Take small crops for third and fourth generation biomass crops Liquid energy production It does not cause any degradation of the natural environment	1st generation crops are used both for the human food pyramid and for energy purposes Limited knowledge of farmers for energy crops At power plants most of the energy comes from combustion of fossil fuels, while biomass is an auxiliary project 1st and 2nd generation energy crops occupy large areas A small fight against the greenhouse effect Not widespread energy production method Consumption of large quantities of water for the maintenance of 1st and 2nd generation crops

Opportunities	Threats
Simultaneous management of solid / liquid waste for biomass production in 3rd generation crops New jobs positions Development of new biomass technologies such as 3rd and 4th generation crops Easily transportable and commercialized, delivering economic benefits from its exports Biotechnology development around modified 4th generation crops for increased CO2 consumption	Large range of biomass products Difficulty in maintaining stable production Use of pesticides and fertilizers to produce energy crops Risk of contamination of 3rd generation crops by external factors Difficulty in maintaining stable environmental conditions for smooth third generation production

Conclusions

This study aimed at exploring the sustainability of RES and at the same time exploring the best solution for energy production. Decision making as well as energy strategic planning is perhaps one of the most complex problems. The combination of the two analyzes (LCA and SWOT) offers another rationale to investigating such dilemmas and offers the best choice to potential investors as well as state actors to implement the optimal policy in their area of responsibility.
Also, elements are emerged which individual analysis cannot solve. On the one hand, the LCA analyzes sustainability and energy consumption and on the other hand the SWOT analysis discusses qualitative characteristics. By incorporating bibliographic information on the cost of each RES, a "technical memorandum" is created, which not only constitutes a measure of sustainable comparison of RES but also a guide for the adoption of appropriate RES. The pollutant emission values, EPBT, fixed and operating costs create a hierarchy in RES, as shown in table (7), from 1 to 5, with position 1 representing the smallest values and with position 5 the largest ones. In this table, it should be noted that RES was ranked according to the average. The overall ranking came from the average of the positions occupied in the four parameters of the table (7).

Table 7. Ranking of RES

A/A	Pollutant release	EPBT	Capital cost	Operating cost	Total
1	Hydroelectric	Geothermal	Solar	Solar	Wind
2	Geothermal	Wind	Wind	Biomass	Solar
3	Biomass	Biomass	Biomass	Wind	Hydroelectric
4	Wind	Hydroelectric	Hydroelectric	Hydroelectric	Geothermal
5	Solar	Solar	Geothermal	Geothermal	Biomass

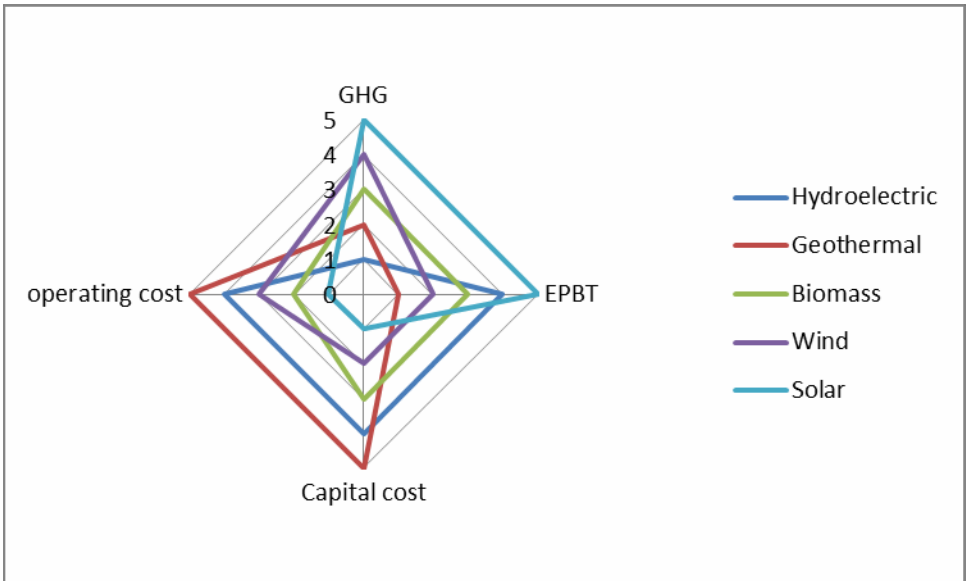

Figure 2. Graph of RES according to the classification of Table 7

It is important to emphasize that hydroelectricity, while emitting fewer pollutants, has one of the longest energy payback times of the investment. Also, the solar energy is in the worst position in the whole, but it ends up in second place due to the low operating and fixed costs. The most sustainable was the wind, with a strong presence both in the active energy payback time of the investment and in the fixed cost.

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Energy policy establishment for off-grid small isolated settlements

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Abstract
This work presents a methodology for identifying the most appropriate location(s) for installing low-scale RES-based hybrid electricity production systems to cover the local energy demands without grid connection. The selection is initially based on geographical, geospatial and demographical data, while the proposed methodis based on the optimal combination of the meteorological data (solar and wind potential), the available resources (in terms of free space and of investment costs) and the desired load. On top of that, optimization of both the size and the operation of the hybrid system is also performed. To efficiently match the produced energy with the demands, a potential interconnection with one nearby settlement with the same characteristics is also considered. Finally, the economic balance of costs (installation, operation & maintenance, replacement) and benefits is presented, and the proposed system is judged against it. In conclusion, this study could act as a policy tool for off-grid power production in national level.

Keywords: Off-grid power production;Renewables.
JEL Classification: Q28; Q42; Q48; Q56.

1. Introduction

As far as world energy demands constantly increase (approximately doubled within last ten years) and deposits of fossils are limited, the need for alternative energy production is nowadays more than necessary (Olabi, 2013). While renewable technology becomes mature with the years, hybrid systems have recently become feasible alternatives that satisfy the requirements for electricity production with environmental protection (see, for instance,Rathore & Panwar, 2007). Given the environmental potential for a specific location, a hybrid energy system combined with an energy storage system is an interesting option to cover relatively low electrical loads in remote areas (Ansong et al., 2017; Boute, 2016;Forde, 2017; Sandwell et al., 2016) where either there is no utility for power supply or it is difficult and cost-ineffective to attain a continuous interconnection to the existing grid. Stand alone and hybrid photovoltaic/wind systems are a very promising option with excellent prospects to cover the energy needs of specific areas in an efficient and sustainable way.These systems have also proved both interesting and environmentally friendly technological solutions for the electrification of remote consumers. However, the installation costs are quite high, while in some occasions the life-cycle cost is also high (Kaldellis and Kavadias, 2007). These systems can offer high reliability for supplying electricity under various environmental conditions, as well as savings in the cost of the energy produced (Veldhuis & Reinders, 2015). Locations of existing systems are in general spontaneous, seeming to have been randomly selected. Our study is mainly focused in establishing a well-defined solid methodology for the selection of the appropriate location where a hybrid power production system could be installed. The criteria that must be satisfied according to this methodology are related to meteorology (solar radiation, wind potential), while demographic, geographical, geospatial, land use and load-satisfaction criteria must be also fulfilled. Furthermore, there is a need to reduce the energy production cost, by installing the most suitable system for the specific area, where its suitability must be based on multi-criteria analysis, on the combination of meteorological data and electrical loads to be covered in a 24X7 basis (objective function). As a case study, the proposed hybrid system is supposed to be installed in two specific small Greek settlements (up to 100 residents), with known low energy demands. Special effort has been put on getting the exact picture of electric consumption of the settlements by collecting electricity consumption data directly from the Greek public power company for the 2012-2017 periods and by recording the number and the electricity consumption of the electrical appliances existing there. Furthermore, an exact measurement of the available space (roofs, public space, etc.) has been also performed to assure installation of the solar panels. Finally, some financial (economic aspects) have been taken into account, as well.

2. Theory

2.1 Methodology

Our methodology for area selection is based on the following data: Solar radiation, wind potential, demographic, geographical, geospatial and land use.

*Solar radiation:*Greece has a particularly high solar potential compared to the northern European countries. Average annual solar radiation in the horizontal plane ranges from about 1400 - 1500 kWh/m^2 in Northern Greece to about 1800 - 1900 kWh/m^2 in the southern Peloponnese, Crete and the Dodecanese (Nikitidou et al, 2015). The selection of settlements was based on the incident solar radiation. The average solar radiation measured in Greece, i.e. from the lowest price of 1400 kWh/m^2 to the highest value of 1900 kWh/m^2, is 1650 kWh/m^2. This value is very close to the price of 1600 kWh/m^2 calculated by Lalas et al. (1983). Then we divided the examined areas into two categories: those below 1600 kWh/m^2(low-power areas) and those above1600 kWh/m^2(high-power areas).

*Wind potential:*Greece is often characterized as one of Europe's most windy areas. The seasonal variations in atmospheric pressures combined with the development of local winds, are the main determinants of wind conditions in the country (Nastos et al, 2002). Wind potential in Greece ranges from 0 m/sec to over 10 m/sec (Centre for Renewable Energy Sources, CRES, http://www.cres.gr). Based on this range, the average value is 5 m/sec. We have again divided the areas into two categories: those below the average wind potential (low wind potentialareas) and those located above the average wind potential (high wind potential areas).

We also make use demographical, geographical, geospatial and land use data to support our methodology. Population range is in a range of approx. 50 to 100 inhabitants in order to assure quite low loads along with relatively low-cost installation, a relatively small amount of land that will be required to install the system and few responses to the population by residents.

2.2 Economical aspects

In the final decision on the installation and operation of the autonomous hybrid energy system, economic issues are in many cases the most importantones. The most critical parameters for designing an autonomous hybrid system are initial and operational costs, calculatedin terms of Net Present Cost (Brealy& Myers, 1991).The economic analysis has to concern the depreciation of the capital costsduring system's lifetime. Initially, the depreciation equations for a system connecting and using local gridand for a hybrid system which is not using gasoline or LPG generators as alternative sourcesare presented in Table 1. The annual operational costs$C_{oper}$are equal to the annual replacement cost$C_{arep}$of the system (Prodromidis, 2014).

Table 1: Equations for depreciation cost for on-grid and off-grid cases

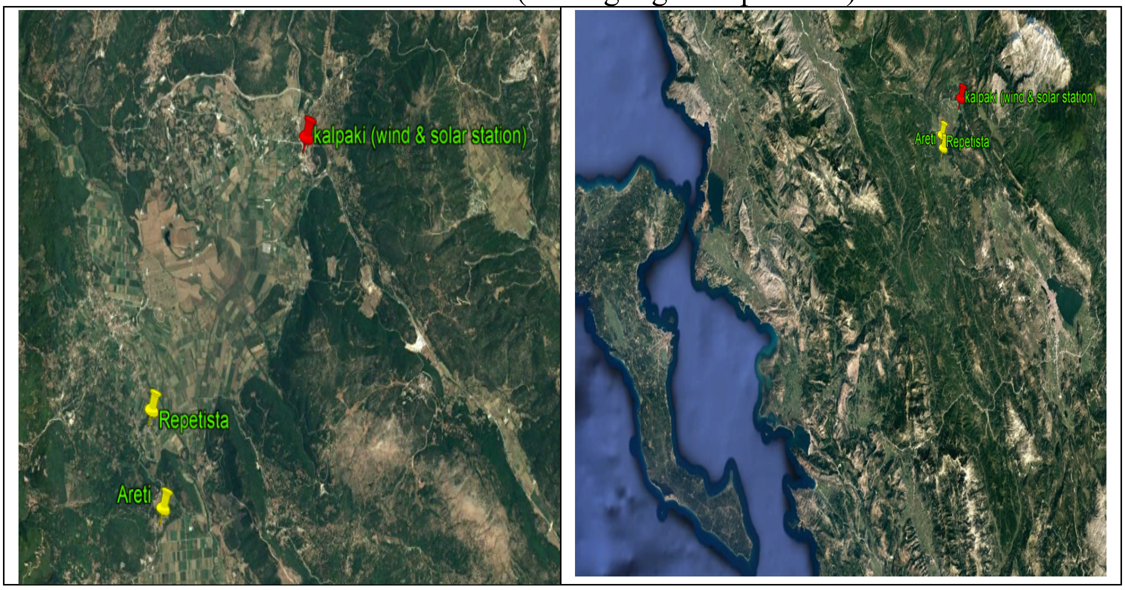
Connected to local grid (Brealy& Myers, 1991)	Off grid system (Prodromidis, 2014)
$Y = \frac{C_{cap} - C_{gridcap}}{C_{ygrid - C_{oper}}}$	$Y = \frac{C_{cap}}{C_{arep}}$
$Y = \frac{C_{cap} - C_{gridcap}}{C_{ygrid} - (C_{oper} - ME_{excess})}$	$Y = \frac{C_{cap}}{C_{oper} + ME_{excess}}$

3. Result and discussion

3.1 Location of our study

According to the solar and wind data, our selected area is a low-power, low wind potentialarea.If the installation of the hybrid system is going to be successful in this area,the same methodology can be performed everywhere.The selected settlements locatedin Epirus region, in Pogoni Municipality, villages Repetista and Areti.In these two settlements, 83 houses, 2 enterprises and 3 public buildings for the village of Repetista and 78 houses, 2 enterprises and 2 public buildings for the village of Areti, were found. The required solar and wind data, as well as the maximum and minimum temperature values have been recorded by a nearby meteorological station in Kalpaki area owened by Department of Physics, University of Ioannina. There is a wide range of meteorological data available (from June 2008 till September 2018) and the proximity of meteorological station ensures high accuracy of the measurements.The average solar radiation for this period is 1.507,4Kwh/m^2, (4,13 Equivalent Sun Hours - ESH). The averaged wind speed is 1,3 m/s, the maximum temperature is 23^o C and minimum temperature is 8,5^o C.

Figure 1: Location of the selected settlements (www.googlearthpro.com)



Solar data are recorded every five minutes, wind data every fifteen minutes and high and low temperatures once per day.

3.2 Hybrid systems scenarios

Before starting to build the hybrid system scenarios, we present the annual electrical consumption of the two settlements provided by the Greek Power Company. Using the data of Table 2, we notice that the highest consumption is duringyear 2012for

Table 2: Settlements' electrical consumption (Greek Power Company)

	2012	2013	2014	2015	2016	2017 (End of June)
Repetista	163.060	144.409	153.281	127.909	127.952	98.595
Areti	131.721	124.723	120.451	126.068	135.824	87.131

Repetista village and at 2016 for Areti village. For the sake ofcompatibility of our measurements, we take 2012 as a reference year because the difference in consumption for the Areti settlement between 2012 and 2016 is small. Solar radiation of 2012 is presented in Table 3 and its total value is 1549kwh/m^2.We, then, recorded the solar radiation values for every five minutes and we calculate the average values for each hour for an entire 24-hour period. Then we performed the same procedure for all the days of the month and, finally, for all the months. The results are presented in Table 4. Then we count each house electric bulbs as well as the street bulbs of the settlement, we made the analytical recording of electrical appliances, as well as the dimensions of the roof (sloping roof) and the dimensions of the top floor slab (terrace-flat roof). From these dimensions we have calculated the ability of photovoltaic capacity in each roof of the two settlements. According to Greek legislation for the installation of solar systems in buildings and plots within area plans and in settlements (Law 36720/2010), installation of PVs should be done within the outline of the roof following its gradient to ensure the aesthetic image of the building.

Table 3: Solar radiation of 2012

MONTHS – 2012												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aver / day (wh/m^2)	98	87	164	170	231	321	302	260	196	137	88	60
Ave / Month (kwh/m^2)	73	59	122	123	172	231	225	193	141	102	63	45

Table 4: Annual radiation of year 2012 (wh/m^2) on a 24-hour basis

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver.
0:00	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00	0	0	0	0	2	6	2	0	0	0	0	0	1
7:00	0	0	0	21	75	137	95	34	2	0	0	0	30
8:00	0	2	50	133	231	332	289	216	123	33	3	0	118
9:00	41	54	200	278	398	497	462	395	305	184	89	29	244
10:00	187	157	355	373	540	645	615	540	455	317	201	110	375
11:00	286	254	469	456	633	766	734	674	562	412	298	169	476
12:00	357	309	555	491	684	855	825	767	632	502	343	241	547
13:00	390	315	559	529	678	908	895	812	657	500	356	276	573
14:00	396	295	529	468	656	890	840	794	611	471	338	235	543
15:00	345	291	464	429	548	811	771	682	506	383	251	201	474
16:00	236	239	348	387	396	693	661	517	410	299	172	137	375
17:00	116	144	257	211	350.7	538	499	420	285	152	58	38	247
18:00	7	39	133	174	248	377	351	261	136	33	1	0	147
19:00	0	0	17	57	102	202	182	111	18	0	0	0	57
20:00	0	0	0	1	12	39	35	8	0	0	0	0	8
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0
23:59	0	0	0	0	0	0	0	0	0	0	0	0	0

For our measurements, we considered as a prototype, a 275 watt photovoltaic panel, with dimensions 1,65m x 0,991m = 1,635m^2 and efficiency of 16,82 % (PV characteristics are being extracted by BIGSOLAR Company wholesale pricelist - www.bigsolar.gr), selected here because of its cost, is the most economical photovoltaic(Table 5), not because it had the lowest cost but the lowest cost per watt.

Table 5 : PV acquisition prices per unit (Ex VAT)

PV types (watts)	250 poly	**275 poly**	315 mono	360 mono	144 a-Si	330 hybrid
Price/unit (€)	221,4	**114,1**	261,5	204	230,8	480,2
Price/produced watt (€)	0,886	**0,415**	0,83	0,567	1,603	1,455

The maximum carrying capacity of photovoltaic in roof frames for the two settlements is presented in Table 6. We have estimated the consumption of the electrical appliances of the two settlements making some assumptions. These assumptions are:

• Non-residents have all appliances closed except from refrigerators and freezers.

• The non-permanent inhabitants of Repetista village stayed on an average of one month in the winter (April) and two months in the summer (July - August) while residents of Aretivillage stayed on an average of one month in winter (15 days December, 15 days April) and one month in the summer (August). It is worth noticing that days-stay are extracted from the questionnaireconducted to the inhabitants.

•Closed homes do not consume electricity.

• Municipal bulbs operate on average 12 hours in the winter and 10 hours in the summer.

Table 6 : Maximum carrying PV capacity on rooftops

	REPETISTA	ARETI
	PV dimensions: 1,635m^2	
PV CAPABILITY	911	728

We, then,created six scenarios of electric coverage depending on the different types of PVs. These scenarios are presented in Table 7 and the analysis of coverage percentageof the two settlements is presented in Tables 8 and 9.

Table 7: The six scenariosof PV arrays

Scenarios	S1	S2	S3	S4	S5	S6
PV (watt) types	250 poly	275 poly	315 mono	360 mono	144 a-Si	330 Hybrid

Table 8: Coverage scenario with photovoltaic elements mounted only on rooftops.

Scenarios	Repetista		Areti	
	PV Num.	% cover	PV Num.	% cover
S1	916	43	792	41
S2	911	51	728	49
S3	908	66	726	64

S4	768	62	613	59
S5	731	10	584	10
S6	890	70	711	67

Table 9: 100% coverage with photovoltaic elements mounted on rooftops and installed on villages plots.

Scenarios	Repetista		Areti	
	PV Num.	% cover	PV Num.	% cover
S1	2151	100	1792	100
S2	1791	100	1492	100
S3	1370	100	1141	100
S4	1244	100	1036	100
S5	7188	100	5988	100
S6	1274	100	1061	100

In Table 8, we estimate how many PV modules could be installed only on the rooftops of each settlement and the percentage of electricity supply according to the different PV technologies. On the contrary, in Table 9, we set the goal of 100% electrification of each settlement and calculate the PV's needed to achieve this goal.

In Table 10 we calculated the cost of the different types of PV modules.As shown in Table 5, the most economic is the 275 W polycrystalline PV with a total cost for both of the settlements 374.590 € (Ex VAT). Thus, we finally take the S2 scenario with the PV with the lowest purchase cost and estimate in Table 11the cost of acquiring the other components of our project.

Table 10 : Total PV acquisition cost (Ex VAT)

Scenarios	Repetista		Areti	
	PV Num.	Total price € (Ex VAT)	PV Num.	Total price € (Ex VAT)
S1	2151	476231	1792	396749
S2	**1791**	**204353**	**1492**	**170237**
S3	1370	358255	1141	298372
S4	1244	253776	1036	211344
S5	7188	1658990	5988	1382030
S6	1274	611775	1061	509492

Table 11 : Total cost for all the components for both settlements

COMPONENTS	**REPETISTA**		**ARETI**	
	NUM	COST	NUM	COST
PV	1791	204.353,10	1492	170.237,20
BATTERIES	155	25.113,00	121	23.004,00
INVERTERS	136	156.069,00	114	131.676,00
CHARGE CONTROLLERS	155	79.000,00	121	60.750,00
CABLES & OTHER PARTS	1km	3.000,00	800m	2.400,00
PV ROOF BASES (911+728)		51.830,00		41.420,00
PLOT BASES (880+764)		36.494,00		31.683,50
TOTAL		555.859,10		461.170,70
UNPREDICTABLE EXPENCES-WORKS (15%)		83.378,87		69.175,61
GRAND TOTAL				**1.169.584,27**

Assuming that the lifetime project is 25 years, inflation has been predicted to be 2%, nominal interest rate has been predicted to be 2%, real rate interest was assumed constant and salvage value =0. With the assist of economical aspects and alsoby using equations in Table 1, we calculated the following expressions depicted in Table 12

Table 12 : Economical data

Real Interest rate	2,45%		
NPC	49773709,04		
C_{cap}	1169584,27		
	Batteries	Inverter	Charge controllers
C_{arep}	393269,86	43701,27	2201062,5
C_{tot}	2701513,9		

3.3 Interconnection scenario

Interconnection is the process of electrical connection between two nearby settlements to exchange the excess electricity through a smart way of asking and offering energy. The goal is not to leave any of these two neighboring settlements without electricity throughout 24 hours a day. As far as the selected settlements are quite isolated and their population is low and very mature, the need for a 24hour energy supply is considered as essential. Although alternative criteria for the optimization can be found in the relative literature, such an option sounds feasible and is widely accepted and used (Prodromidis & Coutelieris, 2010). The optimal design of such a hybrid system should cover a steady electricity flow at the time its consumption, without allowing normal daily fluctuations of RES potential to affect power supply (Little et al., 2007). An interconnected network for delivering electricity from producers to consumers consists in general of generating stations that produce electrical power, transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers (Kaplan, 2009). In our case, producers and consumers are the two nearby settlements which produce and consume the electric power respectively. This interconnection is assumed to be "smart", in the sense that an intelligent automatic system is responsible for passing through the energy excess and asks for extra power when necessary. The distance between the two settlements is 2,3 km, low enough to assure minimal power losses, thus there is no need for specific distribution lines. The costs of installing and maintaining the interconnection cable between the settlements should be taken into account in the general installation cost of our system. The filled questionnaires indicate the positive attitude of residents to this potential interconnection, thus the cost of the project should be increased to 1.176.484,27 €.

4. Conclusion

The methodology of identifying the most appropriate location for the installation of autonomous RES-based hybrid energy systems with battery storage,has been developed in this work,especially for small-scale settlements. Methodology was based on the combination of the local renewable's potential with availability and feasibility of the project. The different PV technologies plays an important role to the selection and finally to the approval and success of the installation. The best scenario will be the totally successful coverage of the electricity supply without using public network. The most cost-effective solution, as well as the appropriate and therefore environmentally friendly use of electrical appliances by the residents has to be identified.Finally, the system should be able to be interconnected with at least one nearby settlement of analogous size in order to integrate a small “smart” grid.

Nomenclature

C_{arep}	Annual replacement cost	€
C_{cap}	Initial cost of the RES components	€
$C_{gridcap}$	Grid connection capital cost	€
C_{oper}	Annual operational cost of the hybrid system	€
C_{ygrid}	Annual cost of the usage of the grid	€
E_{excess}	Excess electrical load	kwh
M	selling price of electricity	€/kwh
NPC	Net present cost	€
Y	Depreciation cost	

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Selection of optimal on shore wind farm sitting locations in Greece, using Multi criteria Decision Analysis

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Abstract

The usage of Renewable Energy Sources (RES) is increasing throughout the world as there is a global effort to reduce the dependence from fossil fuels which are considered as a main cause for climate change. Wind Farms currently are rated among the most common forms of RES applications especially in countries like Greece. The optimization of spatial planning in order to identify the most suitable places for the installation of wind farms is one of the most difficult problems because there is a need to identify and calculate the effect of a variety of both qualitative and quantitative parameters. Multi Criteria Decision Making Methods (MCDM) are commonly used in order to solve this problem and are combined with Geographic Information Systems (GIS) to spatially represent the results from the application of the MCDM methodology. In this paper we demonstrate a methodology which applies the current legislation and uses an MCDM methodology called Analytical Hierarch Process (AHP) and GIS in order to determine the most suitable locations for wind farms installation.

Keywords: MCDM, AHP, GIS, DSS
JEL Codes: Q01, Q20, Q28, Q47, Q48

Περίληψη

Η χρήση των Ανανεώσιμων Πηγών Ενέργειας (ΑΠΕ) αυξάνεται σε όλο τον κόσμο καθώς υπάρχει παγκόσμια προσπάθεια για τη μείωση της εξάρτησης από τα ορυκτά καύσιμα τα οποία θεωρούνται ως κύρια αιτία της κλιματικής αλλαγής. Τα αιολικά πάρκα αποτελούν σήμερα μια από τις πιο κοινές μορφές εφαρμογών ΑΠΕ, ειδικά σε χώρες όπως η Ελλάδα. Η βελτιστοποίηση του χωροταξικού σχεδιασμού για τον εντοπισμό των καταλληλότερων χώρων εγκτάστασης αιολικών πάρκων είναι ένα δύσκολο προβλήμα, διότι υπάρχει ανάγκη να προσδιοριστεί και να υπολογιστεί η επίδραση μιας ποικιλίας ποιοτικών και ποσοτικών παραμέτρων για την επίλυση του. Οι μέθοδοι λήψης αποφάσεων πολλαπλών κριτηρίων (MCDM), που χρησιμοποιούνται συνήθως για την επίλυση αυτού του προβλήματος συνδυάζονται με Γεωγραφικά Πληροφοριακά Συστήματα (GIS) για να υλοποιήσουν την χωρική απεικόνιση των αποτελεσμάτων απο την εφαρμογή της μεθοδολογίας MCDM. Στην παρούσα εργασία παρουσιάζουμε μια μεθοδολογία που εφαρμόζει την ισχύουσα νομοθεσία και χρησιμοποιεί μια μεθοδολογία MCDM που ονομάζεται Αναλυτική ιεραρχική διαδικασία (AHP) και

τα GIS, προκειμένου να προσδιοριστούν οι καταλληλότερες θέσεις για εγκατάσταση αιολικών πάρκων.

Λέξεις Κλειδιά: MCDM, AHP, GIS, DSS
Κωδικοί JEL: Q01, Q20, Q28, Q47, Q48

Introduction

Electricity and energy production play a key role in modern life, and they are considered very important for modern societies. Each country according to its level of development, which is a key indicator of energy consumption, uses imported or domestic sources of energy, in the form of coal, petroleum, natural gas and nuclear fuels (Rahmand and Miad, 2017).

During the last two decades we witness an evolution in the energy sector. Many countries throughout the world are shifting their energy production methods from fossil fuel usage to more environmental friendly methods. These methods are described under the term Renewable Energy Methods and propose the usage of sustainable sources based on Wind, Water, Biomass, Solar Energy and Geothermal Energy for the production of energy (Doukas et al, 2009). This shift was mainly caused due to the increase of public awareness on environmental problems and climate change which are both related to the increase of Green House Gas (GHG) emissions (Rahmand and Miad, 2017;Kaldelis et al, 2012;Giacomarra and Bono, 2015). Under this scope the European Union (EU) has created a legislative framework which is enhanced by a series of actions in order to further develop and encourage the usage of Renewable Energy Sources (RES) in all member states (Giacomarra and Bono, 2015).

The most well-known action is the 20-20-20 target. All EU states are committed to achieve at least 20% reduction of GHGs emissions by the year 2020. The baseline for this reduction is the year 1990. Also the member states should reduce energy consumption by 20% and increase energy efficiency by 20% (Giacomarra and Bono, 2015). The recently legislated EU directive 2009/28/EC entitles member states to implement cooperation mechanisms in order to promote the usage of RES and enables them to more easily achieve the goal of 2020 (Giacomarra and Bono, 2015; Papapostolou et al, 2017; Tampakis et al, 2017).

The evolution which has taken place in the field of wind turbines, with the manufacture of more energy efficient and less noisy turbines has allowed wind energy to be transformed in a major RES, which is expected to evolve in near feature (Tampakis et al, 2013), furthermore the application of wind energy presents minimal environmental implications (Wolsink, 2007). An additional and important role in the installation of RES, is the attitude of citizens.

Therefore, it is essential prior to the investment in a wind farm to understand and analyze local community's attitudes towards the selected locations in order to issue and use the proper strategies which can lead to the mitigation of their reactions. Additionally, we must also take under consideration the relevant national legislation as well as the selection of locations which provide maximum energy production.

In this paper we aim at designing a Decision Support System framework which can encapsulate all the parameters affecting the installation of a wind farm in order to minimize setbacks and maximize the produced energy.

In detail we aim at presenting a methodology framework which will combine all the criteria affecting the location of a wind farm, with the national legislation and at the end, provide a ranking of the optimal locations. The initial selection of areas suitable for wind farm installation will be provided by the application of the legislation. These areas will be further refined by the application of the AHP methodology. Additionally, we will apply the proposed methodology in a prefecture in northern Greece, were we will determine the optimal locations for wind farms installation.

Materials and Methods

Study Area

Drama prefecture is located in Northern Greece; it is part of the Region of East Macedonia and Thrace. The regional unit is the northern most within the geographical region of Macedonia and the westernmost in the administrative region of East Macedonia and Thrace. The north part of the prefecture which borders Bulgaria is very mountainous with two mountain ranges dominating the area (Orvilos and Falakro). The economy is mainly based on agriculture, forestry and mountainous tourism. Overall, Drama presents a lot of opportunities in the field of Renewable Energy Sources as it presents a lot of tributaries suitable for the installation of Small Hydro Power Plants, a significant wind potential and geothermal fields located in the northeast part of the prefecture (CRES, 2009).

Figure 1. Drama Prefecture (Magenta) within the East Macedonia and Thrace Region and Greece

Analytical Hierarchy Process

AHP proposes the creation of a hierarchy of criteria and the parameters affecting a decision. On the top of the hierarchy the goal must be placed (fig 2). The construction of the hierarchy is followed by pair wise comparisons which allow the user to determine the weight coefficients of each parameters and criteria and therefore their impact to the goal (Saaty. 1980).

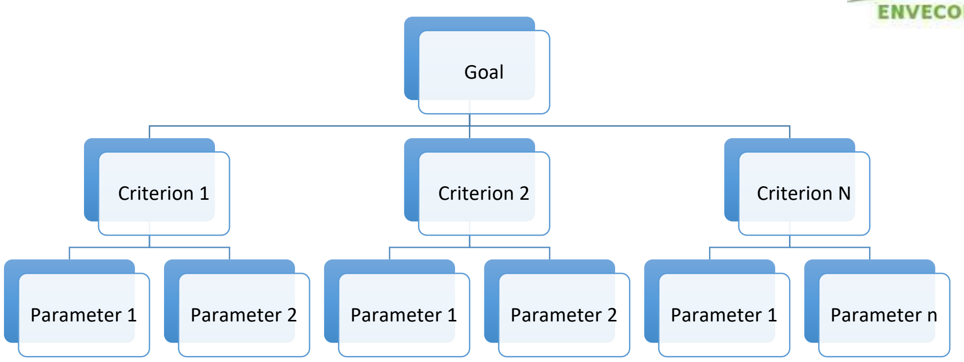

Figure 2. A graphical representation of AHP methodology

If we want to summarize the application of the methodology, we can create 6steps: (Uyan, 2013; Tahri et al, 2015).

In the first step, we set the goal which is followed by the selection of alternatives. Practical judgment is mandatory for selecting criteria which is a measurable facet assisting in illustration and enumeration of alternatives (Khan and Rathi, 2014). In step two we perform the pair wise comparisons among Criteria and among the parameters of each criterion.

The Matrixes of pair-wise comparisons are created by the experts on the fundamental scale from 1 to 9. The comparison matrix is obtained as (n×n) where n denotes the number of criteria. In step 3 we calculate the weight coefficients based on the values given in the previous step. If X_{ij} is the order of preference of ith factor when compared to jth factor, then $X_{ji}=1/X_{ij}$

In Step 4 we create the pair-wise comparison matrix

The next step (step 5) includes the calculation of the Eigen vector, maximum Eigen value and Consistency Index (CI) using equation 1.

$$\text{CI} = \frac{\lambda_{max}-n}{n-1} \quad \text{(Equation 1)}$$

Where λ_{max} is the Eigen value of the paired comparison matrix and n is the number of criteria.

Finally in step 6 the Consistency Ratio (CR) is calculated using equation 2.

$$\text{CR} = \frac{CI}{RI} \text{(Equation 2)}$$

Where, RI is the random index. The values of RI are shown in the following table (table 1).

Table 1. Possible Values of RI

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	**0**	**0**	**0.58**	**0.90**	**1.12**	**1.24**	**1.32**	**1.41**	**1.45**	**1.49**

The acceptable range of CR value is dependent on matrix order e.g. CR value for a 3×3 matrix is 0.05, for a 4×4 matrix it is 0.08 and 0.1 for all the matrices having order ≥5 (Saaty, 2008, 2000).

The following criteria were used for the application of the AHP methodology in order to determine the initial installation locations. The selection of these criteria was partially based on the Special Framework for Spatial Planning and Sustainable Development for RES as it was approved by the Greek Government, via its decision 49828/2008 (Government Gazette B 2464) which aimed to formulate sitting policies of RES power generation projects and partially to other restrictions:

Distance from existing Road Network

The distance from the existing road network plays a very important role in the selection procedure. In general, investors select locations that are already accessible or near to the existing road network regardless of each state. This is mainly due to the fact that it is more economically feasible (reduced installation cost) to exploit the current road network than to create new. In this study we subdivided this criterion into 5 parameters for the distance from the current road network 0-100m, 100-200m, 200-500m, 500-1000m and finally 1000-15000m.

Wind Speed

Wind speed plays the most important role for the installation of wind farms. In this study we used wind speed data for Greece provided in shp format. The data were downloaded from opendata.gov.gr and are available for free (Geodata, 2017). The provided data were divided into 5 categories for wind speeds 0-2,5 m/sec, 2,5-5 m/sec, 5-7,5 m/sec, 7,5-10 m/sec and 10-12,5 m/sec.

Slope

Slope is considered as a very important factor mainly because it affects the accessibility of an area from trucks. Trucks can easily access areas with slopes ranging between 0-20%. Inclinations exceeding 20% are inaccessible to vehicles and therefore these are not suitable for installation of wind farms using conventional methods (Ministry of Environment, 2001). For this reason, we have incorporated a category for slope ranging from 0 – 10%, one for 10-20% and one for 20 to maximum.

Land Uses

Current land usage status is also considered an important factor for the installation of wind farms. The general idea is that we prefer the farms to be installed in remote barren lands with low value. Therefore, for example we prefer the installation to mineral extraction sites and not to agricultural land, because the latter area's value is higher. For this reason, we used data provided by the CORINE 2000 land use mapping program (Corine, 1994). We recognized the following parameters in the specified criterion: Mineral extraction sites, Non irrigated arable land, Irrigated land, Vineyards, Trees and Plantations, Pastures, Agricultural land (in general), Broad leaved forest, Coniferous forest, Mixed forest, Grasslands, Bare rocks, Transitional woodland, Sclerophyllous vegetation, Sparsely vegated areas and Marshes.

Distance from substations

The purpose of this criterion is the determination of the distance between the wind farm installation and the public energy transfer network. In general areas closer to the transfer grid are preferred. This criterion was divided into 3 parameters, one for distances up to 5000, from the energy transfer grid, one for 5000 to 10000m and one for distances from 10000 meters and beyond.

Results

3.1 Exclusion Zones Creation

The first step in the application of the proposed methodology is the exclusion of areas were wind farms cannot be installed due to local legislation restrictions (statute 49828/2008 as issued in the Government Gazette B 2464).

These restrictions are divided in six major categories.

The first category includes the maximum distances from road network, energy transfer network and minimum distance between wind turbines. The maximum distance from any type of road network is considered to be 15.000m whereas the maximum distance from the energy transfer network is set by the independent Greek power transmission operator (ADMIE). In the case of the study area the entire road network and transfer energy network were used in order to create the proper exclusion zones.

The second category includes distances from areas of environmental concern. In these areas there cannot be any type of installation without special permission. Under this category are included Natura 2000 and Ramsar sites, Areas of absolute protection, coastal regions, fowl areas etc. In the case of the study area regions which fall under these restrictions were removed.

The third category includes exclusion zones from archeological sites, historical landmarks, cultural sites etc. In general, there should be a distance of at least 3.000m between the proposed wind farms and these types of areas. In the case of the study area there were no exclusion zones of this type.
The fourth category includes the determination of the distance between the location of the wind farm and towns, villages, settlements, traditional settlements and monastery's. In general, the distance between the proposed wind farm and towns must be at least 1.000m, from traditional settlements at least 1.500m, and from monasteries and other settlements at least 500m. In the case of the study area we created buffer zones around these types of structures in order to create the appropriate exclusion zones.
The fifth category defines the minimum distances from public infrastructure (road network, energy grid, airports, radars etc.). In general, these distances are related to the diameter of the wind turbine and are set as a minimum of 1,5d where d is the diameter of the turbine. In this case we created buffer zones around public infrastructures in order to define the minimum allowed distance having in mind the diameter of the typical wind turbine. The typical wind turbine diameter is set by statute 49828/2008 as 85m.
The sixth category defines the minimum distances from areas of productive activities (high productivity agricultural land, embattled livestock, quarry zones, fish farms, tourist sites etc.). Again the minimum distance is set to be 1.5d expect areas quarry zones where the distance is set as 500m and tourist sites where the distance is set as 1000m. In this case we created also buffer zones to be used as exclusion zones around these types of activities.

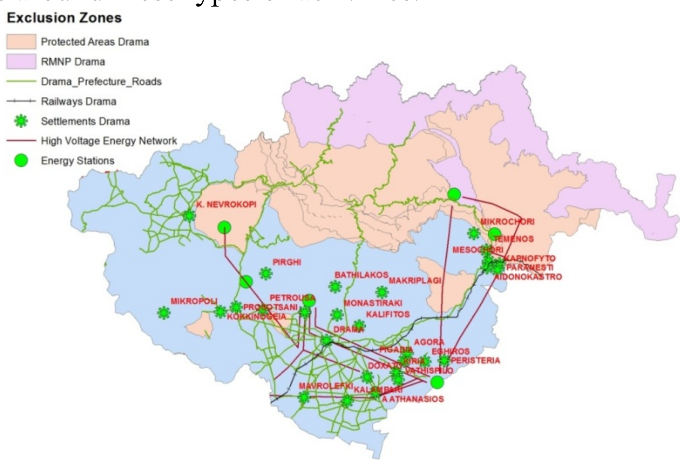

Figure 3. Drama Prefecture Exclusion Zones
After the application of the restrictions described in the legislation and the resulting spatial analysis the initial map of the prefecture is modified as shown in Figure 3. The region in light blue is the area where Wind Farm installation is allowed whereas areas in magenta and orange are protected areas. The buffer zones around villages, road network etc. is not visible due to the map scale.

3.2 Results from the AHP

The application of Analytical Hierarchy Process in the criteria set has created the following results with a Consistency Ratio of 0.08:

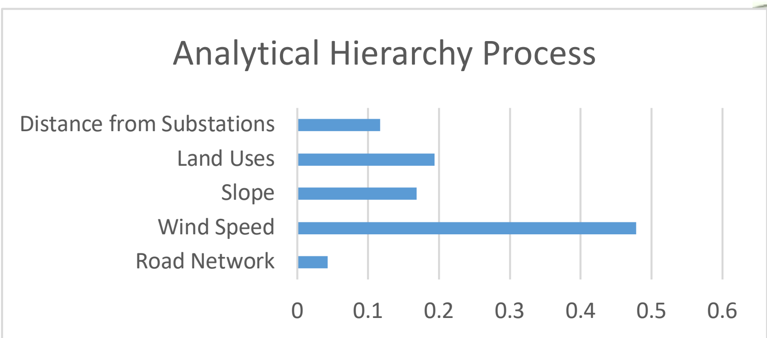

Figure 4. Parameters AHP Results

It is evident from the previous figure that the most important criterion for the selection of the most suitable location for wind farm installation is Wind Speed with a weight coefficient of 0,478, followed by Land Uses with weight coefficient 0,194, Slope with weight coefficient 0,168, Distance from sub stations with weight coefficient of 0,117 and finally Road Network with weight coefficient of 0,043.

The results of the parameters weight coefficient for each criterion are shown in Figure 5.

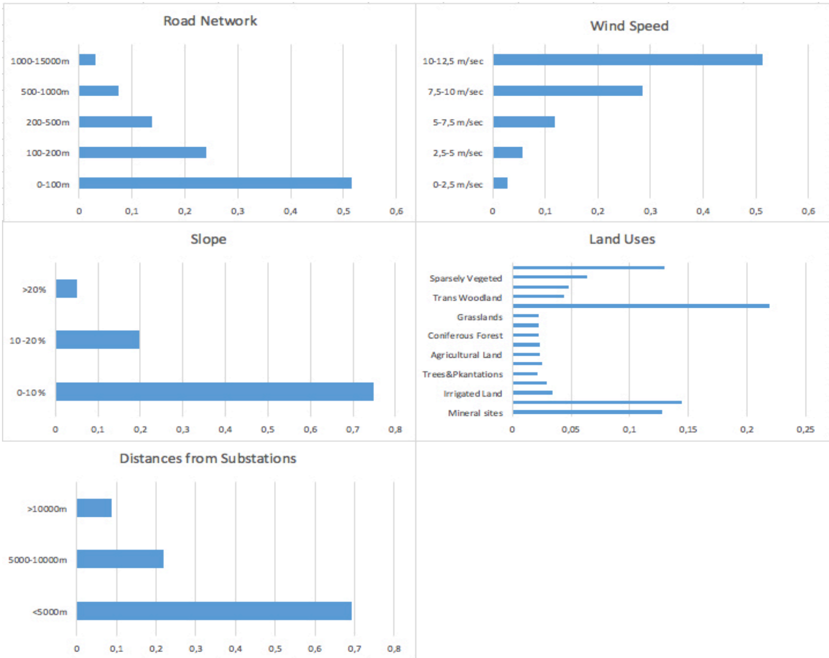

Figure 5. Criteria AHP Results

The results shown in the previous figures (4 and 5) will be incorporated to the corresponding maps using the reclassify tool. The maps will be converted to raster with cell size equal to 250m. The reclassify tool will create classes equal to the presented criteria and each cell will be assigned with the appropriate weight coefficient based on the AHP calculations. Thus the produced raster maps will include a value for each cell.

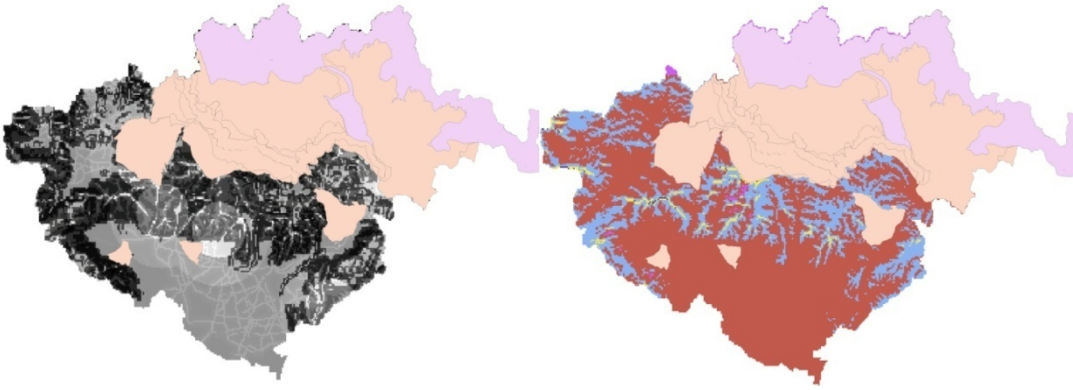

Figure 6. Initial Wind Map and Reclassified Wind Map

The maps presented in figure 6 present the initial wind map (left) without the reclassification. On the right the same map was reclassified using 5 manual classes and each class was assigned to the corresponding weight coefficient as calculated by the application of AHP. The same methodology was applied to the other 4 maps.

Subsequently the 5 maps were used in order to create the final map which presents the location were the installation of wind farms is more suitable based on the parameters set and the legislation. For the creation of the final map we used the following equation which is based on the weight coefficient of the parameters.

$$CV = 0{,}43*RN+0{,}478*WS+0{,}168*SL+0{,}194*LU+0{,}117*SU \quad (Equation\ 3)$$

Where CV is the cell value of the final map, RN is the Road Network Value, WS is the Wind Speed Value, SL is the Slope Value, LU is the Land Uses Value and SU is the Distance from Substations Value for each cell and map as calculated in the criteria analysis of the AHP.

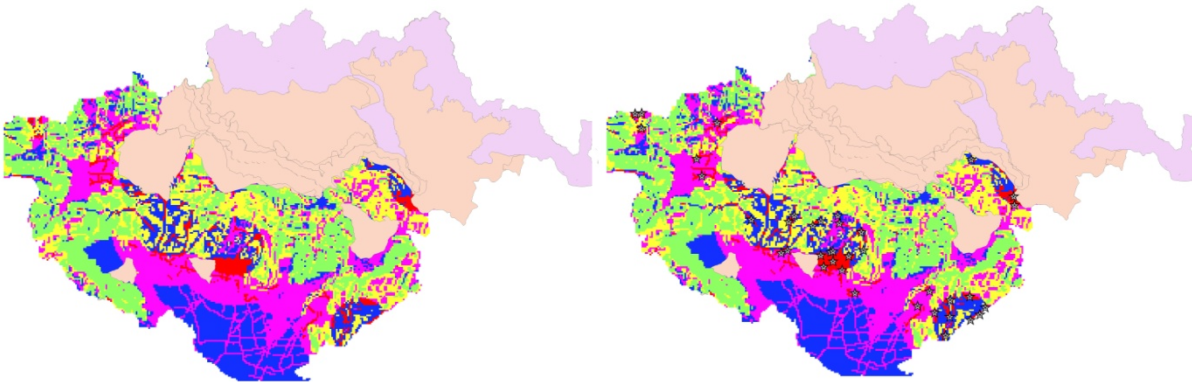

Figure 7. Results from the calculation and Wind Farm Locations

In figure 7 the left map the results from the application of Equation 3 are presented. Areas presented in red color are the most suitable for the installation of Wind Farms, based on the legislation and the criteria set in AHP whereas areas presented in green color are the least suitable for wind farms. On the right map of figure 9 the proposed locations are shown with grey asterisks.

In total 34 areas where selected and the results are shown in the table below.

Discussion

Renewable Energy Sources are considered as a key factor for the sustainable development. The determination of the exact locations for the installation of RES plays a very important role in energy production as well as the acceptance from the general public.
Managers must determine the best possible solution based on a series of parameters that affect the installation location like current land uses, accessibility of the location, legislation framework, production potential etc.
This research on wind power has been based on five assumptions:
The majority of the population has a positive attitude towards wind power.
The opposition therefore is deviant.
People that are against it are misinformed towards wind power.
The oppositions must be understood in order to be overcome.
Trust is a key aspect.

A key in order to increase acceptance for wind power projects is to understand the social context of wind power (Aitken, 2010).
Simultaneously we must also take under consideration the public opinion and their acceptance towards RES installation, mainly because the proposed investments produce noise (especially in the case of Wind Farms), create landscape deformations and optical annoyance to residents etc.
It is therefore evident that there are a lot of parameters that need to be taken under consideration and must be studied prior to the proposal of installation sites.
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Determinants of household electricity consumption in Greece: A statistical analysis

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Abstract
Over the last decades, the contemporary way of living, as well as, the technology development have increased the household electricity consumption. However, the excessive use of electricity consumption has an impact on the environment, increasing the carbon footprint and contributing to the climate change. Governments are concerned regarding the way that our societies consume energy and are committed to reduce the greenhouse emissions. As the residential sector contributes to electricity consumption, it is crucial to investigate the socio-economic parameters, dwellings' characteristics and climate conditions that determine the electricity consumption in households. The data of this study are collected from 1,801 dwellings from all regions of Greece. In the statistical analysis two models are built, both concluding that the most significant determinants that influence the electricity consumption are the number of occupants, the size of the dwelling, the number of bedrooms, the heating type, the heating and cooling hours, the weather conditions and the fact of occupants not going on winter holidays.

Keywords: Electricity, consumption, determinants, socio-economic, statistical analysis.

JEL Codes: P18; P28; Q4; C1.

Παράγοντες που επηρεάζουν την κατανάλωση ηλεκτρικής ενέργειας στα νοικοκυριά στην Ελλάδα: Στατιστική ανάλυση

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Περίληψη
Ο σύγχρονος τρόπος ζωής καθώς επίσης και η ανάπτυξη της τεχνολογίας τα τελευταία χρόνια έχουν συνεισφέρει στην αύξηση της ηλεκτρικής κατανάλωσης στα νοικοκυριά. Η υπερβολική όμως κατανάλωση, έχει σημαντικό αντίκτυπο στο περιβάλλον, αυξάνοντας το αποτύπωμα του άνθρακα και συμβάλλοντας στην αλλαγή του κλίματος. Οι κυβερνήσεις ανησυχούν για τον τρόπο με τον οποίο οι κοινωνίες μας καταναλώνουν ηλεκτρική ενέργεια και έχουν δεσμευτεί να μειώσουν τις εκπομπές αερίων θερμοκηπίου. Ο οικιακός τομέας συμβάλλει σημαντικά στην κατανάλωση ηλεκτρικής ενέργειας, οπότε είναι σημαντικό να διερευνηθούν οι κοινωνικο-οικονομικοί παράγοντες, οι ιδιότητες των κατοικιών και οι κλιματικές συνθήκες που επηρεάζουν την

κατανάλωση ηλεκτρικής ενέργειας στα νοικοκυριά. Στην παρούσα μελέτη έχουν εξεταστεί οι παραπάνω παράγοντες για 1.801 κατοικίες από όλες τις περιοχές της Ελλάδας. Στην στατιστική ανάλυση αναπτύχθηκαν δυο μοντέλα τα οποία συμφώνησαν ότι οι σημαντικότεροι καθοριστικοί παράγοντες είναι: ο αριθμός των κατοίκων, το μέγεθος της κατοικίας, ο αριθμός των υπνοδωματίων, ο τύπος θέρμανσης, οι ώρες θέρμανσης και ψύξης, οι καιρικές συνθήκες και το γεγονός ότι οι κάτοικοι δεν απουσιάζουν για χειμερινές διακοπές.

Λέξεις Κλειδιά: Ηλεκτρική ενέργεια, κατανάλωση, κοινωνικό-οικονομικοί παράγοντες, στατιστική ανάλυση.

JEL Κωδικοί: P18; P28; Q4; C1.

1. Introduction

In the last decades due to the increased demand and the improved lifestyle, energy demand in the residential sector has increased rapidly causing the policy-makers' concern. The climate negotiations, also, keep awake the policy-makers so as to make improvements focusing on enhancement of energy efficiency, reduction of greenhouse emissions and promotion of renewable energy consumption. The recent 2030 Energy Strategy and the Paris climate conference (COP21) focus on the previous objectives to keep global warming below 2 degrees Celsius. According to (Eurostat, 2015), based on 2012 data in Greece, the energy sector is contributing to greenhouse gas emissions by 49%, the industry by 11%, the households by 14%, the agriculture by 13%, the transport by 8% and the services by 5%.

The Public Power Corporation (PPC), established in 1950, was the first public electricity company in Greece. Through the years PPC built an integrated energy production system, by creating lignite (brown coal) power plants and hydroelectric power stations. In 2013, PPC became the leading electricity supplier and had the 75% of the installed capacity of thermoelectric power plants, including in its energy mix lignite, hydro, oil and gas stations as well as renewable energy sources (RAE, 2018). Due to the European Union Directive 2009/72/EC, regarding the organization of the electricity market (European Parliament and Council, 2009b) two companies that were 100% subsidiaries of PPC were established: the Independent Power Transmission Operator (ADMIE S.A.) that has duties of the Operator of the Greek Electricity Transmission System and the Hellenic Electricity Distribution Network Operator (DEDDHE S.A.) that has duties of the Operator of the Greek Distribution Network (RAE, 2017). So, since July 1st, 2004 all commercial and industrial consumers could choose the supplier of electricity. The same right had also had all the residential consumers since July 1st, 2007. In 2011, the retail electricity market was characterized by an increase in inventory switching rates. Especially until the end of 2011, the 12.3% of commercial and the 11.5% of industrial customers had changed supplier (RAE, 2018). Until the end of 2017, 43 companies were licensed to supply electricity (RAE, 2017). According to the RAE's fact (RAE, 2016) until 31st of December 2016, PPC had the 98% of residential customers and the other providers had the rest.

In the last two decades, the Greek governments have given a high priority to the environmental protection, thus they promoted the Renewable Energy Sources (RES). The main aim concerning the RES is to be able to participate in the electricity consumption for at least 40% by the end of 2020. Specifically, Greece under the European Union Renewable Energy Directive 2009/28/EC (European Parliament and Council, 2009a) and with the Law 3851/2010 (Official Government Gazette, 2018) for the contribution of RES, set the targets of at least 20% of the final energy consumption for heating and cooling, of at least 40% of the final electricity consumption and of at least 10% of the final

energy consumption in transportation. In 2015 the proportion of contribution of RES for heating and cooling was 59.9%, for final electricity consumption was 22.1% and for transport was 1.4% achieving a total RES contribution of 15.4%.
Coal is the primary fuel of electricity production in Greece. Based on 2015 results, coal has the 42.6% when the RES (biofuels, waste, hydro, solar PV and wind) have the 28.9%, the gas the 17.5% and the oil 10.9% of total electricity production (IEA, 2015).
Policy-makers have to focus on the distribution of the electricity consumption, in order to detect and improve the most wasteful sectors. Based on 2015 results, the most wasteful sectors of the electricity consumption were the residential with 34.5% and the commercial & public services with 35.3% of total share. The industry had the 24.9% of electricity consumption followed by agriculture/foster with 4.5% and transport with 0.8% (IEA, 2015). In the residential sector the final energy consumption is used by 57% in order to heat the space, while by 20% is used for lighting and appliances, by 12% for heater heating, by 7% for cooking and by 4% for space cooling (Eurostat, 2018).
Consumption per capita is an important indicator to observe the tendency of electricity consumption through the years, as it offers a clear view of the electricity that every individual consumes. In Greece, in 2000 the per capita electricity consumption was 4,586.33 kWh/capita while in 2008 was 5,805.19 kWh/capita (DataBank, 2018). The economic crisis in Greece from 2008-2009 influenced the electricity consumption as in 2013 the consumption fell to 5,029 kWh/capita. Consumption per household consists another indicator to monitor the electricity consumption in the residential sector. In 2000 the electricity per household (hh) was 3,717 kWh/hh while in 2010 was 4,023 kWh/hh (World Energy Council, 2016).
This paper is organized as follows: in Section 2 an overview of the literature review relevant for this study is included. A description of the regression models and the data sources is given in Section 3. In Section 4 the main results are summarized. Finally, the conclusions are presented in Section 5.

2. Literature Review

On the international stage, residential electricity consumption is a considerable studied subject.

2.1 Studies regarding European countries

Wiesmann et al. (2011) examined the relationship between the per capita electricity consumption and dwelling characteristics in Portuguese consumers. They concluded that the income, the appliance ownership, and the floor area had a positive influence on per capita electricity consumption. People who lived in single-family houses and/or in urban households consumed more electricity than those living in a block of flats and/or rural households. People per household, dwellings per building and more heating degree-days influenced negatively the consumption per capita.
McLoughlin et al. (2012) examined the influence of dwelling and occupant characteristics on electricity consumption of 3941 Irish dwellings. Dwelling type, number of bedrooms, age of the head of household (HoH) and electrical appliances that were used for water heating and cooking had a positive effect on electricity consumption.
Bedir et al. (2013) pointed out that in Netherlands the household size, dwelling type, number of general appliances, use of dryers' loads, use of washing cycles and use of showers were a significant effect in the electricity consumption. Also, in the Netherlands, Brounen et al. (2012) analyzed data of 300,000 dwellings. The type of dwelling had an effect on electricity consumption as the detached and semi-detached houses consumed more electricity per capita than row houses or apartments. Houses with children and especially those that have teenagers were found that had a positive effect on per capita electricity consumption. The income had positive impact whereas the number of persons in household had a negative effect on per capita electricity consumption.

Gram-Hanssen (2011) pointed out that the user's practices influence the energy consumption. He examined 8,500 detached houses in Denmark and he found that income, the size of the house and the presence of children between 13-19 (teenagers) had a positive effect on electricity consumption.
Halicioglu (2007) examined how the energy demand in residential sector in Turkey was influenced from the price and income. The income influenced the electricity demand positively and accelerated purchases of electrical goods and services. The price of electricity, influenced negatively the electricity demand when, the urbanization influenced positively the electricity demand, as urbanization means greater access to electricity.

2.2 Studies regarding non European countries

Esmaeilimoakher et al. (2016) accomplished an introduction to the factors that influence the electricity consumption. Their analysis is based on a survey that was conducted in nine households of Perth of Western Australia. The main results were that the Average Annual Electricity consumption per person per m^2 floor area (AAEC/P.m^2) had a negative correlation with the number of occupants and the size of dwellings.
Sanquist et al. (2012) based their research on data from the Residential Energy Consumption Survey (RECS) that was conducted on 2005 in the United States. The air-conditioning, laundry usage, personal computers, climate zone of dwelling and TV use were found that influence significantly the electricity consumption. Kavousian et al. (2013) examined the residential electricity consumption of 952 United States dwellings in a view of daily maximum and minimum. Daily minimum consumption was influenced by weather, location, dwelling size and the number of refrigerators when daily maximum consumption was influenced by the use of appliances that consume a lot and the number of residents. In the summer model, the primary factor that influenced the electricity consumption is the Cooling Degrees Days (CDD).
Ndiaye and Gabriel (2011) analyzed electricity consumption of 62 dwellings of Oshawa, Canada. Number of residents, house status, type of fuel used to heat the pool, type of fuel used in the heating system, type of fuel used in the domestic hot water heater, type of air-conditioning and number of air changes, found that had a positive effect on the electricity consumption. On the other hand, the average number of weeks that the family leaves for vacation and the existence or not of an air conditioning system had a negative effect on the electricity.
Tewathia (2014) conducted a survey in Delhi to find the determinants of electricity consumption. The household income, the number and the usage of electrical appliances, the size of the house, the family size, the time that is spent out of the home and the higher educational level were found to influence the monthly electricity consumption through all the seasons. The educational level had a negative relationship as the higher educated families tent to consume less electricity. Filippini and Pachauri (2004) analyzed the electricity demand in urban Indian households. The price was inelastic in electricity demand, so, the price was not an inhibiting factor in residential electricity consumption. The income, the size, the regions, the degrees of urbanity were found to have a significant influence into the electricity consumption. Dwellings with more residents and younger households head had the tent to consume less electricity from those that had less elder people.
Jones et al. (2015) conducted a broad literature review to investigate the factors that influence or not the domestic electricity consumption. The final result was that 62 factors had been studied as potential factors that determine the electricity consumption. In relation to socio-economic factors, the more household income and disposable income, the more occupants and presence of teenagers had a positive effect on electricity consumption. In relation to dwelling factors the dwelling age, the number of rooms, the number of bedrooms and the floor area were found to influence the electricity consumption. Regarding appliance factors, the following ones had a positive effect: more appliances,

the existence of desktop computer, television, electric oven, refrigerator, dishwasher, tumble dryer and more use of washing machines and tumble dryer.

2.3 Studies regarding Greece

Donatos and Mergos (1991) examined the residential electricity demand in Greece during the period 1961 – 1986. Data were collected from pubic database. It was found that the electricity demand was price inelastic and income elastic. The sales of appliances, as well as, the heating degrees-days were found that had an insignificant effect on electricity demand in contrast with the number of consumers that had a significant impact.

Hondroyiannis (2004) examined the elasticity of price and income in long-run and short-run demand for residential electricity. The examined period was 1986-1999 employing monthly data. In the short-run the electricity demand was income inelastic and independent of the price, while in the long-run period, all variables, income, price and weighted average temperature were found that affected the electricity demand.

Polemis and Dagoumas (2013) conducted a similar with Hondroyiannis (2004) research. They used cointegration techniques and the vector error correction model to observe the long-run and short-run electricity demand. The data that were taken into account were for longer period, from 1970 to 2011. It was found that in the long-run the electricity demand was price inelastic and income elastic, while in the short-run the relevant elasticities were inelastic.

Sardianou (2007) investigated the determinants of household energy conservation. The analysis was based on a survey that was conducted in 586 households of five main Athens' regions. One of the findings was that the people with higher income that own their houses, and had a large family were more willingness to conserve energy. Unlikely, number of rooms, dwelling's size, sex, educational level and marital status were found that had not a significant influence in energy conservation. However, it was found that the larger electricity expenditures negatively influenced the energy conservation behaviors and the older people were more energy-intensive users than the younger ones.

The research in the field of socio-economic determinants that influence electricity consumption in Greece is poor. There are a lot of works focused on macroeconomic factors that determine energy consumption. Only the study of Sardianou (2007) provided research that includes demographic data, however she examined the electricity conservation behavior.

3. Model and data specification

3.1 Model specification

The ordinary least squares (OLS) regression is used to estimate the determinants that affect the electricity consumption in households. A variety of studies that examined the determinants of electricity consumption are conducted using OLS regression (Bedir et al., 2013; Brounen et al., 2012; Filippini and Pachauri, 2004; Gram-Hanssen, 2011; Halicioglu, 2007; Kavousian et al., 2013; McLoughlin et al., 2012; Ndiaye and Gabriel, 2011; Sanquist et al., 2012; Sardianou, 2007; Wiesmann et al., 2011). Two different models are employed to determine the electricity consumption. A simple OLS regression model and a log-linear regression model are used to build the models.

3.2 Data sources and description

Data are collected from a Greek electricity provider and refer only to residential dwellings. Data for the consumption and square meters area have been provided through the actual bills. The period of actual bills is not the same between bills and differs among dwellings. Thus, in order to calculate the consumption with accuracy, the consumption per day was calculated at first. Afterwards, consumption per year was calculated and only dwellings that had consumption in the year 2017 were selected.

Demographics and behavior data were retrieved from a questionnaire that was provided through the electricity provider's online platform. The questionnaire was answered from every individual that covers the bill. Only dwellings that already had a yearly consumption for 2017 and have also answered to all the questions were selected. A preliminary analysis was conducted to that data in order to delete the invalid values, thus the final number of dwellings that are included in the analysis are 1,801. Table 1 illustrates all available variables, as well as, the type and the units of the variables. Table 2 illustrates the summary of statistics of the variables. It also shows the levels of ordinal variables and their correspondence to the converted numbers.

Table 1

Model specification and variable definitions

Variable	Type	Unit	Variable	Type	Unit
Ave. Consumption	continuous	kWh/year	Time Spend	ordinal	
Square meters area	continuous	m^2	Lights:	cat. nominal	
Occupants	discrete		Never		ref. category
Family Type:	cat. nominal		Often		dummy
Young people		ref. category	Sometimes		dummy
Family with older children		dummy	Heating Type:	cat. nominal	
Family with young children		dummy	Central boiler		ref. category
Older people		dummy	Individual cent. boiler		dummy
Age	cat. nominal		Individual local units		dummy
Gender:		categorical	No heating		dummy
Female		ref. category	Secondary Heater:	cat. nominal	
Male		dummy	No		ref. category
Marital Status:	cat. nominal		Yes		dummy
Divorced		ref. category	Heating Hours	ordinal	
Married		dummy	Cooling Type:	cat. nominal	
Single		dummy	No air-conditioning		ref. category
Widowed		dummy	Have air-conditioning		dummy
Occupants Work	discrete		Cooling Hours:	ordinal	
Income	ordinal	€/year	Summer Holidays:	cat. nominal	
Educational Level	ordinal		Other		ref. category
House Status:	cat. nominal		I don't take sum. hol.		dummy
Rent		ref. category	July/August		dummy
Own		dummy	June/September		dummy
Dwelling Type:	cat. nominal		Winter Holidays:	cat. nominal	
Block of flats		ref. category	Other		ref. category
Single family house		dummy	Christmas		dummy
Dwelling Floor	ordinal		Easter		dummy
Rooms	ordinal		I don't take win. hol.		dummy
Bedrooms	ordinal		HDD		10^3 °C · days

Model	Equation
Model 1	$C = \beta_0 + \beta_1 SM + \beta_2 O + \beta_3 FM + \beta_4 A + \beta_5 G + \beta_6 MS + \beta_7 OW + \beta_8 I + \beta_9 EL + \beta_{10} + \beta_{11} DT + \beta_{12} R + \beta_{13} B + \beta_{14} TS + \beta_{15} L + \beta_{16} HT + \beta_{17} SH + \beta_{18} HH + \beta_{19} CT + \beta_{20} CH + \beta_{21} SHol + \beta_{22} WHol + \beta_{23} CDD + \varepsilon$
Model 2	$lnC = \beta_0 + \beta_1 SM + \beta_2 O + \beta_3 FM + \beta_4 A + \beta_5 G + \beta_6 MS + \beta_7 OW + \beta_8 I + \beta_9 EL + \beta_{10} HS + \beta_{11} DT + \beta_{12} R + \beta_{13} B + \beta_{14} TS + \beta_{15} L + \beta_{16} HT + \beta_{17} SH + \beta_{18} HH + \beta_{19} CT + \beta_{20} CH + \beta_{21} SHol + \beta_{22} WHol + \beta_{23} CDD$
Abbreviation	**C**: Consumption, **SM**: Square Meters Area, **O**: Occupants, **FM**: Family Type, **A**: Age, **G**: Gender, **MS**: Marital Status, **OW**: Occupants Work, **I**: Income, **EL**: Educational Level, **HS**: House Status, **DT**: Dwelling Type, **R**: Rooms, **B**: Bedrooms, **TS**: Time Spend, **L**: Lights, **HT**: Heating Type, **SH**: Secondary Heater, **HH**: Heating Hours, **CT**: Cooling Type, **CH**: Cooling Hours, **SHol**: Summer Holidays, **WHol**: Winter Holidays, **CDD**: Cooling degrees days

In the literature review many studies (Donatos and Mergos, 1991; Kavousian et al., 2013; Ndiaye and Gabriel, 2011; Sanquist et al., 2012; Wiesmann et al., 2011), include the weather factors of heating degrees-days (HDD) and cooling degrees-days (CDD). HDD and CDD is the difference, in degrees, of outside temperature and base (18.3 *degrees Celsius*) temperature. HDD and CDD data for each prefecture and for the year of 2017 were downloaded from the weather stations of National Observatory of Athens (NOA). Data were available in the weather website (www.meteo.gr) and had been recorded at a daily basis (Petrou, 2018). The yearly HDD and CDD were calculated per prefecture and then the weather data were connected to the consumption data based on prefecture. Units of HDD and CDD are exposed in 1,000.

The data preparation, manipulation, visualization and the regression analysis is conducted using programming language R through RStudio program.

Table 2
Summary statistics of the variables

Variable	Mean	St. Dev.	Levels of ordinal variables
Ave. Consumption	396.49	223.645	
Square meters area	105.429	52.416	
Occupants	3.062	1.143	
Family Type: Family with older children [a]	0.220	0.414	
Family Type: Family with young children [a]	0.443	0.497	
Family Type: Older people	0.091	0.287	
Age	2.592	0.828	1:"19-29", 2:"30-39", 3:"40-55", 4:"56-67", 5:"68+".
Gender: Male [a]	0.819	0.385	
Marital Status: Married [a]	0.778	0.416	
Marital Status: Single [a]	0.171	0.377	
Marital Status: Widowed [a]	0.008	0.091	
Occupants Work	1.532	0.702	
Income	2.253	0.857	1:Low-income (less than 10,000€), 2:Lower-middle (11,000€ - 20,000€), 3:Upper-middle (21,000€ - 40,000€), 4:High-income (more than 41,000€)
Educational Level	2.835	0.831	1:"No diploma", 2:"High school diploma or equivalent", 3:"Bachelor or equivalent", 4:"Master or equivalent", 5:"Doctoral or equivalent"
House Status: Own [a]	0.721	0.449	
Dwelling Type: Block of flats [a]	0.710	0.454	
Dwelling Type: Single family house [a]	0.290	0.454	
Dwelling Floor	2.189	0.813	1:"1-2", 2:"3-4", 3:"5-6", 4:"7-8"
Rooms	2.149	0.635	1:"1-2", 2:"3-4", 3:"5 or more"
Bedrooms	1.919	0.416	1:"1", 2:"2-3", 3:"4 or more"
Time Spend	2.212	0.548	1:"Less than half-day", 2:"Half-day or more", 3:"All day"
Lights: Often [a]	0.043	0.202	
Lights: Sometimes [a]	0.400	0.490	
Heating Type: Individual central boiler [a]	0.503	0.500	
Heating Type: Individual local units [a]	0.284	0.451	
Heating Type: No heating [a]	0.053	0.224	
Secondary Heater: Yes [a]	0.722	0.448	
Heating Hours	2.351	0.911	1:"0–2 hrs", 2:"2-5 hrs", 3:"5–10 hrs", 4:"10 hrs or more"
Cooling Type: Have air-conditioning [a]	0.870	0.336	
Cooling Hours [a]	1.809	0.832	1:"0–2 hrs", 2:"2-5 hrs", 3:"5–10 hrs", 4:"10 hrs or more"
Summer Holidays: I don't take summer holid. [a]	0.154	0.361	
Summer Holidays: July/August [a]	0.668	0.471	
Summer Holidays: June/September [a]	0.087	0.281	
Winter Holidays: Christmas [a]	0.234	0.424	
Winter Holidays: Easter [a]	0.082	0.275	
Winter Holidays: I don't take winter holid. [a]	0.527	0.499	
CDD (1000)	1.233	0.233	
HDD (1000)	1.113	0.397	

[a] Dummy variable

3.3 Model building

Before conducting a regression analysis, an advanced statistical analysis is conducted to observe any associations or correlation between variables. Thus, pairwise comparisons and a correlation analysis are used. The insights of the analysis show a very high negative correlation between HDD and CDD, approximately -0.809. So, due to high correlation the HDD is selected to be removed from the regression.

In the sample, the final independent variables along with the dummy variables count to thirty five (35). It is essential to determine whether the subset of all independent variables yields to an adequate and appropriate model. Stepwise regression is a method that attempts to find the best regression model, without examining all the possible models (Berenson et al., 2014). There are two approaches of stepwise regression, the "forward selection" and the "backward elimination". The forward and backward selections were set to the regression model and the results were the same. Thus, the forward selection is selected to present the results of the regression model.

Table 3
Estimation results from OLS regression model

Variable	Model 1 Ave. Consumption	Model 2 log(Ave. Consumption)
Square meters area	1.260*** (0.107)	0.002*** (0.0002)
Heating Hours	36.967*** (5.573)	0.072*** (0.013)
Occupants	39.678*** (4.982)	0.089*** (0.015)
Heating Type: Individual central boiler	-18.502 (12.926)	-0.025 (0.031)
Heating Type: Individual local units	43.422*** (14.491)	0.088** (0.035)
Heating Type: No heating	9.297 (22.608)	0.012 (0.054)
Cooling Hours	17.161*** (6.118)	0.057*** (0.015)
Age	13.328** (6.024)	
Secondary Heater: Yes	26.764*** (10.242)	0.069*** (0.025)
Bedrooms	32.887** (13.504)	0.153*** (0.033)
CDD	41.299** (21.023)	0.120** (0.050)
Dwelling Type: Single family house	23.525** (10.828)	
Family Type: Family with older children		0.108*** (0.040)
Family Type: Family with young children		0.074* (0.038)
Family Type: Older people		0.102** (0.045)
Occupants Work		0.033* (0.018)
Dwelling Floor		0.021 (0.014)
Lights: Often		0.075 (0.054)
Lights: Sometimes		0.039* (0.022)
Winter Holidays: Christmas	24.033 (14.677)	0.050 (0.035)
Winter Holidays: Easter	12.858 (19.397)	0.047 (0.047)
Winter Holidays: I don't take winter holidays	34.370*** (12.898)	0.101*** (0.031)
Cooling Type: Have air-conditioning	23.778 (14.652)	0.079** (0.035)
Income	11.142* (5.892)	
Marital Status: Married	-19.540 (23.481)	0.043 (0.056)
Marital Status: Single	6.570 (24.900)	0.040 (0.059)
Marital Status: Widowed	75.510 (53.818)	0.315** (0.129)
Time Spend	12.824 (8.425)	0.076*** (0.021)
Constant	-239.556*** (51.262)	4.007*** (0.122)
Observations	1,801	1,801
R^2	**0.301**	**0.320**
Adjusted R^2	**0.293**	**0.311**
Residual Std. Error	188.058 (df = 1779)	0.452 (df = 1775)
F Statistic	36.509*** (df = 21; 1779)	33.440*** (df = 25; 1775)
Note:		*p<0.1; **p<0.05; ***p<0.01

4. Results

The results of the OLS regressions are presented in Table 3. In general, the results from both models are in agreement with the literature. All the significant variables have the expected sign in both models. In terms of the R-squared the log-linear model (Model 2) has better goodness of fit from the linear model. Both models are enough consistent between each other, but they have differences. Most of variables that are found significant are common in both models, but there are variables that influence one model and not the other.

Square meters area has a significant effect on the average yearly electricity consumption in both models. To be more specific, if the square meters area increases by 1 m^2 then an increase of 1,26 kWh/month according to Model 1 and an increase on average yearly consumption by 0.2% according to Model 2 are expected. That results are in line with previous studies (Bedir et al., 2013; Filippini and Pachauri, 2004; Gram-Hanssen, 2011; Jones et al., 2015; Kavousian et al., 2013; Tewathia, 2014; Wiesmann et al., 2011).

Number of occupants is strongly related with the electricity consumption. In both models more occupants consume more electricity. Studies of Gram-Hanssen (2011), Jones et al. (2015), Kavousian et al. (2013) and Ndiaye and Gabriel (2011) are concluded to the same results.

Heating hours, heating type and the presence of secondary heaters have a significant effect on electricity consumption in both models. To be more specific, heating hours seems to influence positively the electricity consumption regardless the heating type. On the other hand, heating type of local units influences significantly the electricity consumption. Dwellings that use local units for heating the space seem to consume more electricity. The results reveal that houses with heating type of local units use possibly electrical appliances to heat their space which has an impact on their total consumption. The presence of secondary heaters has also a positive significant effect on the electricity consumption. Those results enhance the perspective that the electrical appliances that are used to heat the space have an impact on electricity consumption. Jones et al. (2015) mentioned that there are eight studies that found a positive effect of presence of electric space heating system on electricity consumption.
Cooling hours is also related with the electricity consumption. Both models agree to the positive relationship between cooling hours and electricity consumption. CDD also is found that has a positive effect on electricity consumption in both models. The presence of air-conditioning to cool the space has a significant effect in Model 2 while in Model 1 it is not found that influences the electricity consumption. Jones et al. (2015) through deep literature review found that of the studies that he examined, there were six (6) studies that the presence of air-conditioning had a significant positive effect on electricity consumption; which is aligned with the results of Model 2, and three (3) studies that not found to have any relationship between air-condition and electricity consumption, like the results of Model 1.
In both models the number of bedrooms has a significant effect on electricity consumption, while number of rooms does not seem to have any effect on electricity consumption. The results of the significance of the number of bedrooms are aligned with McLoughlin et al. (2012), while the results of the insignificant effect of the number of rooms are aligned with Wiesmann et al. (2011). However, Brounen et al. (2012) found a negative effect of the number of rooms in electricity consumption. Jones et al. (2015) mentioned that there are five (5) studies that found a positive effect of the number of bedrooms in the electricity consumption, while there are four (4) studies that mentioned a positive effect of the number of rooms on the electricity consumption and one (1) study that found a negative effect of the rooms.
Dwellings with occupants that are not going for winter holidays are found to have a positive significant effect on electricity consumption. On that direction, both models agree. Similar results are published by Ndiaye and Gabriel (2011) that found that the average number of weeks that occupants leave for vacations influence negatively the electricity consumption.
According to Model 1, the dwelling type has a significant effect on electricity consumption, as the single family houses seem to consume more electricity. This result is aligned with past studies of Bedir et al. (2013), Brounen et al. (2012), McLoughlin et al. (2012) and Wiesmann et al. (2011).
According to Model 1, income is found that it has a positive effect on electricity consumption. Model 2 does not take into account the variable of income. There are many studies that are in line with the results of both models. Jones et al. (2015) refer that there are eighteen (18) studies that found positive the impact of income in electricity consumption, while there are three studies that did not find any significance. Kavousian et al. (2013) have similar results of Model 2, while Brounen et al. (2012), Filippini and Pachauri (2004), Gram-Hanssen (2011) and Tewathia (2014) have similar results with Model 1.
An impressive result is revealed regarding the number of occupants who work. Model 2 finds that the number of occupants that work has a positive effect on electricity consumption. This result is not expected as people who work usually leave their home for many hours. However, more people working means higher income, so, that reveals that people who have a higher standard of living

consume more electricity. None of the studies of the literature review has examined the variable of occupants who work.
Model 2 finds that family type has a significant effect on electricity consumption. Families with older children seem to consume more electricity in comparison with families with young children. This result is similar with the presence of teenagers. A variety of studies (Brounen et al. 2012, McLoughlin et al. 2012, Wiesmann et al. 2011) mention that the presence of teenagers influences positively the electricity consumption. However, older people have also a significant effect on electricity consumption. This result is opposite of the results of Brounen et al. (2012) that found that elderly consume less electricity than married couples, even if they spend more time in the house.
On the other side, Model 1 finds that the age influences positively the electricity consumption. So, as long as the occupants that cover the bill are elderly, the more electricity is consumed. This result is aligned with Bedir et al. (2013), Brounen et al. (2012), Kavousian et al. (2013) and McLoughlin et al. (2012). Also, Jones et al. (2015) mentioned that there are eight (8) studies that marked the positive effect of age of head of the household on the electricity consumption.
The lights behavior of occupants that sometimes leave lights on when they leave a room is found that it has a significant positive effect on the electricity consumption. A closer look reveals the energy waste behavior of people that do not have energy efficient habits.
According to Model 2 time spent in house has also a positive significant effect in the electricity consumption. So, dwellings with occupants that spend more time in home have higher electricity consumption. This result is expected and is aligned with the study of Tewathia (2014) that examined the opposite factor, which was the time spent out of home. Tewathia found that the more time it was spent out of home, the less electricity it was consumed.
Model 2 also finds that the marital status of widowed has a positive significant effect on the electricity consumption. This result is not mentioned in any study of the literature review.
Many variables of the collected data are found that have no significant influence on the electricity consumption. Those variables are the gender, the educational level, the house status, and the summer holidays.

5. Conclusions

This study focuses on the investigation of the socio-economic determinants, the dwellings characteristics and the climatic conditions that influence the household electricity consumption. Two regression models, one linear and one log-linear, are built. Both models explained approximately 30% of the variance in electricity consumption.
The number of occupants, as well as, dwelling characteristics of size (square meters area) and the number of bedrooms are demonstrated as considerable predictors for the residential electricity consumption in both models. The hours of cooling and heating contribute to a large extent to the electricity consumption suggesting the intensive electricity demand of cooling or heating appliances. Heating appliances using electricity to operate have an impact on the electricity consumption, as the dwellings that use local units and/or secondary heaters surcharge their overall electricity load. On the other hand, the electricity consumption of dwellings that use other types of heating (using fuels) or not using any heating types remains unaffected. Additionally, the fact of not going on winter holidays has a positive impact on electricity consumption, suggesting that the more time that the occupants spent in the house in winter season, it influences the electricity consumption. Weather conditions also affect the final consumption as higher temperatures contribute to the higher electricity consumption.
Model 1, also predicts that the following factors increase the electricity consumption: higher income, higher age of individual who covers the bill and single family houses. On the other hand, Model 2,

predicts the following factors which burden the electricity consumption: families with young or older children, families of older people, number of occupants who work, the time occupants spent in the house, the usage of air-condition for cooling the space, the behavior of occupants in leaving the lights on when they leave the room and the widowed marital status.

By comparing the two models, this research shows that the dwelling and household characteristics, as well as, the climatic conditions are essential predictors in models of electricity consumption. Further research on occupants' behavior and on presence and functions of appliances will enhance the determinants of electricity consumption in housing.

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Understanding people's perception about biodiversity importance, management and conservation

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Abstract

The aim of present study is to contribute to a better understanding of the ways of the wider public reason about issues of biodiversity change and management, and more to determine the factors that influence people support for biodiversity management measures due to climate changes. For this reason a face-to-face survey of 468 respondents randomly selected was carried out. The sample was stratified to ensure adequate sample sizes to compare results from three geographical areas: 48.7% of the sample was from Pagasetic Gulf area, 26.1% from the Crete-Rethymno area, and 25.2% from the Lesbos (Mytilini). For this purpose, a combination of applied methodological research techniques like Correspondence analysis and Principal Component Analysis was used. The results indicated the relative importance of region to respondents' perceptions knowledge and concern about biodiversity. According to the results biodiversity loss will mainly influence our country due to consequences to environment quality, heritage and financial wealth, following the impacts to world economy, knowledge and inspiration.

1. Introduction

This paper reports on the results of a one-year research project that was aimed to propose a segmentation of people that is oriented toward biodiversity and also exploring the society opinion for marine biodiversity. Segmentation is using in market research as a **method** of **separate** population or a particular public into groups according to their personal characteristics, needs, attitudes, capabilities and behaviours.

For this study, market segmentation gives help to determine the characteristics that empowers individuals to make choices and take actions for marine biodiversity, and provide information as to how management policies should be designed, and how it should be promoted in order to be accepted from society.

In the frame of present study we try to answer the following questions

1. Which biodiversity values rank people as important?
2. Can we segment people according to their views on marine biodiversity?
3. People opinion against biodiversity values affect their preferences for coastal zone management or other actions?

Identifying groups within a population based on common beliefs about the future of biodiversity and the consequences of its loss helps us to design more effective planning because the similar requirements that can be satisfied by a mix of strategies. Segmentation analysis can also determine groups that may not care about biodiversity loss, and different approaches in campaigns would be needed to address these groups.

Finally, segmentation serves to provide information as to how biodiversity conservation measures should be designed, and how it should be promoted in order to satisfy society group needs.

At present study we used biodiversity role classification following Hooper et al. (2005) and MEA (2005). According them biodiversity provide a range of products directly (food, fuel etc.) or indirectly (throw-out regulating, cultural etc.). Understanding why people action for biodiversity protection inaction requires a deep understanding of motivators and barriers related to the behavior goals. Motives and concerns of people vary according to the age and individual perceptions about biodiversity utility and vary across population groups (Sterlinga et al., 2017). Recognition of these groups could help decision making for biodiversity conservation and policy makers for taken effective measures. A number of studies focus on the relationship between noneconomic motives and people's WTP for environmental protection focusing on each attitude to the environment (Kotchen & Reiling, 2000; Cooper et al, 2004; Halkos et al., 2019; Halkos and Matsiori 2018).

2. METHODS

A random sample of 648 individuals was selected foe implementation the research objectives. The sample was stratified in such a way to ensure adequate sample sizes and represent all areas of the Pagasitokos gulf. We used a qualitative approach to investigate society interest about marine biodiversity. A self – administrator questionnaire was used and face-to-face interviews were conducted on-site to understanding respondents' perception about marine biodiversity and changes of its population. For this reason, a number of questions were included in the questionnaire to investigate respondents' behavior (or attitude) about the consequences of changes in marine biodiversity population.

Our present study is a part of a greater research which was aimed to explore people attitude against marine environment and coastal zone. The final questionnaire of the survey consisted of questions for measuring people knowledge to marine environment issues, perception of uses and values of marine biodiversity, perceptions of the effectiveness of strategies to integrate coastal zone and a question to investigate people's intention to pay for coastal zone quality improvement.

Finally, a number of specific questions was used to investigate inhabitants' awareness, feelings and knowledge for Posidonia. We assume that Posidonia oceanica is poorly known and is very interesting to investigate peoples' perception for its conservation. At present study we try to explore the opinion that peoples' behavior against species could be guided form their perception for their fragility, possibility to view, familiarity, endangerment, and belief of the public consensus (Martìn-Lòpez et al., 2007).

The questionnaire were delivered to four parts: i) part 1 which included questions about demographic characteristics of the respondents, ii) part 2 which included questions about knowledge of marine biodiversity, iii) part 3 which included questions about contingent valuation scenario with different payment scenarios for species for financial support, and iv) part 44 which included questions about the individual attitudes towards two selected species.

According to Dolnicar (2002) Multi-Variate Analysis (as Factor and Cluster Analysis) are used to segmentation studies. Principal Component Analysis (PCA) is a statistical analysis that identify a set of values (observations) of potentially correlated variables into a set of new values of non-linearly related variables. The new dimensions then is used to classify respondents into groups with similar stances towards them (Zografos and Allcroft 2010). Then Cluster Analysis (CA) is used to create as much as possible heterogeneous groups of respondents with their responses to those dimensions (Frochot and Morrison, 2000). Finally, sociodemographic or other respondent characteristics can be used to describe the market segments.

3. RESULTS – DISCUSION

3.1. Sample socioeconomic and ecological profile

Table 1 presents the descriptive statistics of the respondents' socioeconomic characteristics.

Table 1: Descriptive statistics of respondents' basic socioeconomic characteristics

	Number of observations	Mean/ Percentage	Standard Deviation
Gender (%)	468	51.7 % (Male)	-
Age (years)	468	41.56	13.62
Education level	468	37.0% (University, Higher Military Schools, Open University)	
Individual total annual income after taxes for the last year (€)	468	18.8% (10000€ - 15000€)	
Employment (%)	468	35. 3% (Working full-time in Private Sector)	-
Number of Household Members	468	3.63	1.261

Only 6.4% of the participants in the survey were members of Non-Governmental Organizations (NGO) and only 2.6% of those have been working in an NGO voluntarily.

3.2.Principal Components Analysis (PCA)

Principal Components Analysis (PCA) was used to measure different public perceptions with regard to economic dimensions of the economic value of marine biodiversity. Specifically, respondents were asked to indicate on a five-point Likert scale for each topic their opinion for the importance of 30 reasons holding economic value to marine biodiversity and Posidonia seagrass. The 30 items were selected according to the connections between biodiversity functions and services that people value (MEA 2005). Described functions represent biodiversity values that people put on them according the way humans conceptualize and understand marine biodiversity.

Environmental economists had linked the functions and services that are provided by biodiversity with their different types of economic values (Turner et al. 2000). Reliability analysis of the question revealed that Cronbach-*a* was 0.712. The PCA has extracted four factors explaining 68.12 % of the fluctuation of the total variance[15]. The Kaiser-Meyer-Olkin (KMO) criterion for sampling adequacy was ***equal*** to 0.800 and the Bartlett's test of sphericity *was equal* to 3421.149 (with a p-value of 0.000, df = 435) (Table 2).

According to the results of the PCA respondents difference the various categories of marine biodiversity values from the set of items provided them. The four factors extracted from the PCA represent the way respondents appreciate and value the various services provided by marine biodiversity and Posidonia Seagrass. It is interesting that the participants prioritize the indirect functions resulting from the loss of biodiversity. Posidonia values were grouped into one alone factor, highlighting the special interest of people in endangered species.

[15] The results of the PCA are not presented here but are available on request.

Table 2. Results of PCA analysis

Factors Identification	Variance Explained (%)	Cronbach's a	Total Cronbach's a	K.M.O.	Bartlett's test of bsphericity
Indirect uses of biodiversity	32.001	.762	0.712	0.800	Approx. χ^2 =3421.149 df = 435 Sig. = .000
Economic values	17.087	.653			
Posidonia values	10.169	.593			
Environment condition	8.863	.340			

First factor that was identified by the respondents represented «*indirect uses of biodiversity*». This was the most ***important factor*** explaining 32.001% of the total variance in the data while Cronbach-*a* was 0.762. First component loaded positively high on items related mainly with marine biodiversity contribution to "Art Inspiration", "Human Knowledge" and "Greek and World Heritage.

The items loading into the 2nd factor are related to marine biodiversity economic values. All items underline the importance of marine biodiversity to economy providing food, jobs and its contribution health of economy, etc.).

The 3rd factor reflects respondents' awareness about Posidonia. More specifically, people showed up Posidonia's contribution to "Art Inspiration", "Human Knowledge" and "Greek and World Heritage. For respondents, Posidonia has an important contribution to regional culture and many times is related to our knowledge for pharmacology by increasing our knowledge of bioactive substances.

The last factor referred to marine biodiversity contribution to ecological balance and its items are assisted with its functional values.

Tests to compare the five factors with respect to age, gender, education, income did not detect any significant relationships except between education and the 5th factor (with Spearman's ρ: 0.123 and P-value=0.008).

3.3. Cluster Analysis: The market segments

The next step involved a k-means Cluster Analysis that was performed to group responses to above factors into clusters. A four-cluster solution was chosen as it provided an acceptable (Table 3). Negative means indicated lower levels of agreement with the PCA items (biodiversity values items) that included to each of the four components.

Table 3. A Four-cluster solution: Four valuation market segments

	Cluster			
	Environment interested	Worried	Posidonia interested	Apathetic
Indirect uses of biodiversity	-.25326	1.16557	-.54514	-.38928
Economic values	-.28185	.69847	-.25837	-.18666

Posidonia values	-1.16019	.23941	.82374	-.54150
Environment condition	.62447	.06055	.19095	-1.59311
Number of Cases	111	124	165	68

The first segment (cluster) was characterized by respondents who express their worries only about environmental conditions seems that are not worried about the loss of any other function (use) of marine biodiversity. Members of this cluster behave in the same way when they are asked express their concerns about the loss of Posidonia uses. We could say that are opposed to all uses of marine biodiversity and for their own consciences the only important use of marine biodiversity is its contribution to environment's health and ecological balance.

The second cluster is characterized by interest in marine biodiversity and its members are full of concern about the loss of biodiversity, with the simultaneous loss of its uses, making it more important to contribute to art and knowledge.

Members of third cluster expressed worries about loss of Posidonia uses. Finally, was characterized by respondents who are not interested in the loss of biodiversity and the uses associated with it.

3.4.Socioeconomic characteristics

Significant differences between the segments were found in the gender, age, education levels and household income (Table 5). Chi-square tests suggest that females dominate in all segments but most of them appear in the fourth cluster (Apathetic). Younger people are most represented at second cluster (Worried) on the contrary older people presented with the highest rate on first cluster (Environment interested). Most educational people (in years) and wealthiest respondents appear in the third cluster (Posidonia interested).

Table 5 Visitor characteristics significantly different between clusters (in %)

	Environment interested	Worried	Posidonia interested	Apathetic
Gender (Chi-square = 12.0 df= 3 p <0.05)				
Male	11.8%	15.4%	19.7%	4.9%
Female	50.5%	41.9%	44.2%	66.2%
Age (Chi-square= 28.64, df=15, p <0.05)				
<18	0.0%	0.0%	0.4%	0.2%
19-34	6.2%	11.4%	8.6%	6.4%
35-44	5.5%	3.8%	7.3%	2.7%
45-54	6.2%	9.3%	15.8%	3.1%
55-64	20.8%	9.7%	12.6%	9.1%
>64	0.7%	0.7%	0.4%	0.9%
Education (Kruskal-Wallis W=6.072, p <0.05)				
	12.75	13.87	14.02	13.41
Income (Kruskal-Wallis W=4.483, p <0.05)				
	12702.78	16673.46	19121.27	13014.79

On the contrary, No significant differences between the segments concerning residence, occupation, marital status and their membership of an NGO.

3.5.Respondents' preferences towards coastal zone

Then AHP analysis (designed by Saaty 1980), was used to how people prioritized between preferences for coastal zone management as elements of future coastal zone integrated management proposal. Statistical tests on the results from the AHP point out that all preferences for coastal zone are statistically significant with four segments.

Lookout the coastal area preferences (Table 5) and at the way each segment prioritizes elements of ecotourism (Table 6) suggests that respondents consider 'biodiversity preservation' as the most important element of ecotourism and that they attach the least significance to 'small-scale development'. The segments also present a more or less uniform pattern of preferences, with most of them stressing the significance of "low use of exhaustible resources" as an element of ecotourism, and a slight preference towards "responsible action" over "local wellbeing" as the next significant aspects of ecotourism. Less significance is assigned to the "learn-and-appreciate" aspect of the activity as well as to the importance of "local control for ecotourism".

Table 5. Respondents' preferences (importance of coastal zone managing issues)

Preferences	Resulting priorities (%)				Total
	Environment interested	Worried	Posidonia interested	Apathetic	
B1 - Increase in the number of hotels and traditional restaurants	7.5	5.5	6	7.9	7.5
B2 – Increase in the number of beaches	8.8	6.2	5.8	8.9	8.8
B3 - Exclusion of recreational fishing	6.5	5.5	6.4	5.1	6.4
B4 -Prohibition of Anchoring	7.3	9.7	8.2	8.9	7.3
B5 - Exclusion of small-scale professional fishing	7.3	9.5	6.5	5.7	7.3
B6 - Alien species are dangerous for swimming	29.7	29.1	32.7	31.1	29.7
B7 - Alien species increase risks to diet	33	34.4	34.4	32.2	33

Table 6. Segment ranking of coastal zone managing preferences

Preferences	Segment				Mean: all segments
	Environment interested	Worried	Posidonia interested	Apathetic	
B1 - Increase in the number of hotels and traditional restaurants	4	6	5	5	5
B2 – Increase in the number of beaches	3	7	7	4	6
B3 - Exclusion of recreational fishing	7	5	6	7	7
B4 -Prohibition of Anchoring	5	4	4	3	3
B5 - Exclusion of small-scale professional fishing.	6	3	3	6	4
B6 - Alien species are dangerous for swimming	2	2	2	2	2
B7 - Alien species increase risks to diet	1	1	1	1	1

Biodiversity clusters and Coastal zone management preferences (Kruskal-Wallis test)

Table 7. Respondents' preferences significantly different between clusters

	p	Decision
B1 - Increase in the number of hotels and traditional restaurants	0.00	Reject the null hypothesis
B2 – Increase in the number of beaches	0.000	Reject the null hypothesis
B3 - Exclusion of recreational fishing	0.000	Reject the null hypothesis
B4 -Prohibition of Anchoring	<0.05	Reject the null hypothesis
B5 - Exclusion of small-scale professional fishing	0.000	Reject the null hypothesis
B6 - Alien species are dangerous for swimming	<0.05	Reject the null hypothesis
B7 - Alien species increase risks to diet	0.000	Reject the null hypothesis

Concerning the importance of people preferences about coastal zone management non parametric tests (Table 7) report significant differences between the segments.

4. Conclusions and Discussion

Our study indent to explore the people believes about marine biodiversity and split respondents into segments following those. Based on respondents' biodiversity values revealed with the help of 30-items question, four groups with different 'mixes' of values emerged. Socioeconomic characteristics of respondents was used to differ resulting groups as well as items associated to people preferences for coastal zone management.

Regarding the use of a biodiversity values based question our PCA produced four factors: three based on marine biodiversity, and one mostly involved Posidonia values. People classified as most important nonuse values of marine biodiversity.

Τα αποτελέσματα της έρευνας επιβεβαιώνουν ότι παρόλο που οι άνθρωποι γνωρίζουν τις υπηρεσίες που προσφέρονται από τη βιοποικιλότητα δεν γνωρίζουμε τον τρόπο που οι άνθρωποι αξιολογούν και ιεραρχούν αυτές τις υπηρεσίες (Fischer et al. 2011).

Our study suggests that biodiversity uses (values) segment people into groups with simultaneous use of its demographic characteristics. Then resulting segments ware used to discover people preferences for coastal zone management. According to our results, different groups based on people hold values to marine biodiversity they generally agree in their prioritization of coastal zone management.

In particular they all are anxious about alien species and they believe that is the most important treatment for recreation activities to coastal zone.

According to the results biodiversity values can be used to segment people in groups with the same preferences and worries relative to the loss of it. Nevertheless, the segments based on biodiversity values do not demonstrate always significant differences in attitudes amongst citizens in relation to the usefulness of biodiversity. Finally, people segmentation is useful to take different measures in different sections of the public in order to promote similar measures for protecting marine biodiversity.

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Preferences and willingness to pay for protecting the marine and coastal environment from plastic waste: a case study of Syros Island, Greece

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Abstract

The presence of plastic waste in the coastal/marine environment poses a high economic burden and is closely associated with social costs in terms of pollution and waste. Thus, in order to preserve the healthy functioning of ecosystem services and ensure environmental sustainability it is deemed critical to reduce all forms of plastic waste at once. This study aims to explore citizens' and stakeholders' preferences and willingness to pay (WTP) for the reduction of plastic waste and especially plastic bags in the coastal/marine environment of Syros Island (Greece). In this framework, two separate surveys were conducted during May-June 2016 and May 2017. In the first survey a choice experiment method was used to assess the values of several ecosystem services most likely to be affected by the accumulation of plastic litter in the coastal/marine environment. A total of 341 completed and useful questionnaires were collected from Syros' Island citizens. In the second survey a contingent valuation technique was used, focusing on a specific target group (hotel/room rental facilities owners), resulting in the collection of 40 useful questionnaires. According to the valuation results of both surveys a significant percentage of both residents and hotel owners of Syros are supporting policies for the protection and conservation of the local coastal/marine environment.

Keywords: marine/coastal environment; plastic waste; willingness to pay; ecosystem services valuation; choice experiment method.

JEL Codes: Q51; Q53; Q57; C25; Q25.

Προτιμήσεις και προθυμία πληρωμής για την προστασία του θαλάσσιου και παράκτιου περιβάλλοντος της Σύρου από τα πλαστικά απορρίμματα

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Περίληψη

Η παρουσία πλαστικών απορριμμάτων στο παράκτιο/θαλάσσιο περιβάλλον συνδέεται με υψηλό οικονομικό κόστος το οποίο συνιστά και κοινωνικό κόστος στο πλαίσιο μόλυνσης και ρύπανσης εξαιτίας των απορριμμάτων. Ως εκ τούτου, για την διατήρηση των οικοσυστημικών υπηρεσιών και τη διασφάλιση της περιβαλλοντικής βιωσιμότητας κρίνεται αναγκαία η άμεση μείωση όλων των ειδών πλαστικών απορριμμάτων. Στην παρούσα εργασία διερευνώνται οι προτιμήσεις καθώς και η προθυμία πληρωμής (willingness to pay) των πολιτών, καθώς και συγκεκριμένων φορέων (stakeholders), αναφορικά με δράσεις που θα επιφέρουν στοχευμένη μείωση της ρύπανσης του παράκτιου/θαλάσσιου περιβάλλοντος της Σύρου από πλαστικά απορρίμματα και κυρίως πλαστικές σακούλες. Στο πλαίσιο αυτό πραγματοποιήθηκαν δυο ξεχωριστές έρευνες κατά την διάρκεια των περιόδων Μάιος-Ιούνιος 2016 και Μάιος 2017. Στην πρώτη έρευνα χρησιμοποιήθηκε η μέθοδος του πειράματος επιλογής (choice experiment), με στόχο την αποτίμηση της οικονομικής αξίας των οικοσυστημικών υπηρεσιών που ενδέχεται να επηρεαστούν από μια ενδεχόμενη συσσώρευση πλαστικών απορριμμάτων στο παράκτιο/θαλάσσιο περιβάλλον. Στη δεύτερη έρευνα εφαρμόστηκε η μέθοδος της υποθετικής αξιολόγησης (contingent valuation) σε συγκεκριμένο δείγμα (ιδιοκτήτες ξενοδοχείων και ενοικιαζόμενων δωματίων). Στην πρώτη έρευνα συλλέχθηκαν συνολικά 341 ερωτηματολόγια, ενώ στη δεύτερη 40 ερωτηματολόγια. Τα αποτελέσματα της ανάλυσης και των δυο ερευνών δείχνουν ότι ένα μεγάλο ποσοστό των κατοίκων της Σύρου αλλά και των ιδιοκτητών τουριστικών καταλυμάτων υποστηρίζει πολιτικές για την προστασία και διασφάλιση του τοπικού παράκτιου/θαλάσσιου περιβάλλοντος.

Λέξεις Κλειδιά: θαλάσσιο/παράκτιο περιβάλλον, πλαστικά απορρίμματα, προθυμία πληρωμής πολιτών, αποτίμηση οικοσυστημικών υπηρεσιών, μέθοδος πειράματος επιλογής.

JEL Κωδικοί: Q51; Q53; Q57; C25; Q25.

Introduction

Plastic pollution in the marine and coastal environment is considered to be an emerging environmental threat at a global scale, taking into account the rather high concentrations of up to 580,000 pieces per km^2 globally distributed and induced by a rapidly growing production (Wilcox et al, 2015). Thus, plastic pollution in the oceans is now classified as one of the most urgent environmental problems of the 21st century (UNEP, 2011). Plastic pollution can be identified as the accumulation of anthropogenic litter, consisting of various types of plastic, in the marine and coastal environment resulting from improper use and discharge to the oceans and rivers that in turn bears harmful environmental implications. Plastic waste, which is categorized under marine litter and debris, is created by humans and is closely correlated with the various socio-economic activities performed on land or at sea. Plastics consist the majority of marine litter and are mainly divided into macroplastics and microplastics, which are the plastic particles <5 mm in diameter also including nanoplastics.

Plastic waste usually originates from both direct and indirect sources, mostly plastic bags (frequently in the form of plastic fragments), bottle caps, lids, food and other packaging, fishing floats, abandoned fishing nets and traps, rope, buoys, balloons, boat hulls as well as plastic films from agriculture (Löhr et al., 2017). Approximately three quarters of the marine litter in the oceans globally is plastic, while recent studies indicate that between 4.8 - 12.7 million tons of plastic waste annually generated eventually enters the oceans. The majority of plastic debris in the oceans is "hidden" given that single-use plastics have been discovered even at depths over 6.000 meters, reaching the world's deepest ocean trench. The European Commission estimates that plastics account for approximately 80–85 % of marine litter by count on European beaches, half of which is categorized as single-use plastics (European Parliament, 2017).

The negative effects of plastic pollution on marine life can be traced to four main aspects. Specifically: i) ingestion and entanglement, strongly associated with high rates of mortality in many marine species as well as the transformation of benthic communities' structure (Consoli et al., 2018; CBD, 2016; Katsanevakis et al., 2007; Gall & Thompson, 2015) and negative impacts on the marine trophic web (Carbery et al., 2018; Nelms et al., 2018), ii) toxic effects via the transportation of persistent organic pollutants (POPs) and the subsequent release of toxic compounds (Mathalon and Hill, 2014; Rochman, 2016; Teuten et al., 2009; Mato et al., 2001), iii) species and trophic transfer, providing assistance in species transportation (Gregory, 2009; Farrell et al., 2013; Tutman et al., 2017) and the increasingly well-substantiated potential for bioaccumulation of the plastic associated chemical pollutants via the food web (Rochman et al., 2015; Worm et al, 2017) and iv) socio-economic impacts such as damages to decreased recreational activities as well as damages in relation to waterfront real estate and property value (CIESM, 2014; Ofiara and Seneca, 2006).

This study contributes to the limited existing literature that investigate the preferences and willingness to pay (WTP) of citizens and stakeholders (hotel and room rental facility owners) for the reduction of plastic waste and especially plastic bags in the coastal/marine environment to a case study in Greece (Syros Island). The aim of the study is to examine the economic value regarding the benefits arising from the sustainable management of coastal/marine ecosystems in Syros Island. The estimation of the economic value of the selected ecosystem services is performed via the application of two methodologies, the choice experiment method (CE) for the citizens and the contingent valuation method (CVM) for the specific target group of hotel/room rental facilities owners. To this date only few CE and CVM applications to marine and coastal ecosystems in Greece exist, while this study consists the first application of a methodology mixture of both CE and CVM in Syros Island.

The structure of the paper is the following: Section 2 reviews the existing literature which is related to the issue under examination. Section 3 describes the case studies. Section 4 presents the survey design for both surveys. The empirical results of the analyses are presented in Section 5, while Section 6 refers to the conclusions.

Literature review

Plastic waste has been discovered and reported as a threat in the marine environment since the early 1970's (Carpenter and Smith, 1972; Colton et al., 1974) in every major type of aquatic system as accurately presented in de Carvalho-Souza (2018), including among others oceans and deep sea (Mordecai et al., 2011; Eriksen et al., 2014; Chiba et al., 2018; Melli et al., 2017), remote islands (Lavers and Bond, 2017), coral reefs and reef ecosystems (Al- Jufaili et al., 1999; de Carvalho-Souza and Tinôco, 2011; Chiappone et al., 2002, 2005; Donohue et al., 2001; Lamb et al., 2018; Critchell et al., 2015; Reisser et al., 2013). Nevertheless, plastic waste is also associated with negative socio-economic impacts, as seen in a 2014 study for the European Commission, where the degradation resulting from marine litter (including plastic waste) costs the EU approximately between €259 - 695 million annually, involving sectors such as tourism (Ofiara and Brown, 1999; Jang et al., 2014) and recreational activities (up to €630 million) as well as the fisheries sector (up to €62 million) (European Parliament, 2017).

A plethora of environmental valuation methods has been extensively applied to assign values to ecosystem services based mainly on revealed and stated preference methodologies. However, taking into account the fact that the marine environment is a type of public goods (Costanza et al., 1997) it can be quite problematic to estimate the economic losses related to marine debris.
Welfare losses can be reflected as a form of indirect cost considering the impacts on non-market services, usually delineated under the terms: indirect use values, non-use values and option values for coastal/marine ecosystem services. In the context of the stated preferences methodology people's preferences are elicited on the basis of hypothetical markets constructed and described by the relevant scenarios. In a number of empirical studies, stated preference methods have been designed to identify the willingness of citizens (households) to pay (WTP) in order to reduce plastic litter in the coastal/marine environment.
In that sense, social cost is estimated in relation to public perception regarding the impact of littering on the beach/coast experience by residents' and/or visitors' willingness to contribute either via collective actions (e.g. voluntary beach clean-up activities) or in monetary terms, by paying an entrance fee or higher local taxes. In general, the accumulative negative impacts induced by plastic waste in the coastal/marine environment are associated with higher WTP values (Latinopoulos et al., 2018). Though, people tend to give lower WTP values for further waste reductions, if certain actions are taken and waste disposal gradually reduces (Coe and Rogers, 1997; Faris and Hart, 1994). Based on Brouwer et al. (2017), beach visitors will place a significant value on the reduction of marine litter, while these values differ depending on the location at each time as well as on the public's perceptions of marine litter, always taking into consideration the socio-economic and demographic profiles of beach visitors.

Case studies

The study area was the island of Syros, located in the island group of the Cyclades in the center of the Hellenic Aegean archipelagos in Greece. Syros is the most populated Cycladic island as well as the economic, administrative and cultural center of the Cyclades (South Aegean) region. Our study aimed at exploring citizens' and stakeholders' preferences and willingness to pay (WTP) for the reduction of plastic waste and especially plastic bags in the coastal/marine environment of Syros Island. Two separate surveys were conducted on the island of Syros during May-June 2016 and May 2017. Both surveys were administered by trained interviewers, using face-to-face interviews by means of a structured questionnaire. The first survey was conducted on two levels, before the launch of an environmental information campaign ("plastic bag free week 2016") that took place during 4–6 May 2016 with a total of 185 completed and useful questionnaires and during the campaign between May 27 and June 5 of the same year, where a total of 156 questionnaires were collected. During the first survey a choice experiment (CE) method was used to assess the values of several ecosystem services most likely to be affected by the accumulation of plastic litter in the coastal/marine environment The second survey was conducted during May 2017 via the use of a contingent valuation technique and was explicitly directed towards a specific target group (hotel and room rental facilities owners), resulting in the collection of 40 useful questionnaires (quite satisfactory sample size according to the total number of hotel owners in the study area).

Survey design

In the context of the CE method applied we firstly selected a set of appropriate attributes which can be used to evaluate a public program that protects the coastal/marine environment of Syros from

plastic waste pollution. The selection was based on two key principles: i) all attributes must be policy relevant to coastal/marine environment protection and ii) they must also be easily communicable to the general public. After thorough research we selected four attributes to describe the potential benefits from the proposed programs to local residents. Specifically: 1) Recreational activities (e.g. bathing, water sports, sunbathing, etc.), 2) Landscape quality, 3) Biodiversity and 4) Commercial fishing activity. In order to minimize confusion, we used qualitative levels for all the above attributes that describe the environmental benefits of the program in terms of impact (risk) reduction. The selected levels were described by means of both textual and visual representations. Furthermore, we also incorporated a policy tool attribute among the selected attributes to explore citizens' preferences regarding future policies which can supplement the plastic waste management program. The cost attribute was presented in terms of an expected bi-monthly cost of implementing the alternative programs (options) represented in the choice. Four price levels, ranging from €3 to €15 were used to represent this attribute.
During the next steps we formed a set of alternative policy options with different attribute levels (profiles) and afterwards we paired these profiles to construct the choice sets. In order to narrow down the complete factorial design that incorporated every possible combination of these five attributes (288 possible policy combinations) to a reasonable and manageable number, a subset of these combinations was used via the application of the SPSS Orthoplan procedure (SPSS Inc., version 20.0, Chicago, IL, USA), resulting in a set of 16 optimal choice profiles (cards), which were further and randomly divided into four different choice cards, given that 16 cards seemed too many for an individual to evaluate.
The questionnaire applied in the CE consisted of four main sections. The first section focused on general knowledge, attitudes and opinions on local environmental issues, mainly in relation to the problem of plastic waste in the coastal area. The second section introduced the coastal protection policies, described the selected attributes, explained the payment vehicle and ended with the four choice cards. The third section consisted of follow up questions with regards to the difficulty in answering the choice cards, the reasons that someone was not willing to pay for any given option and the main motivation of respondents willing to pay for the proposed coastal protection programs. The last section retrieved the participants' demographic and socio-economic characteristics (Latinopoulos et al., 2018).
Regarding the CVM survey a new questionnaire was constructed, taking into consideration that it was focused on a specific target group (hotel/room rental facilities owners). That particular questionnaire was also consisted of four sections. The first one was focused on general knowledge, attitudes and opinions on local environmental issues and, in particular, related to the problem of plastic waste in the coastal area, while the second section acquired all the necessary information, concerning possible environmental practices applied by the enterprises. Section three introduced the coastal/marine protection policy and preventive measures and explained the payment vehicle, thus, extracting the individual's willingness to pay (amount), as well as the reason(s) that someone was not willing to pay and the main motivation behind their reason(s). Finally, in the last section we retrieved the participants' demographic and socio-economic characteristics.

Results

5.1. Socioeconomic characteristics of respondents

The main socioeconomic characteristics of the citizens of Syros Island (attitudes and opinions regarding the coastal/marine environment as well as the waste pollution problem, leisure and

professional activities in the coastal/marine area, etc.), after the exclusion of protest voters, are presented in Table 1. According to these statistics, the two samples (informed and non-informed) are quite similar in relation to key demographics and socioeconomic characteristics
(e.g. age, sex, education, income), while in general, it is safe to say that they can be considered sufficiently similar to rule out any sample selection bias. In that sense, any comparison between informed and not informed citizens is not likely to depend on differences in the samples' characteristics. Furthermore, the main socioeconomic characteristics of the sample regarding the stakeholders (hotel/room rental facility owners) are presented in Table 2, forming a satisfactory sample size according to the total number of hotel owners as well as operational hotels in the study area at that time.

Table 1. Socioeconomic characteristics of the 1st survey respondents (citizens)

Variables	**Description**	**Informed** (n=119)	**Not informed** (n=121)
AGE	Age of respondents	48.89 (11.99)	46.86 (11.49)
SEX	Sex [1=male, 0 =female]	53.7%	52.1%
EDU	Education level		
	1 = Primary education	7.6%	6.6%
	2 = Lower level secondary education	9.2%	9.1%
	3 = Upper secondary education	37.0%	33.9%
	4 = University education	40.3%	43.0%
	5 = Post-graduate studies	5.9%	7.4%
INCOME	Annual household income		
	1 = up to €5,000	11.1%	10.2%
	2 = €5,001-10,000	22.2%	17.8%
	3 = €10,001- 15,000	35.0%	34.8%
	4 = €15,001- 20,000	12.8%	16.9%
	5 = €20,001-25,000	11.1%	16.1%
	6 = €25.001-30,000	5.1%	2.5%
	7= more than €30,000	2.6%	1.7%
FAM_SIZE	Number of household members	2.81 (1.24)	2.71 (1.22)
MAR_ENV	Necessity of further measures to protect the coastal/marine environment [1=Yes, 0=No]	4.1 (1.00)	4.4 (0.82)
TAR_ECO	Importance of protecting the coastal/marine ecosystems [1=Yes, 0=No]	4.69 (0.60)	4.76 (0.68)
RECYCLE	Household recycling [1=Yes, 0=No]	90.8%	91.2%
BEACH_VIS	Frequency of visits to the beach (during the summer) [1= never, 2=less than once a month, 3= once or twice a month, 4=once or twice a week, 5= three of four times per week, 6=every day]	4.71 (1.39)	5.24 (0.82)

Table 2. Socioeconomic characteristics of the 2nd survey respondents (stakeholders)

Variables	Description	(n=40)
AGE	Age of respondents	50.08 (13.91)
SEX	Sex [1=male, 0 =female]	65%
EDU	Education level 1 = Primary education 2 = Lower level secondary education 3 = Upper secondary education 4 = University education 5 = Post-graduate studies	 2.5% 5.0% 47.5% 40.0% 5.0%
EMP	Number of employees	4.52 (2.97)
OCCUPANCY	Annual hotel/rental rooms occupancy rate	91.2%
RECYCLE	Hotel/rental rooms recycling [1=Yes, 0=No]	85.0%
(EU) 2015/720	Awareness regarding Directive (EU) 2015/720 a= Very much aware b= Somewhat aware c= Not aware	 67.5% 32.5% 0.0%
REDUCE_PLASTIC	Likelihood of future reduction in overall plastic use a= Most Probably b= Probably c= Probably Not d= I don't use such products	 52.5% 45.0% 2.5% 0.0%

5.2. Choice experiment and environmental preferences

The exploration of preferences for mitigating the environmental impact of plastic waste on the coastal/marine environment of Syros was performed by means of stated preferences methods. The choice experiment method is based on Lancaster's characteristic theory of value (Lancaster, 1966) and on a random utility maximization model (McFadden, 1973). Based on this method, the utility function U_{ij} of individual for choice j is comprised of a deterministic component V_{ij} and a random error term e_{ij}, which captures the effect of unobserved and omitted variable

$$U_{ij} = V_{ij} (Z_{ij}) + e_{ij} \quad (1)$$

In this context, citizens were asked to choose among the several alternative coastal protection programs (choice cards) that ultimately yields the highest utility. Citizens' utility for coastal protection (i.e. for measures aimed at reducing plastic bags in the marine environment) can then be derived from the set of attributes ($Z_{i,j}$) of the coastal protection program, related to the program's impact on several ecosystem services (e.g. fishing, swimming, biodiversity, etc.), as well as to the program's instruments (e.g. individual costs, measures reducing/banning the plastic bags). Choices

made between alternative programs (options) is a function of the probability that the utility associated with a particular option is higher than that associated with other options (Birol et al., 2006).
Our study reveals that protecting the coastal and marine environment is important to the citizens of Syros Island who, in general (i.e. regardless of the level of information/awareness), are willing to financially support the reduction of the impact and related risks of plastic waste on the ecosystem services (biodiversity conservation, fish production, recreation, aesthetics).
In addition, based on the results of the second survey, as it can be seen in Table 4, regarding the stakeholders the sample can be characterized as quite "environmentally friendly" and specifically "eco-sensitive" in relation to plastic waste.

Table 3. Attributes - levels and variables (citizens

Attribute	**Attribute levels**	**Variable**
Recreational activities	Plastic waste has a significant impact on recreation enjoyment*	RECREAT1 (small impact)
	Plastic waste has a relatively small impact on recreational enjoyment	
	No-impact on recreation	RECREAT2 (no-impact)
Landscape quality	Significant aesthetic degradation due to plastic waste*	LANDSCAPE
	No degradation	
Biodiversity	Plastic waste is a major threat to coastal/marine biodiversity*	BIODIVERSITY
	Plastic waste is a minor threat to coastal/marine biodiversity	
Fisheries	Plastic waste is a major threat to local fisheries* Plastic waste is a minor threat to local fisheries	FISHERIES
Policy tool	No measures taken* Partial ban of plastic bags	BAGS 1 (partial ban)
	Complete ban of plastic bags	BAGS 2 (complete ban)
Expected bi-monthly cost (€)	0*,3, 6, 10, 15	COST

*Note:** Current attribute levels (status quo)

Table 4. Variables and environmental preferences (stakeholders)

Variables	**Description**	**mean**	**sd**	**var**

FISHERIES	Importance of protecting fishery population in the coastal/marine ecosystems of Syros [1=Not at all important, 5=Very Important]	4.95	0.22	0.04
LANDSCAPE	Importance of protecting landscape quality in the coastal/marine ecosystems of Syros [1=Not at all important, 5=Very Important]	4.97	0.15	0.02
SPECIES_DIV	Importance of protecting species diversity in the coastal/marine ecosystems of Syros [1=Not at all important, 5=Very Important]	4.97	0.15	0.02
DANG_ENV	Significance of the excessive everyday use of plastic as an environmental danger (negative impacts on the coastal/marine environment) [1= Not at all important, 5=Very Important]	4.62	0.49	0.24
ENV_EDU	Importance of promoting environmental information/ education [1=Not at all important, 5=Very Important]	4.97	0.15	0.02
PLASTIC FREE	Relevance of plastic free attribute in beach preference [1=Not at all relevant, 5=Very relevant]	4.7	0.56	0.31
RECYCLE_PLASTIC	Plastic recycling as a factor that influences tourist decision making [1=Not at all important, 5=Very Important]	3.94	0.72	0.52

5.3 Willingness to pay

In order to estimate the willingness to pay values for a marginal change in each attribute level we divide the coefficient of this attribute by the coefficient of the cost attribute, as depicted in the following formula:

$$WTP = -w_r \frac{\beta_r}{\beta_{COST}} \qquad (2)$$

where, w_r is a constant depending on attribute's r coding ($w=1$ for continuous and dummy variables, and $w=2$ for effects-coded variables). The WTP estimates were produced by using the β-coefficients, while their 95% confidence intervals were generated using the Wald procedure (Delta method) in LIMDEP 8, NLOGIT 3.0 (Greene, 2007). The estimated annually WTP values regarding the citizens of Syros Island are presented in Table 5. The sample of participants was found to have a higher WTP (compared to non-participants) for reducing all kind of pollution threats and impacts, with only exception the case of partially addressing the pressure on leisure activities (RECREAT 1). After examining carefully each individual coastal ecosystem service (recreational activities, biodiversity, landscape quality and fisheries), it is revealed that the provision of information is expected to increase the WTP values for preserving these services, considering the positive effect of the campaign on the WTP values for preserving "landscape quality" and "fisheries" from our results. It is worth mentioning, based on the results of Table 4, that stakeholders tend to place high values on approximately the same attributes (ecosystem services) as the general public (citizens) with respect to the protection of the coastal/marine environment of Syros Island.
Furthermore, the estimated WTP values for the stakeholders, presented in Table 6, are characterized by a range of €130 and a mean value of €90 annually, taking into consideration the financial restrictions imposed by the economic crisis, as stated by most of the stakeholders who were interviewed.

Table 5. Citizens' WTP estimates (€/year)

Attributes	**Not Informed**	**Informed**
RECREAT1	24.786 [-0.96 , 50.53]	-16.902 [-34.08 , 17.15][b]
RECREAT2	29.124 [6.83, 51.41]	38.232 [-2.42 , 78.90]
LANDSCAPE	10.446 [-4.28 , 25.17]	31.992 [5.90 , 58.08]
BIODIVERSITY	31.494 [13.16 , 49.83]	31.632 [4.30, 58.96]
FISHERIES	9.342 [-6.30 , 24.97]	28.260 [0.642, 55.884]

[b] in brackets: 95% Confidence Intervals

Table 6. Stakeholders' WTP estimates (€/year)

Variables	**€/year**
Min	30.00
Max	200.00
Median	90.00
Mean	94.33
Sd	53.41

Conclusions

This study explores public preferences in the case of both the general public (citizens) and stakeholders (hotel/room rental facilities owners) regarding the effects of plastic waste pollution on the coastal and marine environment of a typical Mediterranean island such as Syros Island. Furthermore, this study also adds to the limited literature on the evaluation of ecosystem services in coastal/marine ecosystems before and after the systematic knowledge provision via an extensive information campaign on plastic waste that was absolutely independent of the evaluation process of our study.

The change in preferences of participants (in the campaign) and non-participants is depicted in our results, based on which, it is revealed that protecting the coastal and marine environment is important to the local residents of Syros Island (both citizens and stakeholders) who, in general, are willing to financially support the reduction of the impact (risks) of plastic waste on the ecosystem services on the marine environment (biodiversity conservation, recreation, aesthetics, fish production). The most important finding of our study is that in terms of the WTP, participants have a significantly higher WTP compared to the non-participants, therefore, assigning a higher economic value in terms of the overall (coastal/marine) ecosystem services affected by plastic waste, corresponding with the hierarchical distribution of the same values regarding the stakeholders. Future work could investigate the effects of information campaigns in cases of polluted coastal/marine environments, taking into consideration the plastic bag levy introduced in Greece since 1/1/2018, as a currently actual payment vehicle.

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Implementing Hedonic Pricing Models for valuing the visual impact of wind farms in Greece

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Abstract
Even though wind energy is a pollution-free and in finitely sustainable form of energy, there is considerable concern over some environmental effects resulting from wind power development. Criticism focuses primarily on the visual impact due to the installation of wind turbines and transmission lines, which results in the deterioration of the landscape and may harm the associated economic activities, namely tourism, real estate, etc. This study presents an application of the Hedonic Pricing Method for valuing the landscape externalities associated with the large-scale exploitation of wind power at the local level. Specifically, the presented research investigates roughly 1,800 sales of single-family homes surrounding 17 existing wind facilities in two Greek islands, namely Evia and Kefalonia. Developing four different hedonic models in the two areas, the results derived diverge. In Evia case study we found that the value of the dwellings per unit area have been reduced within a zone from 2 km from the wind farms. On the other hand, in Kefalonia case study, neither the view of the wind facilities nor the distance of the home to those facilities is found to have a statistically significant effect on sales prices.

Keywords: Visual impact; wind energy; hedonic pricing; energy externalities.

JEL Codes: Q42, Q51.

Εφαρμογή Μεθόδου Ανάλυσης Αγορών Ωφέλιμων Χαρακτηριστικών για την οικονομική αποτίμηση των επιπτώσεων της οπτικής όχλησης από την ανάπτυξη αιολικών πάρκων στην Ελλάδα

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Περίληψη
Παρόλο που η αιολική ενέργεια είναι μια ενεργειακή μορφή ανεξάντλητη και σε μεγάλο βαθμό απαλλαγμένη από την έκλυση ρυπαντικών φορτίων, τα τελευταία χρόνια αναπτύσσονται έντονοι προβληματισμοί σχετικά με τις περιβαλλοντικές επιπτώσεις που σχετίζονται με τη μεγάλης κλίμακας αξιοποίησή της. Επίκεντρο της κριτικής αποτελεί το ζήτημα της οπτικής όχλησης και της αλλοίωσης

του τοπίου που προκαλούν οι εγκατεστημένες ανεμογεννήτριες και τα συνοδευτικά ηλεκτρικά δίκτυα μεταφοράς, καθώς και οι ενδεχόμενες επιπτώσεις σε οικονομικές δραστηριότητες όπως ο τουρισμός, οι αξίες των κατοικιών, κλπ. Η παρούσα μελέτη παρουσιάζει μια εφαρμογή της Μεθόδου Ανάλυσης Αγορών Ωφέλιμων Χαρακτηριστικών για την αποτίμηση των εξωτερικών οικονομιών που σχετίζονται με την υποβάθμιση του τοπίου από τη μεγάλη κλίμακας ανάπτυξη της αιολικής ενέργειας σε τοπικό επίπεδο. Συγκεκριμένα, η παρούσα έρευνα εξετάζει περίπου 1.800 αγοραπωλησίες κατοικιών στην ευρύτερη περιοχή 17 αιολικών πάρκων που έχουν εγκατασταθεί σε δύο ελληνικά νησιά, την Εύβοια και την Κεφαλονιά. Στην περίπτωση της Ν. Ευβοίας βρέθηκε ότι η αξία των κατοικιών ανά μονάδα επιφάνειας, μειώνεται εντός της ζώνης 2 km από τα αιολικά πάρκα, ενώ στην περίπτωση της Κεφαλονιάς, ούτε η θέαση των αιολικών εγκαταστάσεων ούτε η απόσταση του σπιτιού από τις εγκαταστάσεις αυτές φαίνεται ότι έχουν στατιστικά σημαντική επίδραση στις τιμές πώλησης.

Λέξεις Κλειδιά: Οπτική όχληση, αιολική ενέργεια, μέθοδος ανάλυσης αγορών ωφέλιμων χαρακτηριστικών, εξωτερικές οικονομίες ενέργειας.

JEL Κωδικοί: Q42, Q51.

1. Εισαγωγή

Η αξιοποίηση τεχνολογιών Ανανεώσιμων Πηγών Ενέργειας (ΑΠΕ), και ιδιαίτερα αιολικών και φωτοβολταϊκών συστημάτων, αποτελεί βασικό πυλώνα της Ευρωπαϊκής πολιτικής για την αντιμετώπιση της κλιματικής αλλαγής. Έτσι, ενώ το 2000 η εγκατεστημένη ισχύς αιολικών πάρκων στην Ελλάδα ήταν μόλις 226 MW, το 2017 έφθασε στα 2.377 MW και η παραγόμενη ηλεκτρική ενέργεια από αυτά κάλυψε το 7,4% της συνολικής εγχώριας ζήτησης ηλκετρισμού. Με βάση δε τις προωθούμενες πολιτικές της Ευρωπαϊκής Ένωσης, η αξιοποίηση της αιολικής ενέργειας στα ηλεκτρικά συστήματα αναμένεται να ενταθεί τα επόμενα χρόνια, ενώ στην Ελλάδα η εγκατεστημένη ισχύς αιολικών πάρκων ανεμένεται να υπερβεί τα 6.000 MW στο χρονικό ορίζοντα του 2030 (European Commission, 2016)

Η μεγάλης κλίμακας αξιοποίηση της αιολικής ενέργειας έφερε στο επίκεντρο της κριτικής τις περιβαλλοντικές επιπτώσεις των αιολικών πάρκων και ιδιαίτερα το ζήτημα της οπτικής όχλησης και της συνεπαγόμενης υποβάθμισης του τοπίου αλλά και των σχετιζόμενων οικονομικών δραστηριοτήτων (τουρισμός, αγορά ακινήτων, κλπ.). Τα τελευταία δε χρόνια όπου το μέγεθος των εγκατεστημένων ανεμογεννητριών έχει αυξηθεί (ανεμογεννήτριες με ισχύ 2-3 MW, ύψος πύργου 70-90 m και διάμετρο πτερυγίων περί τα 45 m) ο προβληματισμός και οι αντιδράσεις έχουν ενταθεί. Η οπτική όχληση από τα αιολικά πάρκα αποτελεί πλέον αντικείμενο συστηματικής έρευνας και στην Ελλάδα (Tsoutsos et al, 2009, Kaldellis and Kavadias, 2004). Με βάση τη διεθνή πρακτική το περιβαλλοντικό αυτό πρόβλημα αναλύεται κυρίως μέσω των Ζωνών Οπτικής Όχλησης, οι οποίες λαμβάνουν υπόψη το γεγονός ότι η οπτική όχληση μειώνεται με την απόσταση, κατά περίπτωση δε σε συνδιασμό με άλλα εργαλεία όπως οι φωτορεαλιστικές απεικονίσεις, κλπ. Συγκεκριμένα, διακρίνονται 4 βασικές κατηγορίες ζωνών οπτικής όχλησης (EWEA, 2009):

Ζώνη 1: οι ανεμογεννήτριες (Α/Γ) είναι οπτικά κυρίαρχα στοιχεία του τοπίου (visually dominant) και εκτείνεται σε αποστάσεις 0 μέχρι 2 km από αυτές.

Ζώνη 2: οι Α/Γ είναι σημαντικά στοιχεία του τοπίου (visually intrusive), η κίνηση των πτερυγίων είναι ορατή και προσελκύουν τον ανθρώπινο οφθαλμό. Η ζώνη αυτή εκτείνεται σε αποστάσεις 1 έως 4,5 km από τις Α/Γ όταν οι συνθήκες ορατότητας είναι ευνοϊκές.

Ζώνη 3: οι Α/Γ είναι καθαρά ορατές αλλά όχι σημαντικά στοιχεία του τοπίου. Η κίνηση των πτερυγίων είναι ορατή υπό ευνοϊκές συνθήκες ορατότητας αλλά οι Α/Γ εμφανίζονται σχετικά μικρές

στη συνολική εικόνα του παρατηρητή. Η ζώνη αυτή εκτείνεται σε αποστάσεις 2 έως 8 km από τις Α/Γ ανάλογα με τις καιρικές συνθήκες.
Ζώνη 4: οι Α/Γ είναι στοιχεία ενός απομακρυσμένου τοπίου και το φαινόμενο μέγεθός τους μικρό. Η κίνηση των πτερυγίων είναι δυσδιάκριτη. Η ζώνη αυτή εκτείνεται σε αποστάσεις άνω των 8 km από τις Α/Γ.
Στόχος της παρούσας εργασίας είναι η αξιοποίηση τεχνικών της περιβαλλοντικής οικονομίας για τη διερεύνηση της περιβαλλοντικής υποβάθμισης που προκαλείται από τη μεγάλης κλίμακας ανάπτυξη της αιολικής ενέργειας σε τοπικό επίπεδο, ιδιαίτερα δε ως προς το σκέλος που σχετίζεται με την οπτική όχληση και την αισθητική υποβάθμιση του τοπίου. Συγκεκριμένα, στην παρούσα εργασία εφαρμόζεται η Μέθοδος Αγοράς Ωφέλιμων Χαρακτηριστικών (Hedonic Pricing), μέσω της οποίας εξετάζεται σε ποιο βαθμό η προκαλούμενη περιβαλλοντική υποβάθμιση από την ανάπτυξη αιολικών πάρκων, και ιδιαίτερα, η αλλοίωση του φυσικού τοπίου, επιδρά στις τιμές των κατοικιών της ευρύτερης περιοχής εγκατάστασης των αιολικών μονάδων. Η ποσοτική τεκμηρίωση της ύπαρξης ή μη μιας τέτοιας συσχέτισης μπορεί να μας δώσει χρήσιμες πληροφορίες για το οικονομικό μέγεθος των περιβαλλοντικών επιπτώσεων των αιολικών πάρκων, με άλλα λόγια το εξωτερικό κόστος της αιολικής ενέργειας, γεγονός που θα επιτρέψει τη συγκριτική αποτίμηση της τεχνολογίας αυτής σε σχέση με άλλες τεχνολογίες ηλεκτροπαραγωγής στο πλαίσιο του μακροχρόνιου ενεργειακού σχεδιασμού. Η έρευνα πεδίου πραγματοποιήθηκε στη Νότια Εύβοια και στην Κεφαλονιά, περιοχές στις οποίες έχει ήδη εγκατασταθεί μεγάλος αριθμός αιολικών πάρκων, και επομένως οι κάτοικοι μπορούν να αξιολογήσουν ρεαλιστικότερα το πραγματικό μέγεθος των επιπτώσεων που αυτά προκαλούν.

2. Ανασκόπηση Βιβλιογραφίας

Μέχρι σήμερα διάφορες τεχνικές οικονομικής αποτίμησης περιβαλλοντικών αγαθών έχουν χρησιμοποιηθεί για την ανάλυση της οπτικής όχλησης και της αλλοίωσης του τοπίου από την εγκατάσταση αιολικών πάρκων. Κυρίως σε σχετικές μελέτες χρησιμοποιούνται άμεσες τεχνικές ή τεχνικές δεδηλωμένης προτίμησης όπως η Μέθοδος Εξαρτημένης Αξιολόγησης ή τα Μοντέλα Επιλογής (Bergmann et al, 2006, Ladenburg and Dubgaard, 2007). Στην Ελλάδα σχετικές μελέτες έχουν υλοποιηθεί από τους Koundouri et al. (2009) όπου με τη Μέθοδο της Εξαρτημένης Αξιολόγησης διερευνήθηκαν τα οφέλη στην τοπική κοινωνία από την ανάπτυξη ενός μικρού αιολικού πάρκου στη Ρόδο, από τους Dimitropoulos and Kontoleon (2009), όπου μέσω των Μοντέλων Επιλογής διερευνήθησαν οι παράγοντες που επηρεάζουν την προθυμία για αποζημίωση προκειμένου να εγκατασταθούν αιολικά πάρκα σε δύο Ελληνικά νησιά, τη Νάξο και τη Σκύρο, και από τους Mirasgedis et al. (2014), όπου μέσω της Μεθόδου Εξαρτημένης Αξιολόγησης υπολογίσθηκε το περιβαλλοντικό κόστος από τη μεγάλης κλίμακας αξιοποίηση της αιολικής ενέργειας στην περιοχή της Νότιας Εύβοιας.
Αντίθετα, αρκετά πιο σπάνιες είναι οι εφαρμογές έμμεσων τεχνικών οικονομικής αποτίμησης της οπτικής όχλησης από την εγκατάσταση αιολικών πάρκων. Αυτό κατά βάση οφείλεται στη δυσκολία συγκέντρωσης αναλυτικών στατιστικών στοιχείων σχετικά με τις τιμές αγοραπωλησιών των κατοικιών σε μια περιοχή, αλλά και το σημαντικό υπολογιστικό φόρτο που απαιτείται προκειμένου να προσομοιωθεί και να ποσοτικοποιηθεί ο τρόπος επίδρασης των εγκατεστημένων Α/Γ στις κατοικίες της ευρύτερης περιοχής (εγγύτητα, ορατότητα, κλπ).
Οι περισσότερες από τις μελέτες ανάλυσης αγορών ωφέλιμων χαρακτηριστικών για την εκτίμηση των περιβαλλοντικών επιπτώσεων των αιολικών πάρκων έχουν υλοποιηθεί στις ΗΠΑ και στη Μεγάλη Βρετανία την τελευταία δεκαετία. Μία από τις πρώτες μελέτες αυτού του τύπου υλοποιήθηκε το 2008 στην Κορνουάλη της Μεγάλης Βρετανίας (Sims et al. 2008), όπου εξετάσθηκε ο αντίκτυπος της εγγύτητας ενός αιολικού πάρκου 16 Α/Γ στις τιμές των κατοικιών της περιοχής.

Αν και οι τυπικές τεχνικές απλής παλινδρόμησης που εφαρμόστηκαν δεν έδειξαν στατιστικά σημαντικές επιπτώσεις από την εγκατάσταση των αιολικών πάρκων, ωστόσο υπήρχαν ενδείξεις ότι οι αξίες μεμονωμένων κατοικιών επηρεάζονται. Οι Laposa and Müller (2010), εξέτασαν τον αντίκτυπο της ανακοίνωσης εγκατάστασης αιολικών πάρκων στις τιμές των ακινήτων στο Βόρειο Κολοράντο των ΗΠΑ. Για τη συγκεκριμένη μελέτη ελήφθησαν παρατηρήσεις πωλήσεων πριν και μετά την ανακοίνωση του έργου εγκατάστασης του αιολικού πάρκου. Τα αποτελέσματα που προέκυψαν δεν έδειξαν στατιστικά σημαντική επίδραση στην κτηματαγορά. Το 2011 οι Heintzelman and Tuttle (2012), μελέτησαν τις επιπτώσεις εγκαταστάσεων αιολικής ενέργειας στις αξίες των ακινήτων στη Βόρεια Νέα Υόρκη, επίσης στις ΗΠΑ, όπου διαπιστώθηκε ότι οι εγκαταστάσεις Α/Γ σε κοντινές αποστάσεις μπορούν να μειώσουν σημαντικά τις τιμές των ακινήτων. Συγκεκριμένα, βρέθηκε ότι, σε αποστάσεις από το αιολικό πάρκο έως ένα (1) μίλι η αξία ων κατοικιών μπορεί να μειωθεί μεταξύ 7,73% και 14,87%. Οι Hoen et al. (2011), εξέτασαν 7.459 πωλήσεις μονοκατοικιών γύρω από 24 πάρκα παραγωγής αιολικής ενέργειας που ήταν εγκατεστημένα στις ΗΠΑ. Τα αποτελέσματα της ανάλυσης έδειξαν ότι ούτε η θέα των Α/Γ ούτε η απόσταση από αυτές επηρεάζουν τις τιμές των κατοικιών. Στην κεντρική Ευρώπη μια αντίστοιχη τέτοια μελέτη, πραγματοποιήθηκε στη Βόρεια Ρηνανία-Βεστφαλία στη Γερμανία το 2012 (Sunak and Madlener, 2012). Σύμφωνα με τα αποτελέσματα, οι αρνητικές επιπτώσεις των αιολικών πάρκων είναι στατιστικά ανιχνεύσιμες σε κοντινές αποστάσεις από τα αιολικά πάρκα και κυρίως σε απόστάσεις έως 1,5 km. οπό αυτά. Συγκεκριμένα, βρέθηκε ότι σε αποστάσεις έως 1 km από τα αιολικά πάρκα οι τιμές των ακινήτων μειώθηκαν από 21,5% έως 29,7%.

3. Η μέθοδος Ανάλυσης Αγοράς Ωφέλιμων Χαρακτηριστικών

Η εφαρμογή της μεθόδου Ανάλυσης Αγορών Ωφέλιμων Χαρακτηριστικών (Hedonic Pricing Method – HPM), αποτελεί μία από τις παλαιότερες μεθόδους της περιβαλλοντικής οικονομίας, και έχει την δυνατότητα να αποτιμήσει σε οικονομικούς όρους περιβαλλοντικες μεταβολές παρακολουθώντας τις διακυμάνσεις τιμών εμπορεύσιμων αγαθών που επηρεάζονται από διάφορες παραμέτρους, στις οποίες συμπεριλαμβάνονται και περιβαλλοντικά χαρακτηριστικά (Hanley et al, 1998). Με άλλα λόγια η μέθοδος στηρίζεται στην ιδέα ότι η τιμή ενός εμπορεύσιμου αγαθού στην αγορά αποτελεί τη συνισταμένη πολλαπλών επιμέρους ωφέλιμων χαρακτηριστικών. Η μεταβολή ενός χαρακτηριστικού μεταβάλλει και την τιμή του αγαθού. Καθώς περιβαλλοντικά χαρακτηριστικά είναι δυνατόν να επηρεάζουν την τιμή εμπορεύσιμων αγαθών, μπορούμε να εξάγουμε συμπεράσματα για την αξία αυτών των περιβαλλοντικών χαρακτηριστικών, παρακολουθώντας πώς μεταβολές στα επίπεδά τους (ποιοτικά ή ποσοτικά) επηρεάζουν την τιμή του επηρεαζόμενου εμπορεύσιμου αγαθού. Τα εμπορεύσιμα αγαθά που συνήθως χρησιμοποιούνται στις εφαρμογές της μεθόδου είναι η κτηματαγορά και οι τιμές αγοροπωλησιών κατοικιών, γης, κλπ., καθώς και η αγορά εργασίας όπου συνήθως οι αμοιβές των εργαζομένων συσχετίζονται μεταξύ άλλων με την έκθεση σε επικίνδυνες περιβαλλοντικές παραμέτρους, κλπ. Στην παρούσα εργασία ως αγαθό αναφοράς για την εκτίμηση των περιβαλλοντικών επιπτώσεων των αιολικών πάρκων ως προς το ζήτημα της οπτικής όχλησης χρησιμοποιείται η αγορά κατοικίας.

Τα μοντέλα ωφέλιμων χαρακτηριστικών των ακινήτων επιβεβαιώνουν ότι τα άτομα αντιλαμβάνονται τις οικιστικές μονάδες ως δέσμες χαρακτηριστικών και αποκτούν διαφορετικά επίπεδα χρησιμότητας από διαφορετικούς συνδυασμούς αυτών των χαρακτηριστικών. Όταν πραγματοποιούνται συναλλαγές, τα άτομα κάνουν επιλογές για το πόσα χρήματα παραπάνω ή λιγότερα προτίθενται να ξοδέψουν προκειμένου να αποκτήσουν περισσότερες ή λιγότερες μονάδες από τα χαρακτηριστικά που συνθέτουν την αξία των ακινήτων, αποκαλύπτοντας έτσι τις οριακές αξίες αυτών των χαρακτηριστικών. Προκειμένου να εκτιμηθούν οι εν λόγω αξίες, αναπτύσσονται μοντέλα παλινδρόμησης πολλαπλών μεταβλητών όπου οι τιμές πώλησης των κατοικιών (εξαρτημένη μεταβλητή) συσχετίζονται με διάφορα χαρακτηριστικά της κατοικίας. Εν γένει οι ανεξάρτητες μεταβλητές των μοντέλων παλινδρόμησης περιλαμβάνουν (Freeman et al 1993, Kong et al, 2007):

Δομικά χαρακτηριστικά της κατοικίας (εμβαδό, έτος κατασκευής, ύπαρξη γκαράζ ή αποθήκης κλπ.).

Χαρακτηριστικά της ευρύτερης περιοχής που βρίσκεται η κατοικία (προσβασιμότητα, απόσταση από υπηρεσίες, κλπ.).

Περιβαλλοντικές παραμέτρους οι οποίες περιγράφουν τα χαρακτηριστικά του περιβάλλοντος χώρου της κατοικίας (π.χ. θέα, εγγύτητα σε δάσος, εγγύτητα στη θάλασσα, κλπ).

Η δομή λοιπόν της συνάρτησης που περιγράφει την αξία ενός ακινήτου είναι της μορφής:

$$P = f(S_1,\ldots, Sm, Ni,\ldots., Nn, Q1,\ldots Qr) \qquad (1)$$

Όπου P η τιμή του ακινήτου, $S_1,\ldots Sm$, χαρακτηριστικά του ακινήτου (επιφάνεια, αριθμός δωματίων, ύπαρξη χώρου στάθμευσης, αποθήκη, κλπ.), $N_1,\ldots, N_n$ χαρακτηριστικά της ευρύτερης περιοχής (εγκληματικότητα, απόσταση από το κέντρο, ύπαρξη υποδομών, κλπ), και $Q_1, \ldots, Qr$ περιβαλλοντικά χαρακτηριστικά όπως θόρυβος, ποιότητα ατμοσφαιρικού περιβάλλοντος, γειτνίαση με πάρκο, θέα, κλπ. Για να προσδιορισθεί η μορφή της παραπάνω συνάρτησης θα πρέπει να συγκεντρωθούν ικανοποιητικά δεδομένα αγοραπωλησιών ακινήτων στην εξεταζόμενη περιοχή και μέσω της στατιστικής ανάλυσης να εκτιμηθούν οι συντελεστές των ανεξάρτητων μεταβλητών, οι οποίες και δίνουν μια οικονομική αποτίμηση της οριακής μεταβολής των χαρακτηριστικών αυτών για τα υφιστάμενα επίπεδα προσφοράς τους. Ακριβέστερη οικονομική αποτίμηση των χαρακτηριστικών απαιτεί την κατασκευή της καμπύλης ζήτησής τους μέσω μίας δεύτερης ανάλυσης παλινδρόμησης όπου ως ανεξάρτητη μεταβλητή θεωρείται το υπό αποτίμηση αγαθό, πραγματοποιείται όμως εξαιρετικά σπάνια εξαιτίας του πλήθους δεδομένων που απαιτούνται (Bolt et al, 2005).

Τα μοντέλα αγοράς ωφέλιμων χαρακτηριστικών, αν δομηθούν σωστά μπορούν να μας δώσουν εξαιρετικά χρήσιμες πληροφορίες σχετικά με την αξία συγκεκριμένων περιβαλλοντικών αγαθών. Εντούτοις, δεν είναι λίγες οι περιπτώσεις, που δομικά προβλήματα στην ανάπτυξη των μοντέλων οδηγούν σε λανθασμένες εκτιμήσεις της αξίας των εξεταζόμενων περιβαλλοντικών παραμέτρων. Στις συνήθεις αστοχίες περιλαμβάνονται (Hanley et al, 1998):

Η παράλειψη κάποιας ανεξάρτητης μεταβλητής η οποία επηρεάζει την τιμή των ακινήτων και ταυτόχρονα συσχετίζεται με κάποια άλλη ανεξάρτητη μεταβλητή που έχει συμπεριληφθεί στο μοντέλο. Στην περίπτωση αυτή ο υπολογιζόμενος συντελεστής της εν λόγω ανεξάρτητης μεταβλητής θα είναι λανθασμένος.

Η ύπαρξη συγγραμικότητας (multi-collinearity) μεταξύ περιβαλλοντικών παραμέτρων που ενσωματώνονται στο μοντέλο παλινδρόμησης. Στην περίπτωση αυτή απαιτείται η ανάπτυξη διακριτών μοντέλων για κάθε μία από τις μεταβλητές αυτές.

Η επιλογή της μορφής της συνάρτησης, καθώς η οικονομική θεωρία δεν δίνει συγκεκριμένες κατευθύνσεις για τη μορφή της συνάρτησης αυτής.

Το γεγονός ότι οι αγοραίες τιμές μπορεί να ενσωματώνουν και προσδοκίες από πιθανές μελλοντικές μεταβολές στην ποιότητα περιβάλλοντος, κλπ.

Τη γενικότερη στάση απέναντι στον κίνδυνο που έχουν τα άτομα που εμπλέκονται στις εξεταζόμενες αγοραπωλησίες.

4. Μελέτες Περίπτωσης

Στο πλαίσιο της παρούσας εργασίας η εφαρμογή της μεθόδου ανάλυσης αγορών ωφέλιμων χαρακτηριστικών με στόχο την οικονομική αποτίμηση της οπτικής όχλησης από την εγκατάσταση αιολικών πάρκων έγινε για την περιοχή της νότιας Εύβοιας (Δήμος Καρύστου) και της

Κεφαλλονιάς. Οι δύο αυτές περιοχές παρουσιάζουν από τις μεγαλύτερες διεισδύσεις αιολικών πάρκων στη χώρα, με αποτέλεσμα οι εξεταζόμενες αγορές να μπορούν, κατά το δυνατόν καλύτερα, να αξιολογήσουν τις οχλήσεις που δημιουργούνται από τα αιολικά πάρκα. Στη Νότια Εύβοια και σε μια περιοχή συνολικής έκτασης 560 χιλ. στρεμμάτων ήταν εγκατεστημένα, την περίοδο της έρευνας διάσπαρτα **13** αιολικά πάρκα συνολικής ισχύος **83,9** MW. Ο πληθυσμός της περιοχής ανέρχεται σε 40.210 κατοίκους. Αντίστοιχα, η Κεφαλονιά, ένας από τους σημαντικότερους τουριστικούς προορισμούς της Ελλάδος με παγκόσμια φήμη, περιλαμβάνει **4** αιολικά πάρκα συνολικής εγκατεστημένη ισχύος **97,5** MW.

Στη μελέτη περίπτωσης της Νότιας Εύβοιας το δείγμα των παρατηρήσεων περιελάμβανε 400 αγοραπωλησίες ακινήτων και αντίστοιχα η μελέτη περίπτωσης της Κεφαλονιάς 1415 αγοραπωλησίες ακινήτων. Τα δεδομένα αγοραπωλησιών κατοικιών στις περιοχές ενδιαφέροντος ελήφθησαν από τη βάση δεδομένων της Τράπεζας της Ελλάδος (ΤτΕ) και αφορούσαν χρονική περίοδο μιας 10-ετίας (2006-2016).

Και στις δύο μελέτες περίπτωσης επιδιώχθηκε να συσχετισθεί η ανά τετραγωνικό μέτρο τιμή πώλησης των κατοικιών με παραμέτρους που σχετίζονται με τα χαρακτηριστικά της κατοικίας, τα ευρύτερα χαρακτηριστικά της περιοχής που χωροθετείται η κατοικία, και τέλος, περιβαλλοντικά χαρακτηριστικά. Στα περιβαλλοντικά χαρακτηριστικά συμπεριλαμβάνεται ως μεταβλητή και η «απόσταση από τα αιολικά πάρκα» στη βάση της παραδοχής ότι στο βαθμό που η ανάπτυξη της αιολικής ενέργειας προκαλεί περιβαλλοντικές επιπτώσεις (λόγω θορύβου, οπτικής όχλησης, κλπ.) αυτή θα είναι εντονότερη στις περιοχές που γειτνιάζουν με τα αιολικά πάρκα.

Η χωρική συσχέτηση των αιολικών πάρκων και των αστικών περιοχών πώλησης κατοικιών, βάσει της οποίας προέκυψε η μεταβλητή [απόσταση], έγινε με την βοήθεια μιας απλής δομής ενός πληροφοριακού γεωγραφικού συστήματος πληροφοριών G.I.S. ψηφιοποιόντας ως πολύγωνα τις μικρότερες κατά το δυνατόν γεωγραφικές διοικητικές δομές στις οποίες θα μπορούσαν να καταχωρηθούν τα δεδομένα της ΤτΕ. Συγκεκριμένα, σε κάθε μελέτη περίπτωσης ψηφιοποιήθηκαν χρησιμοποιόντας το υπόβαθρο των δασικών χαρτών τα πολύγωνα των αστικών περιοχών δηλαδή τα πολύγωνα τα οποία ήταν χαρακτηρισμένα "εκτός ανάρτησης" και τα οποία συμπίπτουν με: (α) με τα όρια ρυμοτομικών σχεδίων, ή (β) με τα όρια οικισμών, καθώς επίσης και τα πολύγωνα των αιολικών πάρκων έχοντας υπόψη τις συντεταγμένες των κορυφών των πολυγώνων τους, τα οποία δίδονται από το Geoportal της Ρυθμιστικής Αρχής Ενέργειας. Η απόσταση η οποία καταγραφόταν σε κάθε παρατήρηση ήταν η απόσταση μεταξύ των κεντροβαρικών σημείων των αντίστοιχων πολυγώνων.

5. Αποτελέσματα και Συζήτηση

Τα μοντέλα αγορών ωφέλιμων χαρακτηριστικών που αναπτύχθηκαν έχουν την μορφή της Εξίσωσης (1). Ως εξαρτημένη μεταβλητή χρησιμοποιήθηκε ο φυσικός λογάριθμος (προκειμένου να μειωθεί το φαινόμενο της ετεροσκεδαστικότητας) της τιμής πώλησης των κατοικιών ανά μονάδα επιφάνειας.
Ως ανεξάρτητες μεταβλητές των μοντέλων χρησιμοποιούνται:

Παράμετροι που αποτυπώνουν τα χαρακτηριστικά της κατοικίας, και συγκεκριμένα το μέγεθος του ακινήτου, προκειμένου να αποτυπωθούν οι διαφορετικές προτιμήσεις για μεγάλες και μικρές κατοικές (συνεχής μεταβλητή), η ύπαρξη θέσης στάθμευσης (μέσω ψευδομεταβλητής), η ύπαρξη αποθήκης (μέσω ψευδομεταβλητής), η ποιότητα κατασκευής (μέσω ψευδομεταβλητής), η παλαιότητα (συνεχής μεταβλητή), ο όροφος χωροθέτησης (ακέραια μεταβλητή).

Παράμετροι που αποτυπώνουν τα χαρακτηριστικά της ευρύτερης περιοχής / αγοράς που χωροθετείται η κατοικία, συμπεριλαμβάνοντας το μέσο όρο των τιμών της περιοχής ως μέτρο της εκλυστικότητάς της, καθώς και ψευδομεταβλητές για τη χρονική περίοδο της συναλλαγής προκειμένου να αποτυπωθούν οι ευρύτερες διακυμάνσεις της κτηματαγοράς κατά την εξεταζόμενη περίοδο.

Περιβαλλοντικές παράμετροι. Όπως ήδη αναφέρθηκε βασική περιβαλλοντική παράμετρος για την εκτίμηση των επιπτώσεων από τα αιολικά πάρκα είναι η απόσταση των κατοικιών από αυτά. Και στις δύο μελέτες περίπτωσης η εν λόγω μεταβλητή ενσωματώνεται στα μοντέλα που αναπτύχθηκαν είτε ως συνεχής μεταβλητή είτε ως ψευδομεταβλητή, καθορίζοντας ζώνες γύρω από τα εξεταζόμενα αιολικά πάρκα. Μία πρόσθετη περιβαλλοντική παράμετρος που ενσωματώνεται στα μοντέλα που αναπτύχθηκαν είναι η απόσταση από τη θάλασσα (ως ψευδομεταβλητή θέσης).
Τα αποτελέσματα της ανάλυσης συνοψίζονται στον Πίνακα 1. Κατ' αρχήν τα δύο μοντέλα (Ε1 και Κ1) που ενσωματώνουν την απόσταση ως συνεχή μεταβλητή μας παρέχουν μια αρκετά ικανοποιητική ερμηνεία των διακυμάνσεων των τιμών των κατοικιών. Στην περίπτωση της Εύβοιας ενσωματώνονται 13 ανεξάρτητες μεταβλητές ενώ βρέθηκε ότι η απόσταση από τα αιολικά πάρκα επιδρά στις τιμές των κατοικιών κατά τρόπο στατιστικά σημαντικό (οι τιμές αυξάνονται με την απόσταση από το εγγύτερο αιολικό πάρκο). Αντίθετα, το μοντέλο της Κεφαλλονιάς (Κ1) έδειξε ότι η απόσταση από τα αιολικά πάρκα δεν επιδρά κατά τρόπο στατιστικά σημαντικό (επίπεδο σημαντικότητας α=5%) στις τιμές των κατοικιών. Εν γένει όλες οι ανεξάρτητες μεταβλητές που ενσωματώνονται στα δύο μοντέλα έχουν το αναμενόμενο πρόσημο. Ο συνολικός βαθμός σημαντικότητας των δύο μοντέλων υπολογίστηκε σε **52%** για την περίπτωση της Εύβοιας και **40%** για την περίπτωση της Κεφαλλονιάς. Η σχετική χαμηλή ερμηνευτική ικανότητα των μοντέλων θα πρέπει να αποδωθεί στο γεγονός ότι τα στοιχεία της βάσης δεδομένων της ΤτΕ δεν επιτρέπουν την απεικόνιση των κατοικιών σε επίπεδο οικοδομικού τετραγώνου αλλά και η έλλειψη επαρκών δεδομένων για άλλα χαρακτηριστικά των κατοικιών. Για την περίπτωση της Εύβοιας όπου η απόσταση βρέθηκε στατιστικά σημαντική προκύπτει ότι οι τιμές των κατοικιών αυξάνονται κατά 2.4% ανά km απόστασης από το εγγύτερο αιολικό πάρκο.
Προκειμένου να διευκολυνθεί η οικονομική αποτίμηση των περιβαλλοντικών επιπτώσεων που συνδέονται με την ανάπτυξη των αιολικών πάρκων αναπτύχθηκαν τα μοντέλα Ε2 και Κ2 αντίστοιχα για την Εύβοια και την Κεφαλονιά όπου πλέον η απόσταση από τα αιολικά πάρκα μοντελοποιείται μέσω ψυδομεταβλητών που χαρακτηρίζουν συγκεκριμένες ζώνες γύρω από τις αιολικές εγκαταστάσεις (Πίνακας 1). Και στα δύο μοντέλα ενσωματώνονται 16 ανεξάρτητες μεταβλητές, ενώ η ερμηνευτική τους ικανότητα είναι ανάλογη των προηγούμενων.
Για την περίπτωση της Εύβοιας, η περιβαλλοντική παράμετρος "κατοικία εντός ζώνης (0-2 Km)", βρέθηκε ότι είναι στατιστικά σημαντική (τιμή-P=0.019), επηρεάζει δηλαδή τις αξίες των κατοικιών στο επίπεδο σημαντικότητας α=5%. Αντίθετα η περιβαλλοντική παράμετρος, "κατοικία εντός ζώνης (2-4 Km)" βρέθηκε ότι δεν είναι στατιστικά σημαντική (τιμή-P=0.185) ακόμα και για επίπεδο σημαντικότητας α=10%. Επομένως, προκύπτει ότι η αξία των κατοικιών στην Εύβοια που είναι σε μία ζώνη έως 2 km από τα αιολικά πάρκα απομειώνεται κατά 14,5%.

ΠΙΝΑΚΑΣ 1 Στατιστικά μοντέλα ωφέλιμων χαρακτηριστικών για την εκτίμηση των επιπτώσεων των αιολικών πάρκων στη Νότια Εύβοια και στην Κεφαλλονιά.

Παράμετροι	**Νότια Εύβοια**				**Κεφαλλονιά**			
	Μοντέλο Ε1		Μοντέλο Ε2		Μοντέλο Κ1		Μοντέλο Κ2	
	Συν/τής παλινδρό-μησης	P-value	Συν/τής παλινδρό-μησης	P-value	Συν/τής παλινδρό-μησης	P-value	Συν/τής παλινδρό-μησης	P-value
Σταθερά	6.869	0.000	6.939	0.000	6.660	0.000	6.724	0.000
Μέσος όρος τιμών περιοχής	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Εντός ζώνης 800 Μ από θάλασσα (Ναι/Όχι)	-0.064	0.283	-0.109	0.087	-	-	-	-
Εντός ζώνης 200 Μ από θάλασσα (Ναι/Όχι)	-	-	-	-	0.044	0.099	0.033	0.224
Εντός ζώνης 500 Μ από θάλασσα (Ναι/Όχι)	-	-	-	-	-0.101	0.005	-0.101	0.003
Απόσταση από εγγύτερο αιολικό οικόπεδο σε km	**0.024**	**0.030**	-	-	**0.003**	**0.397**	-	-
Απόσταση εντός ζώνης 0-2 km από εγγύτερο αιολικό πάρκο (Ναι/Όχι)	-	-	**-0.157**	**0.019**	-	-	**-0.116**	**0.504**
Απόσταση εντός ζώνης 2-4 km από εγγύτερο αιολικό πάρκο (Ναι/Όχι)	-	-	**-0.097**	**0.185**	-	-	**0.001**	**0.994**
Παλαιότητα κτιρίου	-0.007	0.000	-0.007	0.000	-0.005	0.000	-0.005	0.000
Εκτίμηση εντός Περιόδου 2008-2009 (Ναι/Όχι)	0.072	0.182	0.085	0.121	0.033	0.111	0.036	0.091
Εκτίμηση εντός Περιόδου 2010-2011 (Ναι/Όχι)	-0.069	0.231	-0.056	0.337	-0.134	0.000	-0.119	0.000
Εκτίμηση εντός Περιόδου 2012-2013 (Ναι/Όχι)	-0.315	0.000	-0.305	0.000	-0.397	0.000	-0.399	0.000
Εκτίμηση εντός Περιόδου 2014-2016 (Ναι/Όχι)	-0.537	0.000	-0.527	0.000	-0.360	0.000	-0.323	0.000
Αριθμός ορόφου	0.020	0.406	0.018	0.438	0.023	0.118	0.015	0.328
Ύπαρξη Αποθήκης (Ναι/Όχι)	0.345	0.000	0.351	0.000	0.162	0.000	0.161	0.000
Ύπαρξη θέσεων Στάθμευσης (Ναι/Όχι)	0.260	0.051	0.298	0.030	0.018	0.699	0.045	0.350
Άριστη ποιότητα Κατασκευής (Ναι/Όχι)	-0.002	0.000	0.164	0.024	0.119	0.047	0.109	0.073
Προνομιακή θέση/θέα/περιβάλλον (Ναι/Όχι)	0.147	0.026	-0.009	0.918	0.057	0.039	-0.001	0.551
Εμβαδόν χώρων κύριας χρήσης	-	-	-0.002	0.000	-0.001	0.000	-0.001	0.000
Πρόσφατα ανακαινισμένο (Ναι/Όχι)	-	-	-0.064	0.435	-	-	-	-
Μέγεθος οικοπέδου	-	-	-	-	0.000	0.000		
Αριθμός παρατηρήσεων	400		400		1416		1416	
Αριθμός Μεταβλητών	13		16		16		16	
Adjusted R2	**0.52**		**0.53**		**0.40**		**0.37**	

Στην περίπτωση της Κεφαλονιάς, η περιβαλλοντική παράμετρος "κατοικία εντός ζώνης (0-2 km)" βρέθηκε ότι δεν είναι στατιστικά σημαντική (τιμή-P=0.50), δηλαδή η ορατότητα προς το αιολικό πάρκο εντός της ζώνης αυτής δεν επηρεάζει τις αξίες των κατοικιών στο επίπεδο σημαντικότητας α=5%, ακόμα και στο επίπεδο σημαντικότητας α=10%. Αντίστοιχα, και η περιβαλλοντική παράμετρος "κατοικία εντός ζώνης (2-4 km)" βρέθηκε ότι δεν είναι στατιστικά σημαντική (τιμή-P=0.99*)*.

Με βάση τις εκτιμήσεις αυτές επιχειρείται μια συνολική εκτίμηση της περιβαλλοντικής ζημίας που προκαλούν τα εγκατεστημένα αιολικά πάρκα στην Νότια Εύβοια, λαμβάνοντας υπόψη την υποτίμηση των τιμών των κατοικιών που χωροθετούνται στη ζώνη 0-2 km από τα αιολικά πάρκα. Η ανάλυση βασίζεται στις ακόλουθες παραδοχές:

Η περιβαλλοντική ζημιά κατανέμεται ομοιόμορφα σε όλες τις κατοικίες εντός ζώνης 0-2 km.

Η ετησιοποιημένη αξία των κατοικιών υπολογίζεται με προεξοφλητικό επιτόκιο 1,5% και λαμβάνοντας το χρόνο ζωής των κατοικιών ίσο με 60 έτη.

Ο συντελεστής φόρισης των αιολικών πάρκων της περιοχής ανέρχεται σε 30%.

Με βάση τα παραπάνω το εξωτερικό περιβαλλοντικό κόστος από την μεγάλης κλίμακας ανάπτυξη της αιολικής ενέργειας στη Νότια Εύβοια υπολογίσθηκε σε **2,59** € ανά MWh.

6. Συμπεράσματα

Στην παρούσα εργασία έγινε εφαρμογή της Μέθοδου Αγοράς Ωφέλιμων Χαρακτηριστικών, προκειμένου να αποτιμηθούν σε οικονομικούς όρους οι επιπτώσεις της οπτικής όχλησης από τη μεγάλης κλίμακας αξιοποίηση της αιολικής ενέργειας σε μια περιοχή. Στην εφαρμογή που έγινε στην περιοχή της Νότιας Εύβοιας, όπου κατά την περίοδο διενέργειας της έρευνας η εγκατεστημένη ισχύς σε αιολικά πάρκα ήταν 83,9 MW, τα αποτελέσματα της ανάλυσης έδειξαν ότι ο αρνητικός αντίκτυπος περιορίζεται εντός ζώνης 2 km από τα αιολικά πάρκα ενώ αντίστοιχα στην εφαρμογή που έγινε στην περιοχή της Κεφαλλονιάς, όπου κατά την περίοδο διενέργειας της έρευνας η εγκατεστημένη ισχύς αιολικών πάρκων ήταν 97,5 MW, τα αποτελέσματα της ανάλυσης έδειξαν ότι δεν επηρεάζονται οι τιμές των κατοικιών. Η ειδοποιός διαφορά τον δύο περιπτώσεων ήταν κυρίως η έλλειψη στη μελέτη περίπτωσης της Κεφαλλονιάς ικανού αριθμού παρατηρήσεων εντός της ζώνης 2 km από τα εγκατεστημένα αιολικά πάρκα.

Η ποσοστικοποίηση των επιπτώσεων στην περίπτωση της Νότιας Εύβοιας έδειξε ότι τιμές των κατοικιών σε αποστάσεις μέχρι 2 km από τα αιολικά πάρκα μειώνονται κατά **14.5**%, ενώ το οριακό κόστος της οπτικής όχλησης σε αυτά τα επίπεδα διείσδυσης της αιολικής ενέργειας ανέρχεται σε **2.59** €/MWh Το αποτέλεσμα αυτό είναι άμεσα συγκρίσιμο με το αποτέλεσμα της μελέτης που έγινε το 2013 με εφαρμογής της μεθόδου της εξαρτημένης αξιολόγησης (2,71 €/MWh) στην ίδια περιοχή μελέτης (Mirasgedis et al, 2014).

Φαίνεται επομένως ότι η οπτική όχληση από τη μεγάλης κλίμακας αξιοποίηση της αιολικής ενέργειας συνιστά μια σημαντική εξωτερική οικονομία, εντούτοις είναι κατά πολύ χαμηλότερη των εξωτερικών οικονομιών που προκαλούνται από τεχνολογίες ηλεκτροπαραγωγής με ορυκτά καύσιμα. Η μεγάλης κλίμακας αξιοποίηση της αιολικής ενέργειας και η υποκατάσταση συμβατικής ηλεκτροπαραγωγής συνεπάγεται επομένως σημαντικά περιβαλλοντικά οφέλη τα οποία μπορούν να αποτιμηθούν σε χρηματικές μονάδες.

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Shark aggregation and tourism: Opportunities and challenges of an emerging phenomenon

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Abstract

In the last few winters, sharks have been aggregating near the Israeli Mediterranean coast, at a specific point, near Hadera power station. This unusual phenomenon has fascinated residents, visitors, kayakers, divers and swimmers. We analyse the effects of this intense human interest on the sharks, using contingent behaviour, in Hadera and in Ashkelon, where sharks are present but not the infrastructure for their observation. We also report on changes in shark behaviour due to change in tourism intensity. We find a change of about ILS 4.1 million annually for both sites but a larger individual consumer surplus in Hadera, where sharks are currently observable. Touristic intensity crosses the threshold level by about 12% and making the socio-equilibrium sustainable for both humans and sharks would have a social cost of ILS 0.157 million.

Keywords: Shark aggregation, shark behaviour, human-wildlife conflict, Mediterranean, Travel cost, tourism.

Introduction

Sharks (superorder Selachimorpha) are characterized by *K*-selected life history traits, including slow growth, late age-at-maturity and low fecundity. Thus, once a population is depleted, recovery to pre-exploitation levels may take several decades or longer (Kabasakal et al. 2017). Over the last 60 years, shark catches by industrial, artisanal, and sport fisheries have increased around the world, and sharks are among the most threatened marine animals (Martins et al. 2018).

Today, sharks face possibly the largest crisis of their 420-million-year history. An estimated 100 million sharks are killed by commercial fisheries every year (Berrios 2017), and a quarter of species have an elevated risk of extinction (Simpfendorfer & Dulvy 2017). Sharks are increasingly taken as bycatch in fisheries targeting other species of commercial value (Kabasakal et al. 2017). Large sharks, especially those living in shallow water, are in the most danger of extinction (Dulvy et al. 2014). Sharks are more vulnerable to over-exploitation than most teleosts and other vertebrates (Bradshaw et al. 2018).

Viewing sharks in nature is a popular tourism activity (Haskell et al. 2015). It is a global industry (Gallagher et al. 2015). Examples are the whale shark (*Rhincodon typus*) at Tofo Beach, Mozambique (Haskell et al. 2015), hand feeding (*Carcharhinus leucas*) in the Shark Reef Marine Reserve, Fiji (Brunnschweiler et al. 2018), tiger sharks (*Galeocerdo cuvier*) in the Aliwal Shoal Marine Protected

Area, South Africa (Du Preez et al. 2012), and the white shark (*Carcharodon carcharias*) cage-diving in South Australia's Spencer Gulf important industry (Nazimi et al. 2018).
Wildlife tourism may have the potential to contribute to conservation (Börger et al., 2014; Brunnschweiler et al. 2018). It is said to enhance environmental education, while providing local economic benefits (Grafeld et al., 2016; Nazimi et al. 2018). As Gallagher, et al. (2015) points out; this kind of tourism may induce more alive sharks (for tourism) than dead (in a fish market). However, the tourism industry, if not properly managed, can also threaten wildlife and ecosystems. Negative impacts may include physiological changes, behavioural changes, seasonality change, residency, abundance, and disruptions of space use. Many studies have pointed out that the anthropogenic effects can be detrimental to sharks if not organized or too frequent (Schofield et al. 2015; Nazimi et al. 2018). As top predators in marine food webs, sharks provide regulatory control, maintaining the balance of the ecosystem (Kabasakal et al. 2017), and have an important role in the health of oceanic ecosystems worldwide (Martins et al. 2018).
Although sharks have historically had low economic value, today many have become indirect or direct targets of commercial and recreational fisheries around the world (Kabasakal et al. 2017). Sharks are exploited for their fins (used to produce shark-fin soup), meat (frozen, fresh, brine, smoked, salted), skin (for sandpaper and leather), cartilage (for its supposed anti-cancer properties), teeth, and liver oil (pharmaceuticals and cosmetics) (Berrios 2017). But another kind of economic value of sharks has evolved, derived from tourism and recreation. Cisneros-Montemayor (et al. 2013) suggested that globally about 590,000 shark watchers spend more than USD 314 million per year, directly supporting 10,000 jobs. The travel cost method (TCM) is a popular way to derive recreation benefits either by visitor or by visit. This is done by estimation of the consumer surplus (CS). The method is based on the assumption that there is an inverse relationship between visitation rate and the cost of a visit which provides a possible potential to estimate a downward-sloping demand curve. For example, Du Preez et al. (2012) used TCM to value consumer surplus from tiger shark diving in South Africa, obtaining a value of about 2 million Rand per year. Anna & Saputra (2017) used TCM in local and foreign whale shark tourism in India and obtained IDR 142.35 billion per year.
Estimation of the benefit of a site attribute requires one to know what is the demand for trips to the site for a given level of this attribute (Alberini et al. 2007). One way to overcome this is to ask individuals about the change they expect to have in the number of trips they would take to a site under hypothetical change in an attribute. This contingent behaviour, CB) may later be lumped with observations on actual trips to the site under the current conditions of the attribute (Grijalva et al. 2002). These changes in the attributes of a site are measured through a change in behaviour; that is, visit frequency (Ready et al., 2018; Wang et al. 2017). For example, Pueyo-Ros et al. (2018) developed a combined model with TCM and CB to assess the economic value of coast restoration in Costa Brava (Spain) and to understand the influence of this restoration on visitors' behaviour. This CB method is used to analyze different policies to find the most efficient policy under changes in the quality or recovery of a touristic area (Okuyama, 2018). In this study we apply TCM to a sample of recreation participants to obtain revealed and stated preferences for trips based on the visibility (or not) of sharks at two beaches along the Israeli Mediterranean coast. We also use the pooled CB method and estimate the change in values accordingly.
Phenomenon background: In the winter months (November to April) in each of the last several years, 40–80 sharks (dusky shark, *Carcharhinus obscurus*, and sandbar shark, *Carcharhinus plumbeus*) have aggregated very close to the shore on Israel's Mediterranean coast, near the power station at Hadera (Zemah Shamir, 2018).[16] We speculate that here on the oligotrophic and highly evaporative

[16] http://www.bbc.com/news/av/science-environment-44174183/the-day-spa-for-pregnant-sharks

margins of the Mediterranean, sharks that have adapted to the warm, highly saline water are attracted by water that's even warmer and saltier. The coastline is neither protected nor regulated, so these sharks may face serious negative effects, for example, being caught by artisanal or recreational fishers or being frightened or hurt by jet skis or speedboats. And alongside the human–wildlife conflict there is human–human conflict (Dickman, 2010), between the regulator and the residents, or other stakeholders such as fishers and divers.

It is important to measure the recreational potential as well as signal some potential risks of this phenomenon, which is still only a few years old. The objective of this paper is thus to address this conflict into monetary values and describe the changes in the behaviour of recreationalists under two scenarios: Sharks visit both Hadera and Ashkelon (Figure 1), but they are presently visible to tourists only at Hadera. Using TCM and CB, we consider tourist visits to Hadera and Ashkelon under two conditions: when they can see sharks there (true at Hadera, hypothetical at Ashkelon) and when they can't see sharks there (true at Ashkelon, hypothetical at Hadera. We also look at the trade-off between active tourism (diving) and sustainable ecological conditions for the sharks.

Materials and Methods

2.1 The travel cost model

A travel cost model combining current (revealed preferences) with CB (stated preferences) data was used to analyze how the sharks' appearance would affect the recreational value of the two sites. The cost of traveling included the petrol cost from the declared place of origin, using the rate for an average car of ILS 1.4 per kilometre. To this was added the opportunity cost of time, at one-third of the reported wage (Amoako-Tuffour and Martínez-Espiñeira, 2012). Time and distance are usually obtained using self-reported answers or programs such as Google Maps.

For the two independent models of revealed and stated preferences, an individual travel cost Poisson count model was used. The dependent variable was visits per season, and the independent variables were travel cost (TC) and the socio-demographic variables. In the pooled TC+CB models, each individual in the data set is counted twice. One time in under the current conditions of the attribute and the second time under the hyphothetical change in the level of the given attribute. Therefore, the model should also include a dummy variable that indicates whether the number of visits for that individual was observed data or CB data (Eiswerth et al. 2000).

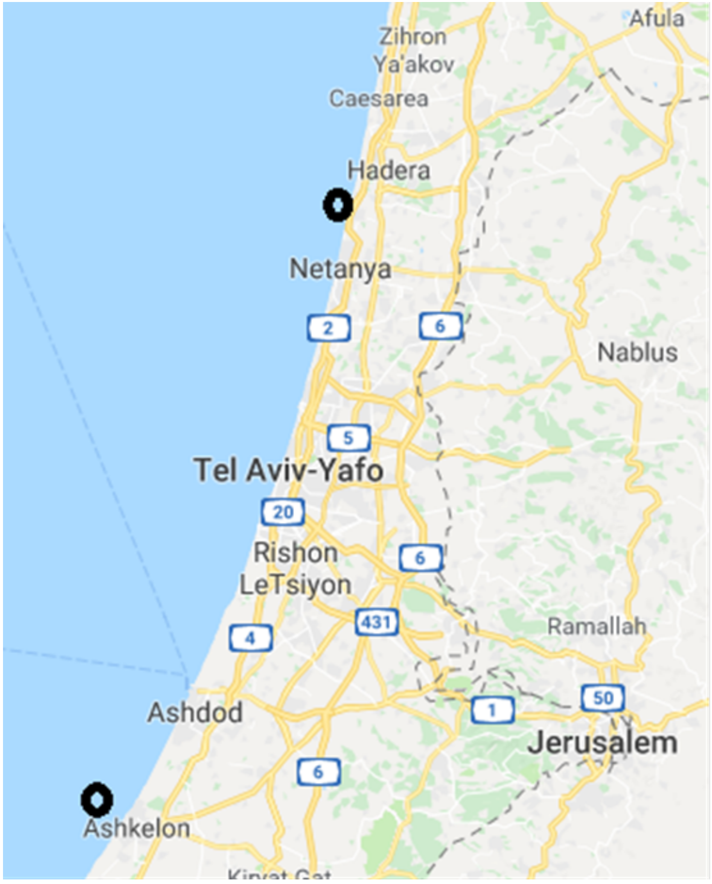

Figure 1: Shark aggregations in Hadera and Ashkelon (in black circles)

Thus, the demand function can be expressed as

$$v = f(c, Z, D)$$

Where v is the visitation rate to the site, c is the round-trip cost, Z is a vector of the sociodemographic characteristics of the individual, and D is the dummy variable that indicates whether the observation is under the current level of the attribute or the hypothetical change in its level (Grijalva et al. 2002). The variables besides the travel cost are gender, age, people per household, origin (native or immigrant), education level (5 levels), membership in a green organization, and income. The Poisson count model enables the estimation of the consumer surplus of a visit to the site. If the cot coefficient is given by β_{cost}, the consumer surplus per visit is given by $(-1/\beta_{cost})$ (Hellerstein and Mendelsohn, 1993). If one uses a pooled model, an interaction term that is the product of CB and cost should be added. Its inclusion is a test to explore exploring whether the contingent scenario changes the slope of the recreational demand (Eiswerth et al., 2008). To estimate the recreational change value, the coefficients of these two variables (CB and CB × cost) must be found significant. If the interaction term is not statistically significant, one can conclude that the shift in the demand function is horizontally without any change in the slope.

2.2 **Survey and data collection**

A survey was conducted at the two different beaches, where sharks can be observed now (Hadera) or hypothetically could be observed in the future (Ashkelon). A paper-based questionnaire was used in a face-to-face setting. Visitors to the beaches were intercepted at random, and an in-person written survey was conducted. Care was taken in order to make the sample representative of the temporal distribution of trips (e.g., sampling at different hours of the day and during week and weekend days). The survey was conducted over a one-month period in February 2018, with 205 successful completions.

The survey itself was in four parts. Part A dealt with some explanations of the phenomenon, including the potential pros and cons of shark tourism. Part B dealt with the distance and time required to visit the site. We also asked about the weight given to sharks in the visit and adjusted the trip cost accordingly (Martinez-Espineira and moako-Tuffour, 2008). Part C asked about visit frequency during the last season and how it would change if there were a change in shark visibility. Part D collected socio-demographic characteristics.

2.3 Biological observations

Seasonal observations using drone surveys, diving, and on-beach observations from November 2017 through early May 2018 show that sharks are being stressed by divers, swimmers, and personal watercraft, along with increasing numbers of coastal visitors. Energy requirements, for instance the standard metabolic rate (in mg O_2/h) of sandbar sharks (*C. plumbeus*), were determined by using best-fit allometric equations referring to temperature calculated by Dowd et al. (2006). Because direct measurements in the ocean are rare and complicated, a common approach to estimating energy requirements in large marine animals is to quantify the correlation between metabolism and body mass in smaller animals, and extrapolate upwards (Payne et al. 2015).

Results

Descriptive statistics for the two locations are presented in table 1.

Table 1: Descriptive statistics

Variable	Mean		SD		Min		Max	
	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera
Travel cost (ILS)	81.526	137.67	40.752	86.730	25.411	26.882	204.549	137.66
Visit before	8.885	3.339	6.677	2.879	.5	.2	24	12
Visit after	13.383	2.577	8.200	1.642	2	0	36	6
Gender	.687	.427	.467	.497	0	0	1	1
Age	34.205	39.097	12.708	13.015	12	9	68	73
People per household	4.217	4.048	1.316	1.023	1	1	7	6
Origin	.626	.893	.487	.310	0	0	1	1
Education	2.795	2.747	1.134	.997	1	0	5	4
Green	.193	.175	.397	.382	0	0	1	1
Income (ILS)	11807.2	11,215.0	4246.8	4,033.8	5000	0	20000	5

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The mean travel cost (including fuel and time) is ILS 81.5 and ILS 137.67 for Ashkelon and Hadera, respectively. This is a substantial difference, which might reduce the impact of shark visibility in Ashkelon compared to Hadera. Visit frequency increased from 8.885 to 13.383 in Ashkelon, while in Hadera it decreased from 3.339 to 2.577. These differences are for the "before" and "after" scenarios, so they should be opposite in sign, since "after" in Ashkelon means sharks appearing while in Hadera it means sharks disappearing.

Three model estimations are executed using revealed preferences ("before"), stated preferences ("after") and the pooled data CB model. The change in the benefit of a given visit before and after the change were measured by the difference in the consumer surplus under the present attribute condition and the new attribute conditions. The pooled model includes two dummy variables. One is dummy sharks, which differentiates between the two scenarios (with or without sharks). The second is dummy cost. As explained above, this variable was created as an interaction term of cost times the variable "dummy sharks". When it is 1, only the stated preferences data are included, and when it is 0, only the revealed preferences data. If the coefficients of both dummy variables are statistically significant, then the demand shifts both upward and also incur a change in slope. The results are given in table 2.

Table 2: Econometric estimations

Scenario	Before		After		Pooled	
	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera
Cost	-0.00637***	-0.002089*	-0.0051***	-0.002639**	-.007681***	-.00371***
Gender	0.419***	-0.231**	.27547***	0.049	-.071***	-.109
Age	-0.0041	0.011***	-.0008	0.005	.0026***	.0094***
People per household	0.03	-0.135***	.0352*	-0.16**	.022*	-.149***
Origin	-0.323***	0.118	-.248*	0.129	.392	-.049
Education	0.369***	0.318***	.217***	0.36***	.138*	.325***
Green	0.123**	0.033*	-.126	0.314**	.173*	.111*
Income	0.00009***	0.044*	.000035**	0.19***	.000025***	.0071*
Constant	2.46***	2.49***	2.724***	1.69***	3.101***	2.471***
Dummy sharks					.221***	.057*
Dummy cost					.00087	.00383
	N = 102 LR $chi^2(8)$ = 160.52 Pr > chi^2 = 0.000 LL = -264 Pseudo R^2 = 0.233	N = 103 LR $chi^2(8)$ = 78.43 Pr > chi^2 = 0.0000 LL = - Pseudo R^2 = 0.126	N = 102 LR $chi^2(8)$ = 145.80 Pr > chi^2 = 0.000 LL = -304.6 Pseudo R^2 = 0.193	N = 103 LR $chi^2(8)$ = 31.60 Pr > chi^2 = 0.0001 LL = -160 Pseudo R^2 = 0.09	N = 202 LR $chi^2(10)$ = 505.60 Pr > chi^2 = 0.0000 LL= -2176 Pseudo R^2 = 0.104	N = 205 LR $chi^2(10)$ = 180.09 Pr > chi^2 = 0.0000 LL = -516.4 Pseudo R^2 = 0.1485

*, ** and *** indicates 90%, 95% and 99% significance level.

Looking at the estimated coefficients across the three models, we can see that first, both "dummy sharks" variables are statistically significant, while the two dummy cost variables are not. That means that the effect of sharks' appearance is a parallel shift in the demand function but not in the slope of the function.

The cost coefficient is statistically negative in all three models, indicating that higher travel cost reduces visit frequency. For Ashkelon the coefficient is larger (in absolute value terms) in the "before" scenario compared to the "after". That means that the consumer surplus is lower, as expected, before sharks appear there. In Hadera it is the opposite: the cost coefficient in the "after" scenario is bigger than in the "before". That means that if the sharks abandon the Hadera beach, consumer surplus will decrease. The cost coefficient in the pooled model is higher (in absolute terms) in both locations compared to the separate scenarios, "before" and "after".[17] That might reflect the difference between the pooled and independent models. In particular, consumer surplus is smaller in the pooled model. But the difference is also a function of the (statistically significant) dummy variable.

Welfare effects are calculated through the changes in consumer surplus (CS) per individual, multiplied by the number of visitors in the associated scenario. To calculate the effect of the overall

[17] "Before" and "after" in the pooled model were estimated by calculating the predicted visit frequency under mean values for the independent variables.

park attribute quality improvements on recreation demand and CS, number of trips and CS are estimated for both current and hypothetical levels of the attribute (with or without sharks). The CS per trip is given in the Poisson model by $-1/\beta_{cost}$ (Hellerstein and Mendelsohn, 1993). To calculate the difference in the entire CS, one needs to also take into account the change in number of visitors (Fishler and Tal, 2011). Hence the relevant equation is

$$(2) \quad \Delta CS = \frac{Visits_A}{\beta_{cost,A}} - \frac{Visits_B}{\beta_{cost,B}}$$

For the pooled model, the welfare effect is:

$$(3) \quad \Delta CS = \frac{Visits_A}{\beta_{cost}+\beta_{Dummy\ cost}} - \frac{Visits_B}{\beta_{cost}}$$

But since dummy cost is not statistically significant, we can ignore the second term in the denominator of the first fraction in the right-hand side of the equation.

Table 3: Welfare effects

	Before		After		Difference		Pooled before		Pooled after		Difference	
	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera	Ashkelon	Hadera
CS per trip (ILS)	157.0	478.7	196.1	378.9	39.1	-99.8	130.2	422.9	158.9	269.5	28.8	153.4
Visits	29898	21452	45066	16518	15168	-4934	24795	18952	36525	11748	11730	-7204
∑CS (ILS millions)	4.7	10.3	8.8	6.3	-4.0	4.1	3.2	8.0	5.8	3.2	2.6	-4.8
Total CS for shark presence (ILS millions)					8.2				7.4			

Table 3 presents the CS per visit under the two scenarios – "before" and "after" – as well as the pooled model. The estimated surpluses in the pooled model are smaller than in the independent ones. That is also reflected in the difference in Ashkelon but not in Hadera. For Ashkelon the difference is ILS 39 and ILS 29 for the independent and pooled models, respectively, while for Hadera it is ILS 100 and ILS 153. Not only is the difference larger in Hadera, but so too are the absolute values. This could be due to the prior experience of respondents, since sharks are already present and observable in Hadera but not in Ashkelon.

The total change in the value of sharks' appearance is ILS 8.152 million and ILS 7.425 million for the independent and pooled scenarios, respectively. While in the independent models the net impact of the two locations is almost identical (about ILS 4 million for each location), in the pooled model the benefit in Ashkelon is ILS 2.58 million while in Hadera it is ILS 4.85 million.

To get a sense of the conflict between shark conservation and tourism, we tried to relate diving and shark fitness. Fourteen diving activities were observed, with two or more divers, using scuba gear. We observed female dusky sharks and male sandbar sharks. About 76 encounters with sharks of both species were documented. Both species changed their behaviour in the presence of the divers. The sandbar sharks (81.6%) fled quickly; the dusky sharks (18.4%) also moved away, but more casually. The vigorous flight of most of the sharks has an energetic price and can be assumed to reduce fitness. How quickly a shark disappears (vanishing point) depends on visibility; an average visibility of 15 m was used in calculations. We calculated the disturbance caused by two divers (with a 15 m radius) as significant. The derived threshold level in the living area, where sharks are staying most of the time (300 m × 150 m), is estimated at 8 divers.
According to the coastal monitoring stations, there were 1,767 divers off Hadera Beach during the last season (Nov. 2017 – May 2018). This number can be analysed under the assumptions that diving is done mostly on weekends (Friday and Saturday) and that a diving session takes an hour, hence there are six diving hours per day (10 am to 4 pm).[18] Table 4 describes the outcome of applying the different parameters.

Table 4: Diving and threshold impact

Divers per season	Number of active diving days	Divers per day	Divers per hour
1767	32	55	9.2

Free entry of divers into the sharks' area will result in an average number of divers 12% higher than the threshold level. Taking the average of the two models, we get an annual value for shark appearances of ILS 4.5 million. Assuming a linear relation between the number of divers and the number of visitors, the change in active divers is 0.29 of the change in beach tourists (based on the average change in number of tourists between the two models). Hence, restricting the number of divers to an average of 8 per hour will result in a touristic welfare loss of ILS 0.157 (0.29 × 0.12 × 4.5) million.

Discussion

This study provides insight into some of the touristic benefits and costs that apperence of sharks can provide. This knowledge can be used as a tool to improve our managerial abilities to control for a balanced weigh between tourism and other ecosystem services (e.g., Fleischer & Tsur, 2003; Ghermandi & Nunes, 2013). The idea is a general one but specific analysys should be carried for different species since the rarer the species, the higher is its conservation value (Festa-Bianchet, 2012). Anna and Saputra (2017) found the annual value of whale shark tourism in a national park in Indonesia to be IDR 142.35 billion per year, or ILS 36.89 million (using tourist data from 2015). Other studies have found annual benefits from ILS 26.6 million to ILS 32.9 million (Cagua et al. 2014). These estimates are based on 72,000–78,000 tourists doing whale shark excursions annually. In our case study, the total number of visitors to the two beaches if we assume sharks are visible at Ashkelon is 66,520. But these visitors go to the beach for other purposes as well.

[18] In the winter, the best time to dive is before 4 pm; after that, there is not enough light under the water. Most diving clubs prefer the early morning for diving preparations—equipment, diver instructions, etc. (https://www.snorkelingonline.com/pages/best-time-of-day-to-go-snorkeling).

We demonstrate here also the applicability of the CB method to analyse such changes. The signs of the parameters are as expected. Also, visitor behaviour indicates an impact of cost on number of trips taken and an effect of shark visibility on visit frequency. Both coefficients have policy implications, with respect to investment in shark observation on the one hand and actions to prevent visitor overcrowding on the other hand.

This study is a first approach toward economic analysis of tourism benefits from an endangered species, where tourism demand is currently rising and may have negative effects on the species. The estimated consumer surplus of recreation in Hadera, where sharks are observable, is ILS 4.14–4.85 million per season. Further, the appearance of sharks changed the individual consumer surplus by 25% and 37% for the independent and pooled models, respectively. Since this is a unique and new phenomenon in Israel, it is hard to compare that to other case studies, but a 30% increase because of one natural attribute is a significant effect.

Our results suggest that considerable recreational benefits could be generated by a shark observation option and may provide another perspective on using economic benefits as a reason for conservation (Hussain & Tschirhart, 2013; Minin et al., 2013). However, considerable additional research is necessary before these values can be used to justify additional investments, given the risk of crowding and its impact on the sharks.

The dusky shark (*C. obscurus*) and the sandbar shark (*C. plumbeus*) are in the group of marine animals who are experiencing the greatest impact of anthropogenic influence on the sea (Payne et al. 2015). It can be assumed that each encounter of the shark with divers causes an escape reaction. In the presence of divers, the sharks' energy cost increases. First, these sharks are relatively large (*C. obscurus,* 3.5–4.2 m long; C. *plumbeus,* 2.2–2.8 m long), and the estimated cost of swimming in a curved path versus a straight line increases with body mass by 0.8–19.9% (Webb 2002, Dowd et al. 2006). Thus, divers cause the sharks to use energy they might not be able to spare. Second, the water temperature increases towards the end of the season, causing a significant increase in metabolic and heart rates, and recovering from stress may take 6–10 h (Dowd et al. 2006) when the stress is significant and encounters with disturbing factors (divers) are frequent.

Thus, conflicts between shark conservation and potential tourism increase are of particular interest. Following Cisneros-Montemayor et al. (2013), Gallagher et al. (2015), Macdonald et al. (2017), Raudino et al. (2016), and Sorice et al. (2003, 2006), our analysis indicates a touristic welfare loss of ILS 0.157 million per season to keep shark disturbance to a sustainable level and may raise a call for a long-term resolution of this human–wildlife conflict (Dickman, 2010). One example solution would be a dynamic marine protected area, i.e., to close the area to fishing (Chae et. al 2012; Hausmann et al. 2017; Mwebaze and MacLeod, 2013; Shiffman and Hammerschlag, 2016) or diving at specific times.

Another solution may be to limit shark observation to certain places. This could have the benefit of keeping sharks free of touristic interaction; the risk is that the area where observation is allowed could become overcrowded. Whether the total combined benefits would increase, or decrease requires further consideration.

Conclusions

We used an individual count model as well as combined pooled contingent behaviour to assess the value of shark tourism in two locations in Israel: Hadera, where sharks are observable, and Ashkelon, where sharks are present but not observable. The economic value of a site with sharks is about ILS 4.1 million in each location. Currently, consumer surplus for Hadera, where sharks are observable, is higher.

People diving alongside the sharks may harm the population, since about 12% more people are doing it than the frequency thought to be sustainable (not having an impact on the sharks' behaviour). We estimate that restricting diving frequency would have an impact of ILS 0.157 million per season. This may seem a modest amount (3% of the total recreational value), but it relates only to diving. An emerging tourism industry that includes kayaking, motor boats, etc. could increase this value very rapidly.

The potential combination of shark tourism and the newly observed shark aggregations raises two important questions. The first is about the effect of this anthropogenic interference on sharks. The second question is about the impact of regulated shark tourism. To answer the first question, an extended ecological-biological analysis will be needed. But the answer to the second question may be found in this manuscript. Different levels of recreation intensity (visitors on the beach, divers, swimmers, etc.) have different effects on the sharks' fitness and different economic value. This may form the basis for zoning for different activities, on a range from passive tourism (observing the sharks from a distance) to active engagement (diving with them).

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Alternative forms of sustainable development: The case of thermal tourism

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Abstract
Thermal tourism is a special form of providing tourist services at special facilities that use recognized thermal natural resources. Thermal tourism blooms in Europe with pioneer country Germany. There are 1,400 developed bathing sites in Europe, visited by millions of patients from all over the world. This industry employs about 750,000 people and has an annual turnover of approximately 45 billion euros.
In Greece, thermal tourism is an important part of our cultural heritage and not only because Greece is one of the richest countries in natural sources with excellent quality water. Despite the fact that Greece is the first country in Europe in the quality and uniqueness of natural thermal resources, its thermal tourism is declining. Furthermore, in this article, efforts will be made to identify the causes that contribute to the reduction of thermal tourism, as well as to draw some conclusions with a view to improving and sustaining the thermal tourism.

Keywords: alternative tourism, thermal tourism, sustainable development.

JEL Codes: Q01, Z32.

Εναλλακτικές μορφές βιώσιμης ανάπτυξης: Η περίπτωση του ιαματικού τουρισμού

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Περίληψη
Ο ιαματικός τουρισμός αποτελεί μια ειδική μορφή παροχής τουριστικών υπηρεσιών σε ειδικές εγκαταστάσεις, οι οποίες χρησιμοποιούν αναγνωρισμένους ιαματικούς φυσικούς πόρους. Ο ιαματικός τουρισμός ανθίζει στην Ευρώπη με πρωτοπόρο την Γερμανία. Στην Ευρώπη υπάρχουν 1.400 αναπτυγμένες λουτροπόλεις, τις οποίες επισκέπτονται εκατομμύρια ασθενείς απ' όλο τον κόσμο. Ο κλάδος απασχολεί περίπου 750.000 άτομα και έχει ετήσιο κύκλο εργασιών περίπου 45 δισ. ευρώ.
Στην Ελλάδα, ο ιαματικός τουρισμός αποτελεί σημαντικό τμήμα της πολιτιστικής της κληρονομιάς και όχι μόνο, καθώς είναι μία από τις πλουσιότερες χώρες σε φυσικές πηγές με εξαιρετική ποιότητα νερών. Παρά το γεγονός ότι η Ελλάδα είναι η πρώτη χώρα στην Ευρώπη σε ποιότητα και μοναδικότητα των ιαματικών φυσικών πόρων, ο ιαματικός τουρισμός της παρουσιάζει φθίνουσα

πορεία. Τέλος, στο συγκεκριμένο άρθρο, θα γίνουν προσπάθειες για τον εντοπισμό των αιτίων, που συμβάλλουν στην μείωση του ιαματικού τουρισμού, καθώς και την εξαγωγή κάποιων συμπερασμάτων με σκοπό τη βελτίωση και τη βιωσιμότητα του ιαματικού τουρισμού.

Λέξεις κλειδιά: εναλλακτικός τουρισμός, ιαματικός τουρισμός, βιώσιμη ανάπτυξη.

JEL Κωδικοί: Q01, Z32.

Εισαγωγικές έννοιες

Ο τουρισμός είναι από τις μεγαλύτερες και κυριότερες (εάν όχι η κυριότερη) πηγές εσόδων για την χώρα μας. Μπορεί η κύρια αξιοποίησή του να έχει ξεκινήσει, τα τελευταία 60 περίπου χρόνια, όμως εμφανίζεται από τα αρχαία χρόνια. Ίσως όχι με τη σημερινή κερδοσκοπική έννοια, καθώς τότε απευθυνόταν σε ανθρώπους ευπόρων οικογενειών, οι οποίοι είχαν την όρεξη και την περιέργεια να εξερευνήσουν νέα μέρη. Σπουδαίες φυσιογνωμίες της ελληνικής ιστορίας, όπως ο ιστορικός Ηρόδοτος αποτέλεσαν με τα ταξίδια τους, τους πρώτους τουρίστες (Τάσιος, 2013: 5).

Η λέξη τουρισμός προέρχεται από την αγγλική λέξη tour (γύρος) και την γαλλική λέξη tourisme (περιήγηση) (Καραγιάννης και Έξαρχος, 2006: 39). Σύμφωνα με τον Παγκόσμιο Οργανισμό Τουρισμού (ΠΟΤ-UNWTO), ο τουρισμός περιλαμβάνει τις δραστηριότητες των ανθρώπων που ταξιδεύουν και διαμένουν σε προορισμούς και περιοχές άλλες, εκτός από αυτές που αποτελούν το συνηθισμένο περιβάλλον τους (π.χ. τον τόπο της μόνιμης κατοικίας τους) και για χρονικό διάστημα που δεν ξεπερνά τον έναν χρόνο, με σκοπό την αναψυχή, την ικανοποίηση των επαγγελματικών τους αναγκών κ.ά.. Αυτός ο ορισμός βοηθά στον εντοπισμό της τουριστικής δραστηριότητας τόσο σε εγχώριο όσο και σε διεθνές επίπεδο (Delitheou and Georgakopoulou, 2017: 174).

Ο τουρισμός χωρίζεται σε δυο κύριες κατηγορίες, το μαζικό τουρισμό και τον εναλλακτικό τουρισμό. Ο μαζικός τουρισμός αναφέρεται στην δραστηριότητα των πολλών και διαφόρων ατόμων, δηλαδή τουρισμός των ευρύτερων κοινωνικών στρωμάτων και τάξεων. Ο εναλλακτικός τουρισμός ορίζεται ως οι μορφές τουρισμού, που είναι συμβατές με τις περιβαλλοντικές και τις κοινωνικές αξίες της περιοχής και οι οποίες επιτρέπουν τόσο στην κοινωνία υποδοχής, όσο και στους επισκέπτες, να απολαμβάνουν μια θετική και αξιόλογη αλληλεπίδραση και κοινές εμπειρίες, σε όλα τα επίπεδα: κοινωνικό, οικονομικό, πολιτιστικό και περιβαλλοντικό (Karagianni et al., 2018).

Μία από τις εναλλακτικές μορφές τουρισμού είναι ο τουρισμός υγείας. Ως τουρισμός υγείας, ορίζεται ο τουρισμός όπου οι τουρίστες συμμετέχουν σε προγράμματα υγείας ή σε προγράμματα που σχετίζονται με την υγεία. Αυτός περιλαμβάνει εναλλακτικές μορφές τουρισμού, οι οποίες είναι ο θεραπευτικός τουρισμός, ο ιαματικός τουρισμός, ο τουρισμός φυσιοθεραπείας, ο τουρισμός υγιεινής διαβίωσης, ο τουρισμός ομορφιάς και ο θερμαλισμός ή θερμαλιστικός τουρισμός (Δεληθέου κ.ά., 2016: 4).

Ο ιαματικός τουρισμός αποτελεί μια ειδική μορφή παροχής τουριστικών υπηρεσιών σε περιοχές των οποίων κύριο χαρακτηριστικό αποτελεί η χρήση αναγνωρισμένων ιαματικών φυσικών πόρων σε ειδικές εγκαταστάσεις (ΦΕΚ Α΄ 230, 2006: 2547). Ο ιαματικός τουρισμός σχετίζεται με τις επισκέψεις τουριστών σε χώρους που έχουν ως σκοπό την ίαση διαφόρων παθήσεων (π.χ. αντικαπνιστική θεραπεία, θεραπεία άγχους, ψυχοθεραπεία, κινησιοθεραπεία, χαλάρωση, διαιτητική, αισθητικής κ.ά.) καθώς επίσης την αναψυχή και την αναζωογόνηση ψυχής και σώματος. Είναι ιδανική επιλογή για όσους αναζητούν χαλάρωση και ευεξία αλλά και για όσους θέλουν να βοηθηθούν να απαλλαγούν από σωματικά προβλήματα που τυχόν να έχουν (Στραταριδάκης και Γρηγοριάδη, 2010: 10).

Ο ιαματικός τουρισμός στην Ευρώπη

Ο κλάδος του ιαματικού τουρισμού αναπτύσσεται παγκοσμίως με ταχύτερο ρυθμό σε σχέση με κάθε άλλη εποχή. Σε παγκόσμιο επίπεδο, τα ταξίδια που έχουν ως στόχο τον τουρισμό υγείας, ευεξίας και αναζωογόνησης υπολογίζονται στα 5 εκατομμύρια ετησίως. Σύμφωνα με την Ευρωπαϊκή Επιτροπή Παρακολούθησης Τουρισμού (European Travel Monitor) οι διακοπές και μετακινήσεις για λόγους υγείας και ευεξίας ξεπερνούν το 15% του συνόλου των τουριστικών μετακινήσεων του πληθυσμού της Ευρώπης (Τουφεγγοπούλου, 2008: 54).
Πολλά οργανωμένα κέντρα λειτουργούν σήμερα στην Κεντρική Ευρώπη και συγκεκριμένα στην Γερμανία, Ιταλία, Γαλλία, Ελβετία, Αυστρία και λιγότερο στο Βέλγιο, Ισπανία, Πορτογαλία, Ελλάδα, Ολλανδία, Φιλανδία, Σουηδία. Επίσης λειτουργούν πολλά κέντρα σε χώρες της Ανατολικής Ευρώπης, όπου ο ιαματικός τουρισμός αποτελεί σημαντικό κομμάτι της οικονομίας τους π.χ. Ουγγαρία, Τσεχία, Σλοβακία, Ρουμανία, Ρωσία, Γιουγκοσλαβία, Βουλγαρία. Η Γερμανία, η Ιταλία και η Γαλλία είναι οι κυριότεροι προορισμοί θερμαλισμού στην Ευρώπη, και, επιπλέον, ο θερμαλισμός ανθίζει στην Αυστρία και Βουλγαρία (Γρηγοριάδου, 2009: 13).
Στην Γερμανία λειτουργούν περίπου 250 κέντρα ιαματικού τουρισμού με 50 εκατομμύρια διανυκτερεύσεις. Στη συγκεκριμένη χώρα, στον κλάδο του ιαματικού τουρισμού, απασχολούνται περίπου 350.000 εργαζόμενοι, ενώ τα παραγόμενα ετήσια έσοδα υπολογίζονται περίπου στα 26 δισ. ευρώ.
Στην Γαλλία λειτουργούν γύρω στα 70 κέντρα θερμαλισμού, από τα οποία τα 50 έχουν ειδίκευση στη θαλασσοθεραπεία. Η χώρα προωθεί τον κλάδο χρησιμοποιώντας υψηλής τεχνολογίας εξοπλισμό, άρτια εκπαιδευόμενο προσωπικό και εξατομικευμένες θεραπείες στις εγκαταστάσεις της. Το ποσοστό του πληθυσμού που επισκέπτεται τα κέντρα δεν υπερβαίνει το 1-2%, ενώ οι ξένοι αποτελούν μικρό ποσοστό στο σύνολο των λουόμενων.
Η Ελβετία είναι σημαντικός ιαματικός προορισμός, λόγω της γεωγραφικής της θέσης και του οικονομικού και αναπτυξιακού επιπέδου της. Ακόμη, η υψηλή ανταγωνιστικότητά της οφείλεται στις παρεχόμενες υποδομές και στον έλεγχο που ασκούν οι κρατικοί φορείς μέσα από ένα οργανωτικό πλαίσιο.
Στην Αυστρία δραστηριοποιούνται 28 ιαματικά κέντρα, τα οποία προσελκύουν περίπου 6,7 εκατομμύρια επισκέπτες κάθε χρόνο, ενώ στη Βουλγαρία υπάρχουν 500 ιαματικές πηγές, λειτουργούν όμως μόνο 45 σύγχρονες εγκαταστάσεις ιαματικού τουρισμού, όπου γύρω από αυτά τα κέντρα διατίθενται αρκετά εκσυγχρονισμένα καταλύματα (Καλόσακα, 2013: 32).
Εξαιτίας της αναγκαστικής παραμονής των επισκεπτών για ορισμένο χρονικό διάστημα στα κέντρα του ιαματικού τουρισμού (π.χ. 21 ημέρες στη Γαλλία, 21-28 ημέρες στη Γερμανία, 12-18 ημέρες στην Ιταλία) απαιτείται η δημιουργία όχι μόνο της κατάλληλης ατμόσφαιρας για χαλάρωση και αναζωογόνηση του οργανισμού αλλά και άλλων δραστηριοτήτων και τρόπων έλξης των τουριστών, που θα τους απασχολούν κατά τις ελεύθερες ώρες (Ζαφειράκη, 2008: 80).
Τα πακέτα διακοπών προορισμού σε αυτά τα κέντρα συνδυάζονται λοιπόν τις περισσότερες φορές και με προσφορά άλλων τουριστικών υπηρεσιών αναψυχής, αναζωογόνησης, σπορ (σκι, ιστιοπλοΐα, ιππασία, τένις κ.ά.) και πολιτιστικών δραστηριοτήτων της υψηλής κοινωνικής ζωής (θέατρο, μουσική κ.ά.), καθώς απευθύνονται όχι μόνο σε ασθενείς, αλλά και στους συνοδούς ασθενών, και σε άλλους επισκέπτες συνήθως ανώτερου εισοδηματικού επιπέδου. Εξάλλου, απαιτείται η μακρά παραμονή των ατόμων σε αυτά τα θέρετρα προκειμένου να φανούν τα αποτελέσματα μιας ορισμένης θεραπείας στην οποία υποβάλλονται, ιδίως αν πρόκειται για ειδικές θεραπείες (θεραπεία του άγχους, κινησιοθεραπεία, χαλάρωση, αισθητικής κ.ά.) (Καλλιλά και Βεργέτη, 2009: 31).

Στην Ευρώπη δραστηριοποιούνται πολλοί φορείς για τον ιαματικό τουρισμό. Οι σημαντικότεροι φορείς είναι η Ευρωπαϊκή Επιστημονική Επιτροπή Θερμαλισμού (E.S.C.O.T) και ο Ευρωπαϊκός Σύνδεσμος Spa (European Spas Association- ESPA). Η Ευρωπαϊκή Επιστημονική Επιτροπή Θερμαλισμού (E.S.C.O.T.) είναι μία μη κυβερνητική και μη κερδοσκοπική Επιτροπή. Κύρια αποστολή της είναι η προώθηση, ο συντονισμός και η τυποποίηση της επιστημονικής έρευνας των θερμών πηγών σχετικά με τις τρείς βασικές πτυχές, που είναι η πρόληψη, η περίθαλψη και η αποκατάσταση. Ακόμα, η Επιτροπή δημιουργήθηκε για να αποτελεί κοινό forum για τη μελέτη και την υλοποίηση έργων, προγραμμάτων, προτάσεων, ερευνών, συνεδρίων και πρωτοβουλιών σχετικά με το θερμαλισμό, με στόχο να αποτελεί έναν έγκυρο και προνομιούχο συνομιλητή με τις εθνικές αρχές, με κάθε κράτος- μέλος της E.S.C.O.T. στην Ευρώπη και με τα Ευρωπαϊκά θεσμικά όργανα (Αγγελίδης, χ.χ.: 68).

Ο Ευρωπαϊκός Σύνδεσμος Spa είναι ένας οργανισμός-ομπρέλα, που εκπροσωπεί 20 ευρωπαϊκές χώρες, δηλαδή αντιπροσωπεύει πάνω από 1.400 ιαματικά λουτρά και κέντρα υγείας, καθώς και εγκαταστάσεις για τη θεραπεία, την πρόληψη και την αποκατάσταση των τουριστών υγείας στην Ευρώπη. Η σχετική ευρωπαϊκή αγορά περιέχει περίπου 12.000 εγκαταστάσεις. Ο κλάδος απασχολεί άμεσα και έμμεσα περίπου 750.000 άτομα και έχει ετήσιο κύκλο εργασιών περίπου 45 δισ. ευρώ (Διαθέσιμο: http://www.espa-ehv.eu/media/130/File/ESPA_Brochure/ESPA-Brochue_Out2014.pdf). Ο στόχος του είναι να προωθήσει τα ιαματικά λουτρά και τη λουτροθεραπεία στην Ευρώπη και να μεριμνήσει ώστε οι φυσικές θεραπείες να γίνονται με βάση ιαματικά νερά (Διαθέσιμο: http://www.europeanspas.eu). Οι συνεργασίες και επιτροπές μάρκετινγκ του ESPA περιλαμβάνουν: α) Συνεργασία Λουτροπόλεων της Βαλτικής Θάλασσας (BSSC - Baltic Sea Spas Co-operation), που έχει ως μέλη την Εσθονία, την Πολωνία και την Γερμανία β) Κέντρο Αρμοδιοτήτων Ευρωπαϊκών Λουτροπόλεων (ESCC - European Spas Competence Centre), όπου συνεργάζονται ανεξάρτητες εταιρείες από την Αυστρία, Γερμανία και Ελβετία γ) Δίκτυο Κλασσικών Φυσικών Θεραπειών (Network of Classical Natural Cures) δ) Βασιλικές Λουτροπόλεις της Ευρώπης (Royal Spas of Europe), η οποία περιλαμβάνει ιστορικές πρώην βασιλικές Λουτροπόλεις στην Ευρώπη ε) Το Ευρωπαϊκό Κοινοβουλευτικό Συμβουλευτικό Συμβούλιο (EPAC - The European Parliamentary Advisory Council) ιδρύθηκε στις 2 Ιουνίου 2000 και έχει ως στόχο να προωθήσει τα συμφέροντα των Ευρωπαϊκών λουτροπόλεων σε τοπικό, εθνικό και ευρωπαϊκό επίπεδο (Μαρή, 2007: 43).

Σύμφωνα με την Οδηγία 2011/24/ΕΕ όλα τα κράτη-μέλη της Ευρωπαϊκής Ένωσης μπορούν να αναγνωρίσουν τον ιαματικό τουρισμό ως μια ειδική μορφή του ιατρικού τουρισμού. Μέσω της Οδηγίας αυτής, τα κράτη-μέλη πρέπει να ανταποκρίνονται στις ευρωπαϊκές ποιοτικές προδιαγραφές, βάσει των οποίων δίδεται το σήμα και η πιστοποίηση των πηγών με γνώμονα την αξιολόγηση της υγειονομικής περίθαλψης, της αξιοποίησης του θερμαλισμού και των πηγών. Επιπλέον, η Οδηγία επισημαίνει για την διασυνοριακή υγειονομική περίθαλψη, ότι οι Ευρωπαίοι μπορούν να επιλέγουν την ιαματική πηγή της επιλογής τους σε οποιαδήποτε ευρωπαϊκή χώρα και τα έξοδα θα τα καλύπτει ο ασφαλιστικός φορέας στον οποίο υπάγονται. Με αυτόν τον τρόπο, ανοίγει ο δρόμος συνεργασίας μεταξύ αλλοδαπών και ημεδαπών ασφαλιστικών φορέων, γεγονός που βοηθά στην προσέλευση περισσότερων επισκεπτών που επιθυμούν να έλθουν για θεραπευτικούς στη χώρα μας με αποτέλεσμα την υψηλότερη οικονομική απόδοση (Διαθέσιμο: http://www.touristiki-agora.gr/article.asp?ID=4127).

Ο ιαματικός τουρισμός στην Ελλάδα

Η Ελλάδα, λόγω της γεωγραφικής της θέσης και της γεωλογικής της δομής, διαθέτει μεγάλο αριθμό ιαματικών πηγών. Σύμφωνα με στοιχεία του Ινστιτούτου Γεωλογικών και Μεταλλευτικών Ερευνών

(ΙΓΜΕ) υπάρχουν καταγραμμένες 822 ιαματικές πηγές. Από το σύνολο των 822 πηγών, οι 752 μπορούν να αξιοποιηθούν, ενώ σήμερα χρησιμοποιούνται -σε μεγάλο ή μικρό βαθμό- οι 348 (δηλαδή το 42%). Τα λουτρά και τα ιαματικά νερά είναι διασκορπισμένα σ' όλη τη χώρα, γύρω από την παράκτια περιοχή, στο εσωτερικό, αλλά και στα νησιά του Αιγαίου. Οι περισσότερες πηγές βρίσκονται στα νησιά και είναι 229, ακολουθεί η Στερεά Ελλάδα με 156, η Μακεδονία με 115, η Πελοπόννησος με 114, η Θεσσαλία με 57, η Ήπειρος με 56 και η Θράκη με 25 (Δεληθέου κ.ά., 2016: 8).

Στον Πίνακα 1, που ακολουθεί, παρουσιάζεται η κατανομή των μονάδων κατά Περιφέρεια και Φορέα εκμετάλλευσης για τα έτη 2010-2015. Το σύνολο των μονάδων που υπάρχουν στην Ελλάδα είναι 82, όπου οι 38 είναι δημοτικές επιχειρήσεις, οι 37 είναι ιδιωτικές επιχειρήσεις και μονό 7 ανήκουν στην Εταιρεία Τουριστικής Ανάπτυξης Α.Ε.. Ακόμα παρατηρείται ότι η Περιφέρεια με τις περισσότερες ιαματικές μονάδες είναι η Στερεά Ελλάδα με 29 μονάδες, ακολουθούν οι Περιφέρειες της Δυτικής Ελλάδας και του Βορείου Αιγαίου με 11 μονάδες η κάθε μία, ενώ οι Περιφέρειες που δεν έχουν καμία μονάδα είναι τα Ιόνια Νησιά και η Κρήτη. Το 2015, στην Ελλάδα λειτουργούσαν μόνο οι 55 λουτρικές μονάδες.

Πίνακας 1: Υπαρκτές Λουτρικές Μονάδες κατά Περιφέρεια και Φορέα εκμετάλλευσης

Περιφέρεια	Υπαρκτές Λουτρικές Μονάδες			
	Δημοτική Επιχείρηση	Ε.Τ.Α.	Ιδιωτική Επιχείρηση	Σύνολο Υπαρκτών Μονάδων
1. Ανατολική Μακεδονία- Θράκη	6	-	-	6
2. Κεντρική Μακεδονία	6	1	1	8
3. Δυτική Μακεδονία	2	-	-	2
4. Ήπειρος	3	-	1	4
5. Θεσσαλία	2	-	-	2
6. Ιόνια Νησιά	-	-	-	-
7. Δυτική Ελλάδα	8	1	2	11
8. Στερεά Ελλάδα	-	3	26	29
Εκ των οποίων: Ιδιωτικές Επιχειρήσεις Αιδηψού με πηγή	-	-	7	-
Ιδιωτικές Επιχειρήσεις Αιδηψού με παροχή νερού από τον Ε.Ο.Τ.	-	-	17	-
9. Αττική	-	-	3	3
10. Πελοπόννησος	1	1	-	2
11. Βόρειο Αιγαίου	8	-	3	11
12. Νότιο Αιγαίου	2	1	1	4
13. Κρήτη	-	-	-	-
ΣΥΝΟΛΟ	38	7	37	82

Πηγή: Ε.Κ.Κ.Ε., 2016, «Ιαματικές πηγές και λουτρότοποι», ιδία επεξεργασία.

Πίνακας 2: Σύνολο των εισιτηρίων στις λουτρικές μονάδες κατά Περιφέρεια για τα έτη 2011-2015

ΠΕΡΙΦΕΡΕΙΑ	ΕΙΣΙΤΗΡΙΑ ΑΝΑ ΕΤΟΣ					
	2011	**2012**	**2013**	**2014**	**2015**	**ΣΥΝΟΛΟ**
Ανατολική Μακεδονία- Θράκη	77.169	49.791	43.936	37.983	37.620	**246.499**
	4,87%	5,69%	4,99%	4,31%	4,26%	**4,83%**
Κεντρική Μακεδονία	616.746	440.054	447.786	463.434	450.910	**2.418.930**
	38,88%	50,26%	50,87%	52,60%	51,10%	**47,38%**
Δυτική Μακεδονία	4.505	1.264	2.162	1.624	2.094	**11.649**
	0,28%	0,14%	0,25%	0,18%	0,24%	**0,23%**
Ήπειρος	26.569	6.860	5.521	5.930	4.894	**49.774**
	1,68%	0,78%	0,63%	0,67%	0,55%	**0,97%**
Θεσσαλία	63.172	35.590	33.360	28.964	30.007	**191.093**
	3,98%	4,06%	3,79%	3,29%	3,40%	**3,74%**
Δυτική Ελλάδα	75.124	25.252	20.903	19.895	20.569	**161.743**
	4,74%	2,88%	2,37%	2,26%	2,33%	**3,18%**
Στερεά Ελλάδα	407.427	130.443	116.847	100.889	86.884	**842.490**
	25,69%	14,90%	13,28%	11,45%	9,84%	**16,5%**
Αττική	156.689	111.354	121.347	124.834	158.402	**672.626**
	9,88%	12,72%	13,79%	14,17%	17,95%	**13,2%**
Πελοπόννησος	68.439	29.276	27.036	36.600	38.138	**199.489**
	4,31%	3,34%	3,07%	4,15%	4,32%	**3,91%**
Βόρειο Αιγαίου	81.147	40.271	56.317	56.265	49.106	**283.106**
	5,12%	4,60%	6,40%	6,39%	5,56%	**5,55%**
Νότιο Αιγαίου	9.109	5.442	4.973	4.671	3.946	**28.141**
	0,57%	0,62%	0,56%	0,53%	0,45%	**0,55%**
ΣΥΝΟΛΟ	**1.586.096**	**875.597**	**880.188**	**881.090**	**882.570**	**5.105.541**

Πηγή: Ε.Κ.Κ.Ε., 2016, «Ιαματικές πηγές και λουτρότοποι», ιδία επεξεργασία.

Ο συνολικός αριθμός εισιτηρίων όλων των λουτρικών μονάδων αυξάνεται μεταξύ 2005-2009 κατά 17,3%. Κατά το 2010 εμφανίζεται πτώση 11% έναντι του 2009. Κατά το 2011 η υστέρηση έναντι του 2009 ανέρχεται σε 31,7%. Η πτωτική τάση είναι ακόμη σημαντικότερη κατά το 2012, οπότε και διαμορφώνεται στο 62,4% έναντι του 2009. Τα επόμενα χρόνια, 2013-2015, η εικόνα σταθεροποιείται σε αυτά τα χαμηλά επίπεδα. Έτσι, κατά το 2015 η μείωση έναντι του 2009 διαμορφώνεται στο 62,0% (Ε.Κ.Κ.Ε., 2016: 6). Η κατανομή των εισιτηρίων κατά Περιφέρεια σε συγκεντρωτική βάση για την πενταετία 2011-2015 (Πίνακας 2) εμφανίζει την Κεντρική Μακεδονία (47,38%) και τη Στερεά Ελλάδα (16,5%) να παρουσιάζουν την υψηλότερη κίνηση ιαματικού τουρισμού. Ακολουθούν η Περιφέρεια Αττικής και η Περιφέρεια Βορείου Αιγαίου με ποσοστό

13,2% και 5,55%, αντίστοιχα, ενώ την χαμηλότερη κίνηση ιαματικού τουρισμού παρουσιάζει η Περιφέρεια Δυτικής Μακεδονίας με ποσοστό 0,23%.

Η ζήτηση για τον ιαματικό τουρισμό στην Ελλάδα χαρακτηρίζεται από έντονη εποχικότητα, ιδίως στις μεγάλες λουτροπόλεις. Οι μικρές ιαματικές πηγές προτιμούνται περισσότερο από τον τοπικό πληθυσμό, ενώ τις μεγάλες λουτροπόλεις τις επισκέπτονται συνήθως άτομα από άλλα μέρη της Ελλάδας. Ο μέσος όρος παραμονής των ατόμων είναι γύρω στις 13-14 ημέρες δηλαδή περίπου ό,τι συμβαίνει στον υπόλοιπο τουρισμό. Όσον αφορά στην ηλικία και στο φύλο των λουομένων παρατηρείται συνήθως πως είναι άτομα τρίτης ηλικίας με τις γυναίκες να αποτελούν το μεγαλύτερο ποσοστό (60-65%). Η φθίνουσα πορεία του ιαματικού τουρισμού στην Ελλάδα οφείλεται κυρίως στον ανταγωνισμό που προέρχεται από το χώρο της φαρμακοβιομηχανίας, στην απροθυμία των γιατρών να αναγνωρίσουν την υδροθεραπεία ως ιατρική μέθοδο και στην έλλειψη της σχετικής διαφήμισης και πληροφόρησης του κοινού από τα μέσα ενημέρωσης (διαδίκτυο, τηλεόραση, ραδιόφωνο , εφημερίδες , περιοδικά κλπ.) τόσο στο εσωτερικό όσο και στο εξωτερικό (Κουσκούκης, χ.χ.). Ένας άλλος βασικός παράγοντας είναι η οικονομική κατάσταση της χώρας, η οποία δεν επιτρέπει στους γηγενείς επισκέπτες να διατηρήσουν το ρυθμό επισκέψεών τους στις λουτροπόλεις ή ακόμα και το χρόνο παραμονής τους σε αυτές. Επιπλέον, τα ασφαλιστικά ταμεία έχουν μειώσει τις δαπάνες ως προς τους ασθενείς, με αποτέλεσμα η επίσκεψή τους σε κάποια λουτρόπολη εκτός περιφέρειας να γίνεται όλο και δυσκολότερη (Φιλοπούλου, 2016: 49).

Στην Ελλάδα, ο ιαματικός τουρισμός διαχειρίζεται κυρίως από δύο μέρη: τον Ελληνικό Οργανισμό Τουρισμού (Ε.Ο.Τ.) και τους Οργανισμούς Τοπικής Αυτοδιοίκησης (Ο.Τ.Α.). Ο Ε.Ο.Τ. έχει την επιστασία των Ιαματικών Πηγών τουριστικής σημασίας και είναι ο Φορέας, που διαμορφώνει την κρατική πολιτική για τον Ιαματικό Τουρισμό (Γκάλβου, 2015: 85). Με τον νόμο 4254/2014 καταργήθηκε η Γενική Διεύθυνση Ανάπτυξης Ε.Ο.Τ. και οι Διευθύνσεις Μελετών και Επενδύσεων, Ποιοτικού Ελέγχου και Εποπτείας Αγοράς, Τουριστικών Εγκαταστάσεων, Επιθεώρησης και Συντονισμού Περιφερειακών Υπηρεσιών, οι δε μεταφερόμενες αρμοδιότητες από τον Ε.Ο.Τ. ασκούνται από οργανικές μονάδες του Υπουργείου Τουρισμού (Διαθέσιμο http://www.gnto.gov.gr/el/Τμήμα-Ιαματικών-Πηγών). Τον επιχειρηματικό ρόλο του Ε.Ο.Τ. έχει σήμερα αναλάβει η Εταιρεία Τουριστικής Ανάπτυξης Α.Ε. (Ν. 3270/2004) και έχει ως σκοπό την πλήρη αξιοποίηση όλης της ακίνητης περιουσίας του Ε.Ο.Τ. και φυσικά των ιαματικών πηγών (Βενετσανοπούλου, χ.χ.: 56).

Ο Σύνδεσμος Δήμων (και Κοινοτήτων) Ιαματικών Πηγών Ελλάδας (Σ.Δ.Ι.Π.Ε.) ιδρύθηκε το 1983, με σκοπό την προστασία, την αξιοποίηση και την εκμετάλλευση των Ιαματικών Φυσικών Πόρων, καθώς και τον εκσυγχρονισμό και τη βελτίωση των συνθηκών λειτουργίας των Λουτροπόλεων της χώρας. Το 1995, συμμετέχει στην ίδρυση του Ευρωπαϊκού Συνδέσμου Λουτροπόλεων (European Spas Association-ESPA), με έδρα τις Βρυξέλλες, κατέχοντας την β΄ Αντιπροεδρία του ESPA. Σήμερα με το Πρόγραμμα ΚΑΛΛΙΚΡΑΤΗΣ (Ν. 3852/2010) ο Σ.Δ.Ι.Π.Ε. αριθμεί 53 Δήμους - Μέλη, από 11 διοικητικές περιφέρειες της χώρας, ενώ δήμοι των περιφερειών Ιονίων Νήσων και Κρήτης είναι υποψήφια μέλη (Διαθέσιμο http://www.thermalsprings.gr/index.php/el/sundesmos/istoriko). Άλλος ένας φορέας διαχείρισης του Ιαματικού Τουρισμού στην Ελλάδα είναι η Διεύθυνση Υδατίνων Πόρων του Υπουργείου Βιομηχανίας, Έρευνας και Τεχνολογίας, που προωθεί και χρηματοδοτεί διάφορα προγράμματα έρευνας και ανάπτυξης του Ιαματικού Τουρισμού (Καραμολέγκου, 2011: 31).

Σύμφωνα με την απόφαση αναγνώρισης ιαματικών φυσικών πόρων είναι δυνατόν να λαμβάνονται ειδικά μέτρα για την προστασία τόσο της περιοχής στην οποία αναβλύζει ή αντλείται ο ιαματικός φυσικός πόρος, όσο και του υδροφόρου ορίζοντα, μετά από γνώμη της Επιτροπής Προστασίας Ιαματικών Φυσικών Πόρων και εισήγηση του Ε.Ο.Τ.. Σε περίπτωση που οι φυσικοί ιαματικοί πόροι εμπίπτουν σε κοινόχρηστους χώρους αιγιαλού παραλίας, αρμόδιος για την προστασία αυτών είναι ο Υπουργός Οικονομίας και Οικονομικών (ΦΕΚ Α΄ 230/24.10.2006).

Η συμβολή του ιαματικού τουρισμού στην βιώσιμη ανάπτυξη της χώρας

Η ανάπτυξη είναι μια δυναμική και συνεχής διαδικασία, που στοχεύει στην αύξηση του Α.Ε.Π. και μέσα απ' αυτή επιτυγχάνεται η βελτίωση της ευημερίας των πολιτών, η βελτίωση της κατοικίας, της υγείας, της παιδείας, της απασχόλησης, η διάσωση του περιβάλλοντος κ.ά.. Σύμφωνα με την Επιτροπή Brundtland, ως βιώσιμη ανάπτυξη ορίζεται η ανάπτυξη, που ικανοποιεί τις ανάγκες του παρόντος, δίχως να μειώνει την ικανότητα των μελλοντικών γενεών ανθρώπων να ικανοποιήσουν τις δικές τους (Γεωργακοπούλου, 2018: 39; Δεληθέου, 2018: 342).
Η τουριστική ανάπτυξη είναι μια διαδικασία μέσα από την οποία δημιουργούνται εγκαταστάσεις διαμονής τουριστών, οδικά δίκτυα πρόσβασης, ειδικότητες παροχής τουριστικών υπηρεσιών του πληθυσμού, προβάλλονται και διαφημίζονται τοπικά ενδιαφέρονται για τους τουρίστες (κλιματολογικά, περιβαλλοντολογικά, πολιτιστικά, ιστορικά) και συμπεριλαμβάνει τη συνεχή ανανέωση και τον εκσυγχρονισμό όλων αυτών. Με την έννοια βιώσιμη ανάπτυξη περιγράφεται ο τύπος της τουριστικής ανάπτυξης που δραστηριοποιείται ισόρροπα στην τοπική, κοινωνική, οικονομική, πολιτισμική και περιβαλλοντική δομή της κάθε τουριστικής περιοχής, διαμορφώνοντας παράλληλα όρους (υπηρεσίες, υποδομές, τεχνογνωσία) για τη συνεχή ανατροφοδότησή της (Delitheou and Georgakopoulou, 2017: 175).
Ο ιαματικός τουρισμός αποτελεί έναν από τους δυναμικότερους και ταχύτερα αναπτυσσόμενους τομείς της παγκόσμιας οικονομίας. Το σημαντικότερο πλεονέκτημα του ιαματικού τουρισμού είναι ότι μπορεί να αναπτύσσεται καθ' όλη τη διάρκεια του χρόνου. Αυτό, κατ' επέκταση, δημιουργεί "άνοιγμα" της τουριστικής περιόδου και δίνει λύση στο μεγάλο ζητούμενο, που είναι η άρση της εποχικότητας. Με τη διεύρυνση της τουριστικής περιόδου πέραν των θερινών μηνών κερδίζονται θέσεις εργασίας καθώς αυξάνεται η απασχόληση τόσο στον τουρισμό όσο και σε ευρύτατο φάσμα δραστηριοτήτων εμπλεκομένων με τον τουρισμό, δημιουργείται υπερδιπλάσια κατανάλωση στην υπόλοιπη οικονομία και αυξάνεται η συνεισφορά στο ΑΕΠ της χώρας μας (Πάλλης, 2013: 6).
Επίσης, ο ιαματικός τουρισμός δέχεται σχετικά υποδεέστερες «διεθνολογικές» επιδράσεις σε περιόδους κρίσεων και στρέφει μια γενικότερη κατηγορία του διεθνούς πληθυσμού στις φυσικές θεραπευτικές αγωγές συνδυάζοντας άμεσα τις διακοπές με ξεκούραση (relax). Τέλος, είναι μια εναλλακτική μορφή τουρισμού φιλική προς το περιβάλλον και υποστηρίζεται από πολλές πληθυσμιακές ομάδες, όπως οι πράσινοι, οικολόγοι κ.ά. (Βενετσανοπούλου, 2006: 245).

Συμπεράσματα- προτάσεις

Ο ιαματικός τουρισμός είναι μια από τις εναλλακτικές μορφές τουρισμού, η οποία συμβάλλει στην τοπική ανάπτυξη της περιοχής και κατ' επέκταση στην οικονομική ανάπτυξη της Ελλάδας, χωρίς να επιβαρύνεται σε μεγάλο βαθμό το περιβάλλον.
Ο ιαματικός τουρισμός αναπτύσσεται παγκοσμίως με ταχύτερο ρυθμό σε σχέση με κάθε άλλη εποχή. Όμως δεν συμβαίνει το ίδιο και στην Ελλάδα. Ο ιαματικός τουρισμός της χώρας μας έχει φθίνουσα πορεία, και αυτό οφείλεται κυρίως στην έλλειψη της σχετικής διαφήμισης και πληροφόρησης του κοινού από τα μέσα ενημέρωσης (διαδίκτυο, τηλεόραση, ραδιόφωνο, εφημερίδες, περιοδικά κλπ.), τόσο στο εσωτερικό όσο και στο εξωτερικό. Επομένως, για να επιτευχθεί η βελτίωση και η ανάπτυξη του ιαματικού τουρισμού στην χώρα μας, θα πρέπει κατ' αρχάς οι δημοτικές και οι ιδιωτικές επιχειρήσεις να ενημερώσουν το κοινό για τις θεραπευτικές ιδιότητες, που έχουν οι ιαματικοί πόροι της περιοχής και τους τρόπους με τους οποίους γίνεται η χρήση των πόρων αυτών.

Στις συγκεκριμένες περιοχές, που αναπτύσσεται ο ιαματικός τουρισμός, θα πρέπει να δημιουργηθούν κατάλληλες και εξελιγμένες εγκαταστάσεις και υποδομές ή να βελτιωθούν οι ήδη υπάρχουσες, κάτι που θα μπορούσε να επιτευχθεί με την συνεργασία του δημοσίου και του ιδιωτικού τομέα (ΣΔΙΤ). Ακόμα, θα πρέπει να αναπτυχτούν και άλλες δραστηριότητες στις περιοχές αυτές για να μπορούν να απασχολούνται στον ελεύθερό τους χρόνο και οι ασθενείς και οι συνοδοί τους.

Όλα τα αναφερθέντα θα έχουν ως αποτέλεσμα την αύξηση των επισκεπτών, την ενίσχυση της τοπικής οικονομίας της περιοχής, με την ταυτόχρονη δημιουργία θετικών εξωτερικοτήτων, και κατ' επέκταση την οικονομική ανάπτυξη της χώρας μας.

Επίσης, οι ιαματικές μονάδες θα πρέπει να διαθέτουν ικανό και εξειδικευμένο προσωπικό, ώστε να μπορούν να ανταπεξέλθουν στις απαιτήσεις των επισκεπτών. Οι δεξιότητες αυτές μπορούν να επιτευχθούν με τη συνεχή εκπαίδευση και κατάρτιση του εργατικού δυναμικού μέσα από διάφορα συνέδρια, εκπαιδευτικά προγράμματα, επισκέψεις σε ιαματικές μονάδες του εξωτερικού κ.ά.. Ακόμα ο ιαματικός τουρισμός είναι μια ειδική μορφή τουρισμού, η οποία προσελκύει τουρίστες υγείας όλον τον χρόνο και αυτός θα είναι ένας βασικός παράγοντας μείωσης της ανεργίας της περιοχής και της Ελλάδας, με παράλληλη συνέπεια τη μετατροπή της εποχιακής εργασίας σε μόνιμη.

Το κράτος για να μπορέσει να αναδείξει τη χώρα μας ως ιαματικό τουριστικό προορισμό θα πρέπει να χρηματοδοτήσει τις περιοχές αυτές, με στόχο τη βελτίωση των υπηρεσιών, την εκπαίδευση του προσωπικού και τη δημιουργία ή τη συντήρηση του οδικού δικτύου, με την απαραίτητη προϋπόθεση ότι το κράτος θα εποπτεύει αν γίνεται ορθή χρήση των διατιθέμενων πόρων. Ακόμα το κράτος σε συνεργασία με τους Ο.Τ.Α. των περιοχών αυτών θα πρέπει να δημιουργήσουν διαφημιστικά βίντεο μικρής διάρκειας, στα οποία θα παρουσιάζεται το φυσικό κάλλος, οι ιαματικές πηγές και οι ιαματικές μονάδες, καθώς και άλλες δραστηριότητες της κάθε περιοχής. Τα βίντεο θα προβάλλονται και στο εξωτερικό και στο εσωτερικό με σκοπό την αύξηση των επισκεπτών.

Τέλος, η χώρα μας για να προσελκύσει όσο το δυνατόν περισσότερους ξένους τουρίστες υγείας θα πρέπει να προσφέρει διάφορα πακέτα διακοπών σε προσιτές τιμές. Αν γίνουν πράξη όλα τα προαναφερθέντα, η Ελλάδα θα καταφέρει να γίνει ένας από τους σημαντικότερους ιαματικούς προορισμούς του κόσμου.

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Integrating sustainable supply chain management (SSCM) amongst Greek supermarkets

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Abstract
The retail supermarket sector has been affected by the recession experienced in recent years in Greece. That is why, supermarkets targeted to increase their performances, achieve reduction to operating costs employing sustainable supply chain management (SSCM). The purpose of the present paper is to analyze green logistics decisions within the retail supermarket sector by using economic, social, operational and environmental metrics. The research problem of this study is to examine the drivers that affect manager's perceptions on relation to sustainable supply chain management (SSCM), employing data from supermarket managers in Athens, Greece. Managers adopted several sustainable supply chain practices in order to increase the performance of the super market stores, such as material handling, waste management and reverse logistic. Results indicate that managers' decision to adopt green supply chain practices combined both environmental and economic criteria.

Keywords: Retail businesses, Supply chain management, Sustainability

JEL Classification: M59, Q01, Q55

Εφαρμογή βιώσιμης διαχείρισης εφοδιαστικής αλυσίδας (SSCM) στα ελληνικά σουπερ μάρκετ

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Περίληψη

Ο κλάδος των σουπερ μάρκετ λιανεμπορίου στην Ελλάδα έχει επηρεαστεί από την οικονομική ύφεση των τελευταίων ετών. Αυτό εξηγεί το γεγονός πως τα σούπερ μάρκετ στοχεύοντας στην αύξηση των αποδόσεών τους επιτυγχάνουν μείωση στα λειτουργικά κόστη τους χρησιμοποιώντας τη βιώσιμη διαχείριση εφοδιαστικής αλυσίδας (SSCM). Ο σκοπός της παρούσας μελέτης είναι να αναλύσει τις πράσινες αποφάσεις εφοδιαστικής αλυσίδας στην περίπτωση του κλάδο λιανεμπορίου των σούπερ μάρκετ λαμβάνοντας υπόψη οικονομικές, κοινωνικές, λειτουργικές και περιβαλλοντικές παραμέτρους. Σκοπός της συγκεκριμένης μελέτης είναι να διαπιστώσει τους παράγοντες οι οποίοι επηρεάζουν την αντίληψη των διευθυντικών στελεχών για την εφαρμογή της βιώσιμης διαχείρισης εφοδιαστικής αλυσίδας (SSCM), αποσπώντας δεδομένα από διευθυντικά στελέχη στην πόλη της Αθήνα, στην Ελλάδα. Οι διευθυντές δήλωσαν ότι υιοθέτησαν διάφορες βιώσιμες πρακτικές εφοδιαστικής αλυσίδας για να αυξήσουν τις αποδόσεις των καταστημάτων σούπερ μάρκετ, όπως είναι η επεξεργασία υλικών, η διαχείριση αποβλήτων και η ανάστροφη εφοδιαστική. Τα αποτελέσματα της μελέτης υποδηλώνουν ότι οι αποφάσεις των διευθυντών να υιοθετούν πρακτικές πράσινης εφοδιαστικής αλυσίδας διαμορφώνονται απο περιβαλλοντικά αλλά και οικονομικά κριτήρια.

Λέξεις Κλειδιά: Επιχειρήσεις λιανικού εμπορίου, εφοδιαστική αλυσίδα, βιωσιμότητα

JEL Κωδικοί: M59, Q01, Q55

1. Introduction

Under recession pressure the retail supermarket sector in Greece has realized the necessity of improving its performance, so as to reduce their operating costs and gain a market competitive advantage (Sari, 2012). One way to this direction is the implementation of eco-friendly supply chain management strategies. The orientation of green strategies is used as a direction for businesses to improve their performances by facilitating supply chain coordination and integrated product design, which increase environmental performance and as a consequence their business results (Hong et al., 2009). In this context, several studies have focused on the characteristics and the effects of the adoption of green supply chain management (GSCM). GSCM is considered to be an innovative field for the businesses (Liu Dan et al., 2010). In particular, GSCM is a strategic approach which associates with the expansion of environmental measures among the whole supply chain (Albino et al., 2009). It is characterized as a quality and time - based strategy that is adopted by the industrial sector and leads to a significant positive impact on business's performances (Laosi Rihongthong et al., 2013). Enterprises are subjected to a variety of stakeholder pressures related to their environmental performance. Within this context a more sophisticated supply chain management system has been launched, the so called sustainable supply chain management (SSCM). While GSCM is focused on environmental management excluding economic and social parameters, SSCM combines the triptych of environment, economy and society. Thus, SSCM is an extension of the GSCM (Ahi and Searcy, 2013 p. 339) which defines sustainable supply chain management (SSCM) as: "The creation of coordinated supply chains through the voluntary integration of economic, environmental and social considerations with key inter-organizational business systems designed to efficiently and effectively manage the material, information and capital flows associated with the procurement, production and distribution of products or services in order to meet stakeholder requirements and improve the profitability, competitiveness, and resilience of the organization over the short and long term". In reviewing the literature, researchers have focused their attention on the practices and motives that implement sustainable supply chain management, so as to benefit businesses' performance.

Taking the existing literature into consideration, the aim of this study is to re-evaluate previous research results regarding the motives adopted in the framework of sustainable supply chain management in the case of retail supermarket sector, in Greece. For that purpose, the rest of this paper is organized as follows: The next section presents the literature relevant to our research. The third section refers to the methodology developed to analyze managers' perspective towards sustainable supply chain management. The fourth section includes the results, while the last section presents the chapter's conclusions.

2. Literature Review

Several studies analyze the dimensions of the GSCM and their effect on companies' environmental performance (Zhu et al., 2005; Zhu et al., 2007; Holt and Ghobadian, 2009; Eltayeb et al., 2011; Laosi Rihongthong et al., 2013; Okemba et al., 2014; Chin et al., 2015; Diab and Abu-Rumman, 2015), the economic performance (Zhu et al., 2005; Zhu et al., 2007; Eltayeb et al., 2011; Laosi Rihongthong et al., 2013; Okemba et al., 2014; Chin et al., 2015; Diab and Abu-Rumman, 2015), the operational performance (Zhu et al., 2007; Eltayeb et al ., 2011; Diab and Abu-Rumman, 2015), as well as the social performance (Zhu et al., 2005; Laosi Rihongthong et al., 2013; Okemba et al., 2014; Chin et al., 2015). The outcomes of environmental performance are involved in both "GSCM" and "SSCM" strategies. Economic performance is as important as the environmental performance for the "GSCM" (Zhu et al., 2005). The operational performance refers to GSCM performance for the overall general operation of the enterprise (Eltayeb et al., 2011). In all cases, it is clear that both operational and economic performances are interrelated in order to achieve a positive environmental performance (Zavvar et al., 2016). The concept of intangible/ social performance refers to the GSCM outcome for enterprise's social image, including intangible results such as business and product image. Also, green decisions may be connected with GSCM performances (Ala – Harja and Helo, 2014). Thus, GSCM and SSCM are two closely associated concepts related to the supply chain management framework because sustainable performance strategies include companies' economic, environmental and social outcomes (Chin et al., 2015).

Companies adopt an array of external and internal practices in order to implement GSCM and SSCM (Holt and Ghobadian, 2009). The bulk of the literature distinguish the following ten GSCM/ SSCM categories of practices: (i) green purchases (Zhu et al., 2005; Holtand Ghobadian, 2009; Eltayeb et al., 2011; Laosi Rihongthong et al, 2013;), (ii) eco-design of products (Laosi Rihongthong et al., 2013; Diab et al., 2015), (iii) eco-design of package (Eltayeb et al., 2011; Laosi Rihongthong et al., 2013; Diab et al., 2015, Alperstedt et al., 2015), (iv) reverse logistics, (Eltayeb et al., 2011; Laosi Rihongthong et al., 2013; Alperstedt et al, 2015; Chin et al., 2015; Diab et al., 2015), (v) interior environmental management (Holt and Ghobadian, 2009), (vi) benchmarking and assessment of suppliers (Holt and Ghobadian, 2009), (vii) green procurement and logistics policy (Holt and Ghobadian, 2009), (viii) supplier education, guidance and consultancy (Holt and Ghobadian, 2009), (ix) industrial networks (Holt and Ghobadian, 2009), and (x) other practices that are not categorized in any other of the above categories, such as the existence of Environmental Management System schemes (Zhu et al., 2005; Zhu et al., 2007; Alperstedt et al., 2015; Diab et al., 2015). The most applied practices for the industrial sector are considered to be the eco-design of product and package followed by green purchases and reverse logistics (Eltayeb et al., 2011). There seems to be a gap between the GSCM practices awareness even through among companies that develop cooperation, such as industrial and logistics industries (Zavvar et al., 2016). However, a partnership for environment improvement can be suggested to be the moderator connecting GSCM practices and sustainability performances, which may entails a win - win situation among the

stakeholders (Liu et al., 2010). The existence of cooperation for environmental improvement among stakeholders may increase the adoption of GSCM practices (Liu, et al., 2010; Okemba and Namusonge, 2014; Thoo You Chin et al., 2015) and consequently increase business's performances (Diab et al., 2015).
Literature focusing on the implementation of green or sustainable supply chain management also examines the reasons behind the decisions to adopt such practices. These reasons may be characterized as drivers to GSCM and SSCM. The most important reason for SSCM implementation has been considered to be the "internal drivers" (Hauschildt and Schulze-Ehlersb, 2014) including CEO's commitment to improve company's environmental performance and the promotion of an environmental friendly organizational culture (Zhu et al., 2005; Holt and Ghobadian, 2009). Environmental legislation is considered as a key driver for the adoption of sustainable supply chain practices (Holt and Ghobadian, 2009; Zhu et al., 2005; Laosi Rihongthong et al., 2013). Achieving a competitive advantage and pressure from social stakeholders, such as suppliers, investors and customers, are also found to be a very important positive factor in the adoption of SSCM practices (Holt and Ghobadian, 2009). Financial effects such as reducing costs of disposal of hazardous materials and cost of environmentally friendly packages are critical drivers (Zhu et al., 2005). Lastly, moral reasons or political regulations are characterized as "sustainable drivers" (Hauschildt and Schulze-Ehlersb, 2014) that affect decisions towards GSCM/SSCM.

3. Methodological issues

3.1 Research questions

To evaluate GSCM/SSCM implementation amongst Greek supermarkets the following research structure is adopted (Fig. 1).

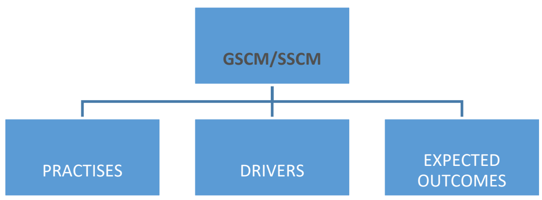

Figure 1: Research structure

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In particular, the target companies are initially asked to demonstrate a certain level of sustainable supply chain practices that have been implemented. In the next stage, managers are asked to choose the reasons (drivers) for implementing SSCM. Finally, managers are asked to report the expected outcomes for the supermarkets from the implementation of the SSCM practices.

3.2 Protocol and data

Given the purpose of our study a structured questionnaire is developed based on previous studies (see for example: Zhu et al., 2005; Holt and Ghobadian, 2009; Laosi Rihongthong et al., 2013; Hauschildt and Schulze-Ehlersb, 2014; Okemba and Namusonge, 2014; Diab et al., 2015). The questionnaire consists of four sections and includes 38 subcategories/questions. The first section presents managers' characteristics, the second section refers to the SSCM practices that supermarkets adopted, the third section reports potential motives to implement SSCM and the last section examines the expected outcomes (environmental, economic, organizational and social) from the implementation of SSCM. The target sample of the study was one hundred top managers who run supermarket stores and are responsible for implementing sustainable supply chain management practices in the store. Survey conducted in Attica, Greece and from the sample of 100 managers in question 30% responded in the questionnaire. The majority of supermarket managers was women (60%) and 40% men. The age of the respondents ranges from 26 to 47 years old (40% of the respondents was above 37 years old). Most respondents (63.3%) were heads of the management division and the rest 36.7% assistant managers. The majority of the managers were university educated 56.7% but only 6.7% of them had a master degree. Four out of ten managers had completed secondary education (43.3%). Managers had on average 8 years of managerial experience. The 30% of the sample mentioned that had been serving over ten years as a manager in the specific supermarket store. The number of employees per store ranged from 8 to 400 people. On average each supermarket employed 42 employees. Finally, 90% of the sampled supermarkets are ISO or EMAS certified.

4. Results

Table 1 indicates SSCM practices that managers adopt in their supermarkets. Findings show that the majority of sampled supermarkets (60%) tend to require that suppliers have ISO certified and comply with specific environmental criteria (46.7%). Only 26.6% of managers utilize life's cycle assessment to evaluate the environmental effects. Many of the respondents implement strategies that focus on the environmental attributes of their products. In particular, 63.3% of the managers check that their products are made from eco-friendly materials. However, a matter of medium (36.7 %) and low (36.7%) importance is the products' manufacture of reused or recycled materials. Contrary, 63.4% of managers tend to collect reusable packaging by customers for recycling and 63.3% return packaging to suppliers for recycling. However, 43.4% of respondents do not collect out-of-date products by customers for recycling purposes. Reduction of hazardous waste is a low (23.4%) and medium (40%) implemented practice. Package waste management is highly implemented by 60% of the sampled supermarkets and 57.6% adopt eco-friendly storage of products.

Many of the respondents intend to implement energy efficiency strategies. In particular, only 10% of the respondents do not adopt energy efficiency practices for lighting and heating of the supermarket and 80% tend to apply energy- efficient systems in their warehouses. The planning of transport routes to decrease energy consumption is a moderate (33.3%) or high implementation (43.3%) choice, whereas the purchase of less energy consuming vehicles is not preferred by 36.6% of the managers in question. Others claim that common strategies implemented within the store are paper recycling (63.4%) and printer inks recycling (73.3%). Four out of ten managers mention that their store is either member of a special corporate partnership that shares good practices or member of a "green" network that shares good environmental or ethical practices. Finally, 43.3% of managers focus on the employees' environmental education and training.

Table 1: Level of implementation of SSCM strategies in the supermarkets (%)

ACTIONS	LOW	MEDIUM	HIGH
Requiring suppliers to have ISO 14001 certified	20.0	20.0	60.0
Supplier comply with specific environmental criteria	33.3	20.0	46.7
Utilization of life's cycle assessment to evaluate the environmental effects	23.4	50.0	26.6
Check that the products are made from eco-friendly materials	13.3	30.3	63.3
Confirmation that products consists of reused or recycled materials	36.7	36.7	26.6
Collection of reusable packaging by customers for recycling	20.9	16.7	63.4

Confirmation that the package can be reused	22.3	36.7	40.0
Return of packaging to suppliers for recycling	16.7	20.0	63.3
Collection of out-of-date products by customers for recycling purposes	43.4	10.0	46.7
Reduction of hazardous materials	23.4	40.0	36.6
Package waste management	20.0	20.0	60.0
Eco-friendly storage of products	13.3	30.0	56.7
Energy efficiency systems for heating and lighting	10.0	40.3	46.7
Use of energy-efficient systems in warehouses	20.0	33.3	46.6
Planning of transport routes in order to decrease energy consumption	23.3	33.3	43.3
Vehicle purchase investment that is less energy consuming	36.6	33.3	30.0
Store is member of a special corporate partnership that shares good practices	23.4	46.3	33.4
Store is member of a general "green" network that shares good environmental or ethical practices	26.7	33.3	40.0
Recycling of printer inks	20.0	6.7	73.3
Paper recycling	10.0	26.7	63.4
Employees' environmental education and training	23.3	33.3	43.3

Next, perceived drivers to the implementation of SSCM are discussed. Table 2, illustrates the significance of various driving forces for the supermarkets sampled. More precisely, the promotion of a socially responsible business profile (63.3%), the managers' commitment (23.3%) and the expectations of the public (56.6%) are considered as important drivers to adopt SSCM. The respondents agree that environmental regulation (36.6%) and its strict enforcement (40%) are significant driving forces for implementing SSCM. However, 43.3% of the managers were neutral about the effect of legislation on the adoption of SSCM. A 40% of the managers are neutral to adopt SSCM due to stakeholders' pressure (including customers, suppliers, shareholders and investors). Half of the respondents (50%) consider ethical reasons to contribute to the environmental protection as an important motive to adopt environmental friendly actions. Finally, budgetary incentives are also considered good incentives for some supermarkets sampled. More precisely, managers at 55.4% believe that companies can improve business performance against competitors by adopting SSCM and achieve operating cost reductions. However, 40% were neutral about the economic effects of SSCM. Managers mention the reduction of costs by disposal of hazardous materials (43.4%), and by using environmentally friendly packages (56.6) as drivers for adopting SSCM.

Table 2. Perceived drivers to the implementation of SSCM strategies in the supermarkets (%)

Drivers	**DISAGREE**	**NEUTRAL**	**AGREE**
Current environmental legislation in Greece	20.0	43.3	36.6
The strict application of environmental legislation	16.7	43.3	40.0
The environmental culture of the business	16.6	36.7	46.7
The manager's commitment to improve the company's environmental performance	26.6	30.0	53.3

The promotion of a socially responsible business profile	10.0	26.7	63.3
The expectations of the public	16.6	26.7	56.6
Customers pressure for environmental friendly business culture	26.7	40.0	33.4
Pressure of suppliers of the products	33.3	40.0	26.7
The pressure from shareholders and investors	16.6	43.3	40.0
Ethical reasons to contribute to the environment protection	20.0	30.0	50.0
Improving business performance against competitors	6.6	40.0	53.3
The savings in the operating cost of the business	6.6	40.0	53.4
The costs reduction of disposal of hazardous materials	33.3	23.3	43.4
The reduction of cost from using environmentally friendly packages	16.7	26.7	56.6
Reduction of the safety and health risk	20.0	20.0	60.0

Finally, respondents at a 73.3% consider that the implementation of SSCM practices have important implications on the environmental performance of the firm. Half of the managers (53.3%) suggest that adoption of SSCM would also have a social impact on the company's performance. Economic and operational benefits of SSCM are characterized as less important with half of the managers in question to disagree or being neutral about their outcomes on the business performance (Fig. 2).

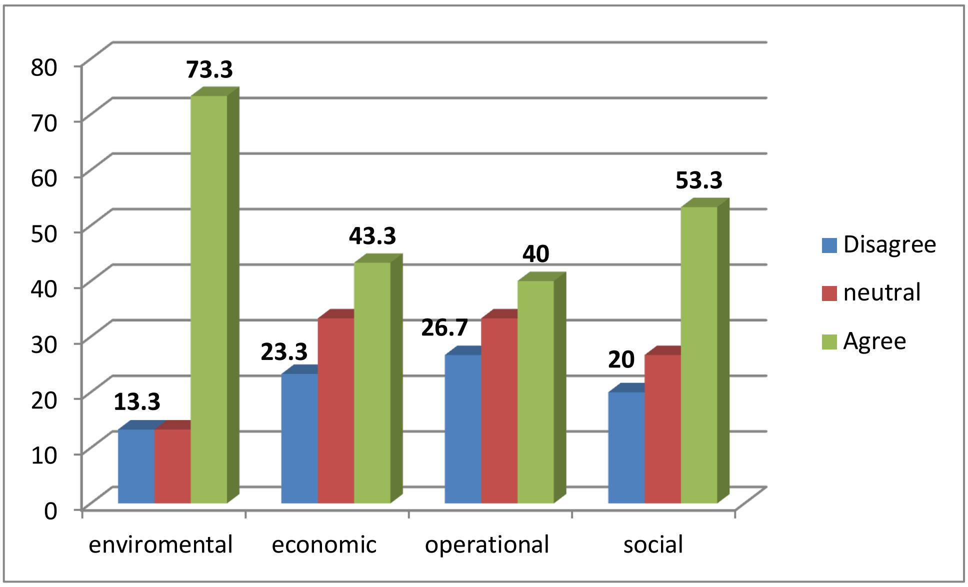

Figure 2: Expected outcomes on business's performance (%)

5. Conclusions

This study aims to reexamining managers' decision-making process with respect motives toward adopting SSCM, employing data from a sample of supermarkets in Athens, Greece. Results support that implementation of environmental legislation, achieving a competitive advantage from the promotion of corporate environmental image and financial effects (such as reducing costs of disposal of hazardous materials and rational use of resources and materials) are considered as key drivers for the adoption of sustainable supply chain practices within supermarkets. These results are in line with a couple of previous studies findings (see for e.g. Zhu et al., 2005; Holt and Ghobadian, 2009) hinting a stimulus in order to formulate a policy that aims to increase the implementation of SSCM strategy.

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Using carbon shadow pricing as a tool to drive de-carbonization of the Greek hotels operations

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Abstract

Nations regard tourism as a low-impact development option and massively invest in tourist-drawing infrastructure. However, recent research has shown that tourism is a carbon intensive activity, accounting for approximately 8% of global GHG emissions. The accommodation sector in particular accounts for approximately 20% of tourism emissions resulting from ventilation, heating, air-conditioning and facility operations, with data varying according to the location, type, size, occupancy and category of the establishments. The average carbon footprint of an overnight stay aggravates heavily if a life cycle perspective is used. The hospitality sector's target for carbon reduction to mitigate global warming and meet the Paris-set 2^{o} Celsius cap requires that hotels reduce their absolute carbon emissions by 66% by 2030 and by 90% by 2050, against a 2010 baseline. These figures are significant but technically achievable and required if the industry commits to decoupling its strong growth from emissions escalation. A number of actions, tools, and innovative approaches may be adopted by hotels to decarbonise their activities. Carbon internal - shadow-pricing is such a tool which, if effectively applied, will accelerate the available solutions. This paper suggests the use of internal - shadow pricing by Greek hotels as an instrument to appraise the sustainable profitability of a hotel project, de-risk business, identify energy inefficiencies, and incentivize low carbon innovation within departments; it also proposes a methodology on how to introduce an internal carbon price in the Greek hospitality domain and how to use this initiative to rationalize capital and operating decisions.

Keywords: Carbon emissions; hotel operations decarbonization; carbon internal pricing; carbon shadow pricing.

JEL Codes: O44; O47; O52; Q43; Q56.

Η χρήση της σκιώδους τιμολόγησης άνθρακα ως εργαλείου μείωσης του ανθρακικού αποτυπώματος των Ελληνικών ξενοδοχειακών επιχειρήσεων

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Περίληψη

Οι διάφορες χώρες αντιμετωπίζουν τον τουρισμό ως δραστηριότητα χαμηλής περιβαλλοντικής όχλησης και επενδύουν μαζικά σε τουριστικές υποδομές. Ωστόσο, πρόσφατες έρευνες έχουν αναδείξει ότι οι τουριστικες δραστηριότητες είναι εντάσεως άνθρακα, υπεύθυνες για σχεδόν το 8% της παγκόσμιας παραγωγής αερίων του θερμοκηπίου. Ο ξενοδοχειακός κλάδος ειδικά παράγει περίπου το 20% των τουριστικών εκπομπών από δραστηριότητες όπως ο εξαερισμός, η θέρμανση, η χρήση air-condition και η λειτουργία των διαφόρων ξενοδοχειακών εγκαταστάσεων. Το μέσο ανθρακικό αποτύπωμα μίας τουριστικής διανυκτέρευσης αυξάνεται σημαντικά αν εφαρμοσθεί η μέθοδος κύκλου ζωής κατά τη μέτρηση του. Ο στόχος του ξενοδοχειακού κλάδου για μείωση του άνθρακα προκειμένου να επιδιωχθεί ο μετριασμός της παγκόσμιας θέρμανσης και να επιτευχθεί ο στόχος του Παρισίου για όριο αύξησης 2^{o} Κελσίου απαιτεί από τις ξενοδοχειακές μονάδες να μειώσουν τις εκπομπές άνθρακα τους κατά 66% έως το 2030 και κατά 90% έως το 2050, με έτος βάσης το 2010 προκειμένου να αποδεσμεύσουν την ισχυρή αύξηση εργασιών του κλάδου από αντίστοιχη αύξηση των αέριων ρύπων του. Διάφορες δράσεις, εργαλεία και καινοτόμες προσεγγίσεις μπορούν να υιοθετηθούν από τα ξενοδοχεία για να μειώσουν το ανθρακικό τους αποτύπωμα. Η χρήση της εσωτερικής- σκιώδους τιμολόγησης άνθρακα είναι ένα τέτοιο εργαλείο που αν εφαρμοσθεί αποτελεσματικά μπορεί να επιταχύνει τις διαθέσιμες λύσεις. Η εργασία αυτή προτείνει τη χρήση της εσωτερικής-σκιώδους τιμολόγησης άνθρακα από τα Ελληνικά ξενοδοχεία ως ένα εργαλείο προκειμένου αυτά να αποτιμησουν τη πραγματική βιώσιμη κερδοφορία τους, απομειώσουν τον λειτουργικό τους κίνδυνο, εντοπίσουν ενεργειακές αναποτελεσματικότητες, και υποκινηθούν στη κατεύθυνση καινοτομιών χαμηλού άνθρακα στα διάφορα τμήματα τους. Η εργασία επίσης προτείνει μία μεθοδολογία εισαγωγής της σκιώδους τιμής άνθρακα στην Ελληνική Ξενοδοχεία και την αξιοποίηση της σχετικής πρωτοβουλίας στην κατεύθυνση εξορθολογισμού κεφαλαιουχικών και λειτουργικών αποφάσεων.

Λέξεις Κλειδιά: Εκπομπές άνθρακα; απαλλαγή από άνθρακα ξενοδοχειακών δραστηριοτήτων; εσωτερική τιμολόγηση άνθρακα; σκιώδης τιμολόγηση άνθρακα.

JEL Κωδικοί: O44; O47; O52; Q43; Q56.

1. Introduction – Conceptual framework

Pricing is defined as the: ‘Determination of a selling price of the product or service produced.’ (CIMA, 2006). A wide array of different pricing methodologies and strategies may be used in pricing, depending on the mission and objectives, costs and constraints, of the individual organization manufacturing the product or service as well as the scope of pricing and its influence of the potential consumers’ perception of the offering.
Many governments and major corporations around the world have begun to apply a price on their carbon dioxide and other greenhouse gas (GHG) emissions. According to OECD and WBG report (2015) by 2015, 39 national and 23 sub-national jurisdictions, representing about 12 percent of global GHG emissions and a market value exceeding $50 billion, were putting a price on carbon. Economists have long argued that well-designed, economy-wide carbon pricing schemes are among the best financial instruments developed to reduce GHG emissions, engaging all market actors to

contribute to a smooth transition towards a decarbonized global economy. However, the rates applied are usually low and uneven and the policies and principles used incoherent.
Shadow pricing is defined as the assignment of a price to an intangible item for which there is no ready market to derive a price from. In the context of this paper shadow pricing refers to the maximum price that a business would be willing to pay for one additional unit of a certain resource (CO_2 emissions abatement). Shadow prices are proxy values, commonly used in incremental decisions and cost-benefit analyses where certain elements of the analyses cannot be quantified by reference to a market price or a cost; they often reflect hypothetical or opportunity costs, the contribution margin lost or the contribution benefit foregone if a business engages, or does not engage, in a specific activity. Shadow prices are frequently considered unproved, inexact or subjective 'guesstimates' which may substantially falsify management decisions even when a probabilistic range analysis rather than absolute values are used.
The UN World Tourism Organization (UN-WTO 2010) defines tourism as people "traveling to and staying in places outside their usual environment for not more than one consecutive year and not less than 24 hours, for leisure, business or other purposes". With 1.3bn international travellers in 2017, seven % up from the previous year, tourism has been appointed to a fast escalating industry to which destination places, local populations and the natural environment are paying a heavy toll. To address this issue, UN-WTO (2005), with the collaboration of international tourism industry associations, has introduced and is promoting the concept of sustainable tourism as "Tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, environment, and host communities". Despite much celebrated relevant initiatives and efforts tourism accounts for eight % of the world's carbon emissions according to a recent research (Lenzen et al, 2018); its global carbon footprint has increased from 3.9 to 4.5 $GtCO_2e$, almost four times larger than previously expected, and projections indicate that tourism will constitute a growing part of the world's greenhouse gas emissions due to its high carbon intensity and continuing growth (ib.id). It seems that the collective inclination of humanity to explore the world is ultimately killing it and efforts to decarbonize tourism activities should be undertaken in a far more structured and organized way. This paper posits that innovative actions, tools, and approaches must be urgently adopted by hotels and other tourism enterprises to decarbonise their activities and that carbon shadow-pricing, if effectively applied can play a key-role to that end. The paper suggests the use of internal (shadow) pricing by Greek hotels as an instrument to co-appraise the sustainable operations and financial profitability of a hotel project and proposes a methodology on how to set an internal carbon price in the Greek hospitality domain in order to pursue this target.

2. Literature Review

2.1 Climate Change, tourism, and hospitality

The relationship between climate change (CC) and tourism is neither newfound nor under-researched. Smith noted in 1990 that in a world rich in CO_2, the overall volume of tourism, the nature of visitor pursuits, customer satisfaction, even the safety levels in certain environments, are likely to change. He suggested then that the tourism industry should be aware of the imminent changes and sensitivities and start planning ahead for the CC threats on key destinations ecosystems. Wall and Badke (1994) addressed the implications of climate and weather changes for tourism activities through a survey of national tourism and meteorological organizations. They examined the attitude of government agencies towards CC and tourism policy formation and found that authorities were unaware of and underestimating CC consequences for tourism. On the contrary, meteorologists and tourism organizations, widely recognized that climate is an important determinant of tourism and that global change might create new challenges and opportunities for the tourism industry, especially in countries heavily depending on tourism for economic stability and prosperity and called for prompt adaptation actions.

Gössling (2002) remarked that though a global activity of the tourism scale can be assumed to have a substantial impact on the environment, its consequences were not sufficiently assessed and quantified. His contribution entailed investigation in five major aspects of the leisure-related alteration of the environment including the use of energy and its associated impacts. Ten years later, he revisited the issue with his colleagues (Scott et al, 2012) focusing on CC. In their research they outlined the complex interrelationships between CC and the multiple components of the international tourism system, noting that tourism is recognized as a highly climate-sensitive sector, strongly influenced by environmental and socioeconomic change but also a growing contributor to anthropogenic CC. They reviewed the emerging within the literature consequences of CC on tourism and highlighted the differential vulnerability of tourism destinations and the fact that the resultant changes in competitiveness and sustainability will transform and undermine established international tourism markets if the latter fail to adapt to the risks and opportunities posed by CC and climate policy.

The same year McKercher (2010) used cluster analysis to examine the willingness of Hong Kong residents to voluntarily modify their travel behavior in order to reduce environmental impacts. His research findings corroborated previous studies identifying a significant gap between tourist awareness and action; the most aware of global warming and CC tourist groups were also the least willing to alter their travel behavior. McKercher concluded that government intervention may be required to create meaningful behavioral change in travel patterns. Simultaneously, Scott et al (2010) examined whether the global tourism sector can achieve its share of greenhouse gas (GHG) emission reduction targets postulated by a range of prominent organizations. Their analysis revealed that if the 'business-as-usual', high-growth emission trends in tourism continued, the sector could become a major global source of GHGs in the future. Success in achieving emission reductions in tourism were found to be largely dependent on major policy and practice changes and requiring extensive tourism and travel decision transformations. Weaver (2011) also contended that tourism's expanding engagement with CC may be more villainous than initially considered because of ignored complications entailing inherent unpredictability, long-term timeframes, lack of directly tangible consequences, vested interests and cost implications in an era of chronic economic uncertainty and an uncommitted tourism industry, conditions which, if combined, would further challenge the success of CC policies and strategies. He argued for adaptation measures addressing local sustainability issues such as air quality and biodiversity protection and for mitigation measures, supported to the extent that they yield practical and tangible short- and medium-term benefits but did not specify these measures at a corporate level.

More recently, Rosselló-Nadal (2014) published a study assessing the most relevant empirical quantitative approaches to evaluating the effects of CC on tourism. This review showed that the effects of CC can firstly be assessed through changes in physical conditions essential to tourism; secondly, by using climate indexes to measure the attractiveness of tourist destinations; and, thirdly, by modeling tourism demand with the inclusion of climate determinants, with all three methodologies resulting in a similar map of those areas mainly affected by the problem. Hoogendoorn and Fitchett (2018) focused their study in the under-investigated African countries, characterized by lower adaptive capacity to the impacts of CC coupled with rapidly growing tourism sectors. Their paper identified current threats and future research trajectories and called for the

development of locally customized knowledge, assisting in the development of appropriate adaptation and mitigation strategies for these vulnerable tourism economies. Michailidou et al (2016) studied the role of tourism as a contributor to CC and presented a generic methodological framework to plan, manage and implement CC mitigation and adaptation measures in the tourism context of Greece. Wilkins et al (2018) argued that CC is expected to influence tourism since weather patterns help determine the attraction of destinations. They employed nonparametric methods to identify the relative impact of 22 weather variables as predictors of tourism spending in three distinct locations in USA and constructed a parametric model to predict potential spending changes due to a warming climate. Results indicated that varying temperatures influence tourism spending in specific ways which, if studied carefully, may allow local businesses to capitalize potential gains in certain months. Finally, Lenzen et al, (2018) attempted a quantification of the industry's total carbon footprint. They found that travel, mostly driven by tourism purposes, is highly income-elastic and carbon-intensive. Global demand for tourism is currently outstripping the decarbonization of tourism operations, and, as a result, is accelerating global carbon emissions. The per capita carbon footprint increases strongly with increasing affluence and decreases weakly with improving technology. Thus, contrary to the popular mindset assuming that tourism is a low impact and non-consumptive development option, tourism accounts for around 8% of global GHG emission. For developing countries the pursuit of economic growth via tourism expansion comes with a significant carbon burden, a finding that should be considered in the design of future national development strategies and policies.
Early papers on the CC and tourism connection were first published in the late '80s. The afore-presented assortment of papers is representative of the 1,600 papers found on ScholarGoogle and researching the CC-tourism connection. Yet, when it comes to investigating the CC-hospitality relationship, one can retrieve fewer than 50 papers, all of them published the last decade and literally all describing the threatening impact and challenges of CC on hospitality activities rather than prescribing specific responses and measures that the industry should take to cope with this problem.

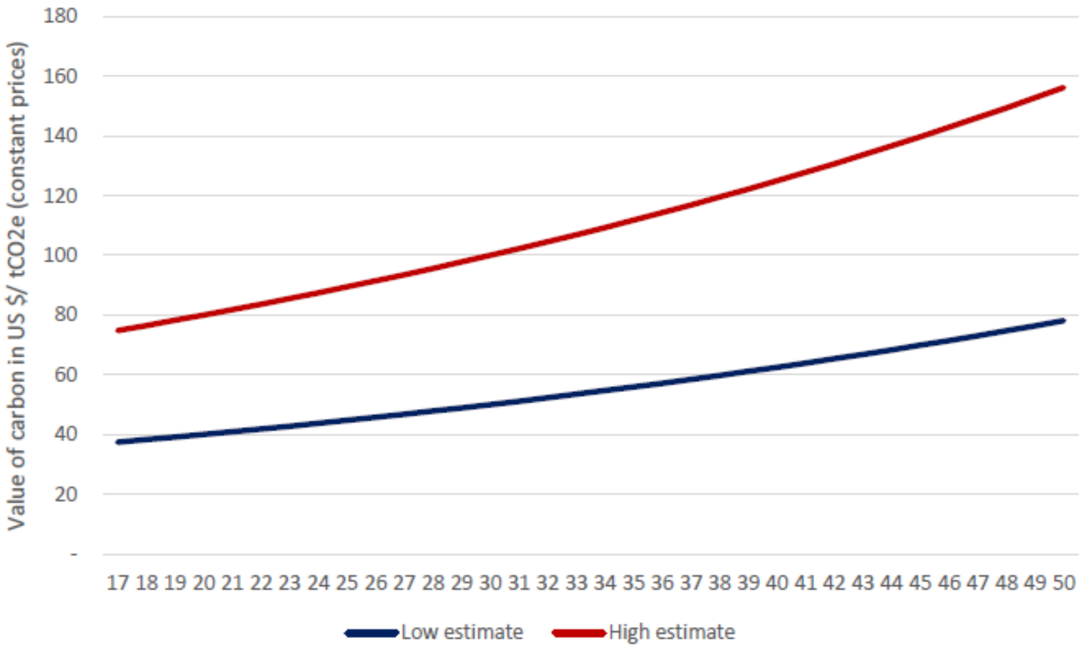
2.2 Shadow pricing

A shadow price refers to the assignment of monetary values to currently unknowable or hard-to-calculate costs. The concept mostly draws on the 'willingness to pay' principle and requires the use of certain assumptions and premises for its calculation. Its inherent subjectivity and inaccuracy has resulted in repeated accusations about the scientific basis of the method. However, assigning a shadow price to unquantifiable, externalized or intangible costs can be an unavoidable condition to determine the total cost of certain decisions, especially decisions made at the margin. In a paper published in 1990, Drèze and Stern suggested the use of social opportunity costs or 'shadow prices' whenever revenues and costs at market prices provide distorted measures of social gains and losses. Shadow pricing enjoyed scientific interest in the 80s and 90s and has become a mainstream technique since then. Indeed, it remains very useful for governments, policymakers and funding institutions to evaluate whether a public project should be pursued and financed.
Its use is also expanding among businesses which often employ it as a conventional tool to support cost-benefit analyses and decisions. The number of companies disclosing to CDP that they embed an internal carbon price into their business strategies has grown from 150 global companies in 2014 to 1,389 companies in 2017 (CDP 2017). Five of these companies reside in Greece; none belongs to the hospitality sector. The reasons for using an internal carbon price entail the disclosure of hidden carbon risks and opportunities to management so that they take prompt mitigation and adaptation actions, the development of a mechanism to drive investments towards cleaner, more efficient alternatives, the encouragement of innovation, the maintenance of sustained economic

competitiveness, and preparation for imminent policies restricting carbon emissions. For businesses, a shadow price is the maximum price that management is willing to pay for an extra unit of a given limited resource, or the contribution margin lost if it does not engage in a specific activity. Assessing the shadow price for any resource requires that the total economic value (TEV) associated with the resource has been considered (DEFRA 2007). TEV comprises Use and Non-Use values and refers to the total gain in wellbeing from a policy, measured by the net sum of the 'willingness to pay' or 'willingness to accept'. The Use value includes direct use where individuals make actual consumptive use of the resource; indirect use appears when individuals benefit from ecosystem services supported by a resource rather than directly using it; and the option refers to the value that people place on having the choice to use a resource in the future even if they are not current users. The Non-Use values are derived from the passive knowledge that the natural environment is maintained and available to use at our discretion.

The use of shadow price of carbon in the economic analysis is already a corporate commitment for all investment projects financed by the World Bank (WB) that are subject to GHG accounting (and expected by all those not-subject to GHG accounting projects). WB (2017) recommends that the scenarios considered in every project economic analysis be done both *with* and *without* the shadow price of carbon. The High-Level Commission (CPLC 2017) concluded that a range of US$40-80 per ton of CO2e in 2020, rising to US$50-100 per ton of CO2e by 2030, is consistent with achieving the core 2^{o}C objective of the Paris Agreement. WB (ib.id) has extrapolated these values from 2030 to 2050 using the same implicit growth rate of 2.25% per year applicable between the 2020 and 2030, leading to values of US$78 and $156 by 2050. The extrapolation provides to interested parties reference values of carbon shadow prices that various projects are recommended to use for the 2017-2050 period. The choice of using a range of values rather than a single value for each year reflects the uncertainty resulting from country considerations, strong past allowance price fluctuations, and the unpredictability of future socioeconomic and technological trends.

Figure 1: Recommended shadow price of carbon in US$ per 1 metric ton of CO2e. Source: High-Level Commission on Carbon Pricing



Year	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Low	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
High	75	77	78	80	82	84	86	87	89	91	94	96	98	100	102	105	107

Year	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Low	55	56	57	58	60	61	63	64	65	67	68	70	71	73	75	76	78
High	109	112	114	117	120	122	125	128	131	134	137	140	143	146	149	153	156

2.3 The use of internal and shadow pricing by hotels to tackle climate change

Kiliçc et al (2017) evaluate, through a life cycle perspective, the average carbon footprint of an overnight stay in 14 Spanish coastland hotels. Inventory and impact data are analyzed and presented for resource use and GHG emissions. The identified key-potential hotspots, responsible for over 75% of the impact, are electricity and fuel consumption, proportional to the number of stars and non-occupancy rate. The authors find that voluntary implementation of environmental management systems promotes collection of detailed and more accurate data, helping in a more efficient use of resources and better investment evaluation. Hung and Lai (2006) identified economic concerns, such as the perceived high initial investment and the need for cost reduction as the major barrier for Taiwanese hotels to participate in environmentally friendly practices. Scott et al (2015) compare potential costs associated with different policy pathways to achieve tourism sector emission reduction ambitions (-50% by 2035, -70% by 2050). They find investment in emissions abatement within the tourism sector to be approximately 5% more cost effective over the period 2015-2050 than exclusive reliance on offsetting, a cost that represents less than 0.1% of the estimated global tourism economy in 2020, or $11 per tourist per trip. Gössling (2016) explicitly suggests the introduction of carbon shadow pricing as a key-measure that tourism industry should take towards decarbonization. Angulo et al (2014) study the shadow price of water, its direct price elasticity and its cross elasticities with other production inputs, for 676 tourism firms operating in the city of Zaragoza, Spain, and find that water provides local hotels and restaurants returns marginally higher on average than its price. Alderighi et al. (2016) contend that availability of information on the load factor of perishable services, such as aircraft seats or hotel rooms, at the time a price is posted, necessitates a shadow cost for each unit of capacity and is required to disentangle an intertemporal price discrimination motive from cost-based pricing.

Therefore, the use of internal or shadow pricing by the tourism industry has been researched academically but is rarely and haphazardly practiced at a hotel business level. However, a recent report (ITP, 2017) shows that hotels will need to reduce their absolute carbon emissions by 66% by 2030 and by 90% by 2050 against a 2010 baseline, to fully play their part in mitigating global warming. This target lies well above what most hotel companies have set for carbon targets so far but, though ambitious, it is considered achievable by hotel representatives. A quarter of the total reduction of 66% targeted by 2030 will be achieved through external grid improvements in efficiency and use of renewables, nationally implemented without the hotel industry's efforts. On average, 50% of the reduction will need to be pursued internally, via three options: energy efficiency, switching to renewable energy, and other mitigation mechanisms. The existing technology literally allows complete decarbonisation of the sector assuming that hotels evolve their tools and approaches regarding energy and carbon valuation and internal pricing (ib.id). At this point, it becomes imperative that hospitality executives understand the real -implicit- costs of disregarding their carbon emissions and that they introduce these costs in their investment and operating decisions. To that end, a model to aid the implementation of shadow pricing follows.

3. The theoretical model

Internal carbon pricing typically takes one of three distinguishable forms which are often used interchangeably in the literature:

An *internal carbon fee* is a monetary value on each ton of CO_2e emitted along the operations of the entity. The process is readily understandable, the outcome measurable or accurately estimated and the fee creates a dedicated cash flow, streamlined to fund the company's investment and operating emissions reduction efforts. Today, the recorded price for entities using an internal carbon fee ranges from \$3 to \$20 per metric ton.
A shadow price is a theoretical price on carbon that can help support long-term business planning and investment strategies, identify and prioritize low-carbon investments, and prepare for future regulation. The observed shadow price for companies using a shadow price ranges from \$2 to \$893 (C2ES, 2017).
An implicit price is based on the GHG-reduction related expenses of an entity and on its compliance costs to various regulations. It helps companies understand their own carbon footprint and identify and minimize unavoidable costs that relate to its management. Setting a hurdle rate on the implicit carbon price can operate as a benchmark, a switch indicating the need to formally launch an internal carbon pricing program.

Companies may combine and adjust attributes from all three forms in an effort to manufacture a hybrid model customized on their needs. The model finally chosen should be embedded in the corporate strategy, making clear to internal stakeholders where the revenues will come from and where they will be invested to.

Establishing a carbon price per unit of output internalizes the cost of GHG emissions associated with a business by assigning a monetary value to each ton emitted. It sends a price signal to the company which can be factored into operating and investment decisions, incentivizing the transition from emissions-intensive to low-carbon alternatives. Interested hotel entities should start with the calculation of their implicit carbon price, *i.e.* the marginal CO_2 abatement cost of the measures and initiatives already implemented including the cost of complying with regulations. This approach would help hoteliers to retroactively appreciate their carbon footprint and evaluate the economic cost of a future regulation on the company.

The carbon fee can be a fixed or a fluctuating value, or a range of values assigned to one metric ton of CO2 equivalent (mtCO2e) resulting from normal business activity. For overtaxed Greek hotels, the fee should be modest and the proceeds should stay in-company to avoid excessive prices and ensure internal stakeholder engagement. The fee should cover emissions classified as Scope 1 or 2 under the GHG Protocol taxonomy but avoid inclusion of Scope 3which could be huge if it included total emissions from the guests travels. The revenue stream raised by the fee can be used to pay for low carbon inputs, renewable energy purchases, and energy efficiency or carbon offset projects.
To incorporate carbon externalities into the investment appraisal analysis, the annual shadow price of carbon (SPC), measured in €/tCO2e should be multiplied by the annual GHG emissions (measured in tCO2e) over the economic lifetime of the investment. Considering the carbon price volatility, multiple calculations should be made including cases such as (i) neglecting SPC, (ii) applying the low value of SPC, or (iii) applying the high value of SPC. The assumptions made, the source of prices used, and the interpretation of the results of each scenario should be presented in the "Management Discussion and Analysis" section and in the annual or sustainability reports published by the company. In the case of comparing equally efficient alternative projects, calculations should be expanded to ensure that the total cost related to the investment (energy transmission, adequate storage, back-up or other supportive services) is included. In the case of asset acquisition or engagement to a project, the benefits and costs associated with the carbon externalities for each asset or project should be added to the traditional net present value (NPV) method resulting in the following form:

$$NPV = -Fixed\ Cost_0 + \sum_{t=1}^{T} \frac{Benefits_t - Costs_t - (\boldsymbol{SPC_t * GHG\ emissions_t})}{(1+Discount\ Rate)^t}$$

A number of considerations should be included in the calculation:

For reasons of consistency, the SPC_t value for each year over the economic lifetime of the project should increase, following a specific 'official' pathway such as the one presented in Figure 1.
In the case of comparing alternative or counterfactual scenarios, all benefits and costs, *including GHG emissions*, need to refer to the same baseline scenario to allow meaningful comparisons. The inclusion of the SPC in the computations will alter the switching value and the economic viability of the project.
In the case of differential analysis where the annual benefits (cash inflows) and costs (cash outflows) of a project are expressed vis-à-vis a baseline or counterfactual scenario, the annual GHG emissions introduced in the formula should represent the difference between the absolute GHG emissions of the project and those of the alternative scenario (incremental or annual net GHG emissions).
The discount rate used should be the same for the costs and benefits of the various alternative investments considered in the analysis.
If the costs and benefits used in the formula include indirect costs and benefits, resulting from induced investments outside the project scope, the emissions generated from these investments should also be considered in the analysis.
If an entity receives carbon payments, credits or other financial subsidies for the emissions reduction delivered by a project, or pays an emissions tax related to the project, and these amounts have been already included in the financial projections, the utilized shadow prices of carbon should be adjusted accordingly to avoid double-counting.

4. Final considerations

The call for a global carbon price was raised before the Rio Earth Summit of 1992 but has gained new momentum in connection with the Paris Climate Agreement. Theoretically, a uniform price could result either from a tax on carbon or from some kind of global emissions trading scheme. However, such a price should be enforced within a homogenous world-trade area which does not exist, just like valid energy prices which vary from place to place. Globally uniform carbon prices are optimal only in the case of unlimited resource transfers from countries with higher marginal abatement costs financing measures in countries with lower marginal abatement costs. Since this condition does not hold prices are better determined at a country level depending on characteristics, such as income level, poverty incidence, economic structure and dependence to fossil fuels, availability of renewables, and ability of local governments to support the transition.
Further, a carbon surcharge (internal pricing), applied to operating transactions, may differ in value from the ‘shadow price’ used to plan long-term strategic infrastructure projects.
Shadow pricing alone can be a value-adding practice for certain sectors, such as food, energy or medicines, enjoying low elasticity of demand. In such cases carbon prices have to soar in order to alter consumers’ decisions. This does not hold true in the case of tourism entities, leading to a disconnection between demand reduction actions led by higher prices and the supply side or market dynamics. Moreover, without wider leverage or cooperation, unilateral climate policies initiated by individual companies will not only fail to combat climate change, but may also have detrimental effects on the economic competitiveness of the pioneering companies and result in their possible displacement from competitors indifferent to carbon pricing (Auffhammer et al, 2016). Companies that increase their costs by adopting low-emission processes and exercising carbon pricing will find themselves at a price disadvantage to rivals that do not.
Constructing the right carbon price for shadow pricing can also be confusing. The ideal carbon price to serve the Paris agreement has not been established yet. At a company level, the real interest of customers in the hotel decarbonization efforts is hard to disclose. The typical practice of collecting data from individuals using questionnaires can suffer from contacting a limited or biased sample of hotel customers; it may also suffer from biased responses in the case that the stated cost or benefit preferences of customers diverges from their actual willingness to pay for a certain resource or project. The internal and shadow prices finally determined may well be challenged by executives within the price-setting companies.
The determination of the appropriate discount rate of future costs and benefits to current values is a typical problem innate in all project appraisal methods. Using the prices estimated by various organizations may also be falsifying. For instance, the World Bank’s shadow-price scheme only reflects the “social value” of reducing emissions, rather than the entire “social costs”. Its shadow price is designed to reflect the emission-reduction targets the countries in question have adopted rather than the real damages done by climate change. In terms of accounting, the International Accounting Standards Board has failed so far to develop a commonly accepted accounting standard to support a uniform way of recording and reporting on carbon emissions and the allowances traded by companies to offset their carbon footprint; related amendments issued the last 15 year were withdrawn while their reconsideration ‘…has been deferred pending the conclusion of work of other relevant projects’ (IAS 2008). Finally, GRI published its first guidance on direct and indirect GHG emissions reporting only few months ago (GRI 2018) making premature any effort to comment on the approval and adoption of the suggested reporting practices by the various entities.

5. Conclusions

Research findings consistently disclose that carbon production is out of control and that the hospitality sector can be heavily harmed by this trend but may also play a critical role in its management. Studies to obtain information about the characteristics of the sector's carbon production and benchmarking values for the various hotels according to their size, location, category or other variables are required to assess the physical and financial implications of hotel carbon production. Such studies will also reveal whether the practices of internal or shadow pricing are currently exercised by Greek hotels, whether the prices set -in case they do- reflect the real marginal cost of carbon emission and whether the sector could assume substantial increases in its current prices without compromising its economic viability. Hotels should engage in this effort by calculating their internal carbon related expenses and their regulation compliance costs. By the time these expenses exceed a certain threshold, hotels should proceed with the establishment of an internal carbon fee on each ton of CO_2e emitted along their operations and utilize the generated cash flows to fund cleaner operations. They should also introduce a carbon shadow price to identify and promote low-carbon investments, and prepare for future regulation. Traditional investment appraisal methods must be adjusted accordingly to accommodate the new parameters.

Such information and practices would be particularly critical for policy makers to introduce pertinent limitations in the design of hotel price policies and use them as a demand management tool, encouraging preservation of resources. Carbon reduction at hotels will largely depend on the regulation of technical characteristics and the adaptation of existing or promotion of innovative appliances and fixtures minimizing carbon emissions. This adaptation or promotion of environmentally friendly investments comes at a cost. Concerted State and industry efforts are needed to allow funding of the capital expenditures required to pursue this goal and even use it as a marketing tool in the context of increasing stakeholder awareness of environmental issues. Accounting and reporting practices being currently developed will standardize and homogenize the procedures allowing comparability and enhancing transparency, accountability, and dissemination of best practices among the industry entities.

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Αιολική ενέργεια, μια ενεργειακή λύση για επιχειρήσεις φιλοξενίας

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Περίληψη
Η ενέργεια αποτελεί κινητήριο δύναμη για τις καθημερινές ασχολίες του ανθρώπου, τόσο στην οικονομία όσο και στην τεχνολογία. Πολλές χώρες παγκοσμίως έχουν συνειδητοποιήσει την επείγουσα ανάγκη για καθαρή παραγωγή ενέργειας, χωρίς την δημιουργία ρύπανσης, και προσπαθούν να έχουν ως κύριο μοχλό για την ηλεκτρική παραγωγή, τις ανανεώσιμες πηγές ενέργειας. (Καπλάνης, 2003).
Σύμφωνα με πρόσφατες μελέτες η πιο οικονομική και προσιτή ανανεώσιμη πηγή ενέργειας έχει καταστεί η αιολική ενέργεια. Τα αιολικά συστήματα είναι ευρέως χρησιμοποιούμενα στην εποχή μας, και σε αυτή τη μελέτη θα θέλαμε να σας παρουσιάσουμε την πρόταση μιας ομάδας μηχανικών του κολλεγίου Sheridan του Ontario του Canada, όπου δημιούργησαν μία μικρή ανεμογεννήτρια που υπόσχεται να καλύψει τις ηλεκτρικές ανάγκες μίας μικρής μονάδας φιλοξενίας, δηλαδή να παράγει ενέργεια αξιόπιστα και με χαμηλό κόστος.
Η Ελλάδα διαθέτει ένα εξαιρετικά πλούσιο αιολικό δυναμικό και η αιολική ενέργεια αποτελεί πρακτικά μια ανεξάντλητη πηγή ενέργειας. Η εκμετάλλευση του υψηλού της δυναμικού στη χώρα μας, σε συνδυασμό με τη ραγδαία ανάπτυξη των τεχνολογιών που ενσωματώνεται στις μικρές σύγχρονες αποδοτικές ανεμογεννήτριες, έχει τεράστια σημασία για τη βιώσιμη ανάπτυξη, την εξοικονόμηση ενεργειακών πόρων, την προστασία του περιβάλλοντος και την αντιμετώπιση της κλιματικής αλλαγής.

Λέξεις Κλειδιά: Αιολική ενέργεια, μικρές ανεμογεννήτριες, μονάδες φιλοξενίας, βιώσιμη ανάπτυξη.

'JEL Κωδικοί: Q01, L83, O13, P28, Q42.

Wind energy, an energy solution for hospitality businesses

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Abstract
Energy is a driving force for everyday human activities, both in the economy and in the technology. Many countries worldwide have realized the urgent need for clean, non-polluting power generation and are trying to be the main driver for electricity, renewable energy. (Kaplanis, 2003).
According to recent studies, the most economical and affordable renewable energy source has become the wind power. Wind systems are widely used in our time, and in this study we would like

to present you the proposal of a team of Sheridan college engineers in Ontario, Canada, where they created a small wind turbine that promises to meet the electrical needs of a small hospitality unit, ie to produce energy reliably and at low cost.
Greece has an extremely rich wind potential and the wind power is practically an inexhaustible source of energy. The exploitation of its high potential in our country, coupled with the rapid development of technologies embedded in small, modern, efficient wind turbines, is of paramount importance for sustainable development, saving energy resources, protecting the environment and tackling climate change.

Keywords: Wind power, small wind turbines, hospitality units, sustainable development

JEL Codes: Q01, L83, O13, P28, Q42

1. Εισαγωγή & Ανασκόπηση

Η οικονομική ανάπτυξη αποτελεί το ζητούμενο όλων των σύγχρονων κοινωνιών. Οι κλάδοι της οικονομίας θέτουν στόχους με γνώμονα τα οικονομικά οφέλη επιτυγχάνοντας ταυτόχρονα το ποιοτικότερο δυνατόν προϊόν. Η βιωσιμότητα όμως των οικονομικών κλάδων και κατ' επέκταση των σύγχρονων κοινωνιών επιτυγχάνεται μόνο βάσει των κανόνων της αειφόρου ανάπτυξης.
Η αειφόρος ανάπτυξη επιτυγχάνεται με την ικανοποίηση των αναγκών των σημερινών γενεών χωρίς να διακυβεύεται η ικανότητα των μελλοντικών γενεών να καλύψουν τις δικές τους ανάγκες - με άλλα λόγια, η διασφάλιση μιας καλύτερης ποιότητας ζωής για όλους, τώρα και για τις επόμενες γενιές. Αυτό απαιτεί βαθιές αλλαγές στον τρόπο σκέψης, στις οικονομικές και κοινωνικές δομές αλλά και στα διαμορφωμένα πρότυπα κατανάλωσης και παραγωγής. Από την άλλη είναι επιτακτική ανάγκη να διασφαλιστεί η προστασία τον περιβάλλοντος καθώς και η διαθεσιμότητα των ενεργειακών πόρων ώστε να μπορεί να εξασφαλιστεί η βιώσιμη ανάπτυξη των μελλοντικών κοινωνιών. Η ανάπτυξη της τουριστικής δραστηριότητας αποτελεί κύριο παράγοντα της ανάπτυξης των σύγχρονων χωρών (WTTC, 2015).
Οι επιδράσεις που ασκεί ο τουρισμός είναι ποικίλες και έχουν σχέση με την οικονομική και κοινωνική δομή, το ανθρωπογενές και το φυσικό περιβάλλον ενός προορισμού, οπότε στον οικονομικό τομέα διαπιστώνεται επίδραση στην απασχόληση, στο ισοζύγιο πληρωμών, στο συνάλλαγμα, στο περιβάλλον και στην κοινωνική συγκρότηση και δομή, κ.ά. (Καραγιάννης & Έξαρχος, 2006).
Οι προκλήσεις για την ανάπτυξη του τουρισμού σε ένα πλαίσιο πράσινης οικονομίας συνοψίζεται στους ακόλουθους βασικούς πυλώνες όπως αναφέρονται από την (UNEP, 2012):
• Ορθολογική διαχείριση ενέργειας.
• Περιορισμό των ρύπων.
• Διαχείριση υδατικών πόρων.
• Διαχείριση απορριμμάτων και λυμάτων.
• Διασφάλιση της βιοποικιλότητας.
• Αειφόρος διαχείριση τον κτιριακού τομέα.
• Διατήρηση ης πολιτιστικής κληρονομιάς.
Παράλληλα, διαφαίνεται η γενικότερη τάση του σύγχρονου πολίτη να αναζητά την ποιότητα ζωής όχι μόνο στην καθημερινή του διαβίωση αλλά και στους χώρους αναψυχής που επισκέπτεται, θέτοντας έτσι το περιβάλλον σε κεντρικό σημείο της στρατηγικής για την τουριστική ανάπτυξη μιας περιοχής. Ωστόσο, η τουριστική ανάπτυξη που βασίζεται στο περιβάλλον μπορεί να αποτελέσει και

σημείο κλειδί για την προστασία των φυσικών πόρων μιας περιοχής (UNWHO, 2006). Άλλωστε σύμφωνα με τους Έξαρχο & Καραγιάννη (2004) ο «πράσινος τουρισμός» και οι «εναλλακτικές μορφές τουρισμού» έχουν προταθεί ως απάντηση στην περιβαλλοντική υποβάθμιση που προκαλείται από την τουριστική βιομηχανία.
Άλλωστε αν δούμε τον τουρισμό ως νούμερα, θα δούμε ότι αντιπροσωπεύει το 10-12% του Παγκόσμιου Ακαθάριστου Προϊόντος, αποτελεί ίσως το σημαντικότερο οικονομικό τομέα, με πολυεπίπεδες επιπτώσεις στην κοινωνία, στο φυσικό και πολιτιστικό περιβάλλον (UNWTO, 2018). Οι διεθνείς αφίξεις τουριστών αυξήθηκαν κατά 7% το 2017 και έφτασαν συνολικά τα 1.322 εκατομμύρια, σύμφωνα με την τελευταία μέτρηση World Tourism Barometer (2018), του Παγκόσμιου Οργανισμού Τουρισμού. Περίπου 52 εκατομμύρια περισσότεροι τουρίστες ταξίδεψαν σε διεθνείς προορισμούς σε όλο τον κόσμο το περασμένο έτος.
Μάλιστα, αναμένεται πως ο παγκόσμιος τουρισμός θα συνεχίσει να αποτελεί παγκόσμιο μοχλό ανάπτυξης (WTTC, 2016). Συγκεκριμένα, σύμφωνα με τον Παγκόσμιο Οργανισμό Τουρισμού (UNWTO, 2018) ο ετήσιος αριθμός των διεθνών αφίξεων προβλέπεται στο 1,8 δις έως το 2030, και ο ετήσιος ρυθμός ανάπτυξης υπολογίζεται περί του 4,2% κατά την επόμενη δεκαετία. Γίνεται αντιληπτό από τα προαναφερθέντα πως ο ανταγωνισμός συνεχώς αυξάνεται σε παγκόσμιο επίπεδο και συνεπώς οι προορισμοί επιζητούν τη διαφοροποίηση και τη συνεχή βελτίωση του προϊόντος τους και της προώθησής του, ώστε να καταφέρουν να ξεχωρίσουν από την συνολική τουριστική προσφορά, να προσεγγίσουν και να προσελκύσουν τους καταναλωτές.

Εικόνα 1: Παγκόσμιος Τουριστικός χάρτης με στατιστικά του 2017

Σε αυτό το σημείο και λαμβάνοντας υπόψιν τα παραπάνω, η παρούσα εργασία παρουσιάζει τις κυριότερες σύγχρονες τάσεις του Παγκόσμιου και Ευρωπαϊκού Τουρισμού, οι οποίες στο σημερινό παγκοσμιοποιημένο περιβάλλον σίγουρα δεν θα πρέπει να αφήνουν την Ελλάδα, τον ελληνικό τουρισμό και τις επιχειρήσεις αδρανείς. Για το λόγο αυτό θα πρέπει να δοθεί ιδιαίτερη έμφαση στο θέμα «περιβάλλον», εάν θέλουμε και στο μέλλον να απολαμβάνουμε τουριστικούς προορισμούς με ωραίο φυσικό περιβάλλον, πάνω στο οποίο πράγματι ο τουρισμός μπορεί να επιδράει και θετικά και αρνητικά.
Από την άλλη η αιολική ενέργεια χαρακτηρίζεται ως ήπια μορφή ενέργειας και περιλαμβάνεται στις "πράσινες" πηγές όπως συνηθίζονται να λέγονται οι πηγές ενέργειας που δεν εκπέμπουν ρύπους. Η αιολική ενέργεια αποτελεί σήμερα μια ελκυστική λύση στο πρόβλημα της ηλεκτροπαραγωγής, τα οικονομικά οφέλη μιας περιοχής από την ανάπτυξη της αιολικής βιομηχανίας είναι αξιοσημείωτα.

Το καύσιμο της είναι άφθονο, αποκεντρωμένο και δωρεάν. Δεν εκλύονται αέρια θερμοκηπίου και άλλοι ρύποι, και οι επιπτώσεις στο περιβάλλον είναι μικρές σε σύγκριση με τα εργοστάσια ηλεκτροπαραγωγής από συμβατικά καύσιμα.

Η αιολική ενέργεια ενισχύει την ενεργειακή ανεξαρτησία και ασφάλεια. Το αιολικό δυναμικό της χώρας μας είναι γεωγραφικά διεσπαρμένο, οδηγώντας στην αποκέντρωση του ενεργειακού συστήματος, ανακουφίζοντας τα συστήματα υποδομής και μειώνοντας τις απώλειες από τη μεταφορά ενέργειας. Η αιολική ενέργεια προστατεύει τον πλανήτη, καθώς αποφεύγονται οι εκπομπές των αερίων του θερμοκηπίου που αποσταθεροποιούν το παγκόσμιο κλίμα (Παπούλιας, 2004).

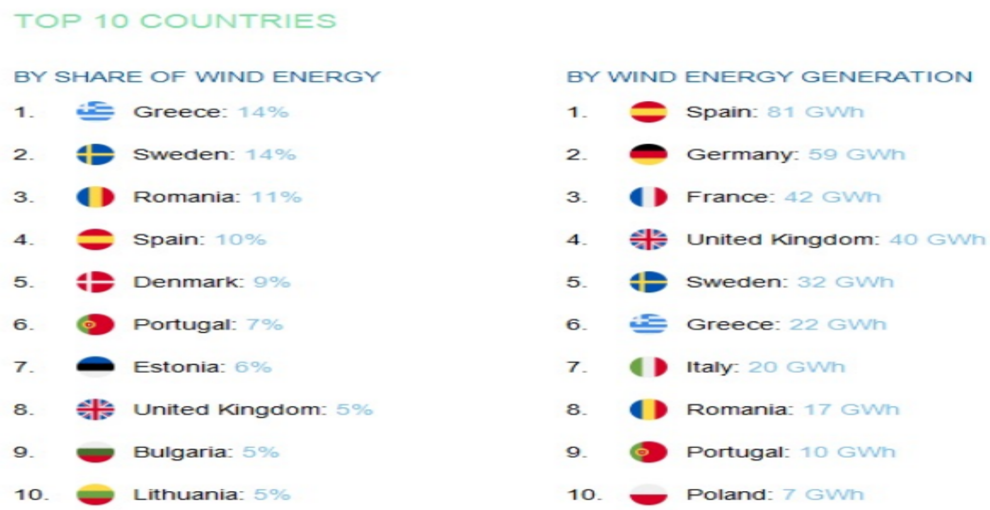
Η Ευρωπαϊκή Ένωση Αιολικής Ενέργειας εκτιμά ότι 230γιγαβάτ (GW) της αιολικής δυναμικότητας θα έχουν εγκατασταθεί στην Ευρώπη μέχρι το 2020.Από τα οποία θα αποτελείται από 190 GW στην ξηρά και 40 GW υπεράκτιων αιολικών εγκαταστάσεων. Επιπλέον θα παράγουν το 14-17% της ηλεκτρικής ενέργειας της Ε.Ε., αποφεύγοντας κατά 333 εκατ. τόνων CO_2 ετησίως και εξοικονόμηση 28 δισεκατομμύρια € το χρόνο ελαχιστοποιώντας το κόστος των καυσίμων.

Η παγκόσμια αγορά για ανεμογεννήτριες έφτασε τα 51,5 δισεκατομμύρια δολάρια το 2017 και αναμένεται να φθάσει τα 71,2 δισεκατομμύρια δολάρια μέχρι το 2022, αυξάνοντας με σύνθετο ετήσιο ρυθμό ανάπτυξης (CAGR) 6,7% από το 2017 έως το 2022 (EIA, 2017).

Η Ευρώπη εγκατέστησε 16,8 GW (15,6 GW στην ΕΕ) πρόσθετης ισχύος αιολικής ενέργειας το 2017, σημειώνοντας ένα χρόνο ρεκόρ σε ετήσιες εγκαταστάσεις. Με συνολική καθαρή εγκατεστημένη ισχύ 169 GW, η αιολική ενέργεια παραμένει η δεύτερη μεγαλύτερη μορφή δυναμικότητας παραγωγής ενέργειας στην Ευρώπη, προσεγγίζοντας στενά τις εγκαταστάσεις αερίου.

Σύμφωνα με την WindEurope η Ελλάδα κατέκτησε την πρωτιά στην Ευρώπη σε ποσοστό συμμετοχής της αιολικής ενέργειας στην ηλεκτροπαραγωγή και την έκτη θέση σε απόλυτα νούμερα ηλεκτροπαραγωγής.

Εικόνα 2: Οι 10 πρώτες Ευρωπαϊκές χώρες σε ποσοστά & απόλυτα νούμερα συμμετοχής αιολικής ενέργειας στην ηλεκτροπαραγωγή



Ο πρωτοπόρος Δανός επιστήμονας Henrik Stiesdal επισημαίνει ότι η Ελλάδα έχει εξαιρετικούς φυσικούς πόρους για την παραγωγή πράσινης ενέργειας και ότι η αιολική ενέργεια μπορεί να αποτελέσει μέρος της οικονομικής ανάπτυξης της χώρας. Η εκμετάλλευση της ενέργειας του ανέμου

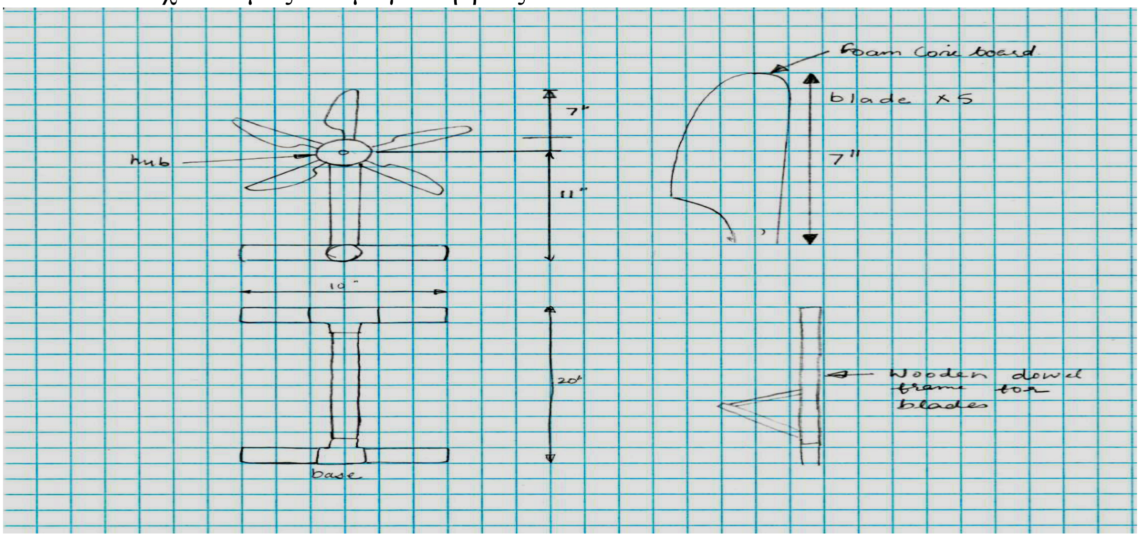
από τον άνθρωπο αποτελεί μία πρακτική που βρίσκει τις ρίζες της στην αρχαιότητα. Χαρακτηριστικά παραδείγματα εκμετάλλευσης της αιολικής ενέργειας είναι τα ιστιοφόρα και οι ανεμόμυλοι. Σήμερα, για την αξιοποίηση της αιολικής ενέργειας χρησιμοποιούμε τις ανεμογεννήτριες.
Σκοπός της παρούσας εργασίας είναι να εξετάσει τη δυνατότητα βιώσιμης τουριστικής ανάπτυξης με τους κανόνες της αειφορίας, προτείνοντας τη λύση μικρών ανεμογεννητριών για τις επιχειρήσεις φιλοξενίας. Ειδική έμφαση δίνεται στη συνεισφορά της χρήσης ενέργειας σ' αυτή την κατεύθυνση και στο κατά πόσο είναι εφικτή η εφαρμογή των προτεινόμενων πρακτικών με τις νέες τεχνολογίες.

2. Πρόταση

Έτσι μία μικρή ομάδα μηχανικών σχεδίασης προϊόντων και συστημάτων από το κολέγιο Sheridan στο Οντάριο του Καναδά με επικεφαλής τον κο. Δημήτριο Κοβό, μας κατέθεσαν μία τεχνική πρόταση για την κατασκευή μιας μικρής κλίμακας ανεμογεννήτριας που θα μπορούσε να καλύψει τις ανάγκες μίας μικρής τουριστικής επιχείρησης φιλοξενίας.
Η ομάδα έκανε ένα πολύ απλό και αποδοτικό σχεδιασμό της ανεμογεννήτριας, η οποία περιλαμβάνει μια έλικα με πέντε λεπίδες, λόγω της οποίας η τουρμπίνα μας θα είναι σε θέση να παράγει περισσότερο ηλεκτρισμό ακόμα και σε χαμηλή ταχύτητα ανέμου. Χρησιμοποιώντας υλικά που προέρχονταν και χρησιμοποιούνταν στο κολέγιο και συγκεκριμένα:

• Σωλήνες PVC για τη βάση και τον πύργο.
• Πλάκα πυρήνα αφρού 15 "x 20", για τις λεπίδες των προπέλων.
• Ξύλινο πύρο ¼ "x 48", για την έλικα.
• Ξύλινα μπαστούνια Popsicle - 4 τεμάχια για πτερύγια προπέλας.
• Hub Tamiya 72002 18: 1 Κιβώτιο ταχυτήτων για αύξηση της ταχύτητας του κινητήρα.
• Κινητήρας DC για παραγωγή ρεύματος DC.

Εικόνα 3: Σχεδιασμός Ανεμογεννήτριας



Οι ανεμογεννήτριες είναι μηχανές οι οποίες μετατρέπουν την κινητική ενέργεια του ανέμου σε ηλεκτρική ενέργεια. Η μετατροπή αυτή γίνεται σε δύο στάδια. Στο πρώτο στάδιο, μέσω της πτερωτής, έχουμε την μετατροπή της κινητικής ενέργειας του ανέμου σε μηχανική ενέργεια με την μορφή περιστροφής του άξονα της πτερωτής και στο δεύτερο στάδιο, μέσω της γεννήτριας, επιτυγχάνουμε την μετατροπή της μηχανικής ενέργειας σε ηλεκτρική.
Συνεπώς πρόκειται για μια ανεμογεννήτρια οριζοντίου άξονα, δηλαδή τα πτερύγια της περιστρέφονται με άξονα περιστροφής οριζόντιο προς την επιφάνεια της γης, αυτού του τύπου οι ανεμογεννήτριες οριζοντίου άξονα έχουν επικρατήσει γιατί έχουν υψηλότερο βαθμό απόδοσης (35-

40%) σε σχέση με τι ανεμογεννήτριες καθέτου άξονα (15%). Πολύ απλής κατασκευής με απλά και απολύτως οικονομικά υλικά που το συνολικό τους κόστος δε 100$, ήτοι 88€.
Ο τελικός σχεδιασμός είχε σχήμα τραπέζιο με μήκος παράλληλων πλευρών 4,1 και 5,5 ίντσες αντίστοιχα και 2 ίντσες εύρος από την επιθυμητή περιοχή. Οι λεπίδες συγκρατήθηκαν υπό γωνία 23 μοιρών. Το μέρος που συνέβαλε στο καλύτερο αποτέλεσμα ήταν οι ίδιες οι λεπίδες και ο κύριος λόγος για την παραγωγή 3,04 βολτ ήταν το σχήμα, το μέγεθος και η απόσταση μεταξύ κάθε λεπίδας. Το κιβώτιο ταχυτήτων με μεγαλύτερη σχέση μετάδοσης μπορεί να οδηγήσει σε καλύτερη επίδραση στα αποτελέσματα της τάσης εξόδου.
Η απόδοση της ανεμογεννήτριας ήταν απολύτως ικανοποιητική ή ακόμη καλύτερα θα μπορούσαμε να πούμε καταπληκτική και η ποιότητα κατασκευής και εκείνη πολύ καλή. Συνοψίζοντας έχουμε να αναφέρουμε ότι με απλά, οικονομικά αλλά και ποιοτικά υλικά κατασκευάσαμε μία μικρή ανεμογεννήτρια ήταν μεγάλη. η ηλεκτρική τάση εξόδου δίνεται στο παρακάτω γράφημα.

Εικόνα 4: Τελική μορφή ανεμογεννήτριας και πτερυγίων

Πρέπει να σημειωθεί ότι η οικονομική βιωσιμότητα των μικρών ανεμογεννητριών εξαρτάται σε σημαντικό βαθμό από το διαθέσιμο αιολικό δυναμικό της περιοχής. Είναι προτιμότερο η εγκατάσταση ανεμογεννητριών να γίνεται σε περιοχές με μέση ταχύτητα ανέμου τουλάχιστον μεγαλύτερη από 5,5 m/s (σε ύψος 10 m). Περιοχή με μέση ταχύτητα ανέμου μεγαλύτερη από 6 m/s θεωρείται ευνοϊκότερη. Είναι σημαντικό επίσης να αναφερθεί ότι η ταχύτητα του ανέμου αυξάνεται με την αύξηση του ύψος του ιστού της ανεμογεννήτριας.
Η παραγωγή ηλεκτρικής ενέργειας από μικρές ανεμογεννήτριες, μπορεί να συνεισφέρει σημαντικά στη μείωση των εκπομπών του διοξειδίου του άνθρακα, συμβάλλοντας στον αγώνα κατά των κλιματικών αλλαγών. Ενδεικτικά, με ένα σύστημα 3kW, το οποίο καλύπτει τις ανάγκες μιας μέσης οικογένειας-, οι εκπομπές CO2 που εξοικονομούνται ετησίως είναι περίπου 4,5 τόνοι.

3. Συμπεράσματα

Στην Ελλάδα κάποιες από τις ανανεώσιμες πηγές ενέργειας φαίνεται να έχουν εισχωρήσει σημαντικά στην τουριστική δραστηριότητα ενώ άλλες όχι Το δυναμικό της Ελλάδας σε όλες τις μορφές ΑΠΕ χαρακτηρίζεται ως υψηλό. Η ηλιακή ενέργεια έχει καθιερωθεί σε πολλές ξενοδοχειακές μονάδες τόσο για την παραγωγή ζεστού νερού όσο και για την ηλεκτροπαραγωγή μέσω των φωτοβολταϊκών συστημάτων. Σε αυτή την κατεύθυνση βοηθούν οι εφαρμοζόμενες πολιτικές παράλληλα με τα κατάλληλα κίνητρα για την ανάπτυξη αυτού του τύπου των τεχνολογιών.

Η αιολική ενέργεια μπορεί να συμβάλλει κατά κύριο λόγο με τη φτηνή ηλεκτροπαραγωγή σε μία τουριστική περιοχή βελτιώνοντας ταυτόχρονα και το περιβάλλον με τον περιορισμό των εκπεμπόμενων ρύπων από αντίστοιχες συμβατικές μονάδες ηλεκτροπαραγωγής.
Στην Ελλάδα τα παραδείγματα χρήσης αιολικής ενέργειας σε τουριστικές εφαρμογές είναι περιορισμένα καθώς το μέγεθος των μονάδων είναι τέτοιο που δεν επιτρέπει μεγάλες επενδύσεις και καθιστά την απόσβεση τον κεφαλαίου αδύνατη. Επίσης, έχουν γίνει ελάχιστες εφαρμογές αιολικής ενέργειας και αυτό διότι δεν αποτελούν ευρέως διαδεδομένες πρακτικές και είναι οικονομικά ασύμφορες.
Η δική μας πρόταση είναι πολύ εύκολη στη δημιουργία, με απλά και οικονομικά υλικά και ουσιαστικά με μηδαμινό κόστος. Τα οφέλη που θα προκύψουν για τις ξενοδοχειακές επιχειρήσεις είναι η μείωση του λειτουργικού κόστους με γρήγορη απόσβεση της επένδυσης, η βελτίωση της περιβαλλοντικής εικόνας της ξενοδοχειακής μονάδας και η προσέλκυση νέας κατηγορίας τουριστών με οικολογική συνείδηση, οι οποίοι συνήθως προέρχονται από περιοχές με υψηλότερα εισοδηματικά κριτήρια.
Το συμπέρασμα είναι ότι με σωστή οργάνωση και διαχείριση των διαθέσιμων ΑΠΕ στην Ελλάδα ο τουρισμός πω αποτελεί και βασικό κλάδο της οικονομίας Ου μπορούσε να αναπτυχθεί βιώσιμα αρκεί να αρθούν ορισμένα εμπόδια που σχετίζονται με τη νομοθεσία, τα οικονομικά κίνητρα αλλά και τη διαμορφωμένη νοοτροπία σχετικά με τις επενδύσεις χάνω στον τομέα της ενέργειας.

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Research Intensities and R&D Input-Output Multipliers: An Examination of their Intertemporal Stability Using Data on the US Economy

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ABSTRACT

Input-Output (IO) Analysis methods and their expansion to cover Research and Development (R&D) issues, resulted in the adoption of extended IO R&D multipliers. The latter show how changes in one or more sectors' final demands affect R&D expenditures in all sectors of the economy. The concept of sectoral research intensity defined as the R&D expenditures of a sector per unit of its own production value, is a necessary tool for the estimation of IO R&D multipliers. These intensities and multipliers are particularly useful for the quantitative analysis of the relationships between economic growth with R&D activities at a detailed sectoral level and for the whole economy as well. Knowledge of such relationships is particularly useful in order to device R&D policies and incentives. In order to achieve such a goal and make safe predictions, the stability of multipliers and intensities is a prerequisite. Using OECD data on the US economy, i.e. US IO tables and sectoral R&D expenditures for a series of years, we estimate sectoral research intensities and multipliers. Subsequently, their stability is evaluated using several established criteria in the literature with encouraging results which are presented and discussed.

Keywords: Input-Output Multipliers, Research and Development, Research Intensities.
JEL Codels: C67, D57, 031

Introduction

Reduction of production and marketing costs, quality improvement of inputs, products, and human capital, are associated with research and development (R&D). Expenditures to finance the R&D effort are producing knowledge, innovation, and diffusion of those between geographic regions, economic sectors and enterprises. The extent to which R&D expenditures produce innovations and spillovers depends on several factors. Similarly, economic, social, and institutional variables determine the size and structure of R&D expenditures of an economy. Statistical and econometric techniques have been devised and used to capture these relationships.

Methods of Input-Output (IO) analysis and their extensions have found limited so far applications on issues related to R&D. Nevertheless, IO approaches in R&D studies have appeared in the literature and so have combinations of IO methods and data, with statistical and econometric techniques. The detailed description of inter-sectoral transactions, final demand, and valued added, found in IO tables, make IO analysis a particularly attractive tool for studies aiming to obtain results at an equally detailed sectoral level of the economy.

Traditional final demand or value added driven multipliers which are the usual and main tools of IO analysis, have been altered to account for different scenarios and policies or extended to obtain multipliers related to income, employment, energy, environment, etc. IO R&D multipliers can be constructed exactly as all other extended final demand driven multipliers, and they have already been proposed and used in the literature. They can offer estimates and predictions on how changes in the final demand of one of more sectors affect the R&D activity in all other sectors of the economy. As in the case of other extended multipliers additional information to IO tables is needed, i.e. R&D investment of economic sectors per unit of their output (research intensities)

Their usefulness in associating the GDP and its structure with R&D investment at sectoral level is obvious. However, it is the accuracy and stability of estimates at least in the short-run, that will determine to what extent they can be used to analyze the relationship between economic changes and innovation and devise policies that target and promote certain types of R&D. The purpose of this study is to investigate the inter-temporal stability of IO R&D multipliers for the economic sectors of the US economy and their associated research intensities. It covers the period 2002-2011 and estimates annual R&D intensities and multipliers for twenty-four sectors in the beginning of the period, while two more sectors were added for subsequent years as data became available.

The study uses the IO tables of the US economy provided by OECD and the calculated Leontief multiplier matrices. It also uses the ANBERD database on R&D expenditures by sector provided by OECD. Research intensities and R&D IO multipliers are calculated and their intertemporal stability is evaluated using three of the most frequent criteria found in the literature.

A literature Review

The relationship between R&D investment and the innovations produced in an economy have been recognized and taken under consideration in the academic literature (Acs and Audretsch, 1988). An immense amount of related research and literature has been produced in the last three decades. R&D activity and produced innovations in a region, combined with the ability of this region to absorb knowledge and innovations produced elsewhere, contribute substantially to this region's growth (Romer 1986, Grossman and Helpman, 1991). Regional inequalities are related to geographic patterns of innovation and knowledge diffusion (Swan et al. 1998, Verspagen, 1998). Foreign direct investment (FDI) which contributes substantially to growth (Coe and Helpman, 1995, Caselli and Wilson 2004, etc.), does so via knowledge and technology spillovers as well (Xu 2000, van Pottelsberghe de la Potterie and Lichtenberg, 2001). On the other hand, the work of Jaffe et al. (1993) followed by subsequent research (Peri 2005, Thomson 2006, Alcacer and Gitelman 2006, Griffith et al. 2011, etc.) supports that geographical distance itself is a barrier to knowledge diffusion. Interregional knowledge diffusion across regions in this literature is taken under consideration through patent citations across regions.

Different channels of knowledge spillovers have been discussed in the literature. The work of Mowery and Ziedonis (2015) for example examined the role of two channels of geographic knowledge spillovers, i.e. patent license trade and interregional patent citations. Spulber (2008) focuses on the role of traded patents, while Giuri and Mariani (2013) focus on interactions between inventors that contributed to patent production supporting similar findings for the role of even social interactions (Agrawal et. al, 2006). Kim and Marschke (2005) find that inventors' mobility is significant for enhancing interregional citations in the nanotechnology sectors.

Drivas et al. (2016) provide a framework to consider and capture simultaneously the role of interregional trade which includes imports embodying new knowledge, patent trade, patent citations, and the interregional mobility of researchers and inventors. Imports and trade of patents comprise the market mechanisms of knowledge spillovers while patent citations and inventors' mobility are the non-market mechanisms. The study of Drivas et al. (2016) utilizes data sets on US states and shows the constraints that distance and administrative boundaries can pose on spillovers of embodied and disembodied knowledge even within the same country. Moreover, it is found that flows of disembodied knowledge (patent trade and citations) are less geographically restricted and more conducive to innovation than the flows of embodied knowledge that involve interregional imports and inventors' mobility. Such a conclusion agrees with the discussion in Grossman and Helpman (1991), and Rivera-Batiz and Romer (1991). The result is also in agreement with Savvides and Zachariades (2005) when the outcome on total factor productivity (TFP) is examined, although Papageorgiou et al. (2007) found the role of embodied knowledge transfer more significant, for health outcomes in particular.

R&D expenditures may not directly appear in econometric models that investigate the effect of geographical distance or other factors on knowledge flows and their particular channels, but their role is then implicitly considered since the research efforts of the sender and recipient regions are not to be ignored. In Drivas et al. (2017) for example R&D expenditures are used to calculate the variable of technological proximity which is subsequently used together with ranges of geographical distance as independent variables affecting channels of knowledge spillovers.

The R&D stock of a period (R&D expenditures of this period and previous ones) is a measurement of accumulated stock of knowledge. Econometric estimation of innovation production functions, where produced patents are frequently used as the dependent variable, directly involves R&D stock variables as independent. These refer to domestic and non-domestic R&D stocks in order to capture the impact of both domestic knowledge stock and knowledge spillovers. Most often non- domestic R&D stock variables are weighted according to the objectives of the study and other variables are included as well (Drivas et al. 2016, Deltas and Karkalakos 2013, etc.) Even though this is customary in the literature, different views exist on the functional forms and returns to scale (Jones 1995, Kortum 1997, Aghion and Howitt 1998, Dinopoulos and Thomson 1998, Peretto and Smulders 2002).

The significance of R&D investment and stock has been well documented well therefore, as a factor that influences the production of knowledge and innovation, as a channel of diffusing knowledge, and as a factor exercising influence on the role of other channels of knowledge spillovers. The positive effects of R&D investment on TFP and growth are reciprocated by the influence of GDP and macroeconomic variables on the size of total R&D activity. Moreover, econometric studies and estimates on the above issues refer to national or regional units and quite often the role of geographical patterns and distances. As a consequence, the data used refer to such units[1].

Detailed interindustry R&D studies on the above issues using aggregate data, with the different sectors comprising the observation units and different influential factors are met much less in the literature. Exceptions are found in econometric studies -at least as far as the nature of data used is concerned- as in Bloom et al. (2013) where "product market distance" refers to products of firms belonging to similar or not industries and is a factor affecting knowledge spillovers between forms. In Drivas et al. (2016) "structural closeness" of US states is calculated using patent data on a sector by sector.

The structure and detailed intra-sectoral and inter-sectoral information provided in the IO tables for all economic sectors, and the exposition of their relation to final demand and value added, are suitable and used in R&D studies where different variables are considered on a per sector basis. Different inter-industry relations related to R&D are used or investigated, and conclusions are derived for several different sectors (Van Meijl 1997, Van Pottelsberghe de la Potterie 1997,

Kristkova 2017 etc.). Such studies may combine IO information with econometric techniques but fewer ones have utilized all the detailed sectoral information using IO multiplier analysis which allows for causes and effects to be empirically estimated on a detailed sectoral level. Among those, Dietzebancher and Loss (2002) use backward, final demand driven R&D IO multipliers which as extended multipliers measure the impact of final demand changes on sectoral R&D expenditures. They measure benefits of R&D effects and their spillovers, and they apply forward, value added driven multipliers, to measure the impact of sectoral R&D costs on the price of the sector's output. Brachert et al. use R&D IO employment multipliers to identify embodied R&D flows.

There is certainly room for additional use of IO analysis in R&D studies, extended beyond the mere utilization of information and data included in the IO accounts. This means that in addition to the data wealth of IO accounts, existing IO multipliers of different types and purpose, as well as new multipliers, should be used to deal with issues of knowledge production and spillovers. National and multiregional IO data and multipliers, provide us with the ability of multisectoral research at detailed levels and variable numbers beyond the capacity of usual econometric models. Multiplier analysis can be used in combination with econometric applications too.

[1] An exception is of course the literature on R&D investment as a firm's competition strategy, R&D's effect on companies' TFP, and in general R&D theoretical studies referring to firms or empirical literature where observations refer to firms, possibly of a sector.

R&D Input-Multipliers associating final demand of each sector and its changes, with R&D expenditures of every single sector as discussed in Dietzenbacher and Los (2002), are the most obvious form of relevant extended multipliers. Their calculation takes place using the Leontief inverse –as is the case for all final demand (backward) extended IO multipliers in use- and the coefficients of research intensities for each sector. Their usefulness in devising policies and incentives targeting specific sectors and their outputs and estimation of their implications requires their stability, and as a consequence depends on the stability of the utilized intensities and Leontief multipliers.

It is the objective of this study to investigate the stability of R&D IO multipliers and the part information needed for their calculation which is associated with R&D activity, i.e. the research intensities. Given the relationship between the technical coefficients used in backward IO multipliers, and the sales ratios used in forward IO multipliers our results provide also strong indications for the stability of these multipliers too. R&D IO multipliers and R&D intensities are expected also to be crucial in other forms of IO multiplier analysis to be developed and implemented in the future on R&D studies.

As a case study we selected the R&D intensities and IO multipliers of the US economic sectors. The choice was affected by the size and significant R&D activity of the US economy. The analysis covers the period of 2002-2011. Calculations of research intensities and R&D IO multipliers took place for twenty-four initially sectors of the US economy, increasing gradually to twenty-six as new data became available. The US IO tables provided by OECD contained thirty-four sectors but data on R&D investment were not available for all of them. The stability of intensities and multipliers was evaluated using the criteria of Mean Absolute Difference, the Root Mean Squared Error (Euclidean Metric Distance), and the Differenced Correlation Coefficient. We also evaluated deviations of intensities and multipliers as a percentage of their actual range in the second period.

Analysis and Results

Outputs of 34 US economic sectors into which the US economy is divided, are provided by the OECD IO tables for the US economy. In the ANBERD database of OECD we have data on R&D expenditures of 24 sectors and the ANBERD sectors have been easily corresponded to the economic sectors of IO Tables[2]. Dividing the R&D investment for each sector i and year t $(R\&D)_{it}$ by the value of its output X_{it} we have the research intensity of this sector ψ_{it}, i.e. $\psi_{it} = \frac{(R\&D)_{it}}{X_{it}}$

which can be used to construct the (nx1) vector $\boldsymbol{\Psi}_t = [\psi_{it}]$ where n is the number of economic sectors at time t. The sectors for which R&D intensities and subsequently multipliers were estimated are[3]:

1) Mining and quarrying	13) Electrical machinery and apparatus, nec
2) Food products, beverages and tobacco	14) Motor vehicles, trailers and semi-trailers
3) Textiles, textile products, leather, and footwear	15) Other transport equipment
4) Wood and products of wood and cork	16) Electricity, gas, and water supply
5) Coke, refined petroleum products, and nuclear Fuel	17) Construction
6) Chemicals and chemical products	18) Wholesale and retail trade; repairs
7) Rubber and plastics products	19) Transport and storage
8) Other non-metallic mineral products	20) Financial intermediation
9) Basic metals	21) Real estate activities
10) Fabricated metal products	22) Computer and related activities
11) Machinery and equipment, nec	23) R&D and other business activities
12) Computer, electronic, and optical erquipment	24) Health and social work

Using the IO tables, we can derive technical coefficients and IO multipliers for all sectors. As usual we denote as $\boldsymbol{A_t} = [\alpha_{ijt}]$ the (nxn) matrix of direct technical coefficients at time t showing the amount of sector's i output needed per unit of sector's j output at time t. We denote as
$\boldsymbol{L_t} = (\boldsymbol{I} - \boldsymbol{A_t})^{-\mathbf{1}}$ (1), the (nxn) Leontief inverse or matrix of total requirements with $\boldsymbol{I}$ being the unitary matrix with units on the diagonal and zeros for all non-diagonal elements. Each element λ_{ijt} of $\boldsymbol{L_t}$ is an IO final demand-driven (backward) multiplier which shows the amount of sector's i output needed to accommodate a unitary change in final demand for sector's j output at time t, considering direct and indirect intra and inter-sectoral effects. Summing the multipliers across a column j of $\boldsymbol{L}$ we derive the effect of a unitary change in final demand for sector's j product, on the sum of all sectoral outputs (total multiplier). Together with the IO tables including intra and inter-sectoral transactions, value added and final demand elements for each sector, the OECD database provides also the multiplier matrices $\boldsymbol{L}$ calculated.

Using the vector of estimated research intensities and the Leontief multiplier matrix we can estimate an (nxn) matrix of IO R&D multipliers $\boldsymbol{\Phi_t} = [\varphi_{ijt}]$. Each element in the i th row and j the

[2] There are however four industries in IO tables which could not be corresponded entirely to a specific industry of the ANBERD database. These are "Manufacturing nec; recycling", "Renting of machinery and equipment", "Other community, social and personal services", and "Private households with employed persons". We have not corresponded them as such, to any ANBERD sector for which R&D expenditures are available. This should not be a problem, not only because any correspondence should be partial but their R&D expenditures are small to non- existent.

[3] In the 2003-2004 period another sector was added to the ANBERD database and in 2008-2009 another one as well. Even though we present the results of analysis with the original 24 sectors for all annual periods and the whole period 2002-2011, we conducted the analysis also with the

different number of research intensities for their appropriate periods. Results remained remarkably similar.

column shows the impact of a unitary change in final demand for the j sector's output on the R&D expenditures of sector i, at time t. Matrix $\boldsymbol{\Phi_t}$ is derived as $\boldsymbol{\Phi}_t = \hat{\boldsymbol{\Psi}}\boldsymbol{L}_t$ (2) where $\boldsymbol{L}$ is as in (1) and $\hat{\boldsymbol{\Psi}}$ is a diagonal matrix with elements ψ_{it} on the diagonal and zeros elsewhere. In other words,

$$\begin{bmatrix} \varphi_{11t} & \cdots & \varphi_{1nt} \\ \vdots & \ddots & \vdots \\ \varphi_{n1t} & \cdots & \varphi_{nnt} \end{bmatrix} = \begin{bmatrix} \psi_{1t} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \psi_{nt} \end{bmatrix} \begin{bmatrix} \lambda_{11t} & \cdots & \lambda_{1nt} \\ \vdots & \ddots & \vdots \\ \lambda_{n1t} & \cdots & \lambda_{nnt} \end{bmatrix} \quad \text{(2a)} \quad \text{with } \varphi_{ijt} = [\psi_{it}\lambda_{ijt}].$$

The sum of all elements across a column j of $\boldsymbol{\Phi}$ provides the total R&D IO multiplier of sector j, i.e. the impact of a unitary change in final demand of sector j on the total R&D expenditures of all sectors. All such total multipliers can be derived as an (nx1) vector $\boldsymbol{\Psi}'\boldsymbol{L}$ (2β) where $\boldsymbol{\Psi}'$ is the (1xn) vector of research intensities. Quite often, in many types of IO analysis it is the derivation of only total multipliers that concerns us. However, the advantage of using (2a) is not only the additional detailed multipliers that provides, but the possibility of calculating multipliers φ_{ijt} even when data on research intensities are not available for all n sectors into which the economy is divided in the IO tables[4]. If intensities are available for m sectors (m<n) we can calculate (m x n) individual multipliers, elements of matrix $\boldsymbol{\Phi}$[5]

Intertemporal stability of research intensities and R&D IO multipliers

t

We can evaluate the stability of intensities and multipliers using criteria similar to those applied in the evaluation of forecasts or deviations between certain corresponding values, and in particular in IO analysis as well. A long list of such criteria can be found in Wiebe and Lenzen (2016). We adopted three of them here which are the most widely known and applied, namely the Mean Absolute Difference (Lahr 1998), the Root Mean Squared Error/Euclidean Metric Distance (Lahr 1998) and the Reciprocal Correlation Coefficient (Lahr 1998, Gallego and Lenzen, 2009). Values of one period can be treated as forecasts of a next period and compared with the criteria. In addition, we have used the "stricter" criterion of considering all changes (deviations) from one period to a next as a percentage of the actual whole range of values during the next period. This, because quite often small absolute errors occur only due to small numbers considered.

For the multipliers considered, the mean absolute difference (MAD) is given by:

[4] Accuracy in the correspondence between sectors in the IO tables, and the sectors for which coefficients needed to derive extended multipliers are available, remains a requirement. However, such coefficients (e.g. research intensities) are not always available for all IO sectors, as in our case. This hinders the direct calculation of total extended multipliers and (2a) is suitable for the calculation of individual multipliers.

[5] The rest of multipliers, non-available in $\boldsymbol{\Phi_\tau}$ become zero in the results because in order to perform matrix calculations in (2a) we used zero values for the missing intensities in $\hat{\boldsymbol{\Psi}}$ without affecting the individual multipliers φ_{ijt} that can be derived. There are of course intensities and multipliers that can be actually zero.

$$100\frac{\sum_j \sum_i \left|\varphi_{ijt} - \varphi_{ij(t-1)}\right|}{mn} \qquad (3)$$

where m is the number of sectors for which intensities are available, n as before is the number of all sectors in IO tables, for which Leontief multipliers are available, and the product mn gives the number of multipliers φ_{ijt} available at each period t (i=1…m and j=1…n). The root mean squared error (RMSE/EMD) is:

$$\frac{\left[\sum_j \sum_i (\varphi_{ijt} - \varphi_{ij(t-1)})^2\right]^{1/2}}{mn} \qquad (4)$$

Here mn=814 for each period. Additional information is given also by the correlation or the reciprocal correlation coefficient. The reciprocal of the correlation coefficient is given by DCORR = 1 - CORR (5) where CORR is the correlation coefficient between the two distributions of φ for each i and j. A value of DCORR close to zero shows strong positive linear correlation between the distributions of the multipliers and their variation in the two periods t and t-1. Estimations based on (3), (4), and (5) took place for the deviations of research intensities ψ_{it} as well with a denominator n only and n=24. An estimate is provided for intensities/multipliers for each period. Moreover, based on the above the data used for each calculation of (3), (4), and (5) in each period is 24 for research intensities and 816 (24 x 34) for research multipliers.

It is believed using this criterion that a strong positive correlation is due to the high stability of the observations of intensities/multipliers from one period to the next, which makes the distributions at t-1 and t similar. High correlation of course may occur in the extreme case of general, strong and proportional changes as well, but chances are that higher instability will be of different sizes and directions for different intensities/multipliers, and correlation will become then small. In any case the existence of high correlation can strengthen conclusions based on small MADs and RMSEs, and can be used as an additional indication of stability.

The size of deviations may be small or large depending on the size of multipliers themselves and the latter affects also the percentage deviations form period to period (small multipliers can have small absolute but large relative deviations and large multipliers can have large absolute but small relative deviations). The magnitude of deviations may be what concerns us for all practical purposes, and criteria such as MDA and RMSE/EMD may serve their purpose very well. However, in order to evaluate the method of using intensities and multipliers as predictors of the corresponding values in the next period, i.e. the assumption of stability, we also adopted another “stricter” criterion. We estimate for every ψ_{it} and φ_{ijt} the size of deviation as a percentage share of the whole range of intensity/multiplier values at the end of each period. Hence, for each i, j, t the calculations were based on:

$$\theta_{ijt} = \frac{|(\varphi_{ijt} - \varphi_{ij(t-1)}|}{|(max\ \varphi_{ijt}\ - \min \varphi_{ijt}\ |} \qquad (6)$$

For each period from (t-1) to t we estimated 816 values of (6) for multipliers. Again, (6) was calculated also for research intensities ψ_{it} deriving 24 θ_i for each period (subscript j is not included now since there is one ψ for each sector i).

We present first results on sectoral research intensities, with Table 1 below presenting estimates of (3), (4), and (5) for all annual periods and the whole period 2002-2011 as well.

Table 1: Intertemporal stability of research intensities

Time Period	**MAD**	**RMSE/EMD**	**DCORR**
2002-2003	0.208	0.001	0.018
2003-2004	0.325	0.001	0.007
2004-2005	0.120	0.004	0.001
2005-2006	0.137	0.006	0.002
2006-2007	0.147	0.006	0.003
2007-2008	0.395	0.002	0.023
2008-2009	0.353	0.001	0.002
2009-2010	0.288	0.001	0.004
2010-2011	0.202	0.001	0.005
2002-2011	*0.978*	*0.004*	*0.039*

Results were subject to rounding to three decimals. All estimates above suggest that there is significant stability over the years in research intensities of the US economic sectors. The values of MAD from year to year are considered small. Intensities are always positive values and less than one taking now values from zero and close to that, up to approximately 0.16. The overwhelming majority of them are constantly below 0.05. Given these values and also the multiplication by 100 in the calculation of MAD a threshold of one as a rule of thumb seems appropriate and rather strict. All MAD estimates are below that. The remarkable annual stability is a result which can easily be extended to five year periods. Even for the whole decade 2002- 2011, the value of MAD remains below one.

The multiplication by 100 makes MADs usually higher than other criteria and even though this is not their only difference, it changes significantly the scale of measurement. “Aggregating” and “averaging” deviations also differ. The values of RMSE/EMD as expected provide smaller values and they are still significantly small for all annual periods. In some instances, they are very close to non-existence. Even for the whole period the value remains small. An appropriate and rather strict again threshold of 0.01 now, is not even approached.

The results of DCORR that can take values between 0-2, are now so close to zero (all below 0.1) that a very strong positive correlation between distributions of intensities at the beginning and end of a period can be well established. Given the small values of MADs and RMSE/EMDs the high positive correlation enhances the view that small and insignificant changes in the values of intensities have left the distributions of the 24 intensities largely unchanged.

Table 2 presents the maximum values of θ_i for the 24 intensities, for the different annual periods and the whole period as well.

Table 2: Maximum values of changes in research intensities as percentages of intensity range

Period	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	*02-11*
Maxθ_i	0.23	0.16	0.03	0.09	0.08	0.32	0.10	0.11	0.09	*0.39*

All 24 values of θ_i’s are very small for every period. This certifies further that together with the non-violation of thresholds of MDA’s and RMSE/EMDs, and small DCORRs, that small changes in intensities are not due to small values they take. Since we have 24 estimates of θ_i’s for each period, we present here the largest values showing the largest changes in intensities as percentages of the whore range of actual intensity values at the end of each examined period. Even the largest values we publish are relatively small.

Only two annual changes of a sectoral intensity for example are above 20% of the range and these maximum values are the only ones in each period that exceed that threshold and even then, all other 23 θ_i’s are below that. In fact, the majority of all θ_i’s in all periods are less than 10% of the range. For the overall period 2002-2011 instability with this criterion is of course higher and the highest value is 39% of the range. However only two other deviations exceed marginally the 20% threshold. Similar comments as for the other 21 θ_i’s apply, as in the case of annual changes.

In any case this criterion shows stability too and is used as an additional information or indication and the previous comments on its purpose apply[6].

[6] This criterion is used often to evaluate forecasting ability of trained machine learning algorithms, in out of-used data- sample testing and the 20% threshold is used in some relevant software to characterize a forecast as good or not. In IO analysis it has been used in Papadas and Hutchinson (1999) to evaluate the performance of a Back- propagation neural network, in forecasting technical coefficients and compare it to the RAS method for a five-year period only, and for highly aggregated IO tables of the British economy.

Tables 3 and 4 below, present the same kind of results for the intertemporal deviations of research multipliers.

Table 3: Intertemporal stability of R&D IO multipliers

Time Period	MAD	RMSE/EMD	DCORR
2002-2003	0.009	3.84×10^{-5}	0.012
2003-2004	0.018	4.15×10^{-5}	0.006
2004-2005	0.006	1.17×10^{-5}	0.001
2005-2006	0.007	1.92×10^{-5}	0.001
2006-2007	0.007	1.57×10^{-5}	0.001
2007-2008	0.017	7.61×10^{-5}	0.019
2008-2009	0.018	3.83×10^{-5}	0.001
2009-2010	0.016	4.07×10^{-5}	0.004
2010-2011	0.009	3.19×10^{-5}	0.005
2002-2011	*0.041*	1.21×10^{-5}	*0.033*

The estimates of MAD for the 816 multipliers each period, show substantial intertemporal stability of them. In fact, they seem even more satisfactory than the stability of research intensities, used in the multiplier estimation. The values of multipliers are in general smaller than those of intensities. This is because of their estimation which consists of multiplication of intensities with individual Leontief multipliers. The latter are lower than one even though this is not necessary, (with total Leontief multipliers being more frequently larger than one). All MAD values are still very small.

Given the values of resulting individual research multipliers a reduced threshold value by two decimals can be adopted and is still rather strict. Yet, only in three instances the MAD value exceeds 0.01 and that, slightly. Similar comments as in the case of intensities apply with regards to the calculation of MDA and its size, and the other criteria such as RMSE/MDE. Reducing similarly the previous threshold of RMSE/MDE to 0,0001 we see that no estimated value exceeds that. Actually, they are considerably smaller and this testifies to the significant stability of research multipliers. The values of RMSE/MDE compared to the previous thresholds are actually disproportionally smaller than in the case of intensities indicating greater stability

What reinforces however the results on the stability of multipliers, is the values of DCORR. They are smaller and close to zero. Some, profoundly smaller than their corresponding values for intensities. The high positive correlation between distributions of multipliers at the beginning and end of each period shows that distributions vary similarly because as the previous results show, they are similar and corresponding values very close to each other.

Table 4: Maximum values of changes in R&D IO multipliers as percentages of multiplier range

Period	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	*02-11*
Maxθij	0.22	0.14	0.03	0.08	0.06	0.34	0.09	0.13	0.10	*0.33*

The values of absolute deviations of R&D multipliers for each period as percentages of the whole range of their values at the end of the period remain small. Since these percentages are in general very small and less than 10% we present here their maximum values for each period. Again they are all less than the threshold of 20% and in one instance only, the annual changes exceed it slightly. Even for the whole period 2002-2011, the maximum percentage is 33% with two other multipliers only in the 814 exceeding 20%. These results also suggest that the multipliers are very stable over the years reinforcing all other estimates on their behavior, and showing that they cannot be attributed to the range of multiplier values.

Conclusions

Using OECD data and IO tables we estimated research intensities and individual R&D IO multipliers for 24 US economic sectors. Estimations took place for all years of the 2002-2011 period. We subsequently examined annual changes in the size of intensities and multipliers evaluated their stability using different methods such as MDA, RMSE/EMD, DCORR in combination also with the absolute changes of intensities/multipliers as percentages of their value ranges at the end of each period. We conducted the same evaluations of stability for the whole period as well.

All evidence from our case study suggests that intensities and research multipliers exhibit stability which covers longer periods as well. The stability of multipliers which rests on the stability of intensities and Leontief multipliers, shows a clear relationship between final demand, growth and its sectoral structure with the R&D expenditure of the economic sectors. This is particularly important for quantitative analysis and theoretical assumptions as well. R&D investment is a significant input in the process of knowledge production and diffusion, while aggregated over time R&D investments are a proxy for the accumulated stock of knowledge. R&D IO multipliers allow for the investigation of the impact of growth on these factors as well.

Knowledge of these multiplier affects and facilitates R&D incentives and policy making, which targets sectors of the economy, and the evaluation of such policies as to their effects at sectoral levels.

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Population projections at potential risk of rising sea level (2025-2050): The case of the Gironde (Estuaire de la Gironde)

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Abstract
As part of the effort to address the degree of vulnerability and the potential risk of flooding from the rise in sea level due to climate change, the coastal area of the Gironde delta (Estuaries of Gironde) shows that this vulnerability can be perceived only from an environmental point of view. In this paper, we tried to prove the inextricable interaction between the pure environmental dimension and the population dimension. At this time, rising sea levels do not contribute in the same way to the potential emergence of flood risk in coastal areas such as river delta estuaries. This means that the concept of risk intensity should be carefully considered because a municipal unity that currently has a very low degree of vulnerability could very well in the future change its risk category. Local-regional bodies should focus on the fact that the group of municipalities that currently have a low level of vulnerability is potentially able to cope with rising population pressures over a 2050-time horizon. Some municipalities currently showing low risk, may face a heightened risk in the future because not only it is not excluded that new coastal areas and estuaries of the rivers could be flooded, but also possible population growth can cause additional human pressures.

Keywords: Environmental Migration, Human-Environmental Vulnerability, Climate Change, Coastal Area.

JEL Codes: Q01, Q54, Q58.

5. INTRODUCTION

The aim of the present paper is to define a conceptual framework in order to examine the population's displacements related to environmental risks. For about twenty years, several terms have emerged to describe the displaced people such as: *environmental refugees*, *eco-refugees*, *climate refugees* or *eco-migrants*. The terms and the status attributed to these populations are largely dependent on the nature, strength and speed of the environmental event contributing to their displacement. It is therefore necessary to specify the criteria in order to avoid any confusion and to be able to assess the physical flows generated by the environmental disasters. Our analysis is focused on the risks of submersion and inundation along the coast and in the delta areas associated with rise in the sea levels. In view of these increasing risks, it is absolutely necessary to set up a "proactive strategy", based on the triptych protection - prevention - anticipation. For each type of risk considered, this strategy requires, beyond the delimitation of the geographical areas concerned, quantification and qualification of the potentially affected populations. In this context, the main aspect of our problematic combines two types of vulnerability: the first due to environmental disasters' risks such as floods and the second due to the often observed increasing population pressure in such areas. Finally, due to the fact that these risks are mainly dependent on local characteristics, the estimation of the potential size of population movements at the horizons 2025 and 2050 is limited to one specific region: The Gironde estuary in France which is considered as a highly vulnerable region.

6. METHODOLOGY

To address the issue of quantifying the potential populations affected by environmental risks and hence to examine the plausible flows of migrants due to these phenomena, it is necessary not only to detect and delimit the areas at risk but also to determine the time horizons of realization of such risks. In the case of a progressive environmental degradation produced by climate change, the "time" factor is fundamental because it allows to take into account a second aspect: the degree of exposure - risk which is in itself a determinant factor. Any estimate of the Persons Displaced for Cause of Disaster or Environmental Degradation (PDCDE) is de facto based on a dual scale: temporal and spatial.
The present analysis is limited to one type of exposure (sea level risk) whereas it is well known that the littoral and estuary areas are in fact exposed to various other forms of natural risk such as erosion, tsunamis or saltwater seepage especially in estuaries (Nicholls 2002, Small and Nicholls 2003). For most of the other forms of risk, it is especially difficult to foreseen and estimate their future amplitude while more and more models and consequently scenarios concerning the sea level risks are available. Nevertheless, the concept of risk for these areas and their populations is all the more complex and difficult to quantify as the process of urbanization often tends to be accentuated over the years. This raises the question of magnitude / degree of exposure and population vulnerability (McGranahan et al, 2007). For some authors (Nicholls and Small, 2002), it would even be necessary to distinguish between the populations directly concerned - those that are therefore at direct proximity to the sea or estuaries - and the populations exposed more indirectly - those who are less closed but undergoing the socio-economic impacts of flooding. On the other hand, it seems that victims of natural disasters tend to stay close to the site of the disaster (Tanner, 2009) and this means that most of the flows would involve travel within the same region or at most within the same country. This would consist primarily of travel to reception sites, not far from the original place of residence, while international travel corresponding to settlement abroad would be in very low proportion (EJF, 2009). From this point of view, it seems more appropriate to reason at the regional level, especially since the rise in sea level and its various consequences have a high degree of variability from one region to another[19].
In this context the empirical approach proposed below is limited to one region of France. The choice of the study area was based, on the one hand, on the systematic exploitation of maps relating to the natural risks of the major technologies of the communes of France[20], and on the other hand on a set of criteria such as the surface of the territories at risk, the importance of anthropogenic factors, the demographic pressure approached through population density (Paskoff, 2000) and the presence of major urban centers. This analysis resulted in the choice of the Gironde estuary for which a database at the scale of the communes was built. This database includes both geomorphological and geographic data as well as socio-demographic data covering the period 1990-2010.
Given that the demographic data are produced according to the administrative division of the country, the administrative delimitation of the estuary was therefore chosen as a support for the analysis and concerned 229 municipalities. The degree of vulnerability of these municipalities to the potential risk of flooding was assessed according to the methodology of the National Plan for the Prevention of Natural and Technological Risks (PPR) as described in **Table 1**. Finally, it appears that only 167 of the 229 municipalities of the estuary present a real risk.

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[19]See « No place like home – Where next for climate refugees? Environmental Justice Foundation – EJF, 2009, London.

[20] Cartorisque (http://www.developpement-durable.gouv.fr/Site-Cartorisque.html).

Table 1: Assessment of the degree of vulnerability to the possible flood risk

Flood risk degree	Main characteristics of flood risk
Risk 1 (Low Risk)	Only a small area of the municipality is classified red (*). It does not include habitat. The chief town of the town is not affected.
Risk 2 (Medium Risk)	Part of the communal area is affected. The habitat is very scattered and sparse. The chief town of the town is near the red zone and often surrounded by the red zone.
Risk 3 (High Risk)	The vast majority of the communal area is in the red zone. The habitat is directly affected. The capital of the municipality is also concerned.

(*) The red zone corresponds to the lands most exposed to high risks, thus endangering the inhabitants as well as the constructions (definition of the DDRM).

Population quantification and sociodemographic diagnosis of the 167 communes were based on a limited number of criteria (**Table 2**). Finally, taking into account the INSEE population projection scenarios[21], an attempt is made to evaluate demographic trajectories at the horizons 2025-2050 in order to detect the extent of future risks for local populations.

Table 2 : Criteria – Variables - Meaning

CRITERIA	VARIABLES	MEANING
1. Quantification and Distribution of the Population	Size of the Population	Current extent of vulnerable populations
	% by Risk Zone	
2. Demographic Trajectory	Average annual rate of population growth over 20 years	Increasing demographic pressure
	Average annual rate of population growth in the last decade	
	Share of Natural Balance (SN) and Apparent Migration Balance (SMA) in Population Change	
3. Demographic Structure	Aging Index	Characterization of populations
	Mean age	

[21] National Institute of Statistics and Economic Studies, OMPHALE Method.

	Structure by major groups of age	Detection of past migration types
4. Active population	Activity rate (Population 15-64 years)	Degree of involvement of people in economic life
	Activity rate of young people (Population 15-24 years)	
	Activity rate of seniors (Population 55-64 years)	
5. Habitat	Growth in the number of main residences	Emphasis on human pressure
	Growth in the number of secondary residences	
	Share of secondary residences for 100 main	
	% of owners of Principal Residences	

3. FRENCH COAST AND ATLANTIC FACADE

In mainland France, the coastline stretches over 5,840 km spread over three maritime facades: The English Channel - North Sea, the Atlantic and the Mediterranean. The coastal area includes 885 municipalities of which 785 are communities while it covers only 4.0% of the national territory but it represents around 10% of the total population (2009). The population density is 2.5 times higher than the national density (**Table 3**), highlighting a pronounced process of artificialisation of maritime facades in France. The construction of dwellings and the part of the artificial territory are also 2.6 times more important on the coastal zones compared to the national average while the urbanized zones represent 23% of the lands located at less than 250 m of the declining coasts (Eurosion, 2004).

Table 3: Importance of coastal zones in the Metropolitan France

Maritime facades	**Municipalities**	**Number of municipalities**	**Population**	**% of Metropolitan France**		**Density (Hab/km^2)**	
		2009	**2009**	**Surface**	**Population**	**1999**	**2009**
All maritime facades combined	Littoral	885	6.159.864	4	9,9	269	285
Channel - North Sea	Littoral	264	964.832	0,5	1,5	366	358
Atlantic	Littoral	405	2.013.967	1,9	3,2	184	197
Mediterranean	Littoral	216	3.181.065	1,6	5,1	339	365

FRANCE	36.568	62.465.709	100	100	108	115

Source: NISES, Population censuses 1999-2009, Key figures - Evolution and structure of the population.

With a density slightly lower than 200, the Atlantic façade as a whole, compared to the other two facades, presents a less intense urban pressure, but a sustained demographic growth (+ 6.9% between 1999 and 2009) due to the installation of new residents. With a very positive Migration Balance (MB) (7.8% against 2.6% for France) and a slightly negative Natural Balance (**Table 4**), this façade is characterized by a real attractiveness, especially for households close to retirement or already retired. The majority of the net migration balance concerns effectively this population group while the population 20-34 years old is underrepresented. This explains why the average age on the Atlantic (44 years old) is clearly higher than the two other maritime facades (41 for the English Channel-North Sea and just over 42 years for the Mediterranean).

Table 4: Attractiveness of the coastline of Metropolitan France

Maritime facades	Municipalities	Population		% of variation	Natural Balance	N.B. as % of	Apparent Migration	A.M.B. in % of the	100 x A.M.B. / Absolute difference
		1999	2009		1999-2009		1999-2009		
All maritime facades combined	Littoral	5.822.108	6.159.864	5,8	82.261	1,4	255.495	**4,4**	75,6
Channel - North Sea	Littoral	986.037	964.832	-2,2	32.955	3,3	-54.160	**-5,5**	**255,4**
Atlantic	Littoral	1.883.055	2.013.967	7	-15.208	-0,8	146.120	**7,8**	**111,6**
Mediterranean	Littoral	2.953.016	3.181.065	7,7	64.514	2,2	163.535	**5,5**	**71,7**
FRANCE		58.520.688	62.465.709	6,7	2.444.853	4,2	1.500.168	2,6	38

Source: NISES, Population censuses 1999-2009, Key figures - Evolution and structure of the population.

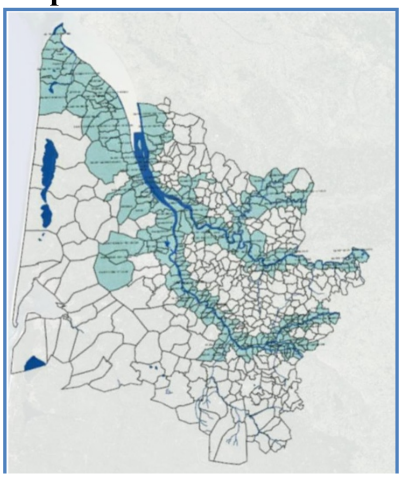
In the light of the above data, it is clear that the issues for the littoral areas are of prime importance for many reasons: **(i)** a population density two and a half times higher than the national average, **(ii)** sustained population growth, especially on the Atlantic facade which contributes to the accentuation of the artificialisation of coastal area and **(iii)** a growing residential economy in conjunction with high development of tourism, essential activity for the economy of these regions and the country, since it represents 50% of the economy, nearly 9 billion euros of added value according to the Ministry of Ecology, Energy, Sustainable Development and the Sea (2009).

4. LOCATION AND CHARACTERISTICS OF THE ESTUARY OF GIRONDE

The Aquitaine coast stretches 270 km from the northern tip of the Medoc to Spain, 59% of which concerns the Gironde coastline. Its estuary (**Map 1**), 75 km long and up to 12 km wide, is the largest in Europe. It comprises 229 communes covering an area of 3,172 km2 and is one of the main sites under the threat of rising water and an increased erosion process (**Map 2**).
The succession of storms since 1999 has highlighted the vulnerability of the Estuary and the Arcachon Basin. Apart from human issues, the Gironde and its estuary face major industrial challenges due to the presence of the Blaye nuclear power plant and oil warehouses as well as chemical industry and important industrial-port areas.

Map 1: The Study Area in France - Gironde

Map 2: Delineation of risk areas in Gironde



Source: Préfecture de la Gironde, Departmental Dossier of Major Hazards..

The population of the estuary in 2009 is about 830,000 inhabitants with a density of 262 hab/km^2, high level due to the presence of the Urban Community of Bordeaux (CUB). This zone also has a population growth about 10% between 1999 and 2009, which represents more than 28,000 additional inhabitants in ten years (**Table 5**). Net migration is the main component of population growth, confirming the attractiveness of this region, which is thus welcoming more and more new residents. This phenomenon has been intensified during the last decade. Indeed, during the previous decades, the population growth of the 229 municipalities was much more limited (+ 5.9% between 1982 and 1990 and + 4.3% between 1990 and 1999).

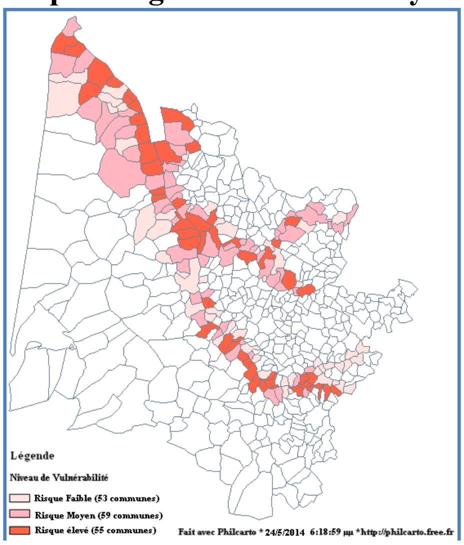
Table 5: Components of Population Growth in the Gironde Estuary 1999-2009

	Population		% of variation	Natural Balance (N.B.)	N.B. as % of the 1999 population	Apparent Migration Balance (A.M.B.)	A.M.B. in % of the population of 1999	100 x A.M.B. / Absolute difference 1999-2009
	1999	2009		1999-2009		1999-2009		
Department of Gironde	1.287.532	1.434.661	11,4	42.339	3,3	104.790	8,1	71,2
229 communes of the DDRM	755.798	831.032	10,0	28.465	3,8	46.769	6,2	62,2

Source: NISES, Census of Population, Key Figures - Evolution and Structure of the Population.

Among these 229 municipalities, 62 of them have a very low level of vulnerability due to the almost no areas at risk of flooding while the few areas partially exposed are uninhabited. As regards the 167 other communes, they are divided into three (3) groups: 53 have a low level of vulnerability, 59 are characterized by an average level while the other 55 communes face a level of vulnerability considered high (**Map 3**).

Map 3: Degree of vulnerability in the Gironde estuary



Source: Our own treatment

5. QUANTIFICATION OF EXPOSED POPULATIONS AND SOCIO-DEMOGRAPHIC DIAGNOSIS OF THE 167 COMMUNES AT RISK

As already mentioned, the diagnosis is based on five (5) criteria.

Criterion 1: Quantification and Distribution of the population according to the level of vulnerability

60% of the population residing in this area lives in communes with low flood risk, three quarters being concentrated in the communes of the CUB. Only 13% would be threatened by a high risk, they are mainly small municipalities, some of them having less than 100 inhabitants whereas only three of them have more than 5,000 inhabitants. As for the municipalities presenting a medium risk, their size presents a strong variability, ranging from 300 inhabitants to 25,000.

Criterion 2: Demographic trajectory

Over the last twenty years, the population of the study area has increased by 15%, and population dynamics have sharply increased since 1999 (**Table 6**) while communes with low-risk flooding are characterized by a clearly less pronounced demographic growth.

Table 6: Population growth according to the level of vulnerability of communes of the Gironde estuary (1990-2009)

Risk level	Number of municipalities	Population			Average annual rate of population growth (%)		
		1990	1999	2009	1990-2009	1990-1999	1999-2009
Low	53	356.615	367.844	402.790	0,64	0,35	0,91
Medium	59	144.849	153.036	173.797	0,96	0,61	1,28
High	55	76.848	79.967	89.059	0,78	0,44	1,08
Study zone	**167**	**578.312**	**600.847**	**665.646**	**0,74**	**0,43**	**1,03**

Source: NISES, Population censuses, Key figures - Evolution and structure of the population.

The population growth is once again the result of the arrival of new permanent residents, which is particularly strong for municipalities at medium and high risk of flooding. The contribution of the apparent migratory balance represents about 80% of the population's increase. It appears that for these municipalities, the vulnerability to the flood risk is strengthened by an additional human risk, at least in terms of habitat (construction of new residences) (**Table 7**).

Table 7: Components of population growth according to the level of vulnerability of municipalities in the Gironde estuary (1990-2009)

Risk level	Population	% of variation	Natural Balance	S.N. as % of the 1999 population	Apparent Migration Balance (A.M.B.)	A.M.B. in % of the population of 1999	100 x A.M.B. / Absolute difference 1999-2009

	1999	2009		1999-2009		1999-2009		
Low	367.844	402.790	9,5	15.664	4,3	19.282	5,2	55,2
Medium	153.036	173.797	13,6	4.479	2,9	16.282	10,6	78,4
High	79.967	89.059	11,4	1.562	2,0	7.530	9,4	82,8
Study zone	**600.847**	**665.646**	**10,8**	**21.705**	**3,6**	**43.094**	**7,2**	**66,5**

Source: NISES, Population censuses 1999-2009, Key figures - Evolution and structure of the population.

Criterion 3: Demographic Structure

Concerning this third criterion, the study area is characterized by a deceleration of the aging process: after a long period of increase, it has decreased from around 100 to 96 during the last decade, due to a relatively pronounced decrease as concern the low-risk municipalities (from 108 to 99.5) in which the city of Bordeaux figures. On the other hand, the percent of residents near from retirement age (55-64) is increasing in all areas while the age group corresponding to families with children (30-54 years) remains relatively stable (**Table 8)**. These two elements allow us to stipulate that the study area benefits from a double migration, both economic (partly linked to the existence of industrial sites) and lifestyle choices for retirement.

Table 8: Evolution of the demographic structure in the vulnerable communes of the Gironde estuary study area (1990-2009)

Age groups	Study area: Gironde Estuary			Low risk area			Medium risk area			High risk area		
	1990	**1999**	**2009**	**1990**	**1999**	**2009**	**1990**	**1999**	**2009**	**1990**	**1999**	**2009**
0 - 19	25,2	23,6	23,0	23,5	22,2	22,1	27,8	25,5	24,1	28,1	26,0	25,0
20-29	17,1	16,3	15,4	19,5	19,2	18,5	13,6	12,0	10,9	13,1	11,1	9,8
30-44	22,1	21,5	20,9	21,5	20,9	20,7	23,2	22,4	21,2	23,1	22,5	21,3
45-54	9,5	13,5	13,1	9,3	12,9	12,3	10,0	14,5	14,2	9,6	14,3	14,2
55-64	10,3	8,3	11,6	10,1	7,9	10,8	10,5	8,9	12,9	10,8	9,0	12,9
65+	15,8	16,8	16,0	16,2	16,8	15,5	15,0	16,6	16,6	15,3	17,0	16,8

Source: NISES, Population censuses, COMMUNITY ROCKET TABLE - FIFTH-YEAR-TO-GRIP POPULATION.

Criterion 4: Labor Force

Overall, the study area and the three (3) groups of municipalities have an activity rate equivalent to the metropolitan France (71.9). The relatively limited activity rate of Youth population in the low-risk area is explained by the presence of one of the most important French university in Bordeaux, city located in this group of area (**Table 9**).

Table 9: Activity rate in vulnerable communes of the Gironde estuary study area (2009)

Age groups Risk level	15 - 64 ans	15 - 24 ans	25 - 54 ans	55 - 64 ans

Low	69,8	36,4	89,0	48,9
Medium	74,1	48,0	91,0	41,6
High	73,9	48,5	90,9	39,9
Study zone	71,4	39,8	89,8	45,5

Source: NISES, Census of Population, 2009, Infra-communal data, activities of residents.

Lastly, regarding the activity rate of seniors, it is noticeably lower in medium and high-risk municipalities, which reinforces our finding regarding the attractiveness of these municipalities for young retirees.

Criterion 5: Habitat - Growth in the number of residences

This criterion completes the diagnosis made on the basis of the second criterion because it allows to take into account not only the increase in the number of principal residences but also that relating to second homes.

As expected, the anthropogenic pressure is very clear in all the study area, the increase in the number of principal residences is even stronger than that recorded in terms of population and this, whatever the area considered (**Table 10**). In addition to the increase of principal residences, there is also an important development of secondary residences, especially in medium and high-risk areas.

Table 10: Evolution of the number of residences in the vulnerable communes of the Gironde estuary study area (1990-2009)

Risk level	% increase in population	Main residences		Secondary residences		Number of second homes for 100 main residences 2009	% of main residences occupied by Owners 2009
		2009	% increase 1999-2009	2009	% increase 1999-2009		
Low	9,5	201.877	14,6	8.172	8,7	4	40,8
Medium	13,6	73.790	22,5	4.545	27,4	6	59,5
High	11,4	36.020	19,3	4.858	24,1	13	68,4
Study zone	10,8	311.687	16,9	17.576	17,1	6	48,4

Source: NISES, Tables (i) Population and Housing Since the 1962 Census, (ii) Key Figures - Statistical Summary of the 2009 Census.

Finally, the area highly exposed to flood risk has two additional characteristics: on the one hand, the proportion of secondary residences is twice the average of the area, which gives it a much more pronounced tourist character. On the other hand, the percentage of owners of principal residences is much higher, which increases the vulnerability since in case of flood, it is indeed their real estate capital that is concerned.

In fact, if the most threatened populations represent only 13% of the studied territory, the demographic and anthropic pressure during the last decade is especially high in the municipalities with medium risk where the highest increase of population and principal residences as well as secondary is observed. High-risk municipalities have an additional vulnerability in terms of real estate holdings, as more than two-thirds of the residents own their habitat, which is significantly higher than the other two groups of municipalities (**Table 11**).

Table 11: Summary of the diagnosis for the three groups of at-risk communes in the study area of the Gironde estuary

	Flood risk level		
	Low	**Medium**	**High**
Distribution of population	**61%**	**26%**	**13%**
Demographic trajectory			
✓Average annual growth rate (1990-1999)			
✓Average annual growth rate (1999-2009)	3,1%	5,7%	4,1%
✓Contribution from S.M.A. to population	9,5%	**13,6%**	**11,4%**
variation	+55%	**+78%**	**+83%**
Demographic structure	102		86
✓Aging index (2009)	Sharp	91	Slight
✓Trend compared to 1999	decline	Slight drop	increase
Active population			
✓Activity rate 15-24 years	36,4%	48,0%	48,5%
✓Activity rate 55-64 years	48,9%	41,6%	**39,9%**
Habitat			
✓Increase in principal residences (1999-2009)	14,6%	22,5%	19,3%
✓Increase of secondary residences (1999-2009)	8,7%	27,4%	24,1%
✓ % Owners of their main residence (2009)	40,8%	59,4%	**68,4%**

6. WHAT VULNERABLE POPULATIONS IN 2025 AND 2050?

Three different approaches were used to estimate future changes in the population of the study area.
<u>/ i / Continuation of the the trends observed in the two previous decades (1990-2009)</u>
If the average annual rate of population growth is maintained, the population of the study area could reach in 2025, nearly 750,000 inhabitants, or approximately 84,000 additional residents (+ 12.6%) while the increase of the population in high-risk municipalities would be about 11,800 people, or + 13% (Table 11). By 2050, the total population gain for the study area would be around 240,000, an increase of 35% over 40 years, while that of high-risk municipalities would exceed 33,000 (+ 37%). However, we can consider that this is a "high" scenario, approaching the upper limit of future human pressure. It is unlikely that demographic behavior, but especially migratory flows, will remain at current levels.
<u>*/ ii / Evaluation of future trends, by applying population projection scenarios of the Gironde department (OMPHALE)*</u>.
Three fertility scenarios are considered (high, low and medium fertility). The transposition of the scenarios to the three groups of communes is an approximation because it supposes that the demographic behaviors are identical to those of the department.
For each five-year period (2010-2015, 2015-2020 etc.), the population projections were obtained as follows:

$$P_{t+5} = (1+r).P_t$$

with r = average annual growth rate during the period (t, t + 5), in accordance with the OMPHALE projections of INSEE for the Gironde department. With no department-wide projections for the period 2030-2050, the average annual rate for the previous period (2025-2030) was retained.

The transposition of the central scenario of the OMPHALE model for the Gironde department to the study area leads to population projections at the 2025 and 2050 horizons relatively similar to those obtained by simply prolonging the trend (Table 12). The number of additional residents in 2025 compared to 2009, would be about 88,000 (against 84,000) while in 2050 the population would be around 896,000 people, a total increase of approximatively 230,000 (against 238,000). Concerning the high-risk municipalities, similarly large orders of magnitude are also obtained: the population gain is around 12,000 in 2025 and 31,000 in 2050, a difference of 2,000 compared to the method based on the past trend.

/ iii / Application of the logistic growth model on the population of the Gironde estuary.

The Verhulstë logistic growth model (1804-1849) refers to a sigmoid growth curve, according to the principle that any territory is characterized by a saturation level. In the case of areas vulnerable to the flood risk, this principle is of particular interest due to the fact that the endangerment of people and buildings generates new regulations with main objective, the limitation of building permits in order to counteract the anthropic pressure.

The logistic growth function is based on two parameters: the growth rate (r) and the saturation level (S) and takes the following form:

$$P_t = \frac{S}{1+e^{a-r.t}}$$

S is the growth limit while α is a parameter determined by the difference between the initial population Po and S.

The results obtained through this model are clearly distinguishable from the previous ones. The demographic growth would be during a first phase more pronounced compared to the two previous approaches while it would result, because of saturation, on a smaller population increase at the horizon 2050 (Table 12). The study area would not exceed 840,000 people (+ 26%) against nearly 900,000 for the two previous analyzes. This model is very similar to the low scenario of the OMPHALE method. Nevertheless, it also shows for high risk areas, a demographic growth by 2050 quite comparable to that obtained when the central scenario of the OMPHALE method concerning the department of Gironde is transposed to the study area.

Ultimately, even if population growth in the study area were to slow down (low scenario), human pressure would continue, especially in high-risk areas, where the population in 2050 could exceed 800,000 (lower limit). The confidence interval related to the average trend based on the 5 scenarios examined confirmed that the increase at the horizon 2050 will be above 25% (**Table 12**).

Table 12: Summary of projections - Vulnerable areas of the Gironde estuary

Scenarios		Low risk municipalities		Medium risk municipalities		High risk municipalities	
		2025	2050	2025	2050	2025	2050
Past Trends		446,3	523,8	202,6	257,5	100,8	122,4
OMPHALE Model Gironde	Intermediate	455,9	541,3	197,4	234,4	101,1	120,0
	Top	464,8	570,3	201,3	246,9	103,0	126,4
	Low	446,9	512,9	193,5	222,1	99,1	113,7
Logistics Growth		458,5	497,9	207,6	220,0	106,8	119,7
Average trend based on the five scenarios		454,5	529,2	200,5	236,2	102,2	120,4
95% Confidence Interval	Lower limit	444,7	494,6	193,8	216,2	98,5	114,7
	Upper limit	464,3	563,9	207,1	256,1	105,8	126,2
Average Rate of Variation		**13%**	**31%**	**15%**	**36%**	**15%**	**35%**

7. CONCLUSION

Through the above attempt to approach the vulnerability of the Gironde estuary to the flood risk, it appears that this vulnerability cannot be conceived solely in environmental terms. There is indeed a close interaction between the purely environmental dimension and the demographic one.
While sea level rise nowadays does not contribute equally to the possible occurrence of flood risk in estuary areas, it is recognized that future risks could be extended to zones that until today, are not or very little concerned by this danger (Poulos et al, 2009). For this reason, it is necessary not to limit such kind of analysis and population's estimation only to the high-risk municipalities. This also means that the notion of risk intensity must be considered with caution since a municipality or commune not really vulnerable nowadays could effectively change of category in the future and therefore be exposed to greater risks.
The above analysis has finally highlighted the diversity of situations and the complexity of the relationship between stricto-sensu environmental vulnerability and "anthropo-environmental" vulnerability. In the Gironde estuary, the group of municipalities facing the highest flood risk is also the group with strong demographic dynamics for which it is difficult to envisage a real reversal of trend in the future. At most, a slowdown in the process could be conceived. The most pessimistic projections as regards population growth lead to an increase of permanent residents about 13% until 2025 and more than 30% by 2050. If it is generally accepted that the regular monitoring of environmental phenomena as well as climate changes' impacts has to be a priority - an unavoidable necessity - it is also obvious that monitoring the demographic trajectories of areas directly or indirectly exposed to risks has to be a priority for local, regional and national authorities.

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