Journal of Regional & Socio-Economic Issues
Volume 9, Special Issue 2, October 2019
ISSN 2049-1409

Guest-Editor: Prof. Christos Frangos

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Indexed by Copernicus Index, DOAJ (Director of Open Access Journal), EBSCO, Cabell's Index
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JOURNAL OF REGIONAL SOCIO-ECONOMIC ISSUES (JRSEI)

Volume 9, Special Issue 3, October 2019

Journal of Regional & Socio-Economic Issues (Print) ISSN 2049-1395

Journal of Regional & Socio-Economic Issues (Online) ISSN 2049-1409

Indexed by Copernicus Index, DOAJ (Director of Open Access Journal), EBSCO, Cabell's Index

The journal is catalogued in the following catalogues: ROAD: Directory of Open Access Scholarly Resources, OCLC WorldCat, EconBiz - ECONIS, CITEFACTOR, OpenAccess

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Aims of the Journal: Journal of Regional Socio-Economic Issues (JRSEI) is an international multidisciplinary refereed journal the purpose of which is to present papers manuscripts linked to all aspects of regional socio-economic and business and related issues. The views expressed in this journal are the personal views of the authors and do not necessarily reflect the views of JRSEI journal. The journal invites contributions from both academic and industry scholars. Electronic submissions are highly encouraged (mail to: **gkorres@geo.aegean.gr**).

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International Institute of Organized Research (I2OR) database
The journal is catalogued in the following catalogues: ROAD: Directory of Open Access Scholarly Resources, OCLC WorldCat, EconBiz - ECONIS, CITEFACTOR, OpenAccess

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The effects of Greek Economic and Social Crisis on Education, Psychology, Income Inequality and the welfare of human population: A special Issue of the Journal of Regional and Socioeconomic Issues

We would like to express our warm thanks to Chief Editor Professor George Korres for being a keynote speaker to the Third International Conference for Quantitative, Social, Biomedical and Academic Issues, which has taken place from 23rd to 24th of May 2019 and for making available a special Issue of the Journal of Regional and Socio-economic Issues for presentation of the following articles

The present Special Issue of the Journal of Regional and Socio-Economic Issues, under the Chief Editorship of Professor George Korres of Aegean University and Guest Editorship of Former Professor Christos Frangos, contains seven scientific articles with the following main subject:

The consequences of the Greek Social and Economic Crisis on Education, Psychology, Income Inequality and welfare of the general population.

In the first article, under the title: **Managing poverty: Regression Models relating the at-risk-of poverty rate with unemployment and income inequality for all member-states of the European Union, i**t is determined, through some statistical models, the influence of the following three socioeconomic indexes, namely, **"Inequality of income distribution**", as measured by Gini coefficient, **"Social protection rate",** as defined by Eurostat (EUROSTAT,2013;2017;2018), and "**Unemployment rate"** ,on the economic indicator : **"at -risk-of -poverty rate".**

In the second article, under the title: **The consequences of the financial crisis for children and old age people in the European Union. Which age group has been most affected with respect to poverty and material deprivation?** the authors investigate the impact of the Great Recession of 2008-2017 on child and pensioner poverty across the EU-27 , including Switzerland, Ireland and Norway and compare the risk -of-poverty rate for children with the risk-of-poverty rate for elderly people. The findings of the paper are the following: (a). The at-risk-of poverty rate for children is greater than the one for pensioners. (b). There is a correlation between the working-age unemployment and child poverty.

In the third article, under the title: **Greek Economy Competitiveness, 2010 – 2018** the authors attempt to offer an understanding of the Greek economy competitiveness drop from the 67th position in 2008-2009 to the 87th in 2017-2018 and its subsequent rise to 57th in 2018 based on the "The Global Competitiveness Report" of the World Economic Forum (WEF). From a methodological perspective, the authors take into consideration the data provided by the World Economic Forum report.

In the fourth article, under the title: **"E-learning in primary education - "The participation of two selected Greek schools in the e-twinning program",** the authors refer to the major changes that have been recently in the way that education programs are implemented and in the diffusion of innovation into these programs. An important role is played by the European Union through the e-twinning program for the implementation of collaborative projects between schools in Europe through a dedicated digital collaborative platform. The purpose of the current paper is to investigate the effectiveness of e-twinning in primary education in Greece.

In the fifth article, under the title: **An Introduction to the Natural Differential and Integral Calculus , without the Infinite,** the author goes further from the digital continuous

axiomatic Euclidean Geometry and introduces the basic definitions and derives the basic familiar properties of the differential and Integral Calculus without the use of the infinite, within finite sets only. No axioms are required in this treatment. The author calls it the natural Differential and Integral Calculus.

In the sixth article, under the title: **Association between negative affect (i.e. depression,anxiety,stress) and obesity: the role of self-efficacy and eating self-efficacy as moderators,** the objectives of this author are to explore the association between negative affect (stress, anxiety and depression) and obesity (measured through BMI), to investigate the role of self-efficacy and eating self-efficacy relevant to the aforementioned association and to explore the emotional eating prevalence, given that high prevalence of obesity is controversially supported by literature review regarding its relation with psychological health.

In the seventh article, under the title: **Is brain drain an effect of the economic crisis?** The author supports the conclusion that the reason for the emigration of Greeks abroad is not the economic crisis but other reasons, like studying abroad. As noted by the author, in absolute numbers the higher and technological education graduates of Greece as well as Master's degree holders are constantly increasing for the period 2000-2017.Among the employees, the group most affected are those who do not hold an academic degree. More specifically, there are three labour pools in Greece: Foreign universities, Greek universities and graduate migrants.

The above seven articles have been presented at the Third International Conference for Quantitaive, Social ,Biomedical and Economic Issues which has taken place in Athens, Crystal City Hotel, on the 23rd and 24th of May 2019,with web page:
https://www.icqsbei2019.weebly.com

Prof. Dr. Christos Frangos, President Greek Research Institute for the study of Quantitative, Social, Biomedical and Economic Issues, Athens, Greece. Email: **cfragos@uniwa.gr**

Managing poverty: Regression Models relating the at-risk-of poverty rate with unemployment and income inequality for all member-states of the European Union

Abstract

In view of the elaboration of policies designed to help reach the European Union's target : "Europe 2020" of lifting 20 million people out of poverty(European Commission 2010), it is important to study the influence of the following three socioeconomic indexes, namely, "Inequality of income distribution", measured by Gini coefficient, "Social protection rate", as defined by Eurostat (EUROSTAT,2013;2017;2018), and "Unemployment rate" ,on the economic indicator : "at -risk-of -poverty rate". In this paper, we derive some statistical models and we test them for the 31 countries of Europe, relating ,the above socioeconomic indexes. Our main conclusion is that the income inequality which is a byproduct of the present financial crisis and of the past performance of the economic and political authorities, is a main risk factor of poverty for the European populations, especially in the Southern region of Europe.

Key Words : Gini Coefficient, at-risk-of poverty rate, Income Inequalty, financial crisis in Europe

JEL:I,M,I3

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1. Introduction

1.1 Definitions of Socioeconomic indexes

We give the following definitions of socioeconomic indexes and conditions which we shall encounter in the investigations undertaken in this paper :

Definition 1. People are said to be living in poverty, if their income and resources are so inadequate as to preclude them from having a standard of living considered acceptable in the society in which they live.Because of their poverty they may experience multiple disadvantages through unemployment, low income, poor housing, inadequate health care and barriers to lifelong learning, culture, sport and recreation. They are often excluded and marginalized from participating in activities (economic, social and cultural) that are the norm for other people and their access to fundamental rights may be restricted. (EUROSTAT, 2013;2018).

Definition 2. At-risk-of-poverty rate (AROP) is the share of people with an equivalised disposable income (after Social Transfers) below the **at-risk-of-poverty threshold**, which is set at 60 % of the national median equivalised disposable income after Social Transfers. The **equivalised disposable income** is the total income of a household, after tax and other deductions, that is available for spending or saving, divided by the number of household members converted into equalised adults. Household members are equalised or made equivalent by weighting each according to their age, using the so-called modified OECD equivalence scale. (EUROSTAT, 2013)

Definition 3.At-risk-of poverty or social exclusion (AROPE) is the share of people who are at-risk-of poverty or severely materially deprived(SMD) or living in households with very low work intensity.(WI)

Definition 4. People who suffer from severe material deprivation (SMD) are the people who experience at least 4 of the 9 following deprivation items:

They cannot afford : i. to pay rent or utility bills, ii. keep home adequately warm, iii. Face unexpected expenses, iv. Eat meat, fish or a protein equivalent every second day, v. a week holiday away from home, vi. a car, vii. a washing machine, viii. a colour TV, ix. a telephone.

Definition 5. The Gini Coefficient is a popular measure of income inequality. The Gini coefficient is equivalent to the size of the area between the Lorenz curve and the 45^0 line of equality divided by the total area under the 45^0 line of equality.The Lorenz curve shows the percentage of total income earned by cumulative percentage of the population. (Fernando G De Maio,2007). In the sequel we shall refer more extensively to Gini Coefficient.

1.2. The effect of the Economic crisis 2009-2017 on the Poverty of children and adults ,the Income inequality and the Unemployment ,in the European Union(EU) .

1.2.1 Efforts of the EU to eliminate young people's poverty and unemployment.

During the financial crisis , the economies of the European Union member-States contracted by 3,6 % (Organization of Economic Cooperation and Development(OECD)(2014),(Keeley and Love,2010),(Chzhen ,2016).This major economic downturn became known as the "Great Recession"(Jenkins et al.,2013).The effect of the economic crisis of 2009-2017 ,was the increase of the poverty of the population of all ages, especially of children.

The European Commission, in 2013, adopted the following recommendation: Investing in children: Breaking the cycle of disadvantage(European Commission,2013), as a key element of its Social Investment Package. The European Commission ,continued its efforts to improve living conditions and the well-being of the populations of member-states ,particularly of children, launching,in 2017,the European Pillar of Social Rights (European Commission,2017).This document has 20 key principles, one of which refers to children's

rights, as follows:a.Children have the right to affordable early childhood education. b.Children have the right to protection from poverty. c. Children from disadvantaged backgrounds,especially Roma or children from immigrant populations,have the right to specific measures to enhance equal opportunities.

In a Progress report,(European Commission,2017),they summarize the findings of the National Surveys on Poverty across the 35 countries of Europe,as follows: Four countries(Estonia(EE),France(FR),Ireland(IE) and Malta(MT)) have taken measures to strengthen their policies and programs in order to decrease the poverty of large sections of their poor populations,including children,of age 0 to 17.Another eight countries : (Bulgaria(BU),Iceland(IS),Lithuania(lt),Latvia(LV),The Netherlands(NL),Portugal(PT),Slovenia(SI) and Slovakia (SK)) ,have made modest progress towards eliminating poverty and increasing Social Protection. Germany ,Denmark, Finland ,Sweden, Norway and Belgium, have maintained the conditions of very little poverty of the different population sectors ,including children and adequate level of Social Protection. However ,there are the following countries in which very limited progress has been in most areas of poverty,material deprivation and low work intensity: (Cyprus,(CY),Greece(EL),Spain(ES),Croatia(HR), Hungary(HU),Italy(IT),Fyrom(MK),Romania(RO),Servia(RS),Turkey(TR) and England(UK))

The above conditions of poverty among children are particularly disturbing given the high levels of children at risk of poverty or social exclusion in the European Union(27% in 2015) and the very wide divergence between countries:10 countries ,mainly in the North-Northwestern Europe, have low proportions of young people at risk of poverty , (14-20%) (AROPE),whereas ,on the other hand, seven countries, in the South, the Balkans, Turkey and England have very high proportions (38-56%) of children at risk of poverty (AROPE).

1.2.2. Relative position of Greece between the Countries of EU and during the years of the financial crisis with respect to people at risk of Poverty or Social Exclusion

Greece is in the first position between the European Countries with respect to people at risk of poverty or social exclusion in households with three or more adults with dependent children (EUROSTAT,2017).The following Tables 1and 2 show the at-risk_of poverty rate for 33 European countries in 2015,compiled from data given in Tsampra (2018) and the at-risk_of poverty rate for children in Greece during years 2008 to 2015:

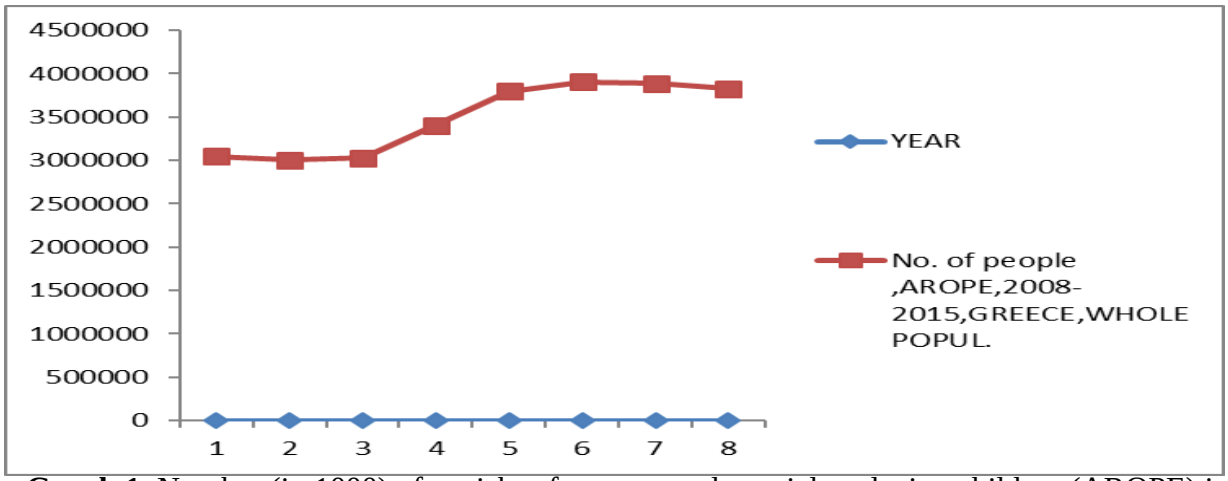
COUNTRY	AT-RISK-OF POVERTY RATE,2015
EU	30,1
EA	30
AUST	18,2
BEL	20,4
BUL	41
CRO	22,8
CYP	32,5
CZE	10,4
DEN	9,4
EST	12,6
FIN	20,7
FRA	23,6
GER	10
GRE	50,9
HUN	33,7

IRE	24,1
ITA	38,4
LAT	26
LIT	17,6
LUX	22,3
MAL	21,8
NET	6,8
POL	27
POR	33,5
ROM	43,9
SLVA	19,5
SLVE	13,2
SUE	12,3
UK	25,7
FYR	40,6
ICE	4,6
NOR	11,9
SER	41,4
SWI	15,7
TUR	54,3

Table 1.At-risk-of poverty rate for 33 European countries (2015)

YEAR	No. of people ,AROPE,2008-015,GREECE,CHILDREN(1000)
8	552
9	572
10	547
11	597
12	686
13	734
14	692
15	710

Table 2.Number of children (0-17)years old in Greece, at-risk-of poverty during years 2008 to 2015.



Graph 1. Number (in 1000) of at-risk- of poverty and social exclusion children (AROPE) in Greece during the years of financial crisis 2008-2015

From Table 1 we conclude that Greece was first (after Turkey) in Europe with respect to no. of people who are at risk of poverty or social exclusion in 2015.

From Table 2 and Graph 1 we conclude that the effect of financial crisis for the socioeconomic index : At-risk-of poverty rate(AROPE) for children in Greece, is that this index have been increased from 550000 in 2008 to 700000 children in 2015 .In graph 2,number 1 on the x-axis denotes year 2008 and number 8 on the x-axis denotes year 2015 .

1.2.3. Comparative Studies of the relative Risk of Poverty for children and the whole population in the countries of EU and OECD,during the years 2008 to 2015 of the financial crisis .

It is interesting to note that, in most industrialized countries, children were found to be at a greater risk of poverty than the population as a whole. In a notable study of income distributions across the OECD countries, Foster and Mira D'Ercole (2005), found that the rates of relative income poverty for children were higher than the ones for the population as a whole. In 2005, the Social Protection Committee of the EU, has highlighted that in most member-states the relative risk of poverty for children was higher than the relative risk of poverty for the whole population(European Commission,2008),(EUROSTAT, Statistics on Income and Living Conditions,SILC,2017).Similar finding,including severe material deprivation have found other researchers (European Commission,2010;Bradshawand Chzhen.2015;Tarki,2011).

It is important to note that children's poverty has long-term consequences, concerning the Educational ,Social and Economic level of preparations of the young people for their life as adults and, also, for the level of the economy and Social Protection measures of the country where the poor children live). For this reason, investment in children is seen as an effecting way of achieving equality of opportunities for all.The EU has adopted the strategy of "Reducing child poverty everywhere and applying Social Protection measures that will reduce the number of poor people in Europe by 20 Million by 2020:.(European Commission, 2013).

Researchers Muriel and Sibieta (2009), have studied the relative risk of poverty for children during the financial crises of England (the 1970s,the early 1980s and the early 1990s).They have concluded that the risk of poverty for children increased faster than the risk of poverty for adult members of the population.

According to Matsaganis (2013) ,the increase of children's poverty between 2009 and 2012 in Greece,was two-fold (from 21,8% to 42,6%). He found this result, using the poverty line anchored in 2009, for the Greek population.

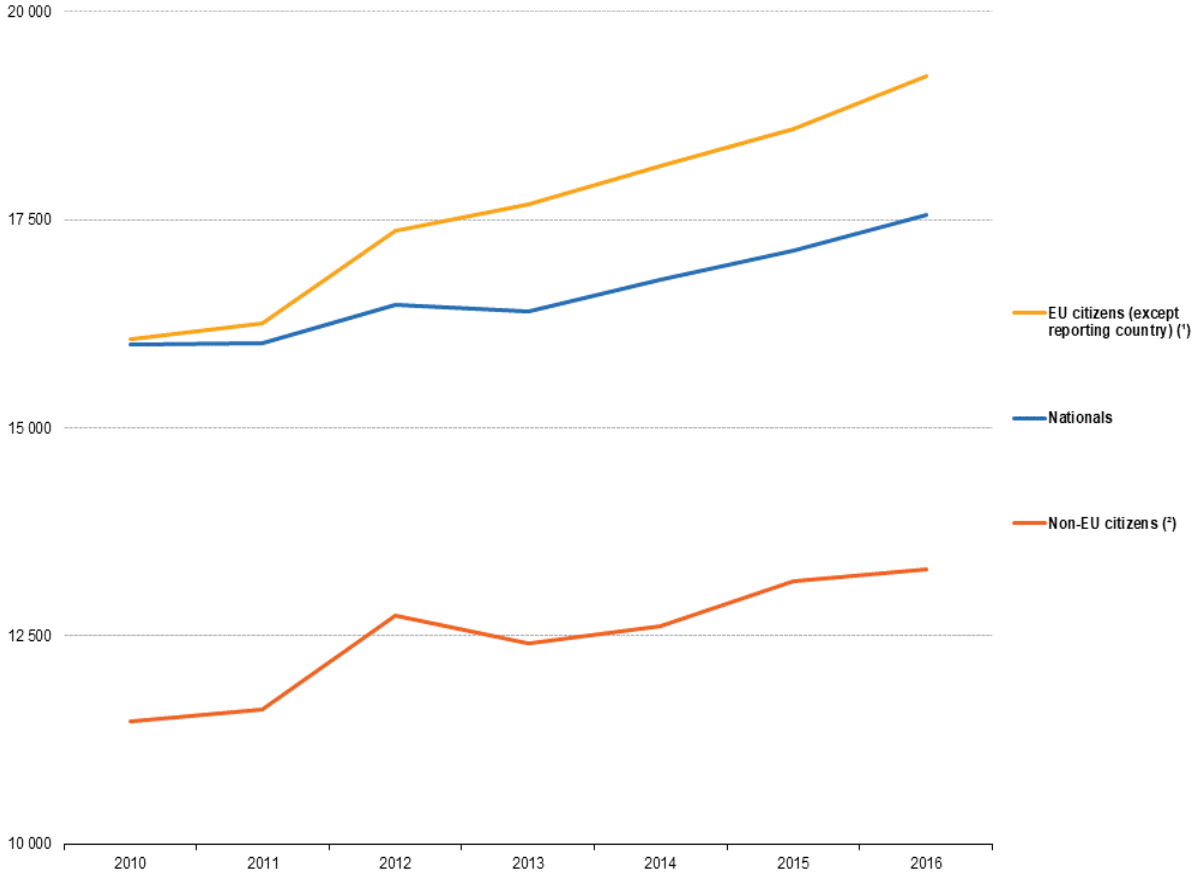
Kenworthy (1999) and Backman and Ferrarini (2010) and Caminada et al.(2012) reported a strong negative correlation between different measures of social protection and poverty rates .

It is of interest to find whether or not this relationship holds for a more diverse sample of 30 countries during the years 2008 to 2015 of the financial crisis.

In this article it is shown ,with the help of Correlation Analysis and Regression Statistical Models, based on OECD data and using the Statistical Package for the Social Sciences, that the socioeconomic indicator :at-risk-of poverty rate ,is negatively correlated with Social Protection and positively correlated with Income Inequality and Unemployment,for the EU countries and for the period 2008 to 2015.

1.2.4 Comparative study of the relative poverty of European citizens whose country of origin is non-European (immigrant populations) and of European nationals by citizenship and birth.

The economic development of a country depends heavily on the contribution of migrants who live and work in that country. The continuing fight against poverty and social exclusion are important elements for the well-being of individual members of the society. This is why the goal of the EU is to reduce the number of poor people in Europe by 20 million by 2020. It is of interest to know the average income of the people in the European Union by citizenship,for the time interval 2010-2016. The following graph 4 shows the Median incomes (equivalised) of the population aged 20-24,by citizenship.Eu-28,2010-2016.The upper line refers to the EU –citizens,the middle line refers to the Eu-Nationals and the lower line refes to the Non-EU-citizens (migrants).(EUROSTAT. 2017)



(¹) 2010 and 2013-2016: low reliability. 2011 and 2012: estimates.
(²) 2010: low reliability. 2011-2016: estimates.
Source: Eurostat (online data code: ilc_di15)

Graph 4.Median equivalised income of the population aged 20-24,by citizenship,EU-28,2010-2016

2. Data, variables and methods

This paper uses data from the following sources:

a.Organization of Economic Cooperation and Development(OECD).Statistics.(2014).

b.Eurostat data,especially for Gini coefficient of equivalised disposable income - EU-SILC survey(2017) , mortality and self-perceived health

c.Eurostat. Luxemburg study on Income and Social Conditions in Europe (LIS) (2017)

d.European Commission(2013).Investing in Children: Breaking the Cycle of Disadvantage(2013).
e. Social Protection Committee(2014).

The European Survey on Income and Social Conditions is the main source of information on living standards in the European Union, collecting nationally representative statistics on income and Social Inclusion.

In order to measure the change in living standards since the beginning of the financial crisis, the baseline (2008) poverty line is held constant. It is adjusted for price inflation but not for changes in median incomes , so that a person can compare his material circumstances with those of the average person in the society,

The indicators used are the following:

A1. Spending on social protection benefits(Social Protection).
A2.Unemployment.
A3. Gini coefficient of income distribution.
A4. At-risk-of -poverty rate or social exclusion (AROPE).
A5.Gross Domestic Product(GDP).
A6.Mortality
A7.Percentage of overwight persons
A8. Percentage of smokers

A6.Change in at-risk-of poverty rate before and after of social transfers. This is a useful indicator for assessing the influence of social transfers in changing the at-risk-of-poverty rate.

The types of household considered are the following: very low work intensity household, single person, lone parent status ,two parent with dependent children family, large family(three or more adult persons family),migrant status (with one or more adults born outside the European Union).

All statistical models are estimated separately by year in order to capture differences in the levels of social spending across countries for each year.

The software packages used is the Statistical Package for the Social Sciences(SPSS,VERSION 21,IBM-SPSS INSTITUTE (2015)) and the Microsoft Office.

3. Statistical investigations. Introduction of regression Models.

3.1 Correlations

We find the Pearson's correlation coefficients of the socioeconomic
Indexes for year 2014,for the 31 countries of Europe.
Gini coefficient
Risk-of-poverty rate
Social Protection
Perceived State of health
Unemployment
School Expectancy
The following table 1, shows the results

	Gini Coefficient	Risk-of-Poverty Rate	Social Protection	Per. St. Health	Unem Ployment	School Expectancy
Gini Coefficient	1	0,476**	-0,160	-0,252	0,213	-0,118

Risk-of-Poverty Rate	0,476**	1	-0,164	-0,336	0,324	-0,115
Social Protection	-0,160	-0,164	1	0,243	-0,034*	0,005
Perceived State of Health	-0,252	-,0336	0,243	1	-0,366*	-0,022
Unemployment	0,213	0,324	-0,034*	-0,366*	1	-0,108
School Expectancy	-0,118	-0,115	0,005	-0,022	-0,108	1

Table 1. Correlation Coefficients_associating the Socioeconomic Indexes.

From the above table ,we conclude that there is a statistically significant correlation between Risk-of-poverty and Gini coefficient and ,also ,between Risk-of-poverty and Perceived State of Health.

3.2 Introduction of Linear Regression Models relating Socioeconomic indexes ,tests and estimation of coefficients

Consider the data for the years 2003 to 2017 for the socioeconomic indexes :
Gini coefficient,at-risk-of poverty rate,Social Protection,Perceived State of Health,Unemployment,School expectancy,provided by Eurostat,Statistics Explained,(February,2017).

Modivated by the associations shown in table 1, we propose the following model ,which we test for the years 2003 to 2014.for all the countries of European Union,including SWITZERLAND,FYROM,TURKEY,SERBIA:

$$\textbf{(Risk-to-Poverty)}_{2014,i}\textbf{=a+b(Gini Coeff.)}_{2014,i}\textbf{+c (Unemployment)+e,}\ (1)$$

where
i:country of EU,for which the risk_ to-poverty rate of the whole population and Gini coefficient have been calculated for the year 2014.
E(e)=0.
a,b are unknown parameters to be estimated.
With the use of SPSS, we found the following statistics for model (1):

R=0,582	R^2=0,338	F=8,187	p-value=0,001		VIF=1,04
a=6,187	p-value=0,211	b=0,288	p-value=0,02	c=0,447	p-value=0,01

Table 2. Estimation of Coefficients and Model Summary results for Model (1) and for year 2014.

According to Martorano(2014) and the Social Protection Committee(2014),there is a change in the national child poverty rate before and after social transfers. Hence, the socioeconomic index:Social Protection is related to the reduction of the national poverty rate in a country for the whole population and for children, in particular.

In order to test the above relationship of Social Protection spending and the national rate poverty in each country of the EU and for each year 2008 to 2014,adopting an

approach of panel data,we propose the following model,where the subscript (i) denotes country of the EU(I=1,…,31) and the subscript (j) denotes year (j=2008,…,2014):

(Risk_of_Poverty Rate)$_{ij}$ =a+b(Social Protection)$_{ij}$ +c(Unemployment rate)$_{ij}$ +d (Gini Coeff.)$_{ij}$ +e$_{ij}$ (2)

It is assumed :

$E(e_{ij})=0$.

a,b are unknown parameters to be estimated.

With the use of SPSS, we found the following statistics for model (2):

Estimation for year 2008

R=0,844	R^2=0,713	F=25,67	p-value=0,0001		VIF=1,01
a=-1,06	p-value=0,83	b=-0,254	p-value=0,085	c=0,279	p-value= 0,059
d=0,908	p-value=0,0001				

Estimation for year 2009

R=0,808	R^2=0,652	F=19,37	p-value=0,0001		VIF=1,01
a=2,79	p-value=0,61	b=-0,313	p-value=0,03	c=0,166	p-value=0,2
d=0,87	p-value=0,0001				

Estimation for year 2010

R=0,534	R^2=0,285	F=4,11	p-value=0,014		VIF=1,01
a=13,54	p-value=0,09	b=-0,232	p-value=0,232	c=0,425	p-value=0,04
d=0,24	p-value=0,08				

Estimation for year 2011

R=0,597	R^2=0,357	F=5,73	p-value=0,003		VIF=1,01
a=11,89	p-value=0,11	b=-0,21	p-value=0,024	c=0,44	p-value= 0,03
d=0,31	p-value=0,02				

Estimation for year 2012

R=0,581	R^2=0,338	F=5,27	p-value=0,005		VIF=1,01
a=11,64	p-value=0,14	b=-0,22	p-value=0,22	c=0,30	p-value=0,03
d=0,47	p-value=0,028				

Estimation for year 2013

R=0,372	R^2=0,139	F=2,65	p-value=0,08		VIF=1,01
a=25,34	p-value=0,0001	b=-0,229	p-value=0,03	c=0,32	p-value=0,06
d=0,41	p-value=0,03				

Estimation for year 2014

R=0,600	R^2=0,360	F=5,79	p-value=0,0003		VIF=1,01
a=10,416	p-value=0,11	b=-0,146	p-value=0,032	c=0,42	p-value=0,02
d=0,29	p-value=0,03				

Table 3. Estimation of Coefficients and Model Summary results for Model (2) and for years 2008 t0 2014.

3.3. Statistical interpretation of results for models (1) and (2).

A.The interpretation of the results of model (1) is the following:

The statistic F is statistically significant at the level of significance 0,005
because F=8,187,with (2) and (32) degrees of freedom and p-value=0,001<0,005 .(Pallant,J.(2008).
R=0,582,meaning that model (1) explains 47,8 % of variance in at-risk-of poverty rate.
The independent variables :Gini coefficient (p-value=0,02)and unemployment (p-value=0,01)were both statistically significant .

The Variance Inflation Factor(VIF) is1,04,indicating a very low multicollinearity. Model (1) has shown that the independent variables :Gini coefficient and Unemployment affect the dependent variable :at-risk-of poverty rate.This means that in periods of financial crisis the relative poverty of the various age groups of the whole population increases. In a future paper we shall explain which age group is most affected by the financial crisis.

B. The interpretation of the results from model(2) is the following:
Adopting an approach of panel data,we performed separate linear multiple regressions for each year 2008 to 2014,covering most period of the financial crisis in the European countries.We fount the following results for year 2014 ,which are similar for any other year from2008 to 2014:

The statistic F is statistically significant at the level of significance 0,005
because F=5,79,with(3) and (31) degrees of freedom and p-value=0,0003<0,005 .
R=0,600,meaning that model (2) explains 60 % of variance in the dependent variable: at-risk-of poverty rate.

The independent variables :Social Protection(p-value=0,03), unemployment (p-value=0,02) and Gini Coefficient (p-value=0,03)were statistically significant at the level of significance (α=0,05).

The Variance Inflation Factor (VIF) is 1,01, indicating a very low multicollinearity. Model (2) has shown that the independent variables : Social Protection, Gini coefficient and Unemployment affect the dependent variable :at-risk-of poverty rate. This means that in periods of financial crisis the relative poverty of the various age groups of the whole

population increases and various social transfers and unemployment benefits are relief measures for the poor. *It is interesting to note that the coefficient of Social Protection has a negative sign.This means that the increase of social protection spending has the effect of reduction in the relative poverty of the population*.

4. Conclusions

We have shown that the socioeconomic indicator: At-risk-of poverty rate is associated with the Gini coefficient of income distribution which measures the income inequality of the different members of the population in a country, as well as the Social Protection Spending and the Unemployment rate. This has been shown for all the countries of Europe and for the years 2008 to 2014. The important conclusions are that the children are worst affected from the present financial crisis and that the income inequality increased during the present financial crisis in most countries of Europe. The present financial crisis has affected Greece as Graph 1 shows. In 2015, Greece was second in THE European countries, after Turkey, in the Socioeconomic index: at_risk_of-poverty rate. It could be interesting if these findings could serve as a guide to the political and economic authorities to relief the poverty of the various population groups by distributing social transfers and unemployment benefits.

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The consequences of the financial crisis for children and old age people in the European Union. Which age group has been most affected with respect to poverty and material deprivation?

Abstract

The effects of the financial crisis 2008-2017 in the European and world economy were the austerity and the increase of poverty for the population of countries in the cyclone of recession. In this paper we investigate the impact of the Great Recession of 2008-2017 on child and pensioner poverty across the EU-27 , including Switzerland, Ireland and Norway and compare the risk -of-poverty rate for children with the risk-of-poverty rate for elderly people.The findings of the paper are the following: a. The at-risk-of poverty rate for children is greater than the one for pensioners. b. There is a correlation between the working-age unemployment and child poverty. c. Social protection spending (social transfers and unemployment benefits) are an effective relief measure for poor children and elderly people. d. There is a statistically significant difference in the at-risk-of poverty for a single person before and after Social Transfers. The paper recommends that social spending should be directed more towards children than pensioners ,in line with the European Commission's goal : Investing in children.(EUROSTAT,2018),(EU,SILC,2016).

Key words: at -risk-of poverty rate ,children's poverty, pensioner's poverty, European Union ,Great Recession 2008-2017.

JEL :I,M,I3

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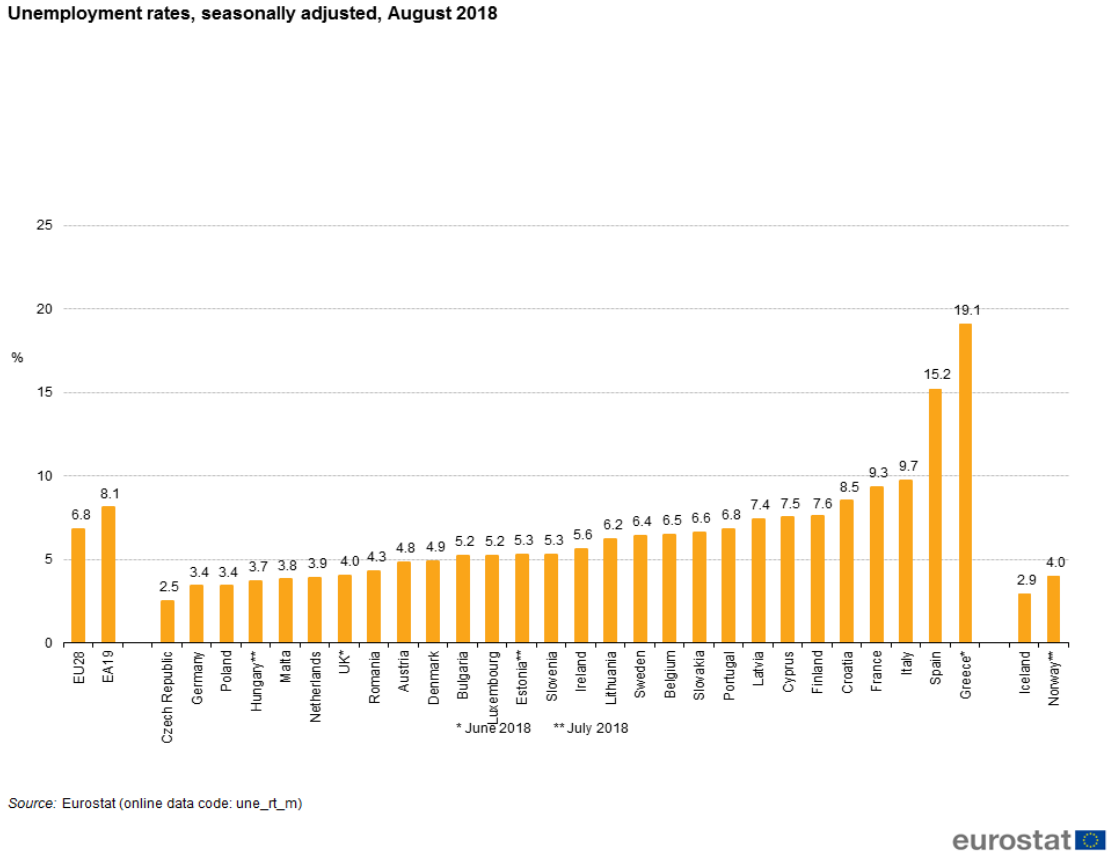
1. Introduction

The main consequences of the Great Recession(2008-2017) in the European countries, according to a series of research papers (Jenkins et al.(2013), Keeley and Love(2010), Mortorano(2014), Frangos et al.(2018)), are the following:

a.Rise of unemployment .
b.Rise of income inequality.
c.Reduction of Social transfers and unemployment benefits .
d. Rise in suicides and suicide attempts.
e.Reduction of Gross Domestic Output.
f. Reduction of salaries and pensions .
g. Deterioration of the conditions in Health, Education, Public Safety, Agriculture, Judicial System.
h. Reduction of exports and
i. Increase of a very important Socioeconomic index: at-risk-of poverty rate, concerning the population of countries where the financial crisis had remained for a long time, like Greece, Italy, Spain, Portugal, Fyrom ,Romania and Serbia. (EUROSTAT, Statistics Explained,2018), OECD(2014) ,(Bradshaw and Chzhen,(2015), Chzhen,(2017) , Caminada et al. (2012))

As a main result of the financial crisis in Europe,the following graph 1 is presented which shows the unemployment levels across countries of Europe in August 2018,where Greece is the country with the highestin unemployment level.



Graph 1. Unemployment levels of European countries in August 2018.

It is of interest, not only for academic research purposes, but as a policy guide to the political and economic authorities of each country to compare the risk-of-poverty rates for

the various age groups, especially children,(0-17) years old and people ,(65+) years old, mostly pensioners or living on social benefits.

The following table, shows the percentage of people at-risk-of poverty in each age group, for the 34 countries of Europe:

People at risk of poverty or social exclusion, by age group, 2016
(% of specified population)

	Total	Children (aged 0-17 years)	Adults (aged 18-64 years)	Older people (65 years and over)
EU-28	23.5	26.4	24.2	18.2
Euro area (EA-19)	23.1	25.3	24.3	17.3
Belgium	20.7	21.6	21.7	16.4
Bulgaria	40.4	45.6	37.2	45.9
Czech Republic	13.3	17.4	13.0	10.1
Denmark	16.7	13.8	20.2	9.2
Germany	19.7	19.3	20.2	18.3
Estonia	24.4	21.2	20.3	41.4
Ireland	24.2	27.3	24.4	17.4
Greece	35.6	37.5	39.7	22.0
Spain	27.9	32.9	30.4	14.4
France	18.2	22.6	19.2	10.0
Croatia	27.9	26.6	26.9	32.8
Italy	30.0	33.2	31.5	23.2
Cyprus	27.7	29.6	28.1	22.9
Latvia	28.5	24.7	25.0	43.1
Lithuania	30.1	32.4	27.3	37.4
Luxembourg	19.8	22.7	21.0	9.1
Hungary	26.3	33.6	27.2	15.1
Malta	20.1	24.0	17.3	26.1
Netherlands	16.7	17.6	18.4	10.0
Austria	18.0	20.0	18.6	13.7
Poland	21.9	24.2	22.7	16.1
Portugal	25.1	27.0	25.6	21.8
Romania	38.8	49.2	37.0	34.0
Slovenia	18.4	14.9	19.1	19.9
Slovakia	18.1	24.4	17.6	12.3
Finland	16.6	14.7	18.2	13.6
Sweden	18.3	19.9	18.1	17.0
United Kingdom	22.2	27.2	21.8	18.0
Iceland	*12.2*	*14.4*	*12.7*	*6.3*
Norway	15.3	14.9	17.1	9.5
Switzerland	17.8	20.5	15.0	25.5
Former Yugoslav Republic of Macedonia	41.1	46.1	40.8	34.6
Serbia	38.7	40.3	40.5	31.2
Turkey (')	41.3	48.2	38.5	37.8

(') 2015.
Source: Eurostat (online data code: ilc_peps01)

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Table 1. Percentage of at-risk -of poverty people for the ages (0-17) and (65+) for all the European Countries in 2016**.**

2. Comparison of the risk-to poverty for children and pensioners by Statistical procedures

The paired -data statistical test for comparing means is applied to the data of Table 1,using the Statistical Package for Social Sciences,version 21, (Pallant,(2008), IBM-SPSS INSTITUT(2015).

The following table 2, shows the results:

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	% of children at-risk-of poverty,2016,age(0-17) years,2016 - % of old people at-risk-of poverty,2016,age (65+) years,2016	5,31111	8,79239	1,46540

Paired Samples Test

		Paired Differences		
		95% Confidence Interval of the Difference		
		Lower	Upper	t
Pair 1	% of children at-risk-of poverty,2016,age(0-17) years,2016 - % of old people at-risk-of poverty,2016,age (65+) years,2016	2,33619	8,28603	3,624

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	% of children at-risk-of poverty,2016,age(0-17) years,2016 - % of old people at-risk-of poverty,2016,age(65+) years,2016	35	,001

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	% of children at-risk-of poverty,2016,age0-17 years,2016	26,6889	36	9,83006	1,63834
	% of old people at-risk-of poverty,2016,age 65+ years,2016	21,3778	36	10,83052	1,80509

Table 2.Paired-samples test on the relative poverty rates for children and old people (data of table 1)

From the above results, we conclude that there is a statistically significant difference of the mean at-risk-of poverty rates of children (0-17) years old and old people 65+ years old. It is shown that t-test=3,624, df=36, p-value=0,001<0,005. The mean at-risk-of poverty

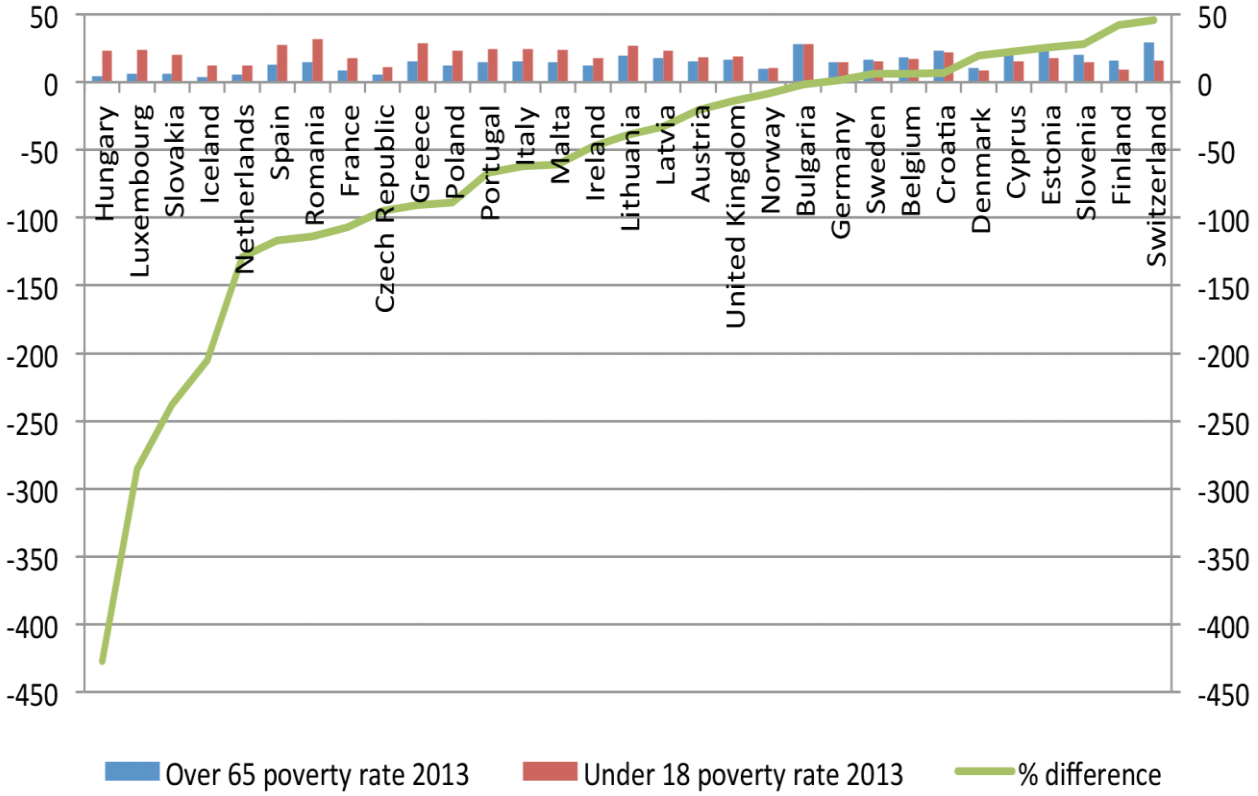
rate for children is 26,69, whereas the mean at-risk-of poverty rate for people (65+) years old is 21,38 for all the European Countries on 2016.

3.Ranking of the European Countries with respect to the difference (at-risk-of poverty rate for old people)-(at-risk-of poverty rate for children)

During the first 4 years of Economic crisis in Europe, spending in Social transfers in Euros purchasing power parity(PPP) has fallen in 13 European countries, mainly in the South and South-Eastern part of Europe, for which Eurostat provides comparable data .(Chzhen,Hamalainen and Vargas(2014)) .

(UNICEF, Office of Research Innocenti (2014).Social protection benefits on pensioners increased more than Social Protection benefits on children in every country except Switzerland, Germany, Bulgaria and Turkey.

It is of interest to see the ranking of European countries with respect to the difference of the at-risk-of-poverty rate for old people (65+) years old minus the at-risk-of_poverty rate for children (0-17) years old .Bradshaw and Chzhen,(2015) provide the following graph which shows the ranking of the European countries with respect the above difference. One observes that in 21 countries the above difference is negative in favor of the old people and in 13 countries the above difference is positive in favor of the children:



Graph 2. Variation in the effectiveness of transfer systems in European countries.

All countries reduce their pre-transfer poverty rates through transfers, but the percentage reduction varies from 27% in Greece to78% in Finland. Belgium starts with a middling to low pre-transfer child poverty rate and its transfers reduce child poverty by 48%.

4. The effect of social transfers on the socioeconomic index: at-risk-of poverty rate.

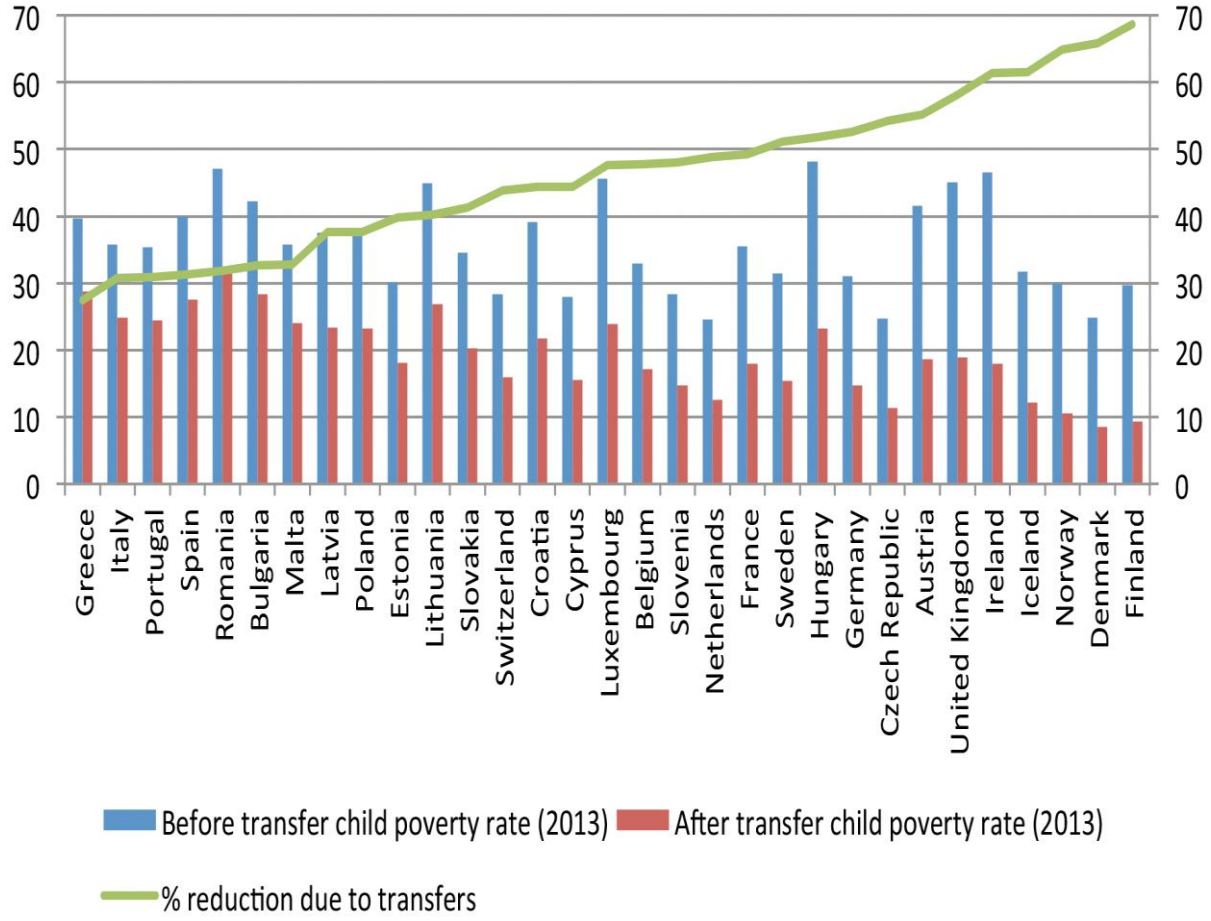
The factors which influence child poverty in any country are three:

A.Demographic change-for example change in the proportion of lone-parent families or families with three or more adults

B.Unemployment or partial employment or employment with low pay,and
C. Policy changes such as changes on spending as social transfers for families with children.

During the financial crisis, demographic changes in most countries have been negligible.On the other hand, unemployment had increased and many countries have adopted the policy of reducing their deficits by reducing the social transfers. We are interesting to know what is the percentage reduction in at-risk-of poverty rates in the European countries. This percentage varies, from 27% in the case of Greece to 78% in the case of Finland. This means that the social transfers in Greece were very limited whereas the social transfers in the rich countries were very generous.

The following graph 3 shows clearly the variation in percentage reduction of the child property before and after social transfers:



Graph 3. : Pre- and Post-Transfer child poverty rates 2013,pensions excluded.
Source:Bradshaw and Chzhen (2015), EUROSTAT, Statistics Explained (,2018)

4a.Comparison of the children's poverty before and after Social Transfers by Statistical Procedures

The following table 3, shows the at-risk-of poverty rates for a single person in 2015 and 2016.

At-risk-of-poverty rate for a single person before and after social transfers, 2015 and 2016
(%)

	At-risk-of-poverty:			
	before social transfers		after social transfers	
	2015	2016	2015	2016
EU-28	26.1	25.9	17.3	17.3
Euro area (EA-19)	25.7	25.7	17.2	17.4
Belgium	26.7	26.3	14.9	15.5
Bulgaria (')	28.4	27.9	22.0	22.9
Czech Republic	16.8	16.3	9.7	9.7
Denmark	25.8	24.9	12.2	11.9
Germany	25.1	25.3	16.7	16.5
Estonia	27.8	28.9	21.6	21.7
Ireland	36.2	34.7	16.3	16.6
Greece	25.5	25.2	21.4	21.2
Spain	30.1	29.5	22.1	22.3
France	23.9	23.6	13.6	13.6
Croatia	31.0	27.3	20.0	19.5
Italy	25.4	26.2	19.9	20.6
Cyprus	25.4	25.0	16.2	16.1
Latvia	27.3	27.8	22.5	21.8
Lithuania	28.6	27.9	22.2	21.9
Luxembourg (')	27.2	27.1	15.3	16.5
Hungary	25.7	25.8	14.9	14.5
Malta	23.7	23.8	16.3	16.5
Netherlands (')	22.3	22.1	11.6	12.7
Austria	25.6	26.3	13.9	14.1
Poland	22.9	22.9	17.6	17.3
Portugal	26.4	25.0	19.5	19.0
Romania	29.3	29.5	25.4	25.3
Slovenia	24.8	24.3	14.3	13.9
Slovakia	19.0	18.4	12.3	12.7
Finland	26.8	27.0	12.4	11.6
Sweden	29.8	29.9	16.3	16.2
United Kingdom	29.3	28.1	16.6	15.9
Iceland	*19.9*	*19.8*	*9.2*	*8.8*
Norway	26.5	26.3	11.9	12.2
Switzerland	24.9	24.7	15.6	14.7
Former Yugoslav Republic of Macedonia	24.8	25.7	21.5	21.9
Serbia	37.2	35.9	25.4	25.5
Turkey	24.2	:	22.5	:

(') Break in series.
Source: Eurostat (online data codes: ilc_li10 and ilc_li02)

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Table 3.At-risk-of poverty rates for a single person in 2015 and 2016.

It is of interest to find whether the mean difference in the index :at-risk -of poverty for a single person before and after social transfers in 2015 is statistically significant.

The paired -data statistical test for comparing means is applied to the data of Table 3, for 2015, using the Statistical Package for Social Sciences, version 21, (Pallant,(2008),IBM-SPSS INSTITUT(2015)).

The following table 4, shows the results**:**

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	at -risk-of poverty rate before social transfers for a single person in 2015	26,3500	36	3,98006	,66334
	at -risk-of poverty rate after social transfers for a single person in 2015	17,1833	36	4,26578	,71096

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	at -risk-of poverty rate before social transfers for a single person in 2015 & at -risk-of poverty rate after social transfers for a single person in 2015	36	,587	,000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	at -risk-of poverty rate before social transfers for a single person in 2015 - at -risk-of poverty rate after social transfers for a single person in 2015	9,16667	3,75386	,62564

Paired Samples Test

		Paired Differences		
		95% Confidence Interval of the Difference		
		Lower	Upper	t
Pair 1	at -risk-of poverty rate before social transfers for a single person in 2015 - at -risk-of poverty rate after social transfers for a single person in 2015	7,89654	10,43679	14,652

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	at -risk-of poverty rate before social transfers for a single person in 2015 - at -risk-of poverty rate after social transfers for a single person in 2015	35	,000

Table 4.Paired-samples test on the relative poverty rates of a single person before and after social transfers. (data of table 3).

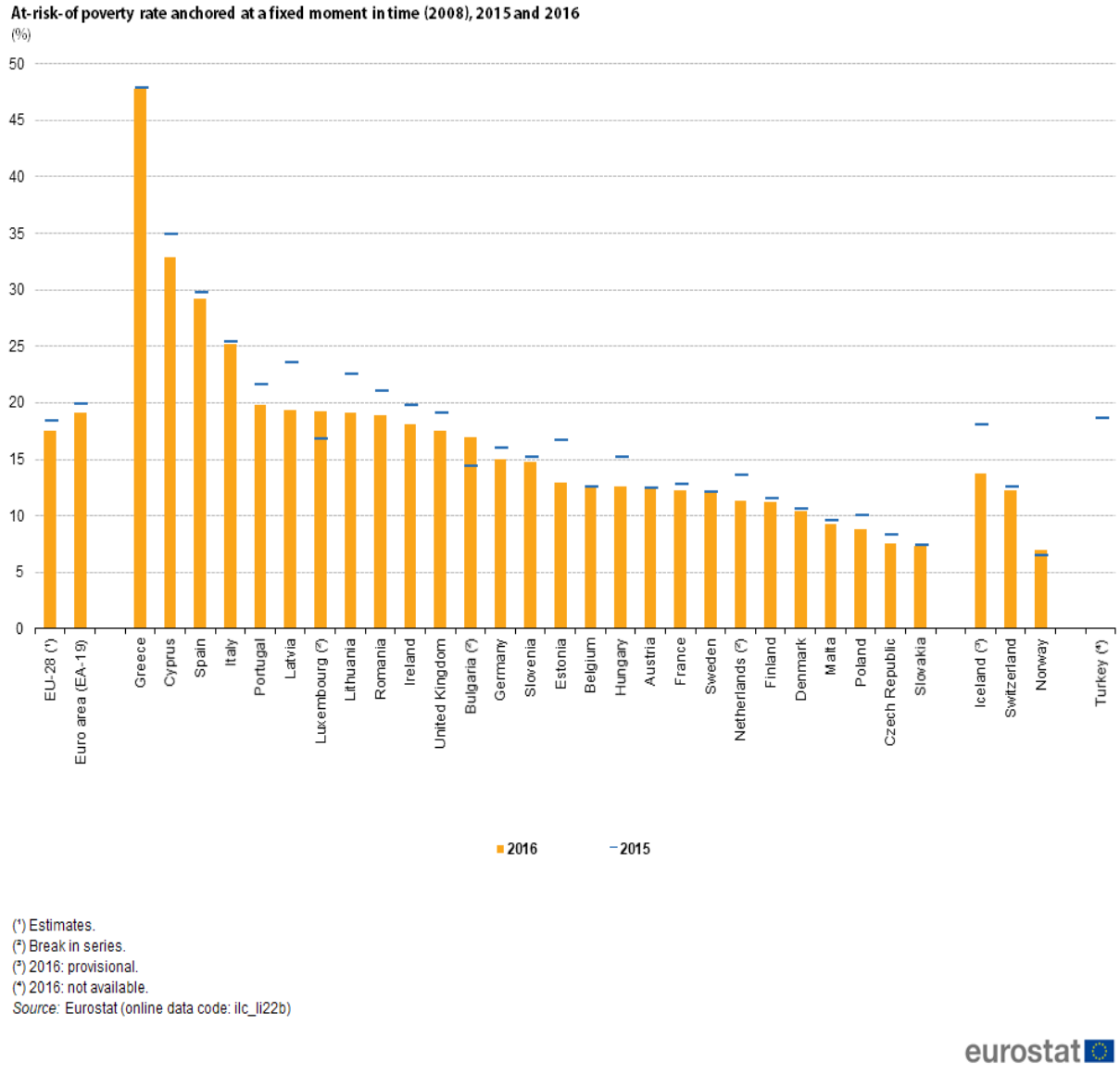
We find that
t-test=14,66, df=36, p-value=0,0001<0,005.
Hence , the difference in at-risk-of poverty rates before and after social transfers in 2015 is statistically significant.

5. Source of Data

The data used in this section are primarily derived from
EU statistics on income and living conditions (EU-SILC).,
EUROSTAT Statistics Explained
Data extracted in May 2018.
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Proportion_of_the_population.

The reference population is all private households and their current members residing in the area of an EU Member State at the time of data collection; persons living in collective households and in institutions are generally excluded from the target population.

The EU-28 aggregate is a population-weighted average of individual national figures. The following graph 4 shows the index: at -risk-of poverty rate anchored at a fixed moment in time (2008),2015 and 2016.This means that the poverty threshold (60% of the national median income), (Frangos,2018), has been considered as the one existing in 2008, adjusted for inflation.



(1) Estimates.
(2) Break in series.
(3) 2016: provisional.
(4) 2016: not available.
Source: Eurostat (online data code: ilc_li22b)

eurostat

Graph 4 . Index: at -risk-of poverty rate anchored at a fixed moment in time (2008), 2015 and 2016,for all the countries in Europe**.**

6. Conclusions

In this paper we have shown two important results:

a. There is a statistically significant difference of at-risk-of poverty rates for old people minus the at-risk-of-poverty rates for children.

b. In the European Union, spending on the old people had risen in all countries since 2008 . However, spending on children has fallen in more than 30% of the countries.

c. There is a statistically significant difference of at-risk-of poverty rates for a single person before and after Social Transfers in all European countries.

d. The European Commission Social Investment Package (SIP) is a stimulus for European countries to focus on social investment. The public policies for social investment are designed to improve human capital and serve as a support base for people's participation in economic and social life.The return of social investment is certain during the life-cycle of the people who are the beneficiaries of the social protection benefits. Hence ,one expects that children would and should be given priority in social investment from the heads of economic and social policies in the European countries.

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Greek Economy Competitiveness 2010 – 2018

Abstract:
This paper concentrates on the analysis of the Greek economy's competitiveness during the period of 2010 – 2018. We intend to stress on the sectors of the Greek economy which were heavily affected either in a positive or a negative way during the years of recession.

In 2009 Greece confronted a fiscal crisis as a result of a wider economic downturn in western economies in 2008 and of its unsustainable sovereign debt. Greek economy suffered from twin deficits (fiscal and trade), while the general government deficit as a share of the GDP in 2010 was projected to reach 12,5%. At the same time, public debt had surpassed 300 billion euros. The late response of the Greek government by taking fiscal measures didn't succeed to appease international markets and to regain their confidence. Hence, the spreads of Greek government bonds reached an unprecented height of 367 units. The competitiveness of the Greek economy during the years 2001 – 2009 had collapsed by 19% based on the relative consumer price index and by 28% based on relative unit labour cost among 28 countries. As a result, in May 2010 the two counterparts of the International Monetary Fund, European Central Bank and the European Commission decided to offer financial support to Greece, anticipating the collapse of its economy and a potential domino effect in the global economy.

Since 2010, Greece endured an austerity program signing three Memorandums of Economic and Financial Policies (2010, 2012, 2015); taking regulatory measures in the financial and the public sector in order to eliminate its high public debt and deficit. In addition, Greece took steps to rationalise its public management by implementing an internal devaluation. That devaluation led many businesses to go bankrupt or to layoff employees resulting in the rise of the unemployment index to 24.3% in 2012. Additionally, the minimum wage was cut by 22 per cent in 2012 and the poverty rate rose from 28,1% in 2008 to 34,8% in 2017.

Throughout this paper we will attempt to offer an understanding of the Greek economy competitiveness drop from the 67th position in 2008-2009 to the 87th in 2017-2018 and its subsequent rise to 57th in 2018 based on the "The Global Competitiveness Report" of the World Economic Forum (WEF). From a methodological perspective, we will take into consideration the data provided by the World Economic Forum report. We will categorise our analysis in the twelve pillars of competitiveness based on the WEF report and in particular the qualitative or quantitative determinants which affected the Greek economy the most during the period between 2010-2018. Our analysis will be accompanied by chart visualisations, averages and growth rate estimates.

Apart from the data on Greek economy from the World Economic Forum we will refer to academic studies and reports of European and national institutions on the Greek economy and competitiveness before and during the recession years.

Key-Words: Greek Competitiveness, Recession, Austerity, Internal Devaluation
JEL:I3,J3

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1. Introduction

The burst of a speculative bubble in the American mortgage market in 2008 led to a chain of financial crises threating the global economy, and one of the weakest links was proven to be the Greek economy. Our aim in this paper is to review the performance of the Greek economy's competitiveness during the years 2010-2018, being under the supervision and the financial support of the three institutions (European Commission, European Central Bank, International Monetary Fund) and undergoing the implementation of a set of austerity measures aiming to rationalise its economy at the expense of its banking and market liquidity. In addition, we will try to investigate the conditions that should be fulfilled in order to improve the index's ranking of Greece.

In particular, Greece had already been sufferingin 2009 from double deficits, with its fiscal deficit to soar at 15,2% of the GDP and the government account deficit at 12,3% of the GDP. This had plummeted the competitiveness of the Greek economy. Since the credit ranking of Greece was downgraded by Standard and Poor's, losing its credibility and consequently its access to the international bond market, in May 2010 Greece came to an agreement with the IMF signing its first economic adjustment program, granting to the Greek economy a loanof €110bn. The implementation of austerity measures led to a loss of 14,1% of GDP and to an unprecedented increase in unemployment to 17,9% in 2011. The following year, a second Memorandum of Understanding was agreed between Greece, the IMF and the EU; the additional loan took the total loaned amount to €164,5bn. The lack of political stability in the country in the following years led the Greek population in 2015 to start withdrawing their deposits risking the liquidity and survival of the banking system. As a result, capital controls and a third economic adjustment program were implemented in Greece increasing the granted loan by €86bn. Hence, with Greece suffering from a deepening recession, its competitiveness followed the same course.[3]

What does competitiveness mean exactly though? According to the definition ofScott and Lodge in 1985, competitiveness is*a country's ability to create, produce, distribute and/or service products in international trade while earning rising returns on its resources*[4]. Also, Paul Krugman defined it in 1994 as *our ability to produce goods and services that meet the test of international competition while our citizens enjoy a standard of living that is both rising and sustainable*[5].

According to the World Economic Forum,*competitiveness is defined as the set of institutions, policies, and factors that determine the level of productivity of a country. The level of productivity, in turn, sets the level of prosperity that can be earned by an economy. The productivity level also determines the rates of return obtained by investments in an economy, which in turn are the fundamental drivers of its growth rates. In other words, a more competitive economy is one that is likely to sustain growth.*[6]

2. Methodology and Limitations

The empirical part of the paper is based on8 years of data analysis between 2010-2018. In the process we used 110 variables of the competitiveness index which were divided into 12 pillars. The index which was chosen for the analysis was the World Economic Forum annual Index Report, which is based on the Global Competitiveness Index (GCI).The Global

[3]Hardouvelis G.A. & Gkionis I. (2016). A Decade Long Economic Crisis: Cyprus versus Greece. Cyprus Economic Policy Review. Vol.10,No2, pp. 5-9

[4]Scott, B. R. & Lodge, G. C. (1985). U. S. competitiveness in the world economy. Harvard Business School Press, p. 3

[5]Krugman P. (1994). Competitiveness: A dangerous obsession. Foreign Affairs, Vol. 73, No2, p. 31

[6]Sala-I-Martin X. et Artadi E. (2015). The Global Competitiveness Index.Global Competitiveness Index Report, pp. 51-80

Competitiveness Index Growth was created by the merging of the Competitiveness Index and the Business Competitiveness Index.[7]

In order to group each variable based on its level of riskwe took the 8-year average of each variable and divided them into clusters using the Knime software, creating three distinct groups. Then we distinguished and analyzed the variables in cluster 2, as it is projected in table 1, which exerted the higher risk on Greek Competitiveness over the examined period.The limitations of our research include the fact that a number of variables were not continuously used in the World Economic Forum Report. As a result, these variables were excluded and we kept only those with at least 7-8 yearsof data.

3. Results

First and foremost, in 2008 at the peak of the global economic crisis, Greece was ranked by the Global Competitiveness Index at the 67th position leaving behind only two other European Union countries, Romania and Bulgaria, at the 68th and the 76th positions respectively. As the recession in Greece was deepening the Greek economy's competitiveness started to plummet as well reaching the 96th position in 2012, between the economies of Serbia and Jamaica, while being surpassed by Vietnam, Cambodia and Lebanon. Since then a steady improvement took place elevating the country to the 81st position in 2014 and 2015. Furthermore, data analysis showed that in 2018 the ranking of Greece reached a better position at the57th rank. The course of the Greek Competitiveness Index is presented in figure 1.

Figure 1 Global Competitiveness Index Greece (2008-2018)

[7] ibid

Furthermore, we clustered and isolated the 8-year data average of each variable, in order to analyze below the most threatening risks towards the improvement of the Greek economy's competitiveness. The clusters developed in Knime Software and used in the research are shown in table 1. Thus, the pillars which experienced higher risk over the examined period are: **Institutions, Macroeconomic Environment, Higher and Primary Education, Good Market Efficiency, Labor Market Efficiency, Financial Market Development, Technological Readiness, Business Sophistication, and Innovation**. The variables in high risk are shown in table 2 in the appendix.

Table 1 Clusters of Average Rank of Variables (2010-2018)

Clusters	Average Rank (2010-2018)
Cluster 0	25,45
Cluster 1	70,19
Cluster 2	112,455

3.1 Institutions

The index of each country is formed by specific variables which are divided into 12 pillars. The first pillar is institutions, concerning the public and the private sectors, the efficacy of the judicial system, as well as the reliability of the police and the height of organized crime and terrorism.

With reference to the public sector, during the last decade Greece experiencedsignificant drawbacks as the burden of government regulation, low governmental transparency, diversion of public funds, favoritism in decisions of government officials, as well as the wastefulness of government spending reached an unprecedented rank at the 104-144rd position, especially during the years 2012 and 2013. As a result, the 'public trust of politicians'variable was also gravely influenced during the same period ranking at the 123rd, the 141rd and the 138rd positions during the years 2011-2013. The 'public trust of politicians' was slightly improved reaching the 106th rank in 2017.The trend of variables in this pillar can be seen in figure 2.

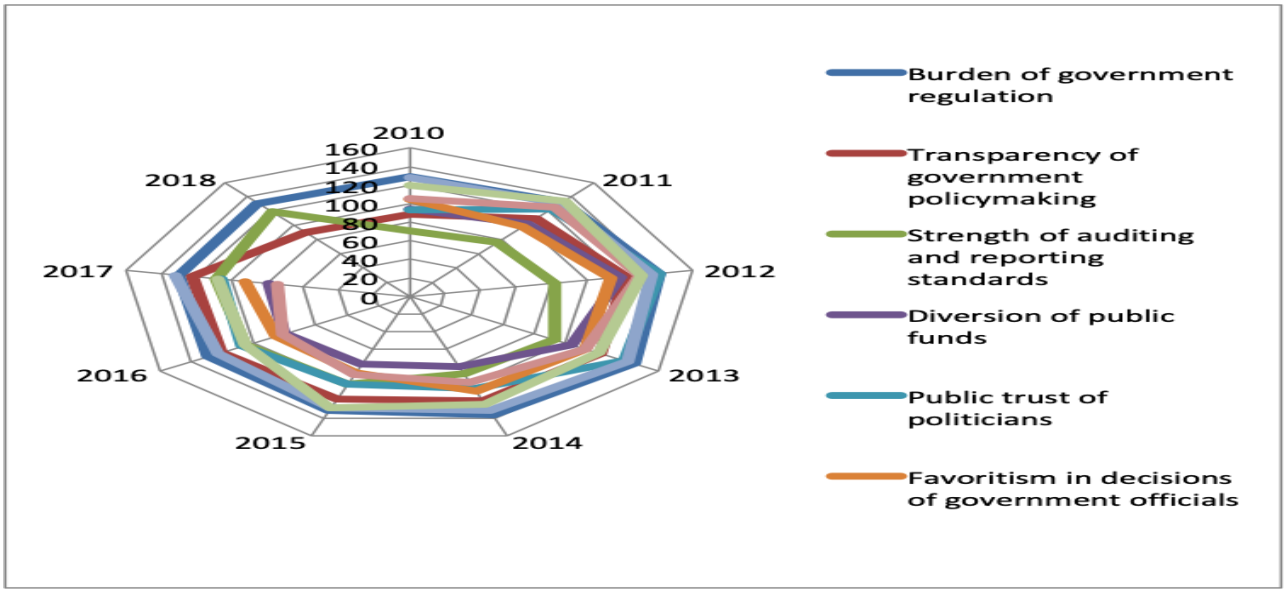

Figure 2 institutions in Greece (2010-2018)

3.2 Macroeconomic Environment

Without a doubt Greece in the past suffered from an unsustainable government deficit which had resulted in the creation of an extremely vulnerable macroeconomic environment. The same period (2012) that the rest of the Eurozone had an average surplus of 0.95% of GDP, Greece was striving to cope with a deficit of -5,32% of GDP[8]. Hence, Greece ranked over the 130th position since 2010 until 2013in the framework of the World Economic Forum Index's variable Government Surplus/Deficit, as it can be seen in the figure below. However, the adoption of supplementary measures towards the rise of its tax revenue has led to a government surplus since 2014, ameliorating the position of Greece among the rest of the countries in the index's ranking. On the contrary, theaggregate indebtedness brought the Greek economy to its knees exceeding the 130th rankin the World Economic Forum Index over the examined period. The same course followed the variables of the National Savings Rate and the Country's Credit Rating as well, reaching a peak at 135rd and 129rd in 2012 and 2013.

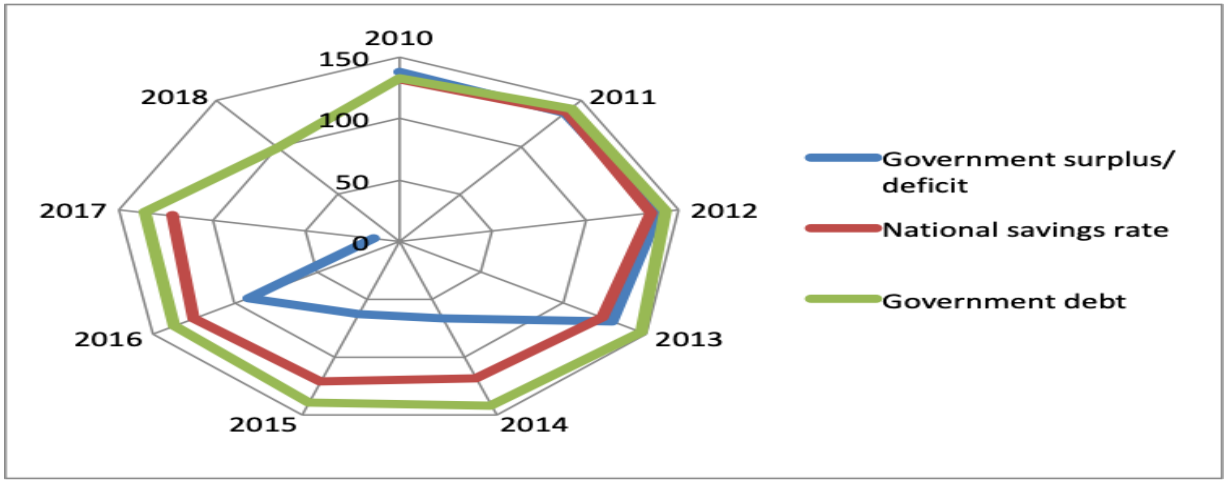

Figure 3 Macroeconomic Environment in Greece (2010-2018)

3.3 Higher Education and Training

Among the variables in the pillar of Higher Education and Training, Greece underscored the most in the quality of the educational system. Indeed, in a total of 144 countries, Greece was ranked during the years 2010-2018 between 106th – 120th positions, reaching its peak in 2011. However, as far as it concerns the variablequality of management schools, apart from the years 2011 and 2012, Greece did relatively well, positioning in the 80th rank. However, during the data analysis,therewas observed a lack of staff training, scoring in the variable of the extent of staff training over the 110th position during the years 2010-2014. Last but not least, Greece underscored in the local availability of research and research services as well, starting in the 88th rank and reaching steadily the 106thposition in 2016,descending at the 100th position in 2017. Below in figure 4 we project the behavior of each variable in the pillar of Higher Education and Training for the years 2010-2018.

[8]Economakis G., Markaki M., Anastasiadis A. (2015). Structural Analysis of the Greek Economy. Review of Radical Political Economics, Vol. 47, No. 3, pp. 424-445.

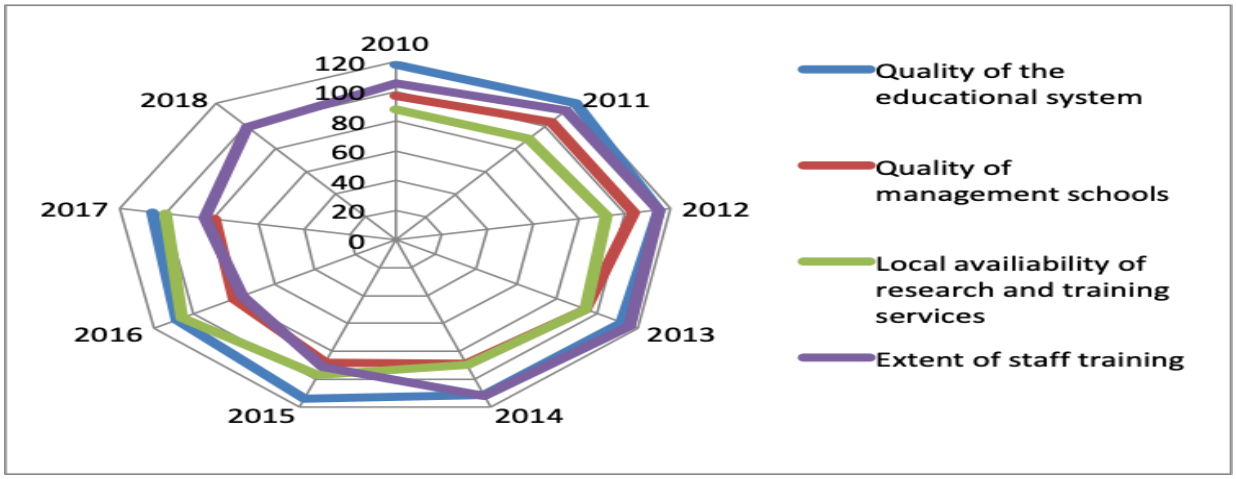

Figure 4 Higher Education and Training in Greece (2010-2018)

3.4 Goods Market Efficiency

As far as it concerns the pillar of Goods Market Efficiency the variables which were singled out were the Total Tax Rate and the Extent and Effect of Taxation. The Total Tax Rate since 2012 really increased in the expense of Greek Competitiveness. Thus, the rising of taxes led to a worsening of the Extent and effect of Taxation experiencing a free fall in 2013 at the 142nd rank and remaining over the 136th rankuntil 2018, among 144 countries. Unexpectedly, the agricultural policy costswere really high, downgrading the ranking of Greece between the 119 – 144th position over the examined period.

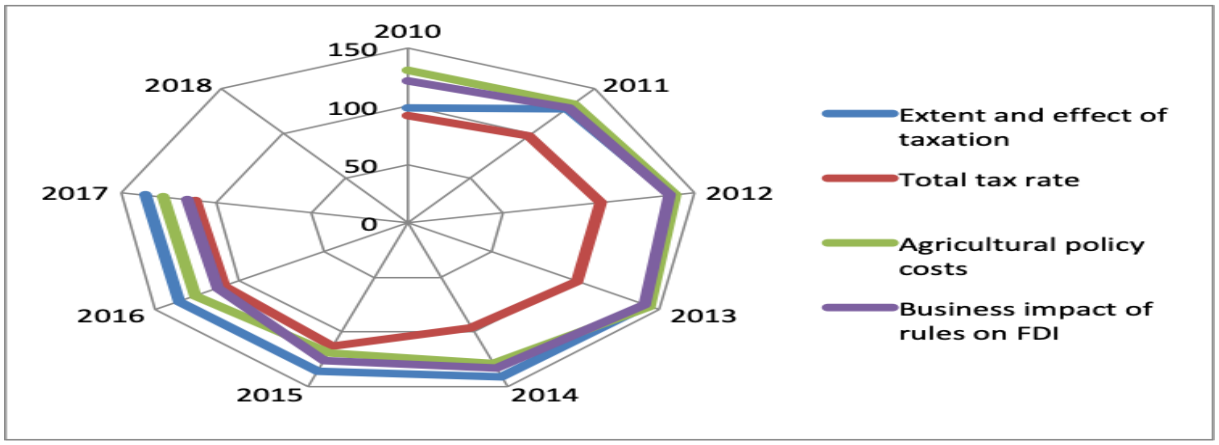

Figure 5 Good Market Efficiency in Greece (2010-2018)

3.5 Labor Market Efficiency

In the Labor Market, the situation was not in favor for Greece as during the first years of recession, until 2013 and 2014, the Cooperation in labor-employer relations, as well as the flexibility of wage determination, were ranked at the 130th and 136th position respectively. The same downward trend, as it is shown in figure 6, followed the Hiring and Firing Practices, the Pay and Productivity, as well as the Reliance on Professional Management. A small improvement took place during the next years, though without exceeding the 80th rank among the rest of countries.

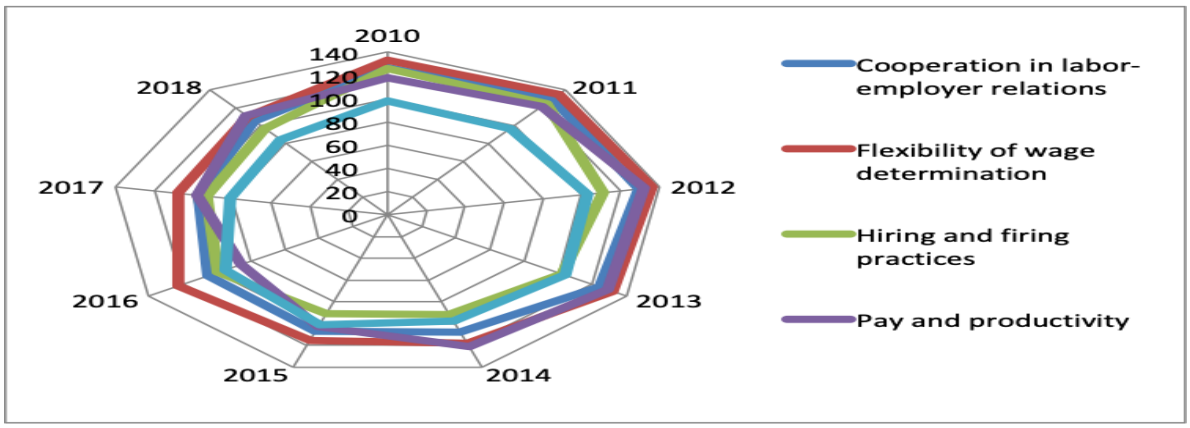

Figure 6 Labor Market Efficiency in Greece (2010-2018)

3.6 Financial Market Development

The data processing revealed the Financial Market Development as a serious pitfall for Greek Competitiveness. In particular, eventhough during the first years of the examined period the banking sector and the available financial services seemed almost unaffected by the recession, since 2012 the sector experienced a serious deterioration. In fact, Greece was ranked between the 135th and the 146th position from 2012 until 2018 in the variables of the Ease of Access to Loans as well as of the Venture Capital Availability. Also, the same course went hand in hand with the variables of the Availability and the Affordability of Financial Services as well as the Soundness of Banks and the Financing through Local Equity Market reaching the 136th rank since 2013. Last but not least, a steep deterioration was also seen in the Regulation of Securities Exchange and the Legal Rights Index. In fact, our research showed that the majority of the variables in this pillar is heavily affected until today, situated among the least developed economies of the World Economic Forum Index.The trend of the pillar is shown in figure 7 below.

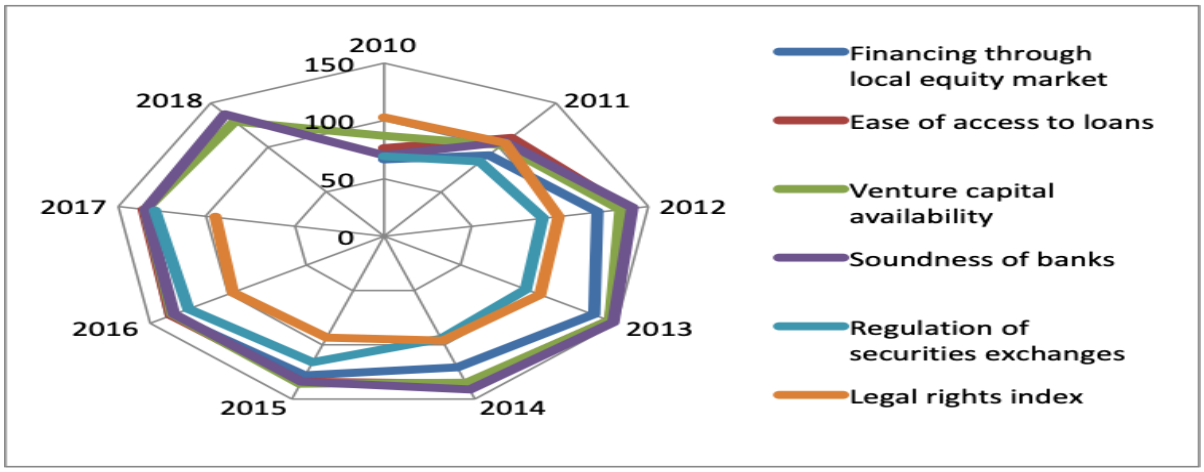

Figure 7 Financial Market Development in Greece (2010-2018)

3.7 Technological Readiness

In the pillar of Technological Readiness, as it can be seen in figure 8, Greece did really well during the years 2010-2018 especially concerning the variable Availability of latest technologies. However, the FDI and technology transfer variable seemed a hurdle to staying in between the 109th (2010) and the 112th position (2018).

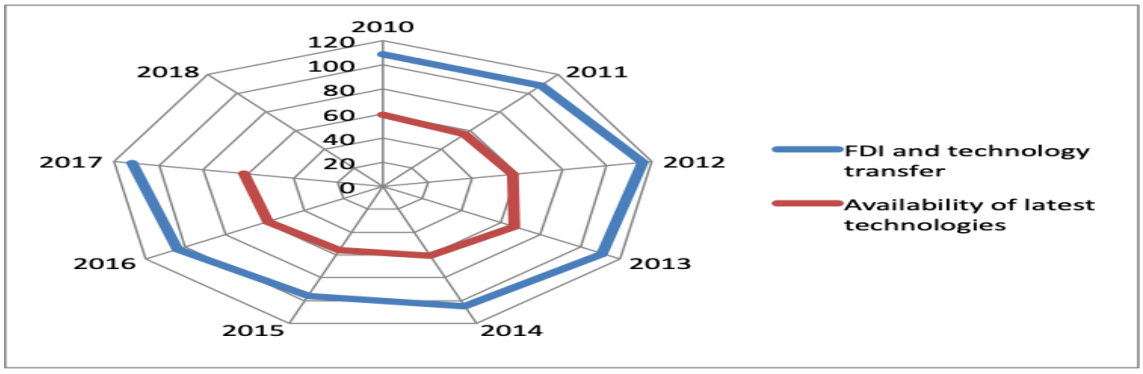

Figure 8 Technological Readiness in Greece (2010-2018)

3.8 Business Sophistication

As far as the Business Sophistication pillar is concerned, two variables that drew our attention were: the State of Cluster Development and Willingness to Delegate Authority. The performance of Greek Economy in attracting cluster development was not satisfying, proving a serious difficulty to sustaining its rank below the 125th position for the most of the examined period, reaching the 127th position in 2018. The same course was followed in the case of Willingness to Delegate Authority, as Greece was ranked at 102nd position in 2010 and 100th in 2018, peaking at 110 Rank in 2012.The course of the variables during the examined period is projected in figure 9 below.

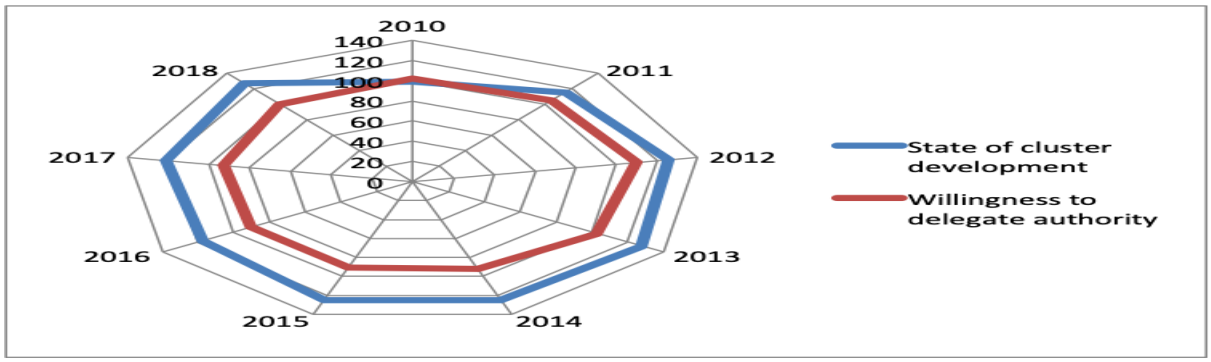

Figure 9 Business Sophistication in Greece (2010-2018)

3.9 Innovation

The Capacity for Innovation of the Greek Economy underperformed during the years 2010-2017. Also, the variable Company Spending on R&D peaked the first three years (2010-2013) at 126th to 129th position. However, in more recent years, Greece managed to improve its standing in both variables. The most astonishing improvement took place in the Company Spending on R&D reaching the 40th position, lowering the Competitiveness of the Country. However, the lack of University-Industry Research Collaboration in R&D continued to pose a heavy strain on the economy through the examined period justifying its nonetheless disappointing ranking since 2010 between the 112th and the 129th positions. The same failure was identified in the variable of Gov't Procurement of Advanced Tech Products peaking at 141st rank in 2013. The trend of variables in innovation is shown in figure 10 below.

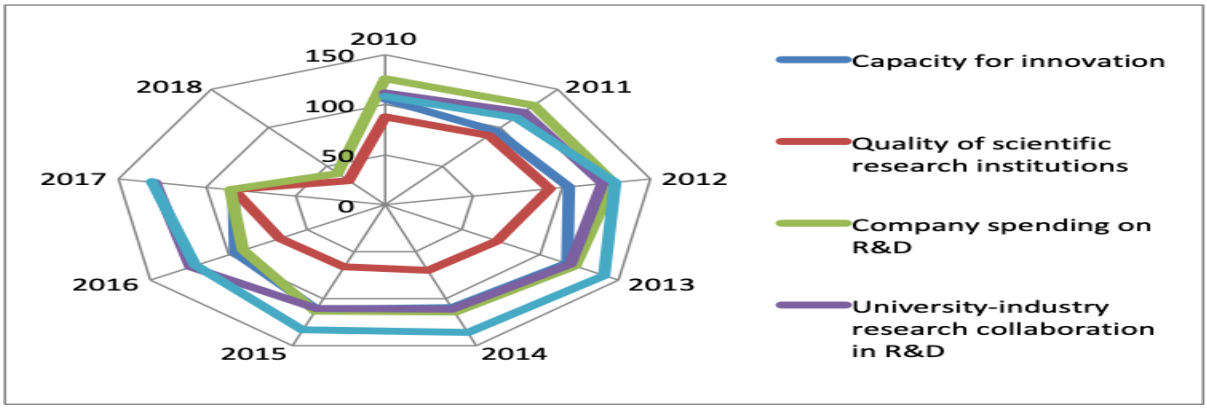

Figure 10 Innovation in Greece (2010-2018)

4. Discussion

From theanalysis presented in the previous section, we can conclud that the Greek economyis suffering in diverse fields, which are required in order for a countryto be competitive on an international level.To sum up, the risks which posed and still posean imminent threat upon the Greek economy over the examined years (2010-2018)are the Government Debt, the Burden of government regulation, the Extent and effect of taxation, the Wastefulness of government spending, the Agricultural policy costs, the Efficiency of legal framework in settling disputes, the National savings rate, the Business impact of rules on FDI, the Ease of access to loans and the Venture capital availability.

Through this period of recession Greecehas lost 25% of its GDP; from $332billion in 2007 it was diminished to $239 billion in 2013 and to $200billion in 2018. The unemployment rate is steadily at 21,1% and the official Greek debt stands at €330billion, exceeding 180% of GDP[9][10]. In the meantime the tax rate is skyrocketing, putting a strain on households with taxes ranging from 19,4% to 32,4% in 2016, while the average in the OECD countries was 15,2%-30,8%. Moreover, the tax rate on the private sector was much more severe at 50,7%, exceeding the OECD average which was in 2016 at 40,9%.[11][12]

Indeed, the burden of government regulations seems to be a problem of great importance towards the function of the private sector as well. In fact, the issue of an excessive number of laws and regulations burdening the tax system, making it costly and time-consuming for business and individuals, has led to a creation of a shadow economy which also results in lower public revenues due to tax evasion.[13][14]

Looking on the bright side, the data-analysis also showedthat the performance of Greece in the sector of infrastructure during the last decade was relatively good. In particular, the quality of overall infrastructure clearly depicts a downward trend, starting from the 49th position in 2008 and steadily deteriorating towards the 64th position in 2016 falling again to the 63rd position in 2018. The quality of the railroads seems to experience the most crucial problems as over the examined period it exceeded the 60th position in the ranking, reaching the 77th position in 2018. At the same time, the quality of roads, ports, and airports peaked at

[9]Mink M., & de Haan J. (2013). Contagion during the Greek sovereign debt crisis. Journal of International Money and Finance, Vol. 34, pp. 102–113

[10]Zettelmeyer J., Avgouleas E., Eichengreen B., Maduro M.P., Panizza U., Wyplosz C., Porter R., di Mauro W.B. (2018). How to Solve the Greek Debt Problem. Peterson Institute for International Economics

[11]Macdonald, R. (2018). A Financial and Economic Crisis in Greece. Eurocritical, pp. 25–84

[12]https://data.worldbank.org/country/greece

[13]Katsios S. (2006). The shadow economy and corruption in Greece. South-Eastern Journal of Economics, Vol. 1, pp. 61-80

[14]Kottaridi C. & Thomakos D. (2018). "Regulate me not": The regulatory failures of taxation: A tale from Greece. Manage Decis Econ, pp. 1–9

the 74th and 71st positions in 2010 and 2012 respectively. Nowadays, Greece has improved its infrastructure returning below the 40th position in the index.

As far airport infrastructure is concerned, in Greece there are 39 commercial airports, of which 15 are international, 13 are hybrid and 11 are designed for domestic flights. Among them, 28 are constructed on Greek islands[15]. Moreover, 14 regional airports were acquired in 2016 by the German group Fraport and Sentel. Results of recent research on Greek airports showed that the average airport increased their productivity by 3,6%, as a result of improvements in technology and technical efficiency.[16]

The railways, however, need renovation, since they haven't been renovated sincethe 1990s, with a 2550km long track which is obstructed by the mountainous terrain. The main drawback of the Greek railways is the limited speed of 160km/h without the option of electric traction explaining its low efficiency and ranking in the Global Competitiveness Index. Moreover, the quality of roads has improved in recent years expanding the existing national roads by constructing a series of Motorways like the Egnatia, the Ionian, the Attica, the Nea Odos, the Aegean, the Olympia Odos and the Moreas, minimizing the distances for commuters between Northern and Southern Continental Greece.[17][18]

Also, the outburst of the economic crisis in 2008 and the subsequent recession led the Greek local governments, which were exposed to debt and limited liquidity, to spend less and to save more money, leaving behind the politics of patronage and the political party mechanisms as a medium towards public support and popularity. The implementation of the Kallikratis reform reduced the number of the existing local governments, as well as it led to the adoption of austerity measures, such as the decrease and the cuts of salaries to employees, the decrease of subsidies from the general government to LGs, as well as the prohibition of any deficit to LGs. As a result, since then the management of the Local Governments has been rationalized, experiencing surplus. Having said that, the governmental wastefulness has been steadily reduced.[19]

Moreover, in Greece there is a long-standing perception of high corruption and opacity in the public sector. With this in mind, in 2010 there was introduced by the Greek Government the Transparency Programme initiative, which resulted in a publication of 28 million administrative acts and decisions of public authorities from 2010 to 2018 that became available to the general public. In fact, since 2014, Law 4305/2014 has been put into force, which regulated the opening of the public sector's official documents. Another initiative which was implemented is "opengov.gr" which aims to increase the transparency of the recruitment of employees in the public sector. These measures resulted in the improvement of Greece in this particular variable in the years 2017-2018.[20]

In addition to that, the level of the provided national security and economic stabilityin a country also play an important role in its competitiveness, as the most secure economies

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[15]Efthymiou M. & Papatheodorou A. (2015). Intermodal passenger transport and destination competitiveness in Greece. Anatolia: An International Journal of Tourism and Hospitality Research, pp. 5-6

[16]Fragoudaki A., Giokas D., Glyptoy K. (2016). Efficiency and productivity changes in Greek airports during the crisis years 2010-2014. Journal of Air Transport Management, Vol. 57, pp. 306-315

[17]Efthymiou M. & Papatheodorou A. (2015). Intermodal passenger transport and destination competitiveness in Greece. Anatolia: An International Journal of Tourism and Hospitality Research, pp. 5-6

[18]Moschovou, T., Tyrinopoulos, Y. (2018). Exploring the effects of economic crisis in road transport: The case of Greece. International Journal of Transportation Science and Technology, p.6

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seem to attract increased foreign investments and business activity[21][22]. In relation to that, the 'provided security services', as well as the 'increase in organized crime and terrorism' variables, based on the data analysis, kept a steady course over the examined period. Indeed, especially in the the year 2009 the business costs of crime and violence were rather high due to the lack of political stability and riots in the streets of Greece. Furthermore, the activity of organized crime and terrorist organizations such as "Rouvikonas organization", in 2018 brought Greece in a grave position at 79th and 107th position respectively. Indeed, the rise of unemployment, poverty and social inequality during the years of recession, led to an increase in petty crime, and in the exercise of excessive violence on behalf of the far-right and far-left organizations in Greece.[23][24]

Last but not least, eventhough, the variables Brain Drain and the Ability to Attract and Retain Talent were not included in the final data process, as there was a lack of continuous data during the examined period, they remain a serious drawback for the Greek Economy. A possible establishment of cooperation between the universities and the private sector and R&D could reverse this situation in favor of the Greek competitiveness retaining experienced scientists of added value from abroad, as well as attracting more Foreign Direct Investment, which was in fact increased in 2017 to $27billion returning back to its 2009 level.[25]

5. Conclusion

To deal with this conundrum, the Greek economy needs to be more extroverted, relaxing government regulation and taxes inthe private sector and households. This in turn would increase the market size and the liquidity of the banking system, makingfinancial services more affordable, to facilitate access to loans and as a result to attract more foreign direct investment, leading to a decrease in unemployment. Lastly, massive reforms should be implemented aiming to a rise of quality in the educational system, heading towards a more market-oriented education sector.[26]

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Appendix

Table 2 Variables in Great Risk, Greek Competitiveness 2010 – 2018

Variables in Great Risk	Rank Average of Greece (2010-2018) Out of 144 Countries
1. Government debt	135th
2. Burden of government regulation	134th
3. Extent and effect of taxation	132th
4. Wastefullness of government spending	131th
5. Agricultural policy costs	131th
6. Efficiency of legal framework in settling disputes	127 th
7. National savings rate	127th
8. Business impact of rules on FDI	127th
9. Ease of access to loans	127th
10. Venture capital availability	127th
11. Soundness of banks	127th
12. Gov't procurement of advanced tech products	127th
13. Flexibility of wage determination	123th
14. Efficacy of corporate boards	122th
15. State of cluster development	120th
16. University-industry research collaboration in R&D	119th
17. Financing through local equity market	117th
18. Cooperation in labor-employer relations	115th
19. Public trust of politicians	114th
20. Imports as a percentage of GDP	114th
21. Transparency of government policymaking	113th
22. Quality of the educational system	113th
23. Pay and productivity	113th
24. Efficiency of legal framework in challenging regulations	111th
25. Affordability of financial services	110th
26. FDI and technology transfer	108th
27. Company spending on R&D	106th
28. Hiring and firing practices	104th
29. Total tax rate	103th
30. Capacity for innovation	103th
31. Ethical behavior of firms	102th
32. Favoritism in decisions of government officials	101th
33. Extent of staff training	101th
34. Availability of financial services	101th
35. Country credit rating	100th
36. Regulation of securities exchanges	100th
37. Legal rights index	99th
38. Willingness to delegate authority	98th

39. Government surplus/deficit	97th
40. Reliance on professional management	96th
41. Local availiability of research and training services	95th
42. Strength of auditing and reporting standards	94th
43. Diversion of public funds	92th
44. Quality of management schools	92th

"E-learning in primary education - "The participation of two selected Greek schools in the eTwinning program"

Abstract:
In recent years, there have been major changes in the way that education programs are implemented and in the diffusion of innovation into these programs. An important role is played by the European Union through the e-Twinning program for the implementation of collaborative projects between schools in Europe through a dedicated digital collaborative platform. The purpose of the current paper is to investigate the effectiveness of e-twinning in primary education in Greece. For this reason, the research was done by the triangulation method with the distribution of a questionnaire and focus group to students and through in-depth interviews with two teachers. The results of the survey show that there are many benefits such as the use of collaborative tools and the practice of English language for pupils and the exchange of know-how for teachers while the use of collaborative tools is important. More generally, e-Twinning has many benefits to bring to students. It should be noted that research suggests that enrollment and education of teachers involved in e-Twinning should be intensified and that more social media and other collaborative applications should be used. Finally, it should be noted that the contribution of this research relates to it providing a picture not only about the operation of e-Twinning but also about the benefits that has not been done by other surveys and studies.

Key words: eTwinning, social media, Information and communications technology (ICT), European Union.

JEL Classification:

I2 – Education

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1. The Need

The area of education has to present important innovations and interventions aimed at upgrading the educational work offered by the educational units to the students. To a large extent, these innovations have been promoted by the high penetration of new technologies in school facilities. At this point, it should be mentioned that there is a number of technologies and applications that help learning through the knowledge and skills that are built by the acquaintance with new peoples and the acquisition of multiple skills through cultural exchange over the Internet (Zhang et at, 2016). It is worth mentioning another parameter, that of upgrading the interest in education at the political level, and in particular from the European Union. This is done through the implementation of programs related to the cooperation of school units within the Union such as Norway. Within this context of the continued penetration of New Technologies and coordination in education in the framework of cooperation between the EU Member States, is the case of eTwinning (Cruz-Jesus, et al, 2016). eTwinning aims to upgrade pupils' knowledge and skills across a wide range of areas of action such as specific educational fields (intercultural education, environmental education, etc.) as well as to learn them how to use creatively new technologies as well as how to collaborate with students from other EU countries (Papadakis, 2016). This means that we are talking about a training program related to the acquisition of multiple skills for students, including the use of collaborative tools, designing and implementing projects and other similar skills. It should be noted that this program is widely accepted by both educators and students (Vuorikari et al, 2015). Of course, it should be noted that the program has the special ability to constantly change and adapt, as well as a continuous flow of new data and information. For this reason, it is considered necessary to have a description and evaluation of the studies so far done through a scientific study which will synthesize all previous studies so as to draw conclusions about the course of eTwinning so far.

In recent years, great changes have been made to education in Greece. One of the most important innovations is the introduction of the tools of distance learning in schools. It is important for students to have a range of choices as to the sources through which they will identify the knowledge. In the present paper, a reference is made to a particular innovation that helps to enhance student interaction and collaboration, and this is eTwinning. According to Anastasiades (2016), eTwinning is one of the most important actions aimed at promoting ICT in the conventional education system. More specifically, eTwinning is a very popular program and can help students acquire more knowledge than schools provide and, in particular, get in touch with pupils from other countries, as well as a very important aspect - as Anastasiades (2016) - is that it contributes greatly to school cooperation at international level. So, it is necessary that such an important program be explored in terms of pupils' experiences and prospects. It should be noted that there are studies such as Tsapras (2011) that have advanced in the study of eTwinning actions by not only recording the views of the stakeholders but also the content of the programs. Given that eTwinning is an ongoing and continuously enriched program, it is considered necessary to have a collective record of what has been done so far.

2. E-Learning in Primary Education

Lionarakis (2010) reports that distance learning based on a mechanistic interpretation, is a process where the trainee is at a physical distance from the trainer and therefore he/she needs to understand with the help of new technologies how he/she should work alone in a heuristic course of self-learning and knowledge. Thus, since 1990, the enormous technological advances have invaded the field of distance learning and have shown a tremendous growth which has been defined as a new framework of methodology and terminology, with the result

that new technologies today evolve at a very high rate (Anastasiades, 2004). Particularly based on the available technological resources, educational approaches to the learning environment can often be ignored. In recent years the way in which pedagogical approaches are used may in some cases raise concerns. In the learning environment, the emphasis given to technological tools in recent years can in many cases not substitute for the pedagogical and social dimension of learning (Anderson &Dron, 2010).

Primary education is in many cases at risk from a digital dualism, and in this sense, education is called to integrate new technologies creatively and to harmonize it with education by reforming how children will be taught so that they meet the goals themselves that education puts. The trends in distance learning, especially in primary education, are intensifying to the present day through the formal education system. However, conventional education, which is seen as teaching within the classroom, continues to be the first in its field. Distance learning has been used as a term for the first time in the 1970s, and nowadays interest is essentially focused on the fact that distance learning is always open and accessible in response to each learner's learning needs (Carr &Kemmis, 1997).

Since the mid-1990s, distance learning has provided additional impetus in the field of primary education, contributing dynamically to its proliferation and giving it a new character (Bonk & Graham, 2006). Initially, there were technocratic approaches that contributed to the creation of a new educational environment that did not favor critical thinking, with the result that, for a while, a tendency to transfer social standards had been created. Moreover, in recent years, the pedagogical dimension of the use of distance learning is at the center of research interest as it contributes to the creative integration of a child into the wider social and learning context by exploiting new technologies. This has the effect of creating the conditions for the development of a collaborative knowledge building network that encourages research thinking and shapes a set of conditions for a multidimensional education that is multidimensional, flexible and democratic.

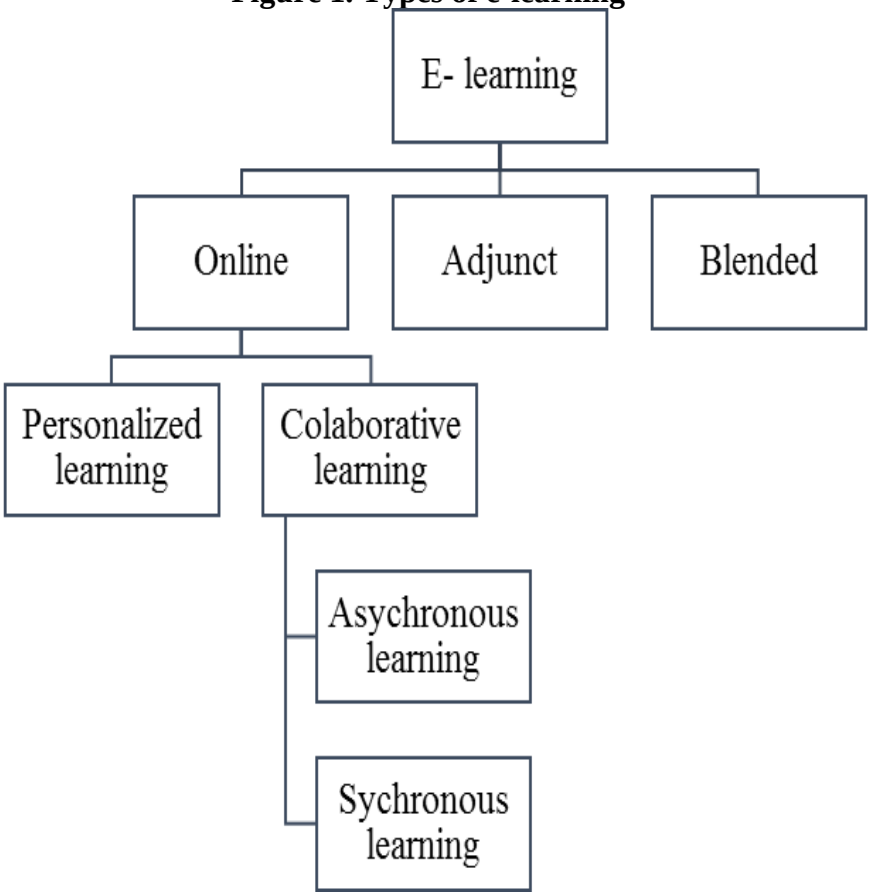
At the same time, this training works complementarily at all levels by activating the learner in a self-learning way and working autonomously (Abrami et al., 2011). The modern form of distance education through technology and synchronous transmission also enables the instructor and student to interact through the image and sound in real time regardless of the geographical area, with the result that the advantages are the adequate time reaction, interaction and the use of effective technology (Anastasiades et al., 2010). Contemporary and asynchronous education should not work competitively but complement each other, thus creating the conditions for an integrated learning environment, highlighting the need for an environment that works with specific pedagogical prerequisites by combining the positive elements of both together with face-to-face teaching. In general, blended learning (see Figure 1) involves a series of dimensions. It combines blending of a range of web technologies that aim to achieve educational goals, combining pedagogical approaches to positive learning outcomes, combining teaching technologies with face-to-face teaching, and technology blending in real-world conditions. Learning, from the learner's point of view, is based on forms of teaching that have their roots in pedagogical processes. The consequence of this is that the term "learning" needs to be redefined. Mixed learning offers learning gains attributed to how it works and a new way to understand its theoretical basis based on the theory of the use of online services (Lionarakis, 2010). However, it is noted that there are no specific methods for this mixed, blended learning environment to work, so that the best possible success of this model is based on a well-organized teaching approach in which the model will have the basics of educational theory, logistical infrastructure and evaluation mechanisms (Oliver &Trigwell, 2005).

Collaboration through eTwinning is based on presentations through schools and explaining material through blogs to other students from foreign countries. The hanging material reflects the work that teachers have to conclude with their students. The material

tends to be the result of initiatives or individual efforts made by teachers within the program. From the point of view of the proposed activities, most teachers seem to consider communication via email, videoconference, presentations, development of photo albums, e-journals, etc. particularly important for enhancing knowledge. A smaller percentage of innovative activities include the participation of pupils from many countries around the world in cooperative development and presentation activities of their countries, the design of scientific experiments and discussions with colleagues from other countries, etc. (Velea, 2011).

At this point, it should be mentioned the criticism of Anastasiadis (2017) which states that the purpose of the schools is to educate tomorrow's citizens. But one particular thing is that we do not know how societies will be in the future due to the constant changes in the environment. The constant changes in the social and economic environment result in the accumulation of a large amount of information on the internet. Lee et al (2016) refers to the phenomenon of over-accumulation of information and the increasingly frequent use of digital media and e-learning, so teachers often do not have the capacity to evaluate which material should be used, but and how. For this reason, Murayama et al. (2016) conclude that e-learning is a particular challenge for the education system and especially for the educator, because it is no longer a matter of being able to use e-learning systems but above all to be able to evaluate the information they have in their hands and use them in the best possible way.

Figure 1. Types of e-learning



To make the learning environment in Greece more comprehensible, a PEST analysis with four macro-environmental dimensions will be summarized:

• Social dimension: Both the social crisis and changes in demographic data are important. Elements such as the rise of immigrant pupils who need to be integrated and address some

misconceptions, but also the fact that many children carry in school the faculties they encounter at home and in society in school. An important issue is a conservatism in society, but it seems that schools are not going through.

• Technological dimension: It is now understandable that new technologies affect education, and for this reason the Ministry of Education has given a similar importance to the introduction of new technologies in schools as well as to the training of staff. Also, teachers themselves are now familiar with the use of new technologies.

• Economic dimension: The economic crisis is forcing the Ministry to make cuts in the structures and programs it runs.

• Political dimension: Education is still hostage to fragmentation, while the education system remains highly centralized.

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Table 1. PEST Analysis of the Greek educational system

• **Economic**	Country development rate, education costs, school funding
• **Social**	The social characteristics of the school area
• **Technological**	Technological achievements, innovations
• **Political**	Political situation, legislation, political objectives for the Greek education system

As a result, learning is addressed to an audience that is constantly expanding both in quality and in scale. At the same time, trainees have the opportunity to choose how they are trained and the time they will attend their courses, with the result that new technologies and media can significantly facilitate learning.

3. The Innovation in Education and the Role of ETwinning

Educational innovation is defined as a set of actions that incorporate and promote new concepts of education in terms of changing principles and beliefs, the application of new teaching approaches and the use of new teaching tools (Dakopoulou, 2008). On this basis, the concept of innovation concerns the process of transforming an idea into a commodity that can be applied to a market or have a use for society. Innovation may also be an improvement on an existing product (Griffin, 2009). Creating a partnership in an international environment, as eTwinning does, has the effect of generating benefits for pupils because students interact, understand and share specific ideas, thus making it a step for learners to take responsibility for their learning and therefore a methodological change such as planning and social strategy is required.

At the same time, teachers need to get acquainted with the way they make decisions and teach by acquiring skills that will be useful to them in the future, such as working in collaborative environments. Intercultural benefits are based on new collaborations through schools, which have the effect of providing students with new skills and knowledge in relation to the experiences of other countries, while benefiting from the supportive structures of promoting European cooperation. In order to support schools in this action, they need to develop credible structures that will be recognized and provide pedagogical proposals for cooperation and support during its implementation (ETwinning Net., 2018). This structure

includes an office supported by experienced teachers and the technical support service at European level as well as the technical support service of each country. In Greece, the staff consists of experienced information technology educators who have enough familiarity with the educational system of our country to support and assist students in the context of cooperation.

More generally, eTwinning is an important effort that is being developed at many levels, both at the level of teachers and at the level of students, and involves an approach which is a multi-level initiative. This collaboration is de facto fruitful and results in both teacher and student groups. It can also be a whole school approach for a multilevel initiative. On the occasion of student and teacher exchanges, schools have exchanged teachers and pupils for several years, translating friendship as a pedagogical experience. Against older collaborations, schools are linked to other actions such as "Socrates" that continue to strengthen their ties. As far as older collaborations are concerned, they strengthen the newer partnerships as many schools want to complete a generalized cooperation and strengthen the concept of the European dimension (Stamenos and Prokos, 2011). A particular element of eTwinning is that it allows students, but also teachers, to be creative.

According to Camilleri (2016), what is particularly valuable in eTwinning is that it allows students to be innovative and creative, which often cannot be done within the classroom. This is what makes eTwinning so important, as Papadakis (2016) confirms, referring to the fact that pupils are now looking to be creative, and this is done through actions outside the classroom, with a tough example of eTwinning. Also, groups of teachers are twinned by selecting thematic programs where the same lesson is taught, and teachers are working on common issues, comparing different approaches to cultural differences.

They can also choose cross-curricular programs where they teach different subjects on a common topic and they discover that the world of education is one. There is also a selection of a multidisciplinary program where two groups of pupils are the focus of the project, accompanied by all the teachers responsible for the specific program, with the result that the presence of the two groups is treated as a cooperation on thematic pairs and cross-thematic groups. The cooperation of the schools is a possibility of a European opening of the educational potential that wants to get in touch with other colleagues. This can cause the interest of students making the process particularly innovative and exciting. At the same time, educators are informed about the new systems of other countries and are taught new different cultures developing a cultural consciousness.

At the same time, they are familiar with the new information technology environment to eliminate physical distances and explore seemingly difficult issues while simultaneously exchanging electronic pedagogical ideas enriching their experiences. All schools that declare their cooperation on the European portal receive a specific approval in the framework of cooperation by the national support service. This is a digital certificate that includes the signatures of the national service and country support service. These services choose the best partnerships that appear for a month at the service's central gateway. This gives countries the opportunity to show which actions are most innovative. Thus, eTwinning promotes quality and gives high recognition to collaborations by responding to questions such as whether it is necessary to use information technology today to improve the knowledge of both teachers and students. During the pupils' engagement with eTwinning, they themselves benefit from their knowledge and skills with the support of teachers, incorporating the pedagogical process in their everyday life. Thus, during eTwinning, students benefit from the knowledge and skills they acquire and learn from the online way to manage the experiences they acquire. The topic chosen is flexible and adaptable to the needs of schools so as to avoid any difficulties. Questions about eTwinning can be answered through corresponding seminars as well as other curricula provided by many European countries. This is a turning point in the digital age,

which changes aspects of the life of pupils who are required to acquire skills and abilities to take advantage of the opportunities open to them. But not only digital skills, as pupils need basic knowledge to live, learn and communicate within the new global society (Teacher Education, 2018).

More generally, eTwinning is a learning community in which the student interacts with the trainer (Velea, 2011) within a system, as members first enroll on the platform and then participate as a community of education. The goal is to connect the individual with problem solving and share his/her ideas to develop a relationship with other learners and teachers within a friendship that promotes communication.

4. Methodology

Triangulation validates the data during the survey using the available information. This method reinforces the research part of the diploma because the data with their processing can be further analyzed. The methodology of triangulation occurs when multiple theories, materials or methods are used, such as a combination of qualitative and quantitative investigation. Data from different types of data sources, such as primary and secondary data using interviews, documents, public records, and triangulation observations using multiple data collection methods, are used to ensure the validity and credibility of present research (Patton, 1990).

Additional information sources often give more insight into a subject while the deficiencies identified in the data are minimized when multiple sources confirm the same data. Multiple sources also provide verification and validity while considering all data and information making it easier to analyze them to draw conclusions (Wright, 1997).Using these two different approaches to data collection, it acquires different information that provide complementary datasets (Wright, 1997).

In the present case, the use of triangulation is intended to reinforce the student's attempt to cover the subject from different visual approaches. On the one hand, they are the students and the teachers on the other. Through triangulation, the researcher can record different elements, such as student views (quantitative) and teacher experience (qualitative element). In this way, it can also cover the issue from different sources, but also cross-check whether these data converge or not. Another perspective is that triangulation allows for a research that will reduce the disadvantages of each approach, such as quantitative research cannot identify the causes of behavior-perception, while quality research is based on generalizations and personal interpretations. Therefore, the combination of these two approaches allows to limit the impact of these weaknesses (Morgan, 1997).If both approaches yield results supporting the hypothesis or bibliographic review theory, the data is more valid. The researcher could also combine these datasets with the results from conducting an observation or combine them with another tool, such as the use of focus groups. This type of data triangulation is slightly different because it incorporates results that show greater power. It also helps the researcher to have a better understanding of the data gathered. (Patton, 1990).The research tools are the student questionnaire, the individual interview with teachers and the focus group with students. The SPSS statistical tool was used in order to analyze the answers.

5. The Sample and Process

The sample consisted of students and teachers from schools in the municipalities of Attica. The basic prerequisite for the participation was that the school had participated in an eTwinning program as well as the two schools that were under investigation.
As to the sample of work, it consisted of 3 groups that were:

- 86 students who participated in the eTwinning program and completed the relevant questionnaire
- 8 students who participated in the focus group
- 2 teachers whose departments participated in eTwinning

It should be noted that the approach was done by sampling ease, while before the survey was made, the Director of the school unit as well as the teachers and the parents were informed that their consentfor participation, in order to ensure an ethical process.

6. Results

A. Quantitative Research

Quantitative research was carried out by distributing 87 questionnaires to a sample of students who participated in an eTwinning program at a school in the Northern Sector of Athens. The first issue to be considered is which instruments were used for eTwinning.

Table 2: e-mail

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	14	16,1	16,1	16,1
	I used it but not many times	25	28,7	28,7	44,8
	I used it many times	42	48,3	48,3	93,1
	I always used it	6	6,9	6,9	100,0
	Total	87	100,0	100,0	

Email seems to be a highly accepted medium, although 44.8% refers to the fact that they either did not use it or used it very little.

Table 3:Chat

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	26	29,9	29,9	29,9
	I used it but not many times	33	37,9	37,9	67,8
	I used it many times	20	23,0	23,0	90,8
	I always used it	8	9,2	9,2	100,0
	Total	87	100,0	100,0	

Although Chat is very widespread today, it appears to have used it to a high degree only 30.2% of the sample of students who participated in the survey.

Table 4: Forum					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	41	47,1	47,1	47,1
	I used it but not many times	30	34,5	34,5	81,6
	I used it many times	11	12,6	12,6	94,3
	I always used it	5	5,7	5,7	100,0
	Total	87	100,0	100,0	

In relation to the forums, their usefulness was limited to only 12.6% who used them several times and to a 5.7% who always used them.

Table 5: Video call					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	8	9,2	9,2	9,2
	I used it but not many times	13	14,9	14,9	24,1
	I used it many times	40	46,0	46,0	70,1
	I always used it	26	29,9	29,9	100,0
	Total	87	100,0	100,0	

The video call, for example via Skype, seems to be particularly popular since 46% said it used it many times while 29.9% always used video calls.

Table 6: Additional- collaborative programs (for example Google docs)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	12	13,8	13,8	13,8
	I used it but not many times	37	42,5	42,5	56,3
	I used it many times	23	26,4	26,4	82,8
	I always used it	15	17,2	17,2	100,0
	Total	87	100,0	100,0	

As far as co-operative programs are concerned, there is a group of students who said they used them. More specifically, 26.4% used them several times while 17.2% said they always used them.

Table 7: Social media					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	4	4,6	4,6	4,6
	I used it but not many times	13	14,9	14,9	19,5
	I used it many times	34	39,1	39,1	58,6
	I always used it	36	41,4	41,4	100,0
	Total	87	100,0	100,0	

Social media are particularly popular in our days, and this is shown by the results of the survey that 39.1% said they used them several times while 41.4% said they always used it.

Table 8: Other

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I did not use it	69	79,3	79,3	79,3
	I used it but not many times	14	16,1	16,1	95,4
	I used it many times	3	3,4	3,4	98,9
	I always used it	1	1,1	1,1	100,0
	Total	87	100,0	100,0	

In relation to the use of other instruments, there does not seem to be any particular interest.

The fifth question, which is a series of Likert-scale statements in relation to the implementation of the program, is then considered. Statements have been registered by them with the least acceptance to them with the highest acceptance.

Table 9: Implementation of eTwinning

	N	Minimum	Maximum	Mean	Std. Deviation
Through eTwinning I learned things I could not learn at school	87	1,0	5,0	3,264	1,0616
It helped me become more social	87	1,0	5,0	3,379	1,2318
It helped me to learn a foreign language	87	1,0	5,0	3,540	1,1793
Through eTwinning I improved my communication skills	87	1,0	5,0	3,563	1,1483
ETwinning helped me better use new technologies	87	1,0	5,0	3,667	1,0192
Through eTwinning I realized that I live in a global society and I can learn a lot from this world	87	1,0	5,0	3,793	1,1426
ETwinning taught me things that will be useful to me in the future.	87	2,0	5,0	3,989	,8693
Through eTwinning I learned to respect people from other countries	87	1,0	5,0	4,000	1,0783

At eTwinning I met children from other countries and I worked with them, which I think is very good	87	1,0	5,0	4,046	1,0105
It helped me work in groups and share information with other team members	87	1,0	5,0	4,046	,9010
ETwinning helped me learn new things	87	3,0	5,0	4,264	,7227
Valid N (listwise)	87				

It should be noted that eTwinning has generally been widely accepted by the answers to the statements. The most popular statements were:

- *At eTwinning I met children from other countries and I worked with them, which I consider to be very good* (4,046)
- *It helped me to work in groups and share information with other team members* (4,046)
- *ETwinning helped me learn new things* (4,264)

These statements show that their pupils are very fond of getting in touch with pupils from other countries and the spirit of cooperation in general. It is also very positive that very often the issue of eTwinning programs are issues that have not been elaborated in the classroom and they consider it very important to understand them.

As far as the statements were less important, but without being negative because they were above the average, these were the following:

- *At eTwinning I learned things I could not learn at school* (3,324)
- *It helped me become more social* (3,379)
- *It helped me learn a foreign language* (3,540)

They are statements that relate to socialization and the acquisition of non-school knowledge (although it contradicts the statement: eTwinning helped me to learn new things). Finally, it is very important that the overall picture of eTwinning is positive.

Regarding whether the content of the program was understandable, it should be noted that all the answers were positive, so it does not need to be presented with a table. This also shows how well eTwinning is acceptable from students and that educational communities should invest even more in it. Regarding the benefits of using eTwinning, the students stated that they helped them with elements such as better understanding of the use of social media and ICT in general, as well as intercultural dialogue as they come in contact with students from other countries, which helps them to better understand culture from other countries. Then the respondents are asked to state what the problems they are most concerned about with the use of eTwinning.

Table 10: Problems with implementation

	N	Minimum	Maximum	Mean	Std. Deviation
Lack of infrastructure	87	1,0	4,0	1,862	,9785
Difficulty working with other children	87	1,0	4,0	2,023	1,1511
Lack of knowledge in new technologies	87	1,0	4,0	2,115	,9453
Lack of time	87	1,0	4,0	2,172	,9176
My parents did not support me	86	1,0	4,0	2,233	1,3344
Difficulty communicating with children from abroad	87	1,0	4,0	2,345	1,0210
Valid N (listwise)	86				

In general, it does not seem that the issues in question have been heavily concerned. Perhaps these issues that require greater understanding are the difficulty in communicating with children from abroad because they speak another language, as does the lack of support from parents. On the other hand, the issues that least concerned them were infrastructure and the difficulty in working with other children.

As far as acquiring skills, the answers were the following:

Table 11: Skills acquired

	N	Minimum	Maximum	Mean	Std. Deviation
Writing skills	87	1,0	4,0	2,506	,9260
Communication skills	87	1,0	4,0	2,770	,8311
Reading	87	1,0	4,0	2,862	,9044
Acquiring knowledge that I learned at school	87	1,0	4,0	2,989	,9584
Use of new technologies	87	1,0	4,0	3,000	,9022
Use a foreign language	87	1,0	4,0	3,023	,9880
Valid N (listwise)	87				

It is expected that it did not help eTwinning in writing as everything is digital but it seems to have given a significant boost to acquiring new knowledge as well as to using new technologies as well as to using the foreign language.

Then the students were asked about how prepared the teachers were:

Table 12: Did the teacher show that he/she knows the program and is prepared?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	83	95,4	95,4	95,4
	No	4	4,6	4,6	100,0
	Total	87	100,0	100,0	

It is especially positive that teachers were prepared and aware of how to use eTwinning and its applications, which is particularly positive for the operation of eTwinning.

The next question is the general support that existed during the program.

Table 13: How do you judge your support during the eTwinning program?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Exceptional	39	44,8	44,8	44,8
	Very good	36	41,4	41,4	86,2
	Good	9	10,3	10,3	96,6
	Moderate	2	2,3	2,3	98,9
	Bad	1	1,1	1,1	100,0
	Total	87	100,0	100,0	

The overall picture is that support was excellent (44.8%) to very good (41.4%). This shows that eTwinning has the appropriate support for its implementation.

Data analysis continues with the demographic analysis of the survey.

Table 14: Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Boy	55	63,2	64,0	64,0
	Girl	31	35,6	36,0	100,0
	Total	86	98,9	100,0	
Missing	System	1	1,1		
Total		87	100,0		

As for gender, the sample consists mainly of boys (63.2%), while girls are 35.6% of the sample.

Table 15: Class					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5th class of Primary school	43	49,4	49,4	49,4
	6th class of Primary school	44	50,6	50,6	100,0
	Total	87	100,0	100,0	

For the pupils' class levels, 49.4% are pupils of the fifth class, while 50.6% are students of the 6th class.

Table 16: What was the name of the eTwinning you participated in and what was the subject:					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Human Rights	38	43,7	43,7	43,7
	My city	49	56,3	56,3	100,0
	Total	87	100,0	100,0	

The survey was conducted in a sample of students who participated in previous two weeks in two eTwinning programs: Human Rights (43.7%) and My City (56.3%).

B. Qualitative Research

-The results from the focus group

The focus group study was conducted on a sample of 8 students who discussed the programs they participated in. For the purpose of this study, it has been done to decode the main phrases in order to understand what the students' experiences from this program have been. The analysis has been made on thematic axes related to research questions.

Axis 1: Description of the program

This section provides a description of the program and its content. As stated, "*Our program was about our city and how we will make it known to our classmates. In the end, we produced a printed and electronic magazine that included general information about our city, its map, access and historical background. Also, there were suggestions for accommodation, food and entertainment complete guide to the city's attractions such as museums, churches, parks, public buildings, statues-monuments. Information about cultural events, customs and customs - traditional food and various cultural and sports clubs that are active in our city are also lacking. " It is very important that students enter into a process of discovering the city, but also get into collecting relevant information. Sure, it is a process that enhances the understanding of the cultural content of their place and of its analysis. Another report said that "the texts were accompanied by images and were also written in English. We sent the whole package in printed form with a Greek flag to get into their library. It cost us a little expensive but the parent club has covered the costs. "* At this point, support from the Parents Association appears, although in quantitative research it was mentioned that parents did not support as much as they should. Another statement stated that "our program was about human rights and, in particular, the rights of children. For example, we chose an article from the Convention on the Rights of the Child and presented it as a work of art, we worked in groups, and we prepared a list of proposals for classroom rules that are in harmony with the rights of the child. We created illustrated reference cards where on one side had a picture, and on the other a text relevant to the rights of the child and so on. The texts were written in English, the material was in electronic form and only for our use in printed form. We started in mid-November with our teacher in Social and Political Education and Master of Computer Science completing it in the middle of the year. " This statement states how eTwinning has helped in a number of critical elements such as statehood. In this way children get conscious. Also, an important aspect is the fact that they learn to use English in practice as well as ICT.

Axis 2: Use social media and other media

In both programs, students used skype and viber for their teleconferencing, email, presentations such as power point, padlet, voki, animoto and others. One description says that *"Facebook, twitter and Instagram did not use it, however, we learned the existence of many other web applications that we did not know"*. The truth is that social media is very often very toxic to students and they are paying particular attention. There are also other social media that may be more useful to students. For this reason, organizers must be particularly careful with the operation of the relevant programs

Axis 3: What were the cognitive benefits?

As far as the cognitive benefits are concerned, it was reported that "*the best of all is that we learned to speak better English and we are not afraid to use language to talk to other children. Of course, we did it well and the other kids were like us. At first, we thought that they would speak perfectly. This gave us courage. Because we had to translate our works with the help of our lady, we learned more words*". From the answers to this question, it is clear that eTwinning helped to better understand and use the English language, which is a very basic skill and for the professional future of children. It was also reported that "what we really liked was our computer engagement and our acquaintance with applications that were unknown to us. The computer was not just a means for Facebook but a means to create, communicate, and connect with a world we were unaware of but there is. In the end, the internet tools were playful for us, and the IT owner helped us. We were forced to work in a team, and that gave us more confidence about the outcome of our work. We learned to cooperate with each other and expose our work to compare it with others. " A second point that seemed to be particularly useful is the fact that they gained skills in terms of better understanding of social media and more generally the use of the internet. For this reason, it is considered to be a very important benefit for the pupils' future.

Axis 4: More general impression

The overall impression is positive. As stated, "*we would very much like to participate in such a program for years, and I wish we could accommodate and host children from other countries. We were very impressed by the result, although at first, we did not understand well what was happening. I have made new friends and I hope to continue to communicate with them*". It should be noted that the overall impression is positive for the future. What they would like would be physical contact with the future implementation of eTwinning programs.

-The results from the interview with teachers

The interview was conducted on a sample of teachers who had previous experience from eTwinning. The analysis will be made per question.

1. Describe the eTwinning program you have participated in

The interviews state that the main purpose of the program was to get children to know, understand and learn their rights, in relation to the cooperation of other peers from the countries of Europe. The very important objective of the program was to acquire and values, skills and attitudes in their everyday life and their way of thinking with the ultimate goal of becoming future active citizens who know their rights and respect their obligations. The program was attended by the students of the 6th grade and the teachers involved were: the teacher who taught Social and Political Education, the computer scientist and the English teacher. The program lasted for one year and produced rich material - printed and electronic - and presented to their classmates and parents at the end of the program. It was also mentioned that "*the main objective of the program was to capture the cultural heritage of the cities from which we come, knowing them through a rich material of electronic and printed tourist guides enriched with photos, written in the basic language of each country, English primarily and finally a multilingual vocabulary of basic communicative phrases, trying to highlight the similarities and differences concerning the cultural culture of each country. Specifically, for our city we have shown all the historical monuments, museums, parks, churches, recreation areas, etc. We used the Flexible Zone time one hour a week*". The overall picture is that through eTwinning programs both students and teachers acquire a better picture of the surrounding environment.

2. How do you evaluate the effectiveness of the program?

The general experience was positive, and many teachers have mentioned how important it is to interact with another culture but also to understand the use of ICT. More specifically, it was mentioned that *"for the first time I started when I was a pupil of the 6th grade and because my parents knew very well English, I had the ability to communicate later with my colleagues from all over Europe and exchange between us our experiences. I certainly widened my knowledge of the differences in education systems in the countries of the European Union and further improved my oral communication in English as I had to use them in practice. I had previously participated in e-twinning projects in contact with students and colleagues in Europe at a more exciting time when I was fortunate to take part in a pupil exchange program in Bulgaria*". In addition to language and intercultural dialogue, there is also a better understanding of use and ICT in a globalized environment. In particular, it is stated that "*my first experience with something beyond my country was e-twinning. The language barrier was overcome using English, so for the first time I came into contact with colleagues and students across my country. We exchanged views, information, opinions and especially realized that there is another reality beyond ours. E-twinning is an experience that has allowed me to see that I am part of a larger piece of the world and that has helped me develop my personal development and my ability to adapt to a globalized modern society. I have made many friendships and I keep contact even if the work is over. I also advise my students to take advantage of e-twinning and encourage them to make friends".*

3. How do you evaluate eTwinning in terms of its effectiveness for your students?

As a follow-up to what has been said in the previous question, eTwinning has an important role in upgrading knowledge in ICT and communication. As stated, "*in my opinion, the greatest benefit to my students was that they learned the importance of programming in media and ICT respectively. Their communication skills have improved and developed. They realized that learning foreign languages opens their horizons, enabling them to communicate with them. So, they are better prepared for their future and career in general. E-twinning promotes open thinking and supplies students with a lot of resources because they communicate with peers from one end of Europe to the other, make friends and know different cultures and a different way of seeing the world*". Another point is that "*eTwinning opened for my students the window to Europe by giving them the opportunity to communicate in a foreign language while also adding knowledge to various scientific fields such as science, culture etc.With a lot of anticipation, I remember the first virtual communication through skype with their classmates. Their level of knowledge in the use of English and ICT improved significantly. They met and made new friends, gained new experiences, and saw a different way of living than the European partners in the program. The more they liked skype conferences where, with the help of the English teacher, they had the opportunity to get to know each other. The main goal of our work of getting to know our city of others and at the same time acquiring knowledge about their own cities and their cultural culture has been achieved. In the end, the students became more responsible and more confident*". More generally, it is clear that students must understand that they operate in a global society. This also means that they have to understand that they are living in a globalized society, so they should also think as citizens of the world. In this process, i.e. the transition to a model of the citizen of the world, ICT has an important role to play and an understanding of the English language, which helps eTwinning.

4. More specifically, how do you assess the skills, knowledge and skills your students have acquired?

The interviews indicate that the students gained confidence, were ready and had no hesitation in the course of the program (at first, they were shy and afraid) to speak in front of a different audience than their classmates. Public communication, even though it is via the Internet, can hardly be developed anywhere else, even though it is needed everywhere. This gap will best cover e-twinning.

Participation in the program strengthened and developed the communication skills, critical thinking and the ability of students to handle the opportunities offered by new technologies. For example, students used Animoto, Prezi, Padlet for their presentations, knowing in this way how to use online tools that they had never heard before.

They are also reported to have chatted live via skype and viber, learned to make posters and to prepare with the help of their teachers a short video to present the sights of their city. have become more creative discovering new ways of acquiring knowledge. E-twinning was an entertaining way for children to learn. Another skill they developed was the translation of texts, enriching their vocabulary in English and French-German. In this way, they understood the language better through their necessity to use it and eventually encouraged them by giving them the motivation to work and learn foreign languages. Students' attitudes towards reading changed, became more creative, gained courage and learned through practice. Finally, their co-operative skills were developed as the program required in many places' cooperation within groups. In the long run, they learned to respect different views and use business reason to support their own.

5. How do you evaluate the benefits of the program?

In addition to benefiting students, the benefit to teachers was also examined. More specifically, it was mentioned that "my benefit from my participation in the eTwinning program helped me as a responsible departmental teacher first of all to improve my English and my oral communication gave me the opportunity to meet and to present my work to a group of completely unknown people. It provided me with a deeper knowledge of human rights and the ability to lead the group of my class who participated in the project. My experience was amazing not to be afraid to get involved in new adventures. I realized more deeply that the borders are artificial, around us there are people with different cultures and together we are a globalized society where we cannot have our windows closed. " It was also reported that "I realized in the best way that around me there are thousands of European teachers ready to listen to me willingly to learn and to benefit from me. This is also a two-way relationship. Even today, when I speak to you, I have been contacting two of my colleagues from Italy via Facebook (Facebook) with whom I exchange views and ideas in our quest for self-improvement in the transmission of knowledge, values and skills to our students. " These statements are clear and the fact that teachers also have a lot to gain. The program takes them out of the routine of work and allows them to look at how other education systems work. It is also possible to examine how they can transfer technical and teaching skills from other countries to their own program.

6. Did you have the required support? (training, infrastructure, etc.)

A very important parameter is the support that exists. As one teacher reported, *"With regard to support, I can say that it was excellent. There was direct communication with the program coordinator in Athens and every question that at first was many solved directly. Of course, there were training sessions to get acquainted with the eTwinning program*". Also, the other

teacher said: *"In our school unit we were lucky because we had a fully equipped room with twenty-four computers, while in our class we had an active table. That's where we did our teleconferencing. We also had the support we received from the school management that passionately strengthened our effort by converting our connection to vdsl 50mbs*". The overall impression is that there are now the necessary infrastructures for a unit to be able to host and organize a program based on the use of new technologies. In all cases the infrastructures exist, so the implementation of eTwinning is largely a matter of will.

7. Which media did students use more?

Teachers were asked to state what means their students used. The answer was "*The most used medium for our conferences was skype and less the viber. The project method was selected to run it. Cooperative learning, research, brainstorming, experiential learning and artistic activity were applied. In the need to present and highlight our projects, we have used Cooperative Programs such as Google Docs*". At this point, it should be noted that teachers' responses were similar to those of their students, namely that skype and collaborative tools were the main tools used.

8. What the efficacy of eTwinning

In connection with the benefit that eTwinning may have, the answers were that *"eTwinning contributes to the formation of personality. It creates experiences and new friendships for the future. Perhaps the most exciting is the discovery that neither the language nor the distance nor the country can prevent anyone from opening up their horizons, conquering new friendships, acquiring new knowledge, building bridges among the peoples of Europe. Our participation in the program was fascinating, expanded our horizons, gave us unforgettable memories and opened new paths for our future personal development*". And the second teacher mentioned that "*eTwinning allows you to escape from the strict curricula of the curriculum, teach more and more and ultimately more freely than the textbooks suggest. Another benefit could be the ability of the individual to think critically, to make public speeches without fear. My experience has shown that it makes you more open and receptive to new ideas in a world that constantly changes at a dizzying pace*". In this issue, there seems to be a consensus with students that eTwinning brings many benefits to students both in terms of communication skills and ICT use, and in particular in learning to work in groups and especially in an international environment.

9. How can eTwinning improve in the future?

Finally, respondents are asked to state how these programs can be improved, always in their view. The answer was that "*if a program could be funded by the European Union as it clearly serves its purpose and bringing the peoples of Europe together. Also, joining the formal curriculum could involve more educators and consequently more students benefit from its benefits*". The answers contradict those given by the students who emphasized the need for more physical contact.

7. Conclusions based on research questions

The analysis in this module will be based on the research questions.

1) How is eTwinning implemented in Primary Education schools in Attica?

The way of implementation is common to all EU countries. Of course, each school unit can be differentiated, for example, for the means and applications to be used. However, one important observation is that implementation is based on new technologies

2) What are the experiences of the teachers and pupils involved in the operation of eTwinning?

The experiences are positive from both groups. If there is a dimension, this is from a part of the teachers who encounter some difficulties in using the new technologies and especially the integration of the new technologies in the curriculum they have designed.

3) Is eTwinning effective as an action that promotes school collaboration?

It is a program that is judged to be particularly important and this is commonly accepted by all respondents. The fact that its idea is based on the cooperation of the schools gives itself a particular value and creates a program that is particularly effective in promoting school co-operation.

4) What are the cognitive benefits of eTwinning for pupils and teachers?

For the best value-benefit evaluation, there is a figure presenting the cognitive and other benefits, presented in Table 17:

Table 17. Developing skills and skills from participating in e twinning

Students	**Teachers**
- Foreign Languages - Cooperation - Tracking issues that are not taught at school - Better use of ICT - Looking the way of life in other countries - Communication in foreign languages - Project implementation	- Transfer of know-how - Better understanding of the use of ICT - Organization and Implementation of a Project

The study aimed at a very important function of modern technologies related to the educational process in the member countries of the European Union but also in other European countries, which is e-twinning. The operation of this platform can bring multiple benefits to participants in this program.Before analyzing the empirical research data, a brief description of the program should be made.

The purpose of eTwinning is to bring students from different European countries together to work together to implement a project. The implementation of the project can be done by using a special platform from the European Union, as well as other applications related to student communication, such as the use of collaborative tools and communication through Skype. One particular detail is the fact that the first students to implement are related to particular issues such as the environment and culture. Indeed, in many cases, issues are taught at school and do not allow them to process them. This means that the benefits of implementing eTwinning are multiple.

It should be noted that there is no particular difference with how it is implemented in other EU countries. The reason is because it works on a particular platform and there are specific specifications (Teacher Training in ICT, 2018). Indeed, although there is a picture that Greece lags behind reforms and the use of ICT, the reality for the operation of eTwinning in our country is that there is a very high level (ETwinning Net., 2018) as the country is dynamically participating in the start of the program. In terms of this use, schools put

particular emphasis on programs that are not taught in the curriculum but also value the pupil, as we have seen in the case of the human rights program and the program to teach children the city who reside and promote it to other schools that participated in the program. It is also very positive that there is now infrastructure to make eTwinning work in an effective way, as shown by Alamantariotou et al., (2014). In a recent study, Manca&Ranieri (2017) refers to the fact that eTwinning now relies heavily on social media focusing on co-operation. It should be noted that for many parents and educators, social media is considered as something negative and for this reason they often discourage them.

However, as reported by Vuorikari et al (2015), social media is not just facebook, but there are many pedagogical tools such as collaborative tools. Indeed, this research shows that collaborative tools, as well as skype applications, which are essentials rather than fun (such as Facebook and istangram) were the ones most used. So, there has been a realistic use of social media for communication and collaboration.

Another negative observation is that the current program can also be used outside of school, mainly in students' homes. That means that they can have access from everywhere there is an Internet connection and thus there is not a monitoring from their teachers. Such openness, caused some problems, mainly between the students from Turkey and Greece. These groups of students, due to historical reasons, made negative nationalistic and critical discussions and comments.

As regards the effectiveness of the program for students, as reported by a number of surveys (Kearney & Gras-Velazquez, 2015; Heindl, 2018; Boffo et al, 2018), referring to the high degree of satisfaction among the participants the programs. This is confirmed by this study, which has a particularly high level of satisfaction, both by teachers and by students.

Concerning the teachers that had not be participated in this process, they were very hesitant about this trend, mainly due to lack of IT knowledge and due to their persistence in traditional methods of teaching.

More generally, this research was conducted on a sample of pupils and teachers from schools in Northern Athens who had participated in the program. The aim was to have a more general picture of the functioning of eTwinning both on the part of the students and on the part of the teachers who implemented it. Indeed, it should be noted that the research shows that the beneficiaries are not only the pupils but also the teachers.

Let's get to the essence of the research, which made very useful conclusions:

(1). The first general conclusion is that students are particularly pleased with the operation of eTwinning as well as the end-result benefits that have existed. From quantitative and qualitative research, it can be said that the benefits that have been made are very specific and are as follows with regard to students.

a) The first benefit is the benefit of communicating in a different language, with pupils and teachers outside the cultural context in which the students reside. The fact that students have done a project with (other country pupils) their classmates from other countries means that they have been conducting an intercultural dialogue with the other students as well as having learned to use (using) the English language that was main language of communication with the other groups. It is easy to understand that it is very important for pupils to be able to use the English language and to interact with pupils from other countries.

b) Another benefit that has been recorded is that of using modern technological means. In order to be able to implement a project in eTwinning, students should learn to combine the use of a number of applications related to new technologies. Indeed, research has shown that students have not only limited to the most common applications, such as email, but have also used some more developed ones such as collaborative tools and the use of video calls. All

these are tools that are useful both for social development and for the professional recognition of today's young people. Indeed, the fact that students can use them in the fifth and sixth primary class level means certainly a significant benefit. At the same time, students understand that new technologies are not just fun, but they ultimately help them work together and deliver a project that benefits both society and themselves.

c) An additional benefit that eTwinning offers to students is to acquire knowledge that is not within the school curriculum. Both programs developed by the present work were aimed at studying the students such as the culture and monuments of their city or human rights. This means that students developed skills related to social research. Indeed, these works are of value not only to students but also to the whole of society. For example, learning pupils better about the city they live in and presenting them to students from other countries means that the city itself wins from viewing abroad but also from the fact that its students will learn better secrets of the city.

2) So far, the benefits have been reported for pupils, but also for society itself. A particular aspect that has been addressed is the benefits for teachers. Indeed, it can be said that it is an aspect that was investigated as originally envisaged in the objectives set. Indeed, research has shown that there are significant benefits for teachers as well. The benefits can be gained from the very simple benefits of improving their skills in relation to the use of new technologies, but there are many other benefits, such as the fact that they come in contact with other education systems and can be passed through practices that use schools located in other European countries, especially those in northern Europe. At the same time, it should be mentioned that for teachers eTwinning is an opportunity to escape from the everyday life of how many creative people can become outside the school curriculum.

3) A particular issue is language. Although students seem to have no communication issues, there were teachers who shared Crisan's (2013) view that language influences the effectiveness of eTwinning, and that a portion of teachers have limited skills and knowledge in new technologies. Of course, the main problem is language that restricts communication or creates problems in the implementation of eTwinning projects.

The overall impression from this research is the fact that eTwinning has much to offer to students and educators as well as that it offers substance benefits related to their skills and knowledge where the participants have it. But it should also be considered what should be done to continue the same is to be both creative and efficient. The more general picture is that when an educational system works correctly and effectively because of a lot of changes, but some special additions. What many students have mentioned is physical contact with the schools with which they collaborate in eTwinning. Of course, it should be mentioned that the e-twinning philosophy is to implement projects through remote collaboration with the use of related distance learning technologies. Finally, there is the particular question that physical contact between students greatly increased the cost of running the program, which has the effect of influencing its overall functioning. In this case, some resources should be sought in order to bring in contact between schools that also present very original, innovative programs and ideas within the framework of this program.

8. Suggestions for future research

In the case of a future study, teachers' satisfaction should be examined, as Drivas et al (2018) reports that many surveys focus on pupils but not the benefits to the teaching staff. This is why our proposal for future research on this issue. The most important results related to e-learning and communication are related to participation in debates regarding the duties of teachers in these communities. In general, learning facilitation and direct instructions have a strong correlation with the participants' satisfaction with electronic communication at

eTwinning. Consequently, electronic communication is a strong indicator of satisfaction. Providing helpful and creative feedback and assessing teachers' contribution is an effective technique that teachers use online as part of their educational role and teaching experience. Especially in electronic environments, informative feedback should be provided in time as this process is critical compared to face-to-face discussions, as learners may feel isolated due to the nature of the media. We also have to say that teachers are likely to be more satisfied when there is a good feedback quality offered by the program facilitator, so the importance of mediation should also be explored.

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An Introduction to the Natural Differential and Integral Calculus, without the Infinite

Abstract

In this paper I go further from the digital continuous axiomatic Euclidean geometry ([8]) and introduce the basic definitions and derive the basic familiar properties of the differential and integral calculus without the use of the infinite, within finite sets only. No axioms are required in this only successfully chosen definitions. I call it the natural differential and integral calculus. Such mathematics is probably the old unfulfilled hitherto dream of the mathematicians since many centuries. Strictly speaking it is not equivalent to the classical differential and integral calculus which makes use of the infinite (countable and uncountable) and limits. Nevertheless, for all practical reasons in the physical and social sciences it gives all the well-known applications with a finite ontology which is directly realizable both in the physical ontology of atomic matter or digital ontology of operating systems of computers. Such a natural or digital calculus has aspects simpler than the classical "analogue" calculus which often has a complexity irrelevant to the physical reality. It can become also more complicated than the classical calculus when more than 2 resolutions are utilized, but this complexity is directly relevant to the physical reality. The natural differential and integral calculus is of great value for the applied physical and social sciences as its ontology is directly corresponding to the ontology of computers. It is also a new method of teaching mathematics where there is integrity with what we say, write, see, and think. In this short outline of the basic natural differential and integral calculus, we include on purpose almost only the basic propositions that are almost identical with the corresponding of the classical calculus for reasons of familiarity with their proofs.

Key words: Digital mathematics, Calculus

MSC : 00A05

JEL:C,Y

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1. Introduction

Changing our concept of physical material, space and time continuum so as to utilize only finite points, numbers and sets, means that we change also our perception our usual mental images and beliefs about the reality. This project is under the next philosophical principles

1) In the human consciousness we have the experience of the infinite.

2) But the ontology of the physical material world is finite.

3) Therefore mathematical models in their ontology should contain only finite entities and should not involve the infinite.

4) Strange as it may seem, the natural or digital mathematics are the really deep mathematics of the physical world, while the classical mathematics of the infinite ("analogue" mathematics) are a "distant" phenomenology, convenient in older centuries, but not the true ontology.

This paper is part of larger project which is creating again the basics of mathematics and its ontology with new definitions that do not involve the infinite at all.

Our perception and experience of the reality, depends on the system of beliefs that we have. In mathematics, the system of spiritual beliefs is nothing else than the axioms of the axiomatic systems that we accept. The rest is the work of reasoning and acting.

Quote: "It is not the world we experience but our perception of the world"

Nevertheless it is not wise to include in our perception of the material world and its ontology anything else than the finite, otherwise we will be lead in trying to prove basic facts with unsurpassed difficulties as the classical mathematics has already encounter , **The abstraction of the infinite is phenomenological** and it seems sweet at the beginning as it reduces some complexity, in the definitions, but later on it turns out to be bitter, as it traps the mathematical minds in to a vast complexity irrelevant to real life applications. Or to put it a more easy way, we already know the advantages of using the infinite but let us learn more about the advantages of using only the finite, for our perception, modelling and reasoning about empty space and physical reality. This is not only valuable for the applied sciences, through the computers but is also very valuable in creating a more perfect and realistic education of mathematics for the young people. H. Poincare used to say that mathematics and geometry is the art of correct reasoning over not-corresponding and incorrect figures. With the natural or digital mathematics this is corrected. **The new digital continuums create a new integrity between what we see with our senses, what we think and write and what we act in scientific applications.**

The continuum with infinite many points creates an overwhelming complexity which is very often irrelevant to the complexity of physical matter. The emergence of the irrational numbers is an elementary example that all are familiar But there are less known difficult problems like the 3rd Hilbert problem (see Boltianskii V. (1978)"). In the 3rd Hilbert problem it has been proved that two solid figures that are of equal volume are not always decomposable in to an in equal finite number of congruent sub-solids! Given that equal material solids consists essentially from the physical point of view from an equal number of sub-solids (atoms) that are congruent, this is highly non-intuitive! There are also more complications with the infinite like the Banach-Tarski paradox (see Banach, Stefan; Tarski, Alfred *(1924)*) which is essentially pure magic or miracles making! In other words it has been proved that starting from a solid sphere S of radius r, we can decompose it to a finite number n of pieces, and then re-arrange some of them with isometric motions create an equal sphere S1 of radius again r and by rearranging the rest with isometric motions create a second solid Sphere S2 again of radius r! In other words like magician and with seemingly elementary operations we may produce from a ball two equal balls without tricks or "cheating". Thus no conservation of mass or energy!. Obviously such a model of the physical 3-dmensional space

of physical matter like the classical Euclidean geometry is far away from the usual physical material reality! I have nothing against miracles, but it is challenging to define a space , time and motion that behaves as we are used to know. In the model of the digital 3-dimesional space, where such balls have only finite many points such "miracles" are not possible!

The current natural or digital version of the differential and integral calculus is based on the atomic structure of matter as hypothesized 2,000 years ago by the ancient Greek philosopher Democritus and which has developed in the modern the atomic physics. Also the role of computers and their digital world is important as it shows that space, time, motion, images, sound etc can have finite digital ontology and still can create the continuum as a phenomenology of perception.

The famous physicist E. Schrodinger I his book (*E. Schroedinger. Science and Humanism Cambridge University press 1961)* mentions that the continuum as we define it with the "analogue" mathematics involving the infinite is problematic and paradoxical, therefore needs re-creation and re-definition. It is exactly what we do here with the digital differential and integral calculus.

We enumerate some great advantages of the natural differential and integral calculus compared to the classical calculus with the infinite.

1) The digital continuity and smoothness (derivative) allows for a variable in scale of magnitude and resolution such concept and not absolute as in analogue classical mathematics. A curve may be smooth (differentiable) at the visible scale but non-smooth at finer scales and vice versa. This is not possible with classical definitions.

2) Corresponding to the concept of infinite of classical mathematics in digital mathematics there is the concept seemingly infinite and seemingly infinitesimal at its various orders, which is still finite. Thus many unprovable results in classical mathematics become provable in natural or digital mathematics. This also resurrects the 17^{th} and 18^{th} century mathematical arguments in Calculus and mathematical physics that treated the "infinitesimals" as separate entities in the derivatives.

3) Many unsurpassed difficulties in proving desirable results in the infinite dimensional functional spaces of mathematical analysis disappear and allow for new powerful theorems because the seemingly infinite is still finite.

4) Integration is defined as finite (although seemingly infinite) weighted sum of the volumes of the points at some precision level, exactly as Archimedes was measuring and integrating volumes with water or sand. Contrary to classical mathematics any computably bounded function is integrable (see proposition 3.6)

5) Therefore, there are vast advantages compared to classical analogue calculus. The natural differential and integral calculus is a global revolution in the ontology of mathematics in teaching and applying them comparable with the revolution of digital technology of sounds, images . motion, etc compared to the classical analogue such technologies.

6) There are although "disadvantages" too , in the sense that if we do not restrict to a natural or digital calculus relative 4 precision levels but include many more and grades of differentiability and integrability then the overall calculus will become much more complicated than the classical calculus.

In this short outline of the basic digital differential and integral calculus, we include on purpose only the basic propositions that are almost identical with the corresponding of the classical calculus for reasons of familiarity with their proofs. An exception is the proposition 3.6 which has an almost obvious proof.

2. The Definition of the Natural or Digital Real Numbers

THE MULTI-PRECISION DECIMAL DIGITAL REAL NUMBERS R(m,n,p,q)

Rules for phantasy and drawing of figures.

As initially we considered a system of digital real numbers R(m,n,p,q) we consider the points of P(m), P(n) as visible in the figures while the points of P(p) as invisble pixels , and those of P(q) as invisible atoms. Therefore, even the points and seemingly infinitesimals that will be defined below, of P(n) relative to P(m) are considered as visible. This is in accordance with the habit in classical mathematics to make the points visible, although they claim that they have zero size.

a) The **rational numbers** Q, as we known them, do involve the infinite, as they are infinite many, and are created with the goal in mind that **proportions** k/l of natural numbers k,l exist as numbers and are unique. The cost of course is that when we represent them with decimal representation they may have infinite many but with finite period of repetition decimal digits.

b) The **classical real numbers** R, as we know them, do involve the infinite, as they are infinite many, and are created with the goal in mind that **proportions** of linear segments of Euclidean geometry, exist as numbers and are unique (**Eudoxus** theory of proportions). The cost of course finally is that when we represent them with decimal representation they may have infinite many arbitrary different decimal digits without any repetition.

c) But in the physical or digital mathematical world, such costs are not acceptable. The infinite is not accepted in the ontology of digital mathematics (only in the subjective experience of the consciousness of the scientist). Therefore in the **multi-precision digital real numbers**, proportions are handled in different way, with priority in the Pythagorean-Democritus idea of the **creation of all numbers from an integral number of elementary units**, almost exactly as in the physical world matter is made from atoms (here the precision level of numbers in decimal representation) and the definitions are different and more economic in the ontological complexity.

We will choose for all practical applications of the digital real numbers to the digital Euclidean geometry and digital differential and integral calculus, the concept of a system of digital decimal real numbers with three precision levels, lower, low and a high.

Definition 1.1 The definition of a PRECISION LEVEL P(n,m) where n, m are natural numbers , is that it is the set of all real numbers that in the decimal representation have not more than n decimal digits for the integer part and not more than m digits for the decimal part. Usually we take m=n. In other words as sets of real numbers it is a nested system of lattices each one based on units of power of 10, and as union a lattice of rational numbers with finite many decimal digits. We could utilize other bases than 10 e.g. 2 or 3 etc, but for the sake of familiarity with the base 10 and the 10 fingers of our hands we leave it as it is.

The Definition 1.2 of the Natural or Digital Real Numbers R(m,n,p,q)

We assume at least four precision levels for an axiomatic decimal system of digital real numbers.

Whenever we refer to a real number x of a (minimal in precision levels) system of real numbers R(m,n,p,q) , we will always mean that x belongs to the precision level P(m) and that the system R(m,n,p,q) has at least four precision levels with the current axioms.

Whenever we write an equality relation $=_m$ we must specify in what precision level it is considered. The default precision level that a equality of numbers is considered to hold, is the precision level P(m).

Some of the Linearly ordered Field operations

The field operations in a precision level are defined in the usual way, from the decimal representation of the numbers. This would be an independent definition, not involving the infinite. Also equality of two numbers with finite decimal digits should be always specified to what precision level. E.g. if we are talking about equality in P(m) we should symbolize it my $=_m$, while if talking about equality in P(q) we should symbolize it by $=_q$ .If we want to define these operation from those of the real numbers with infinite many decimal digits, then we will need the truncation function [a]x of a real number a , in the Precision level P(x). Here for the rounding function we use the rounding to the left for positive numbers and to the right for negative numbers.

Then the operations e.g. in P(m) with values in P(n) m<<n would be

$[a]_m+[b]_m=_n[a+b]_n$ (eq. 3)

$[a]_m* [b]_m=_n[a*b]_n$ (eq. 4)

$([a]_m)\text{^}(-1)=_n[a\text{^}(-1)]_n$ (eq. 5)

(Although, the latter definition of inverse seems to give a unique number in P(n), there may not be any number in P(n) or not only one number in P(n), so that if multiplied with $[a]_m$ it will give 1. E.g. for m=2 , and n=5 , the inverse of 3, as $([3]_m)\text{^}(-1)=_n[1/3]_n$ =0.33333 is such that still $0.33333*3\neq_n1$).

Nevertheless here we will not involve the infinite and the classical real numbers, and we take the operation of digital real numbers from the standard operations of them as numbers with finite digital decimal representation and truncation by rounding.

Such a system of double or triple precision digital real numbers, has closure of the linearly ordered field operations only in a specific local way. That is If a, b belong to the Local Lower precision, then a+b, a*b , -a, a^(-1) belong to the Low precision level, and the properties of the linearly ordered commutative field hold: (here the equality is always in P(n), this it is mean the $=_n$).

1) if a, b, c belong to P(m) then (a+b), (b+c), (a+b)+c, a+(b+c) belong in P(n) and
(a+b)+c=a+(b+c) for all a, b and c in P(n).
2) There is a digital number 0 in P(n) such that
2.1) a+0=a, for all a in P(n).
2.2) For every a in P(m) there is some b in P(n) such that
a+b=0. Such a, b is symbolized also by -a , and it is unique in P(n).
3) if a, b, belong to P(m) then (a+b), (b+a), belong in P(n) and
a+b=b+a
4) if a, b, c belong to P(m) then (a*b), (b*c), (a*b)*c, a*(b*c) belong in P(n) and
(a*b)*c=a*(b*c).
5) There is a digital number 1 in P(n) not equal to 0 in P(n), such that
5.1) a*1=a, for all a in P(n).
5.2) For every a in P(m) not equal to 0, there may be one or none or not only one b in P(n) such that a*b=1 . Such b is symbolized also by 1/a, and it may not exist or it may not be unique in P(n).
6) if a, b, belong to P(m) then (a*b), (b*a), belong in P(n) and
a*b=b*a
7) if a, b, c belong to P(n) then (b+c) , (a*b), (a*c), a*(b+c), a*b+a*c, belong in P(n) and
a*(b+c)=a*b+a*c

Which numbers are positive and which negative and the linear order of digital numbers is precision levels P(m), P(n), etc is something known from the definition of precision levels in the theory of classical real numbers in digital representation.
If we denote by PP(m) the positive numbers of P(m) and PP(n) the positive numbers of P(n) then
8) For all a in PP(m), one and only one of the following 3 is true

8.1) a=0
8.2) a is in PP(m)
8.3) -a is in PP(m) (-a is the element such that a+(-a)=0)
9) If a, b are in PP(m), then a+b is in PP(n)
10) If a, b are in PP(m), then a*b is in PP(n)
It holds for the inequality a>b if and only if a-b is in PP(n)
a<b if b>a
a<=b if a<b or a=b
a>= b if a> b or a=b
and similar for PP(n).

Similar properties as the ones from P(m) to P(n) hold if we substitute n with m, and m with p, q.
For the R(m,n) the integers of P(m) are also called computable finite or countable finite, while those of P(n) are unaccountable finite or non-computable finite or also seemingly infinite relative to P(m).
Also, the *Archimedean property* holds only recursively in respect e.g. to the local lower precision level P(m).
In other words, if a, b, a<b belong to the precision level P(m) then there is k integer in the precision level P(n) such that a*k>b. And similarly for the precision levels P(n) and P(p),P(q).
The corresponding to the *Eudoxus-Dedekind completeness* in the digital real numbers also is relative to the three precision levels is simply that in the precision levels all possible combination of digits are included and not any decimal number of P(m) or P(n) is missing. Still this gives

The Supremum Completeness Property of the Digital Real Numbes.
From this completeness we deduce the supremum property of upper bounded sets (and infimum property of lower bounded sets) in the P(m) (but also P(n)) precision levels. This is because in well ordered sets holds the supremum property of upper bounded sets. Here lower bounded sets have also the infimum property and this holds for any resolution of the digital real numbers

Mutual inequalities of the precision levels **(AXIOMS OF SEEMINGLY (m,n) -INFINITE OR (m,n)-UNCOUNTABLE OR NON-COMPUTABLE FINITE AMONG RESOLUTIONS and seemingly finite or visibly finite or bounded or computable finite numbers.)**
We impose also axioms for the sufficiently large size of the high precision level relative to the other two, and the sufficient large size of the low precision level relative to the local lower precision level. That is for the mutual relations of the integers m, n, p, q.

It may seem that these differences of the resolution or the precision levels are very severe and of large in between distance, and not really necessary. It may be so, as the future may show. But for the time being we fell safe to postulate such big differences.

There are definitions modeled after the definitions of **inaccessible cardinals** in classical mathematics. Here we give a weaker alternative definitions with **weaker concepts of seemingly infinite that** would correspond to that of inaccessible cardinals. In other words **we do not include the operation of power.**

We may conceive the countable finite as a finite computable by a computational power of some computer, and unaccountable finite as the finite not computable by a type of a computer

Transcendental Orders of (m,n) seemingly infinite, as in classical mathematics transcendental orders of ordinal numbers are also definable. E.g. if a, b are (m,n)=seemingly infinite then a is transcendental larger than b, in symbols a>>b iff b/a=$_m$0 in P(m).

And similarly transcendental orders of seemingly infinitesimals. E.g. if a, b are (m,n)=seemingly infinitesimals then a is transcendental smaller than b, in symbols a<<b iff a/b=$_m$0 in P(m).

We may compare them with the small o() and big O() definitions of the classical mathematics, but they are different as the latter involve the countable infinite, while former here involve only finite sets of numbers.

9) **Requirements of the Seemingly Infinite** *If we repeat the operations of addition and multiplication of the linearly ordered commutative field starting from numbers of the precision level P(m), so many times as the numbers of the local lower precision level P(m), then the results are still inside the low precision level P(n). In symbols if by |P(m)| we denote the cardinality of P(m), then*

|P(m)|(10^m), and (10^m)^|P(m)|<=10^n . Similarly for the pair (m,q). We may express it by saying that the 10^n is seemingly infinite or unaccountable finite compared to 10^m, or that the numbers less than 10^n are countable or computable finite. If we include besides the addition and multiplication the power operation too, then 10^m is inaccessible seemingly infinite compared to 10^m (a concept similar to inaccessible cardinal numbers in classical mathematics). Similarly for the precision levels P(p), P(q).*

10) **Requirements of the Seemingly Infinitesimals** *The smallest magnitude in the low precision level P(n) in other words the 10^(-n), will appear as zero error in the low precision level P(m), even after additive repetitions that are as large as the cardinal number of points of the lower precision level P(m) and multiplied also by any large number of P(m). In symbols*

10^(-n)|P(m)|*10^m<=10^(-m). Similarly for the pairs (n,p), (p,q).*

This may also be expressed by saying that the 10^(-n) is seemingly infinitesimal compared to the 10^(-m) . Other elements of P(n) symbolized by dx with |dx|<10^-m with the same inequalities, that is |dx||P(m)|*10^m<=10^(-m) are also seemingly infinitesimals, provided the next requirements are also met:*

The seemingly infinitesimals dx of P(p) relative to P(m) (thus |dx|<=10^(-m)) are by definition required to have properties that resemble the ***ideals in ring theory*** *(see e.g.* VAN DER WAERDEN *ALGEBRA Vol I, chapter 3, Springer 1970). More precisely what it is required to hold is that:*

*If a, b are elements of P(m) , and dx dy seemingly infinitesimals of P(p) relative to P(n) (thus |dx|, |dy| <=10^(-n) ,thus relative to P(m) too) then the linear combination and product are still seemingly infinitesimals. In symbols adx+bdy , are seemingly infinitesimals of P(n) relative to P(m) and dx*dy is seemingly infinitesimal of P(q) relative to P(p) and thus relative to P(m) too.*

We call this ***the ideal-like property of the seemingly infinitesimals.***

One very important equation is of course that the digital real numbers is the union of the four precision levels.

R(m, n, p, q)= P(m)∪P(n)∪P(p) ∪P(q)

Two digital systems of Real numbers R(m,n,p,q) , R(m',n',p',q') with m=m', n=n', p=p',q=q' and the above axioms are considered isomorphic.

0. **The Definition of the Natural or Digital Functions, Natural or Digital Continuity and Natural or Digital Differentiability**.

A **digital real function** at 2 precision levels is a function in the ordinary set-theoretic sense, that sends elements of the digital real numbers to elements of the digital real umbers. It has to be defined so that **it respects the precision levels**. This is defined so that a **parallelogram diagram**, of the two functions, the restriction function and the rounding function **commute** in the sense of the theory of **categories**. Usually the standard way is to **define it for the highest resolution** and then extend the definition for the lower resolutions by the **rounding function** (left for positive numbers and right for negative numbers). This process is called **natural rounding extension on lower resolutions,** and defines the rounded functions on the lower resolutions **so that the arrow diagrams commute** that $[f(a)]_n = f_n([a]_n)$ if a, f(a) in P(q) and we define f on P(n) (The rounding of the image is the value of the rounded function on the rounded argument, so that rounding function and functions commute). **We only need to define the rounding for a pair of precision levels for differentiation and integration. Here for P(m)/P(n). The f_m is the rounded function, and it is for all practical purposes the one only function observed. But it starts from a function f on P(n). So for all digital function that we will consider, we will conceive them as double functions the finest of: P(n)->P(n) and the rounded , f: P(m)->P(m) , and r is the restriction from P(n) to P(m) then a commutation of diagrams is the $[(of([x]_m)]_m = {}_m f$**

In some situations (e.g. definition of continuity) we will assume that the digital function is defined in 3 precision levels oof: P(p)->P(p) of: P(n)->P(n) and the rounded , f: P(m)->P(m) , and by the restriction from P(n) to P(m) and from P(n) to P(p) a commutation of diagrams holds :$[(of([x]_m)]_m = {}_m f$ and $[(oof([x]_n)]_n = {}_n$ of.

And in some cases we will need all 4-precision levels

For those that feel convenient to start with the classical mathematics with the infinite, and their functions, digital functions as above can be obtained by the rounding functions $[]_m$ $[]_n$ in the precision levels P(m), P(n). E.g. starting with the classical exponential function $g(x)=e^x$ to obtain a digital function in P(m), P(n), we use the formulae $oof(x)=[e^{[x]}{}_p]_p$, $of(x)=[e^{[x]}{}_n]_n$ and $f(x)= [e^{[x]}{}_m]_m$

Definition 2.1

*A digital real function defined on a closed interval $f :[a,b]_m \to P(m)$, of: $:[a,b]_n \to P(n)$, oof: $:[a,b]_p \to P(p)$ is **(digitally)P(m)/P(n)/P(n) continuous at a point x** of its domain of definition $[a,b]_m$ in P(m), if and only if for every other point x' of the domain of definition $[a,b]_n$ in P(n), such that x,x' are of seemingly infinitesimally distance dx=x'-x (belongs to P(n)) ,relative to P(m) , then also the dy=of(x')-of(x) is seemingly infinitesimal of P(n) relative to P(m). It holds in particular:*

$dy = {}_n df(x) = {}_m dx = {}_m 0$

Similar definitions hold for P(m)/P(p), P(n)/P(p) and P(m)/P(q) continuity.

We concentrate on functions of P(n) of R(m,n,p.q) but we may we not leave unused the precision levels P(p), P(q). We mention also that the definitions can be also for the triples of precision levels P(m)-P(n)-P(p), P(n)-P(p)-P(q) as finer forms of continuity. If it is for all precision levels then it seems equivalent to the classical definitions.

If digital real function is digitally continuous at all points of its domain of definition it is called **a (digitally) P(m)/P(n) continuous digital real function.**

Definition 2.2 *A digital real function defined on a closed interval $f:[a,b]_m \to P(m)$, of: $:[a,b]_n \to P(n)$, oof: $:[a,b]_p \to P(p)$ is* ***(digitally)P(m)/P(n)/P(p) continuous at a point x*** *of its domain of definition $[a,b]_m$ in P(m), if and only if for every other point x' of the domain of definition $[a,b]_p$ in P(p), such that x,x' are of seemingly infinitesimally distance dx=x'-x (belongs to P(p)) ,relative to P(m) , then also the dy=of(x')-of(x) is seemingly infinitesimal of P(n) relative to P(m). It holds in particular:*

$0=_m dy=_n dof(x)=_m dx=_m 0$

Similar definitions hold for P(n)/P(p)/P(q), P(m)/P(p)/P(q) continuity etc.

It would be nice if it is possible to derive also the digital P(m)/P(n) continuity as the standard continuity of topological space. The next definition gives the best idea for such a topological space. A topological space is defined by its open sets (see e.g. [9] J.Munkress) . But the open sets can also be definite by the limit points of sets too.

We consider the Cartesian product set P(m)xP(n) =P(m)xP(n), where we define the disjoint union space P(m)+P(n) and we do not consider that a coarse point of P(m) contains fine points of P(n) but we treat them separately. Our topological space will be the Y=X+oX= P(m)+P(n) . Subsets A of Y can be split to A=oA+cA , where oA are the fine points of A in P(n) and cA are the coarse points of A in P(m) .

Definition 2.3 *A point x of X=P(low)=P(m) or of oX=P(high)=P(n) is a limit point of a subset A of Y=* P(low)+P(high) *(and oA is a subset of oX) , iff there is a positive seemingly infinitesimal de of P(high) such that for any positive seemingly infinitesimal da of P(high) less that de , there is a fine point y of oA such that |x-y|=da. We denote the set of fine points of P(high) limit points of A by oL(A) and all coarse points of P(low)=P(m) by L(A). We define as closure cl(A) of a subset A of Y , the cl(A)=A union Cl(A). A set is open if its complement in Y is the closure of a set.*

Notice that with the closure we add only coarse visible points not fine (possibly invisible) points. For this reason the closure operator has the idempotent low Cl(Cl(A))=Cl(A). For the relations of limit points, closure, boundary, open sets etc see [9] J. Munkress. In addition Cl(A union B)= Cl(A) union Cl(B) and Cl(A intersection B) =Cl(A) intersection Cl(B). We define that a x point of Y is seemingly in contact with the subset A of Y iff x belongs to A union Cl(A). In other words either it belongs to the set or it is a limit point of it.

The concepts of boundary points and interior points are defined so as to have the usual properties as well as the concept of open set, base of open sets and base of neighbourhoods in Y. Similarly for connectedness. (See e.g. [9] J.Munkres)

The concept of topological **lowest visible or accountable or computable compactness** is defined in the usual way , where far the existence of finite sub-cover for any cover, we require , existence of **lowest visibly finite cardinality of a sub cover**. Similarly for the concept of **lower visible or computable or accountable compactness** or simply **visibly compactness** of a set of points. For a first outline of the Natural or Digital Calculus we will not proceed in these details.

The basic properties of continuity are:

1) Continuity is invariant by linear combinations
2) Continuity and product
3) Continuity and quotient
4) Composition of natural or digital continuous functions are digital continuous
5) Bolzano theorem (after the supremum property of digital real numbers)
6) Mean value theorem.

Proposition 2.1 (CONTINUOUS COMPOSITE)
Let two digital functions $f:[\alpha,\beta]_m->R(m,n)$, with oof: $[\alpha,\beta]_p->P(p)$, $of=[oof]_n$, $f=[of]_m$ and $h:[f(a),f(b)]_m->R(m,n)$, with ooh: $[f(a),f(b)]_p->P(p)$, $oh=[ooh]_n$, $h=[oh]$, that the first is (digitally) P(m)/P(n)/P(p) continuous and the second P(m)/P(p)/P(q) continuous such that their composition f(h)(x): $[\alpha,\beta]_m->R(m,n)$ defined by $oor=[oof(ooh([x]_p))]_m$ (and or ,r defined in the obvious way), is also a digital function with values in P(m) (in other words its diagram commutes) . Then this composition function is also a (digitally) P(m)/P(n)/P(q) continuous function in $[a,b]_m$.
Hint for a proof: From the definition of the composite digital function oor on x of $[a,b]_p$ if dx is a seemingly infinitesimal at x of P(p) , then from the P(m)/P(n)/P(p) continuity of ooh at x we get that the $dy=_n ooh(dx)$ is a seemingly infinitesimal of P(n) relative to P(m) , and from the P(m)/P(n) continuity of the of we get that the of(dy) is a seemingly infinitesimal of P(n) , relative to P(m). Thus the composite r is digitally P(m)/P(p) continuous. QED

Proposition 2.2 (CONTINUOUS LINEAR COMBINATIONS) *Let two digital functions $f:[a,b]_m->R(m,n)$, with of: $[a,b]_n->P(n)$, $f=[of]$, and $h:[a,b]_m->R(m,n)$, with oh: $[a,b]_n->P(n)$, $h=[oh]$, that are (digitally) P(m)/P(p)/P(q) continuous such that for any digital scalars a, b of P(m), the functions af+bh, f*h, 1/f are also digital functions on $[a,b]_m$ with values in P(m), then they are also (digitally) P(m)/P(n)/P(q) continuous functions.*
Hint for a proof: From the P(m)/P(p)/P(q) continuity of the f and h we get that for dx seemingly infinitesimals of P(q), the df(x), dh(x) are seemingly infinitesimals of P(p) and from the ideal-like property of the P(p) seemingly infinitesimals (see definition of digital real numbers 10)) the adf(x)+bdh(x) is a seemingly infinitesimal of P(n) relative to P(m), thus the linear combination is P(m)/P(n)/P(q) digital continuous . QED

Proposition 2.3 (CONTINUOUS PRODUCT) *Let two digital functions $f:[a,b]_m->R(m,n)$, with of: $[a,b]_n->P(n)$, $f=[of]$, and $h:[a,b]_m->R(m,n)$, with oh: $[a,b]_n->P(n)$, $h=[oh]$, that are (digitally) P(m)/P(p)/P(q) continuous such that for any digital scalars a, b of P(m), the functions f*h, is also digital functions on $[a,b]_m$ with values in P(m), then they are also (digitally) P(m)/P(n)/P(q) continuous functions.*
Hint for a proof: From the P(m)/P(p)/P(q) continuity of the f and h we get that for dx seemingly infinitesimals of P(q), the df(x), dh(x) are seemingly infinitesimals of P(p) and from the ideal-like property of the P(p) seemingly infinitesimals (see definition of digital real numbers 10)) the df(x)*dh(x) is a seemingly infinitesimal of P(q) relative to P(m). Then the $df(x)h(x) =_p f(x+dx)h(x+dx)-f(x)h(x)=_p (f(x)+df(x))(h(x)+dh(x))-f(x)h(x)=_p$ by multiplying out we get a linear combination of seemingly infinitesimals of P(p) and P(q) that by the ideal-like property of the seemingly infinitesimals are also seemingly infinitesimals of P(n) relative to P(m) . Thus the product is P(m)/P(n)/P(q) digital continuous. QED

Proposition 2.4 (CONTINUOUS INVERSE) *Let a digital functions $f:[a,b]_m->R(m,n)$, with of: $[a,b]_n->P(n)$, $f=[of]$, that is (digitally) P(m)/P(p)/P(q) continuous such that the functions 1/f is also definable digital functions on $[a,b]_m$ with values in P(m), then it is also (digitally) P(m)/P(n)/P(q) continuous function.*
Hint for a proof: From the P(m)/P(p)/P(q) continuity of the f we get that for dx seemingly infinitesimals of P(q), the df(x), is seemingly infinitesimals of P(p). The $d(1/f(x)) =_p (f(x+dx)-f(x))/f(x)*(f(x+dx)=_p (df(x))/f(x)*(df(x)+f(x))$. The denominator is a computable finite number and non-seemingly infinitesimal of P(m), while the numerator is a seemingly infinitesimals of P(p). From the ideal-like properties of the seemingly infinitesimals we

deduce that the ratio is a seemingly infinitesimal of P(n). Thus the inverse is P(m)/P(n)/P(q) digital continuous. QED.

Proposition 2.5 (BOLZANO) *Let a digital (digitally) continuous functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] f:P(m)->P(m), defined in a finite interval [a,b]$_m$ of P(m) such that , f(a), f(b) have opposite signs, that is f(a)f(b)<$_m$0, (e.g. assume f(a)<=$_m$0) then there is at least one point c in the open interval (a,b)$_m$, such that for its next higher point c' in [a,b]$_m$ holds f(c)<=$_m$0 and f(c')>=$_m$0*

Hint for a proof: We apply the supremum completeness property for upper bounded sets of the digital real numbers at the P(m) precision level for the set A={x/ a<=$_m$x<=b that the f is negative in the [a,x] }. QED

Proposition 2.6 (MAXIMUM) *Let a digital (digitally) continuous functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] f:P(m)->P(m), defined in a finite interval [a,b]$_m$ of P(m) , then it attains its maximum in [a,b]$_m$, in other words there is a number y in [a,b]$_m$ in P(m), such that f(x)<=$_m$f(y) for all x in [a,b]$_m$ in P(m).*

Hint for a proof: We apply the supremum property of the digital real numbers at the P(m) precision level for the set A=f([a,b]) in P(m) . As A is a finite set it has a maximum element.

Definition 2.3 *A digital real function defined on a closed interval f :[a,b]$_m$ ->P(m), of: :[a,b]$_n$ ->P(n), is* ***(digitally) is P(m)/P(n)/P(n) differentiable at a point a*** *of its domain of definition [a,b]$_m$ in P(m) , if for every other point x' of its domain of definition [a,b]$_n$ in P(n) , such that the distance of a and x' is* ***seemingly infinitesimal*** *belonging in P(n) and relative to P(m)) with dx=$_n$ x'-a, then dy=$_n$f(x')-f(a)is a seemingly infinitesimal relative to P(m) , belonging to P(n) and the ratio dy/dx=$_m$(f(x')-f(a))/(x'-a)* ***is always the same as number c of P(m) , independent from the choice of x' which is called the derivative of f at a ,c=$_m$ df(x)/dx|$_a$,*** *while the c- dy/dx=$_n$ c-(f(x')-f(a))/(x'-a) is a seemingly infinitesimal relative to P(m) and belonging to P(n).*

Notice that when change seemingly infinitesimals dx, the dy/dx may change as number of P(n) ,but remains constant as number of P(m).

Similarly we may define differentiation by the pairs of precision levels P(m)-P(p), and P(m)-P(q).

Definition 2.4 *A digital real function defined on a closed interval f :[a,b]$_m$ ->P(m), of: :[a,b]$_n$ ->P(n), is* ***(digitally) is P(m)/P(n)/P(p) differentiable at a point a*** *of its domain of definition [a,b]$_m$ in P(m) , if for every other point x' of its domain of definition [a,b]$_n$ in P(n) , such that the distance of a and x' is* ***seemingly infinitesimal*** *(that is in P(p) and relative to P(n) and P(m)) with dx=$_n$ x'-a, then dy=$_n$f(x')-f(a)is a seemingly infinitesimal relative to P(m) , belonging to P(p) and the ratio dy/dx=$_m$(f(x')-f(a))/(x'-a)* ***is always the same as number c of P(m) , independent from the choice of x' which is called the derivative of f at a ,c=$_m$ df(x)/dx|$_a$,*** *while the c- dy/dx=$_p$ c-(f(x')-f(a))/(x'-a) is a seemingly infinitesimal relative to P(m) and belonging to P(n).*

Notice that when change seemingly infinitesimals dx, the dy/dx may change as number of P(n) ,but remains constant as number of P(m).

Similarly we may define differentiation by the pairs of precision levels P(m)-P(p), and P(m)-P(q).

The basic properties of differentiability are

1) Chain Rule
2) Linearity
3) Product or Leibniz rule
4) Quotient rule

Proposition 2.7 (CHAIN RULE)
Let two digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , and h:[f(a),f(b)]$_m$->R(m,n) , with oh: :[f(a),f(b)]$_n$ ->P(n) , h=[oh] , that are the first (digitally) P(m)/P(n)/P(p) differentiable at a(in P(m)) and the second P(m)/P(p)/P(q) differentiable at f(a) in P(m) such that their composition f(h)(x): [a,b]$_m$->R(m,n) defined by oor=[oof(ooh([x]$_p$))]$_m$ (and or ,r defined in the obvious way),is also a digital function with values in P(m) (in other words its diagram commutes), and the product (df/dx)(dh/dx) exists in P(m) too. Then their composition function is also a (digitally) P(m)/P(n)//P(q) differentiable function at a and*

$$\frac{d(f(h(x))}{dx}|_a =_m \frac{df(y)}{dy}|_{f(a)} * \frac{dh(x)}{dx}|_a$$

Or in other symbols if df(a)=db, df(h(a))=dγ, da=dx|$_a$

$$\frac{d\gamma}{da} =_m \frac{d\gamma}{db} * \frac{db}{da}$$

Hint for a proof: We start with a seemingly infinitesimal dx of P(q) relative to P(p), then from the P(m)/P(n)/P(p) differentiability of h, the dh(x) is a seemingly infinitesimal of P(p), relative to P(n) and the derivative dh(x)/dx exists in P(m). Taking this dh(x) seemingly infinitesimal of P(n) relative to P(m) , from the P(m)/P(n)/P(p) differentiability of f, the df(h(x))/dh(x) exists as element of P(m) and thus by multiplying (df(h(x))/dh(x))* dh(x)/dx=$_m$ df(h(x)/dx, the quotient by the hypotheses exists in P(m) therefore the composite is P(m)/P(n)/P(q) differentiable and the chain rule holds. QED

Proposition 2.8 (Linear combination) *Let two digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , and h:[a,b]$_m$->R(m,n) , with oh: :[a,b]$_n$ ->P(n) , h=[oh] , that are (digitally) P(m)/P(p)/P(q) differentiable at a point x such that their linear combination adf(x)/dx+bdh(x)/dx for constants a, b of P(m),is again inside P(m). Then their linear combination af(x)+bh(x) function at x is also a (digitally) P(m)/P(n)/P(q) differentiable function and*

$$\frac{d(af(x)+bh(x))}{dx} =_m a\frac{df(x)}{dx} + b\frac{dh(x)}{dx}$$

Hint for a proof: If dx is a seemingly infinitesimal of P(q) relative to P(p), then it holds that The d(af(x)+bh(x)=$_n$ adf(x)+bdh(x) is seemingly infinitesimal of P(p) relative to P(n). Thus from the P(m)/P(p)/P(q) differentiability of the f and h, the d(af(x)+bh(x))/dx=$_m$ adf(x)/dx+bdh(x)/dx is by hypotheses in P(m) too, and the property holds. QED.

Proposition 2.9 (Leibniz product rule) *Let two digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , and h:[a,b]$_m$->R(m,n) , with oh: :[a,b]$_n$ ->P(n) , h=[oh] , that are (digitally) P(m)/P(p)/P(q) differentiable at a point x such that the expression (df(x)/dx)*h(x)+f(x)*(dh(x)/dx) is again inside P(m). Then the product f(x)*h(x) function at x is also a (digitally) P(m)/P(n)/P(p) differentiable function and*

$$\frac{d(f*g)(x)}{dx} =_m \frac{df(x)}{dx} * h(x) + f(x) * \frac{dh(x)}{dx}$$

Hint for a proof: If dx is a seemingly infinitesimal of P(q) relative to P(p), then $d(f(x)*h(x))=_p(f(x+dx)h(x+dx)-f(x)h(x))=_p((f(x)+df)(h(x)+dh)-f(x)h(x))=_p(fdf+hdf+dfdh)$ and by the ideal-like property of the infinitesimals it is in P(p). Thus $d(f(x)h(x))/dx=_m f(dh(x)/dx)+h(df(x)/dx)+ df*(dh(x)/dx)$. The last terms is zero in P(m) because the df is seemingly infinitesimal relative to P(m),and the sum of the first two terms exists in P(m) by the hypotheses, thus the product is P(m)/P(n)/P(q) differentiable and the Leibniz product rule holds. QED

Proposition 2.8 (Quotient) *Let two digital functions $f:[a,b]_m->R(m,n)$, with of: $[a,b]_n->P(n)$, $f=[of]$, and $h:[a,b]_m->R(m,n)$, with oh: $:[a,b]_n ->P(n)$, $h=[oh]$, that are (digitally) P(m)/P(p)/P(q) differentiable at a point x such that their quotient f(x)/h(x) is defiable and inP(m) and the right hand of the formula below is computably finite , that is it belongs to P(m) when the terms of do. Then the quotient f(x)/h(x) function at x is also a (digitally) P(m)/P(n)/P(p) differentiable function and*

$$d\frac{f}{h}(x) =_m \frac{(\frac{df(x)}{dx} * h(x) - f(x) * \frac{dh(x)}{dx})}{[h(x)]^2}$$

Hint for a proof: Similar, as in the product rule. It is based on the ideal-like properties of the seemingly infinitesimals, and the hypotheses of the theorem. We start with a seemingly infinitesimal of P(q) relative to P(p), and calculate the d(f/h). We substitute the f(x+dx) , h(x+dx) with f(x)+df , h(x)+dh in P(p) , make the operations , we use the P(m)/P(p)/P(q) differentiability of the f and h, and that the right hand side of the formula in the theorem, also belongs to P(m) and we get the P(m)/P(n)/P(q) differentiability of the quotient. QED.

Proposition 2.10 (Continuity of differentiable function) *Let a digital functions $f:[a,b]_m->R(m,n)$, with of: $[a,b]_n->P(n)$, $f=[of]$, which is (digitally) P(m)/P(n)/P(p) differentiable at a point a of P(m). Then it holds that it is also a (digitally) P(m)/P(n)/P(p) continuous function at a.*

Hint for a proof: From $f(x)'=_m df(x)/dx$ in P(m) and a seemingly infinitesimal dx of P(p) we get that $df=_n f(x)'*dx$. And from the ideal-like properties of the seemingly infinitesimals, the right hand side is also in P(n) and seemingly infinitesimal. Thus the f by the definition of continuity is P(m)/P(n)/P(p) digitally continuous. QED

Definition 2.4 (Higher dimension total derivative of a digital k-vector function.) *Let A_m closed rectangle subset of $P^k(m)$ and let a digital vector function $f:A_m->P^s(m)$, of: $A_n ->P^s(n)$,$f=[of]_m$.We define that f is (digitally)* ***P(m)/P(n)/P(p) differentiable*** *at a point a in A_m iff there is a linear transformation $L: P^k(m)->P^s(m)$, such that for any seemingly infinitesimal vector dh of $P^k(p)$ relative to $P^k(m)$, it holds that*

$$\frac{||f(z+dh)-f(a)-L(dh)||}{||dh||} =_m 0 \text{ in } P(m)$$

The linear transformation L is denoted by D(f(a)) and is called total derivative of f at a.
It can be proved that any such linear transformation L if it exists it is unique.
This is somehow equivalent to that

1) For every seemingly infinitesimal dh of P(p)^k at a point a of P(m), $d_h f(a)=_m L(dh)$
2) And also for this seemingly infinitesimal dh , the $d_h f(a)$-L(dh) as seemingly infinitesimal of P(n)^k is transcendentally smaller than the seemingly infinitesimal dh of P(p)^k .

L is can be a function of P(n) not only of P(m) that is definable in seemingly infinitesimals too. Properties of classical total derivative are:

1) Partial derivatives per coordinate exist and their Jacobean matric is the matrix of the total derivative (differential)
2) Conversely if they exist and are continuous in a region then the total derivative exist, and the digital vector function is called continuously differentiable.

3. The Definition of the Natural or Digital Archimedean Measure and Integral

At first we define the digital Archimedean Integral and then also the Archimedean measure, although it can be vice versa.

Definition 3.1 *Let a subset A of a closed interval $[a,b]_n$ of P(n) , with $[a,b]_m$ belonging to P(m), of cardinal number of points |A| which is a number of P(n) and in general seemingly infinite relative to P(m) . We define as Archimedean measure of A, in symbols m(A) , and call A , P(m)/P(n)-countably measurable, or simply P(m)/P(n)-measurable, a possibly of seemingly infinite terms relative to P(m) sum of |A| times of the P(n)-sizes of the points of A, such that the P(m) rounding of the sum belongs to P(m). In other words as each point of A in P(n) has size 10^{-n} then $m(A)=[|A|*10^{-n}]_m$ which is a number required to belonging to P(m) for A to be P(m)/P(n)-measurable.*

Similar definition exists for higher dimensions R^k(m,n,p,q)

Definition 3.2 *Let a digital functions $f:[a,b]_m$->P(m) , with of: $[a,b]_n$->P(n) , f=[of] . Then we define as Archimedean P(m)/P(n)-integral of f on the closed interval $[a,b]_m$, and call the f Archimedean P(m)/P(n)-integrable, the possibly of seemingly infinite terms relative to P(m) sum of $|[a,b]_n|$ times of the P(n)-sizes of the points dx of $[a,b]_n$ multiplied with the value of(x) at each point dx of $[a,b]_n$,such that the P(m) rounding of this weighted sum belongs to P(m). In symbols*

$$I =_m \int_a^b f(x)dx \text{ in } P(m)$$

Notice that according to that definition the Archimedean measure of a subset A of $[a,b]_m$ is the Archimedean of the characteristic function X_A of A. In symbols

$$m(A) =_m \int_a^b X_A dx \quad \text{is in } P(m)$$

Similar definition exists for higher dimensions R^k(m,n,p,q)

Similarly we may define measure and integration by the pairs of precision levels P(m)-P(p), and P(m)-P(q) etc.

The basic properties of the classical Integral are:

1) Continuous=> Integrable
2) Linearity
3) Inequality
4) Additivity at the limits of integration
5) Upper, Lower bounds and the limits of integration
6) Absolute value inequality
7) Additive property of point measure
   $m(A \cup B) =_m m(A)+m(B)-m(A \cap B)$

8) It holds also that functions that differ only at a set of measure zero have equal integrals.

Proposition 3.1(Measure zero)
Let two digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , and h:[a,b]$_m$->R(m,n) , with oh: :[a,b]$_n$ ->P(n) , h=[oh] , that are (digitally) P(m)/P(n) integrable on [a,b]$_m$, such that they differ in values only on a subset of [a,b]$_m$ of (Archimedean) measure zero , then their (Archimedean) integrals are equal.

$$\int_a^b f(x)dx =_m \int_a^b h(x)dx$$

Hint for a proof: It suffices to prove that the Integral of their deference is zero. Which is point-wise zero at all points of $[a,b]_n$ in P(n), except at the points of a subset A of the closed interval of measure zero, $m(A)=_m 0$. Since the A is a finite set, the f(A) has a maximum M in P(m) , which when factored out in the finite sum which is the Archimedean P(m)/P(n) integral, it will give an upper bound for the integral of the f(x)-h(x) , of the type M*m(A). But as m(A)=0, then the integral of f(x)-h(x) is lso zero in P(m) QED.

Proposition 3.2 (Continuity implies intergarbility)
Let a digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , which is (digitally) P(m)/P(n)/P(p) continuous in the closed interval [a,b]. Then it holds that it is also a (digitally) P(m)/P(p) integrable function at [a,b]$_m$ and

$I =_m \int_a^b f(x)dx$ *is in P(m)*

Hint for a proof: Since the f(x) is continuous on [a,b] by proposition 2.6, it has a maximum M. As in the proof of the previous proposition when M is factored out in the finite sum which is the Archimedean P(m)/P(n) integral, it will give an upper bound for the integral of the f(x) , of the type M*|b-a| . Therefore the integral sum is upper bounded in P(m) and it exists therefore as a number of P(m). Thus if(x) is P(m)/P(n) integrable QED.

Proposition 3.3 (Additive decomposition of interval) *Let a digital functions f: [a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , which is (digitally) P(m)/P(n) integrable on the closed interval [a,b]$_m$. Then for an c of [a,b]$_m$ in P(m) it holds that f it is also a (digitally) P(m)/P(n) integrable function on [a,c]$_m$ and [c,b]$_m$ and*

$$\int_a^b f(x)dx =_m \int_a^c f(x)dx + \int_c^b f(x)dx$$

Hint for a proof: Direct consequence from the associative property of finite sums in P(n). QED

Proposition 3.4 (Linear combination) *Let two digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , and h:[a,b]$_m$->R(m,n) , with oh: :[a,b]$_n$ ->P(n) , h=[oh] , that are (digitally) P(m)/P(n) integrable on [a,b]$_m$, such that their linear combination kf(x)+lh(x) for constants k, l of P(m),is again inside P(m). Then their linear combination kf(x)+lh(x) function is also (digitally) P(m)/P(n) integrable digital function on [a,b]$_m$ and*

$$\int_a^b (kf(x) + lh(x))dx =_m k\int_a^b f(x)dx + l\int_a^b h(x)dx$$

Hint for a proof: Direct consequence from the associative and distributive law, of finite sums in P(n).QED.

Proposition 3.5 (Upper, Lower bounds inequalities) *Let a digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , which is (digitally) P(m)/P(n) integrable on the closed interval [a,b]$_m$,such that for constants m, M of P(m), it holds that m<=$_m$f(x)<=$_m$ M . Then*

m(b-a)<=$_m$* $\int_a^b f(x)dx$ *<=$_m$ M(b-a).*

Hint for a proof: Direct consequence from the distributive law and corresponding inequalities of finite sums. QED.

Proposition 3.6 (Integrability) *Let a digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_n$->P(n) , f=[of] , which is upper bounded by a number of P(m): f(x)<=$_m$ M and M and also (b-a)M are in P(m) for all x in P(n). Then it is Archimedean P(m_)/P(n) integrable:*

I=$_m$ $\int_a^b f(x)dx$ *exists as a number of P(m)*

Indication for a Proof: In the definition of the Archimedean integral, in the finite (but seemingly infinite) sum of terms f(x)dx in P(n) we may substitute f(x) with its bound M , and factor out the M, by the distributive law of finite sums, while the sum of dx's give the length of the interval [a,b]=$_m$ b-a. Therefore the integral is upper bounded by (b-a)M in P(m) , which means that the rounded in P(m) sum and Integral exists also in P(m), thus the function is Archimedean integrable.

Proposition 3.7 (Inequality with absolute values) *Let a digital functions f:[a,b]$_m$->R(m,n) , with of: [a,b]$_m$->P(n) , f=[of] f:[a,b]$_n$->P(m), which is integrable on [a,b]$_m$ .Then it holds that |f| is also integrable on [a,b]$_m$ and*

$$\left|\int_a^b f(x)dx\right| \leq_m \int_a^b |f(x)|dx$$

Hint for a proof: Direct consequence from the corresponding same inequality property of absolute values for finite sums in P(n). QED

Proposition 3.8 (Integration by parts) *Let two digital functions $f:[a,b]_m$->$R(m,n)$, with of: $[a,b]_n$->$P(n)$, $f=[of]$, and $h:[a,b]_m$->$R(m,n)$, with oh: $:[a,b]_n$ ->$P(n)$, $h=[oh]$, that are (digitally) P(m)/P(p) integrable on $[a,b]_m$, such that the next integrals on $[a,b]_m$ exist*

$$\int_a^b f(x)(\frac{dh(x)}{dx})dx,\ \int_a^b h(x)(\frac{df(x)}{dx})dx$$

then

$$\int_a^b f(x)(\frac{dh(x)}{dx})dx + \int_a^b h(x)(\frac{df(x)}{dx})dx =_m f(b)h(b) - f(a)h(a)$$

Where the derivatives are P(m)/P(n)/P(p) differentiation.

Hint for a proof: Remember that here the seemingly infinitesimals dx are real finite numbers of P(p). By cancelling out the dx in the integrals in the left side, and substituting the df(x) , dh(x) , with their equals in P(p), f(x+dx)-f(x) , h(x+dx)-h(x) , we multiply out them so that these terms as terms of successive finite differences in the finite sum, which is the integral cancel out, to give the right hand side. QED.

Proposition 3.9 (Inequality 2)
Let two digital functions $f:[a,b]_m$->$R(m,n)$, with of: $[a,b]_n$->$P(n)$, $f=[of]$, and $h:[a,b]_m$->$R(m,n)$, with oh: $:[a,b]_n$ ->$P(n)$, $h=[oh]$, that are (digitally) P(m)/P(n) integrable on $[a,b]_m$ and $f(x)<=_n h(x)$ in $[a,b]_n$ then it holds that

$$\int_a^b f(x)dx \leq_m \int_a^b h(x)dx$$

Hint for a proof: Direct consequence from the corresponding similar property of finite sums, which is the integral here. QED.

Proposition 3.10 (Additivity of Archimedean measure) *Let a sets A, B, in P(n) that are Archimedean measurable. Then also their union $A\cup B$ and their intersection $A\cap B$ are Archimedean measurable and it holds for their Archimedean measure symbolized by m(), that*

$$m(A\cup B)=_m m(A)+m(B)-m(A\cap B).$$

Hint for a proof: Direct consequence from the corresponding same formula of cardinality of finite sets, and the definition of the Archemidean P(m)/P(n) measure of a set as finite sum of that of its points. QED.

Fubini Theorem It can be deduced as in classical Calculus that we can get the value of the integral by iterative one dimensional integrals once the lower or upper one-dimensional integrals exist. It is the results Associative and commutative property of finite sums.

Proposition 3. 12 (Fubini theorem iterated integrals) *Let A closed rectangle subset of $P^k(m)$ and B_m closed rectangle subset of $P^s(m)$ and let digital function $f:AxB$ ->$P(m)$, of: AxB ->$P(n)$,$f=[of]$ (digitally) integrable.*

For x in A let h_x : B->P(m) be defined by $h_x(y)=_m f(x,y)$, and we assume that it is also a digital function and let

$$I(x) =_m \int_B (y)dy$$

which is assumed also a digital function.
Then I(x) is (digitally) integrable on A and it holds that

$$\iint_{AxB} f(x,y)\,dydx =_m \int_A I(x)dx =_m \int_A (\int_B h_x(y)dy)dx$$

Hint for a proof: Direct consequence of the associative and distributive property of the finite sums. QED

4. The Fundamental Theorem of the Natural or Digital Calculus as the Relation of the Natural or Digital Derivative with the Natural or Digital Integral.
It is simply the formal expression that a weighted sum that is the mass of segment when getting its derivative to length it will give the linear density of the segment, which is also a derivative,

Proposition 4.1 (FUNADMENTAL THEOREM OF CALCULUS)
Let a digital functions $f:[a,b]_m$->P(m) , with f=[of]
$f:[,ab]_n$->P(n), which is (digitally) P(m)/P(n)/P(p) continuous thus P(m)/P(p) integrable on the closed interval $[a,b]_m$ and also the next function on $[a,b]_n$ is a digital function.

$$h(x) =_n \int_a^x f(y)dy$$

Then it holds that the function at $[a,b]_m$

$$h(x) =_m \int_a^x f(y)dy$$

is (digitally) P(m)/P(n)/P(p) differentiable and at any c of $[a,b]_m$.

$$\frac{dh(x)}{dx}|_c =_m f(c)$$

Hint for a proof: For a seemingly infinitesimal dx of P(p) relative to P(n) the $dh(x)=_n h(x+dx)-h(x)$. But by the proposition 3.3 of additive decomposition of the integral over its intervals of integration gives $h(x+dx)-h(x)=_n h(x)+f(x)dx-h(x)$, thus $dh(x)=_n f(x)dx$. And by the ideal-like properties of the seemingly infinitesimals it is also a seemingly infinitesimal of P(n). Thus the h is P(m)/P(n)/P(p) differentiable with derivative equal to f(x) in P(m). QED.

5. Conclusions and Perspectives

For all practical reasons in the physical and social sciences the digital calculus gives all the well-known applications with a finite ontology which is directly realizable both in the physical ontology of atomic matter or digital ontology of operating systems of computers. This has vast advantages in applications in, Engineering, Physics, Meteorology, Chemistry, Ecology, social sciences etc.

The digital Calculus also resurrects the 17th and 18th century mathematical arguments in Calculus and mathematical physics that treated the "infinitesimals" as separate entities in the derivatives.

The digital Calculus is also an educational revolution in the Education of Mathematics. . It is a new method of teaching mathematics where there is higher integrity with what we say, write, see, and think.

After [8] that defines the axiomatic Euclidean geometry and the current outline of the digital Differential and Integral Calculus, one may define and solve the digital differential and partial differential equations as essentially difference equations, (with easier applications in the physical sciences), digital fluid dynamics (with easier applications in physics), digital differential geometry, digital functional analysis (appropriate for easier applications in signal theory) etc. The road is open and the digital world of the computers is the direct tool for this.

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Association between negative affect (i.e. depression, anxiety, stress) and obesity: the role of self-efficacy and eating self-efficacy as moderators

Abstract

In our days, overweight and obesity prevalence cause a widespread concern for many health professionals all over the world. High prevalence of obesity is controversially supported by literature review regarding its relation with psychological health. The objectives of this study are to explore the association between negative affect (stress, anxiety and depression) and obesity (measured through BMI), to investigate the role of self-efficacy and eating self-efficacy relevant to the aforementioned association and to explore the emotional eating prevalence.There were 192 participants, 63 males and 129 females, above 18 years old, recruited from City Unity College and social media platforms, such as Facebook. Depression, anxiety and stress were not significant predictors for BMI, as F (3,188): .971, p>.05 and Adjusted R-squared:.000. The model was significant only for eating self-efficacy with F (1,190): 28.706, p<.01 and Adjusted R-squared: .127, beta: -.362. Eating self-efficacy explained 12.7% of BMI. The rest of the predictors were no significant. Emotional eating explained 1.9% of BMI, with F (1,190): 4.672, p=.03 and Adjusted R-squared: .019, and beta: .155. Self-efficacy and eating self-efficacy did not moderatethe predictive power of any of these predictors, at p> .05. Emotional eating had prevalence in the sample with mean: 32,76.Therefore, it is suggested a further exploration of the strong relationship of eating self-efficacy and BMI scores, in order to develop relevant intervention strategies for controlling obesity prevalence. Also, additional studies to be conducted with emphasis on obese population, exploring further the relationship between emotional eating and obesity, in order to design effective programs of self-empowerment and control.

Keywords: Anxiety; body mass index (BMI); depression; eating self-efficacy; emotional eating; moderators; negative affect; obesity; prevalence; self-efficacy; stress; weight.

JEL: I1,I12,I3

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1. Introduction

In our days, overweight and obesity prevalence cause a widespread concern for many health professionals all over the world[2]. This is due the fact that obesity can be caused by a variety of factors, such as genetic, psychological, physiologic, metabolic, socioeconomic ones[3].

1.1. Obesity: a worldwide concern

Based on, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) and its data from the National Health and Nutrition Examination Survey (NHANES) in 2013–2014, in the United States the prevalence of obesity together with its related diseases is rapidly increasing, resulting in 33% of the population being considered obese and 67% overweight[4].

More specifically, at the moment, in the United States, above two-thirds of adult population is overweight ($25 \leq$ Body Mass Index (BMI) < 30.0 Kg/m2) and obese (BMI ≥ 30 kg/m2)[5]. Furthermore, in the next 15 years it is expected that the overweight and obese rates of adults in America will reach 80% of its population[6]. Also, according to Ogden, Carroll, Fryar, and Flegal's survey[7], in the United States, amongst black women above 20 years old 56.9% were obese, while the percentage amongst white women was 35.5%. If the current trend persists, then it is estimated that by 2034 all black women will be either obese or overweight[8].

In the United Kingdom obesity is also a serious issue for the public health sector, since there is a three to four-fold increase of prevalence rates among adult population since 1980s, expecting obesity to reach 60% of UK population by 2050, if current trends remain the same[9]. In Italy, based on the World Health Organization (WHO) and the Global Health Observatory Data Repository on Obesity in 2015, the obesity prevalence among Italians that were above 18 years old of age was 20.4%[10]. Also, according to the Health Interview and Examination Survey for Adults conducted in Germany, it was revealed that more than 23.0% were obese with 53.0% of women and 67.1% of men being overweight[11].

In Korea, based on the Korean National Health and Nutrition Examination Survey (KNHANES) the prevalence of obesity rose from 26% in 1998 to 31.1% in 2007-09[12]. In

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Australia, around 33% of the population is considered obese and 60% is above the weight range considered healthy[13].

Finally, according to the International Obesity Task Force (IOTF), that published a paper positioning obesity in Europe in 2002, Greece came second in IOTF's classification for men with overweight and obesity having a prevalence of 72% among them; regarding women, it came first as 74% of them were overweight or obese[14]. Apparently, obesity is a syndrome concerning developed and developing countries and all groups of the population, since it has no socioeconomic distinction, no age or sex differences and therefore indicates a worldwide and an alarming situation[15]. Its prevalence is increasing steadily[16], having a bigger impact on health outcomes and health care system costs[17]. Obesity is also associated with a number of comorbidities, such as cardiovascular diseases, arthritis, several types of cancer and diabetes[18]. It is considered to be one of the main modifiable risk factor for type 2 diabetes and given the rapid increase of people becoming obese, its impact on type 2 diabetes is considered to be even more significant at the levels of population[19].

The World Health Organization (WHO) has characterized it as a global epidemic that is escalating[20]. Therefore, nowadays, its prevention has become of high health priority worldwide[21].

1.2. Definition and origin of Obesity

In an attempt to define obesity, it can be said that this term refers to an energy imbalance that an individual has, because the energy intake is more than the energy expenditure for a long period of time[22].

According to Willyard[23], obesity is considered to be due to heritage at a percentage of 40% to 70%. Based on genome-wide associated studies (GWAS) researchers managed to compare the genomes among thousands of obese and lean individuals and link over seventy-five genetic variants associated with obesity[24].

On the other hand, based on Frazier, Mason, Zhuang, Beeler & Hendricks[25] the reasons behind this enormous rise in obesity in western countries, although it is not totally

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explained, it is not only due to hereditary factors. It is believed that due to the fact it exists in population that is generally stable, this shows that environmental factors, such as energy imbalance and behavioural attitudes, such as sedentary lifestyle, contributes significantly in its increased rates[26]. Consumption of tasty, energetic fast food, has become extremely prevalent in Western societies, while energy expenditure requirements are reduced, resulting in increased body mass and eventually obesity, due to positive energy balance[27].

High prevalence of obesity, apart from being justified by environmental factors, such as energy imbalance and behavioural attitudes, such as sedentary lifestyle[28], it is, also, controversially supported by literature review regarding its relation with psychological health[29]. There are studies demonstrating a strong relationship between body weight and psychological well-being[30] and there are studies supporting that there is no significant association between them[31].

1.3. Negative affect

Negative affect can be defined as the composition of feelings that are characterized as unpleasant, such as anger, shame, fear, disgust, distress, sadness[32]. However, it is still not certain if negative affect is a separate construct compared to positive affect or both together are opposite extremes of a continuum[33].

Research conducted in Canada[34][35] and the United States[36][37]indicated a relationship between obesity and history of depression, depression symptoms and psychological distress measures[38].Also, obese individuals due to functional impairment, body image dissatisfaction, poor self-rated health and social stigma, may become depressed[39]. However, according to Scott et al.[40] depression is considered less associated with obesity than anxiety may be,

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because individuals suffering from major depression disorder have common feature the loss of their appetite.

Thus mentioned, it seems that obesity is related also with anxiety disorder[41]. Gariepy, Nitka, & Schmitz[42] pointed out that more than half of their studies and pooled analysis demonstrated a significant higher relationship between anxiety disorders and obese adults than non-obese ones. More specifically, through reviewed evidence it was found that severe obesity (BMI>35) had a stronger association with anxiety disorders than moderate obesity (30<BMI>35) had[43]. Nevertheless, it should be mentioned that individuals with anxiety disorders belong to a heterogeneous group, so it is difficult to generalize this finding to all anxiety disorders[44]. Also, epidemiological studies[45][46] showed that obesity has positive association with past diagnoses of panic disorder without agoraphobia, generalized anxiety disorder, specific phobia and post-traumatic stress disorders[47].

A positive relationship seems to exist with obesity and stress as well, since in most people emotional stress can be responsible of appetite fluctuation[48]. Foss &Dyrstad[49] support that there is an association of metabolic disturbance that includes obesity and metabolic syndrome, with alteration of stress or otherwise HPA axis activity. In particular, it is suggested that stress can function as a cause and a consequence as well, having a bidirectional pattern of interaction[50]. Gaining weight might trigger stress activation, which might consequence in gaining extra weight[51].

On the other hand, perceived stress at high levels is related with alcohol usage, smoking, no physical activity, conditions that enhance the risk of obesity and depression[52]. Therefore, strategies developed to deal with stress, anxiety and depression might end to comfort eating, which might result in affecting weight in the extent to lead to obesity[53].

Hence, depression, stress and anxiety disorders are identified as being positively associated with obesity and vice versa[54]. However, there are studies finding no association between mental illnesses and obesity[55][56][57].

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Grundy et al.[58] argued that through a recent review it appeared that only 8 out of 15 prospective studies revealed a significant association between depression and obesity, while, through another meta-analysis conducted it appeared depression was marginally a stronger predictor of obesity compared to other illnesses. Also, according to a study conducted by Vogelzangs et al.[59], there was no association revealed for overall obesity increase and depression seemed to be independent of changes appeared in overall obesity.

Similarly, Gariepy et al.[60], argued there is no clear link between obesity and anxiety, as well, since there are studies showing either significant[6162] or no significant association between them[63]. The reason for this inconsistency in findings might be due to the heterogeneity of the nature of obesity and anxiety disorders, since the association between obesity and anxiety disorders might vary among the different groups of population that have no homogeneity relevant to behavioural, biological and sociodemographic characteristics[64]. For instant, obese women might be more strongly related with anxiety disorders, since they usually face greater social discrimination than obese men do[65]. Also, it seems that obesity is differently linked with different subcategories of anxiety disorders[66].

Therefore, it can be pointed out that, based on recent literature reviews and meta-analyses, it seems that obesity and psychological outcomes have no consistency in their statistically significant relationship[67], and, possibly further exploration of the matter needs to be done relevant to this relationship.

1.4. Self-efficacy and weight control self-efficacy

A different way to predict obesity might also be through understanding the perception an individual may have concerning adopting an effective behaviour that will drive in weight loss

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[63] Grundy, Anne, et al. "Associations between anxiety, depression, antidepressant medication, obesity and weight gain among Canadian women," *PloS one*, 9, 6, 2014, pp. e99780.

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and maintenance[68]. According to Babdura[69] efficacy beliefs can predict the way an individual may behave, at different levels of perceived self-efficacy[70]. Self-efficacy is defined as the belief an individual has regarding his or her ability to plan, organize and implement actions to manage relevant situations[71]. Based on Bandura[72], self-efficacy beliefs have different effect on an individual's psychosocial behaviour, since they influence the copy behaviour initiation, the effort expended and the duration of it. Also, they influence the vulnerability an individual may have towards emotional distress and depression[73]. Self-efficacy is not a catholic essence, since it varies relevant to the territory of the activity, the task on demand and the characteristics of a situation[74].

Therefore, taking into account that self-efficacy beliefs are considered to significantly influence the response of a person in a cognitive, affective and behavioural manner, regarding the differences occurred between standards and accomplishments, it can be suggested that self-efficacy beliefs might be used in obese population to predict weight loss[75].

Hence, self-efficacy varies relevant to the domain of the activity[76]. Therefore, in order to understand better the self-efficacy level of an individual regarding his or her nutrient intake, it is suggested, to examine the individual's weight control self-efficacy[77].

Weight control self-efficacy is the perception a person has regarding the ability to engage in an effective manner in behaviours that have as a result the maintenance or loss of weight[78]. It is suggested that since self-efficacy can minimize perceived stress, the association between stress and nutrient intake may be influenced[79]. This means that at the cases were an individual has a tendency to consume unhealthy food in order to reduce feelings of stress, by achieving higher levels of self-efficacy, this tendency might be reduced, since there will be no such feelings of stress that need to be calmed down through consuming unhealthy food[80]. A study was conducted by Ghaderi&Rangaiah[81] at University of Mysore, with 80 Indian and 80 Iranian students, half men and women. It was revealed that self-efficacy can influence strongly depression, anxiety and stress, since students with low self-efficacy had higher levels

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[68]Presnell, Katherine, et al. "Sex differences in the relation of weight loss self-efficacy, binge eating, and depressive symptoms to weight loss success in a residential obesity treatment program," *Eating behaviors*, 9, 2, 2008, pp. 170-180.

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of stress, anxiety and depression[82]. Thus, apart from the association self-efficacy has with depression, anxiety and stress, it appears to have also, a beneficial role on adapting a healthy behaviour[83].

Therefore, self-efficacy and specifically weight control self-efficacy may play an important role in the adoption and continuation of weight management[84]. Also, since self-efficacy, in an extent, can determine the performance of a behaviour, it may be assumed that there might be a relation of one's weight control self-efficacy and to his or her eating behaviour, especially if this is an emotional related one[85].

1.5. Emotional Eating

The predisposition of one's to increase food consumption, as a response to various negative emotional feelings, in an effort to cope with them is known as emotional eating[86]. Emotional eating usually occurs simultaneously with binge eating, since strong relationship has been revealed through clinical and non-clinical samples[87]. When a negative emotional event occurs, in one's attempt to escape from emotional distress and hence to avoid negative feelings, he or she might have an emotional or binge eating behaviour[88]. Emotional eating is considered as an intermediate uncontrolled eating behaviour, while binge eating has a more severe level of uncontrolled eating[89].

Emotional eating is observed in both healthy individuals and individuals with eating disorders symptoms[90]. Emotional eating can be a predictor of binge eating in anorexia nervosa and in bulimia, therefore women with emotional eating behaviour are more vulnerable in developing eating disorders[91]. Emotional eating has been also related closely to overweight and obese people[92]. It is considered a learning behaviour[93], since most of these individuals use eating to reduce a negative state they are facing, which is succeeded shortly after eating, hence the change in the emotional state reinforce them to adopt a negatively eating behaviour, which becomes worst overtime[94].

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[93]Geliebter, Allan, and Angela Aversa. "Emotional eating in overweight, normal weight, and underweight individuals," *Eating behaviors*, 3, 4, 2003, pp. 341-347.

[94]Wong, Mek, and Mingyi Qian. "The role of shame in emotional eating," *Eating behaviors*, 23, 2016, pp. 41-47.

Furthermore, there are a number of studies investigating the association between emotional eating and negative affect[95], deriving findings pointing out the positive relationship emotional eating has with depression, anxiety and distress symptoms[969798].

Thus, emotional eating seems to be important to be identified early in an individual's life, since it might be an indicator of future disordered eating behaviour[99]. Also, as emotional eating occurs independent of hunger and thus contribute positively to the consumption of food, it results in additional weight gain and thus obesity[100]. This is another significant reason, as well, in order emotional eating to be identified early in a person's life[101].

1.6. Rationale and Significance

Obesity is a worldwide chronic disease[102] that is associated with various chronic health conditions and is also very strongly related with the emotional status of an individual[103]. Weight control self-efficacy is the perception an individual has relevant to his or her ability to regulate daily nutrition intake, especially if influenced by negative emotions and stressors conditions[104]. Also, emotional eating is a behaviour coexisting with negative affect reinforcing the tendency overweight and obese people have to weight gaining.

Therefore, it would be significant to design interventions aiming to reinforce self-efficacy and specifically weight control self-efficacy on overweight and obese individuals, by designing appropriate coping strategies to reduce negative affect, in order to prevent obesity development, enhance individual's sense of self-empowerment and health outcome and eventually manage to decrease health care system cost[105].

1.7. Aim/Objective

The objectives of this study are primly to investigate how self-efficacy and eating self-efficacy moderate the association between negative affect (stress, anxiety and depression) and obesity (measured through BMI) and, secondly, to explore the prevalence of emotional eating. It is hypothesized that anxiety, stress and depression will have a positive association with weight, measured through BMI, and that self-efficacy and eating self-efficacy will moderate this association, acting protectively against the negative impact of mental health on obesity. It

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[95]Wong, Mek, and Mingyi Qian. "The role of shame in emotional eating," *Eating behaviors*, 23, 2016, pp. 41-47.
[96]Konttinen, Hanna, et al. "Emotional eating, depressive symptoms and self-reported food consumption. A population-based study," *Appetite*, 54, 3, 2010, pp. 473-479.
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is also hypothesized that emotional eating will be prevalent in the sample and will be associated with obesity.

2. Methodology

2.1. Research Design

This was a quantitative research and a correlational design using multiple regression and moderators analyses. The predictors were depression, anxiety and stress and criterion was weight, measured through the Body Mass Index. Self-efficacy and eating self-efficacy are the moderators.

2.2. Participants

There were 192 participants, 63 (32,8%) males and 129 (87,2%) females. The mean age was 40,79 years old and the age range was between 18 and 82 years old. While the mean BMI of participants was 25,19, with min BMI 16,90 and max BMI 58,14. Please see Table 1. Demographics, for information on the demographics. Inclusion criteria were to be over 18 years old and have sufficient knowledge of the English language to be able to complete the questionnaires. Individuals under eighteen years old, individuals who report mental health disorders and pregnant women were excluded from the study. To assess the eligibility of individuals to participate, an information sheet and consent form were used.

Table 1. Demographics

Name of Variable	Categories	*f*	%
Occupation	Civil servant	17	8,9
	Private employee	89	46,4
	Self-employed	45	23,4
	Housekeeping	1	,5
	Pensioner	7	3,6
	Unemployed	13	6,8
	Other	20	10,4
Educational level	Primary school	1	,5
	Secondary/High school	16	8,3
	Graduate	70	36,5
	MSc/PHD	93	48,4
	Other	12	6,3
Marital status	Single	64	33,3
	Married	73	38,0
	Divorced	22	11,5
	Widower/Widow	3	1,6
	Living with a long term partner	24	12,5
	Civil Partnership	1	,5
	N/A	5	2,6

2.3. Recruitment/Sampling

Convenience sampling method through snow-ball technique was used[106]. Online and face-to-face questionnaires were used to increase participation rate. Participants were recruited from City Unity College and Social Platforms (i.e. Facebook).

2.4. Materials

A demographics questionnaire was used to assess demographics and body mass index (BMI) of participants, together with the following four instruments; Depression, Anxiety, Stress Scale 21items (DASS21), General Self-Efficacy Scale 10items (GSES10), Weight Efficacy Life short version scale 8itmes (WEL-SF8) and Emotional Eating Scale 25items (EES25).

2.5. Depression, Anxiety, Stress Scale 21items (DASS21)

The information collected for negative affect, such as stress, anxiety and depression, was through DASS21, a short version of DASS-42 items [45]. Depression Anxiety Stress Scale-21 items has three subscales. Each subscale has 7 items that are self-reported and measure the negative emotional state of depression, anxiety and stress respectively[107]. The 21 items consist of four statements each (Did not apply to me at all – Applied to me to some degree or some of the time – Applied to me a considerable degree or a good part of the time – Applied to me very much or most of the time) expressing a different severity level of a particular symptom appeared over the last week[108]. The rating scale is from 0 (Did not apply to me at all) to 3 (Applied to me very much, or most of the time)[109]. Anxiety, Depression and Stress scores are derived by summing up the respective items' scores and then multiplying them by 2[110]. The scale has a good internal validity for all sub-scales and a good construct validity[111][112] and a great convergent, discriminant validity relevant to other instruments[113].

2.6. General Self-Efficacy (GSES)

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[107]Wahed, WafaaYousif Abdel, and SafaaKhamis Hassan. "Prevalence and associated factors of stress, anxiety and depression among medical Fayoum University students," *Alexandria Journal of Medicine* 53,1, 2017, pp. 77-84.

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[111] Henry, Julie D., and John R. Crawford. "The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample," *British journal of clinical psychology*, 44, 2, 2005, pp. 227-239.

[112] Wood, Bradley M., et al. "The utility of the short version of the Depression Anxiety Stress Scales (DASS-21) in elderly patients with persistent pain: does age make a difference?" *Pain Medicine*, 11, 12, 2010, pp. 1780-1790.

[113]Lovibond, Peter F., and Sydney H. Lovibond. "The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories," *Behaviour research and therapy*, 33, 3, 1995, pp. 335-343.

To assess self-efficacy, the General Self-Efficacy (GSES) 10 items scale was used[114]. It is a self-report instrument for adults and adolescents[115]. Its internal reliability is .76 to .90, being most frequently around .80[116]. GSES is widely used when investigating the positive self-belief of an individual in coping with a challenging situation in his life and has been translated in 31 languages[117]. It has a 4-points Likert scale (1 = not at all true, 2 = hardly true, 3 = moderately true, 4 = exactly true) and its total score is calculated in a range from 10 to 40, with 40 indicating higher levels of self-efficacy and 10 the lowest[118]. It has a good internal reliability, with Cronbach's alpha ranging from .76 to .90 in a sample of 23 countries[119]. It also has high construct validity as well, also having very good cross-cultural validity[120].

2.7. Weight Efficacy Life Questionnaire short version (WEL-SF)

Information regarding eating self-efficacy levels of participants was collected through the use of short version of Weight Efficacy Life Questionnaire (WEL-SF)[121]. WEL-SF measures how confident an individual feel about controlling his/her eating behaviour under specific situations[122]. For example, 'I can resist eating when I am depressed (or down), 'I can resist eating even when others are pressuring me to eat'[123]. WEL-SF has 8 items that are measured on a Likert-scales from 0 to 10 scale, with 0 standing for 'not at all confident' and 10 for 'very confident'[124]. WEL scale has a Cronbach's alpha .95, while WEL-SF has a psychometrical validity of eating self-efficacy that is at 94% of the variability in WEL scale[125]. The global scoring of weight control self-efficacy can be from 0 to 80, with 80 standing for high eating self-efficacy[126][127].

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[114]Luszczynska, Aleksandra, UrteScholz, and Ralf Schwarzer. "The general self-efficacy scale: multicultural validation studies," *The Journal of psychology*, 139, 5, 2005, pp. 439-457.
[115]Lani, James. "General Self-Efficacy-Schwarzer (GSES)," *Statistics Solutions*, 2010.
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[121] Ames, Gretchen E., et al. "Eating self-efficacy: development of a short-form WEL," *Eating behaviors* 13, 4, 2012, pp. 375-378.
[122] Churchill, Susan, Anna Good, and Louisa Pavey. "Promoting the avoidance of high-calorie snacks. The role of temporal message framing and eating self-efficacy," *Appetite*, 80, 2014, pp. 131-136.
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[124]Fløl0, Tone N., et al. "Translation, adaptation, validation and performance of the American Weight Efficacy Lifestyle Questionnaire Short Form (WEL-SF) to a Norwegian version: a cross-sectional study," *PeerJ*, 2, 2014, pp. 565.
[125] Ames, Gretchen E., et al. "Eating self-efficacy: development of a short-form WEL," *Eating behaviors* 13, 4, 2012, pp. 375-378.
[126] Ames, Gretchen E., et al. "Eating self-efficacy: development of a short-form WEL," *Eating behaviors* 13, 4, 2012, pp. 375-378.
[127]Fløl0, Tone N., et al. "Translation, adaptation, validation and performance of the American Weight Efficacy Lifestyle Questionnaire Short Form (WEL-SF) to a Norwegian version: a cross-sectional study," *PeerJ*, 2, 2014, pp. 565.

2.8. Emotional eating scale (EES)

Emotional eating scale (EES) was used to investigate the degree emotional stimuli can initiate overeating to participants[128]. It is a 25-item scale requesting from respondents to answer on a 5 point Likert scale (from a 'no desire to eat up' answer to 'an overwhelming urge to eat' one)[129]. EES assesses the extent to which each mood state initiates a desire of an undereating behaviour (great or moderate) or an overeating one (great or moderate)[130]. Emotions included in the scale list refers to worry, nervousness, sadness, irritation, helplessness, fury, uneasiness and others[131]. The total score is ranged from 0 to 100, with the higher score indicating greater urge to eat for managing emotions[132]. The scale has an internal reliability of .95 in Gearhardt et al.[133], and a good construct validity[134].

2.9. Procedure

2.9.1. Face-to-face distribution

After Cardiff Metropolitan/City Unity Ethical Committee approved the research ethical form the whole research material was distributed to participants at a lecture hour, at City Unity College. Participants were requested by the researcher to carefully read the information sheet and write down, at a specified place, a three-digit code, including one letter, as the only identification code of their responses. If they were willing and eligible to participate, they were asked to sign the consent form, and after to complete all questionnaire given to them.

2.9.2. Online distribution

Google forms were used to develop the online questionnaires, which were distributed through a link on social media platforms, such as Facebook. Participants were asked to read carefully the information sheet and if they met the entry requirements and wished to participate at the study, they had to confirm that, through clicking on the appropriate button on-screen. Afterwards, they were directed to the online questionnaires, in order to complete them. In case, they wanted to withdraw from the study, at any time before submitting their questionnaires, they could click the appropriate button on-screen to exit.

2.10. Ethical considerations

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[128]Arnow, Bruce, Justin Kenardy, and W. Stewart Agras. "The Emotional Eating Scale: The development of a measure to assess coping with negative affect by eating," *International Journal of Eating Disorders,* 18, 1, 1995, pp. 79-90.

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[130]Gearhardt, Ashley N., William R. Corbin, and Kelly D. Brownell. "Preliminary validation of the Yale food addiction scale," *Appetite,* 52, 2, 2009, pp. 430-436.

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[132]Goldbacher, E. M., et al. "Factor structure of the Emotional Eating Scale in overweight and obese adults seeking treatment," *Appetite,* 59, 2, 2012, pp. 610-615.

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[134] Ames, Gretchen E., et al. "Eating self-efficacy: development of a short-form WEL," *Eating behaviors* 13, 4, 2012, pp. 375-378.

All ethical considerations were taken into account and all conditions were satisfied, before and after the initiation of the study.

2.11. Data Analysis

Linear Multiple Regression analyses were used to examine whether depression, stress and anxiety predicted BMI/Obesity, while the role of self-efficacy and eating self-efficacy as moderators was also examined through multiple regression. Descriptives and frequencies were also used, as appropriate. An alpha value of .05 was adopted for all statistical analyses.

3. Results

A multiple linear regression was used to examine whether depression, anxiety and stress can predict scores in BMI. The model was not significant, as F (3,188): .971, p>.05 and Adjusted R-squared:.000. So depression, anxiety and stress were not significant predictors for BMI.

A multiple linear regression, with stepwise method, was used to examine whether depression, anxiety, stress, self-efficacy and eating self-efficacy can predict scores in BMI. The model was significant only for eating self-efficacy with F (1,190): 28.706, p<.01 and Adjusted R-squared: .127, beta: -.362. So eating self-efficacy explained 12.7% of BMI. The rest of the predictors were no significant, as p>.05.

Simple linear regression was used to examine whether emotional eating can predict scores in BMI. The model was significant with F (1,190): 4.672, p=.03 and Adjusted R-squared: .019, and beta: .155. So emotional eating explained 1.9% of BMI. Please see Table 2. Emotional eating, for information on emotional eating.

Regression analyses were used to examine whether self-efficacy acted as a moderator between depression, anxiety, stress and BMI. Self-efficacy did not moderate the predictive power of any of these predictors at p> .05.

Regression analyses were used to examine whether eating self-efficacy moderates the relationship between depression, anxiety, stress and BMI. Eating self-efficacy did not act as a significant moderator for any of these predictors, with regard to BMI, at p>.05.

Table 2. Emotional eating

	N	Min	Max	Mean	SD
Emotionaleating	192	0	85	32,76	19,134

4. Discussion

4.1. Summary of the findings

The results of the findings revealed that there was no significant association between negative affect (depression, anxiety, stress) and obesity. Also, self-efficacy and eating self-efficacy did not act as moderators of this relationship. However, there was a significant negative association between eating self-efficacy and BMI levels, indicating that when eating self-efficacy is low then the risk of obesity gets high. Additionally, there was a moderate prevalence of emotional eating, indicating a reliance to food, in order to manage emotional status. Lastly, there was a positive correlation of emotional eating with obesity, suggesting that when there is eating behaviour in response to emotions, there is an indication of obesity appearance.

4.2. Comparison with previous literature

Although there are studies[135][136][137][138][139] arguing that there is an association between depression, anxiety, stress and obesity, the findings of the current study seem to be consistent with the findings from the study conducted by Svard et al.[140], with 5.668 municipal employee participants living in Finland. The results of Syard et al.'s[141]studysuggested that there were no statistically significant differences between obesity and changes in mental health[142].

Similarly, the results of the study agree with the results of the study conducted by Grundy et al.[143], with 3.004 Canadian women participants. The study was investigating the relationship of overweight and obesity with history of anxiety and depression. No correlation appeared between history of depression or anxiety and overweight or obesity status[144].

Additionally, the outcome relevant to self-efficacy not being moderator of the association between obesity and negative affect, seems to coincide with the study by Nastaskin et al.[145], that investigated, in a sample of 136 undergraduate students, the association between diet self-efficacy and stress levels with not healthy eating habits. Specifically, Nastaskin et al.[146] findings reported that self-efficacy was not related with nutrient intake and did not moderate the association between nutrient intake and stress.

However, the same study suggested that the interaction between diet self-efficacy and perceived stress determined sodium and fat intake[147], which indirectly agrees with the significant association of eating self-efficacy and obesity revealed of the study.

Similar results, regarding the negative correlation of eating self-efficacy and obesity were derived as well, by the study conducted by Soheila, Shiva, Arezou, Ramona, &Atefeh[148]. They evaluated the interaction of self-efficacy for eating control, obesity and body image in 300 women[149]. Their findings suggested that women of older age with higher BMI score had

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[148]Soheila, R. A. B. I. E. P. O. O. R., et al. "How Does Obesity, Self-efficacy for Eating Control and Body Image in Women Affect Each Other?" *Maedica,* 13, 3, 2018, pp. 223-228.

[149]Soheila, R. A. B. I. E. P. O. O. R., et al. "How Does Obesity, Self-efficacy for Eating Control and Body Image in Women Affect Each Other?" *Maedica,* 13, 3, 2018, pp. 223-228.

also lower weight self-efficacy and were more dissatisfied with their body image than the rest of the women in the sample[150].

Moreover, the prevalence of emotional eating appeared in the study is in consistent with the finding of the study Fox, Conneely, & Egan[151] conducted, with 97 obese and overweight participants, investigating the association between the psychological factors with emotional eating and obesity. The results highlighted the prevalence of emotional eating in obese and overweight individuals[152].

Also, the correlation of emotional eating with obesity showed from the study is concurred with the review conducted by Frayn et al.[153]. Frayn et al.[154] suggested that internal disinhibition and emotional eating are negatively related with weight outcomes, such as less weight loss, weight maintenance.

Similarly, to this research finding are the suggestions made by Vainik, García-García, &Dagher[155] based on their review on the relationship of emotional eating and obesity. Their findings indicated that uncontrolled eating is genetically and phenotypically linked with BMI levels and food intake. While, it has a mediator role relevant to the relationship of BMI, food intake and psychological constructs, i.e. negative affect, reward sensitivity and lower cognitive control[156].

4.3. Limitations

The findings of the study must be interpreted by caution, since it used self-reports, which are open to bias potentially leading to inaccurate results[157] and the questionnaires in use were not in the native language of the participants. Especially, subjectivity should be considered in regards to height and weight measurements[158], since it has been observed that height and weight are frequently related with direct physical measurements and thus there is usually an underestimation of them[159]. Also, due to self-reporting there is vulnerability to social desirability and hence to reliability issues[160].

Moreover, the sample was collected through the convenience sampling method and therefore there was no access by anyone to participate in the study[161]. Finally, the response

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[150]Soheila, R. A. B. I. E. P. O. O. R., et al. "How Does Obesity, Self-efficacy for Eating Control and Body Image in Women Affect Each Other?" *Maedica*, 13, 3, 2018, pp. 223-228.

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rate of the study, together with a non-gender balanced sample limits the ability to generalize the findings[162].

4.4. Conclusion/Recommendations for future research

The present findings highlight the inconsistency existed in the literature review, regarding the association of depression, anxiety, stress and obesity. While, it indicates that although self-efficacy and especially eating self-efficacy are not moderators of the relationship between obesity and negative affect (depression, anxiety, stress), eating self-efficacy is significantly correlated with obesity, in a negative manner. On the other hand, emotional eating had prevalence in the sample, but observing a positive association of it with obesity, it seems that there are indications that in an overweight and obese population the prevalence might be higher, as well as the correlation between emotional eating and obesity might become stronger[163].

Therefore, it is recommended for further studies to be conducted, in a larger and focused (overweight and obese) population, exploring the relationship between eating self-efficacy, BMI levels and emotional eating. Also, to investigate the prevalence of emotional eating in overweight and obese population, in order to understand the level of impact it has on body weight status.

It is important to further investigate the matter, in order, to design and develop interventions to change attitudes relevant to emotional expression[164]. Also, to develop self-regulatory skills, effective weight management programs and emotional regulation strategies for individuals observed with eating disorders[165].

Last but not least, it is highly recommended the research finding to be replicated and validated[166]. Also to enrich the findings with longitudinal research designs and in a gender balanced population, in order to be able, later on, to generalize them[167].

5. Acknowledgements

This work was supported by the University of Cardiff Metropolitan and City Unity College through the supervision of Dr. Despina Menti, which I would like to thank for her valuable

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help,feedback and support during the development of the study and completion of the dissertation paper.

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Is brain drain an effect of the economic crisis?

Abstract
The caliber and merit of those who abandon a country constitute a deep social loss, as the absence of competent professionals, academics and researchers has rocked social structure and cohesion to its foundations, reducing the growth prospects of a region.As noted in absolute numbers the higher and technological education graduates of Greece as well as Master's degree holders are constantly increasing for the period 2000-2017.Among the employees, the group most affected are those who do not hold an academic degree.More specifically, there are three labour pools in Greece:Foreign universities, Greek universities and graduate migrants.The outward migration of Greeks to other countries is not affected by GDP, HDI and unemployment rates.As it is specified by the econometric models, there was a spiralling increase from 2009 to 2013. A relative stagnation is expected, except for women, where a marked upward trend is predicted.An additional survey datum was that from 1980 to the present highly educated Greeks are continuously increasing. It is speculated that people now decide to emigrate for different reasons than they did in the past.

Key-Words: Brain drain, unemployment, migration

JEL: I,M,I3

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1. Introduction

The economic crisis along with the implementation of economic adjustment programmes has only aggravated the labour market situation in Greece.One of the immediate effects of the economic crisis is the so called "brain drain". The crisis is not the main reason behind this mass exodus, but it undoubtedly is a factor that accentuates it.Besides, the labour force migration has been established as a prevailing situation of international migration and, ergo, of globalisation.

2. Definition, estimate, onsets and the reasons behind it

Brain drain is defined as the flow of young scientists out of the domestic job market and their settlement in more developed countries with decent working conditions. More particularly, a highly skilled immigrant is someone who was born in a different country from that he lives in, he is over 25 and holds an academic degree or has a professional qualification (Marfouk 2006).

The size of the brain drain of a country is estimated by counting people with a higher education level who were born and educated in it, while they live and work abroad, on the proportion of the total amount of people with a higher education level in the country of origin.

Brain drain obviously constitutes a form of migration, but there is no question of survival, as it is every person's career aspirations (Sofianopoulou&Rouziou 2014).

According to Marinakou, Giousmpasoglou&Paliktzoglou (2015), brain drain is proportional to the fall in income and living standards. The loss of human capital has proven to be damaging, as the country of origin had invested in certain people providing education but did not leverage their full potential.

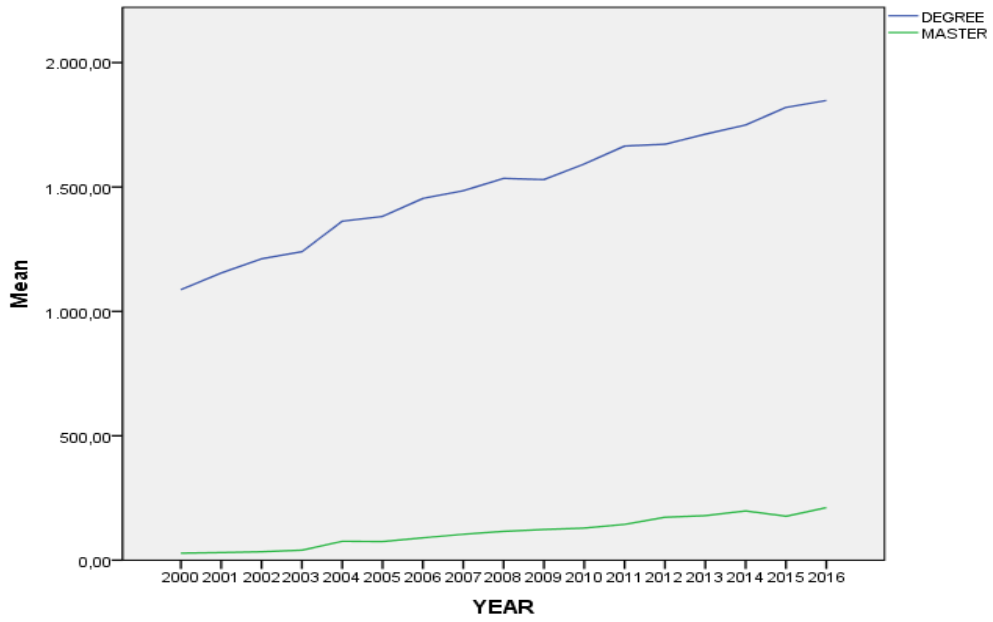
Another important issue that has to be investigated is how the scientific personnel or the trained workforce is defined.A highly trained laborer who invested in his human capital could be included as well.International literature cites a plethora of characterizations like "International migration of skilled workforce" (Findlay 1990), "International movement of the highly skilled" (Cormode 1994), "Global talent flows" (Appleyard 1991). Even so, the majority of researchers refer exclusively to higher education graduates including within the broader category intellectuals, scientists and technologists.University students have been under investigation for the last few decades.

As a consequence, if higher education graduates are the only ones to be included in the brain drain related to Greece, then it will be seen that this was a pre-existing phenomenon in the country.Brain drain obviously constitutes a form of migration, but in the past migration was not that much a question of survival, as it was every person's career aspirations.Nowadays, brain drain is primarily due to the economic situation. It became known through Marinakou, Giousmpasoglou & Paliktzoglou (2015) research that migration is proportional to the fall in income and living standards.

3. Investigating this phenomenon

The following table shows the total population of the country with respect to the educational level.

Table 1: Total population of the country with respect to the educational level.

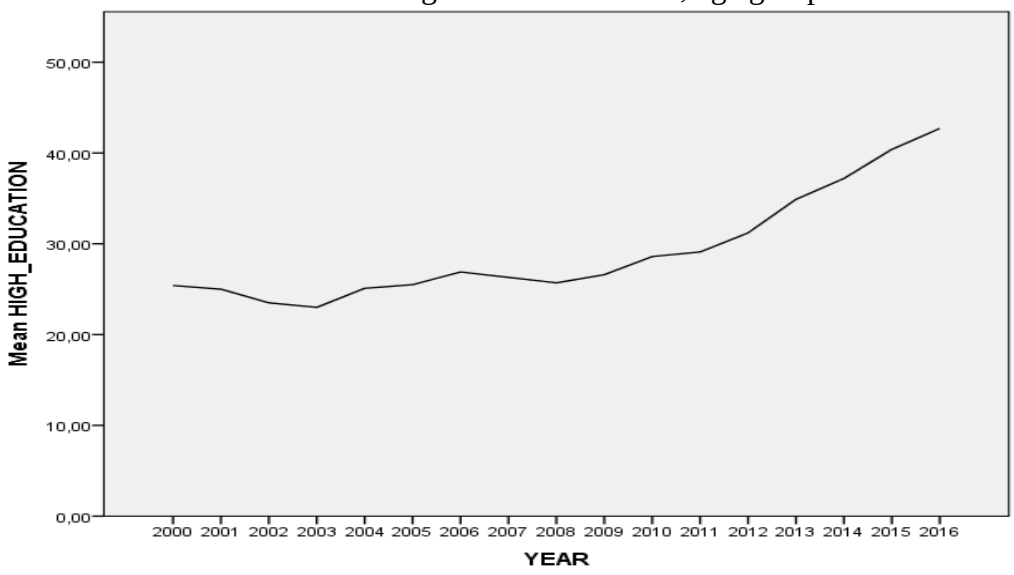


As it is seen in absolute numbers, so that the trend estimated by variables becomes noticeable, the higher and technical education graduates of Greece (blue line) are continuously increasing.MA degree holders (green line), are also increasing with a slight decline between the years 2014-2015.

This overall picture in Greece was expected, as in the past 20 years many university departments (Medical School, Polytechnics etc.) were set up at the public universities of the country. New public technological institutes were also created that offer different areas of specialization.Moreover, during the same years, many Greeks could afford to provide their children with education at private schools abroad.

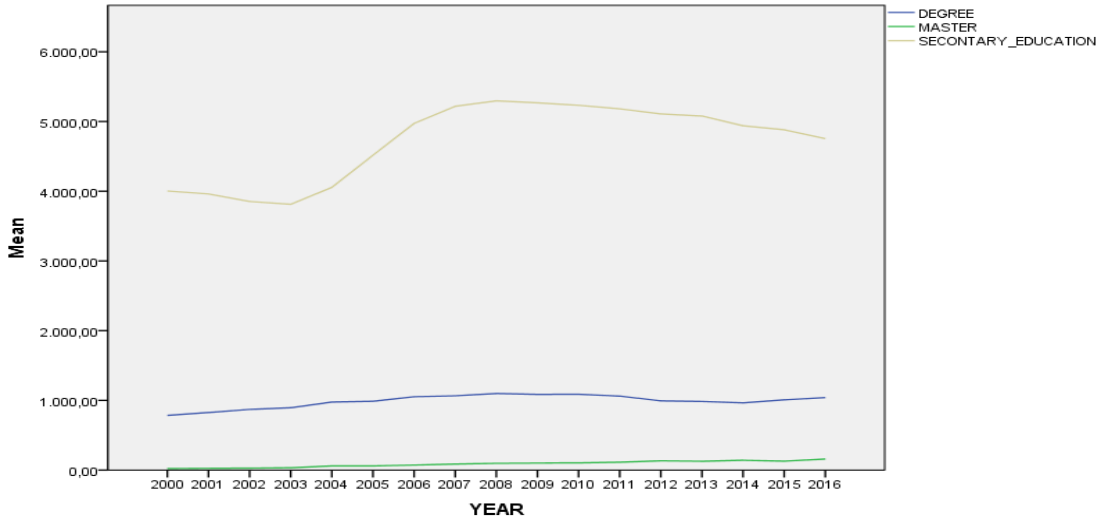
The higher education level is presented below, for the age group 30-34 in Greece from 2000 to 2016 according to Eurostat data.As a general remark, it is stated that the number of degree holders is increasing rapidly.Despite the increasing brain drain, highly qualified scientific personnel that are analogous to Labour market dynamics might have remained in the country.

Table 2: Higher education level, age group 30-34



Regarding the employees of the country in relation to their education level, the following table illustrates the status quo.When it comes to employees, they come from any form of employment, namely civil servants, self-employed and employees with flexible forms of work.

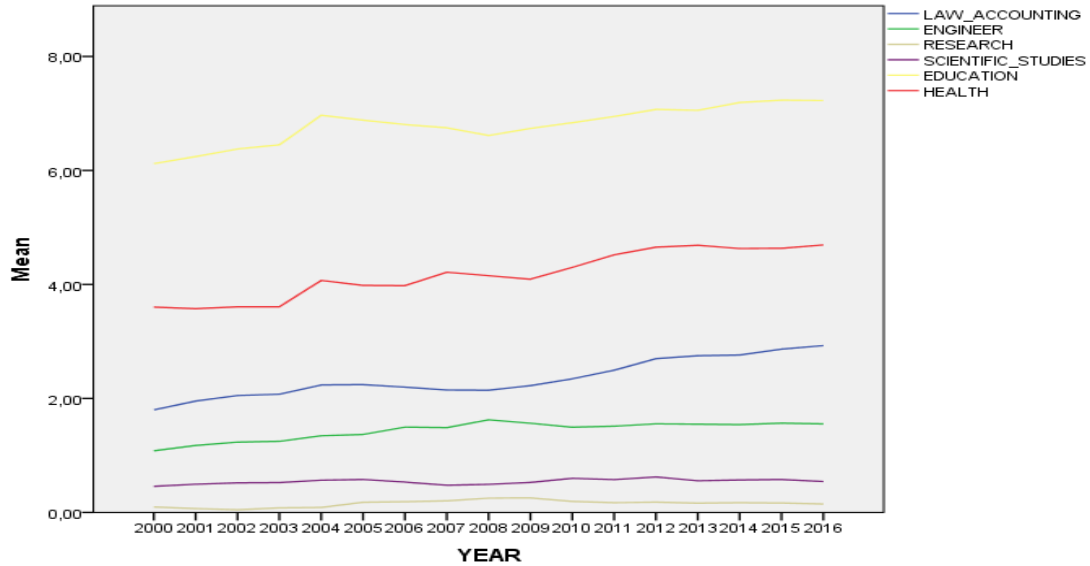
Table 3: Employees in relation to their educational level



It is observed that MA degree holders (green line) are not affected by the years of crisis 2010-2016, given their slight increase.Non-degree holders (yellow line), in stark contast, showed a sharp decline.Higher and technical education graduates (blue line) seem to try to adapt to the new conditions, since they have slight fluctuations.

By analyzing certain employment sectors with a scientific background with regard to the labour market situation, it is noted that the sectors that concern scientific research and development, other professional, scientific and technical activities and the activities of architects and engineers indicate stagnation, if not a downturn.In stark contrast, sectors like legal and accounting activities, health activities and education are on the rise.

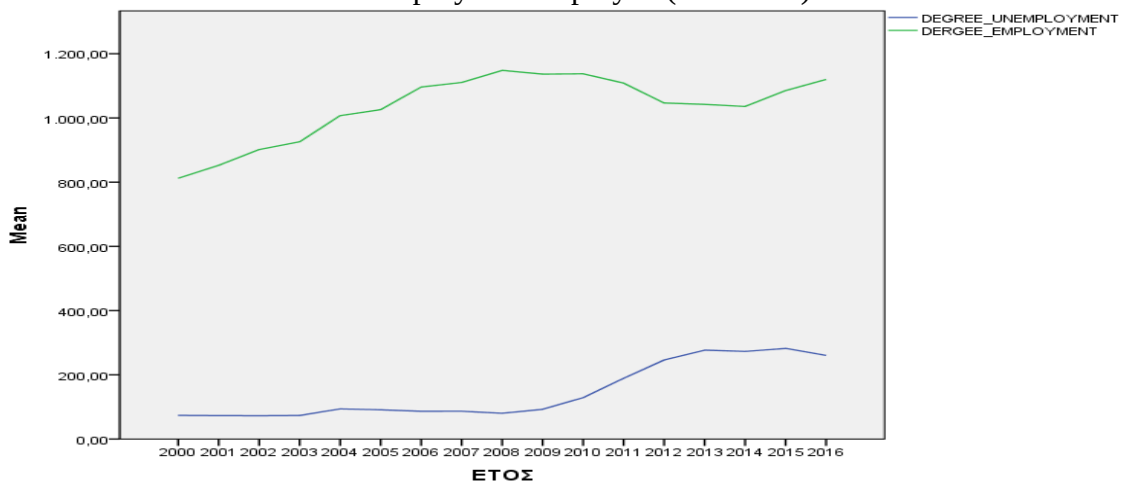
Table 4: Employment sectors 2000-2016



This trend might be due to the fact that the public and private sector ceased to recruit employees, so the second group can operate as self-employed.The first group seems to be trapped in the existing situation, when considering that any form of reconstruction in Greece has stopped and scientific research is not fully funded.

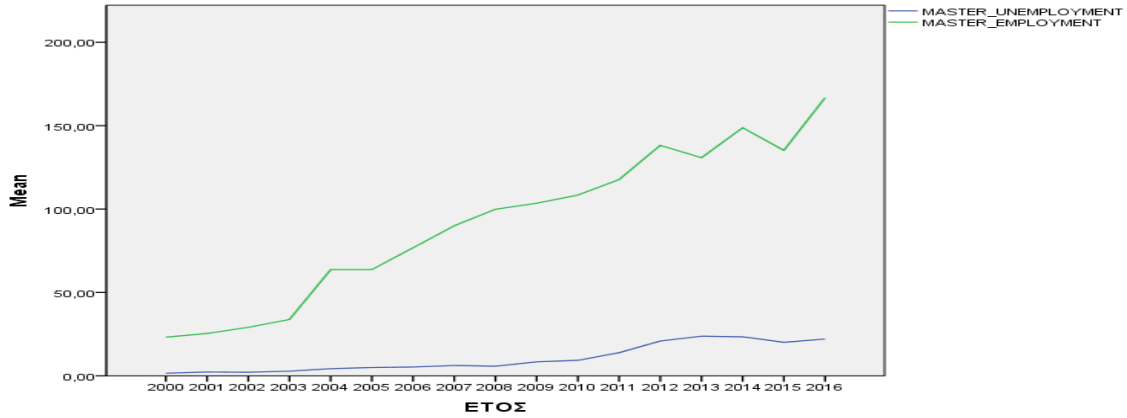
Unemployment rate in Greece has shrunk to 18.3% for the third quarter of this year, compared to 19% for the second quarter of 2018 and 20.2% for the third quarter of 2017, as shown in the data of the Greek statistical authority (ELSTAT).The highest unemployment rates during the third quarter of this year are observed in women (23.3% as opposed to 14.3% in men) and in persons aged from 15 to 19 years old (44.3%).Then, the age groups 20-24 (35.4%) and 25-29 (27.1%) follow, in West Macedonia (27,6%), Western Greece (23.8%), Northern Aegean (20.7%) and in Central Macedonia (20.1%), as well as those who have completed some of the grades of primary school (38,4%). The following tables depict the relation between the employed and the unemployed of Greece, both those who graduated from higher and technical education and those who did not. Unemployment rates for degree holders rose between 2010 and 2016 (blue line) whereas employed of the same educational level decreased (green line).

Table 5: Unemployed - Employed (HEIs/TEI) 2000-2016



Unemployment concerning those with an MA degree (blue line) remained moderate with small variations contrary to the employed of tha same educational level (green line).This trend accompanied by small fluctuations might be due to new forms of employment (e.g. 5-month subsidised empoyment schemes). It is seen that the more educated someone is the more chances he has of finding a job in the labour market of his country.

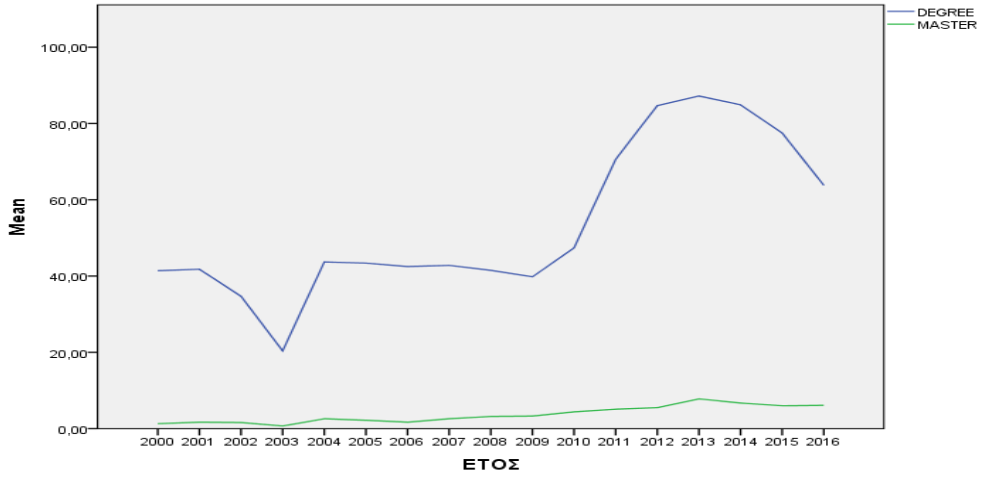
Table 6: Unemployed - Employed (MA degree holders) 2000-2016



Observing young unemployed people with high educational level, who probably comprise the most important part of the brain drain, it is once again concluded that over the course of the years 2010-2014 unemployment rates skyrocketed, but only for BA degree holders. On the other hand, MA degree holders showed a modest increase.Since 2014 there has been a fall in young unemployed people due to their not being registered as workforce

because they leave abroad (artificial fall).Furthermore, flexible forms of employment have risen sharply (part-time employment or on certain days of the week). On the one hand, they still constitute employment, but, on the other hand, their financial rewards are limited.

Table 7: Young HEIs graduates who are unemployed in comparison with MA degree holders



Migration is divided into two categories: immigrants, that is those who enter a country (immigration) and emigrants, those who flee their country (emigration).This wealth of data mainly concerns the first category.The data regarding the second category are incomplete for Greece.

4. The situation of Greek migration

According to the IAB data, the following tables illustrate details of the highly qualified Greeks, men and women respectively, who settled in other countries from 1980 to 2010.It is observed that the countries that received the most Greeks are the USA and Germany from 1995 and on.In terms of highly educated women, a steady increase is witnessed, fact that results from the active part that women took into employment.Country selection criteria are the same for both men and women.

Table 8: Highly educated Greek men that have settled in other countries between 1980 and 2010

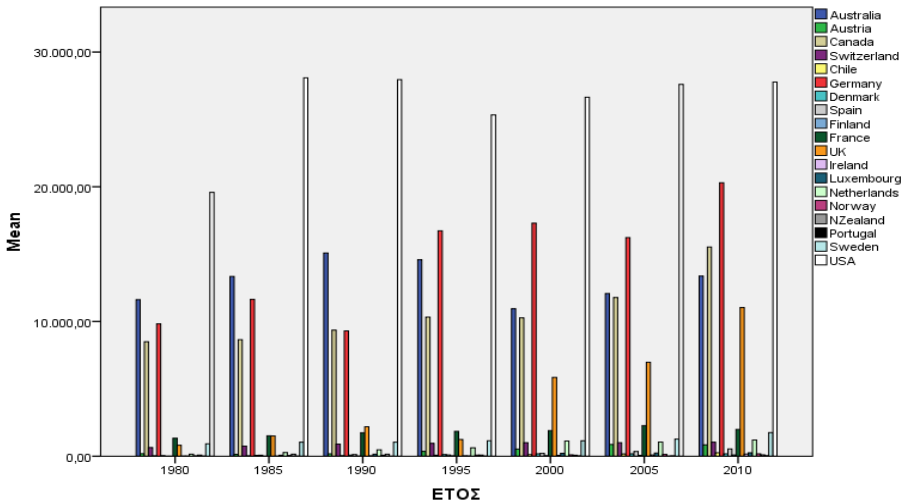
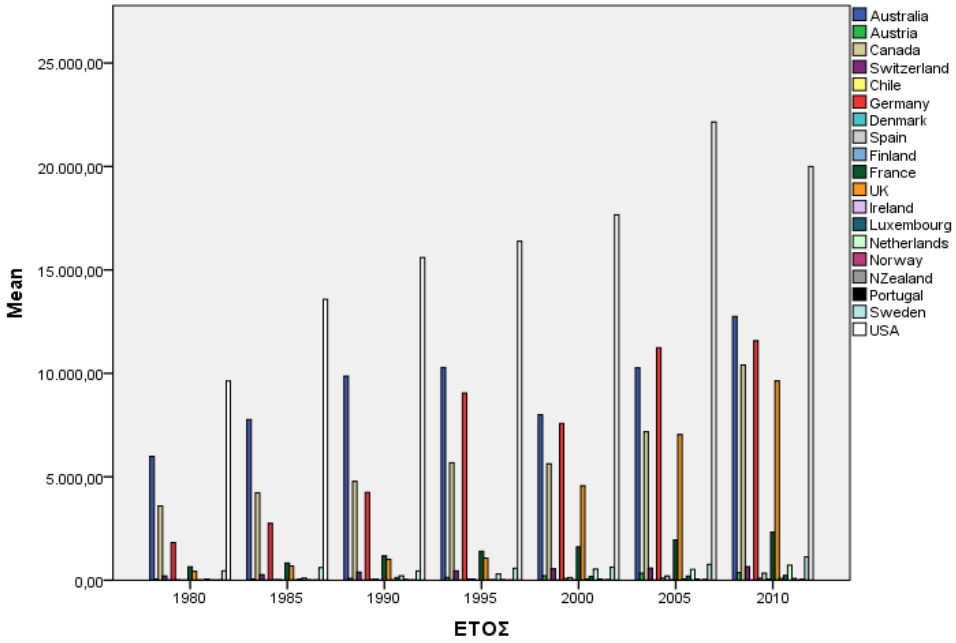


Table 9: Highly educated Greek women that have settled in other countries between 1980 and 2010



According to the IAB data, the following tables illustrate details of the low educated Greeks, men and women accordingly, that settled in other countries from 1980 to 2010.It is observed that the countries that received the most Greeks are the USA and Germany from 1995 and on.Contrary to highly educated people, here Germany takes precedence, whereas the USA is preferred by the other group.As regards low educated women, there has not been the increase that was noticed in highly educated women and this was due to the fact that women had always been a part of the workforce.Country selection criteria are the same for both men and women.Besides, Germany is a country with an important secondary sector, where low educated people resort to in order to look for employment as laborers.

Table 10: Greek men with low or middle level of education that settled in other countries between 1980 and 2010

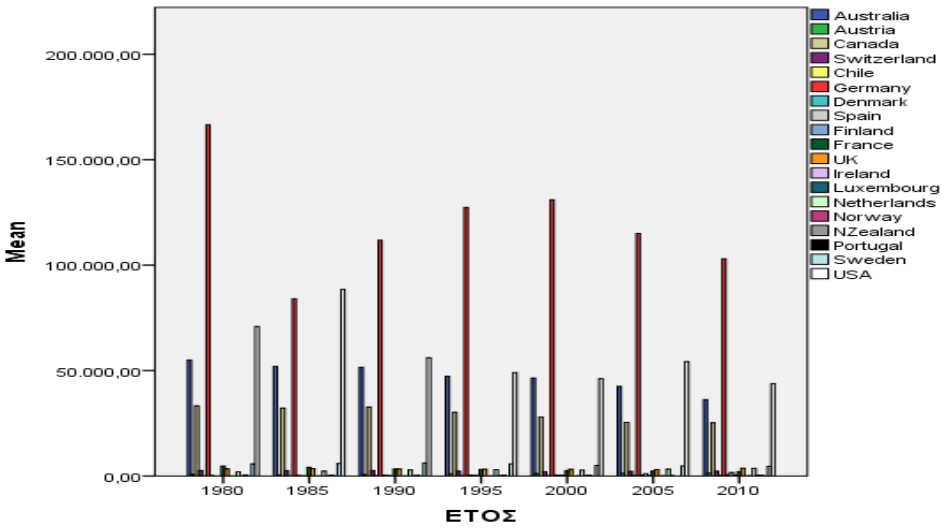
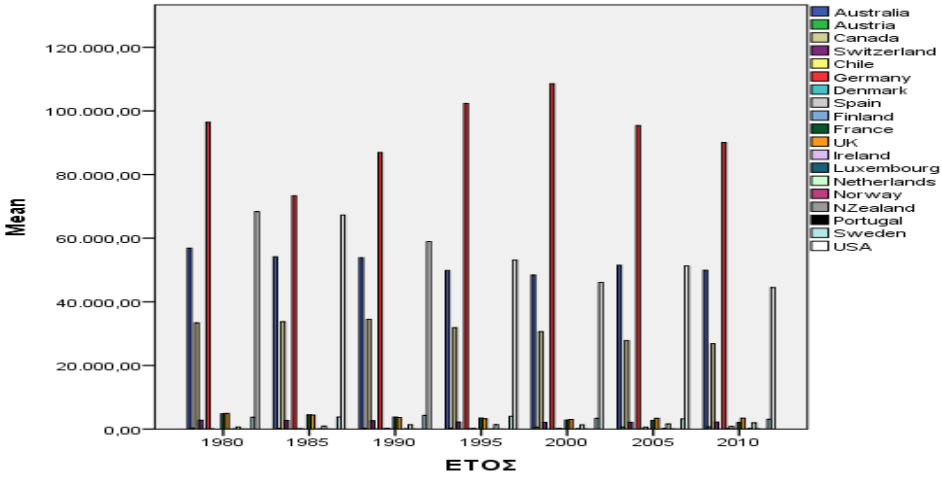
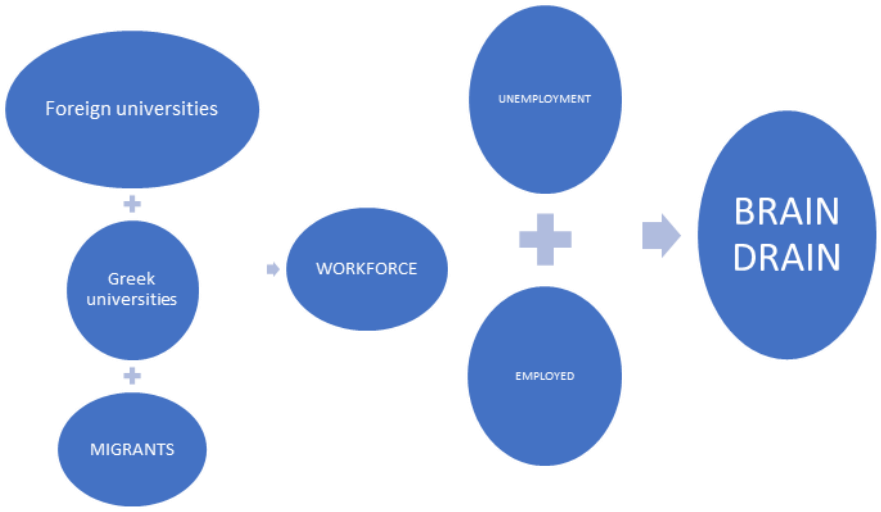


Table 11: Greek women with low or middle level of education that settled in other countries between 1980 and 2010



Brain drain is a complex phenomenon and cannot be addressed with unilateral actions by a government agency or a ministry. Additionally, the consequences of this phenomenon concern and affect Greece as a whole.As it is observed by the following diagram, there are three main labor pools in Greece:Foreign universities, Greek universities and graduate migrants.

Graph 1: The stages that lead to brain drain



Everyone can potentially be deemed as part of the workforce of a country, which comprises all the unemployed and employed people.These two categories lead to brain drain, since it is not necessary for someone to be unemployed in order to migrate. One simply may not be satisfied with his working environment or his standard of living.

At this point a country should meet its needs for scientists, both in terms of quantity and in professional group.It has to be considered that here is the "intersection point" of the Ministry of Education and Ministry of Labor.If they are not properly coordinated, the chances of emergence of unemployed graduates increase. In this way the recommending solutions would be more targeted.

5. Statistical Analysis

In this specific research, data for the statistical analysis originate from Eurostat for the years 2007-2016.Data concern Greek migration to other countries (emigration), unemployment, G.D.P. and UNHDI and how these characteristics are related.

6. Defining HDI and GDP indices

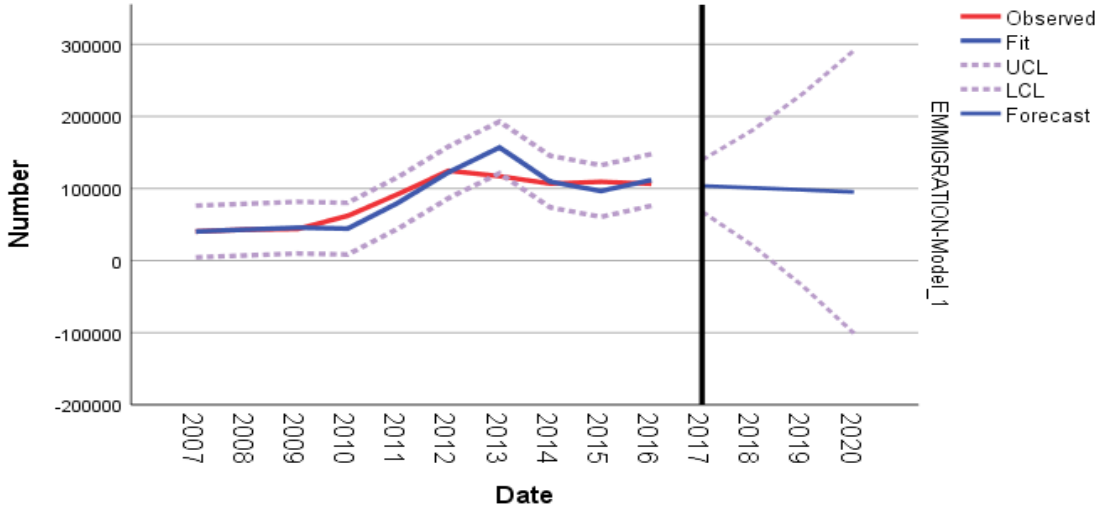
HDI is a complex statistical index of the life expectancy, education and GDP per capita indicator, which is used to classify countries in four levels of human development. This index was selected because a country has a higher HDI when life expectancy, educational level and GDP per capita are also higher.

The GDP of a country's economy can be derived from the totality of the finished products (goods), materials and services that are domestically produced over the course of a certain period, usually within a year.This index was chosen as the level of GDP indicates the standard of living of the inhabitants of a country, as long as the population size is considered.GDP is a variable component.It normally changes from one year to the next, positively or negatively, depending on the prevailing circumstances.

7. The main cause of unemployment

Unemployment arises when an individual is competent and willing to work but unable to find a job as there are surplus occupations.The main cause of unemployment is the low level of development of a country and the law rate of economic growth.The rate of unemployment is exarcebated by the existing long-standing structural problems and malfunctions in input markets, especially in employment, money and products.The level of education and smart specialisation significantly affects those who try to find a job.Finally, unemployment rate is influenced by the number of economic refugees received during certain periods without considering at which point of the economic cycle the economic actitivity of the host country is. The models created for the research concern the migration of Greeks to other countries and to what extent this is affected by GDP, HDI and unemployment rates.Various multivariate time-series models were applied and the optimal time-series models were chosen to better fit the data, based on the correspondent metric analyses. It was investigated whether the independent variables affect Greek migration and through statistical processing it was observed that Greek migration is not affected by these three important economic factors.This resulted in the creation of an ETS (exponential smoothing) forecast model for the total number of people that migrate.

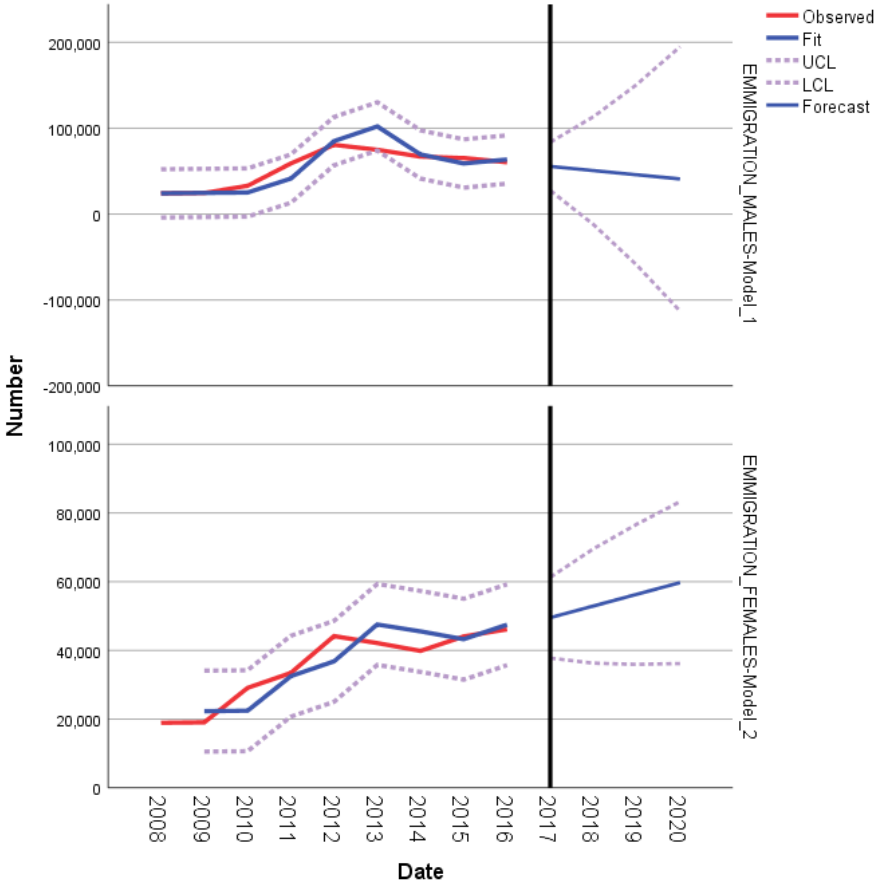
Graph 2: Greek migration 2007-2018



The results set out in the diagram above show that from 2008, namely the onset of the crisis, up until 2010 there was no significant change.The effects of the crisis were followed by a rapidly increasing trend until 2012 owing to the dowturn in production and the increase in degree holders.The stability of emigration is seen from 2013 to date.Relative stagnation is expected when it comes to emigration rate, as most of those who had the potential, have already left the country.

At another level, further analysis was conducted for both sexes, one at a time, where the most appropriate models were applied. According to the statistical criteria, the optimal was chosen.An ETS (exponential smoothing) forecast model was created for men, taking into consideration that the independent variables do not affect their migration.Moreover, in terms of women, an ARIMA model was chosen which proved that the independent variables do not affect their migration.

Graph 3: Greek migration 2007-2018



The results of the graph above about men show a similar pattern to the whole.There was a slight upward trend from 2008 to 2010.This phenomenon peaked between 2013 and 2014.A decline followed since 2014 which is expected to continue in the coming years.

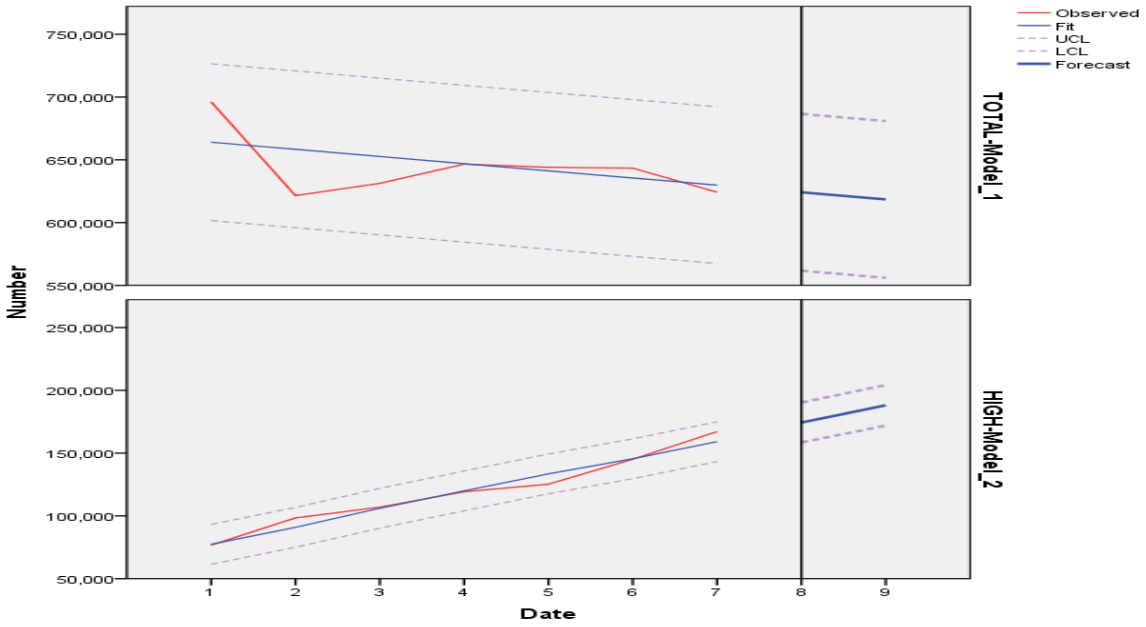
Women exhibit a completely different behavior.Since the onset of crisis up until 2010 they were less likely to migrate. On the contrary, a strong upward trend has emerged since 2011.The overall picture is expected to remain the same in subsequent years.

The analysis was based on the quality and quantity of the existing data. Greek emmigration to other countries has yet to be registered.

A second analysis was applied to another database.An additional statistical analysis on education level was carried out that is confirmed by the previous one. IAB data on Greek migration were used in comparison to the education level between the years 1980 and 2010.

An ETS model was selected to statistically test whether this five-year period has affected the developments in the field of migration.The ultimate goal is to check the influence of these five-year periods of auto-correlations against the estimate of future situations of a ten-year period.

Graph 4: Greek migration based on their level of education between 1980 and 2010



According to the results of Greek migration in comparison to the education level, where all levels are included (low, middle and high), there was a sharp decline of migration from 1980 to 1985.From 1985 to 1995 a considerable increase appeared, whereas stagnation dominates for the next ten years.From 2005 onwards Greek migration has decreased and it is forecast to further decrease up to 2020.

Greek migrants with high level of education present a totally different picture.Those that belong to the brain drain phenomenon from 1980 up to the present reveal a continued upward trend.

Consequently, the factors fuelling the brain drain have completely changed.People once moved to another country in order to enhance their living standards and advance their career, whereas now they choose to do so because of unemployment and low remuneration as compared with their skills.

8. Conclusions

In conclusion, brain drain shows an increasing trend, but it would have still existed, even if economic crisis was imaginary.The fact that the population remains at a standstill while degree holders significantly increase are some of the main reasons of the "brain drain" that render their integration into the labor market impossible.

The aforementioned phenomenon has been aggravated because of the financial crisis that hit the country, as the three main categories of employers that used to absorb workforce have been directly affected.These categories consist of the public sector, medium-sized enterprises and the construction sector.

Therefore,the public sector cannot proceed with recruitments with the same regularity. Construction activity is unable to obtain loans because of the weakness in the banking system.Medium-sized enterprises are plagued by overtaxation which forces many of them to close down and renders others unable to sustain their employees, let alone recruit new ones.

It has been proved that brain drain upward trend was a timeless phenomenon in Greece, even in times when our country was outside of the crisis, when only the first signs were evident.

The emergence of this event in 1980 coincided with the country's accession to the EU, in which case, according to its principles, labor migration is of paramount importance.

As a result, young degree holders and well educated people took advantage of the EU conditions so as to claim higher salaries, a higher standard of living, without this implying that they were unemployed in Greece.Many pursued their studies abroad and, being accustomed to the language and mentality, remained there.

Brain drain is an interaction of the standard of living, the education system, the labour market and the claims offered by the working environment.There may probably not be connection between education and labour market. This resulted in "saturated" branches of science as there is a slim chance that people will be absorbed by the labor market.

Crisis might have aggravated the overall situation but it is not something new. It is a phenomenon that has existed for 40 consecutive years and is still rising.It is obvious that this issue that afflicts the demographic problem and public education was not addressed by the state.

Brain drain can be reversed, only if we record the other way round and find ways by which the educational system will be able to curb this migration trend. Brain drain has to be interpreted not only as crisis driven but also as a wider effect that includes the educational planning of the country and the labour market needs.

More particularly, there should be an obdervatory to monitor the needs for scientific personnel and a higher education planning that will reconcile with the labor market. According to the Athens Medical Association announcement published in 2012, it is stated that the number of Greek medical specialists who move overseas continuously rises.On the other hand, according to OECD 2011 Greece has the highest number of doctors per inhabitant.The arguments above are weighty due to the fact that tertiary education belongs to the state, except for certain master's degrees. As a consequence, the state budget is burdened resulting in having more employees than needed and making scientists that work overseas.Addind tax burdens, economic costs are enormous.

To conclude, the non-flexible and improper graduates planning to better meet the needs of the Greek labour market aggravates the problem of brain drain. Thus, steps should be taken to adjust education to the real labour needs.A complete registration per category should take place, in case tha state is not able to absorb graduates from particular branches in the near future.A future planning based on econometric models is likely to find a possible correlation between the needs and the comparative advantage of the regions of Greece and the dynamics of its educational staff.

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Journal of Regional & Socio-Economic Issues (Print) ISSN 2049-1395

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