DOCTORAL DISSERTATION TITLE


Author: Sophia A. Kassapi

Advising Committee: Professor Costas P. Siriopoulos (Supervisor)
Professor Dimitris Asteriou
Assoc. Professor Aristides Samitas

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«Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Προσέγγιση.»

To Mom, Dad and Foteinoula,

with love
Thank you note

Isaac Newton was known to have said: “If I have seen further than others, it is by standing on the shoulders of Giants”. In my four years of study, having finally reached the goals set from this PhD research project, I would like to acknowledge each and everyone who has offered assistance and support throughout my doctoral studies over the years.

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Abstract

The question addressed here has been whether public investments in the provision of statutory schooling promote economic growth, in terms of GDP per capita, for the case of Greece. This dissertation joins a vibrant discussion of whether public investments compose the necessary pedestal for the private investments to increase, whenever they are targeted towards new infrastructures, providing better market conditions for all business sectors. This study adopts the standard parametric econometric toolbox developed upon Granger causality methodology (1969) and goes one step forward in the direction of the nonparametric analysis. The non-parametric test used in this hypothesis testing is the Diks and Panchenko (2006) modified test statistic, initially proposed by Hiemstra and Jones (1994). The original HJ is not used due to its over-rejection problems. Consequently, the Diks and Wolski (2013) “data sharpening” extension to the DP nonparametric Granger causality test is being applied, in order to address the consistency issues of the basic DP test statistics in multivariate settings, regarding the kernel estimation bias. By applying nonlinear nonparametric Granger C codes on VAR and E-GARCH residuals, annual time series which were converted into quarterly data through cubic spline interpolation method. For the analysis of the data, MATLAB functions and C Codes were developed and used.

The results taken are consistent with more general findings on the impact of public spending on economic growth (ECB, 2008), and do not justify these levels of public investment in schooling, in terms of growth. The promotion of free public schooling
does not promote economic growth for the country in most levels, especially higher education and middle school, while other intermediate causal effects revealed show us an even more complex situation of interdependencies and synergies. Even according to the European Central Bank (ECB, 2005), public investment in human capital and R&D can be a main growth element, under certain conditions. It seems like this expansion in years of schooling alone, was not the only measure needed to provide for better economic conditions. The controversy here implies the importance of cognitive skills in promoting economic growth (Hanushek, E., 2013), and the need to shift our focus on quality for both basic skills and high achievers, either to alleviate poverty, or raise their level of income respectively.

Data were collected from the Greek Statistics Bureau (ELSTAT) and AMECO for the 1960-2015 time. Unfortunately, the data collection process dealt with important data limitations. The lack of consistent and comparable data, and the unwillingness of the officials to cooperate led this study to shrink from a panel data analysis that was previously intended to a time-series one. Hopefully in the near future, another study will provide for more qualitative elements on the “uncertain role of human capital on growth”. Thankfully, the analysis gained robustness from the methods employed, and provided with a clear picture on public spending for schooling in the beleaguered Greek economy.

Τα αποτελέσματα συμφωνούν με πιο γενικά συμπεράσματα για τον αντίκτυπο των δημοσίων επενδύσεων στην οικονομική ανάπτυξη, και δεν αιτιολογούν αυτά τα επίπεδα δημοσίων εξόδων προς την δημόσια δωρεάν παιδεία. Κυρίως για τα ανώτερα επίπεδα όπως η δευτεροβάθμια και τριτοβάθμια εκπαίδευση. Άλλες
δευτερεύουσες αιτιακές σχέσεις που έχουν εμφανιστεί αποδεικνύουν την ύπαρξη πολύπλοκων αλληλεξαρτήσεων και συνεργιών. Σύμφωνα και με τη Ευρωπαϊκή Κεντρική Τράπεζα (ΕΚΠ, 2005), οι δημόσιες επενδύσεις στο ανθρώπινο κεφάλαιο και στην έρευνα και την τεχνολογία, αποτελούν βασικό αυστητικό στοιχείο ανάπτυξης, κάτω από ορισμένες συνθήκες. Τα δεδομένα συγκεντρώθηκαν από την ΕΛΣΤΑΤ και την AMECO για την περίοδο 1960-2014. Δυστυχώς η έλλειψη συγκρίσιμων και ποιοτικών δεδομένων περιορίζει το εύρος της έρευνας, από πάνελ σε ανάλυση χρονοσειρών, καθώς και λόγω της έλλειψης συνεργατικής διάθεσης των αρμόδιων υπαλλήλων. Ευτυχώς τα αποτελέσματα της έρευνας θωρακίστηκαν με συνέπεια και ακρίβεια από τις μεθόδους που ακολούθησαν, και παρέχουν μία καθαρή εικόνα για τις δημόσιες επενδύσεις στην δημόσια δωρεάν παιδεία, στην περίπτωση της δοκιμαζόμενης ελληνικής οικονομίας.
True individual freedom cannot exist without economic security and independence. «Necessitous men are not free men.»

Franklin D. Roosevelt (1944)

“A man always has two reasons for what he does–a good one, and the real one.”

J.P. Morgan

Summary

Up to this date, research on Economics of education was mainly focused on numbers. Numbers that were not directly related with the economy. Years of school attainment and the quantity of schooling received were proved to be very misleading variables for the development of education systems worldwide. Traditional Mincerian methods were also proved unable to grasp the true demand for education in the past decades. All this and much more resulted in the education expansion that we experience today. Even though we all know that most people are poor, T. W. Schultz says that economists find it difficult to understand the preferences and the scarcity constraints that determine the choices poor people make. Schultz also notes that, poor people are no less concerned in improving their lot and that of their children, than rich people are.

The recent global financial crisis brought to the surface all those systemic decays, which were already working underground. Macroeconomic issues like unemployment, inflation and education were suddenly attracting all the attention. It comes as no surprise that education attracted so much attention. The complexity of the global financial system, all those factors that affected the
operation of the national markets, and most of all the phenomenon of “self-selection”, played a very misleading role the past decades in terms of economic growth.

The importance of education as an investment in human capital was clearly stated in early times by Marshall (1842), Smith (1759), Keynes (1841), Friedman (1912). Still, modern research started in the late 50s’ by Schultz, Denison, Ben-Porath, Mincer, Becker, Rosen, and later on by Arrow, Aghion, Barro, Acemoglu, Galor, Almlund, Hanushek, Heckman, Woessmann, Todd, Lochner and many others who developed the theoretical framework of Economics of growth and education. According to the World Bank, the primary mission of the economics of education as a separate field is to identify opportunities for improved efficiency, equity and quality of education and promote effective education reform processes. It is also the network from where a better understanding of the links between education systems and the labor market is provided. According to the World Bank as well, the key issues occupying this field are divided in 6 major categories namely: i) economic analysis of education interventions, ii) finance and expenditures in education, iii) public-private partnerships in the education sector, iv) school-based management v) impact evaluation, vi) quality of education.

The present doctoral dissertation carrying the title “The Long-Run Causal Effects of Public Investments: Economic Growth and the Provision of Schooling. Greece 1960-2015. Parametric and Nonparametric Approach” has a clear research question to answer: whether public investing in schooling is the key factor that provides with a competent labor force, enhanced with all those suitable elements needed to promote Economic Growth in Greece.

An important part of this study focuses on the empirical investigation and econometric estimation of the financial problem at hand. One of the most important issues addressed here, designated even more by the 2008 crisis is the returns to
education, at all levels, emphasizing mainly on the returns of education as an investment in tertiary education, controlling for the available income of the population. To be more specific, the contribution of this particular empirical investigation relies on the examination of the existence of a causal relation between education and income for the country of Greece, which has arose global interest due to the intense fiscal problems its economy has been facing, and the economic adjustment program that is being applied at such a slow pace. Greece is supposed to implement fundamental economic adjustments. These are meant, regardless the short-term costs, to restore the sustainability of public finances, the competitiveness and the foundations for solid long-term growth, and position the Greek economy for robust growth in the years ahead (OECD, 2011). The existence of a positive relationship between public schooling and growth is under consideration for the period 1960-2015, exploring also the occurrence of the phenomenon of “reverse causality” among the figures concerned for the country of interest and its macro perspectives. According to the empirical results the positive relationship is being challenged, while there are no significant signs of reverse causality for the time period observed. But, even though there is vast literature suggesting that education is positively associated with growth, both financial and social, OECD indicator A11 gives an interesting detail about social outcomes. The causal effect of education attainment on life satisfaction, civic engagement and health is at the same level for both adults with tertiary education and adults with upper secondary education, for the case of Greece, while it remains low for those below upper secondary education, which is very useful explanatory information one should bear in mind. The most important finding of this study is that not all educational variables are positively related with GDP growth anymore. The only strong causal relationship is among elementary school enrollments and GDP growth, and unlike past experiences, higher education looks like fading off as an investment. While at the same time interesting intermediate causal relationships arise, from preschool enrollments to secondary school enrollments and from elementary school enrollments to university enrollments.
The conclusions of this dissertation are not only extremely useful for public policy making, but also for guiding individual stakeholders, private institutions that deliver knowledge, such as universities, secondary schools, primary schools, and society as a whole, as it consists a valuable booklet for them to understand learn from the mistakes of the past that brought us here confronting the crisis, and make the right choices when deciding for public schooling. Long run economic performance cannot be achieved only by school enrollment and degree attainment. What’s at stake here is the quantity of skills each student has accumulated at each level, and about one third of their lives. It is pointless to preach that education is good for growth, and promote mere schooling instead. Higher returns, less structural unemployment in the long-run, solid steps towards economic growth and individual success should guide policy makers and economists through. Non economic aspects of well being and social progress should be guaranteed through secure employment, purchasing power parity and GDP per capita growth. As income for all is a basic need, and without it none of the positive social forces can reproduce itself. And of course most important is to build an educational system that will reflect the needs and the goals and the aspirations of the young adult. One has to stop counting degrees, and start building market skills.

Keywords: Government expenditures, Economic Growth, Time-series Forecasting, Parametric, Nonparametric.

JEL Codes: C14, C 22, C51, C58, O38, O15, O11, H52, C32.
Whatever merit there may be in the production of goods must be entirely derivative from the advantage to be obtained by consuming them.

Bertrand Russell, In praise of idleness (1932)

Introduction

The goal of this thesis is to carefully report, examine and analyze the demand for schooling in numbers, and its implications on the country’s economic conditions in terms of growth and development. First of all, to report the very large raise in numbers of people attending and pursuing further with their studies. They seem not to care about the high opportunity cost of further years of schooling, as if the expectations are indeed high. The actual working positions in the market do not justify these choices. The phenomena of mismatch, misemployment, over-qualification have been recorded. Families appear so eager to help their offsprings, sending them off to other countries to study, since the available domestic university positions are not enough to cover this demand. Also, to examine how this high demand for schooling translates in terms of income produced from those accumulated skills, in terms of GDP per capita. And to analyze the results, suggesting appropriate policies. The consideration of the economic value of schooling in this study, aims to offer valuable knowledge unveiling the causal, neutral and maybe negative relationships in action.

Beyond the listing and analysis of the schooling preferences and their fiscal outcomes, a large part of this study is focusing on the econometric estimation and empirical analysis of the data, with the most appropriate and up to date statistical methods suggested by the international literature. More specifically, the contribution
of this study relies on the examination of the school enrolments for the period 1960-2015, covering also the period of the last global financial crisis of 2007/2008 which arouses big public interest, the economic and monetary union of Greece with the EU in 2002, and a number of other incidents. The main interest of this study is to unfold the causal relationship between public spending and schooling, and extract useful conclusions and policy suggestions and contribute to the country’s solid and sustainable economic growth from now on.

When looking back at how the financial environment was formed, some major events are the ones that have had a major impact on public and private agents and their investment behavior, and are worth noting. At the dawn of the 21st century, many important financial transitions were put into action for U.S. and Europe as well, one of them being the introduction of the new euro currency to the EU-member states. The need for better coordinated economic policies and monetary cooperation introduced the new currency not later than early 2002, earlier attempts are dated in the 1960s, while the idea for a European currency emerged back in 1929, in the League of Nations (LN). Meanwhile after 2002, the EU continued to grow large and accept new member states that would also be part of this coordinated European market, seeing it as their safety net. The outburst of the global recession in 2008 pulled euro zone into its first financial crisis. EU as a whole displayed negative growth for the three last quarters of 2008 and the first quarter of 2009 before returning to positive growth. Such a big crisis was feared that could break EU down. In order to avoid any domino effects where one member state could harm the other, all member states agreed to a joint action plan for the Euro zone to stabilize the European economy. Fearing a default for weak members such as Greece, they all agreed to set up a temporary bail out mechanism to overcome any financial solvency and credit limitations that could jeopardize the whole euro zone, aiming at restoring financial stability for Europe, and ensure further economic integration. This would be the start of a new era for Greece, that of austerity. Greece was proven a very special case, an outlier as it is commonly
said, if not the weaker member state in terms of dealing with the onset of a recession. A major adjustment program was going to take place. The process of modernization of its economy and the continuation of the structural reforms dictated and financially supported by the EU/IMF/ECB (Troika), launched in 2010 would continue as announced in the summer of 2011, stating that this was the only way out. European leaders agreed to provide another financial support package to Greece. Greece committed to promote sustainable economic growth by applying all the needed fundamental fiscal and structural reforms (OECD, 2011), in return for their emergency loan that it received.

But 2008 was not the first time a recession was on the way. The investing attitude of people had been challenged many times in the near past. Athens stock market crash of 1999 is such an example. Even though Athens stock exchange was established in 1876, it had not attracted as much public attention until the year of 1999. In anticipation of the 2004 “Welcome Home” summer Olympic Games and the echo of economic and monetary integration of the country that was to come, citizens felt like it was time to invest. Even though Greece qualified for the euro zone in 2000 and was finally accepted in 2001 introducing physical notes and coins in the early 2002, using 1999 only as a reference year. Investors were so excessively keen to succeed and make profit from their savings, putting their fortune at risk, unroused by the absence of a tight operating framework, that no one could keep them from buying, while refusing to bargain their stocks even when collapse had already kicked in and the paper values were starting to fall. Even though their general profile resembled more that of a loss-averse person, according to “endowment effect” and decision theory, in their minds this transaction was framed as a gain rather than a loss. So people “avoided” losing the chance of investing in shares (Kahneman, D, & Tversky, A, 1984), driven by their own human nature. Blinded by their ignorance, they didn’t realize that they were setting in motion another vicious circle for the economy.
Still, the end of this bubble was marked by the beginning of another; this time it was the low interest rates offered by the banks to boost the markets. The favorable interest rates incited public interest and resulted in raising the demand for all types of loans. As a member state, Greece favored the same interest rates like the rest of the EU-countries. The eagerness though of the financial institutions to offer bigger purchasing power parity to people, even to those citizens who didn’t qualify for those loans and all the lending criteria, made them forget the past stock market crash, and start all over setting up of another bubble. Immoderate consumption leading to high inflation rates and absolutely unorthodox growth was the new religion. The excess liquidity from the banks and the unstoppable demand for more products made the prices skyrocket. Apart from disposable goods, the biggest share of their borrowing capacity was devoted to real estate. This phenomenon was common for many countries around the globe. But when the 2008 financial crisis was outside the door, Greek economy couldn’t fight against it, as it was already on the edge. The year of 2009 found the country with a fiscal deficit that had ballooned to over 15% of GDP reflecting uncontained (public) spending, a collapse in tax revenues and the onset of a recession, while public debt reached 140% of GDP in 2010 (OECD, 2011), the highest in the euro zone, not to mention the high private debt. As early as 2010 Greece had started welcoming visitors from several international rescue funds, and found herself committed in several ways in an extensive reform process.

Among other measures, a large part of the adjustment program is devoted to facilitating effective labor market programs, and also an education system that works. Minimizing the high level of unemployment, by facilitating a smooth transition when the time comes for the graduate towards the labor market, while at the same time working towards improving education outcomes (OECD, 2009) and adopting an evaluation framework of adopted policies, and a comprehensive assessment that would be even more necessary (OECD, 2010b), are only some of the goals belonging
to a broader set of structural adjustment policies supposed to improve the productivity of labor.

Ideally speaking, none of these adjustments would have been necessary if this country was an island, a rather remote and self catered one, away from all these regulating institutions. But in modern times no country can be that isolated. A country’s national income, interest rates and market prices affect another country respectively. One country’s economic growth or stagnation, contributes in the economic growth or stagnation of other countries, as the imported goods of a country, constitute the exported ones of the other. Mercantilism as a philosophy towards growth would never bear fruits for any country with a high public deficit in this global economy. Even if a country was to adopt such a policy, this could not last forever, and it would end with negative results. What fosters economic growth for the population is to raise their living conditions by having more products available, which would only take place by making use of each country’s competitive advantage. All economies right now are in some way interdependent, and staying out is not an option, because any extreme decision in one part of this world, affects the lives of the citizens in another country in some other part, not knowing exactly how but definitely provoking a commercial war.

One of the basic goals of this thesis is to analyze and comprehend some of the reasons why some countries experience immense economic growth, while at the same time others don’t. If we think of a country’s economy as an engine, then it is easy to predict that the outcome depends severely on what goes in that engine, the productive elements. A very important element is human labor among a lot of other things. One widely used aphorism in the case of Latin America is that their “manana” culture will never let them be rich (Acemoglu, 2011) even though the widely accused Chinese culture and the Confucian values were proved very effective for the Chinese economy. Acemoglu insists that the extent to which people are able to cooperate and trust each other is what’s important still not attributed to their religion, national ethics or values but is mostly the outcome of a country’s institutions. The level of
organization in a society and the efficiency of its institutions, only them, can guarantee better living conditions for people. **When the institutions are absent should be founded, when already present should be either reformed or shut down.** And since the country under examination here belongs to the developed part of the world where well established institutions are already present, then what remains to be seen is what went completely wrong, and what is there to fix.

In a macroeconomic perspective the economic growth rate of a country is measured under the growth rate of its Gross Domestic Product (GDP), which is the production of the final products and services produced annually. Looking back, about a century ago, at the average annual growth rates of countries such as the U.S., China, India, the U.K, and Japan, we realize that those small percentage differences in growth rates accounted for the big changes in the per capita GDPs’ of these countries and their respective ranking, for a time period from 1870 to 2000. The determinant of long-term growth according to economists is what they call **productivity of labor**, the quantity of product (GDP) produced in one unit of time. It is easy to conclude that a country’s economic growth reflects upon its GDP, provided that a country’s primary concern is to guarantee the enhancement of the productivity of its labor force. Higher levels of technology and education are needed in backing up the productive capacity of the workforce. More and more lately in each country workers are occupied in more services than products produced. It is mentioned that 1 percentage point rise in the human capital stock has the same effect as the same rise in technology or capital. Baumol & Blinder say that for a given stock of capital, human capital and technology, the productivity of labor will be higher if human capital accumulates higher levels of education and knowledge. Education consists of one out of the three major concerns in the field of macroeconomics together with inflation and unemployment. In the modern “Knowledge economy” education is also the crucial determinant for an economy’s economic growth.
It is profound that in a globalised financial environment, schooling is affected in many different respects, as all stakeholders of this unified market such as nations understand the key role that educational institutions have to perform in order to provide students with the skills that a global knowledge economy demands from its workforce and bring them closer through communities of information and knowledge. Work as a notion we all know, has changed by definition. The biggest share of GDP comes from the production of services rather than products in most mature western economies. Knowledge intensive skills are introduced into the work place. The need for a more educated labor force and a better organized schooling system is putting a lot of pressure on emerging and recovering economies, as this is what it takes to make the country competitive and attractive enough to foreign investments. Economic growth worldwide also demands for smaller private sector and lower internal demand. Educational services are being evaluated with international standards, which means that new subjects, new curricula, new ways of testing need to be introduced to achieve international and comparable quality of national education systems. Integration of computer assisted instruction in order to provide with low cost (distance learning), high quality education linking students from all parts of the world, and allowing for the transmission of knowledge. The focus on education systems nowadays is for each unit to acquire a more knowledge based culture, sharing with students of all cultures and different groups the new market values, getting them ready for the labor force of a sustainable future.

Research on education as a source of economic growth and the rate of return to schooling has gone beyond the times when Adam Smith, in 1776, had already stated that the lack of education causes the workers so much disarray and discontent for work, that it constitutes a threat for the workforce. He was actually the one who proposed the institutionalization of compulsory education, regarding that in the long run the cost of education would depreciate to the benefit of society. Economics of
Education has been a core issue long enough, developing as a field in multiple directions since the middle of the past century. In the beginning, the first research questions arising in the field were mostly about the wage differential of the productive skills of the workers. The easiest way to classify these skills was to account for the amount of schooling received, and for the effect that education had on various forms of social life. Other institutional issues such as the impact of the school structure and the curricula applied on the educational outcomes were also troubling researchers, policy makers and practitioners of the economics of education.

After a long period of negligence, the issue of the economic value of education resurfaced when Theodore Schultz (1963), elaborating on the economic value of education together with Gary Becker (1964) and the work of Jacob Mincer (1958, 1962) provided a basis and offered a motive for the beginning of the subsequent major research efforts for the creation of human capital. In the following decades, from 1970 and on, research focused primarily on the relationship between schooling and income.

Mincer, in 1974, assessed and made public the model of Becker & Chiswick (1966). His model, later known as the “Mincer earnings function” was extensively used as a mean for the estimation of the quality of education “revenues”, the measurement of the effect of work experience on the wage differential between men and women, while at the same time as a basis for the economic studies of the benefits from education among developing countries. Recent studies on economics of growth use Mincer model in order to analyze the relationship between growth and the average educational levels of the countries, probably the best known and most prevalent having influenced many researchers, becoming the basis for the creation of newer models. In the economics of education literature, unlike growth literature that sees only good in schooling, education signaling system highlights some parts of schooling as a social waste.
ii) Framework of the study

The present study consists of 5 chapters:

First chapter consists of the presentation of the conditions under which any sector of the economy in Greece is called to act upon and promote sustainable growth, analyzing the concepts of inflation, recession, unemployment and economic growth. So, in this chapter we are drawing a line between deficit reducing measures and long-term fiscal sustainability on one hand, and effective labor market policies on the other, presenting the basic tool of supply and demand. Analyzing the need for integrated reform plans in all key public services, and introducing schooling, education and its macro perspectives. Finally a short reference on the education and training system concerning previous policies that resulted in the weak tailoring of schooling to the needs of the labor market has been conducted on the same basis, in this chapter.

Second chapter introduces a discussion about the role of quality in schooling and how much it affects performance respectively. Also the reports of the international agencies, OECD indicators and the impact of globalization on educational reform strategies is presented. More specifically the four different axes of schooling choice are illustrated here and their underlying philosophy too. Efficiency and effectiveness in education and how this translates in numbers, how much financial and human resources are being invested in schooling, the truth about who actually goes to school, and how the act of schooling is being conducted in numbers as well. This analysis attempts to show if the given culture in classroom is setting the conditions for further development. In this chapter, an overview of the educational reality taking place in Greece is also presented.

Third chapter presents an overview of the international schooling literature, presenting together with the most commonly used methodology, and the most elaborate estimation tools. In the second part, a quick presentation of the Greek
schooling system, and its cultural roots, is attempted in order to highlight the ideology that influenced the country’s educational institutions in the early years.

**Fourth chapter**, we provide the theoretical framework and the literature behind the methods being used. Granger causality, Cointegration, Detection of Unit roots, Linear models, Nonlinear models, Nonlinear Granger causality, nonparametric testing, the Kernel density estimator, Bandwidth choice, and Data sharpening methodology, VAR and GARCH models, are all leading this study in order to summarize the impact of schooling, and the social and financial benefits of suitable educational reforms that have been presented in the previous chapters.

**Fifth chapter** is devoted to the empirical investigation of the situation at hand for the schooling system of Greece, examining the changes in the educational preferences of families and students for the time period 1960-2014. The causality and the interdependence between schooling preferences and the economic growth of the country is being shown and analyzed. The chapter ends with the discussion on the hypotheses being tested and their repercussions, considering the results given by the analysis. Finally, a synopsis of the above economic study is attempted.
AIMS AND OBJECTIVES OF THE STUDY

1. RESTORING ECONOMIC GROWTH
   I. Conditions for sustainable and robust growth

Many econometric toolboxes have been developed in order to examine the existence of sustainable growth in national economies. One ever ending dilemma in finance, which will be kept in mind throughout this study is, and will always be to either to create more jobs by strengthening the market and set a healthy supply and demand equilibrium with an upward trend, or to reduce inflation and tidy up the economy by cutting off bonuses and minimum wages bringing it back to a manageable starting point, luckily before it turns into a financial bubble.

-The International institutions with their external aid programs did prove one thing right about the Greek national economy: financial coherence was missing. As well as many other structural parts.

The expectations stemming from this adjustment program are relatively high. The hypothesis formed by Gary Becker, also known as the “rotten kid theorem” illustrates the facts. According to this scenario, the household head, which in our case can be the national economy, is sufficiently rich and benevolent. In normal situations all other household members are focused on the maximization of the total income of the household, even at the expense of their own private income. The theorem claims the following: “If a family has a caring household head who gives money to all household members, then each member, no matter how selfish, will maximize his or her own utility by taking actions that lead to maximization of total family income. Thus, all family members will act harmoniously in the family interest- at least if they know what is good for them.” Assuming that a family has n selfish kids, these kids are supposed to act in their family’s interest as well, according to the theorem. Then it is much easier for the kid to manipulate a family’s good intentions to his or her own interest, even when it chooses an action that reduces the family income but makes it cheaper for the parents to invest in his/her utility, than that of his/her sibling.

Figure 2. The 10 largest successful Fiscal Adjustments.
Alesina and Ardagna (2012) studied a panel of 21 OECD countries experiencing deficit episodes, including Greece. They concluded to the fact that fiscal adjustment programs based mostly on the cuts spending side, are not likely to be reversed, causing smaller recessions. While according to their results expansionary adjustments are possible, that is adjustments followed by economic growth. A fiscal adjustment is usually a multi-year event, either a 2 or a 3 and on year period. In table 1 the successful adjustment programs that have been demonstrated by Alesina and Ardagna give us the sense that adjustments are possible, if and only if they are “adjusted” perfectly to each episode. Those regarded successful are the ones that, managed to reduce the debt to GDP ratio, while the expansionary according to Alesina definition are the cases where the country experiences higher rates of GDP growth during the adjustment program than before. Another interesting point that stems from this analysis has been the fact that success or failure are indistinguishable in terms of world business cycle, and are rather dependant on the domestic factors at hand.

II. STRUCTURAL FISCAL REFORM

i. Deficit Reducing Measures.

When entering the Eurozone in 2001, Greece had a high rate of growth of 4% per year, which remained stable until the outbreak of the market crisis in 2008. This rate was among the highest in the eurozone, fueled mainly from domestic demand a.k.a. mere consumption, which at the time equaled over 90% of GDP (15 points over the OECD average). The country was already in debt, the magnitude of which in the beginning of 2000 was almost equal to GDP (104%). That wasn’t a problem until the outburst of the 2008 crisis as it was well hidden by high growth rates. Government
debt reached 140% in 2010, and it was when things had gotten out of hand in terms of fiscal deficit. Greece had a sovereign debt that couldn’t be serviced anymore (Figure 3).

Figure 3. Greek debt in comparison to Eurozone average 1999-2016, retrieved from http://www.eurostat.com.

Gross domestic product was declining, with contrastingly severely steep contraction in activity in 2010 (table 1). The government agreed upon a strict general fiscal adjustment program with the IMF/EU/ECB, promising to make the debt shrink, and bring back growth.

Table 1.
Greek Gross Domestic Product 2003-2014
The main features of the fiscal adjustment program of 2010, which were introduced successively between January and September were drawn upon two main resultants: Spending cuts (+5.5%) and revenue increases (+3.6%). Together with the failing one-off measures imposed in 2009 that were expiring, the whole program aimed at reducing the deficit at over 10% of GDP. And two main objectives, efficiency and sustainability. Those were namely,

On the spending side with regard to all expenditure:

Measures that included cuts in pay, jobs and pensions, 2.5% of GDP

Cutbacks on military spending and certain capital investments, 1.1% of GDP

Public sector wages cut, by 15% in nominal terms

Public sector employment reduced, by 82,400 people or 10% of total workforce.
Deficits of public owned enterprises lowered by 20%, by cuts in wages of up to 30% and ceilings on bonuses and wages.

Pensions in private and public sector were cut, by 10%

Social spending on pensions, illness, and pharmaceutical benefits cut, by 10%

While on the revenue side of measures, those involved:

Indirect taxes, 2.6% of GDP. More analytically those involved increases in VAT rates, from 19% to 23%, and tariffs in tobacco, alcohol and fuel by 33%.

Taxes on household income and real estate, 0.7% of GDP.

Some tax hikes, 1.2% of GDP, such as increase in levies on the banking sector and profit making businesses.

The planned implementation of those deficit-reducing measures did not work well though. The large gap between the initial program and the outcomes was well understood. The expected 10% reduction of GDP in 2010 resulted in an actual 5% of GDP. Recession had changed the attitude of households and the composition of demand, but there was more to be seen in this worsening of the budget deficit.

Fiscal adjustment measures

The second phase of the adjustment program took place in 2011 with a second agreement on additional measures, this time more focused than the previous general budget saving for 2010. After the implementation of the 2011 budget, policy makers identified that there was a profound implementation weakness concerning the public sector, especially outside the central government. Between January and May 2011 the state budget deficit was 12.8 bn instead of the initial 10.4 bn.
ii. i Main features

In an attempt to address the shortcomings of the past programs that failed, apart from the recession effect, they prepared another package of “sustainable improvements of public finance” as called.

Implementation problems of the state budget in 2011 and a fiscal slippage of the 2010 adjustment program were recorded. The government adopted a new set of measures of 6.5 bn (2.9% of GDP) in June 2011 as part of the Medium-Term Fiscal Strategy (MTFS) to compensate for both. The new program was extremely focused and precise, while measures were equally shared between spending cuts and increases.

The rules of almost 3% of GDP involved,

**The rationalization of the government wage bill, 0.4% of GDP**
New hiring measures, whereas only 10% of civil servants were going to be replaced from 2011, and 20% between 2012-2015,
50% reduction of contractual employees in 2011, by 10% each year,
Wage drift is to be eliminated,
Working hours increased from 37.5 to 40,
Payment of overtime and supplementary compensation, to be reduced.

**Reduction of non-wage consumption expenditure, subsidies and pharmaceutical spending, by 0.4% of GDP.**
Closing or merging public enterprises, revising the pricing policy for drugs, in all social security funds.

**Reduction of social spending, by 0.4% of GDP.**
Rationalizing of welfare benefits, adjustment of pensions in line with contributions, means-testing introduction in the provision of pension benefits. Introducing also an 8% contribution for those receiving pension under 60 years old, monthly, over 1700 euro.

**Reduction of capital expenditure and transfers, by 0.3% of GDP.**
Increase in revenues of social security funds, by 0.3% of GDP.
Facilitating the one-off “solidarity contribution by public employees and self-employed.

**Reduction of tax exemptions and increases in other revenues, by 1.1% of GDP.**

Measures such as the standardization of “a solidarity contribution for all”, and a raise in the level of presumptive income of the self-employed will be imposed.

An increase on taxes related to property and revenues attached to settlement of zoning infringement.

Higher VAT rate on catering/restaurants from 13% to 23% as of September 2011, and on soft drinks and natural and liquefied gas.

Those measures were also needed in order for Greece to continue receiving financial aid by the EU/IMF package, as ordered by the “Troika”. The inability of the country to regain access to international financial markets, at least until 2012, made those measures imperative.

iii. **The financial stability fund (FSF)**

One of the essential recommendations of OECD for the adjustment program for Greece returning to growth is the access to liquidity. Table 2 shows that the Greek crisis was somewhat a different case from any other similarly severe episode. The economy was walking head to toe towards shrinkage.
2010 measures slowed down the growth in credit, while it turned negative the year next. Recession conditions, together with tighter restrictions from the banks, lessened the demand for credit, while the uncertainty for the future contracted consumption too. Banks also tried to cover their losses by rising the interest rates, making credit choices even more distant. Their inability to finance themselves from the international capital markets, made the situation even more awkward. Deposits fell to the amount of 36.8 bn in the middle of 2011. Liquidity was scarce, and banks were solely dependent upon the Eurosystem. The government went into an extension of the government guarantee for bank deposits up to 100,000 until the end of 2015. And the European Central Bank moved on by taking measures for safeguarding ample liquidity, like direct interference in public debt markets, acknowledgement of government-guaranteed bank paper as collateral for the refinancing procedure, together with the withholding of the downward grading of the sovereign debt.

The doubtful situation created by the shortage of solvency, lead to the creation of a government-financed Financial Stability Fund (FSF) of 10 bn euro. This fund, financed through the EU/IMF/ECB financial support plan, established in July 2010 for a 7-year term. It meant to support the solvency of the Greek banks, and their subsidiaries. It inherited most important assets which equal a 33% of the banking system’s tier 1 capital. Enjoying political autonomy, was able to maintain high levels of transparency and was to be called upon only when all other choices for financing had been exhausted, and the capital needs were not met. In the case of intervention, the capital is to be provided as an equity participation in the form of preferred shares, which in some case might convert into ordinary ones.
Greek banks nevertheless, despite their exposure to debt, managed to remain solvent, and took care of enhancing their capital adequacy on their own by restructuring and recapitalization, and renegotiation of their debts (Bank of Greece, 2010).

![Graph showing economic indicators and crisis countries](http://www.derspiegel.com)

Figure 5. European commission economic Indicators 2011. Data retrieved from [http://www.derspiegel.com](http://www.derspiegel.com)

III. **Long term Fiscal sustainability**

The main standing points of the strategy for preserving long term fiscal sustainability involved the control of the Greek debt dynamics. The paradox phenomenon of this deficit episode was the fact that since 1995 Greek economics started to worsen in terms of debt. The Greek economy experienced unique rates of growth during the first millennium decade, and the lowest real interest rates thanks to being part of a monetary union, the European. None of these seemed to make any difference as indebtedness continued to grow all this time.
The measures called upon to cure this curb, were mostly recommendations on primary budget planning, monitoring implementation, preserving the stability of the banks and their intervention ability, and improving the statistical system.

i. Budget adjustment strategy

![Figure 6. Greece economic indicators 2013, data retrieved from http://www.afponline.org.](http://www.afponline.org)
Reforms in key public services

These reforms included all types of public services like local administration authorities, hospitals, state-owned enterprises etc.

Tax evasion and the tax system was targeted. There was an attempt to tackle tax collection, improve the tools, widen the tax base and reduce tax exemptions. The authorities cooperated against corruption by raising the penalties for fraud, raising the bar for hiring tax auditors and monitoring them. The goal for discipline and transparency was also met through the establishment of a pension audit system crosschecking all beneficiaries by their social number and completing transactions through the banking system. Last but not least the goal of putting an end to tax amnesties is also present.

Public employment system detected as another long term decay of the public governance system was targeted as well. Wages were seen as 30 to 40% higher than those of the private sector. The number of civil servants accounted for the largest in the euro area and the OECD average. The pay system appeared very complex and not clear, and there was no control over payroll costs. Little connection was there among an employee’s competence, level of education and wage progression. The recruitment mechanism was an inefficient procedure, not open to scrutiny. Positions were very often filled through temporary contracts, which under some mysterious way were eventually turned into permanent jobs, which also led to an overstaffed public sector. The establishment of a “Single Payment Authority”, the limitation of unjustified overtime payment, the 20% replacement rule of retired civil servants, and the facilitation of a faster, stricter, more transparent, improved hiring system aimed to target the largest part of corrupted methods that individuals started taking up, in the absence of a central monitoring system.
Restructuring of the state owned enterprises was also a priority, as these also appeared overstaffed, with higher average pay levels, having no real budgetary constraints imposed on them by the central government, demonstrating an absolute lack of proper business management. SOEs were part of the MTFS program, and measures were taken in order to come up with efficient and transparent management. Ceilings on salaries were imposed and personnel were to be moved to other sectors, while a central registry was established for all SOEs to provide with data on all their pay and non-pay activities.

Hospitals are also subject to an adjustment program in order to become more cost-efficient, and regain the trust of the citizens by enhancing the quality of their medical services. The recommendations involved spending cuts namely: a “positive list” of drugs and a reduction in the pharmacist’s margins, an electronic prescription monitoring system, and price monitoring for medical supplies. Also the elimination of informal payments, by changing the way, practitioners are being compensated. The suggestion of separating health insurance and pension services from health care provision by putting all health responsibilities under one ministry was made in order to account for better management. This particular point referred to a better human resource management, ensuring fairness and efficiency.

iii. The 2010 pension system Reform

Major were the changes that affected the calculation of the full pension that is awarded to the person that reaches the retirement age and meets with all the criteria. First of all, the pension reform that took place in July 2010 introduced the reduction of the pension funds from 133 to 13, unifying and simplifying the rules for retirement. Secondly, all pensions were to be calculated upon the same basic allowance summing up with the contributions amount and duration. Effective retirement age was raised and the generosity of the system was long gone. Pensions were also indexed to prices and to GDP growth.
iv. **The Greek Statistical Reform**

The quality of the data provided by the Greek statistical authorities has been a variable of major importance concerning the given fiscal deficit. The importance of high quality data driven by a culture of transparency, efficiency, improvement, and dialogue between the European and the local authorities has been underlined many times during this adjustment program. Things could have been a lot better for the Greek economy if officials had been more careful and precise during the data collection procedure. In March 2010, the Greek government adopted a new legislation concerning the establishment of an independent statistical authority, that would be accountable to the government alone, ELSTAT.

The problems highlighted were of two types: methodological and operational shortcomings.

Methodological problem were mostly attributed to technical problems of data collection and processing of the several units involved.

Those were faced by a series of actions taken by international experts responsible for improving the systems, the techniques and the production of statistical reports like trustworthy up-to-date cyclical indicators and quarterly national accounts elements.

IV. **GETTING PEOPLE BACK TO WORK.**

i. **Labor market reform**

It has been admitted that the Greek labor market consists of a special scenario. The deficiencies that created this high cyclical unemployment have to be fought against as these are the same forces that provoke structural unemployment, and make it impermeable for people to get back to work. The Greek labor market was found extremely biased in sectors of activity such as the wage bargaining system, minimum wages for the young, employment protection and flexible working arrangements (European Commission, 2010a, International Monetary Fund, 2010), and special and targeted reforms were recommended. Low employment and productivity levels are only partly counterbalanced by a high number of hours worked. Of course this does not leave unaffected all other aspects of living.
i.i \textit{Unit labor costs}

Of the 35 countries that are part of the OECD only 26 of them have a minimum wage. A group of those members became holders of a minimum in the 1990's.

![Minimum wages around the world](http://www.weforum.org)

Figure 7. Minimum wage in 2015, at PPP. Data reprinted from World Economic Forum blog, retrieved from [http://www.weforum.org](http://www.weforum.org)

Figure 7 shows the differences and similarities of the minimum wages in the OECD area, expressed according to purchasing power parity in each country. The real minimum wages, as concluded in the last year are given in table 7.
It is very interesting to say that Germany has never had a minimum wage until, and as of January 1st she has her own 1.289 euros per month.

Another very interesting point here is to note how many working hours constitute the equivalent of a minimum wage in each of these countries (Figure 9)
Of course in some countries, regardless of family or not, the laws behave the same towards all minimum wage holders. For example in Greece, where working hours are relatively high, trying to debate low income, single parent families, are usually flirting with the poverty line.

As it has been said for the other sectors of the Greek economy, labour market is also a very regulated one. Job creation is prohibited by a lot of protective agreements. Two distinct facts, the low union density compared to the Nordic countries and the controversial organisation of the wage bargaining system are responsible for a very big part of the injustice.

Even though only the 24% of the workforce is unionized, a.k.a. interested in protecting its working rights, collective agreements at firm, sectoral and occupational
level have been set, in order to serve this small number of syndicated individuals who are presented as the “fathers of labor”. The legislation that has been active since the 1990’s offers the unions the exclusive right to run back and protect the workers in case of anticipation, together with the already privileged access to arbitration. This of course sounds more of a patronage act, collecting favours and distributing jobs on a political basis, leaving no chance of sorting out the real differences.

In December 2010 a new law has been introduced (Law 3899/2010) to correct those deficiencies of wage bargaining system. It introduced a new firm-level of collective agreement, producing less favorable wages, compared to what was happening at the sectoral-level agreements, towards job preservation. It removed the restriction as to the size of the firm (50 employees and up). It also aims to include all interested parties, in and out of the negotiations in the minimum wage formation, taking into account the existing national labor collective agreement.

i.ii Minimum wages: an international comparison

Figures 7, 8 and 9 show what stands today in terms of a minimum wage in terms of hourly compensation, purchasing power parity, and hours worked.

Figure 10 shows how European economies performed in 2011 in terms of GDP. Greece was at the lowest point. GDP shrunk and unemployment reached a new high level. Taken from Paul Krugman, this can happen. Decline can happen at any time, and economies end up shrinking no matter what we do, even though he admits how special a case is the Greek economy. It could have been attributed partly to the budget deficit, but the real problem was that of “economic change”. Even though the discussion about the Greek crisis was indeed “hijacked” by the Greek politicians in favour of their re-election, the solution was simply one: for Greece to become the modern equivalent of itself. How much nicer things would have gone if the country simply fought for regaining its place in the economic ecosystem. Sometimes, skills become redundant, or market niches no longer exist, or whole cities lose their
competitive advantage in the market. As Krugman states using a quote of Joseph Shumpeter, “creative destruction” has two sides, and very often individuals mistakenly believe that they are the “creative destroyers”, while what they really stand for is the “creatively destructed”.

Making good use of technological progress, does not necessarily provide you with any skills or titles, apart from that of the “creative” consumer.


By taking a look at the minimum wages across the continent we see a big disparity in numbers. Figure 11 offers a comparative map illustrating those differences in 2013. We see that many European countries do not have a statutory minimum wage (Germany established one in 2014, enforced January 1st 2015).
While it is very important to note what is the proportion of the average wage covered by the minimum (Table 2).

Table 2.
2010-2011 minimum wage as a proportion of average monthly earnings.
One has to look at the numbers comparatively in order to comprehend if one can make a decent living out of the minimum compared to the average.

i.iii Structural and youth unemployment.

As stated by the OECD, the young Greeks are performing much worse than in any other OECD country.


Lack of experience, weak adjustment of their education and training towards labour market needs, high entrance wages and other non-wage costs, absolutely the youth. Instead they were subjected to other types of employment, mostly informal which of course wasn’t recorded as previous experience. This led to the wage reform for the youth, establishing lower, non subsidised sub-minimum wages for those younger,
What is very interesting is that the policy makers, when suggesting this measure, they took under important consideration the active family network in Greece that could cushion the negative effects, or the limitations of such a wage arrangement. They did not although note that the total package of measures will exhaust the Greek family network, as this consists of mothers, fathers, older brothers & sisters, aunts & uncles probably middle aged with redundant skills, and grandparents relying absolutely on their pension income which has been severely hurt as they were accused of having a tendency to consumption, as if they were the case.

I guess it would be good to illustrate the situation by providing the minutes worked in Greece for a BigMac compared to other countries, as the international rule of thumb for purchasing power parity. This is the so called Big Mac rule, according to which there is no point in raising the minimum wage if commodity prices rise well above that, and people cannot buy more products, but instead they need to work more hours for the same products they were buying in the past with less money. Basic needs products like food, grocery and detergents are all dependent to the minimum wage.
Among the new policy towards boosting the labor market by reducing the high structural unemployment, are the measures taken to relax the strict employment protection legislation (EPL). Even though the new measures can be proven quite radical towards the limitations of the previous hiring and dismissing systems, the long-term goal is to create a more effective field where employers and employees can interact in an efficient way. Employers now benefit from shorter notice periods, from the possibility to provide the severance payments in installments, easier collective dismissals towards their previous employees. While they can make use of the 1 year extended probationary period for hiring new ones, and the extended maximum duration of 36 months for fixed-term contracts. It is expected for unemployment to be raised shortly after, but as recommended by the OECD experts this is likely to be
reduced, as employers “are willing to hire again as the commitment is less costly” (OECD. 2009b), while the good practice of Austria is also underlined\(^1\).

ii. **Product market reform.**

For a market as small as the Greek market, things are easier when talking about product market reform in order to raise competition. If one looks closely into the economy, can distinguish its sectors and limitations. A large part of these shortcomings should be attributed to a lack of business culture, or the existence of a sub-culture that grew throughout the years. Greece ranks very low at an international level, while the local initiatives are either low-content or get stuck at several bureaucratic barriers. One main barrier is the organisation of the judicial system, and the lack of specialised competition courts with the analogous personnel in order to deal with the real limitations of each business proposal, instead of sticking to procedural matters. Of course the existence of extensive state regulation is also to blame for this delay. The low enforcement of Europen Law, public ownership in most big industries like the electricity sector, restrictions on fees or prices, and very high mark ups in sectors like retail, hotels, restaurants and other professional services, are only few signs of absolute lack of competition and incentives in the Greek market.

On the other hand, the private sector is restricted by a series of barriers reminding Hercules tour de force.

Towards these deficiencies a new bill was put in action in 2011, aiming to change the entrepreneurship culture and fight those systemic decays that were active for years. This law targets the start-up procedures, the bureaucratic delays, the high compulsory

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\(^1\) Austrian employers have a completely innovative system of a deposit of 1.5% of the monthly allowance to a personal account, covering the whole period a person is employed. If and when dismissal occurs, the employee has the right to receive this money as severance payment directly from the account, or keep it as a future pension, provided that the employee quits after the three years. Otherwise this money stays with the company, and the right to the money is handed over to the employer (OECD, 2007).
fees, the restrictions in expansion and modernisation of existing companies, and those regulations that hurt their dynamism. Namely instead of 15 procedures, 19 working days and 11% of Gdp per capita that was required for a business start-up, it is now 1 procedure, in one day, at a single contact point instead of the previous 8. This is a very positive step toward boosting innovation, competition and growth, but a close monitoring is required to safeguard this new system in action.

iii. Potential benefits of the market reforms

The expectations are big. The current business environment leaves no room for companies or potential entrepreneurs to enact. Even the big established companies, are facing major difficulties to facilitate a large-scale investment with all those objective limitations. The past has not been blooming in terms of investments. Most efforts of subsiding business proposals in order to enhance the market, have failed, as the outcomes were rather disappointing. Over a period of almost 30 years, around 21,000 enterprises had been funded, resulting in 150,000 employment positions in an economy of 1 million businesses and a labour force of 5 million people, as given by the Ministry of Regional Development and Competitiveness report, the second semester of 2010 (OECD, 2011). The failure was attribute mostly in the heavy bureaucracy, and a general misunderstanding among those granting the funds and those receiving them, as of having no clear goals, and of course not evaluating the results.

As said earlier the expectations are high towards social convergence and cohesion as well. The decays brought to light by the recent fiscal crisis, were being cultivated by the system for years. The inability to provide with jobs in the other regions of the country, such as the poorer ones, is itself selfevident of the misallocation of funds, a lack of funding tools for the feedback and the promotion of a stable business environment, and a lack of interest. Nevertheless, the close monitoring of all the new initiatives in terms of the allocation of funds and the evaluation of the financially supported plans is also crucial at this time too.
These afore mentioned measures and a large number number of privatisations in the most crucial sectors of the economy such as, electricity and gas sectors, railway and urban transport sectors, the road freight sector, public enterprises, closed professions, the tourism sector, export incentives and the deregulation of the retail sector, are implemented and supposed to progress rapidly towards the complete recovery of the Greek economy.

V. Further institutional changes

i. Weak tailoring of the education and training system to labour market needs.

As referred to earlier in the analysis, one big deficiency of the major structural and youth unemployment is the weak tailoring of the education and training system. This is not a recent phenomenon.


Figure 14 shows the number of Greek university graduates on Greek soil, 7 units high above the same type of graduates in Germany, implying that higher level studies did not cure our fiscal episode at all.

Generating jobs is one of the major goals of this program, and more likely one of the largest deficit of the Greek economy the past decades. Mainly because it is not a goal
by itself but mostly because it is the by-product of a total come back of the Greek economy in all sectors. While the easiness of decline of wages is at the same time a blessing and a curse. It implies obedience to the current crisis, and a great loss of competitiveness, as this level kept falling throughout the crisis.

The weak tailoring does not imply extreme down grading, but it can be translated as extreme upgrading, as well as low-content of studies, translated as a large skill deficit of the graduates. The examples can be quite many, and the indicators from the market quite a few as well. During the crisis, and even before this occurred the market seemed to be ruling out many important occupations, for the reason that they would not be able to offer a high «social status” in the long-run. So it all seemed like a panic attack of the working class to the middle class, and of the middle class to the A-class, and so on.

And on the other hand this created the phenomenon of of closed professions all these years. The lack of need for professional accreditation in a closed profession, might as well lower the professional ability of its stakeholders, given the lack of competition, something that should stand for the attainment of higher degrees as well. Still, it should be noted that the “entrance exams” to those professions was the contestant to verify himself as the holder of a relevant degree, whithout any further testing procedure. So, instead of backing up the economy they turned it into a war of social class and power.

Following Greek statistics one usually states that the numbers are well collected. What if the numbers are right but the situation at hand is as complex and corrupted as shown?

Let’s just bear in mind that the numbers are well collected. And those enrolled were indeed the ones who attained the degree, and more likely the ones who attended class. One here starts to wonder whether the expansion in years of schooling involved a subsequent estructural change in the syllabus of each educational institution.
2. GREEK EDUCATION QUALITY & PERFORMANCE

I. Efficiency & effectiveness

The suggested policy recommendations by OECD, IMF and the other international institutions involved in this adjustment programme taking place, have tracked inefficiencies of the education system towards the younger entrants. It has been agreed that in order to get people back to work, a lot of fundamental reforms are needed. Admitted by all counterparts, an unlined switch from the education system to the labour market is required for all age groups. This fundamental rule can bring in action, working as the key to all major reforms. Combating unemployment, is like eliminating slow rates of growth all in once.

Table 20 exhibits the unpleasant truth about what is happening in Greece, until the 2014. Even though unit labour costs were substantially reduced, all other other measures have gotten moderately worse than they previously were.


The Greek education system is suffering from a lot of chronic diseases, but these can be cured. The extreme focus on learning, of those who could or those who “could
invest in learning”, has contradictory effects. As James Heckman(2008) admits as well, improving cognition is necessary but it takes more than “smarts” to be successful in life. This extreme interest of the Greek education system in better grades, and more accumulation of book knowledge, let enough room for all other disparities in education to grow. This could be the lost target of why children are involved in learning, the weak focus on proper employment, the inadequate schooling facilities and an immature teacher-student relationship, among other things as well. A lot has been said about the value of the non-cognitive personality traits. Numerous researches have tried to define their accumulation process, moving in the wrong direction. Heckman (2008) again has found that about 50% of the variance in inequality in lifetime earnings is determined by age 18. The neglected value of family comes again in the spotlight. Successful graduates come from tender parents. On one hand the student has to acquire skills, and for that it takes a lot of hard work and overtime of studying. On the other hand the phenomenon of skill atrophy is a fact, as accumulated talents do depreciate over time like the returns of any other type of capital that is not invested on anything. Avery strong tool, according to Heckman, Stixrud & Urzua (2006), which can only be taught within a family environment, is the socioemotional learning, which comes out of the non-cognitive traits of a person’s personality. Empathy can combat atrophy. This is the proper fertilizer for all measures that target sustainable economic growth to be applied on. But always within the appropriate schooling decisions that comply with.

i. **High entrance-low completion rates in HEIs**

i.ii **Trends in graduation rates.**

Table 3 illustrates perfectly the trend in University Education, both levels, Bachelor and Master’s/PhD’s. Higher education enrollments followed a certain pattern that could be compared to the rising levels of GDP and consumption, the main factor of well being back then. Of course the total numbers of students entering higher
education institutions was not an independent variable, as it was a given number. But the number of students sitting the Pan-Hellenic exams is way beyond those passing the gates of University.

**Table 3.**

**Gross enrollment rate in Greece 1999-2007.**

The gross numbers of registrations had a 52.5% rise (Table 4.) This automatically implies that the students had high expectations of being employed after graduating. Families were eager to send their children off to university “for a better future”. It easily became a status signal of those working towards sustainable growth.

The education system of 1999 was not much different from what it was 2 decades ago. The true maternal and paternal incentives of the time was indeed the high-pitched wages of those educated and their position in the labor market. *This was an international direction that started not later than 1980 according to Murphy & Welch (1992) and Levy and Murnane (1992).*
Table 4.


<table>
<thead>
<tr>
<th>Country</th>
<th>1999</th>
<th>2007</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>5.147</td>
<td>5.000</td>
<td>0.0%</td>
</tr>
<tr>
<td>Greece</td>
<td>3.089</td>
<td>3.078</td>
<td>4.6%</td>
</tr>
<tr>
<td>Norway</td>
<td>4.260</td>
<td>4.277</td>
<td>0.4%</td>
</tr>
<tr>
<td>Sweden</td>
<td>3.818</td>
<td>4.077</td>
<td>7.8%</td>
</tr>
<tr>
<td>Ireland</td>
<td>4.009</td>
<td>4.440</td>
<td>10.9%</td>
</tr>
<tr>
<td>Denmark</td>
<td>3.673</td>
<td>3.815</td>
<td>3.8%</td>
</tr>
<tr>
<td>Spain</td>
<td>3.538</td>
<td>4.081</td>
<td>14.6%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3.087</td>
<td>3.028</td>
<td>1.9%</td>
</tr>
<tr>
<td>Belgium</td>
<td>2.390</td>
<td>1.761</td>
<td>28.7%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.068</td>
<td>1.627</td>
<td>47.7%</td>
</tr>
<tr>
<td>France</td>
<td>3.464</td>
<td>3.576</td>
<td>3.2%</td>
</tr>
<tr>
<td>Portugal</td>
<td>3.145</td>
<td>4.401</td>
<td>-21.0%</td>
</tr>
<tr>
<td>Italy</td>
<td>3.181</td>
<td>4.126</td>
<td>32.7%</td>
</tr>
<tr>
<td>Austria</td>
<td>3.370</td>
<td>3.172</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

Note: Data for tertiary education enrolments from Unesco (2011).

The following three tables illustrate both entry rates and completion rates in the Greek higher education system. It would be interesting at this point to offer a quote of the president of the National Center for Public policy and Higher education in the US, published on December 3rd in the Christian Science Monitor. He says: “Historically, our strength has been access and our weakness has been completion. WE have always said the reason we cannot be expected to do so well on completion is because we are so generous on access. But now, we see countries catching up to us and surpassing us on access and completion”.

For the case of Greece generosity lies within private intentions, and the state tries to tackle this interest by controlling the positions available at campus each year. The preparation of a nation each year to enter university, is like getting armed for war, which in the end turns out to be a war of nerves for the majority of the participants.
Table 5.


![Graph of university entry rates](image)

Note: Data for tertiary type-A programs from OECD (2010c).

Table 6.


![Graph of graduation rates](image)

Note: Data for single year of age, by programme duration. Source: OECD (2010c), Table A1.2.
Note: Data for university-level graduation rates from OECD 2010c.

Table 7.

Graduation rates at advanced research qualification level 1995-2008

Note: Data for graduation rates at advanced qualification level from OECD 2010c.

The graduation rates in advanced programmes are even more intriguing, promoting the idea of no real incentives for further studies rather than the achievement of attaining the “student status”, a.k.a. the entry title in such programmes.

i.ii Distribution of enrollment in Tertiary programs

The most interesting analysis of the distribution is the geographical element. Table 26 shows enrollment in some of the major HEIs in the country. After two years of studies most of these institutions hardly make it for the half of the students enrolled, highlighting the big metropolitan areas as “strong players”. Sadly, this finding does not expose the eagerness to learn, but reveals other limitations stronger ones, that make degree attainment less desirable for most students.
For those students who finish high school, to sit the Panhellenic exams goes unquestionable most of the times, as a family mandate. But as adult life begins, the incentives to enter the market are comparably more attractive and the pay back is immediate.

Table 8.

Students still enrolled after N+2 years after enrollment. (sample)

Note: Data for estimated percentage of first-degree students still enrolled after N+2 years from Ministry of Education, Lifelong learning and Religious Affairs.

ii. **Returns to further education**

Table 9 illustrates the results of a Greek study carried out for the Bank of Greece by Mitrakos, Tsakloglou & Cholezas (2010) published in the Economic report of the Bank, accounting for the definitive factors of wages in Greece with respect towards university graduates. The results are kind of disappointing if one dares to compare this sort of investment with others. The only level that exceeds 10% in is master’s degrees as seen on the chart, which simply makes education even less cost efficient, if one has to complete 16 years of schooling in order to be eligible for such a degree, and only
then be in a position to prove competent enough “for a place in the sun”. What should the remaining 16 years be thought of? Opportunity cost? In other words, a burden on each student’s arms, eating up his time, not making oneself available to the labor market? Why not make every year at school accountable for returns, and wait 17 years for that?
Table. 9.  
Private rates of return to an additional year in education 2004-2007

<table>
<thead>
<tr>
<th>Educational Group</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering &amp; Electronics</td>
<td>7.9%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Agricultural and Food Technologies</td>
<td>3.6%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Business &amp; Economics</td>
<td>3.5%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Nursing &amp; Paramedical</td>
<td>2.8%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Other</td>
<td>3.7%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Universities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering I (Structural, Architecture, etc.)</td>
<td>3.5%</td>
<td>7.9%</td>
</tr>
<tr>
<td>Engineering II (Mechanical, Electrical, Informatics, etc.)</td>
<td>7.7%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>7.4%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Mathematics &amp; Statistics</td>
<td>2.3%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Medicine, Dentistry &amp; Veterinary</td>
<td>7.9%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Horticulture &amp; Forestry</td>
<td>8.2%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Law</td>
<td>6.2%</td>
<td>8.1%</td>
</tr>
<tr>
<td>Business &amp; Economics</td>
<td>6.2%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>3.8%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Humanities</td>
<td>2.7%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Languages</td>
<td>9.9%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Natural Education &amp; Sports</td>
<td>6.8%</td>
<td>6.6%</td>
</tr>
<tr>
<td>Education</td>
<td>8.9%</td>
<td>9.9%</td>
</tr>
<tr>
<td>Other</td>
<td>7.9%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Postgraduate Studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA/MSc</td>
<td>9.3%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>8.9%</td>
<td>8.9%</td>
</tr>
</tbody>
</table>

Note: Data for private returns to an additional year on education from Mitrakos et al., 2010.

iii. Employment of the University graduates

The relative interest of Greek students to enter tertiary education, would suppose an equivalent demand for a correspondingly educated and specialized work force. If not the in the public sector, then definitely in the private sector. Also, given this high level of specialization, Greece should have been able to raise its technological capacity and strengthen the potentials of the existing sector of entrepreneurship. Instead, Table 31 illustrates the high levels of unemployment for university graduates. Absolutely
jobless when young, even if the foundations skills of the scientists can work as rich and virgin soil towards growth. The table shows numbers before crisis where university graduates are shown to have improved their work status from “unemployed” to “employed” after six or more years after graduation. Given the stagnation in the following years, young graduates must prolonged their joblessness, or having left the country. This immigration of human capital bears better private returns, still the country’s workforce gets shrunk.

Table 10.


Note: Data for unemployment rates for university graduates from Mitrakos et al. 2010.

Post graduate studies between 2004-2007 have made a difference in employment (table 10). But one should not miss to mention that this incident has been referred to as overeducation, and the opportunity cost together with the employment possibilities could be of absolute mismatch, if one takes into consideration earlier studies. Asteriou, Lianos & Agiomirgiannakis (2004) analysed the phenomenon of
misemployment of Greek graduates returning home from their studies abroad, and apart from this finding, the fact of having degrees like Msc’s or Phd’s worked only as signaling effects of more qualifications, sometimes positive but most times negative. Young employees did not receive relevant positions or salaries, but were doing better than their less educated peers.

Table 11.

Unemployment rates at the post graduate level.

![Unemployment rates at the post graduate level (2004-07)]

Note: Mitrakos et al. 2010.

Incidents of education spending reported as “overeducation” often imply a negative impact. Duncan and Hoffman’s (1981) analysis implies a possible misallocation of educational resources. They say that to supply the labor market with different types of education has little or no effect if production is not redesigned, jobs are not upgraded, and some graduates end up working in jobs below their skill level.

Let’s just point out that in the process of growth & development, during this chaotic incident of social forces struggling to reach a higher potential, the question of possible misallocation of resources was not posed. It all seemed like a typical case of

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“the gambler’s fallacy”, ignoring the fact that “universe has no memory”. Mathematics and human intuition are 2 absolutely different things.

Sicherman (1981) and Rubb (2003b) note that the only advantage of those working in jobs that require less skills is that they acquire better wages than their coworkers, we add here that this does not happen in the public sector if the job description asks for a certain level of education, but make less income than their classmates would matching jobs. McGuiness (2007) underlines the wage cost of being overeducated, the foregone earnings during studying, and the productivity cost that falls on the economy.

iv. **Earning premiums from education – A8 indicator.**

In terms of average earnings from employment Greece ranks somewhere in the middle, very close to OECD average, when it comes to non tertiary upper-secondary education.

Earning premiums are not only indicators of the supply and demand for skilled and educated individuals, but can also be the motive for people to pursue further with their studies. High earnings premium can be achieved by the highly educated and signal the demand for more highly skilled workers, while low earnings premium indicate low demand for knowledge, and an outdated labor market in terms of technological product and outdated skills.

The data on Greece are not as objective as in other labor markets where the phenomena of overeducation and mismatch are missing. Estimates are quite contradictory. Markets like the US, UK, Canada and Finland with an explicit preference over highly skilled workers is not the case here.

The general rules that apply in most OECD countries comply with the Greek labor market. Namely, Tertiary education brings about 50% more income compared to another individual with non-tertiary upper secondary education. Those who hold an
upper secondary degree earn a 23% more than their counterparts who do not complete that level. Earnings of university graduates increase with age, unless for Greece where this rule does not apply. And in general women earn less than men. Also university graduates, either men or women, earn about 80% more than those with upper-secondary non-tertiary education (EAG, 2011). Clear Incentives for further education stemming out of the earnings premium are not defined.

II. Financial and human resources invested in education

i. Annual expenditures per student

Below at table 11 are the expenditures of tertiary education. One should note here that all institutions of higher education in Greece are public, according to the article 16 of the Constitution. So the prominent source of spending is the percentage of GDP that goes into education, as part of public investments. For the period 2000-2007 about 13% of total government expenditure in developing countries and 17% in developed ones went into education, while the respective percentage of GDP was 5.15% and 4.5%. In most cases, governments are the main hosts of education provision, with a free choice to private education which can also be subsidized. The differences in public expenditures across all 3 educational levels differ a lot.

Table 12.

Public and private spending for tertiary education (per cent by source)
When it comes to private spending on education the differences are major. In an international context Su (2004) and Gradstein (2003) reported that the gap between rich and poor families in poor countries is tremendous. Gradstein (2003) in his quintile analysis pointed out that inequalities in poor countries are the equivalent of 4 times the education provision of the poor, for families in the highest quintile. As mentioned earlier the learning potentials of one’s own child are developed at a 50% till the age of 18. The real effect of the socioeconomic background of a child’s family plays a leading role in its future stance towards schooling, drop-outs; non-college attendance etc. children from financially weak families usually need to leave school in order to add to their families income, adding to their inability to study further. Taken this as a fact, children of middle to high income families pursue further, while children from poor families facing several restraints, drop out of the formal, most of the times public system, and find private alternatives when trying to acquire labor market specific skills.

ii. Limited non-public funding relative to GDP
Another limitation when it comes to funds for education, as it is imposed by the constitution again, is the so-called free of charge provision of education, solely by public facilities. As the state enjoys the right of being the only proprietor of tertiary education, serves also its obligation to finance all activities.
Table 13.

Expenditure on educational institutions relative to GDP per capita.

Note: Data from OECD 2011.
iii. Public and private financial share in education

Table 14 presents the situation in the other OECD countries, which is somewhat different than Greece’s. Here, tertiary education is being highly subsidized by private resources, while the other two levels of educational provision they seem to follow a common path of not more than 20% of private funding.

Table 14.
Share of private expenditure on educational institutions (2008)

Note: Data from OECD 2011.

The restrictions imposed on HEIs are not the same in the lower levels. Primary and Secondary level of schooling, together with preschool can be also provided by privately established units and coexist with the public schools harmoniously.
iv. **Total public spending on education**

Greece education spending ranks rather low as a percentage of the total public spending. The approximation is almost 7.3% according to OECD statistics, well below the OECD average which stands at 12.9% of total public expenditure.

Table 15.

Total public expenditure on education as a percentage of total public spending.

Note: Data from OECD EAG 2011.

**III. Access to education**

i. **Who studies abroad and where.**

The trend of immigrating to another country, of the country of origin to accumulate knowledge in the desired domain has become a trend quite a few decades. In Greece, the limitation of no private universities, and the overall culture of “further

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education” cultivated the idea of travelling as far to find a suitable program to study, enhancing it even more. This of course proved the complete failure of the only level of national exams, the so-called Pan-Hellenic, which unfortunately did not provide the failed contestants with any other options. The existence of high entrance wages into the labour force, and high non-wage costs, left youth with the choice of informal occupation. So, the ones who stopped chasing their educational goals, ended up working on a daily basis without proper credentials that could prove their professional experience delaying their labour market integration, usually the children of less favored families, while the remaining rest opted out of the country, East or West.

Table 16.
Citizens studying abroad by country of destination (2009)
Internationalization of education (table 16) is nowadays a reality in most parts of the world, creating a new knowledge industry. Greece was unfortunately for its declining GDP and public deficit left out, due to its constitutional restrictions, and students who chose to leave, would have to prove their academic proficiency through various...
monitoring methods, in order to get accreditation for their degrees, demonstrating their acquired knowledge.

Figure 16. Evolution by region of destination in the number of students enrolled outside the country of citizenship. (2000 to 2009). Retrieved from OECD EAG 2011.

In the last 40 years, the numbers grew five times large. The need for valid assessment and evaluation methods was created.

Figure 17. Growth in internationalization of tertiary education. Data retrieved from OECD statistics, Unesco institute for statistics, OECD eag 2011.
Figure 18. Percentage of foreign tertiary students enrolled in each country of destination, retrieved from OECD and Unesco institute for statistics, from OECD eag 2011.

**Study programmes offered in English.**
Figure 19. Programmes offered in English, data retrieved from OECD eag 2011.

Greece is again present, providing no or little instruction in English, together with a mixed group of countries each of which has no such programmes for very different reasons. One should not attempt to compare as the assumptions vary.

\( ii. \quad \text{Participation rates in tertiary education} \)

Internationalization is nowadays a necessity, as economies become more and more interconnected. Individuals are trying to expand their skills and knowledge and acquire the experience of studying on a different program. Since millennium the number of international students has increased by 77% with an average annual growth rate of 6.6%, and a total 79% among OECD countries (OECD, 2011). The Greek education system could benefit from a major reform towards that direction. Become more open, attractive and more competitive following a different strategy of expanding participation and raising revenues, with more innovative courses.

Table 17.

Trends in entry rates at the tertiary level (1995-2009)
iii. Drop outs- Indicator C4

There is no golden rule of the optimum time of years in education. Education is accumulative process, and whenever one feels like the knowledge acquired is good enough to pursue a job, then this is a benchmark. Even the notion of life-long learning wants skills to be used and appreciated. The notion of drop outs concerns mostly those
groups of people who have a negative relationship with schooling and cannot even complete basic education.

Unemployment in Greece differs a lot in nature. Mainly now after the crisis it tends to become structural, and not a temporary issue. But OECD experts insist that even a problem like this defeated, by raising the educational attainment levels.

Table 18.

Proportion of the 15-29 year-olds in education and not in education by duration of unemployment.

Note: Data from OECD 2011.
IV. Participation of schools- the learning environment-policy recommendations for Greece

Education reform is the country’s last chance to boost future economy and bring back the quality of life. At the same time it will help maintain those social commitments of social justice and equity.

Greece has a series of problems that are unknown or distant to the policy makers, and solutions might be lacking. Of course those problems are nested within the lack of eagerness to follow the proposed solutions. Most of the suggested solutions were either not implemented or were applied in a wrong way. From what has been analyzed up to this point of analysis, it is obvious that Greece falls behind many of the OECD countries with similar or lower status. When compared to other countries who subsidized their educational systems at the same level and outperformed the comparison is disappointing.

Greece holds another record, that of one of the countries who doesn’t accept external evaluation of any quality assurance mechanism, such as reliable indicators, evaluation of schools, teaching and learning.

The Greek school network holds another international uniqueness. It consists of small schools, low teacher–pupil ratios, small classes, high costs per student, low salaries, and other controversies.

HEIs are characterized by the comparatively low completion rates, high entrance rates, while an ever growing number of students tackle upper secondary school to sit for the Pan-Hellenic exams to enter university.

Tertiary education enrollments increase together with the number of departments and institutions, but the low completion rates, which are not monitored, result in departments with few or none student.
Nowadays governments came into discussions with European authorities and admitted the need for a strong reform that will cover the gap between the good intentions and the bad implementation results.

The need for a more decentralized and flexible education system is identified. Greece needs to closely work on increasing the capacity of schools and tertiary institutions, and the job satisfaction of teachers, faculty members and researchers.

Greece has agreed to a comprehensive reform of education, with absolute respect to the country’s history, culture and policy context, but driven by equity, efficiency and effectiveness. The commitment of the constitution for social justice (article 4) and free education (article 16) have to be met.

Other special characteristics like the agrarian family base of our society has to be further analysed in every move.

The centralized governance of the country that fosters national cohesion against regionalism has to be continued, together with the high public sector employment.

All these have to be taken into account when analyzing the prospect reform measures, and have to be of good use if not otherwise.

i. Time in classroom

In primary and secondary education teacher’s working hours are set by the government. On an average basis, teachers in both levels work not more than 30 hours a week, and not more than 6 hours a day. This is the sum of both teaching and administrative duties. Teaching time shows a complex variety depending on several other dimensions, but the main direction is the minimization of teaching time, given the opportunity. Hours tend to decrease by in-service years, by size of schools, number of grades, and age of course. Teachers fall into the administrative staff as years of service go by, and instead of offering their valuable knowledge, they spend
their working hours conducting low-content administrative tasks. University teachers follow the same pattern, but their duties are pure teaching ranking from 24 to 20 hours, depending on in-service years again.

The length of the school year is considerably shorter than in many other countries in Europe. The hot climates of June and August make it impossible for children to attend, and it makes no point to stretch the school year over these months. This is also a factor that shortens net contact time of students and teachers in classroom, within every level of compulsory classroom time, where Greece also ranks low, well below the OECD and the EU21 average (OECD, 2011).
Table 19.

Instruction time in classroom, compulsory and intended, in public institutions (2009).

<table>
<thead>
<tr>
<th>Country</th>
<th>Age range of compulsory (7-11)</th>
<th>Age range of non-compulsory (12-14)</th>
<th>Average number of hours per year of total compulsory instruction time</th>
<th>Average number of hours per year of total intended instruction time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>5-16</td>
<td>7-11, 12-14</td>
<td>977, 971, 981, 964</td>
<td>977, 971, 983, 964</td>
</tr>
<tr>
<td>Austria</td>
<td>5-16</td>
<td>7-11, 12-14</td>
<td>977, 971, 981, 964</td>
<td>977, 971, 983, 964</td>
</tr>
<tr>
<td>Belgium (Ft.)</td>
<td>5-16</td>
<td>7-11, 12-14</td>
<td>977, 971, 981, 964</td>
<td>977, 971, 983, 964</td>
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Note: Data from OECD eag 2011.
Table 20.
PISA 2006 results

Note: Data from OECD, PISA 2006.
Table 21.

Instruction time per subject as a percentage of the total instruction time, 2009.

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<th>Social studies</th>
<th>Modern foreign languages</th>
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<th>Technology</th>
<th>Arts</th>
<th>Physical education</th>
<th>Practical and vocational skills</th>
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Note: Data from OECD 2011.
ii. Student–teacher ratio.

The average class size in the Greek education system is set by law to be 25 students in primary classes and 30 students for secondary schools. According to statistics, the real numbers are much worse, and very low among OECD countries (OECD, 2010c). Greece shows an average of about 18 students in each classroom, with Finland at about 20, Australia 23, and 21 in Portugal.

When looking at how many students are the equivalent of one teacher at primary level statistics say 1:10, at pre-primary 1:12, at lower secondary and upper secondary 1:8, and tertiary 1:23 (OECD, EAG, 2009). Obviously, we have been missing some teachers here, putting all numbers side by side. Those numbers have decreased over the past decade gradually becoming what they are today.

Numbers taken from the Ministry of Education, Life Long Learning and Religious Affairs tell us the truth. Greece can be characterized as the country with small school units. In a number of 1300 schools which all have less than 25 pupils per classroom, and about 250 lower secondary schools and 70 upper secondary schools having less than 50 students per school unit. 8 only primary schools exist in the country with more than 400 students which provide upper secondary schooling, and belonged to a special program of pilot schools subsidized by the Government, which stopped (Polyeladiko lyceum).
iii. Teachers remuneration

When the discussion involves public money then it comes down to the Greek budget and its way of execution. The main concern of the Greek government is “the legality and propriety” of expenditure (OECD 2011). The fact that teachers pay system is centralized and, for every new public servant, salaries come directly from the Ministry of finance. No one else, no other public entity gets in the middle of the payment process. So having one central authority being responsible for all payments, then one can imagine the difficulty of debating over any further reform on the payment system. It is self evident that institutions cannot provide any incentives for improving productivity and efficiency in education, as their role is restricted to basic bureaucratic contributions.

So the real problem is not the inefficient management of education, but the inefficient centralization of resources together with the conformity of the whole public system.
Other than the fact that teacher’s salaries constitute the most of the education budget money, salaries remain comparably low. The fact that throughout one’s career no performance related chances are given to teachers, worsens the educational reality by not being able to attract competent students in the field, and again leaves no room for an efficient reform towards this problem. This is the case in Primary and Secondary education, giving academics a little more freedom towards their finances.

Table 23.

Teachers salaries in 2009. (sample)

«Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεά Παιδείας. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Προσέγγιση.»

Note: Data from OECD 2011.

iv. Teaching hours for teachers

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Table 25.

Teaching hours in Greece for primary schools constitute not more than a total of 600 hours per year. Same stands for lower secondary level. The average teaching day for a teacher is 3 hours or less a day.
Net statutory yearly teaching hours in all educational levels.

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<td>Korea</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>Mexico</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>Norway</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>South Africa</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>Spain</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1200</td>
<td>1300</td>
</tr>
<tr>
<td>Turkey</td>
<td>1200</td>
<td>1300</td>
</tr>
</tbody>
</table>

Note: Data from OECD, eag, 2011.

Compared to what is happening in all other OECD countries and the OECD average Greece is ranking at the last position in terms of teaching hours in all formal educational levels where attendance is obligatory (Table 25). According to law, this number is reduced in relation to years of service. For example a secondary teacher starts off with 21 hours a week, but can drop off to 16 teaching hours after 20 years of service, spending the remaining hours at school necessarily, in order to complete his normal working hours.

Table 26.
Time organization of teachers. (2009 indicative)

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary education</th>
<th>Lower secondary education</th>
<th>Upper secondary education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of instruction</td>
<td>Number of days of instruction</td>
<td>Net teaching time in hours</td>
<td>Working time required at school in hours</td>
</tr>
<tr>
<td>Australia</td>
<td>40</td>
<td>40</td>
<td>197</td>
</tr>
<tr>
<td>Austria</td>
<td>38</td>
<td>38</td>
<td>180</td>
</tr>
<tr>
<td>Belgium (Fl.)</td>
<td>37</td>
<td>37</td>
<td>170</td>
</tr>
<tr>
<td>Belgium (Fr.)</td>
<td>38</td>
<td>38</td>
<td>183</td>
</tr>
<tr>
<td>Canada</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Chile</td>
<td>40</td>
<td>40</td>
<td>191</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>40</td>
<td>40</td>
<td>189</td>
</tr>
<tr>
<td>Denmark²</td>
<td>42</td>
<td>42</td>
<td>200</td>
</tr>
<tr>
<td>England³</td>
<td>38</td>
<td>38</td>
<td>199</td>
</tr>
<tr>
<td>Estonia</td>
<td>39</td>
<td>39</td>
<td>175</td>
</tr>
<tr>
<td>Finland</td>
<td>39</td>
<td>39</td>
<td>185</td>
</tr>
<tr>
<td>France²</td>
<td>35</td>
<td>35</td>
<td>m</td>
</tr>
<tr>
<td>Germany</td>
<td>40</td>
<td>40</td>
<td>193</td>
</tr>
<tr>
<td>Greece</td>
<td>36</td>
<td>32</td>
<td>177</td>
</tr>
<tr>
<td>Hungary</td>
<td>37</td>
<td>37</td>
<td>181</td>
</tr>
<tr>
<td>Iceland³</td>
<td>36</td>
<td>36</td>
<td>176</td>
</tr>
<tr>
<td>Ireland</td>
<td>37</td>
<td>33</td>
<td>183</td>
</tr>
<tr>
<td>Israel</td>
<td>43</td>
<td>42</td>
<td>183</td>
</tr>
<tr>
<td>Italy</td>
<td>39</td>
<td>39</td>
<td>172</td>
</tr>
<tr>
<td>Japan³</td>
<td>40</td>
<td>40</td>
<td>201</td>
</tr>
<tr>
<td>Korea</td>
<td>40</td>
<td>40</td>
<td>220</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>36</td>
<td>35</td>
<td>176</td>
</tr>
<tr>
<td>Mexico</td>
<td>42</td>
<td>42</td>
<td>200</td>
</tr>
<tr>
<td>Netherlands</td>
<td>40</td>
<td>m</td>
<td>195</td>
</tr>
<tr>
<td>New Zealand</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Norway</td>
<td>38</td>
<td>38</td>
<td>190</td>
</tr>
<tr>
<td>Poland</td>
<td>37</td>
<td>37</td>
<td>181</td>
</tr>
<tr>
<td>Portugal</td>
<td>37</td>
<td>37</td>
<td>175</td>
</tr>
<tr>
<td>Scotland</td>
<td>38</td>
<td>38</td>
<td>190</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>38</td>
<td>38</td>
<td>187</td>
</tr>
</tbody>
</table>

Note: Data from OECD, eag, 2011.

v. Schools accountability and national examinations.
The most common method of holding schools accountable in Greece is the system of examinations and grades. When it comes to regulation, according to table 55, Greece together with Italy and Austria are the stakeholders that have not established an evaluation system holding them accountable. Teachers are not held responsible for the educational outcomes they deliver each year. The schools organization is not affected by percentage of students graduating with good grades. It is something that either happens, or it doesn’t.

Table 27.
Schools accountability, regulatory and performance, in public schools 2009.

Note: Data from OECD, eag, 2011.

Table 28.
Regulatory accountability (indicative)

<table>
<thead>
<tr>
<th>Country</th>
<th>School board (S)</th>
<th>Municipal or local government/education authority (M)</th>
<th>Regional government/education authority (R)</th>
<th>National government/education authority (N)</th>
<th>Parents and students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>M</td>
<td>M</td>
<td>S/M</td>
<td>No</td>
<td>N/N</td>
</tr>
<tr>
<td>Austria</td>
<td>M</td>
<td>M</td>
<td>S/M</td>
<td>No</td>
<td>N/N</td>
</tr>
<tr>
<td>Belgium (Fl)</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m/N</td>
</tr>
<tr>
<td>Belgium (Fr.)</td>
<td>S/M</td>
<td>No</td>
<td>S/M</td>
<td>No</td>
<td>N/N</td>
</tr>
<tr>
<td>Canada</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m/N</td>
</tr>
<tr>
<td>Chile</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Denmark</td>
<td>S/M</td>
<td>No</td>
<td>S/M</td>
<td>No</td>
<td>N/N</td>
</tr>
<tr>
<td>England</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>No</td>
<td>N/N</td>
</tr>
<tr>
<td>Estonia</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Finland</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M/N</td>
</tr>
<tr>
<td>France</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Germany</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Greece</td>
<td>M</td>
<td>No</td>
<td>S/M</td>
<td>No</td>
<td>S/M</td>
</tr>
<tr>
<td>Hungary</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M/N</td>
</tr>
<tr>
<td>Iceland</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Ireland</td>
<td>S</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Israel</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Italy</td>
<td>M</td>
<td>No</td>
<td>S/M</td>
<td>No</td>
<td>N/N</td>
</tr>
<tr>
<td>Japan</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m/N</td>
</tr>
<tr>
<td>Korea</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M/N</td>
</tr>
<tr>
<td>Mexico</td>
<td>S</td>
<td>No</td>
<td>S/M</td>
<td>No</td>
<td>S/M</td>
</tr>
<tr>
<td>Netherlands</td>
<td>S</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
<tr>
<td>New Zealand</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m/N</td>
</tr>
<tr>
<td>Norway</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m/N</td>
</tr>
<tr>
<td>Poland</td>
<td>S/M</td>
<td>S</td>
<td>S/M</td>
<td>S/M</td>
<td>S/M</td>
</tr>
</tbody>
</table>

Note: Data from OECD, eag, 2011.

vi. Social inclusion

In the academic cycles, social theories for growth and development prevail. There are two main approaches, the Classical and the Modern Perspective. In times after industrialization, Classical approach enhanced the hypothesis that inequality was good for development. Development economists like Rosenstein-Rodan (1943), Lewis (1954), Baldwin (1956), North (1959) and Murphy, Shleifer & Vishny (1989) later on, all supported the idea that the agricultural sector was the main source of income, as well as the main factor of income distribution, believing that there was no profound
external demand for local industrial goods. But all that was rejected from the influential Neoclassical approach. Kuznets (1955) explained that the inverted U relationship between inequality and economic growth is not the final product, rather than what the process of development itself does to the distribution of income. The modern perspective that was developed later on, through a large body of research, proved the adverse effect of inequality on the process of development.

The literature on the latter approach debates a lot on inequality of income distribution, credit markets imperfection channel and equality of opportunities. Aghion and Bolton (1997) underline the importance of redistribution, as it creates a state of equal opportunities, which improves economic efficiency of resources, and targets the “trickles down” process from the rich to the poor. Galor and Zeira noted that inequality to the extent of the intergenerational mobility process, brings even more obstacles in the allocation talents across occupations. This relationship studied from Galor and Zeira on the effect of income inequality on the equality of opportunities has been justified by many other researchers such as Fershtman, Murphy, and Weiss (1996), Owen and Weil (1998), Checci, Ichino, and Rustichini (1999), Maoz and Moav (1999), Hassler, Mora and Zeira (2007). Benabou (1996), Durlauf (1996a &b), and Fernandez & Rogerson (1996) outlined the effect of this inequality, and characterized the results on education and income as “persistent gaps”.

Getting down to the local level, the biggest challenge for the Greek schooling system is achieving diversity. Another hot subject brought up by the latest reforms attempts, is the lack in management and systematic evaluation of schools, teacher’s and student’s performance. The reality that was happening all these years is that none of the agents involved, a.k.a. students, teachers, educational administrators, policy makers, parents, communities, tax payers, education professionals meant to cooperate. Each and every one of them did his or her own part and went home. This automatically set a very low set of standards across all public schools, giving rise to a “degree accumulation” process instead of capacity and knowledge building. The education system while not at the front line of an economy, is a lot to blame for.
One should refer at this point to all the other previous reform attempts, which more or less did the damage. Greece in the 1970’s had the highest growth rate in Europe. Former Prime Minister Caramanlis managed to get the country in the European Economic Community in 1974 in order to maintain its balanced and growing macroeconomic indicators. What came next is a fairy tale of funds spread across the region. No accountability, no evaluation was going on for years. High levels of public debt were being built on free will and good intentions. Based on political interference the choices for education specific funding were taken.

Now education has to get down to business, clear out the inputs, the processes and the outcomes, and follow a strict program of evaluating the measures taken.

Public education, in the case of tertiary education, is not a panacea, and we have the numbers for it. Taxing the whole workforce, knowing beforehand that children coming from disabled families will hardly attend the 10 years, does not make our education system fair only because books are free of charge, and there are no tuition fees for attendance. One should look at the numbers, and tailor the system towards the needs of the labor market.

The table below (table 29) characterizes Greece, as early as in 2010-2011, as a country of low inequality, but with high levels of vulnerability. It means that a great shock in the economy, such as the ongoing crisis, might lead the 15 year olds of middle income out of school, due to all kinds of dangers Greek families might face in non-favorable situations.

Table 29.

Social vulnerability and inequality when it comes to school choice.
Note: Data from OECD, eag, 2011.

Education quality and performance has to be improved and the current economic crisis revealing inefficiencies of the system should be seen as “the catalyst for change” (OECD, 2011) and sustainable growth.
3. SCHOOLING REVIEW

I. Previous studies

By quantifying the economic benefits of education on growth, there comes an answer of major importance to the policy makers. It is no secret that education has long term benefits for individuals and society as a whole. The private benefits come as a result to the individuals of their private investments. One major benefit is that of the effect of education on wages, the most widely acknowledged. Of course, the effect on better health, richer life skills, even marriage prospects are important private benefits as well.

But since all goods in all market sectors have a monetary worth together with their social meaning, it is ok to say that higher lifetime earnings guarantee more access to material assets, better services, more choices in life. Education brings all this to the table.

Many studies have examined the social and private returns on education investments throughout the years. Dearden (1999) and Blundell et al (2005) estimated the private returns on educational qualifications in the UK on a cohort of individuals born in 1958, using the NCDS, the National Child Development Study. Jenkins et al (2007), BIS report (2001), Hunt and McIntosh (2007), Sutton Trust’s Mobility Manifesto (2010) are only few of the studies that have contributed to the literature on the private benefits of education.

i. The causal impact of education. “The spill over effect”.

The initial interest in the causal relationships hidden in the “education agenda” were was illustrated in the form of OLS estimates. Even though highly biased, for a long time until today, this has proven to be the most adequate method of analyzing private benefits using micro data without any time dimension.
An unaccounted dimension of education though, remains to be the spillover effect of one’s own education to one’s own social environment. This is what we traditionally say that the models cannot quantify, or simply do not grasp. It is also the reason why, when accounted for by others, people start developing a high interest in education for “spillover” reasons.

ii. Innovation versus austerity

There has been a lot of discussion and analysis over the past few years looking for models that will drive the country out of the crisis. Many studies prove that innovation is the most certain way out of the crisis. Successful new applications, new materials and new products in general contribute to productivity growth, to an easier daily routine, better quality of products and services, and to a more competitive economy.

The most important return of such an investment would be the implicit, intermediate and the long run benefits of such investments: as time goes by, the successful innovations become common ground for a growing number of sectors that facilitate growth. So it is to the advantage of each and every economy, as they provide a new basis for more innovations and new cycles of growth.

To illustrate the theories, we provide the outcome of an OECD study that was conducted in 2010. It showed that the doubling alone of the internet access speed of a country results in a 0.3% GDP growth. In Finland, according to the Finnish Institute of Investments in Research, Growth and Innovation, half of the GDP growth that was achieved in 2011 in Finland was attributed to the improvement of their productivity, which came as a result of investing in research and innovation. One projection in the future shows that if all Eurozone countries invest each year a 3% of their GDP in Research and Development, not only will the European GDP grow by 800 m per year, but also, 4 m new jobs will be created by the year 2020- 1 m of them in R & D.
Apart from these benefits, European investments in innovation can reduce imports and increase exports of the EU, by boosting its economic aggregates and the position against its technological competitors, Japan and USA, and its role in the global financial system.

There is no doubt that all evidence prove that innovation leads in development and prosperity. The decision-makers have already figured this out. Representatives in the European Commission speak about “a state of emergency for innovation” in Europe. It has been recently stated that European Union has entered a game of survival. A fight for workplaces and prosperity.

iii. **High-yield investments in education and training**

As it is known to most European citizens, measures in each country are being taken according to the local average of the EU that is the average Eurozone standards. Deriving from this fact, the European Commission rendered high-yield investments in education as an immense and immediate need. Europe, is suffering from ineffective and inadequate investments in human capital. Despite the fact that the state-members of the EU, just like the U.S devotes, an average percentage of 5% of their GDP to public spending in education and training, clearly there is a deficit of private spending. Given that according to the European social model, private funds were always considered as a supplement and not as a substitute of public spending, following the new challenges of globalization, the rise of those funds is considered as absolutely necessary.

In order to help the education and training systems decisively contribute to the accomplishment of the strategic goal of the European council of Lisbon to “empower European union to become the most competitive and powerful economy of knowledge worldwide”. The member states were called upon to invest sufficient funds, and also to ensure that these goals will be targeted, consisting of the subject of the most efficient management possible.
EU dictates that in an international and extremely demanding and dynamic framework, the investment policy in education and training has to take under consideration the new needs of the knowledge economy. At this present phase, EU puts the blame on the U.S. The weakness it demonstrates in keeping its talents within the European territory is a matter that stems out from a delay caused by the US. The productivity gap continues to grow between EU and US. In order to turn this trend around, supplementary investments are needed, not only in Research-Development and IT, but also in the European system of education and training in whole.

In order to guarantee the profitability of the financing funds, EU calls upon the member states to focus their trials on the handling of those signals of ineffective investments. Such indications would be the high level of school failure, the drop outs from school, the unemployment of young graduates, the excessively long duration of studies and the low level of knowledge. The call should be to focus the attention on the training of the teaching staff, the new skills required, life-long learning, IT technologies, active citizenship and information rights.

As far as the means of activating extra human and financial funds, the importance of the development of an entrepreneurial relationship approach with businesses and individuals is outlined from a European perspective. This is a goal that could be established thanks to a more efficient management of the existing funds and decentralization at a regional level of the fund and programs management. The decentralization process should be accompanied by a larger coordination among the ministries, and should take under consideration the European dimension of the decisions for investments.

The demands of the European Commission, in order to make education and training contribute substantially to the European labor strategy, as much as to the strategy of the Lisbon treaty, get down to the following conclusions:

- to guarantee the level of public funding that is dictated by the European social model
- to facilitate entrepreneurial relations and to create incentives for more, continuous investments by businesses and individuals.
to focus financing on sectors that are more likely to bring results
- to make reforms related to class subjects, quality and recognition, in order to maximize their efficiency at European level.

The framework under which the goals of the education and training systems is being examined, together with the most adequate use of existing funds, is a very general scope on education and training investments, paying extra attention to the dimensions of research, life-long learning and employment.

According to the Lisbon treaty, it is the government’s obligation to strengthen universities in order to reassure their contribution to the strategy of Lisbon.

Alison Wolf (2002) though argues that an unquestioning faith in the economic benefits of Education has brought with it huge amounts of wasteful Government spending, attached to misguided and even pernicious policies. Wolf continues that the simple one-way relationship that so entrances and thrills our politicians and commentators which is “Education spending in, economic growth out”, simply does not exist. Commenting that education is most certainly a signaling procedure, used for ranking, screening and selecting people, especially when hiring, she concludes that the link between growth in education and economic success does not exist. Exploring the “tiger” economies of the Far East, no direct or definitive linkage comes along. Outlining the Overeducation phenomenon of the UK, she goes further saying that Switzerland is performing well in economic growth without being such a big spender in education.

Touching the subject of vocational training, it is well said by Wolf that this stands as an exceptional idea “for other people’s children”. She justifies the big interest of young people in HE mainly as an “overconfidence bias”, explaining that they are being “incorrigibly optimistic about their chances in life, and indeed about the general likelihood of good things happening, such as winning the Lottery”. 


«Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Προσέγγιση.»
iv. **Causal implications of all educational enrollments on GDP growth**

The interest for the economic benefits of education is dated back in the era of industrial revolution, and the times of when Adam Smith in 1776 suggested educating the workers. Education, he said, drives away all the disarray and discontent. Generates a self-interest in the person and thus improves its levels of productivity. After a very long period, education is again a key factor for production, development and growth. Theodore Shultz (1963) with his work on human capital and the economic value of education, the focus of Gary Becker (1964) on the critical role of education on human capital formation, and the seminal work of Jacob Mincer (1958, 1962, 1974) and his earnings regressions made a restart to the issue of economics of education and the creation of human capital as a major research field. The past few decades the production of working papers on this problem has been immense. Researchers have approached it from several angles and combined financial resources and educational results data in order to provide with answers. But of course finance and education, both hard to describe and conceive as they both shape according to the ever changing socioeconomic and environment. The trend of each time has direct effect on the financial choices of individuals and the consumers’ choices.

v. **IV and causality**

Jacob Mincer in 1974 progressed his studies through the model of Becker and Chiswick (1966) which would be later on called as “the Mincer model”. It was extensively used to calculate the rate of return to education and the effect of experience on the wage differential. It also became the basis for the evaluation of the economic benefits of education in developing countries. More recent studies used “Mincer model” as a mode of analysis between growth and the average educational levels at country level. Recent literature though proves that, the assumptions of Mincer model for the 1960 labor market are no longer strong and for that reason the model is not able to grasp the current conditions. Mincer’s belief that markets...
operated under perfect certainty, and that individuals were facing no direct costs other than their time (a free good), misled him and the method was biased. The entrance of skill-biased technological change in the labor market had changed everything people knew until then. Future educational tastes, needs, choices, were easy to predict, as heterogeneity was rising high, even within cohorts.

Card (1995, 1999, 2001) following the work of Mincer, used the basic form of his human capital function and attempted to estimate the average growth rate of earnings looking for a causal effect. He attempted to reveal the connection between education and earnings taking into account the heterogeneity of individual decisions. He examined the school endogeneity and tried to unleash the “hidden” ability of each person. Unlike Mincer who regarded that education is exogenous, Card(1995, 1999), Willis (1986), Willis & Rosen (1979), Heckman & Vytlacil (1998, 2003), Taber (2001), Kling (2001), Cameron & Taber (2004) focused on the endogeneity of schooling using the method of instrumental variables (IV), too often defining the problem itself as the IV variable. Card (1999, 2001) used tuition fees, the distance from school, family background, IQ, individual ability, parental education, the low cost of education compared to other investment options, to account for endogeneity, searching for those individuals who chose education based on the instrument and not on the appealing marginal average return to education. He attributed the heterogeneity of individual decisions to the different opportunity cost for each person. The different opportunity cost, which was either the result of different ability, or of the different level of access to funds available. One of is findings that is very interesting for those who believe education is chosen from individuals for its earnings-augmenting capacity, is that for some people going to school it is not the best option available, but the most affordable one. IV methodology also proved that marginalized groups were more favored. Another finding is that IQ proved a strong predictor for the $\frac{1}{4}$ of men, even though many times it is correlated with the educational level of the parents. Willis & Rosen (1979) found that people take into account not only the supply side of
education, but also the demand for higher education graduates, as the IRR are not completely depending on supply. They examined the hypothesis that the financial benefits of education may vary between educational levels, but also between persons of the same educational level as well, controlling for endogeneity of schooling. Their method was taking the basic Roy model (1951) performing causality testing and examining human choices on education, by observing the same person in two reverse conditions for example, having graduated from college, and not having graduated from college.

Gronau and Heckman (1974) examined the choice of a married woman to find a part-time or a full time job. Their selection method consisted of a two step estimator for married women, calculating a shadow price function for a wife’s time, defining a trichotomy among women at work, women not being currently employed but looking for work, and for those women who were out of the labor force conducting house work being occupied as full time house wives. They found that the major determinant for whether a woman would conduct a full-time or a part-time job was the number of under aged children in the family, as the major constraint keeping a woman out of a labor force. Lung-Fei-Lee (1978) used the same model to study a worker’s choice to unionize or not, and its counter effect to productivity. Unionism was found to have a very positive effect on wage. The participation though had to do with the hiring policy of the employer and the hiring perks. The companies who operate under unions choose the most productive workers, using productivity as a criterion. They found that the most productive employees are chosen from unionized firms and less productive employees get hired from non unionized firms. Operation costs don’t differ enough in order to push the unionized ones out of the market. Miller (1984) examined the individual choice of profession, controlling for heterogeneity, and the importance of schooling in the decision to switch a job. He found that there is a causal relationship between the amount of education a person has received, and the speed and quality of one’s own choices for work. He also found that the younger cohorts opt for the most risky jobs in the market. Heckman and Sedlacek (1985) studied the option of being
employed at the industrial sector and how this choice is made. They found that education plays again an important role especially when it comes to deciding to work for the construction-manufacturing sector. They also found that the decision process of individuals from different demographic groups is conducted using countable and non-countable characteristics. Their findings showed that workers choose to work for an employer judging on whether their utility function is being maximized, and not according to their earnings based on social benefits, training, consumption benefits and so on. McElroy & Horney (1981) examined the civil status of people and particularly the decision of an individual to marry or not. They found this decision is mostly affected by the demand for marriage in a society for the current period, a person’s after-tax income, family decisions and predisposition, where education or more likely culture plays an important role in the expectation formation process. Buchinsky & Leslie (2000), Carneiro, Hansen & Heckman (2003), Cunha et al (2005) are only a few of those who present empirical research for alternative models of expectations formation regarding education. Willis & Rosen (1979), following the IV approach, with better data and tools at hand, examined whether the education of an individual is directly affected by parental education and the number of siblings in the family as instrumental variables. They found that the educational background has a positive relation, while the number of children in a family has an adverse effect, due to the educational cost like tuition, books and so on, and the perceptions towards schooling based on ex post predictions. Kane & Rouse (1995) examined tuition fees as an instrumental variable, indicating the importance of money in the formation of the decision for education.

Cameron & Heckman (1998), Carneiro et al.(2005), Cameron & Taber (2004) used local market variables such as the local labor market unemployment to illustrate the situation in a low-skill labor market. Their findings showed that when the demand for qualification is poor, meaning that no critical thinking or initiative or any cognitive abilities are needed to get a job, the prerequisites have to do with obedience, lack of initiative, physical stamina, persistence. In this setting they found that the
demand for education is missing. Cameron & Taber went a step further and examined how important the local constraints, i.e. local wage, might be for financing the cost of studies through lending, due to expected earnings. They controlled for the opportunity cost of education compared to other available options, i.e. the industrial sector wage of the unskilled in the local market, and their analysis showed that local unemployment concerns only the educated and the highly skilled.

**Harmon & Walker (1995)** studied the changes in legislation for the UK compulsory schooling reform from the age of 14 to 15, and then for a second time from 15 to 16. They found that this mainstream reform augmented the skill capacity of those who would attend compulsory schooling, and did not affect the decision for education for those who would drop out anyway. **Meghir & Palme (2005)** used educational Reform as an instrumental variable for the country of Sweden, and studied the implementation of the gradual rise of compulsory schooling after the age of 12 in the municipalities. They compared municipalities with the new and the old system and found that Education Reform had a positive effect on individuals with low socioeconomic level towards wages and skill levels. For those with high SES not only it had no positive effect, but it caused an income reduction onto their entire lifetime earnings. Also, education reform was found to be correlated with earnings, but nevertheless it remains a sufficient policy measure.

**Angrist & Krueger (1991)** took the quarter of the birth of a person for men born between 1930-1959 and examined the amount of education one was receiving according to his date of birth and the compulsory schooling laws that defined as a starting age September when they turned 6. First of all their instrument was proven weak due to a number of biases. Their findings showed that those who were to leave school earlier, before turning 16, would do it anyway, even with an official schooling year less, and that the only effect was on an individual level, some differences per month of birth.

**Acemoglu & Angrist (1999)** combined the variable of education reform and the quarter of birth, demonstrating positive effect on quality, as the school attendance
rises and the composition of the population was changing with many more educated members, while they found a mixed effect on dropout rates.

Cameron & Heckman (1998) also examined the effect of family resources and background as the IV variables on the decision for further education and found a decreasing effect in higher educational levels. They also examined the financial support policies, and showed that they result in attracting lower quality students, that is of lower ability. These students later on are the one who will settle for lower wages. Also, what is more important in the decision making for education is the long run financial state of the student, and not the additional late supplements.

Most instrumental variables as seen also above, tend to correlate with individual cognitive abilities, violating the fundamental hypothesis of freedom e.g. family background correlating with IQ measurement not illustrating the real ability of the person under examination, with maybe the only exception that of the measurement of local labor market unemployment, which reflects purely e.g. the unemployment of the educated due to a clear mismatch with the low skills in demand.

Available data sets of education and earnings do not include separate measurements of the cognitive ability of individuals, in which case it is included in the residuals, implying not accurate results.

All studies have approached the contribution of educational expenditure to growth very sufficiently but none of them has ever managed to quantify other individual characteristics that refer to the family, such as particular features of the person etc.

Even fewer are the studies that are directed towards the social and economic structure of an economy and its comparative advantage. Asteriou & Siriopoulous (1997) in a study on Greece they studied the Greek educational system and found that emphasis is needed on vocational higher education for the 1960-1994 period.
vi. **Panel data.**

So far, empirical literature on macroeconomic growth included mostly measurements of the years of schooling, controlling with growth models; Barro (1991), Mankiw et al (1992), Levine and Renelt (1992) used rates of school attendance in their studies; On an international level, we have the studies of Barro and Lee (1993, 2001, 2010), where a very rich sample of countries and years had been deployed with international comparative data on the average educational level for each country. Indicatively, a simple model that examines only earnings relation to years of schooling, with the addition of cognitive skills, the percentage of the economic growth variance explained by the model goes from 25% to 73%.

In a whole, the literature on the relation of years of schooling and growth is positive. But the average level of years of schooling as a variable might be both misleading and inadequate, in international as well as in national level, when used in the comparative study of human capital among countries.

vii. **Quality of the Workforce, International comparisons**

What is derived from the following research studies is that each and every quality characteristic of the workforce brings a country closer to growth.

Hanushhek and Kimko (2000), examined a sample of 31 countries. They studied the effect of quality of the workforce on growth, calculating the GDP per capita growth rate during 1960-1990. They found that the quality of the workforce played a major role in growth, while school quantity tends to minimize its importance.

Lee and Lee (1995) from a sample of 17 countries examined the effect of education on growth, calculating the growth rate of the real GDP during 1970-1985. They found an explicit effect of student achievement scores on GDP growth, and a decreasing fertility rate.
Barro (2001) in a sample of 43 countries studied the effect of education on growth for 1965-1995. He found that quality of schooling is much more important than quantity. A positive effect of science test scores on growth.

Grundlach et al (2002) in a sample of 131 countries calculated the differences on growth rate through employee earnings for 1990. Their managed to prove, through their quality-adjusted measures of human capital, that it is this quality that explains the 45% of the variation in output per worker globally. For the OECD countries this measure accounts for 100% of the variation.

Woessmann (2003c) took the data employed by the study of Hanushek and Kimko (2000) for a number of countries (starting from 29 and up to 132), making comparisons with the various measurements of human capital using employee earnings of 1990. He found that it is quality that generates income. According to their measures for a sample of 64 countries with non inputed data, quality-adjusted human capital explains 60% of the variation in output per worker.

The first economic study using a plethora of micro data for school performance, family background, educational material on international level, in an extended multivariate cross-sectional function of education production was Woessmann (2003b). He found a positive connection between SES and achievement at student level. Parental education (books at home) and student performance had a positive impact as well.

On a national level we have some similar studies of Bishop (1997), Hanushek and Kimko (2000), and Lee and Barro (2001).

viii. The Sampling method. Omitted variable bias

The method of sampling was severely criticized from the international community as the main source of distortion in international comparisons of school success (Baker, 1997) (Adams, 2003) (Rotberg, 1997) (Prais, 2003).
There is a chance for the sample of students being examined in each country, not to illustrate the real conditions. In this case the results from the test scores might not be able to offer a realistic view of the general population.

Also, another important issue is the unobserved heterogeneity on a national level meaning that e.g. the cultural values of a country that will be missing from the econometric model, will in the end result in inaccurate findings derived from the education production function. As very often is the case, one year of school attendance in Europe happens to be in many respects different from one year in Asia, or between countries for example.

The comprehension of the way individual agents decide on the way they will distribute their wealth upon the cultivation of themselves and their families is something that remains to be seen.

II. The Greek Educational System. Historical Data.

The Greek Nation appeared as a modern state after 4 centuries of Turkish oppression. The war of independence started in 1821 and was successfully ended in 1827. The new Nation that was formed at that started started off with a population of 750,000 inhabitants and its economy absolutely devastated.

In 1828 Ioannis Kapodistrias who had served as a Minister of Foreign Affairs of Russia came to Greece as the first non-elected governor. Kapodistrias, who is considered the founder of modern Greece, was murdered in 1831 due to the restrictions he imposed on the rights of citizens and the political rivalry/contradictions of that time.

2 years later Greece became a monarchy. The Great forces (Great Britain, France, Russia), aiming to protect Greece chose Othon as a king. During his monarchy
Greece was set up according to the German guidelines. The effect of the German neoclassicism on Greeks augmented their interest for Ancient Greece. The absolutarian way of governance that Othon followed though, led to his dethronement. In 1864 a new dynasty, that of Glyxburg was imposed on Greeks. At the same time Greece was enlarged and Greece’s population became 1,450,000 inhabitants.

Political and socio-economic aspects of life was beginning to stabilize with Harilaos Trikoupis, as the leading man in the political scene of the country. The Trikoupi government applied a massive growth program that was dealing with all sectors of life. It was then when the construction of roads, railways and ports began. In the field of education, even though the government had shown real interest, progress was quite modest, due to the archaic and religious spirit that was still present in the social and cultural life of the country.

During the time between 1895-1922 the independence movements of the country shocked Greece. Greeks, still under Turkish oppression were struggling for their liberation. So, the independence movements all over Greece drove things to a new war against Turkey. The result of the first phase of this war was Greece’s failure in 1897. Together with the financial bankruptcy that followed, all this resulted in the 1909 revolution.

Eleftherios Venizelos’s importance was underlined after the revolution together with his prominence in the political life of the country. His governance promoted serious economic growth. There was a new wind of administration in all sectors and Greece was starting to become modernized. The National Survey of 1910 showed a 33% increase of the population of the urban areas comparing to the 8% that was in 1850.

Balkan wars that followed together with World War I freed even more regions. As a result Greece doubled its extent and the population reached 5m. At the end of World War I Greeks attempted to free and take back Asia Minor but they were defeated by the Turks in 1922. The socioeconomic and political consequences of this war were immense, as 500,000 refugees were forced to leave Asia Minor and reside permanently in Greece.
This downfall of Asia Minor created the perfect climate for a reform to come in the political life of the country. In 1924 the prevailing regime was the Presidential Democracy. This came along with political instability and continuous revolutions until 1928, when political stability was back. The political changes that occurred in Greater Europe, like the dictatorships in Germany, Italy and Spain.

In 1936 dictatorship was imposed on the Greeks together with the establishment of the monarchy. World War II, The German occupation, National Resistance and the 2 civil wars brought tremendous destruction in the economic and social life of the country. Greece paid a heavy price on World War II. The hostilities that started off in 1940 lasted until 1949. The casualties in human lives were more than 474,000, adding 300,000 lives due the raise in mortality rates as a result of the physical discomfort. 50,000 people, members of the minorities left Greece because of the war. 200,000 were left incompetent for work. All together this sums up to 1m total loss in human capital.

Not to mention the material annihilation that the country experienced. The damage was extensive. Reduction in the primary sector production in cereal, raisin, cotton, tobacco, vineyards and so on. 50% decline in live stock farming. 20% decrease of the forests. 50% reducement of the industrial production. Absolute destruction of the mining sites and the mining business. 73% loss of the transport and commercial shipping. Destruction of houses. Destruction of many public and productive projects. About 5,000 school buildings that were destroyed, together with the depreciation of our national currency, up to the level of extinction.

Having said all this, it is clear that Greece was supposed to build a future upon such ruins. While in the other European Countries the rebuilding started no later than 1945, by the end of World War II, Greece managed to start getting back on track in the beginning of 1950s. It was then when Greece became a member of the NATO and start cooperating closely with the European Economic Community from 1961

i. **Content & Direction of the educational system**
The factors that define the direction and content of education in a country are:

1. The state
2. Parents aspirations for their children’s education.
3. The Church
4. Tradition and discrimination against stereotypes
5. The mentality of the educators, and their influence on the system.
6. The demand of the students for better and more education. The employability factor

ii. The State

The state consists of a major influence that directs in a large extent the direction and the scope of education, as it controls the human capital, the financial resources and the means.

It is the State that dictates which are the necessary specialties for its governance. Moreover, education is considered as the most effective means for the better coordination of the society. As Aristotle said, the educational system has to be deeply rooted in the Constitution, as it is education that can help restore national compliance and prevent from the social decay of the State.

In non-democratic states, governments use education to accomplish national dogma. In developing countries though, governments see education as a basic feature of their independence and the instrument that can create the national conscience of the new State.

In the last decades, governments all over the world have stressed out the importance of education in economic growth and are directing their educational systems towards this orientation. The upsurge of Educational public spending shows clearly the
increasing desire for more and better education. This could be easily explained as education has a direct relation to economic and social growth.

\[ \text{iii. The Greco-Christian Civilization} \]

The Greek civilization is deeply rooted in Ancient Greece and the Byzantine. It consists of an amalgam of the ancient Greek Philosophy and the Christian dogma. This mixture is known to Greeks as Greek-Christian culture.

The question here is how do the pagan ancient times combine with the Christian Orthodox beliefs. The Great Fathers of the Greek Orthodox Church incorporated and transformed the Platonic and Aristotelian philosophy into a new synthesis of Greek Christian Philosophy.

The Greek Orthodox Church acquired a national character under the Turkish oppression, since it played an important role in the fight for the conservation of the national identity. That is why historical and religious facts became interconnected and for that reason non-segregated. In that long period of Turkish oppression, Greek nation was the equivalent Greek Orthodox community. The leader of the nation was the Greek Orthodox Patriarch of Constantinople (Istanbul). This way, by strengthening the byzantine culture, the church became the guardian, the carrier, and the transmitter of the "national" culture. Reading, writing, and literature were deeply guided by religion.

After the Independence, the new Nation started searching for its ideology in the Greek-Christian culture in order to form its identity and maintain its cohesion. The alliance between the Ancient Greek history and the Orthodox Church set the foundation of the modern Greek culture. Another very important detail was that the language used in the Bible was not far from Ancient Greek.

As one would expect the effect of the Greek-Christian civilization on education has been huge, as education was the medium that helped in the configuration of
civilization. The mix of philosophical and religious ideas consisted of the new ideal according to which the new Nation was supposed to grow. So the role of education up to this point was obvious. It had to cultivate the spirit of the Greek youth and help build a “good life” compatible with the beliefs of their ancestors and the lectures of the Greek Orthodox Church. “the scope of education in the new Greek state of 1830 was not to create new ways of thinking but to revive the ancient Greek culture. In this attempt of theirs, they faced the problem of combining 2 great cultures, the Ancient Greek and the Medieval Christian” as professor Kazamias had to say on this.

One main point of the interference of the Church in the process of education was its ethical and religious direction. In the end of 19th century the quality of education remained poor. The number of lessons taught at school was big and imbalanced with the level of the teachers. The schools’ core was the lesson of the ancient Greek and its grammar, where they insisted the most. The whole idea of schooling was soaked with this ideal: memorizing difficult linguistic types, and long, obscure linguistic rules. The tutoring of ancient Greek on 7 year-olds had very negative consequences on the education of the Greek people, contributing to the high level of illiteracy of the masses. Even though we couldn’t find such numbers it can be easily understood that the children who could not attend school, were the children of farmers and workers. Not an inclusive system after all. The children of middle-income and high-income families had a greater support, and for that reason they could bear the unrealistic difficulties of the educational system.

Happily, the reforms that followed contributed to the growth of the Greek Educational system and simplified the process of learning and teaching. Namely, the reforms that followed, were the one of 1929 for secondary education, the reform of 1959 for the technical and professional education, and as well the one of 1964. The reform of 1964 was actually the most radical as it introduced the measure of free public education at all grades, from primary to university. It also changed the compulsory years from 6 to 9, cancelled the preliminary exams in secondary level, divided secondary level into
v. Higher Education in modern Greece

During the Turkish oppression there was no university on Greek soil. In 1923, the Ionian Academy was established on the island of Corfu, at the time when the Ionian Islands were under British occupation. The Academy was forced to shut down in 1864 when these islands became part of Greece.

v. Athens University

University of Athens was founded in 1837. During its time, students had to pay tuition, unless for the poor and the scholars. Due to the fact that most students were poor, the university suspended the measure of tuition fees on students’ behalf. Tuition fees were officially cancelled from the constitutions of 1844 and 1864. University started off with 52 real students and 75 auditors which were all public servants. In 1841 these numbers became 159 and 133 respectively.

The initial regulations of the university should be characterized as unrealistic, as students were supposed to proceed for examination only once during their studies, that is the final examination for the award of the degree. This made their studies difficult as they were supposed to be examined on lessons that they had been taught 4 years ago. That made their studies last 6 to 7 years instead of 4, which was the number of school years. Nevertheless the contribution of the university in the first years of its operation was tremendous.

The demand for higher education has increased in the recent past. That is mostly due to the fact that, in 1964 education became a free public good. Another major factor was the consistently improving living conditions of the citizens. The fact university graduates were receiving significantly higher salaries comparing to those of high school graduates, made higher education studies very appealing also, while positions
Once held by high school graduates now were taken by university graduates. Another crucial reason that caused this rise is the little-to-no-growth of the technical studies, sending off possible candidates to university too. The system made young people and their families searching for white-collar jobs, trying to avoid manual labor. Also the exclusively humanitarian orientation of the curriculum of the Secondary education level added to the above rise of demand. The results though were nothing particularly special. This strategy produced about 40 to 45% public servants while in France or Britain the results are 4 and 5 respectively. From what it seemed back then, the gap between supply and demand in education was severely wide. The quality of educational provision in universities was low in both quantity and quality.

vi. Remarks

The scope of this analysis is the empirical investigation of public funding in Education in the Greek Market, and how this is connected with or caused by the financial choices of the families.

This study thoroughly investigates government expenditures in education in all levels, starting from preschool, and going up to higher education institutions. This study used several data sources, and searched for a lot more databases available. The inability to collect such long and comparable data series in a time span of 4 years, which is how long this study lasted, made this analysis to limit to one country and one educational system, following the methodology of a previous national study, namely Asteriou & Siriopoulos, 1997 analysis of the Greek educational system.

The time series concerning the number of educational enrollments in the Greek educational system were collected from the Greek Statistics Bureau, ELSTAT. Data on Educational expenditures were also collected from ELSTAT, while GDP per capita was taken from the AMECO database. All numbers concerning educational enrollments involved the number of students going to school at the beginning of the
school year, and referred to the total number of students enrolled in each educational level. Educational public expenditures were all expressed in euro currency. Gdp per capita was measured in current prices, in order to catch a bigger percentage of the diversification of the change in prices, as followed by many other scholars in the past who examined similar case studies.

The main argument here in this study is whether public education in Greece is a proper sector for sustainable investments, or is it still consuming public funds and available human capital without promoting economic growth, in any respect. The reason that led us take the study of Asteriou & Siriopoulos one step further, was first of all, the fact that the results of the former study were rather in terms of growth, despite the fact that Greece experienced unique rates of growth in the decade 1990-2000, in many important sectors of the economy. The phenomenon of “reverse causality” that shocked the researchers, and made them reluctant to suggest any further sustainable reform measures was definitely a main point of interest along with the fact that Greek families were showing immense interest in sending their kids off to university, without facing any constraint.

It remains to be seen whether education sector is ready to accept even more public funds with the underlying infrastructure, or it is a time-consuming, money-spending sector, supposedly ready to accept all the necessary reforms and become a sustainable field of investment, in both terms of money and human capital.
4. Methodology

In this paper, we are searching for causal relations in terms of growth. Linear and nonlinear Granger causality tests are used in order to examine the dynamic relationship between the economy and education in a European country such as Greece, namely public expenditures in education, GDP per capita, students’ enrollments of all levels, preschool, primary, secondary and higher education. This study includes the years of the latest economic crisis from 2008 and on, that affected the developed world and the so called “service economies” mostly. The interest of this analysis is focused on how the development of the Greek Nation along the years, and financial decisions of the individual agents towards personal, social and financial growth, affected their educational choices. The results however indicate the absence of causal relationship running from education to economic growth in this whole period of study, which is from 1960 to 2014.

A previous study, which was the lead paper, that consecutively produced this research, indicated causality running from all educational variables towards growth, except for preschool level which was added in this dissertation just now, as it became compulsory as well. Asteriou D. & Siriopoulos C., as early as in 1997, studied the relation between education and growth. The interest in education at that time was big. The Greek market was at that time experiencing unique rates of growth in major sectors. Public Education was not directly involved but the demand for education was big. Apart from unidirectional causality, most important was the phenomenon of “adverse causality” between higher education and GDP per capita. Detecting a strong, as well as “wrong” relationship. Families and students improved their knowledge and skills, together with their financial status, a finding that is usually there in developing countries, using education as the sterile trademark of “new money in the block”. As
mentioned earlier, people were dealing with education and white-collar jobs as a rescue from poverty and agriculture.

Causality tests can provide useful information on whether the changes of one educational level improve short-run forecasts of current and future movements of another educational level, of the public expenditures, of economic growth, and vice versa.

All previous studies on causal relationship, the majority at least, rely on traditional linear tests. What is left out though from the estimations of the linear approach to causality tests is that such tests can be weak in detecting certain kinds of nonlinear causal relations, as Baek and Brock (1992) said. The main driver of following the non-linear methodology is that financial time series most of the times exhibit non-linear dependence, as stated in many studies, while Granger (1989) himself argues that the real world is not linear. The complexity of the real world can be translated only by univariate and multivariate non-linear models. According to Granger, the proper way to model the real world is “most certainly non linear”.

I. Granger Causality (1969)

Granger causality is not the same concept as in everyday life. Causality in econometrics is a completely different notion: it is the ability of one variable to predict the other. Let’s suppose two variables, \( x_t \) and \( y_t \), which affect each other. This relationship can be illustrated by using a VAR model.

Granger therefore created a rather simple model for causality that can be defined as follows. In this case we say that a) \( x_t \) causes \( y_t \), if past and former values of \( x_t \) give us a better prediction of the future values of \( y_t \) b) \( y_t \) causes \( x_t \) if past and former values of \( y_t \) gives a better prediction of \( x_t \), rather than if we hadn’t been using this past values, keeping all other terms stable.
i. The Pairwise Linear Granger Causality Test

The first procedure of the Pairwise Granger causality test of two stationary variables involves the estimation of a 2-equation VAR model, given as follows:

\[ \begin{align*}
  y_t &= \alpha_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t} \\
  x_t &= \alpha_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + e_{2t}
\end{align*} \]

Where both \( e_{1t} \) and \( e_{2t} \) are uncorrelated white-noise terms.

Following the philosophy of this model we examine certain different outcomes/possibilities:

Case 1: The lagged terms \( x \) in equation 4.1 might be different from zero as a group, and the lagged \( y \) terms in equation 4.2 not statistically different from zero, so we come to the conclusion that \( x_t \) causes \( y_t \).

Case 2: The lagged \( y \) terms in equation 4.2 may be statistically different from zero as a group, and the lagged \( x \) terms in equation 4.1 not statistically different from zero, so we come to the conclusion that \( y_t \) causes \( x_t \).
Case 3: Either set of terms x and y are statistically different from zero in equations 4.1 and 4.2, in which case there is bi-directional causality.

Case 4: Either set x and y are not statistically different from zero in equations 4.1 and 4.2, in which case we say that $x_t$ and $y_t$ are independent variables and no causality is detected running both ways.

To proceed with the Granger causality test, we form the null hypothesis and the alternative hypothesis for equation 4.1 first:

$$H_0: \sum_{i=1}^{n} \beta_i = 0 \text{ or } x_t \text{ does not cause } y_t.$$

$$H_1: \sum_{i=1}^{n} \beta_i \neq 0 \text{, or } x_t \text{ does cause } y_t.$$

Then we regress $y_t$ on the lagged $y$ values only and obtain the sum of squared residuals from the restricted model, namely $SSR_R$

$$y_t = a_1 + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t}$$
Then we regress $y_t$ on the lagged values of both $x$ and $y$ terms, as follows:

$$y_t = a_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t}$$

And estimate the sum of squared residuals from the unrestricted model of this regression, and call it $SSR_U$.

Then we proceed with calculating the F-statistic using the Wald test on coefficient restrictions given by:

$$F = \frac{(SSR_R - SSR_U)/m}{SSR_U/(n - k)}$$

Which follows the $F_{m,n-k}$ distribution, and $k = m + n + 1$. 

ii. The Sims test

According to Sims proposition in order to determine whether one variable \( x_t \) causes \( y_t \), we have to exclude the option of the future values to be able to predict the present. Therefore we estimate the following VAR model:

Equation 4.4

\[
y_t = a_3 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + \sum_{\rho=1}^{k} \zeta_{\rho} x_{t+\rho} + e_{1t}
\]

Equation 4.5

\[
x_t = a_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + \sum_{\rho=1}^{k} \xi_{\rho} y_{t+\rho} + e_{2t}
\]

In this 2-equation model, we notice that apart from the lagged values of \( x \) in 4.4 we also have leading values of \( x \) and in equation 4.5, respectively we also have leading values of \( y \).

So if we say that \( y_t \) causes \( x_t \) then there must be some relation between \( y \) and the leading values of \( x \), and instead of the lagged values we test for \( x_{t+\rho} \). The null hypothesis in this case is: \( H_0 : \zeta = 0 \). Rejection of the null means that \( y \) causes the (leading values of) \( x \), and not the opposite as, the future cannot present the present, as
said. Losing more degrees of freedom we do the testing as in Granger causality test, using the F-statistic.

II. Cointegration


“Time series $Y_t$ and $X_t$ are said to be cointegrated of order $d,b$ where $d \geq b \geq 0$, written as $Y_t, X_t \sim CI(d, b)$ if (a) both series are integrated of order $d$ and (b) there exists a linear combination of these variables say $\beta_1 Y_t + \beta_2 X_t$ which is integrated of order $d-b$. The vector $\{\beta_1, \beta_2\}$ is called the cointegrating vector.

In economics, most financial time series are trended, have an underlying rate of growth, constant or not, and most of the times are non-stationary. Take for example GDP, market prices, money supply. They all tend to grow at a regular rate, and their mean is rising. One solution to this trend, in order to normalize any estimation problems is to check for unit roots, applying a unit root test. Nevertheless this solution is not ideal.

The existence of a trend at a time series, either stochastic- these are also called unit root processes- or definitive is a major problem as it might lead us to spurious regressions with incorrect conclusions. The existence of stationarity is necessary, as if the time series was to be non-stationary all the results from the classical regression would not be valid, aka spurious correlation results. Standard detrending techniques might end up providing data that are still non-stationary.
Stationarity is a key concept underlying the whole procedure of time series analysis. Nevertheless, it is not an ideal solution to the problem, alone. By taking the first differences of a time series, integrating the time series at order 1 (1), we lose the long run characteristics of that series, since first differences do not contain any long run trend, by definition. What is needed here is an econometric model that would include both short term dynamics (deviations from equilibrium) and long run expectations (corrections to equilibrium), but maintain the property of stationarity.

Cointegration in this case is important since it allows us to describe the possible conditions of equilibrium between 2 or more financial time series, each one of them being non-stationary. When testing hypotheses between non-stationary time series running a classical regression on I (1) variables only without controlling for cointegrating vectors, then the whole procedure of testing might be misleading and biased.

Regression analysis, when dealing with non-stationary variables, could end up detecting relationships even when there are none.

Checking for Cointegration is the detangling answer to the limb method of detrending. The condition of long run equilibrium between the integrated variables of order one is defined as: the condition when no other trend is detected among the variables, other than a state of “random walk between the drunk and her dog” that exhibits some sort of pulling one another inside the variables system. And the confirmation of Cointegration is “the leash” in the hands of the drunk that forces the dog not to go his own way.

Long run equilibrium is an expression used to describe a relationship of balance that a system converges into in time. This fact results in the systematic linear movement between economic variables which sets an example of how an economic system behaves in the long run. This notion is somewhat more abstract from the definition of equilibrium in economic theory as it refers to any behavior of the different styles of a system.

Three major reasons why Cointegration is crucial for cointegrated time series and the detection of long run equilibrium are:
It connects high-order integrated time series, among which there is a linear combination of a lower order of integration, that could justify the equilibrium relationship that exists between them, which would not have been detected otherwise. Cointegration testing offers the data that can distinguish a spurious regression from a real one. Regressions make sense, only when the variables are cointegrated. This comes as a result of the identification of Cointegration as a state of equilibrium.

When a group of variables we say that is “cointegrated”, then this can be expressed as a model in which the deviation between the observed prices and the condition of long-run equilibrium, is expressed. In other words, when the phenomenon of Cointegration is present, an error correction mechanism is there to justify the existence of the cointegrating vectors that can be described in the model as the way the variables adjust to match their long-run equilibrium, aka the leash.

In order to decide that among two variables $x_t$ and $y_t$ there is a cointegrating relationship, a linear combination of the two is required, a I(0) stationary variable:

Equation 4.6

$$Y_t = \beta_1 + \beta_2 X_t + u_t$$

And their residuals:

Equation 4.7

$$\hat{u}_t = Y_t - \hat{\beta}_1 - \hat{\beta}_2 X_t$$

If $\hat{u}_t \sim I(0)$ are said to be cointegrated.
Cointegration can be defined in a more mathematical way. This is given by a set of 2 variables of order one \( \{X, Y\} \sim I(1) \), and a vector \( \{\theta_1, \theta_2\} \) that gives a linear combination of \( \{Y, X\} \) which is stationary, denoted by:

\[
\theta_1 Y_t + \theta_2 X_t = u_t \sim I(0)
\]

\(\{X, Y\}\) is the Cointegration set and \(\{\theta_1, \theta_2\}\) the coefficients vector. The long run relationship is given by:

\[
Y_t = \beta X_t
\]

Which results from normalizing another equation, 4.8:

\[
Y_t = -\frac{\theta_1}{\theta_2} X_t + \epsilon_t
\]
i. Error Correction Mechanism and Cointegration

The confusion that comes from regressions that give us spurious results comes from data that are non-stationary. So if we have two variables $Y_t$ and $X_t$ that are non-stationary at level and need to be integrated of order one, that is $I(1)$ then the regression of:

$$Y_t = \beta_1 + \beta_2 X_t + u_t$$

Will give us misleading results. If we regress their first differences $I(1)$, in order to achieve stationarity of the time series, the model transforms:

$$\Delta Y_t = \alpha_1 + \alpha_2 \Delta X_t + \Delta u_t$$
This way the model overcomes the problem of non stationarity and we might get correct estimates for the coefficients $\alpha_1$ and $\alpha_2$, but the fact that our data are filtered to avoid spurious results, we also lose the long run trend of the time series, which is also the main interest of our research. The long run relationship between the two variable is given by the following:

\[ Y_t = \beta_1 + \beta_2 X_t \]

Variables here are I(1). If those variables were I(0), that is, there was a linear combination between them, then we say that the variables are cointegrated and equation 6.1 no longer gives spurious results but provides us with their long run relationship as well. In all other cases this does not hold and we need to proceed with further more intelligent ways of estimating.

The above is an excellent illustration of what brought us to the doorstep of Cointegration and error-correction mechanism which are both important econometric tools.
This is the illustration of the relationship between the two variables $Y_t$ and $X_t$ using ECM.

This model gives us both the short run and the long run characteristics of the variables.

The advantages of the error correction mechanisms are many. Some of the most important features are:

It measures the correction form the disequilibrium of the previous period, which is useful information concerning its economic implications.

As shown above error correction models are set in terms of first differences, which automatically resolves the problem of spurious results by eliminating the trends of the variables system.

The disequilibrium error term is a stationary variable, by definition. This prevents the errors of become larger.

The ease at which they make good fit into the data, searching for the optimal ECM model.

III. Detection of Unit Root (Engle-Granger test)

As we’ve mentioned earlier all economic series are trended. The need for detrending the data by integrating them of higher order $I(d)$, created the need for identifying non-stationary time-series. In a stationary time series, shocks are temporary and eliminated.
over time, while non-stationary time series contain long run properties that are maintained throughout the econometric analysis, and are highly misleading. Lets consider the autoregressive function of a time series where all future prices of the variable are a function of past prices and the error term, which is a white-noise process:

\[ y_t = \alpha y_{t-1} + e_t \]

The possibilities are: 
- \(|\alpha| < 1\), then the series is stationary
- \(|\alpha| > 1\), then the series explodes
- \(|\alpha| = 1\), the series contains a unit root and is not stationary. In this case we take the first differences and the series becomes stationary.

In general a non-stationary time series needs to be integrated more than one time to become stationary. In this case we say that a variable that is differenced \(d\) times, is integrated of order \(d\).

\[ i. \text{ Testing for unit roots} \]

The process of defining the order of integration of a time series is a test for the number of unit roots and it has three steps:

**Step 1.**
We test the variable at level to see if it is stationary. If yes then we consider \(y_t \sim I(0)\).

If the variable is found to be non-stationary, then we continue until we define the order of integration, in which case we say \(y_t \sim I(d) \quad d > 0\)

**Step 2**
We take the first differences of the variable and test them to see if it is stationary. If yes then $y_t \sim I(1)$ if no then $y_t \sim I(d) d > 0$.

Step 3
We take the second differences of the variable to test if it is stationary. If yes then $y_t \sim I(2)$. If not then $y_t \sim I(d) d > 0$ and so on until it is found to be stationary.

ii. The simple Dickey-Fuller (DF) test for unit roots

The hypothesis here for Dickey and Fuller (1979, 1981) was a rather simple assumption that testing for unit roots was the same like testing for non-stationarity. The test is based on the AR (1) model of the form:

\begin{equation}
    y_t = \beta y_{t-1} + u_t
\end{equation}

The question to be answered here is whether $\beta = 1$ which indicates the existence of a unit root.

\begin{equation}
    H_0: \beta = 1 \quad H_1: \beta < 1
\end{equation}
Dickey and Fuller (1979) also suggested two alternative regression equations when testing for a unit root. One that contains a constant in the random-walk process and the second one, that contains a non-stochastic time trend. This test is based on the Mackinnon (1991) special critical values created for each of the three models.

iii. The Augmented Dickey-Fuller (ADF) test for unit roots

These three equations consist the three different models used in order to test for the existence of unit roots. Dickey and Fuller after realizing that the error term $u_t$ cannot be white noise, when dealing with the possibility of a trended time series, went on extending their testing method. They provided with the augmented version of their test, including lagged terms of the dependent variable, thus eliminating autocorrelation. The optimum lag length is determined by either Akaike information criterion, AIC, or Bayesian information criterion, BIC.

Equation 4.1.9

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=1}^{P} \beta_i \Delta y_{t-i} + u_t$$

Equation 4.2.1
Unless the econometrician knows the structure of the data, he has to decide which equation is more appropriate. The critical values used for the ADF are the same with simple DF test.

iv. Testing for Cointegration. Johansen approach

The test used in Cointegration testing in this study is the Johansen procedure, and there is a reason for that. According to the theory, when there are n variables in a model, there can be found n-1 cointegrating vectors. So, between two there is a possibility of having one cointegrating vector, which is the simplest case. But when n>2 then the possibility is rising, and the simple Engle-Granger (1981) Cointegration test cannot give a clear view of the number of vectors involved.

The process that is followed is described below in steps:

\[ \Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + u_t \]

Equation 4.2.2
Step 1: The most important issue here is to define the order of integration of our variables. Economic time series most of the times contain unit roots, and their trend does not allow us to take real results. So to avoid setting up a spurious regression, we difference our data, and make sure that all variable are integrated of the same order. This allows us to proceed with the cointegration test.

Step 2: We estimate a VAR model of all our variables at levels, for a large number of lags. Finding the optimal lag length guarantees that the results will not suffer from non-normality, autocorrelation, heteroscedasticity and so on. The estimation process will gradually reduce the number of lags, until zero lag is reached, in order to define using AIC and SBC criteria together with other diagnostics that detect autocorrelation, heteroscedasticity, possible ARCH effects and the normality of the residuals.

In this study, the Johansen Juselius Cointegration test was conducted with the aid of econometric package of Eviews.

Step 3: We need to define the form of the model, according to the structure of our data. The general model that describes all options is:

\[
\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \cdots + \Gamma_{k-1} \Delta Z_{t-k+1} + \alpha (\beta Z_{t-1} \mu_1 \delta_1 t) + \mu_2 + \delta_2 t + u_t
\]

According to this general illustration, five models can be taken into account. What we can have is a constant, with coefficient \( \mu_1 \), a trend with coefficient \( \delta_1 \) in the Cointegrating Equation(CE), and a constant with coefficient \( \mu_2 \), and a trend with coefficient \( \delta_2 \) in the VAR model (short-run model). So the following combinations apply:
1) a model with no deterministic components, i.e. no intercept or trend in CE or VAR. Practically this is unlikely to happen as the intercept is generally needed in all models.

2) a model with intercept (no trend) in CE, no intercept or trend in VAR. In this case we exclude any short-run effects in the model, the first differences will give us a zero mean, and the intercept will stick to the long-run effects of the model (the cointegrating equation).

3) Intercept in CE and VAR, no trends in CE and VAR.

4) Intercept in CE and VAR, linear trend in CE, no trend in VAR.

5) Intercept and quadratic trend in the CE intercept and linear trend in VAR.

The most appropriate and the least restrictive model is number 4.

Step 4: At this stage we define the number of cointegrating vectors in this relationship. The methods, and the statistics that follow them are two, and we proceed with both of them. They both apply their statistics on the same matrix $\Pi$. This matrix is a $k \times k$ matrix with rank $r$. Both of the aforementioned methods work with eigenvalues, which are basically roots, based on a different approach.

a) This test is defined by the method of estimation. It replies according to the maximum eigenvalue, for that it’s called maximum eigenvalue statistic ($\lambda_{max}$). This first method does Hypothesis testing where the null hypothesis is that there are up to $r$ cointegrating vectors, against the alternative that says there are ($r+1$) cointegrating vectors. In order to say how many of the eigenvalues are definitive the test uses the following statistic:

$$\lambda_{max}(\rho, \rho + 1) = -T \ln (1 - \hat{\lambda}_{r+1})$$

b) The second method is called Trace statistic and follows the likelihood ratio test for the trace of the matrix $\Pi$. Hypothesis testing in this involves a null hypothesis where in
In this case the number of cointegrating vectors can be less than or equal to \( r \), against the alternative that the trace might increase by adding more eigenvalues beyond the \( r^{th} \). It follows this relationship:

\[
\lambda_{\text{trace}}(r) = -T \sum_{i=r+1}^{n} \ln \left( 1 - \hat{\lambda}_{r+1} \right)
\]

The concept for both tests is working downwards until we reach an eigenvalue that exceeds the critical values given by Johansen and Juselius (1990). When working with a statistical package such as Eviews, critical values are given directly on screen when using the Johansen approach.

Step 5: Weak exogeneity testing. Given the number of cointegrating vectors the next procedure involves determining which of the variables are weakly exogenous. If a variable is found to be weakly exogenous, then we can simply regard this as an endogenous part of the system. The variable will still be there on the right hand-side of other equations, while its own definitive equation will be disregarded.

Supposedly we have a set of three Variables \( X_t, Y_t, Z_t \) which can all be expressed in the form of a matrix \( S_t = [X_t, Y_t, Z_t] \) The possibility for each one of them to be endogenous is equal.

\[
\text{Equation 4.2.6}
\]
Which can be transformed in a vector error correction model:

Equation 4.2.7

\[ \Delta S_t = \Gamma_1 \Delta S_{t-1} + \Gamma_2 \Delta S_{t-2} + \cdots + \Gamma_k \Delta S_{t-k} + \Pi S_{t-1} + u_t \]

\[ S_t = A_1 S_{t-1} + A_2 S_{t-2} + \cdots + A_k S_{t-k} + u_t \]

\[ \Pi = \alpha \beta' \]

\( \alpha \) = speed of adjustment to equilibrium coefficients

\( \beta' \) = the long-run matrix of coefficients

Defining that \( k=2 \) we now have:
Equation 4.2.9

\[
\begin{pmatrix}
\Delta Y_t \\
\Delta X_t \\
\Delta Z_t
\end{pmatrix}
= \Gamma_1 \begin{pmatrix}
\Delta Y_{t-1} \\
\Delta X_{t-1} \\
\Delta Z_{t-1}
\end{pmatrix}
+ \Pi \begin{pmatrix}
\Delta Y_{t-1} \\
\Delta X_{t-1} \\
\Delta Z_{t-1}
\end{pmatrix}
+ e_t
\]

Or,

Equation 4.3.1

\[
\begin{pmatrix}
\Delta Y_t \\
\Delta X_t \\
\Delta Z_t
\end{pmatrix}
= \Gamma_1 \begin{pmatrix}
\Delta Y_{t-1} \\
\Delta X_{t-1} \\
\Delta Z_{t-1}
\end{pmatrix}
+ \begin{pmatrix}
\alpha_{11} & \alpha_{12} \\
\alpha_{21} & \alpha_{22} \\
\alpha_{31} & \alpha_{32}
\end{pmatrix}
\begin{pmatrix}
\beta_{11} & \beta_{12} & \beta_{13} \\
\beta_{21} & \beta_{22} & \beta_{23} \\
\beta_{31} & \beta_{32} & \beta_{33}
\end{pmatrix}
\begin{pmatrix}
Y_{t-1} \\
X_{t-1} \\
Z_{t-1}
\end{pmatrix}
+ e_t
\]

Testing for exogeneity means testing which of the rows of $\alpha$ are equal to zero. A variable is found to be weakly exogenous when the parameters generating this variable are independent of the parameters generating all other variables in the equation, and the long-run coefficients are equal to zero, leaving no doubt that this variable is a function of lagged variables only.
This step is very important as the CLRM model is consistent only when all explanatory variables are exogenous.

Step 6: Johansen method is programmed to provide the researcher with the linear restrictions in the cointegrating vectors. This is an important feature when one wants to predict a relationship in the long-run and needs to be aware of the properties of this relationship.

IV. Non Linear Granger non-causality testing

The classical linear regression model
There is a reason and a justification of why economists are so interested in finding better ways to justify their theories, one of those being econometrics. Things nowadays are not as clear as in the past. Multiple agents at the same time make decisions that affect their lives and the lives of others. Planners need to avoid uncertainty and define the process of individual decision-making and planning. An econometric model is not an easy task to set up. Choosing upon which and how many variables are to be included in the model is itself a lot of work. The classical linear regression model is a way of examining the real world. But a linear model could be dealing with major problems. Leaving out a large part of the phenomenon leads to the $u_t$ term, either called disturbance, or simply put the residuals of the estimation while a large part of the phenomenon might be hidden in it.
The factors that produce the disturbance term are quite a few, apart from the main rule of thumb that “the world is most certainly non-linear” Granger (1989). The omission of explanatory variables. The aggregation of the variables needed in order to make a smaller model. 3. Model misspecification meaning that we might have not grasped the phenomenon exactly. Measurement errors, which is always a possibility of course given that the sources might not be very reliable. But the most important factor that makes a Linear regression model unable to predict and estimate the coefficients of the variables involved is that, we might be discussing about a non-linear relationship, and by making it linear, leaving the phenomenon out of the door. Of course, we can never be sure of that but it is an obligation of a researcher to follow a different path when the results do not satisfy him.

i. Hiemstra Jones Non Linear Causality Testing

Hiemstra and Jones (1994) were the ones most discussed among those who applied nonlinear methodology to detect causality in dynamic relationships, between variables.
that were so far been examined exclusively in a linear way following the traditional patterns developed. Linear methodology was unable to uncover such underlying relationships, if any of course. Hiemstra and Jones used the modified non-parametric Baek and Brock nonlinear Granger causality test. The difference lies within the assumptions concerning the dataset. The modified test overcomes the assumption that the time series need to be mutually independent and individually independent and identically distributed (iid distribution). It allows the time series to practice weak short term dependence. Hiemstra and Jones revealed major differences in the findings between linear and nonlinear granger tests, proving the latter a very useful tool in the examination of the dynamics between economic variables.

Baek and Brock(1992a) initiated the application of the nonlinear methodology due to the limitations of the linear methodology to detect certain kinds of nonlinear causality. The philosophy of the linear model itself restricted its predictive power.

Equation 4.3.2

\[ X_t = \beta Y_{t-L} \cdot X_{t-M} + e_t \]

By definition , and according to Baek and Brock (1991) such a model would fail to uncover the causality between \( X_t \) and \( Y_t \), as both the independent variable and the disturbance term follow a normal distribution and are both i.i.d. N(0,1) time series. With this method Baek and Brock revealed a lot of nonlinear causal relations between money and income (BAEK and Brock, 1992a), aggregate stock returns and macroeconomic factors (Hiemstra and Kramer, 1993), producer and consumer price indices (Jaditz and Jones, 1993).
ii. A short discussion on the Baek and Brock (1992a) Nonlinear causality testing

Baek and Brock’s approach to nonlinear causality was a rather modest one, and that is the main reason why the Hiemstra-Jones modification was so gracefully applied, and found solid justification from the results.

Consider two stationary and weakly dependent time series \( \{ X_t \} \) and \( \{ Y_t \} \), \( t = 1, 2, \ldots \)

**Equation 4.3.3**

\[
X_t^m = (X_t, X_{t+1}, \ldots, X_{t+m-1})
\]

\( m=1, 2, \ldots, \ t=1, 2 \)

**Equation 4.3.4**

\[
X_{t-Lx}^{Lx} = (X_{t-Lx}, X_{t-Lx+1}, \ldots, X_{t-1})
\]

\( Lx=1, 2, \ldots, \ t=Lx+1, Lx+2, \ldots \)
Equation 4.3.5

\[ Y_{t-Ly}^{Ly} = (Y_{t-Ly}, Y_{t-Ly+1}, \ldots, Y_{t-1}) \text{, } Ly=1,2,\ldots, t=Ly+1, Ly+2,\ldots \]

For given values of \( m, Lx \) and \( Ly \geq 1 \) and for every \( e > 0 \), \( Y \) does not strictly Granger cause \( X \) if:

Equation 4.3.6

\[
Pr\left( \|X_t^m - X_s^m\| < e \|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\| < e, \|Y_{t-Ly}^{Ly} - Y_{s-Ly}^{Ly}\| < e \right) = Pr\left( \|X_t^m - X_s^m\| < e \|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\| < e \right)
\]

Where \( Pr(.) \) denotes probability and \( \| . \| \) denotes the maximum norm. The probability on the LHS (left hand side) of the equation is the conditional probability that 2 arbitrary \( m \)-length lead vectors \( \{X_t\} \) are within a distance \( e \) of each other, given that the corresponding \( Lx \)-length lag vectors of \( \{X_t\} \) and \( Ly \)-length lag vectors of \( \{Y_t\} \) are within \( e \) of each other. The probability on the RHS (right hand side) of the equation is the conditional probability that 2 arbitrary \( m \)-length lead vectors of \( \{X_t\} \) are within a distance \( e \) of each other, given that their corresponding \( Lx \)-length lag vectors are within a distance \( e \) of each other.

iii. The Nonparametric Nonlinear Causality Testing procedure
In order to proceed with nonlinear Granger causality testing, we first need to take out any predictive power of the variables by applying a Linear VAR model. What remains from the estimation, aka the residuals, is what we use to go further with the nonlinear causality testing, as any remaining predictive power is non-linear. The VAR model can be written as follows:

\[ R_{i,t} = \sum_{i=1}^{n} \beta_{i,j} R_{i,t-1} + \varepsilon_{i,t} \]

The Granger non-causality condition in the VAR model can be given in the following equation:

\[ CI1(m + Lx, Ly, e) \equiv Pr \left( \|X_{t-Lx}^{m+Lx} - X_{s-Lx}^{m+Lx}\| < e, \|Y_{t-Ly}^{Ly} - Y_{s-Ly}^{Ly}\| < e \right) \]
Where CI1, CI2, CI3, CI4 are the correlation integral estimators of the joint probabilities, as given by Hiemstra and Jones (1994) and:

Equation 4.4.3

\[
\frac{CI3(m+Lx, L, e)}{CI2(Lx, Ly, L, e)} = \frac{CI1(m+Lx, L, e)}{CI4(Lx, L, e)}.
\]
for given values of $m$, $Lx$, and $Ly \geq 1$ and $e>0$

$CI1(m + Lx, Ly, e)/CI2(Lx, Ly, e)$ and $CI3(m + Lx, e)/CI4(Lx, e)$ are the ratios of joint probabilities referring to the left hand side and the right hand side of the equation respectively.

Correlation integral estimators of the joint probabilities can be written as:

Equation 4.4.4

$$CI1(m + Lx, Ly, e, n) \equiv \frac{2}{n(n-1)} \sum_{t<s} I(x_{t-Lx}^{m+Lx}, x_{s-Lx}^{m+Lx}, e) \ast I(y_{t-Ly}^{Ly}, y_{s-Ly}^{Ly}, e)$$

Equation 4.4.5

$$CI2(Lx, Ly, e, n) \equiv \frac{2}{n(n-1)} \sum_{t<s} \sum I(x_{t-Lx}^{Lx}, x_{s-Lx}^{Lx}, e) \ast I(y_{t-Ly}^{Ly}, y_{s-Ly}^{Ly}, e)$$

Equation 4.4.6

$$CI3(m + Lx, e, n) \equiv \frac{2}{n(n-1)} \sum_{t<s} I(x_{t-Lx}^{m+Lx}, x_{s-Lx}^{m+Lx}, e)$$
Equation 4.4.7

\[ C14(L_x, e, n) \equiv \frac{2}{n(n-1)} \sum_{t<s} I(x_{t-L_x}^{L_x}, x_{s-L_x}^{L_x}, e) \]

t, s = \max(L_x, L_y) + 1, ..., T - m + 1, \quad n = T + 1 - m - \max(L_x, L_y).

Using the joint probability estimators in the above equation, the Granger non causality condition in the equation can be tested. For given values of m, Lx and Ly≥1 and e>0, under the assumptions that \{X_t\} and \{Y_t\} are strictly stationary, weakly dependent, and satisfy the mixing conditions of Denker and Keller (1983), \{Y_t\} does not strictly Granger cause \{X_t\} then,

Equation 4.4.8

\[ \sqrt{n} \left( \frac{C11(m + L_x, L_y, e, n)}{C12(L_x, L_y, e, n)} - \frac{C13(m + L_x, e, n)}{C14(L_x, e, n)} \right) \]

\[ \approx N \left( 0, \sigma^2(m, L_x, L_y, e) \right) \]
To test for nonlinear Granger causality between X and Y, the test in the above equation is applied on the two estimated residuals series from the VAR model in equation (1). In this case the null hypothesis is that Y does not non-linearly Granger cause X, and equation above holds for all m, Lx, and Ly≥1 and for all e>0.

Baek and Brock’s version of the test is based on the assumption of mutually independent and individually iid for the errors of the VAR model. This modified test holds under the general assumption where the errors are allowed to be weakly dependent. The fundamental difference between the two versions of the test occurs in the estimators of σ²(m,Lx,Ly,e) in the last equation.

iv. The BDS Nonlinearity test

Before applying the nonlinearity tests it is a common practice in similar studies to implement the BDS nonlinearity test proposed by Brock et al. (1987, 1996) in order to determine the existence of nonlinear dependence in the time series. The test is applied on the residual of the series. If the test statistic is greater than the critical value for the normal distribution at the conventional levels. BDS test is based on the correlation integral of the time series as follows:

Equation 4.4.9

\[ W_m(\varepsilon,T) = \frac{\sqrt{T}[C_m(\varepsilon,T) - C_1(\varepsilon,T)^m]}{\sigma_m(\varepsilon,T)} \]

\[ W_m(\varepsilon,T) \text{ represents the test statistic,} \]

\[ \sigma_m(\varepsilon,T) \text{ stands for the standard deviation of } C_m(\varepsilon,T) \]
, m is the embedding dimension, while ε stands for the maximum difference between pairs of observations used to estimate the correlation integral. BDS test statistic is asymptotically normally distributed with zero mean and unit variance \( N(0,1) \). The null hypothesis of the BDS test is that the data are independently, identically distributed (i.i.d.) Null hypothesis of linearity is rejected if the estimated test statistic goes over the critical value of the test. Rejection of the null hypothesis reveals the presence of nonlinear dependencies in the time series.

V. Non Linear Testing Methodology

A new test statistic for nonparametric Granger causality testing

Granger causality(1969) turned out to be a useful and practical notion in the analysis of dependence relations between time series in econometrics and economics in general. Traditional parametric tests however, for Granger causality within linear autoregressive models have already reached a mature status and are considered as a part of any economists’ toolbox.

Diks and Panchenko (2006) proposed a new statistical method for nonlinear Granger causality testing, attempting to correct for the problem of over-rejection as observed in the methodology that Hiemstra and Jones (1994) developed. Both of them papers analyze the same bivariate case, while there is plenty of room left for all other case remaining untouched. The kernel density estimator…

Among the various nonparametric tests used for testing nonlinear causality, the Hiemstra and Jones test (called HJ hereafter) is the one preferred by economists and most commonly used in economics and finance. Just for the record we make a
reference to the other methods developed by Bell et al (1996) and Su and White (2003) for nonlinear causality testing. Nevertheless, the modification concerns only the HJ test.

Even though widely used, the reason for proposing this modification by Diks and Panchenko (2005) is the finding that HJ can severely over-reject if the null hypothesis is true. The researchers followed a certain path before developing their new test statistic. First, they stated the conditions under which the HJ test over-rejects, and then went on proposing their own modification that would free the HJ from producing spurious results. Diks and Panchenko (2006) showed that the reason why HJ suffers from such limitations is its own global nature that, this does not allow for the test to grasp the possible variation in conditional distributions that might be present under the null hypothesis. The new test statistic in order to account for this variation automatically, allows the bandwidth tends to zero at an appropriate rate. This alteration allows for an asymptotically correct size.

As Diks and Panchenko (2006) finding stands true, this practically should mean that all cases for which Granger causality was evident based on HJ test, could be attributed to the sole tendency of the HJ test to over-reject. The size of the spurious regressions is unthinkable, considering for instance HJ stated causality between NYSE Stock exchange between volume and volatility (Brooks, 1998), (Abhyankar, 1998), futures markets (Moosa, 1999), exchange rates (Ma & Kanas, 2000), between stock markets (Ciner, 2001), real estate prices and stock markets (Okunev et al, 2000, 2001), London Metal Exchange cash prices and some of its possible predictors (Chen and Lin, 2004), which are few of the cases that need statistical justification, according to Diks and Panchenko(2006) methodology.

The HJ test has been analytically been presented in a previous chapter, so we will go straight to the presentation of the Diks and Panchenko modification. After illustrating
The problem that rejection probabilities under the null hypothesis tend to one as the sample size increases, the reason will be further analyzed.

HJ test can be rephrased in terms of conditional dependence, as in two vectors X and Z, given a third vector Y, HJ can be sensitive to the variations of the conditional distributions of X and Z that might be present under the null. To overcome this problem, Diks and Panchenko (2006) replace this global test statistic by a local conditional dependence measure, letting the bandwidth tend to zero at appropriate rates. The most important feature of this new test statistic is that it chooses the bandwidth based on the sample size, following the asymptotic theory under certain practical guidelines.

The null hypothesis under HJ is:

\[ H_0: \{X_t\} \text{ is not Granger causing } \{Y_t\}, \]

In the case of nonparametric setting, conditioning on the infinite past is impossible without an assumption that the order of the process is finite. So, in order to proceed with conditional dependence testing a model restriction of finite lags \( L_x \) and \( L_y \), is required.

\[ \text{Equation 4.5.2} \]
in this paper, we test for \( k=1, l_x = l_y = 1 \)

Where \( X_t^{lx} = (X_t-l_x, ..., X_t) \) and \( Y_t^{by} = (Y_{t-l_y-1}, ..., Y_t) \). As the only choice taken is \( l_x=l_y=1 \) this can be written as \( W=(X, Y, Z) \), where \( W \) is a continuous three-variate random variable distributed as \( W_t = (X_t, Y_t, Y_{t+1}) \) considering \( Z_t = Y_{t+1} \). Dropping the time dimension is allowed as the statement of the null is a time invariant distribution of \( W_t \).

The problem in HJ test is found deep in its structure. Simple remedies won’t work for \( H \), such as transforming the data and filtering out GARCH structure. Diks and Panchenko (2005) proved that for a process of instantaneous dependence in conditional variance the actual size was distorted.

In their paper in 2006 they illustrated the problem of over rejection by using a simple example of a bivariate process. They chose the values of the coefficients in such a way that the process remains stationary and ergodic. Performed some Monte Carlo simulations to estimate the empirical size of the HJ test for the ARCH process( \( c=1, a= 0.4 \)). Generated more than 1000 realizations for various sample sizes of the bivariate sample process. Data were normalized for unit variance, and bandwidth was set to 1, which is within the common range (0.5, 1.5.) They showed that for time series length \( n<500 \) the test based on the original series under-rejects. Its size is close to nominal for series length \( n=500 \). For longer series the actual size increases and becomes close to one for series length=60 000.

The test statistic was found biased since it does not converge in probability to zero under the null as the sample size increases. As the sample size increases, the bias
converges to a non zero limit and variance decreases to zero, providing apparently significant values of the test statistic. As a conclusion, the current process indicates less size distortion.

Suggestions like transforming the time series into a uniform marginal distribution by using ranks, or filtering out the conditional heteroscedasticity using a univariate GARCH specification, might reduce or remove the bias of the HJ test, but the major drawbacks could affect the dependence structure and reduce the power of the test. A (G)ARCH filter also, might not remove the conditional heteroscedasticity in the residuals. For example, if a misspecified ARCH(1) filter might not be able to remove a large part of the source of bias, HJ test is that sensitive that will over-reject, even in the case of shorter time series.

The assumption that HJ argue that:

\[
\frac{f_{X,Y,Z}(x, y, z)}{f_{X,Y}(x, y)} = \frac{f_{Y,Z}(y, z)}{f_Y(y)}
\]

The above equation implies the following equation to hold in general, for any given \(e\):

\[
\frac{C_l_{X,Y,Z}(e)}{C_l_{X,Y}(e)} = \frac{C_l_{Y,Z}(e)}{C_l_Y(e)}
\]
This is the inconsistency found in HJ NONLINEAR CAUSALITY TEST. Actually this assumption can be true only in specific cases, i.e. when the conditional distributions of Z and X given Y do not depend on y. These are the probabilities under the null for the conditional distributions of the time series involved:

Equation 4.5.5

\[
P[\|X_1 - X_2\| < e, \|Z_1 - Z_2\| < e \| Y_1 = Y_2 = y] = P[\|X_1 - X_2\| < e \| Y_1 = Y_2 = y]P[\|Z_1 - Z_2\| < e \| Y_1 - Y_2 < e]
\]

And,

Equation 4.5.6

\[
P[\|X_1 - X_2\| < e, \|Z_1 - Z_2\| < e \| Y_1 - Y_2 < e] = P[\|X_1 - X_2\| < e \| Y_1 - Y_2 < e]P[\|Z_1 - Z_2\| < e \| Y_1 - Y_2 < e]
\]

The above conditions are not equivalent. In general, under the null the conditional distributions of X, and Z are allowed to depend on Y. Therefore the distributions of \(X_1 - X_2\) and \(Z_1 - Z_2\) will generally depend, under then null, on \(Y_1\) and \(Y_2\). Even for small \(\varepsilon\) the condition in the last equation stays valid for many close but very different
Pairs. And the lhs of the last equation will be an average of the lhs of former equation for all values of y. According to the above relationship HJ test is generally inconsistent with the null hypothesis. Letting the bandwidth tend to zero at an appropriate rate with increasing the sample size would not solve all problems of under- or over-rejection caused by negative or positive covariance respectively of the HJ test. According to Diks and Panchenko (2006) none of these remedies can control for the deficiency of the HJ test. There are simulations for a particular process and small to moderate sample sizes one can often use an adequate rate for bandwidths vanishing according to $\varepsilon_n = Cn^{-\beta}$, with which the size of the HJ test remains close to nominal. However, this won’t work either for HJ test in practice. C and $\beta$ values, who define bandwidth rely deeply on the data generating process, and according to the findings of Diks and Panchenko HJ test is highly inconsistent for typical processes, such as those with non-vanishing covariance of concentrations of X and Y.

Since the problem of the HJ test is a problem of essence for the technical characteristics of the method, researchers provided us with a new test statistic, that provides with consistent results as $\varepsilon$ tends to zero. The central idea is to measure the dependence between the variables locally. Allowing for the bandwidth to decrease with the sample size, variations in the local distributions of the variables are taken into account by the test statistic. As mentioned before the risk of taking spurious results from the HJ statistic cannot be eliminated by using (G)ARCH filtering, or by letting the bandwidth decrease with the sample size.

i. **Diks & Panchenko modified test statistic (2006)**

Forming the null hypothesis, it implies:
Where \( g(x, y, z) \) is a positive weight function. Under the null hypothesis, the term within the round brackets vanishes, so that the expectation is zero. Even though we are discussing about a rhs test, that rejects when its estimated value is too large, it remains powerful.

The possible choices for the weight function \( g \) are several, having i) \( g_1(x, y, z) = f_{y}(y) \)

ii) \( g_2(x, y, z) = f^{2}_{y}(y) \) and

iii) \( g_3(x, y, z) = f_{y}(y)/f_{x,y}(x, y) \).

While \( g_1 \) and \( g_2 \) behave more stable than \( g_2 \), the interest lies within the \( g_2 \), as its corresponding estimator has a representation as a U-statistic, allowing the asymptotic distribution to be derived analytically for weakly dependent data, without demanding any other bootstrap procedure. So, option ii) will be referred to as \( q \).
A natural estimator of $q$ based on indicator function is:

$$q = E\left[f_{X,Y,Z}(X,Y,Z)f_Y(Y) - f_{X,Y}(X,Y)f_{Y,Z}(Y,Z)\right].$$

The test statistic can be reinterpreted as an average over local BDS test statistics (Brock et al., 1996) (Diks and Panchenko, 2006) for the conditional distribution of $X$ and $Z$, given $Y=y_i$.

Indicating local density estimators of a $d_w$-variate random vector $W$ at $W_i$ by:

$$T_n(\varepsilon) = \frac{(2\varepsilon)^{-d_X-2d_Y-d_Z}}{n(n-1)(n-2)} \sum_{i} \sum_{k,k\neq i} \sum_{j,j\neq i} \left(I_{ik}^{XYZ} I_{ij}^{Y} - I_{ik}^{Y} I_{ij}^{YZ}\right),$$

where $I_{ij}^{W} = I(\|W_i - W_j\| < \varepsilon)$.
Then we simplify the test statistic to its following form:

\[ T_n(\varepsilon) = \frac{(n - 1)}{n(n-2)} \sum_i (\hat{f}_{XYZ}(X_i, Y_i, Z_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i)\hat{f}_{Y,Z}(Y_i, Z_i)). \]

For a proper sequence of \( e_n \) of bandwidth values these estimators are consistent and the test statistic consist of a weighted average of local contribution:

\[ \hat{f}_{X,Y,Z}(x,y,z)\hat{f}_Y(y) = \hat{f}_{X,Y}(x,y)\hat{f}_{Y,Z}(y,z) \]
Diks and Panchenko proved that their modified test is consistent, using the approach of Powell and Stoker (1996), for \( d_X = d_Y = d_Z = 1 \) if we let the bandwidth depend on the sample size according to the following function:

Equation 4.6.4

\[
\varepsilon_n = C_n^{-\beta}
\]

For any positive constant \( C \) and \( \beta \in \left( \frac{1}{4}, \frac{1}{3} \right) \). This way the test is asymptotically and normally distributed in the absence of dependence between the vectors \( W_t \). Given the appropriate mixing conditions, this can be extended to a time series context provided that covariances between the local density estimators are acknowledged, having:

Theorem 1. For a sequence of bandwidths \( \varepsilon_n \) given by the above relationship \( Cn^{-\beta} \) the test statistic satisfies the following:

Equation 4.6.5

\[
\sqrt{n} \left( \frac{T_n(\varepsilon_n) - q}{S_n} \right) \overset{d}{\rightarrow} N(0,1)
\]

**ii. Bandwidth choice**
When local bias tend to zero at a rate $\varepsilon^2$, the bandwidth is defined by:

Equation 4.6.7

$$\varepsilon_n^* = C^* n^{-\frac{2}{7}}$$

Bandwidth choice is optimal as it asymptotically provides estimator $T_n$ with the smallest mean squared error. The constant $C$ is given by the following equation:

Equation 4.6.8

$$C^* = \left( \frac{18 \times 3q_2}{4(E[s(W)])^2} \right)^{\frac{1}{7}}$$

And more analytically:

Equation 4.6.9
Where $\text{erfc}(s) = 1 - \text{erf}(s)$ and:

Equation 4.7.1

$$E[s(W)] = \frac{\sqrt{6} \alpha / \pi}{768 \sqrt{2} a^{3/2} \pi^{3/2}} \left( (3 + \alpha) + (\alpha(\alpha - 6) - 9) e^{3/(2a)} \text{erfc}(\sqrt{3/(2a)}) \right)$$

Equation 4.7.2

$$q_2 = \frac{1}{1152 \sqrt{2} a^{3/2}} + o(\alpha)$$

And,

Equation 4.7.3

$$E[s(W)] = a^2 \left( \frac{1}{288 \sqrt{\pi} 3 \pi^2} + o(\alpha) \right)$$

The important difference about the consistency of this test here is that it does not require filtering, i.e. (G)ARCH filtered data, prior to testing, and it is possible to obtain a rough indication of the optimal bandwidth for raw returns. As the covariance between conditional concentrations for bivariate financial time series is mostly due of ARCH/GARCH effects, equations for the parameters $q_2$ and $E[s(W)]$ can be used.
together with an estimate for the ARCH coefficient $\alpha$ to obtain a rough indication of the optimal constant $C$ for applications to unfiltered financial returns data. That could probably mean that when $\alpha = 0.4$, $C \approx 8$, which is an asymptotically optimal value. Therefore, in order to avoid unrealistically large bandwidths for small $n$, the need to truncate the bandwidth is real and is defined as:

$$\varepsilon_n = \max \left( Cn^{-2/7}, 1.5 \right)$$

**Diks and Panchenko modification in practice**

This new test statistic constructed by Diks and Panchenko, gives rise to a whole new set of weakened evidence against the null hypothesis. Taking into account the variations in conditional concentrations, this test removes a large part of of the bias found in the HJ test, which over-rejected the null even if the bandwidth tends to zero. According to asymptotic theory, the new test was developed as a U-statistic with bandwidth values that tend to zero and the sample size at appropriate rates, while the asymptotically optimal multiplicative factor for the bandwidth was developed. For ARCH type processes the optimal bandwidth can be expressed in terms of the ARCH coefficient, which gives an idea of the order of bandwidth magnitude to be used in practice for financial returns data.

### iii. Data Sharpening Method (2012)

Later on, in 2012 Diks and Wolski proposed an extension of the nonparametric test, originally introduced by Diks and Panchenko (2006). The reason behind this modification was that the test statistic lacked consistency in a multivariate setting. Kernel density estimator was producing bias, as it does not converge at a sufficient
rate when the number of conditioning variables is larger than one. That is why the researchers went on developing the data-sharpening method for bias reduction.

We will go one step further and present the problem of dimensionality that gave rise to this “sharpened” test statistic. Let’s suppose we increase the variables by one, let’s call it Q, and condition the causal relationship in this multivariate setting:

\[
Y_{t+1}^l \left( X_t^{l_x}, Y_t^{l_y}, Q_t^{l_q} \right) \sim Y_{t+1}^l \left( Y_t^{l_y}, Q_t^{l_q} \right)
\]

Equation 4.7.5

Keeping \( l_x = l_y = l_q = 1 \), and following the reasoning of the previous test statistics, the asymptotic normality condition dictates that \( \beta \) is defined to be within a range between \( \frac{1}{2\alpha} \) and \( \frac{1}{(d_x + d_y + d_z + d_q)} \).

Even if we keep the same kernel density estimator with the local bias of order 2, if we increase the dimensionality of the original problem examined by HJ and DP test statistics by any number \( \theta \geq 1 \) this would leave no possible \( \beta \)-region that could endow \( T_n(e) \) with asymptotic normality. When increasing the vector space, the estimator precision is decreased, affecting the MSE of the test statistics.

This is the curse of dimensionality, as defined and described by Scott (1992). According to Scott, increasing the bandwidth window the precision of the estimator is decreased, violating the consistency test results. There are several methods for decreasing dimensionality problem, selecting ‘precision improvement’ as the optimal method, involving no particular data structure in the estimator bias reduction process.

As to the philosophy of the Data Sharpening method (DS), the whole idea is to slightly perturb the original dataset by a sharpening function \( \psi_p \). The main idea is to work on the data by concentrating points where they are dense and thin them where they were already sparse.
In the Granger causality environment the DS method can provide us with a sharpened form of the estimator:

\[
\hat{f}_W^*(W_i) = \frac{\varepsilon^{-dW}}{n-1} \sum_{j \neq i} K_{\text{multi}} \left( \frac{W_i - \psi_p(W_j)}{\varepsilon} \right)
\]

Where \( K_{\text{multi}}(W) = \frac{1}{(2\pi)^{dW/2}} \exp \left( -\frac{1}{2} W^T W \right) \) is the standard multivariate Gaussian kernel, as described in Wand and Jones (1995) and Silverman (1998).

The corollary provided Disk and Wolski (2012) is the reasoning behind this alteration: "For any sufficiently smooth, continuous and infinitely differentiable density, there exist a sharpening function \( \psi_p(\cdot) \) where \( p \) is the order of bias reduction, for which one may find a sequence of bandwidths \( \varepsilon_n = Cn^{-\beta} \) with \( C > 0 \) and \( \beta \in \left( \frac{1}{2p}, \frac{1}{p} \right) \), where \( D < \infty \) is the total dimensionality of the problem, which guarantees that for a weakly-dependent process the sharpened test statistic \( T_n^* \) satisfies:

\[
\sqrt{n} \left( \frac{T_n^*(\varepsilon_n) - q}{S_n} \right) \to N(0, 1)
\]

Where \( S_n \) is the autocorrelation consistent estimator for \( \sigma^2 \)

For the dimensionality problem DS the following application:

\[
\psi_4 W = 1 + \varepsilon^2 \frac{\kappa_2}{2} \hat{f}(W)
\]

The original kernel estimator bias which is of order \( o(\varepsilon)^2 \) can be reduced to \( o(\varepsilon)^4 \) by applying the sharpening form of the above equation, being possible to define \( \beta \)-values within a range that would give asymptotic normality, between \( \beta \in \left( \frac{1}{8}, \frac{1}{4} \right) \)
iv. Bandwidth selection under the DS Method

DS method follows the same patterns with the Diks and Panchenko test statistic for defining the optimal bandwidth selection.

\[ e^* = C' n^{-\frac{2}{2+\gamma}} \]

\[ C^* = \left( \frac{18\gamma q_2}{2\alpha E[s(W)^2]} \right) \]

According to the DS philosophy the sum of squared terms is minimized, and the reported optimal bandwidths are relatively smaller than those of the Diks and Panchenko (2006) method, as an immediate result of the DS method. DS is meant to reduce the bias of the kernel estimator, leaving all other properties the same, not having to include such a wide range of points in order to yield similar properties.

There might be other methods of kernel bias reduction, that might also successful in this setting. Their properties though do not guarantee a clear-cut asymptotic theory for the test statistics.

v. The BEKK Model

ARCH-type models, autoregressive conditional heteroscedasticity models, are usually employed in modeling observed time series, whenever there is a reason to believe
that, at any point in time they demonstrate time-varying volatility, in other words periods of deviating motion followed by periods of relative rigidity.

In the context of testing for symmetric nonlinear causal relationships among our variables, according to Panchenko methodology, the BEKK asymmetric GARCH model is needed in order to help us detect most of the nonlinear relationship. This model is supposed to filter out any linearity from the time-series put in, so that the remaining part on which the method is applied will offer more accurate results on the existing nonlinear causal relationship.
5. **Macroeconomic growth and causality in Education provision.**

I. Greece & the world under the microscope.

In an attempt to discover, all those elements that resulted in the formation of an educational culture in Greece; On a quest for all those factors that raised the number of enrollments in Greek universities; Trying to define the reasons why all these data available do not verify and are not being verified by the outcomes of the labor market; In an effort to clarify if the research conclusions for Greece are justified; and in need of proposals of immediate implementation to support growth and development in Greece, several economists tried to shed light on the Greek case, investigating the causes and effects of this problematic situation.

Psacharopoulos and Papakonstantinou (2004) examined the private and social cost of free public education in Greece using a sample of 3441 fresh year students for the school year of 1999-2000 with the method of questionnaires. They found that the opportunity cost of education for that year was over 7.4% surpassing the deposit rate, while the returns of the non-university tertiary education were extremely negative, this way displaying an aversion for this category. Psacharopoulos and Magoula (1999) using more appropriate data, found the rate of non-university technical education for the year 1993 to be of about 6%. Psacharopoulos and Tsamadias (2001), as well as Tsamadias (2002) reported returns for the same level of education of around 5% for the year 1997, when the bank deposit rate was nearly double. They all confirm the increase of higher education enrollments and the decreasing interest for higher technical education.

Patrinos X. (1992) studied the financing of higher education studies and inequality in Greece, and in 1995 he examined the relationship between social class, schooling, experience, ability and financial rewards. He was interested in accounting for social mobility in Greece through the public character of the education system, finding a positive relation among them.
Kanellopoulos and Psacharopoulos (1997) examined the expenditure for private education in relation with free public education. In September of 2002 George Psacharopoulos presented a working paper at the 19th annual conference of the European Union of legal and economic sciences that was titled: “The social cost of an outdated law: Article 16 of the Greek Constitution” quoting a reality in numbers of applicants, students, expenses of studies, employed and unemployed graduates underlining the stagnation of the Greek Legislation. In fact, they acknowledge the trend towards private education and the discrediting of the public character of education.

Asteriou and Siriopoulos (1997) employed a VAR model, conducting Linear Pairwise causality testing examining whether the accruement of education in developing countries, could bring economic growth, while for the case of Greece they came to the conclusion that, what would have more positive impact to economic growth would be the promotion and funding of secondary technical education.

Asteriou and Agiomirgianakis (2001) studied the period 1960-1994 for the economic growth in Greece. They followed Lucas (1988) and the endogenous growth model with human capital, followed by cointegration tests, and causality test and hypothesis testing for that matter:

$$ Y_t = AK_t^{\alpha}(v_t h_t L_t)^{1-\alpha} $$

Where A is the level of technology, $K_t$ the stock of human capital, $v_t$ the fraction of non leisure time households spend working, $h_t$ is the quality measure for every worker, $L_t$ is labor, and $Y_t$ is the output. And the symbols in the brackets illustrate the effective human capital for the entire economy.

Taking GDP per capita, for all three levels of education, and the educational expenditure. They found that the first two levels of education, primary and secondary, interact with GDP and contribute to economic growth. Their findings for the
aforementioned time span imply that education is a master key element to growth up to high school graduates, and they have a vague picture concerning higher education and the productivity of those holding such degrees. They are suggesting that funding for higher education should be directed only to those professions that have a substantial link with the forces of technological change that drive modern growth, such as mathematicians, IT experts, and applied scientists.

Lianos et al (2004) did “a fact-finding “study. They examined the problem of the foreign university graduates and their performance in the Greek labor market, following the OLS Methodology. Their financial rewards and the acknowledgement of their qualifications, confirmed the obvious misemployment of those graduates and the mismatch of supply and demand, stating also a problem of overeducation, and an absolute direction towards a supply-side economy. They found that the Greek labor market is not an ideal workplace for university graduates. EU graduates though are better place and have more chances to be employed than their counter parts that have been educated in the Balkans and other similar countries. Overeducation is not making people more attractive to employers, but adds to their salaries. They also found that work experience was an asset for a potential employer, together with a master’s degree either MSc or MA. The notion of being overeducated is relevant to the parents’ level of qualifications, while those graduate who though highly of themselves concerning their qualifications towards the requirements of work, got higher salaries.

Linear & non linear Granger methodology. Economic growth in other countries.

Alexakis and Siriopoulos (1999) studied six Asian Stock Markets, namely Japan, Hong Kong, Singapore, Malaysia, Taiwan and Thailand for the time, before, during and after the stock market crisis of October 1997. They used linear and non-linear Granger causality tests to examine the dynamic relationships between the six Asian stock markets in the whole period that is from January 2, 1997 to October 1, 1998.
first method is the traditional linear approach as it has been used in many previous studies to detect linear pairwise Granger causality. The second method they followed is the statistical technique developed by Baek and Brock (1992) and modified by Hiemstra and Jones (1994), a new method for those times, to test for non-linear Granger causality. For the linear hypotheses, before crisis, the main results showed causality between Malaysia towards Singapore and Hong Kong towards Malaysia at a 99% confidence level. At a 95% causality existed from Malaysia to Hong Kong, Japan to Malaysia, and Taiwan to Malaysia. Finally, at 90% confidence interval linear causality from Japan to Hong Kong was detected. During the crisis, at a 99% level, linear causality exists from Japan to Hong Kong, and Singapore to Thailand. At a 95% level linear causality is detected from Hong Kong to Thailand, Thailand to Singapore and Singapore to Hong Kong. At a 90% level linear causality existed from Hong Kong to Malaysia, Japan to Singapore, Japan to Malaysia, Malaysia to Thailand. After the crisis the causal relationships revealed were Hong Kong to Malaysia (95%), Singapore to Hong Kong (95%), Thailand to Hong Kong (95%), Malaysia to Singapore (95%), Malaysia to Taiwan (99%), Singapore to Taiwan (99%), and Thailand to Taiwan (95%). For the whole period, causality was detected from Hong Kong to Malaysia (99%), Hong Kong to Singapore (99%), Hong Kong to Taiwan (99%), Thailand to Hong Kong (95%), Hong Kong to Taiwan (99%), Thailand to Hong Kong (95%), Hong Kong to Thailand (90%), Singapore to Malaysia (95%), Malaysia to Singapore (99%), Malaysia to Taiwan (99%), Singapore to Taiwan (99%), and finally Singapore to Thailand (95%). The results of the nonlinear Granger tests were quite similar to the linear ones. The passive role of Japan is confirmed, as the stock market of Tokyo had no lead or lag influence in any case. The reported differences were towards more causal relationships revealed, namely the role of Hong Kong and the role of Japan in the post crisis period. Hong Kong showed a strong bi-directional non linear causal relationship with Malaysia and Singapore, and also a uni-directional non linear Granger causality towards Taiwan, Thailand and Japan in the post crisis period only. During the month of the crisis the bi-directional
non linear causal relationships seemed to multiply, as well as after the crisis. The results of the analysis suggest the existence of dynamic relationships in all three periods, and the appearance of a “panic behavior, implying systemic risk due to the number of the non linear causal relationships established, mainly.

Chandra Abhijeet (2010) studied the relationship between education spending and economic growth in India for the period 1951-2009. He followed the methodology of linear Granger causality, the “traditional method” as said, and the non linear Granger methodology as developed by Baek and Brock (1992) and modified by Hiemstra and Jones, used for testing linear and non linear Granger causality relationships respectively. After integrating all necessary steps, the linear causality tests indicated a linear unidirectional causal relationship running from economic development, expressed by the Indian GDP to the education spending. Using lagged values of 8th order, the study revealed that this relationship turns bi directional, implying that having invested in education in the past this affects some way economic growth in the future. The modified Baek and Brock(1992) model, with the provided results, supported the results of the linear Granger causality tests to a large extent. As shown, the causation runs from economic growth to education expenditure during the whole period, while a change in education expenditure is expected to affect economic growth even after some years, due to the non linear causality at hand. Abhijeet in his conclusions, noted that first his data contained unit roots and became stationary at first differences. That the causation between economic growth and education spending is bi directional. That the effect of education spending on economic growth is not immediate, but it takes effect after some 5 or 6 years according to his findings. And last, that economic growth has always played a major role in education public spending historically, supporting that education is a major influence on economic growth.

Md. Mostafizur Rahman (2012) examined the effect of different level of education on GDP for two BCIM countries, namely Bangladesh and China for the period 1980-
2009. He used the logarithms of the time series of total enrollments at primary, secondary, and tertiary level and real GDP in order to account for the expected non-linearities. He also found some missing data which were recovered with the means of smooth averaging. He followed the methodology of stationarity, cointegration, error correction models and VAR Granger causality/Block exogeneity Wald tests. His findings showed that the variables were non stationary with the exception of primary data, and then considered the first differences were all of the variables were found stationary at 1% and 5% level of significance. The findings of this study supported the existence of long run equilibrium among these variables for both countries. For Bangladesh the strong relationships were those of primary and secondary enrollment on economic growth, and for China those of secondary and tertiary total enrollment on economic growth. The Block exogeneity Wald tests provided evidence of unidirectional causality from GDP to tertiary education and secondary to primary total enrollment in Bangladesh. In China the dynamic causal relationships of primary to GDP (unidirectional), secondary to GDP (unidirectional) and between primary and secondary enrollment (bi-directional).

Varsakelis and Kyrtsov (2010) conducted non-linear causality test for determining the source of causal relationships when a certain class of complex dynamics, that includes chaotic non-linearities is present. They followed the previous work of Kyrtsov and Labys (2006, 2007) deploying a special type of non-linear structure, known as the bivariate noisy Mackey-Glass model (Kyrtsov and Labys, 2006, 2007). They take into account all existing powerful tests the Baek and Brock test (1992), and its modifications by Hiemstra and Jones (1994) and Diks and Panchenko (2005). Their paper produced a bi-variate testing procedure that is validated for time series with chaotic components and can be used in the presence of both linear stochastic and chaotic series.

Qazi, Raza and Jawaid investigated the relationship between higher education and economic growth in Pakistan for the period 1980-2011. They followed the
methodology of ARDL bound testing cointegration approach confirming the existing positive relationship between higher education and economic growth both long and short run. The results of the Granger causality test, Yoda, Yamamoto modified Wald test and variance decomposition test certified the bidirectional causal relationship for higher education and economic growth in Pakistan. He also validated the importance of higher education commission that was formed in Pakistan in 2002, through the results of a rolling window analysis.

Riddel and Song (2011) analyzed the causal effects of education on individuals’ transition between employment and unemployment, with particular focus on the extend to which education improves re-employment outcomes among unemployed workers using data from the Current Population Survey 1980-2005 and the 1980 Census. They employed the OLS methodology and IV, indicating that education significantly increases re-employment rates of the unemployed. Especially in the cases of 12 and 16 years of schooling the impact is proven large.

Christopoulos and Tsionas (2001) investigated the long run relationship between financial depth and economic growth, using panel unit root tests and panel cointegration analysis, threshold cointegration tests and dynamic panel data estimation for a panel-based vector error correction model. The ordinary least squares methodology, fully modified was used for the estimation of the long run relationship. They used data for 10 developing countries. Save for output, investment share, inflation, finance depth for Ecuador, Jamaica, Thailand, Colombia, Paraguay, Peru, the Dominican Republic, Kenya, Honduras and Mexico. Their results showed that the only cointegrating relation implies unidirectional causality from financial depth to economic growth, and a strong support towards the hypothesis that there is an equilibrium relation between financial depth, growth and ancillary variables.

II. The Method
To examine the true causal effect of education on earnings and total economic growth in modern times, the non parametric, non linear Granger non-causality methodology will be followed. For this reason, the model of Hiemstra and Jones (1994), called also as HJ, modified by Diks and Panchenko (2006).

The whole idea of non linear testing presupposes the estimation of a linear VAR model, in which case for $X_t$ and $Y_t$ :

Equation 5.2

$$Y_t = \alpha_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t}$$

Equation 5.3

$$X_t = \alpha_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + e_{2t}$$

When testing for Granger non-causality the idea is to collect evidence against the null hypothesis:

$H_0$: $\{X_t\}$ is not Granger causing $\{Y_t\}$

The modified test statistic, which has been extensively analyzed in the previous chapter, is consistent if it lets the bandwidth depend on the sample size, and satisfies the relationship:

Equation 5.4

$$e_n = Cn^{-b}$$
Where $e_n$ is the optimal bandwidth estimator, C is a positive constant, and b is the estimation parameter.

The relationship between investments in education, EDEX, and economic growth, GDP per capita, is being used in order to detect for causality. According to previously estimated growth models, we expect for education enrollments and education public expenditures to be a positive linear function of economic growth, and when economic growth is present, we expect for statistically important $\beta$ and $\delta$ coefficients. Given the effect of the financial time series on the educational variables due to abnormalities of the market, we expect for a large part of the phenomenon to be hidden in the residuals, and explained through the nonlinear testing.

i. Hypothesis formation

Alltogether we could make the following hypotheses:

Hypothesis 5.1:

More education has a positive effect on economic growth, since it provides with a better skilled workforce. In the presence of Linear Granger causality both coefficients $\beta_i, \delta_i > 0$ and we expect to reveal a linear causal relationship between variables.

If the past values of one variable can predict the future values of another, then we expect the appearance of linear causality with statistically important coefficients. We proceed next with the examination of the hypothesis 5.2, in which case there is a possibility that causality is correlated with the individual characteristics of each variable, aka educational level and the number of yearly enrollments in each case

\textit{Hypothesis5.1.1:}

\textit{Investments in primary education promotes growth}

\textit{Hypothesis 5.1.2:}
**Investments in elementary education promotes economic growth**

**Hypothesis 5.1.3:**

**Investments in secondary education promotes growth**

**Hypothesis 5.1.4:**

**Investments in higher education promotes growth**

Individual agents are simply trying to maximize their utility function by adding to their skills targeting the workforce.

**Hypothesis 5.2:**

**Investing in education has little or no effect on economic growth*****

i) Absence of Linear Pairwise Granger causality gives us coefficients $\theta_i > 0$ and $\gamma_j > 0$, while $\beta_i = 0$ and $\delta_j = 0$

ii) Linear Pairwise Granger Causality is detected only among some of the variables under examination.

If no causality is detected in the residuals too, then economic growth is eventually not promoted by education, and there is no need to discuss about funding rather than reforming.

If this is the case, then we are dealing with an education system that is not growth-driven, but it is directed elsewhere. And it is more likely not supporting economic growth in the given national environment. The possibility of Education having nothing to do with a declining economy is also examined here.
Hypothesis 5.3:

Promoting economic growth has a positive effect on education (adverse causality). Also, the phenomenon of ‘adverse causality’ might be present and part of this asymmetry.

According to some researchers, linear causality might be detected in the lower levels of education, up to high school, whereas the more the graduates, the faster the economic growth (Asteriou & Agiomirgiannakis, 2001), while in higher education the results can be either adverse (Asteriou & Siriopoulos, 1997) or positive for growth in a selective mode (Asteriou & Agiomirgiannakis, 2001).

This is the case in most developing countries, where as economic growth serves as a key driver to promoting education.

Hypothesis 5.3.1:

Economic growth promotes primary education

Hypothesis 5.3.2:

Economic growth promotes elementary education

Hypothesis 5.3.3:

Economic growth promotes secondary education

Hypothesis 5.3.4:

Economic growth promotes higher education

In order to clear out any doubt that there might be the slightest causal inference in the residuals not detected, for the first time the modification of Data-sharpening of Diks & Wolski (2012), removing the bias of the Kernel estimator that doesn’t converge to zero at a fast rate when the number of conditioning variables is larger than one, also called as the ‘dimensionality problem’.
Hypothesis 5.4:

No Linear Causality is detected. Causality might be hidden in the residuals, due to several reasons (omitted variables, non linearities etc.). In the presence of non linear causality relationships, it is expected to estimate statistically significant $e_{1t}$ and $e_{2t}$.

This hypothesis under examination shows the possibility that there might be a large part of the phenomenon not examined in the study, and for that it is necessary to proceed further with the non parametric methods of Granger non-causality.

Hypothesis 5.5:

Investments in education have a negative effect on economic growth.

Hypothesis 5.6:

In a period of economic crisis, private investments in education are expected to correlate with the problem itself, and react in a causal way, that is $\beta_i > 0$ and $\delta_i > 0$.

III. Data Analysis

i. Descriptive STATISTICS

The data originally collected were the yearly time series of the following 6 variables. Annual observations of these variables between 1960-2014 are presented in the table below.
Table 30.

Descriptive statistics n=55.

<table>
<thead>
<tr>
<th></th>
<th>EDEx</th>
<th>GDP</th>
<th>P</th>
<th>E</th>
<th>S</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.30E-09</td>
<td>6790.250</td>
<td>124720.9</td>
<td>802673.9</td>
<td>598096.7</td>
<td>111228.2</td>
</tr>
<tr>
<td>Median</td>
<td>5.16E+08</td>
<td>2618.510</td>
<td>141010.0</td>
<td>865660.0</td>
<td>669812.0</td>
<td>107968.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.77E+09</td>
<td>21641.85</td>
<td>168578.0</td>
<td>979395.0</td>
<td>750891.0</td>
<td>167729.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>500000.00</td>
<td>46.08000</td>
<td>40247.00</td>
<td>528592.0</td>
<td>273390.0</td>
<td>28320.00</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>2.84E+00</td>
<td>7573.169</td>
<td>37572.24</td>
<td>133530.7</td>
<td>137440.7</td>
<td>41707.40</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.929458</td>
<td>0.6690774</td>
<td>-1.001029</td>
<td>-0.215278</td>
<td>-0.887879</td>
<td>0.067736</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.404358</td>
<td>1.905693</td>
<td>2.794392</td>
<td>1.291184</td>
<td>2.640726</td>
<td>2.209039</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>8.731217</td>
<td>7.104654</td>
<td>10.41566</td>
<td>7.116006</td>
<td>2.589066</td>
<td>1.475768</td>
</tr>
<tr>
<td>Probability</td>
<td>0.012077</td>
<td>0.0027397</td>
<td>0.005471</td>
<td>0.028487</td>
<td>0.009764</td>
<td>0.478125</td>
</tr>
</tbody>
</table>

Note: Data taken from Elstat and Greek Ministry of Education, Lifelong learning and religious affairs.

The mean values for public expenditures, GDP per capita, preschool enrollments, elementary enrolments secondary enrollments and higher education enrollments are 2,300,000,000 €, 6790.250 €, 124720.9, 802673.9, 598096.7, 111228.2 respectively. The minimum and maximum values indicate that the tie series varied during the period under consideration. For instance GDP per capita varied from a minimum of 46.08 to a maximum of 21641.85 Euros. Education public expenditures had the greatest variability from the mean as indicated by the standard deviation. Both education expenditures and GDP per capita are positively skewed, while the other variables, educational enrollments are negatively skewed apart from higher education that exhibits positive kurtosis. Based on Jarque-Berra Statistics, the null hypothesis public expenditures for education, GDP per capita, and education enrollments for all
levels are normally distributed, is rejected at a 5% significance level in all cases except for higher education.

The graphs below reveal the volatility of the variables involved.

![Graph](image)

**Figure 20. Education Public Expenditure and GDP per capita variance. Annual observations 1960-2014. Data retrieved from Elstat for Edex, and from Ameco database for GDP.**
Figure 21. All educational enrollments. Annual observations 1960-2014. Data retrieved from Elstat statistical yearbook (several volumes).

Based on the Jarque-Bera statistic, or in other words the normality test, the null hypothesis is being rejected for all 5 variables, apart from higher education distribution. This is being presented more analytically in the histograms and statistics of each time series. We use the p-values given automatically by Eviews econometrics package.

As seen in the case of Higher education, Jarque-Bera statistic states a normal distribution of the errors of H. Jarque-Bera test is believed to have asymptotic validity, however when applied on small samples it is believed to be facing ‘size distortion’. Recent findings suggest that the power of the test might be low in a number of alternative hypotheses (Thadewald & Buning, 2004).
Figure 22. Histogram and Stats of Preschool enrollments, Elementary education enrollments, Education public expenditures, GDP per capita, Secondary education enrollments, higher education enrollments. (Distribution. Data retrieved from elstat statistical yearbook (various volumes), AMECO database.

Consequently, we proceed with a brief description of the different sectors that constitute Public Education in Greece, the mainstream direction of the Educational System in Greece, according to the Ministry of Education, Lifelong Learning & Religious Affairs. The existing categories of the typical system are the following:

-Preschool: It involves children from the age of 5, that is the year they turn 5, and is obligatory for one year. The mode of calculation goes according to the calendar;
therefore, children turning 5, anytime between January 1st and December 31st, are the classmates of that year. There is another school year before, for children turning 4, which is on a voluntary basis. At the end of the 2nd school year, students graduate and a certificate is given to them in order to complete their registration into primary school, which is a prerequisite. The reason that led policy makers create this rule, was mainly because all the past years from the day that preschool was established, children were not obliged to a certain curriculum. That fact made empty classrooms being the rule, all this time. Otherwise, children’s absence is excused when followed by a doctor’s note, or any major constraint that can be expressed formally. We should note that we added all the official private preschools, which are known by the ministry, and by EL.STAT, providing the analogous stats.

-Primary school: Students enter primary school at the age of 6, following the same mode of calculation, and continue their studies up for the year they turn 12, that is for six consequent years. Relative to the previous sector, we have added all those private primary schools, which are officially registered at the Ministry of Education, Research & Religious Affairs, and provide EL.STAT with the necessary statistics. There are no entrance exams for Secondary school. The headmaster provides all students with a graduation certificate, in order to continue their studies to Secondary school. Of course, this does leave without drop-outs.

-Secondary school: This sector consists of six grades, which are dissected into lower high school, called Gymnasio, and upper high school, called Lykeio. Gymnasio forms the three last years of the 10 total obligatory years of schooling. Lykeio on the other hand, is not obligatory, but is a prerequisite for those who want to go further with higher studies of any kind i.e. university, college etc. It is also itself a useful degree to hold for many white-collar jobs, such as office employees etc. It was very popular since the 80’s when the public sector started taking on new employees as public servants. It was then when the expansion of the public sector as an employer was made to happen. One other thing is that there are no examinations between Gymnasio
and Lykeio either, but there are grades, on a scale from 1 to 20, using near 10 as the base grade. According to the methodology given, the study included the mainstream units of secondary schools. While Gymnasio is the only comprehensive and uniform choice at this level of schooling, after the 10 obligatory years things change. So, it needs to be made clear that for both levels of middle school, the method counted in the comprehensive schools, that is, those that lead to higher level studies such as University Faculties, both public and private.

As to the other variables used, a short explanation concerning their characteristics is offered:

- Public Expenditures on Education: it concerns the amount of money from the state budget that goes into the ministry of Education, Research & Religious Affairs. It was kindly offered by the Bureau of Greek Statistics, EL.STAT, on a special request.

- GDP per capita: well known as the measure for growth, taken by AMECO database. The data collected for this study were taken from the Greek Statistics Bureau after several attempts, emails, and persona requests, in an attempt to have as accurate data as possible. GDP per capita was taken from the European Economic Database AMECO, mainly because of the different methodologies that ELSTAT used for their GDP measurements, especially after the Euro integration. 1960 to 2014 is a time span long enough to take into account. The phenomena under examination though and their annual appearance, together with the strive for accuracy, led to the conclusion that more elaborate methods should be used. This study attempted to offer a small cornerstone to the international literature, and suggested a combination of macroeconomic and financial tools at hand, in order to make a prediction for the future. So, keeping this in mind, the idea of cubic spline interpolation came along, and looked like the perfect idea in order to multiply our observations, and allow for our
Instruments to estimate the diversity hidden in the phenomena. Cubic spline is a method used mostly by financial analysts to make up for those daily observations missing from the table when attempting to make predictions of “buy and sell”. Inspired by Maynard Keynes, and his belief that macroeconomic decisions are deeply hurt by the microeconomic decisions of the financial agents, this analysis went ahead with 216 observations at hand. Below, a short presentation of cubic spline is included.

**ii. Cubic Spline Interpolation Method**

Cubic Spline interpolation is a piecewise continuous curve, passing through each of the values given. The starts from a table of points \( \{x_i, y_i\} \) for \( i=0,1,…n \) for \( y = f(x) \). This way \( n+1 \) points are created and \( n \) intervals between them. For each interval a separate cubic polynomial is constructed, with each own coefficients:

\[
S_i(x) = \alpha_i(x - x_i)^3 + b_i(x - x_i)^2 + c_i(x - x_i) + d_i \quad \text{for} \quad x \in [x_i, x_{i+1}]
\]

These polynomials constructed all together constitute the spline, \( S(x) \).

Cubic spline produces a line that looks seamless from the outside. C spline avoids the distortions in the end of the line like other straight polynomial interpolations, and it is easy to use.

In order to construct the spline a Matlab source code was used, found on the internet.

The conditions standing in order to match the \( n \) intervals with the \( 4n \) parameters as defined in the spline \( S(x) \), go accordingly to the following functions:

**Equation 5.6**

\[
S_i(x_i) = y_i
\]
Applying these conditions to the values given for $i=1,2,\ldots,n-1$ results in $2(n-1)$ constraints. The new time series obeys in two more conditions:

### Equation 5.8

- $S_0'(x_0) = 0$
- $S_{n-1}'(x_n) = 0$

The philosophy underlying this method, which is widely used, is to cover missing values, especially in the case of daily closing prices for stock markets. What motivated this certain study to use the cubic spline interpolation was fact that the 55 years of observations were hiding a big quantity of heteroscedasticity, whereas with this method, it is at a satisfying rate revealed. The interpolation turned annual observations into quarterly data, so as to give a real dimension to the variance of the time series. It is supposed that a quarter of the year is a sufficient time for students to exhibit any change in their educational attitude, as it is also the official time of when grades are given.
216 quarterly observations

Table 31.

Descriptive statistics n=216

<table>
<thead>
<tr>
<th></th>
<th>EDEX</th>
<th>GDP</th>
<th>P</th>
<th>E</th>
<th>S</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.29E+09</td>
<td>6726.597</td>
<td>124841.1</td>
<td>803855.5</td>
<td>501277.3</td>
<td>110921.9</td>
</tr>
<tr>
<td>Median</td>
<td>4.97E+08</td>
<td>2574.386</td>
<td>140559.6</td>
<td>868004.8</td>
<td>874306.4</td>
<td>107690.5</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.83E+09</td>
<td>21541.85</td>
<td>167100.2</td>
<td>979395.0</td>
<td>763493.4</td>
<td>187263.7</td>
</tr>
<tr>
<td>Minimum</td>
<td>50000.00</td>
<td>46.08000</td>
<td>40247.00</td>
<td>528494.8</td>
<td>273390.0</td>
<td>28362.00</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>2.83E+09</td>
<td>7499.131</td>
<td>36594.62</td>
<td>132151.0</td>
<td>135145.1</td>
<td>4038.66</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.941046</td>
<td>0.722508</td>
<td>-1.071234</td>
<td>-0.227574</td>
<td>-1.015759</td>
<td>0.079490</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.413356</td>
<td>1.982771</td>
<td>2.825591</td>
<td>1.301999</td>
<td>2.675095</td>
<td>2.215645</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>35.11342</td>
<td>28.66284</td>
<td>41.58530</td>
<td>27.81331</td>
<td>38.08791</td>
<td>5.764387</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000001</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.005012</td>
</tr>
<tr>
<td>Sum</td>
<td>4.95E+11</td>
<td>145294.5</td>
<td>2596569</td>
<td>1.74E+08</td>
<td>1.30E+08</td>
<td>2395934</td>
</tr>
<tr>
<td>Sum Sq. Dev.</td>
<td>1.72E+21</td>
<td>1.21E+10</td>
<td>2.88E+11</td>
<td>3.75E+12</td>
<td>3.93E+12</td>
<td>3.61E+11</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
</tr>
</tbody>
</table>

Note: Data retrieved from ELstat statistical yearbooks (enrollments), AMECO database (GDP), ELSTAT (education expenditures).

Figure 23. Interpolated- quarterly time series of Education Public Expenditures and GDP per capita 1960-2014. Data retrieved from ELstat and Ameco database.
Figure 24. interpolated- quarterly time series of all levels of educational enrollments 1960-2014. Data retrieved from ELstat and Ameco database.
Figure 25. Histograms and Stats of all Interpolated/quarterly data. Data retrieved from Elstat and Ameco database.
ii.ii EGARCH RESIDUALS from the interpolated data

On table 7.5 the results of the EGARCH residuals analysis are presented, using the descriptive statistics analysis, to give an overview of their structure.

Table 32.

Descriptive statistics of E-Garch time series n=214

<table>
<thead>
<tr>
<th></th>
<th>EDEXF</th>
<th>GDPF</th>
<th>PF</th>
<th>EF</th>
<th>SF</th>
<th>HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>49467.4</td>
<td>1.169757</td>
<td>1.613614</td>
<td>-1.257485</td>
<td>-59.31411</td>
<td>-0.796304</td>
</tr>
<tr>
<td>Median</td>
<td>-120599.4</td>
<td>0.785307</td>
<td>-40.44961</td>
<td>-4.015728</td>
<td>-48.65061</td>
<td>0.254759</td>
</tr>
<tr>
<td>Maximum</td>
<td>-4375135</td>
<td>65.90829</td>
<td>1565.522</td>
<td>2785.957</td>
<td>11125.21</td>
<td>7389.787</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.11E+08</td>
<td>-48.70628</td>
<td>-1243.865</td>
<td>-1670.475</td>
<td>-11244.18</td>
<td>-6851.940</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>18745720</td>
<td>13.27994</td>
<td>384.2206</td>
<td>552.8773</td>
<td>1826.254</td>
<td>2327.220</td>
</tr>
<tr>
<td>Skewness</td>
<td>-2.384702</td>
<td>0.090076</td>
<td>0.450520</td>
<td>1.029335</td>
<td>0.094038</td>
<td>0.188599</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>1287.571</td>
<td>487.3525</td>
<td>36.7491</td>
<td>300.4703</td>
<td>4174.903</td>
<td>20.02887</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Sum</td>
<td>-1.06E+08</td>
<td>250.3231</td>
<td>345.3583</td>
<td>-254.8047</td>
<td>-12693.22</td>
<td>-170.4090</td>
</tr>
<tr>
<td>Sum Sq. Dev.</td>
<td>7.48E+16</td>
<td>37562.31</td>
<td>31450.771</td>
<td>65108.495</td>
<td>7.10E+08</td>
<td>11535883</td>
</tr>
<tr>
<td>Observations</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
</tbody>
</table>

Note: Data from Elstat and Ameco database.

The figures below illustrate the evolution of each time series from the Egarch analysis.
Figure 26. Histograms and Stats of quarterly Egarch residuals. Data retrieved from Elstat.
Figure 27. Histograms of E-garch distributions. Data retrieved from Elstat, Ameco database.

Histograms offer a view of the distribution of each variable, none of which is anything close to a normal distribution.
ii.iii VAR Residuals of the interpolated data

On Table 5.3 we have the basic descriptive statistical measures for the time series of the residuals resulting from the estimation of the VAR model. It is worth noting that for the estimation of the residuals we run an OLS regression for every variable.

Table 33.
Descriptive statistics of VAR residuals n=214

<table>
<thead>
<tr>
<th></th>
<th>EDEX</th>
<th>GDP</th>
<th>P</th>
<th>E</th>
<th>S</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-168674.7</td>
<td>1.169757</td>
<td>1.013814</td>
<td>-1.237405</td>
<td>-59.31411</td>
<td>-57.96304</td>
</tr>
<tr>
<td>Median</td>
<td>-120999.4</td>
<td>0.756307</td>
<td>-40.44961</td>
<td>-4.015728</td>
<td>-46.55061</td>
<td>0.25479</td>
</tr>
<tr>
<td>Maximum</td>
<td>43761835</td>
<td>85.50828</td>
<td>1565.522</td>
<td>2786.857</td>
<td>11125.21</td>
<td>738.9787</td>
</tr>
<tr>
<td>Minimum</td>
<td>-1.11E+08</td>
<td>-48.70828</td>
<td>-1243.845</td>
<td>-1670.475</td>
<td>-11244.18</td>
<td>-689.1949</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>18745725</td>
<td>13.27654</td>
<td>384.2506</td>
<td>552.8773</td>
<td>1826.254</td>
<td>232.7220</td>
</tr>
<tr>
<td>Skewness</td>
<td>-2.384702</td>
<td>0.097076</td>
<td>0.456520</td>
<td>1.229335</td>
<td>0.094038</td>
<td>0.188599</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>1287.671</td>
<td>487.3625</td>
<td>36.79481</td>
<td>300.4703</td>
<td>4174.503</td>
<td>20.02867</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Sum</td>
<td>-1.05E+08</td>
<td>250.3281</td>
<td>345.3553</td>
<td>-264.8047</td>
<td>-1263.22</td>
<td>-170.4020</td>
</tr>
<tr>
<td>Sum Sq. Dev.</td>
<td>7.48E+16</td>
<td>37562.31</td>
<td>31450771</td>
<td>65108480</td>
<td>7.10E+08</td>
<td>11535993</td>
</tr>
<tr>
<td>Observations</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
</tbody>
</table>

Note: ELSTAT, AMECO.
Figure 28. The time series of the estimated residuals of P, E, S, and H. Data retrieved from ELSTAT.
Figure 29. Histograms and stats for the Time Series of the estimated residuals of the VAR model. Data retrieved from ELSTAT, AMECO database.
IV. Linear granger causality testing-all steps

The methodology consists of three steps. First we test all time series for unit roots. In the case of financial time series this is mostly the case though. We proceed with cointegration tests. Then, we convert our data into stationary time series by taking the first differences and we conduct the linear granger causality test.

Our time series deal with annual financial phenomena, but we interpolated them into quarterly data in order for the nonlinear causality methodology to fit better. Of course the method of spline interpolation allows for even longer time series, but in order our data to have a real life explanation, even though all phenomena evolve continuously, we chose the quarter frequency.

i. Empirical results

From our interpolated time series we see that all time series contained a unit root. By taking the first differences the next step of the study was the cointegration test, which proved, following the Trace statistic that there can be found 4 cointegrating vectors between the variables under examination. Moving on with the Linear granger Pairwise test the relationships revealed are a lot different than the Asteriou &Siriopoulos (1997) study.
Table 34.

Unit Root Tests Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>t-Statistic</th>
<th>Probability</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>-2.26763</td>
<td>18.60%</td>
<td>55</td>
</tr>
<tr>
<td>E</td>
<td>0.738571</td>
<td>82.76%</td>
<td>55</td>
</tr>
<tr>
<td>S</td>
<td>-2.619939</td>
<td>9.53%</td>
<td>55</td>
</tr>
<tr>
<td>H</td>
<td>-0.143759</td>
<td>93.84%</td>
<td>55</td>
</tr>
<tr>
<td>EDEX</td>
<td>-6.336023</td>
<td>0.00%</td>
<td>55</td>
</tr>
<tr>
<td>GDP</td>
<td>-1.294557</td>
<td>62.57%</td>
<td>55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>t-Statistic</th>
<th>Probability</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>-1.689598</td>
<td>43.50%</td>
<td>216</td>
</tr>
<tr>
<td>E</td>
<td>-1.20409</td>
<td>67.28%</td>
<td>216</td>
</tr>
<tr>
<td>S</td>
<td>-1.830838</td>
<td>36.48%</td>
<td>216</td>
</tr>
<tr>
<td>H</td>
<td>-0.401091</td>
<td>90.53%</td>
<td>216</td>
</tr>
<tr>
<td>EDEX</td>
<td>-1.987657</td>
<td>29.22%</td>
<td>216</td>
</tr>
<tr>
<td>GDP</td>
<td>0.934031</td>
<td>99.58%</td>
<td>216</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>t-Statistic</th>
<th>Probability</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>-2.410765</td>
<td>14.38%</td>
<td>55</td>
</tr>
<tr>
<td>E</td>
<td>-0.738571</td>
<td>82.76%</td>
<td>55</td>
</tr>
<tr>
<td>S</td>
<td>-2.559528</td>
<td>10.79%</td>
<td>55</td>
</tr>
<tr>
<td>H</td>
<td>-0.819749</td>
<td>93.84%</td>
<td>55</td>
</tr>
<tr>
<td>EDEX</td>
<td>-1.751506</td>
<td>40.00%</td>
<td>55</td>
</tr>
<tr>
<td>GDP</td>
<td>-0.919299</td>
<td>77.44%</td>
<td>55</td>
</tr>
</tbody>
</table>

Note: ELSTAT, AMECO database.

The null hypothesis of unit root testing, supposes that our time series contain unit roots. This hypothesis cannot be rejected. It is a little bit tempting when the results for higher education over exceed the critical t-statistic when letting the Eviews software choose the optimum lag length. But for a time series as long as 55 annual observations this does not illustrate the case as perfectly well as a smaller lag length as shown above. We test our time series taking the case of intercept.
Conducting unit root testing for both the original and the interpolated time series of the variables, the results all time series contain unit roots. Looking at the results, all time series have a trend, that is all of them are to be integrated at order one I(1). Even though public expenditures in education have been indeed rising over the years, this cannot be seen from the annual I(0) observations when choosing the maximum lags, but it is more than obvious in our interpolated I(0) sample, as well as in the max lag=2 methodology of the last table.

We continue the analysis with the interpolated time series. Allowing for a linear deterministic trend in our data, we control for a cointegrating equation with intercept and no trend and test VAR. Cointegration testing is based on the Maximum Likelihood method of johansen (1988) and Johansen & Juselius (1990) suggesting two tests, the Maximum Eigen value test and the Trace test. Proceeding with Johansen (1988) cointegration tests, in order to detect the number of cointegrating vectors the results are shown below:

Table 35.

Trace Test results

<table>
<thead>
<tr>
<th>No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.190768</td>
<td>134.7809</td>
<td>95.75366</td>
<td>0</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.139337</td>
<td>90.11873</td>
<td>69.81889</td>
<td>0.0005</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.125598</td>
<td>58.45773</td>
<td>47.85613</td>
<td>0.0037</td>
</tr>
<tr>
<td>At most 3 *</td>
<td>0.080225</td>
<td>30.13841</td>
<td>29.79707</td>
<td>0.0457</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.050315</td>
<td>12.49338</td>
<td>15.49471</td>
<td>0.1347</td>
</tr>
<tr>
<td>At most 5</td>
<td>0.007556</td>
<td>1.600454</td>
<td>3.841466</td>
<td>0.2058</td>
</tr>
</tbody>
</table>

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level.
*Denotes rejection of the hypothesis at the 0.05 level
** MacKinnon-Haug-Michelis (1999) p-values

Note: ELSTAT, AMECO database.
The long run properties of the variables show that a positive long run equilibrium relationship among them exists. The hypothesis of no integration is definitely rejected.

Trace statistic indicates the existence of 4 cointegrating vectors, which is the signal that allows us to continue further with the analysis. The fact that the random walk of our variables, is relatively not that random at all, is immediately translated as a very close relationship at hand.

Table 36.

Max-Eigen Value results.

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.190768</td>
<td>44.66219</td>
<td>40.07757</td>
<td>0.0142</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.139337</td>
<td>31.661</td>
<td>33.87687</td>
<td>0.0899</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.125598</td>
<td>28.31932</td>
<td>27.58434</td>
<td>0.0402</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.080225</td>
<td>17.64503</td>
<td>21.13162</td>
<td>0.1437</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.050315</td>
<td>10.89293</td>
<td>14.2646</td>
<td>0.1596</td>
</tr>
<tr>
<td>At most 5</td>
<td>0.007556</td>
<td>1.600454</td>
<td>3.841466</td>
<td>0.2058</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level, *Denotes rejection of the hypothesis at the 0.05 level ** MacKinnon-Haug-Michelis (1999) p-values

Note: ELSTAT, AMECO database.

Max-eigen statistic indicates one cointegrating relationship, which again confirms our hypothesis, and allows us to go further with the procedure of causality testing.

Granger linear Pairwise testing
Next step is the application of the Pairwise Linear Granger causality test. Fitting a 2-equation vector autoregressive model (VAR), we apply the method on our variables. This is an absolute stationary process, where all our time series are differenced of order one I(1). Granger causality is not the classical meaning of causality, as it is argued that regressions can provide us with simple correlations. The notion of Clive Granger though implies the utility of one variable’s past values in forecasting the future values of another. So, in econometrics we say that the power of the test is “predictive”.

The number of lags to be used is determined by an information criterion such as the Akaike information criterion (AIC), Bayesian information criterion (BIC) and so on. The null hypothesis of no Granger causality is not rejected, if and only if no past values of the explanatory variable have been included in the regression. Null hypothesis is rejected when past values of the explanatory variable add predictive power to our model and explain the phenomenon at an acceptable confidence interval of 95%, $\alpha=0.05$. 


«Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Προσέγγιση.»
Table 37. Linear Pairwise Granger test. Results from VAR model analysis.

<table>
<thead>
<tr>
<th>Null Hypothesis:</th>
<th>Obs</th>
<th>F-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic growth does not Granger Cause Education Public expenditures</td>
<td>213</td>
<td>157.327</td>
<td>2.42303E-42</td>
</tr>
<tr>
<td>Education public expenditures do not Granger Cause Economic growth</td>
<td></td>
<td>40.168</td>
<td>1.77481E-15</td>
</tr>
<tr>
<td>Economic growth does not Granger Cause Higher education</td>
<td>213</td>
<td>0.216</td>
<td>0.8057</td>
</tr>
<tr>
<td>Higher education does not Granger Cause Economic growth</td>
<td></td>
<td>1.796</td>
<td>0.1685</td>
</tr>
<tr>
<td>Economic growth does not Granger Cause Secondary sch. Enrollments</td>
<td>213</td>
<td>0.318</td>
<td>0.7279</td>
</tr>
<tr>
<td>Secondary sch. enrollments do not Granger Cause Economic growth</td>
<td></td>
<td>3.708</td>
<td>0.0262</td>
</tr>
<tr>
<td>Economic growth does not Granger Cause Elementary sch. enroll.</td>
<td>213</td>
<td>3.362</td>
<td>0.0366</td>
</tr>
<tr>
<td>Description</td>
<td>$t$</td>
<td>$p$</td>
<td>Significance</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>Elementary education enroll. do not Granger Cause Economic growth</td>
<td>2.522</td>
<td>0.0827</td>
<td>**</td>
</tr>
<tr>
<td>Preschool enrollments do not Granger Cause Economic growth</td>
<td>4.579</td>
<td>0.0113</td>
<td>*</td>
</tr>
<tr>
<td>Economic growth does not Granger Cause Preschool enrollments</td>
<td>213</td>
<td>3.868</td>
<td>0.0224</td>
</tr>
<tr>
<td>Elementary enrollments do not Granger Cause Preschool enrollments</td>
<td>213</td>
<td>0.375</td>
<td>0.6878</td>
</tr>
<tr>
<td>Preschool does not Granger Cause Elementary school</td>
<td>0.137</td>
<td>0.8721</td>
<td></td>
</tr>
<tr>
<td>Secondary school does not Granger Cause Preschool</td>
<td>213</td>
<td>0.346</td>
<td>0.7081</td>
</tr>
<tr>
<td>Preschool does not Granger Cause Secondary school</td>
<td>213</td>
<td>0.145</td>
<td>0.8652</td>
</tr>
<tr>
<td>Preschool does not Granger Cause higher education</td>
<td>0.952</td>
<td>0.3878</td>
<td></td>
</tr>
<tr>
<td>Education Public expenditures do not Granger Cause Preschool enrollments</td>
<td>213</td>
<td>1.907</td>
<td>0.1511</td>
</tr>
<tr>
<td>Preschool does not Granger Cause Education Public Expenditures growth</td>
<td>3.236</td>
<td>0.0413</td>
<td>*</td>
</tr>
<tr>
<td>Secondary school does not Granger Cause Elementary school enrollments</td>
<td>213</td>
<td>0.684</td>
<td>0.5058</td>
</tr>
</tbody>
</table>
### Elementary school enrollments does not Granger Cause Secondary school enrollments

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>p</td>
</tr>
<tr>
<td>Higher Education enrollments</td>
<td>0.807</td>
<td>0.4477</td>
</tr>
<tr>
<td>Elementary school enrollments do not Granger Cause Higher education enrollments</td>
<td>5.269</td>
<td>0.0059 *</td>
</tr>
<tr>
<td>Education Public expenditures do not Granger Cause Elementary school enroll.</td>
<td>3.956</td>
<td>0.0206 *</td>
</tr>
<tr>
<td>Elementary sch. enroll. do not Granger Cause Education Public exp. Growth</td>
<td>0.206</td>
<td>0.8138</td>
</tr>
<tr>
<td>Higher education enroll. do not Granger Cause Secondary school enroll.</td>
<td>0.363</td>
<td>0.6961</td>
</tr>
<tr>
<td>Secondary school enroll. do not Granger Cause Higher Education enroll.</td>
<td>4.277</td>
<td>0.0151 *</td>
</tr>
<tr>
<td>Education Public expenditures do not Granger Cause Secondary school enroll.</td>
<td>0.775</td>
<td>0.4620</td>
</tr>
<tr>
<td>Secondary sch. enroll. do not Granger Cause Education Public expenditures</td>
<td>1.307</td>
<td>0.2729</td>
</tr>
<tr>
<td>Education Public Expenditures do not Granger Cause Higher education</td>
<td>3.326</td>
<td>0.0379 *</td>
</tr>
</tbody>
</table>

**Note:**
- p-values are in bold if significant at the 5% level.
Higher education does not Granger Cause Education public expenditures

|              | 0.485 | 0.6165 |

Note: ELSTAT, AMECO database.
From the linear Granger causality analysis we get 12 significantly causal relationships at a 95% significance level, and one at a 90% significance level. As said before, the initial interest for this study arose from the Asteriou & Siriopoulos (1997) working paper. This study had a major influence on the educational policies back then. It showed that Higher education was exhibiting “adverse causality” implying that the interest for pursuing further with their studies did not reflect the actual rate of return of the degrees obtained. The Greek economy together with the Athens exchange stock market, and the market itself were experiencing moments of economic growth, as shown by the numbers alone. The amount of available income was at that time rising, and the living conditions of the population were improving daily. Together with these alterations Greek were all in all, aiming ‘higher’. For a country under development this fact was very satisfying, compared to other studies from the developing world. Specifically Abhijeet for India suggested that economic growth should be present in forward, this would work as a ‘lead’ for the so much desired education expansion.

20 years later, and with the same methodology, and data collection methods, the results conclude that higher education is not Granger causing Economic growth anymore. In other words, the growth in numbers of higher education enrollments, is not a fact that can predict the evolution of economic independence of the beneficiaries. Unlikely to higher education, the other three tiers contribute still to economic growth. The two first educational levels demonstrate bi-directional causality, preschool at a 95% significance level and elementary at a 90% significance level. The interplay from Preschool to Secondary and from Preschool to educational public expenditures is another dynamic relationship in a Granger causality context.

What is also worth noting is the chain reaction of higher education to Secondary education, which can be interpreted in terms of the ‘opportunity cost’ of university level studies, and it is something unavoidable as we see the numbers of university students rising, unreasonably too much and disproportionally to GDP per capita. Secondary education is highlighted through the linear Granger causality results as
that level of education that provides the necessary human capital for the leverage of the labor market. Secondary education, we should mention, is Granger causing education expenditures, together with the Preschool level. Economic growth and Education expenditures show a bidirectional Granger causal relationship, which is sustained throughout the study as the relationship that validates the results, and has a natural meaning compatible with the findings in other Asian developing countries. One last finding emphasized from the linear tests is the bi-directional causality of higher education and elementary education.

**According to the results of the Linear testing, the only 2 educational levels that promote growth were Preschool and Secondary education, according to their enrollments. But the relationship among preschool and GDP per capita is bi-directional, which according to the definitions, could be a phenomenon of ‘adverse causality’ not very useful in terms of growth. It implies the fact that as long as there is economic growth, parents will be able to afford and send their children off to preschool, and the contrary. Even though preschool level according to the legislation became obligatory, its educational value is still little to parents. And economic growth is, from what it looks like not promoted by higher studies anymore. Secondary education enrollments “Granger cause” gdp per capita, implying a “predictive power of the explanatory variable, Secondary education, towards the growth of the average annual income per capita (Gross Domestic Product per capita). The true causes of this phenomenon remain to be examined at a later stage.**
V. Nonlinear testing

Hiemstra- Jones test for Granger Non causality


When it comes to economic growth and education, researchers have also followed the nonlinear methodology, using the HJ test such as Chandra Abhijeet (2011) for the Indian economy between education spending and economic growth for the period 1951-2009, finding a positive causal flow from GDP to education spending, whereas this relationship turns bidirectional with a lag value of 6 or more, reporting this as the desired result for developing countries. Abhijeet uses both linear and nonlinear Granger methodology, leaving out the latest modifications.

MD Rahman Mostafizur (2012) studying the long run effect of education enrollments on GDP for Bangladesh Economy for the time period 1990-2009 and Chinese economy, following the linear Granger methodology (stationarity, cointegration tests and linear Granger causality tests). Also, he presented the extended form of Solow growth model by including Education and health capital. He found unidirectional causality from GDP to Tertiary education and from Secondary education to primary education. For the Chinese economy, he found unidirectional causality from Primary
to GDP and from Secondary to GDP, and bidirectional causality between Primary and Secondary education.

In 2010, following the same methodology MD Rahman Mostafizur examined the relationship between health expenditure, education expenditure and GDP for Bangladesh. He found the existence of bidirectional causality from education expenditure to GDP and also from education expenditure to health expenditure, while only unidirectional causality is found from health expenditure to GDP.

Grigoriou and Graziosi (2005) analyzed the effects of education and health expenditures on child labor for some developing countries and found that each type of public spending influence on the individual trade-off through a particular way such as: education spending increases the return on education, health spending reduces the risk of children death.

Qazi et al (2013) studied the relationship between higher education and economic growth for Pakistan for the time period 1980-2011 following the ARDL bound testing cointegration approach and the Linear Granger methodology. His study detected a positive relationship both long and short run between higher education development and economic growth. Bidirectional causality was detected between Higher education and GDP through the linear Granger causality tests.

The nonlinear granger causality lies on the premises of Standard Linear Granger causality toolbox, as an absolutely ultimate add up to the whole Causality testing procedure. It has not, until today, been extensively used even though it offers an insight in every causal relationship around.

In 2005 Cees Diks and Valentyn Panchenko developed a new non-parametric test for Granger non causality which avoids the over rejection of the null hypothesis, as observed in the case of the most frequently used test developed by Hiemstra and Jones (1994). The problem that scientists want to repair was that rejection probabilities
under the null hypothesis may tend to one as the sample increases. The Hiemstra Jones test was proven very sensitive. The conditional distributions of two vectors $X$ and $Z$ that may be present under the null, affect the third vector $Y$, so they replaced this global test statistic with an average of local dependence measure, which is dependent on the sample size. When letting the bandwidth tend to zero at appropriate rates, this new test takes account for the conditional variations automatically. Diks and Panchenko offered optimum methods based on the asymptotic theory to construct the bandwidth according to the sample size. They also applied their new nonparametric test on a previously tested application by Hiemstra and Jones, concluding that Granger causality was found much weaker than proposed by Hiemstra and Jones.

In the same year, 2005, Diks and Panchenko produced “a note on the Hiemstra and Jones test for non-causality”, addressing the consistency problem in this commonly used nonparametric test for Granger causality developed by Hiemstra & Jones. The Monte Carlo simulations which used a certain methodology satisfying the null hypothesis proved that for a given nominal size the test is rejecting the null hypothesis as the sample size augments. What they actually provide us with is results that profoundly prove that the previous evidence on non linear causality illustrated in the applied empirical literature should be reexamined.

In 2012, Cees Diks and Martin Wolski produced an extension to the nonparametric test, to the original one that was first developed in 2006. The problem of the kernel density bias that does not converge to zero at a fast rate when the number of conditioning variable is larger than one. To let this problem behind they applied the “data sharpening method” for bias reduction, and controlled for its performance in real numbers. The field of study was the US grain market, in a Pairwise setting, suggesting that causality runs from bigger to smaller grain markets. They stated that this understanding of nonlinear economic dynamics might result in preventing from bubbles and possible food price rises like the ones observed in 2007-8.
Francis, Mougoue and Panchenko (2009) added to the body of research by examining causal relationships between large and small capitalization stocks providing evidence that the causal relationship is symmetric, while both linear and non linear. Another important finding of them is that the nonlinear relationship is caused by information flow, touching the premises of market efficiency. Their question is on the structure between large and small capitalization stocks, which is the lead and which is the lagged variable. Their data covered the period of July 1, 1963 to May 31, 2006. They tested their hypothesis on all existing models and methodologies of Granger causality. They applied the non parametric test to residuals of the model following the BEKK parameterization framework, to the residuals of the VAR model, and on the first differences of the time series of the bi-variate VAR model. Their findings showed that lagged returns on large firms linearly Granger cause the returns on small firms, which is consistent to previous studies. But together with this finding their study reported also statistically significant linear Granger causality running from the small firms returns to the returns of large firms. The nonlinear results showed significant nonlinear bidirectional Granger causality and implied that the relationship between the two variables at hand is more complex than previously thought. Also, they stated that market capitalization has no effect on the predictive power of one portfolio onto the other, as measured by the power of the lagged returns to predict the current returns. The model they used was the asymmetric GARCH model (BEKK model with a leverage term). They obtained similar results like the ones derived from the VAR model for linear causality. Diagnostics tests on the residuals though suggested that the nonlinear causality that was previously reported by the VAR model, was now critically reduced. The nonparametric test for Granger causality testing on the residuals is mainly used as a diagnostic device. Comparing the results of the VAR model to those of the BEKK model, they observed significant reduction in the number of rejections of the null hypothesis. This suggested that the BEKK model captures most of the nonlinear Granger causality detected from the residuals of the VAR model.
As a general idea in the whole process of nonlinear testing, Diks & Panchenko proposed in (2006) a modification of the Hiemstra-Jones nonlinear tests aiming to correct the over-rejection problem observed in the original methodology. But of course the dimensionality problem is still present, as scientists did not manage to overcome the bivariate case, which “is the case”. Diks and Panchenko (2006) tested the new software and applied the new nonparametric test on historical returns and trading causing returns of the Standard and Poor’s index between January 1950 and December 1990, which indicates that the evidence for volume Granger-causing returns is weaker than suggested by the Hiemstra-Jones (1994) strong evidence for volume causing returns (1947-1990) for the Dow Jones Index.

This new statistical approach, applied on both VAR residuals and EGARCH filtered residuals does not over-reject the null. Instead it shows that no true causal relationship is detected between any educational variable and economic growth, apart from public expenditures, stemming out of the Greek Educational System anymore. Even though after filtering out seasonalities, linear structure and (GARCH) structure, the whitening of the data may lead to smaller rejection rates; it still does not affect our conclusions in typical cases.

The only true causal relationship that survived the test was the relationship between Economic growth and Education public expenditures, which validates the results of our test as well. Diagnostic tests on the residuals of the Garch model indicate that the nonlinear causal relationships found previously on the residuals of the VAR model are significantly reduced.
### Table 38. Nonlinear Granger Causality test - all bandwidths.

**ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST**

<table>
<thead>
<tr>
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<td>ECONOMIC</td>
<td>GROWTH DOES NOT CAUSE ELEMENTARY</td>
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<td>GROWTH DOES NOT CAUSE HIGHER</td>
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<table>
<thead>
<tr>
<th></th>
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<th>ECONOMIC GROWTH DOES NOT CAUSE SECONDARY</th>
<th>EDEX DOES NOT CAUSE ECONOMIC GROWTH</th>
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<th>EDEX DOES NOT CAUSE HIGHER</th>
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<td>----</td>
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<td>14</td>
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«Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Προσέγγιση.»

<table>
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<tr>
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<th>HIGHER DOES NOT CAUSE EDEX</th>
<th>HIGHER DOES NOT CAUSE ELEMENTARY</th>
<th>HIGHER DOES NOT CAUSE PRESCHOOL</th>
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<td>0.194 0.42315 0.603 0.27328</td>
<td>0.866 0.19334 0.744 0.22836 1.212 0.11283</td>
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Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Προσέγγιση.

<table>
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<tr>
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<table>
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<td>0.44307</td>
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<td>0.51936</td>
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<table>
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<table>
<thead>
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<td>2.20</td>
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</tbody>
</table>

Doctoral Dissertation Sophia A. Kassapi

<table>
<thead>
<tr>
<th></th>
<th>\textbf{ECONOMIC GROWTH}</th>
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<th></th>
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<td>0.506</td>
<td>0.30653</td>
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</tr>
<tr>
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<td>0.15553</td>
<td>1.783</td>
<td>0.03733</td>
<td>1.751</td>
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\textit{Note: ELSTAT, AMECO database.}
The application of the new non parametric test, with the modification extension of the ‘sharpening method’ together with the Diks and Panchenko way of defining the optimal bandwidth, and the 2 very commonly used bandwidths (1.5, 0.6) in previous studies that followed the traditional Baek and Brock (1992) test, modified by Hiemstra and Jones (1994). The results revealed 12 other statistically significant relationships among the variables, some of them verified by more than one bandwidth.

First of all we should mention the bi-directional Granger non causality between Economic growth and Education expenditures, at all bandwidths chosen. This is also the relationship that justifies further our method relative to all other relationships revealed.

Concerning the tiers that promote economic growth, at this stage of analysis only two of them are in a causal relationship with GDP per capita. Secondary education is still Granger causing economic growth at ε=0.33, 0.6, 1.319, and Preschool is Granger causing economic growth. The latter is a unidirectional causality, having lost its bi-directional character, and is verified only at ε=0.33.

Higher education is again a very weak time series in a Granger causality context, having a direct effect only on Elementary education at ε=1.5, 1.319, 0.6. While elementary education is Granger non linearly causing Preschool and Secondary level at ε=0.6 for preschool and ε=0.33, 1.319, 0.6 for secondary.

Education expenditures are backing up, ‘predicting’ the Preschool and the Secondary education in a nonlinear Granger causality context with ε=1.5 in both cases.

Finally the test revealed that Preschool is Granger causing Secondary at ε=1.319, Secondary education is, Granger causing higher education at ε=0.33 and also Granger causing Education expenditures at ε=0.33, 1.319, 0.6.
Further to our analysis and for comparative reasons we applied the previous non linear Granger method (asymptotic) to the residuals of the BEKK representation model. The bandwidths used were the optimal ones estimated by the Diks & Panchenko method, and by their Diks and Wolski(2012) modification-added method.
Nonlinear Granger causality test- eGarch residuals.

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<tr>
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<th>NULL HYPOTHESES</th>
<th>T-Stat</th>
<th>p-value</th>
<th>T-Stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
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<td>2.282</td>
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<td>0.00330*</td>
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<tr>
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<td>0.99022</td>
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<tr>
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<tr>
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<td>0.063</td>
<td>0.47487</td>
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### Table 1: Long-Run Causal Effects of Public Investments

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<th>Equation</th>
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<th>p-value 2</th>
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<table>
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</tr>
<tr>
<td>26</td>
<td>Secondary does not cause economic growth</td>
<td>0.95</td>
<td>0.94988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Secondary does not cause elementary</td>
<td>0.296</td>
<td>0.13607</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Secondary does not cause higher</td>
<td>0.608</td>
<td>0.09102**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Secondary does not cause preschool</td>
<td>-1.114</td>
<td>0.667</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Doctoral Dissertation Sophia A. Kassapi
SECONDARY DOES NOT CAUSE EDEX

|   |   | 1.484 | 0.06895 | -0.439 | 0.66982 |

Note: ELSTAT, AMECO database.
From this test we concluded to 8 relationships defined by the existence of Granger non causality.

The strongest relationship of nonlinear Granger causality is bi-directional between economic growth and educational expenditures both at $\epsilon=1.319, 0.33$.

The relationship were Secondary education Granger caused Economic growth is now gone, as detected previously on VAR residuals at the same optimal bandwidths $\epsilon=0,33, 1,319$, and economic growth is not caused by preschool anymore at $\epsilon=0,33$ in contrast to the previous test results.

On the contrary, Education expenditures as seen on this test are again Granger caused by preschool at $\epsilon=1,319$ (90% significance level). Elementary and Preschool are being Granger caused by Secondary at 90% significance level, while Secondary Granger causes Higher education at 90% significance level and $\epsilon=0,33$.

Finally, Secondary education is Granger causing education expenditures at 95% significance level and $\epsilon=1,319$.

As we walk down the non linear analysis we are loosing the most important relationships, onto which the educational policies were built upon. Secondary education not having anything to do with the augmentation of the available income, even at this point of the analysis, in the residuals is worth discussing further.

But still, the relationships at hand show that our Garch filtered data, have sufficient predictive power in our analysis. This is worth noting as we continue with our bootstrapped testing.

### ii. Bootstrapped Granger non causality testing

Due to kernel density estimator, which is the correlation integral, methodology cannot be extended to multivariate and maintain asymptotic normality at the same time. This happens due to the fact that kernel
estimator bias tend to zero too slowly as the sample goes to infinity. The prices that \( \beta \) parameter is allowed to take as the kernel estimator bandwidth \( \epsilon \) goes to zero at a rate \( \epsilon \sim n^{-\beta} \) have to be smaller than and larger than \( \frac{1}{4} \) at the same time!!!
Table 40.

Bootstrapped Nonlinear Granger Causality test results.

<table>
<thead>
<tr>
<th>BOOTSTRAPPED NONLINEAR GRANGER</th>
<th>DIKS &amp; PANCHENKO</th>
<th>DIKS &amp; WOLSKI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egarch filtered</td>
<td>1000 realizations</td>
<td>MODIFIED epsilon=0.33</td>
</tr>
<tr>
<td>DP</td>
<td>e=1.319</td>
<td>e=0.6</td>
</tr>
<tr>
<td>Public expenditures on education</td>
<td>l=-2 p-value</td>
<td>0.857</td>
</tr>
<tr>
<td>Elementary education</td>
<td>l=-1 p-value</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>l= 0 p-value</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>l= 1 p-value</td>
<td>0.947</td>
</tr>
<tr>
<td></td>
<td>l= 2 p-value</td>
<td>0.826</td>
</tr>
<tr>
<td>Public expenditures on education</td>
<td>l=-2 p-value</td>
<td>0.125</td>
</tr>
<tr>
<td>Economic growth</td>
<td>l=-1 p-value</td>
<td>0.016*</td>
</tr>
<tr>
<td></td>
<td>l= 0 p-value</td>
<td>0.016*</td>
</tr>
<tr>
<td></td>
<td>l= 1 p-value</td>
<td>0.029*</td>
</tr>
<tr>
<td></td>
<td>l= 2 p-value</td>
<td>0.084**</td>
</tr>
</tbody>
</table>

### Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>Public expenditures on education</th>
<th>$l=-2$</th>
<th>$l=-1$</th>
<th>$l=0$</th>
<th>$l=1$</th>
<th>$l=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher education</td>
<td>0.446</td>
<td>0.46</td>
<td>0.387097</td>
<td>0.446</td>
<td>0.51</td>
</tr>
<tr>
<td>$l=0$ p-value</td>
<td>0.835</td>
<td>0.83</td>
<td>0.903226</td>
<td>0.835</td>
<td>0.79</td>
</tr>
<tr>
<td>$l=1$ p-value</td>
<td>0.835</td>
<td>0.83</td>
<td>0.903226</td>
<td>0.835</td>
<td>0.79</td>
</tr>
<tr>
<td>$l=2$ p-value</td>
<td>0.704</td>
<td>0.71</td>
<td>0.774194</td>
<td>0.704</td>
<td>0.68</td>
</tr>
<tr>
<td>$l=3$ p-value</td>
<td>0.91</td>
<td>0.9</td>
<td>0.903226</td>
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<td>0.87</td>
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</table>

<table>
<thead>
<tr>
<th>Public expenditures on education</th>
<th>$l=-2$</th>
<th>$l=-1$</th>
<th>$l=0$</th>
<th>$l=1$</th>
<th>$l=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool</td>
<td>0.384</td>
<td>0.39</td>
<td>0.548387</td>
<td>0.384</td>
<td>0.44</td>
</tr>
<tr>
<td>$l=0$ p-value</td>
<td>0.386</td>
<td>0.36</td>
<td>0.612903</td>
<td>0.386</td>
<td>0.33</td>
</tr>
<tr>
<td>$l=1$ p-value</td>
<td>0.386</td>
<td>0.36</td>
<td>0.612903</td>
<td>0.386</td>
<td>0.33</td>
</tr>
<tr>
<td>$l=2$ p-value</td>
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<td>0.88</td>
<td>0.870968</td>
<td>0.897</td>
<td>0.91</td>
</tr>
<tr>
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<td>0.924</td>
<td>0.96</td>
<td>0.967742</td>
<td>0.924</td>
<td>0.88</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Public expenditures on education</th>
<th>$l=-2$</th>
<th>$l=-1$</th>
<th>$l=0$</th>
<th>$l=1$</th>
<th>$l=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary enrollments</td>
<td>0.735</td>
<td>0.68</td>
<td>0.83871</td>
<td>0.735</td>
<td>0.83</td>
</tr>
<tr>
<td>$l=0$ p-value</td>
<td>0.821</td>
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<td>0.903226</td>
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<td>0.78</td>
</tr>
<tr>
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<td>0.821</td>
<td>0.85</td>
<td>0.903226</td>
<td>0.821</td>
<td>0.78</td>
</tr>
<tr>
<td>$l=2$ p-value</td>
<td>0.507</td>
<td>0.54</td>
<td>0.580645</td>
<td>0.507</td>
<td>0.57</td>
</tr>
<tr>
<td>$l=3$ p-value</td>
<td>0.954</td>
<td>0.97</td>
<td>0.935484</td>
<td>0.954</td>
<td>0.97</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Public expenditures on education</th>
<th>$l=-2$</th>
<th>$l=-1$</th>
<th>$l=0$</th>
<th>$l=1$</th>
<th>$l=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary education</td>
<td>0.678</td>
<td>0.66</td>
<td>0.741935</td>
<td>0.678</td>
<td>0.69</td>
</tr>
<tr>
<td>$l=0$ p-value</td>
<td>0.983</td>
<td>0.99</td>
<td>0.935484</td>
<td>0.983</td>
<td>0.97</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economic growth</th>
<th>$l=-2$</th>
<th>$l=-1$</th>
<th>$l=0$</th>
<th>$l=1$</th>
<th>$l=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$l=0$ p-value</td>
<td>0.835</td>
<td>0.83</td>
<td>0.903226</td>
<td>0.835</td>
<td>0.79</td>
</tr>
<tr>
<td>$l=1$ p-value</td>
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<td>0.83</td>
<td>0.903226</td>
<td>0.835</td>
<td>0.79</td>
</tr>
<tr>
<td>$l=2$ p-value</td>
<td>0.704</td>
<td>0.71</td>
<td>0.774194</td>
<td>0.704</td>
<td>0.68</td>
</tr>
<tr>
<td>$l=3$ p-value</td>
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<td>0.9</td>
<td>0.903226</td>
<td>0.91</td>
<td>0.87</td>
</tr>
</tbody>
</table>
### Table: Long-Run Causal Effects of Public Investments: Economic Growth and the Provision of Schooling


<table>
<thead>
<tr>
<th>Education Level</th>
<th>Parameter</th>
<th>l= 2 p-value</th>
<th>l= 1 p-value</th>
<th>l= 0 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elementary enrollments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l= -2 p-value</td>
<td>0.238</td>
<td>0.28</td>
<td>0.225806</td>
<td>0.238</td>
</tr>
<tr>
<td>l= -1 p-value</td>
<td>0.811</td>
<td>0.82</td>
<td>0.83871</td>
<td>0.81</td>
</tr>
<tr>
<td>l= 0 p-value</td>
<td>0.81</td>
<td>0.82</td>
<td>0.83871</td>
<td>0.81</td>
</tr>
<tr>
<td>l= 1 p-value</td>
<td>0.668</td>
<td>0.71</td>
<td>0.83871</td>
<td>0.668</td>
</tr>
<tr>
<td>l= 2 p-value</td>
<td>0.398</td>
<td>0.41</td>
<td>0.580645</td>
<td>0.398</td>
</tr>
<tr>
<td><strong>Preschool enrollments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l= -2 p-value</td>
<td>0.149</td>
<td>0.15</td>
<td>0.129032</td>
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<tr>
<td>l= -1 p-value</td>
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<td>0.88</td>
<td>0.83871</td>
<td>0.868</td>
</tr>
<tr>
<td>l= 0 p-value</td>
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</tr>
<tr>
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<tr>
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<td>0.16129</td>
<td>0.243</td>
</tr>
<tr>
<td><strong>Secondary enrollments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l= -2 p-value</td>
<td>0.138</td>
<td>0.09**</td>
<td>0.16129</td>
<td>0.138</td>
</tr>
<tr>
<td>l= -1 p-value</td>
<td>0.209</td>
<td>0.21</td>
<td>0.225806</td>
<td>0.209</td>
</tr>
<tr>
<td>l= 0 p-value</td>
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<td>0.225806</td>
<td>0.208</td>
</tr>
<tr>
<td>l= 1 p-value</td>
<td>0.613</td>
<td>0.57</td>
<td>0.741935</td>
<td>0.613</td>
</tr>
</tbody>
</table>

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### Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th></th>
<th>$l=2$ p-value</th>
<th>0.216</th>
<th>0.32</th>
<th>0.258065</th>
<th>0.216</th>
<th>0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic growth</strong></td>
<td>$l=-2$ p-value</td>
<td>0.15</td>
<td>0.96</td>
<td>0.903226</td>
<td>0.15</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>$l=-1$ p-value</td>
<td>0.458</td>
<td>0.87</td>
<td>1</td>
<td>0.458</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>$l=0$ p-value</td>
<td>0.458</td>
<td>0.87</td>
<td>1</td>
<td>0.458</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>$l=1$ p-value</td>
<td>0.41</td>
<td>0.68</td>
<td>0.677419</td>
<td>0.41</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>$l=2$ p-value</td>
<td>0.258</td>
<td>0.96</td>
<td>0.935484</td>
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<td>0.93</td>
</tr>
<tr>
<td><strong>Higher education</strong></td>
<td>$l=-2$ p-value</td>
<td>0.842</td>
<td>0.88</td>
<td>0.806452</td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>$l=0$ p-value</td>
<td>0.694</td>
<td>0.69</td>
<td>0.741935</td>
<td>0.694</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>$l=1$ p-value</td>
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<td>0.419355</td>
<td>0.519</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>$l=2$ p-value</td>
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<td>0.91</td>
<td>0.903226</td>
<td>0.912</td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Economic growth</strong></td>
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</tr>
<tr>
<td></td>
<td>$l=0$ p-value</td>
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<td>0.387097</td>
<td>0.901</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>$l=1$ p-value</td>
<td>0.901</td>
<td>0.38</td>
<td>0.548387</td>
<td>0.901</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>$l=2$ p-value</td>
<td>0.679</td>
<td>0.42</td>
<td>0.548387</td>
<td>0.679</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>Preschool</strong></td>
<td>$l=-2$ p-value</td>
<td>0.962</td>
<td>0.21</td>
<td>0.354839</td>
<td>0.962</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>$l=-1$ p-value</td>
<td>0.588</td>
<td>0.53</td>
<td>0.516129</td>
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<td>0.47</td>
</tr>
<tr>
<td></td>
<td>$l=0$ p-value</td>
<td>0.588</td>
<td>0.53</td>
<td>0.516129</td>
<td>0.588</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>$l=1$ p-value</td>
<td>0.588</td>
<td>0.53</td>
<td>0.516129</td>
<td>0.588</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>$l=2$ p-value</td>
<td>0.588</td>
<td>0.53</td>
<td>0.516129</td>
<td>0.588</td>
<td>0.47</td>
</tr>
</tbody>
</table>

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Doctoral Dissertation Sophia A. Kassapi

Σελίδα 231

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>Preschool</th>
<th>l=-1 p-value</th>
<th>l= 0 p-value</th>
<th>l= 1 p-value</th>
<th>l= 2 p-value</th>
<th>l= 3 p-value</th>
<th>l= 4 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool</td>
<td>0.439</td>
<td>0.46</td>
<td>0.580645</td>
<td>0.439</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Higher education</td>
<td>0.384</td>
<td>0.45</td>
<td>0.290323</td>
<td>0.384</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Secondary enrollments</td>
<td>0.491</td>
<td>0.53</td>
<td>0.419355</td>
<td>0.491</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Preschool enrollments</td>
<td>0.245</td>
<td>0.23</td>
<td>0.290323</td>
<td>0.245</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Secondary enrollments</td>
<td>0.468</td>
<td>0.5</td>
<td>0.548387</td>
<td>0.468</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Preschool enrollments</td>
<td>0.576</td>
<td>0.49</td>
<td>0.580645</td>
<td>0.576</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Secondary enrollments</td>
<td>0.233</td>
<td>0.26</td>
<td>0.258065</td>
<td>0.233</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

Note: ELSTAT, AMECO database.
We filtered the data in order to detect possible sources of the non-linearities. Possible sources can be the differential reaction to information flow as proxied by GARCH effects. Using a multivariate GARCH model (the BEKK model with a leverage term) and applying the diagnostic tests on the residuals of the model illustrated that the nonlinear causal relationship(s) that previously characterized the residuals, as seen before, are nonetheless deteriorated. In the nonlinear GARCH analysis, as well as in the VAR residuals analysis, any linear predictive power has already been removed. In this study a common lag length of two lags has been chosen.

The causal relationships revealed are indeed few. There is no Granger non-causality running from the education system towards economic growth, very disappointing as evidence.

The null hypothesis implies no causality in both directions and is can be stated as: ‘negative lag x(lag) cause y’ and positive lag y(lag) causes x’. According to the null hypothesis, apart from the valid Granger non-causality between public expenditures on education and economic growth at ε=0.06, 0.33, few more have been reported. Economic growth lagged value (-2) Granger causes Secondary enrollments at a 90% significance level with ε=1.5. Also, another relationship revealed, Secondary enrollments lagged values(2) Granger cause higher education with ε=1.5, 0.33 at a 90% significance level.

Results from the bootstrapped nonlinear testing indicate much less causal flow, concerning the relationships that revealed themselves in the linear Pairwise and the asymptotic nonlinear test. With this test, secondary education has no causal effect on economic growth. Based on all three sets of results, it is obvious that education pay-off has little to do with income, as the major variable, GDP per capita is very little affected. The fitted values of the variables in the VAR model show also a bidirectional causal flow between preschool enrollments and economic growth, similar to the findings of previous studies on developing economies, and it is actually desired.
Hypothesis 5.1:

More education has a positive effect on economic growth, since it provides a better skilled workforce. In the presence of Linear Granger causality both coefficients $\beta, \delta > 0$ and we expect to reveal a linear causal relationship between variables and more public expenditures.

If the past values of one variable can predict the future values of another, then we expect the appearance of linear causality with statistically important coefficients.

5.1.1: Public Investments in preschool education promotes growth

5.1.2: Public Investments in elementary education promotes economic growth

5.1.3: Public Investments in secondary education promotes growth

5.1.4: Public Investments in higher education promotes growth

The educational system in Greece has moved from the promotion of true causal relationships running from all educational variables towards economic growth, to the phenomenon of “adverse causality” in higher education, to “no causality” in the upper 5 levels of the educational system, and adverse causality in newly “officially” imposed preschool level.

One possible explanation might be that the Educational system has reached a mature status, and as all production function equations imply, it is time for a retirement in order to allow for more inclusive and growth-oriented methods to take its place.

VI. Hypothesis discussion & analysis

Hypothesis 5.1:

If the past values of one variable can predict the future values of another, then we expect the appearance of linear causality with statistically important coefficients.

Hypothesis 5.1.1:
Investments in preschool education promotes growth,

Preschool level serves as two things. One and foremost is the training & knowledge that students receive at an early age which by definition offers a more wide range of personal and professional choices to them as grown-ups, opening up their mind. Second, and quite equally important is the facilitation of this grade, which is a major social reform in the context of family life and children upbringing, by giving mothers the choice to return back to their working environment. Economic growth linearly Granger causes preschool, while Education public expenditures also linearly Granger cause preschool education.

Hypothesis 5.1.2:

Investments in elementary education promotes economic growth

Economic growth has a linear causal relation to elementary education. Now public investments in education do not seem to promote elementary, linear or nonlinear.

Hypothesis 5.1.3:

Investments in secondary education promotes growth.

Secondary education in a failing economy is the only grade that serves for growth, as seen from the linear Granger Pairwise testing. Investing in Secondary education is also important, as education expenditures Granger cause Secondary education, in the linear context. And sec. education serves for growth.

Hypothesis 5.1.4:

Investments in higher education promotes growth
Higher education in both linear and nonlinear context is unable to comprehend and capitalize the changes in society and in the market. A total reform, as the one suggested in August 2011 from the OECD report should be considered before any financing further. At this point the idea of skill deficit comes in mind.

We proceed next with the examination of the hypothesis 5.2, in which case there is a possibility that causality is correlated with the individual characteristics of each variable, aka educational level and the number of yearly enrollments in each case.

**Hypothesis 5.2:**

According to the Linear Pairwise Granger causality results, some causality still exists running from secondary education and preschool towards growth. That maybe because the subjects taught provide with useful basic market skills, and are introduced at this level for first time.

Non Linear Granger Causality tests are unfortunately disproving any chance for growth as nonexistent, detected only among some of the variables under examination. Investing in the educational system as it is presented right now has to be done under severe caution and with more delicate procedures. Education
as presented right now, must be deeply flawed, no matter what the intermediate causalities, as it doesn’t serve sustainable growth. The skills provided here are not capable of bearing the process of poverty alleviation and providing for better economic conditions.

If this is the case, then we are dealing with an education system that is not growth-driven, and has lost its real meaning. And it is more likely not supporting economic growth in the given market environment. The possibility of Education being responsible for a declining economy is also examined here.

**Hypothesis 5.3:**

Promoting economic growth has a positive effect on education (adverse causality). Also, the phenomenon of ‘adverse causality’ might be present and part of this asymmetry.

According to some researchers, this is the case in most developing countries, where as economic growth serves as a key driver to promoting education

5.3.1: Economic growth promotes primary education

5.3.2: Economic growth promotes elementary education

5.3.3: Economic growth promotes secondary education

5.3.4: Economic growth promotes higher education

In order to clear out any doubt that there might be the slightest causal inference in the residuals not detected, for the first time the modification of Data-sharpening of Diks & Wolski (2012), removing the bias of the Kernel estimator that doesn’t converge to zero at a fast rate when the number of conditioning variables is larger than one, also called as the
promoting education. But the mistake that most developing countries do in order to catch up with the developed countries is that they raise the years of schooling, but pay no attention to the content and the process, when in class. This finding in fact, is more of a problem than of a solution as it has proven to be very misleading. If the country that has risen the years of schooling and has directed students towards school attainment, does not do the same for its schooling quality is doomed to fail in its long-run economic performance.

**Hypothesis 5.3.1:**

**Economic growth promotes primary education**

Primary education is promoted by economic growth, a finding from the linear Granger causality tests that is a shed of light towards economic growth. As said before, preschool has not been an official schooling level until recently. So the lack of order makes it even more important that preschool serves as an educational choice for little students.

**Hypothesis 5.3.2:**

**Economic growth promotes elementary education**

This finding holds for the linear Granger causality testing. Elementary is profoundly supported by economic growth in a linear way.

**Hypothesis 5.3.3:**

**Economic growth promotes secondary education**

This hypothesis is not verified in any of the testing procedures in this study, nor does it follow any logic. Secondary schooling is an intermediate level, and as such is not desired by any agent that is experiencing interesting levels of economic growth.

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Hypothesis 5.4:

No Linear Causality is detected. Causality might be hidden in the residuals, due to several reasons (omitted variables, non linearities etc.). In the presence of non linear causality relationships, it is expected to estimate statistically significant $e_{1t}$ and $e_{2t}$.

This hypothesis under examination shows the possibility that there might be a large part of the phenomenon not examined in the study, and for that it is necessary to proceed further with the non parametric methods of Granger non-causality.

Hypothesis 5.5:

Investments in education have a negative effect on economic growth.

Hypothesis 5.6:

In a period of economic crisis, private investments in education are expected to correlate with the problem itself, and react in a causal way, that is $\beta_1 > 0$ and $\delta_1 > 0$.

Hypothesis 5.3.4:

Economic growth promotes higher education

This used to be the case until 1994, according to Asteriou & Siriopoulos (1997). Nowadays, in the times of high external debt, and austerity measures taken, there is no lead or lag power in this relationship. In countries like India, Pakistan and other developing parts of the world, economic growth is indeed the lead power for the promotion of the pursuit of a university degree. But as said earlier these developing countries will find it very difficult to improve their long run financial status.

Hypothesis 5.4:

Unlikely to this hypothesis the Granger causality detected is mostly linear as 13 of the 30 stated interactions were found causal. The only situation that serves this hypothesis is the inability of the higher education institutions to serve as major determinants of economic growth.

Hypothesis 5.5:

Investments in education have a negative effect on economic growth.

Hypothesis 5.6:

In a period of economic crisis, private investments in education are expected to correlate with the problem itself, and react in a causal way, that is $\beta_1 > 0$ and $\delta_1 > 0$. 

The conclusions of this study need to be analyzed further. Investments in education ‘are good for growth’, but in order to make this a reality and not a blessing, a lot of steps need to be taken further.
Education is not helping the economy if no monitoring on the investments in education is not established, and the choice of actions is to be made upon the will of each and every political person in charge. Education has it’s own political rules, and decisions should be made according to these rules, and not based on the ethics of each political system applied by the voters.

Policy implications & suggestions

As Galor has said, inequality is persistent. The education system in many countries is supposed to offer social mobility chances to the smartest, and also to the most competent students. This fact itself presupposes a healthy market, where the chance of graduating from an institution of knowledge with good grades will be acknowledged, or at least a market “pulling” those graduates inside.

Market, in the case being examined here, looks unable to provide for this supply of graduates, which is enhanced by graduates arriving from abroad with even more specialized degrees. The market is limb.

On a lecture in Greece, economist Philippe Aghion in 2014 talked about the “smart state”, and marked with his words the facilitation of a vicious circle. The need for a perfect market, dictates the need for very well informed citizens, in other words very well educated ones, more than one generation.

According to Krueger and Dunning (1999), the fact that the citizens lack both skills and information of how much they lack skills, facilitates this vicious
circle, and maybe even more. Aghion offers a good example on the imperfect market saying that sometime someone will need to borrow from the credit market, but due to market imperfections, there will not be enough information on how competent a new client might be in the future. Let’s just suppose that this client is on a wheel chair. Now imagine a banker taking the risk of financing this person’s studies. Not knowing if this person will be there in the long-run, finish the studies, make money and pay back the bank. The risk of this investment is huge and the chances of paying back very few.

Education and schooling have of course many other multiplicative effects. It is the system through which the values of a society are transmitted and the basic skills of each citizen. From a financial point of view investing in public schooling is good in that it restores the economy and raises productivity, considering that it is the competitive advantage of all western mature economies.

Post WW Europe was developed through imitation. Economies grew based on technologies of others, like in developing countries. From 1945 and on, until the first oil schock, Europe had greater rates of growth than the U.S. and much less unemployment. Having a country developing so far from the technological frontier of humanity, it is reasonable to say that it is necessary to look for the next step.

Economies of the West, have no choice but to become economies that will be based on innovation. What is needed here is a much different type of country-state, a “smart” government that will promote innovation, instead of suffocating individual initiatives. A different Welfare state, that will not share the industrial policy of the past. New businesses have to replace the old ones, and stay away from the policies of “national champs”, which can only be catastrophic.
The anticyclical policies of the government have to stop having as their basis, the economics of demand, but the economics of supply. In recession times, instead of assisting incomes with allowances, one should be constantly reinforcing the innovation capacity of businesses. If research follows the pattern of the economic cycle in recession times and is forced to stop, then it is completely damaged.

The same stands here for people. While the old welfare state cared to provide with benefits for the unemployed, now it’s time to consider the “creative destruction” that is taking place.

The new state has to provide for a system of continuous re-education of those people whose skills were made redundant due to the technological process at hand, and reintegrate them into the labor market.

According to Philippe Aghion there are four suggestions in order to move forward and progress with innovation: a). Larger investments in higher education, but within a system of independent universities away from the control of the state, b). Complete deregulation of the markets good. c). Decontrol of the labor market, but with “flexicurity” systems, similar to those of Denmark. As it is very important for businesses to be able to hire and lay off easily. And then a good statutory system of training and re-educating right next to the labor market, like the reform that Denmark, Germany and Sweden successfully followed. d). Financing of the innovating businesses, demanding a large private financial sector, since innovation contains a lot of risk that the state will not be able to bear.

The last technological breakthrough that took place in history, which is computer science, took place in a country with a liberal market, where people were given the chance to try, succeed, and fail. Thousands of people like Bill Gates, all coming from the middle class, that the public school gave them the initial strength to open their wings and enrich society with their products.
Education in Greece has to stop following the patterns of developing countries. Greece is a mature economy, with provided infrastructure. The satisfaction stemming from the causal relationship where economic growth promotes education, which used to be the case in 1994, is no longer a virtue for the Greek economy. Greece has made remarkable progress in trying to close the gap with the Western European economies in terms of school attainment. And the results of this research project highlighting the fact that education is not influencing economic growth anymore, together with the uncertain part of human capital on economic growth, shows that little closing the gaps in terms of cognitive skills has occurred.

In general, access to education, infrastructure and funds are good for growth. But this lack of causality demands a different strategy. Just providing more resources is generally ineffective. Many of the past decisions on access and quality should be reconsidered. The results from this growth analysis appear especially large for the Greek economy and the Greek market.

**Critique on GDP as a measure for Growth - Recommendations**

As many scholars have cited the issue of education having a causal effect on the economic growth of the country is mainly a problem scrutinized by emerging economies like the BCIM and such. Developed economies have never had any doubt about their leading role in convergence.

Analyzing the results of this study we dare to say that the Greek Economy stands somewhere in the middle. Nor has it ever neglected the effect of education on its own economic growth responding with quantitative investments (building new schools, hiring additional personnel etc), neither
has it ever occupied itself only with qualitative issues such as time in classroom, teaching subjects, restrictions from entering (apart from HE) etc.

So, the direction of the researchers, i.e. in developing countries they explore the education-growth relationship, while in developed countries they explore other relationships like education-well-being, education-self-awareness, education-philosophy, education-cohesion, education-drop-outs etc, reveals a lot about the situation at hand in their country. No researcher has he or she ever wondered if education brings growth in the US or GB etc, because this thing is self-evident. Education is a whole business sector, that brings economic growth in itself and its counterparts if done properly, but it is also the business sector that integrates progress and technological change in its textbooks and promotes individual economic growth in any functioning economy and competition.

I would only leave out one relationship between education and real wages which should be a problem investigated in developing countries also, but it is better analyzed in the organized western economies that flourish by default, as there are plenty of available data there.

Some other scholars and international institutions have started a campaign against the credibility of GDP as a measure for Growth saying that it is outdated and cannot grasp the “technological effect” that has been imposed onto the market and the way business is done nowadays.

If we were to create a new index measuring the level of convergence for an emerging economy, or for any economy in doubt, should we not ignore the causal effect between education and GDP per capita. Of course, it would be a lot easier to continue the seminal work of Mincer provided that we could monitor the whole labor market day by day, and have a clear picture of who gets paid for what. But even Mincer himself couldn’t open these channels of information, and that was one of the main reasons why his work in 1974
betrayed him. People integrate change in their lives and respond by changing lifestyles, tastes, choices and attitudes towards life.

So, we suggest a fictional new “Economic Convergence sub-Index”, that would also take into account the adverse relationship of education and growth, whereas revenues have no significant impact on growth (if any) and expenditures have none or negative impact on growth.

The less causal this relationship, higher the level of convergence of an economy, in other words comparatively closer to the developed economies. The p-value of both the linear and non linear Granger causality test could serve as one of the coefficients of the economic growth equation.

Synopsis

The driver for this research project was a central question wandering in the mind of the researcher. “Why countries need external financial aid? Why national governments need other governments to tell them how to run their own country? Is it a macroeconomic issue, or is it the individual agents and their choices who drive the success and failure of a country?”. The question is not new, but the answers given so far, are not fully answering the question.

Evolution, development, technological progress is a reality for many decades now, but still in some cases it can act as a tool that depowers people, if in the hand of the competitor.

The focus of the analysis has been the estimation of the long-run causal effect of public sector provision of schooling on the total economic growth of the
country. The nature of the phenomena of this analysis is by default long-run, and as such, it is very difficult to make predictions using regression analysis.

The econometric methodology of the dissertation (Time Series Analysis) is the appropriate one and is used in similar international studies (Asteriou & Siriopoulos, 1997, Cheng, B. S. and Hsu R. C., 1997, Hamdi, Hakimi & Sbia, 2013), especially after mid 90's.

This study has contributed in the literature by including the innovation of non-linear dependencies, and using all the advanced time-series analysis methodology. It has been an innovative idea to extend technical analysis towards a more integrated framework, the non-linear methodology approach, as this added more accuracy to the results of the analysis, taking into account the whole range of the variance. The researcher produced her own codes in matlab and C programming language, (found the source codes and modified those to the needs of her study). The results of the study reached the following conclusions,

a) This study revealed a change concerning the findings of previous studies on the effect of education public expenditures on economic growth,

b) This change is impressed upon Greece concerning the efficiency of public investments in education, and finds no effect on economic growth,

c) The use of advanced econometric tools and methods allows for the diagnosis of those important observations.
To conclude with, there two questions to be posed to the reader. What is a school? And what was school thought to be back in the industrialization era?

The discontent and disarray that Adam Smith believed schools could make disappear when illiterate workers identified no satisfaction at work, was one thing back at that time. Nowadays, the trend for schools is that they should provide for a social hub where minds meet and exchange ideas, as this is what is needed in the market and the society alone. What companies ask for, from their employees is not mere cognition anymore. Taking a look at an online job site of a newspaper one can distinguish among type A non-cognitive skills “…punctuality, persistence, concentration, docility, compliance, ability to work with others…”, as traits of the low level jobs, and type B qualifications “…self-esteem, self-reliance, versatility, capacity to assume leadership roles…” as the traits of the top level occupations. This was widely misunderstood by orthodox economists of education up to the 70’s. Bowles and Gintis (1976) theoretical analysis in their book on why youth unemployment is much bigger than any other group’s, lays out the fact that secondary schools failed to incorporate those required skills and personality traits that make school leavers employable. Unfortunately from this study in 2016 here, the findings are very disappointing for even higher levels of schooling such as tertiary education. Graduates are no longer employable, which makes the opportunity cost of schooling reaching the highest levels of any other type of investment.

This issue of the economic meaning of schooling is to be further discussed, as the intriguing findings of this analysis leaves no choice but to approach schooling from every angle and propose and predict a better and more efficient model for public investments.

“Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.”
### APPENDIX A.1 Results

#### Unit Root Tests

*(Annual data 1960-2014)*

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>E</th>
<th>S</th>
<th>H</th>
<th>EDEX</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>124720.9</td>
<td>802673.9</td>
<td>598096.7</td>
<td>111228.2</td>
<td>2.30E+09</td>
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<tr>
<td>Median</td>
<td>141010</td>
<td>865660</td>
<td>669812</td>
<td>107968</td>
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<tr>
<td>Maximum</td>
<td>166576</td>
<td>979395</td>
<td>750891</td>
<td>187729</td>
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<tr>
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<td>273390</td>
<td>28302</td>
<td>5000000</td>
<td>46.08</td>
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<td>Std. Dev.</td>
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<td>138540.7</td>
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<td>0.067736</td>
<td>0.929408</td>
<td>0.696774</td>
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<td>Kurtosis</td>
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<td>1.291184</td>
<td>2.640828</td>
<td>2.209039</td>
<td>2.404358</td>
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<td>Probability</td>
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<td>0.028487</td>
<td>0.009764</td>
<td>0.478125</td>
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<tr>
<td>Sum</td>
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<td>44147065</td>
<td>32895318</td>
<td>6117551</td>
<td>1.27E+11</td>
<td>373463.7</td>
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<td>Sum Sq. Dev.</td>
<td>7.62E+10</td>
<td>9.63E+11</td>
<td>1.03E+12</td>
<td>9.39E+10</td>
<td>4.34E+20</td>
<td>3.10E+09</td>
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<tr>
<td>Observations</td>
<td>55</td>
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<td>55</td>
<td>55</td>
<td>55</td>
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Null Hypothesis: P has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on AIC, MAXLAG=10)

<table>
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<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% level</td>
<td>-2.26763</td>
<td>0.1860</td>
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Test critical values:

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<th>5% level</th>
<th>10% level</th>
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<tr>
<td>Test</td>
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<td>-2.91765</td>
<td>-2.59669</td>
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Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P)
Method: Least Squares
Date: 09/06/15 Time: 23:47
Sample (adjusted): 1962 2014
Included observations: 53 after adjustments

<table>
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<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<td>P(-1)</td>
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<td>D(P(-1))</td>
<td>0.260348</td>
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<td>C</td>
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<td>R-squared</td>
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<td>Adjusted R-squared</td>
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<td>S.D. dependent var</td>
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<td>S.E. of regression</td>
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<td>Sum squared resid</td>
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<td>Log likelihood</td>
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<td>F-statistic</td>
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<td>Prob(F-statistic)</td>
<td>0.004491</td>
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"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

<table>
<thead>
<tr>
<th>Null Hypothesis: $E$ has a unit root</th>
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<td>Test critical values:</td>
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<tr>
<td>1% level</td>
<td>-3.562669</td>
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<td>5% level</td>
<td>-2.918778</td>
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<td>10% level</td>
<td>-2.597285</td>
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Augmented Dickey-Fuller Test Equation
Dependent Variable: $D(E)$
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Included observations: 52 after adjustments

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<td>$E(-1)$</td>
<td>-0.009594</td>
<td>0.011536</td>
<td>-0.739571</td>
<td>0.4839</td>
</tr>
<tr>
<td>$D(E(-1))$</td>
<td>0.443939</td>
<td>0.141099</td>
<td>3.148295</td>
<td>0.0026</td>
</tr>
<tr>
<td>$D(E(-2))$</td>
<td>0.212337</td>
<td>0.141906</td>
<td>1.496324</td>
<td>0.1411</td>
</tr>
<tr>
<td>$C$</td>
<td>4874.777</td>
<td>9624.219</td>
<td>0.506511</td>
<td>0.6148</td>
</tr>
</tbody>
</table>

R-squared: 0.335833
Adjusted R-squared: 0.295120
S.E. of regression: 10794.93
Akaike info criterion: 21.48534
Schwarz criterion: 21.63544
Hannan-Quinn criterion: 21.54299
Durbin-Watson stat: 1.996533

Doctoral Dissertation Sophia A. Kassapi

Σελίδα 252
Null Hypothesis: $S$ has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-2.619939</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level
- 5% level
- 10% level


Augmented Dickey-Fuller Test Equation
Dependent Variable: $D(S)$
Method: Least Squares
Date: 09/07/15 Time: 00:10
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S(-1)$</td>
<td>-0.076253</td>
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<td>-2.619939</td>
<td>0.0115</td>
</tr>
<tr>
<td>$C$</td>
<td>50804.54</td>
<td>17887.87</td>
<td>2.840174</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

R-squared       | 0.116609    | Mean dependent var | 5130.867 |
Adjusted R-squared | 0.099621    | S.D. dependent var | 3103.938 |
S.E. of regression | 29447.83    | Akaike info criterion | 23.45495 |
Sum squared resid | 4.51E+10    | Schwarz criterion | 23.52861 |
Log likelihood   | -631.2836   | Hannan-Quinn criterion | 23.48336 |
F-statistic      | 0.860481    | Durbin-Watson stat | 1.682365 |
Null Hypothesis: H has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th></th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-0.143759</td>
<td>0.9384</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.571310
- 5% level: -2.922449
- 10% level: -2.599224


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(H)
Method: Least Squares
Date: 09/07/15  Time: 00:13
Sample (adjusted): 1966 2014
Included observations: 49 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(-1)</td>
<td>-0.002605</td>
<td>0.018117</td>
<td>-0.143759</td>
<td>0.8864</td>
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<td>D(H(-1))</td>
<td>0.374550</td>
<td>0.140437</td>
<td>2.506400</td>
<td>0.0162</td>
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<tr>
<td>D(H(-2))</td>
<td>0.271984</td>
<td>0.163800</td>
<td>1.660461</td>
<td>0.1043</td>
</tr>
<tr>
<td>D(H(-3))</td>
<td>-0.030288</td>
<td>0.171982</td>
<td>-0.176113</td>
<td>0.8611</td>
</tr>
<tr>
<td>D(H(-4))</td>
<td>-0.113525</td>
<td>0.166311</td>
<td>-0.692606</td>
<td>0.4966</td>
</tr>
<tr>
<td>D(H(-5))</td>
<td>-0.272956</td>
<td>0.156190</td>
<td>-1.747588</td>
<td>0.0878</td>
</tr>
<tr>
<td>C</td>
<td>2456.475</td>
<td>2207.395</td>
<td>1.112839</td>
<td>0.2721</td>
</tr>
</tbody>
</table>

R-squared          | 0.402178   | Mean dependent var | 2647.531
Adjusted R-squared | 0.316775   | S.D. dependent var  | 5283.262
S.E. of regression  | 4307.007   | Akaike info criterion | 19.73311
Sum squared resid   | 8.01e+08   | Schwarz criterion   | 20.00337
Log likelihood      | -476.4611  | Hannan-Quinn criter. | 19.8564
F-statistic         | 4.709180   | Durbin-Watson stat  | 1.973112
Prob(F-statistic)   | 0.000951   |                    |          

Doctoral Dissertation Sophia A. Kassapi
Null Hypothesis: GDP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP(-1)</td>
<td>-0.007809</td>
<td>0.006033</td>
<td>-1.294557</td>
<td>0.2014</td>
</tr>
<tr>
<td>D(GDP(-1))</td>
<td>0.876859</td>
<td>0.072898</td>
<td>12.02852</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>86.06289</td>
<td>62.14161</td>
<td>1.384948</td>
<td>0.1722</td>
</tr>
</tbody>
</table>

R-squared          0.743645  Mean dependent var 306.3858
Adjusted R-squared 0.733391  S.D. dependent var 627.9127
S.E. of regression 324.2179  Akaike info criterion 14.45565
Sum squared resid  5255863  Schwarz criterion 14.56717
Log likelihood     -380.0747  Hannan-Quinn criter. 14.49854
F-statistic        72.52094  Durbin-Watson stat 1.707641
Prob(F-statistic)  0

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 10/03/15   Time: 03:57
Sample (adjusted): 1962 2014
Included observations: 53 after adjustments

Augmented Dickey-Fuller test statistic
Test critical values:
1% level -3.560019
5% level -2.91765
10% level -2.596689

Null Hypothesis: EDEX has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic based on SIC, MAXLAG=10)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-6.336023</td>
</tr>
<tr>
<td>Test critical values:</td>
<td>1% level</td>
</tr>
<tr>
<td></td>
<td>-3.574446</td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EDEX)
Method: Least Squares
Date: 10/03/15   Time: 03:58
Sample (adjusted): 1967 2014
Included observations: 48 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDEX(-1)</td>
<td>-0.262483</td>
<td>0.041427</td>
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<td>0.181</td>
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<tr>
<td>D(EDEX(-1))</td>
<td>0.279868</td>
<td>0.113497</td>
<td>2.465873</td>
<td>0.0181</td>
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<tr>
<td>D(EDEX(-2))</td>
<td>0.442697</td>
<td>0.122673</td>
<td>3.608759</td>
<td>0.0008</td>
</tr>
<tr>
<td>D(EDEX(-3))</td>
<td>0.458668</td>
<td>0.202692</td>
<td>2.262876</td>
<td>0.0219</td>
</tr>
<tr>
<td>D(EDEX(-4))</td>
<td>0.327571</td>
<td>0.197087</td>
<td>1.662064</td>
<td>0.1043</td>
</tr>
<tr>
<td>D(EDEX(-5))</td>
<td>1.15629</td>
<td>0.246846</td>
<td>3.895257</td>
<td>0.0004</td>
</tr>
<tr>
<td>D(EDEX(-6))</td>
<td>1.846994</td>
<td>0.327477</td>
<td>5.640068</td>
<td>0.0001</td>
</tr>
<tr>
<td>C</td>
<td>17594100</td>
<td>47764369</td>
<td>0.368352</td>
<td>0.7146</td>
</tr>
</tbody>
</table>

R-squared 0.722879 Mean dependent var 95336657
Adjusted R-squared 0.675558 S.D. dependent var 4.20E+08
S.E. of regression 2.39E+08 Akaike info criterion 41.57329
Sum squared resid 2.29E+18 Schwarz criterion 41.88516
Log likelihood -989.759 Hannan-Quinn criterion 41.69115
F-statistic 14.98059 Durbin-Watson stat 0.7146
Prob(F-statistic) 0
Time Series Analysis. Descriptive Statistics

Throughout our research, we had to deal with several econometrics packages to present our work and results. This part has been conducted using Eviews package.

i) Preliminary Statistics

At first, this study has to introduce the variables being used. A group of time-series dated from 1960 to 2013, with annual observations, later on we will explain the reason why we interpolated our annual time-series into quarterly data.

Series: Education Public Expenditures

Sample: 1960-2015

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

Date: 10/03/15   Time: 04:00
Sample: 1960Q1 2013Q4

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>E</th>
<th>S</th>
<th>H</th>
<th>EDEX</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>124841.1</td>
<td>803855.5</td>
<td>601127.3</td>
<td>110921.9</td>
<td>2.29E+09</td>
<td>6726.597</td>
</tr>
<tr>
<td>Median</td>
<td>140559.6</td>
<td>865804.8</td>
<td>674306.4</td>
<td>107600.6</td>
<td>4.97E+08</td>
<td>2574.386</td>
</tr>
<tr>
<td>Maximum</td>
<td>167100.2</td>
<td>979395</td>
<td>763493.4</td>
<td>187253.7</td>
<td>8.83E+09</td>
<td>21641.85</td>
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<tr>
<td>Minimum</td>
<td>40247</td>
<td>628494.6</td>
<td>273390</td>
<td>28302</td>
<td>5000000</td>
<td>46.08</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>36694.62</td>
<td>132151</td>
<td>135145.1</td>
<td>40385.66</td>
<td>2.83E+09</td>
<td>7499.131</td>
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<tr>
<td>Skewness</td>
<td>-1.071234</td>
<td>-0.227574</td>
<td>-1.015759</td>
<td>0.07949</td>
<td>0.943046</td>
<td>0.722508</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.825591</td>
<td>1.301999</td>
<td>2.676085</td>
<td>2.215645</td>
<td>2.413356</td>
<td>1.952771</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>41.5853</td>
<td>27.81331</td>
<td>38.08791</td>
<td>5.764387</td>
<td>35.11342</td>
<td>28.66284</td>
</tr>
<tr>
<td>Probability</td>
<td>0</td>
<td>0.000001</td>
<td>0</td>
<td>0.056012</td>
<td>0</td>
<td>0.000001</td>
</tr>
<tr>
<td>Sum</td>
<td>26965669</td>
<td>1.74E+08</td>
<td>1.30E+08</td>
<td>23959134</td>
<td>4.95E+11</td>
<td>1452945</td>
</tr>
<tr>
<td>Sum Sq. Dev.</td>
<td>2.89E+11</td>
<td>3.75E+12</td>
<td>3.93E+12</td>
<td>3.51E+11</td>
<td>1.72E+21</td>
<td>1.21E+10</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
</tr>
</tbody>
</table>

― Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

“Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.”

<table>
<thead>
<tr>
<th>Series:</th>
<th>Gross Domestic Product</th>
<th>Sample:</th>
<th>1960-2013</th>
</tr>
</thead>
</table>

Doctoral Dissertation Sophia A. Kassapi

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

Null Hypothesis: E has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic based on AIC, MAXLAG=14)

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-1.204090</td>
<td>0.6728</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.462574
- 5% level: -2.875608
- 10% level: -2.574346


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(E)
Method: Least Squares
Date: 09/07/15 Time: 00:19
Sample (adjusted): 1963Q2 2013Q4
Included observations: 203 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E(-1)</td>
<td>-8.12E-05</td>
<td>6.74E-06</td>
<td>-1.204090</td>
<td>0.2301</td>
</tr>
<tr>
<td>D(E(-1))</td>
<td>3.102137</td>
<td>0.066354</td>
<td>46.75103</td>
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</tr>
<tr>
<td>D(E(-2))</td>
<td>-3.749409</td>
<td>0.199274</td>
<td>-18.81531</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(E(-3))</td>
<td>-2.265367</td>
<td>0.256599</td>
<td>8.828493</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(E(-4))</td>
<td>-2.204827</td>
<td>0.235297</td>
<td>-9.370408</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(E(-5))</td>
<td>4.615554</td>
<td>0.246165</td>
<td>18.74635</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(E(-6))</td>
<td>-5.357226</td>
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<td>-15.65017</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(E(-7))</td>
<td>3.099757</td>
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<td>9.041799</td>
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</tr>
<tr>
<td>D(E(-8))</td>
<td>-1.635423</td>
<td>0.240231</td>
<td>-6.561882</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(E(-9))</td>
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<td>0.226291</td>
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<tr>
<td>D(E(-10))</td>
<td>-2.714745</td>
<td>0.238924</td>
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<td>0.0000</td>
</tr>
<tr>
<td>D(E(-11))</td>
<td>1.482423</td>
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<td>8.171182</td>
<td>0.0000</td>
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<tr>
<td>D(E(-12))</td>
<td>-0.322073</td>
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<td>C</td>
<td>42.94757</td>
<td>55.82103</td>
<td>0.769380</td>
<td>0.4426</td>
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</tbody>
</table>

R-squared: 0.998770
Adjusted R-squared: 0.998665
S.E. of regression: 120.0401
Sum squared resid: 2723421

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
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<tbody>
<tr>
<td>Mean dependent var</td>
<td>1456.997</td>
</tr>
<tr>
<td>S.D. dependent var</td>
<td>3310.875</td>
</tr>
<tr>
<td>Akaike info criterion</td>
<td>12.48000</td>
</tr>
<tr>
<td>Schwarz criterion</td>
<td>12.70850</td>
</tr>
</tbody>
</table>

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Σελίδα 261

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

Null Hypothesis: E has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th>Test statistic</th>
<th>I-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-0.739571</td>
<td>0.8276</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.562669
- 5% level: -2.918778
- 10% level: -2.597285


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(E)
Method: Least Squares
Date: 09/06/15  Time: 23:56
Sample (adjusted): 1963-2014
Included observations: 52 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>I-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E(-1)</td>
<td>-0.008594</td>
<td>0.011636</td>
<td>-0.738571</td>
<td>0.4638</td>
</tr>
<tr>
<td>D(E(-1))</td>
<td>0.443939</td>
<td>0.141009</td>
<td>3.148205</td>
<td>0.0028</td>
</tr>
<tr>
<td>D(E(-2))</td>
<td>0.212337</td>
<td>0.141906</td>
<td>1.493624</td>
<td>0.1411</td>
</tr>
<tr>
<td>C</td>
<td>4874.777</td>
<td>9624.219</td>
<td>0.506511</td>
<td>0.6148</td>
</tr>
</tbody>
</table>

R-squared          0.336583   Mean dependent var   -5756.615
Adjusted R-squared 0.295120   S.D. dependent var   12857.66
S.E. of regression 10794.93   Akaike info criterion 21.48534
Sum squared resid   5.59E+09   Schwarz criterion   21.63544
Log likelihood     -554.6189   Hannan-Quinn criter. 21.54289
F-statistic        8.117569   Durbin-Watson stat   1.909533
Prob(F-statistic)  0.000179   "Doctoral Dissertation Sophia A. Kassapi"
Null Hypothesis: EDEX has a unit root  
Exogenous: Constant 
Lag Length: 12 (Automatic based on AIC, MAXLAG=14)  

<table>
<thead>
<tr>
<th>Test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller</td>
<td>-1.987557</td>
<td>0.2922</td>
</tr>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.462574</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-2.875608</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.574346</td>
<td></td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation  
Dependent Variable: D(EDEX)  
Method: Least Squares  
Date: 09/07/15  
Time: 00:23  
Sample (adjusted): 1953Q2 2013Q4  
Included observations: 203 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDEX(-1)</td>
<td>-0.000256</td>
<td>0.000134</td>
<td>-1.987557</td>
<td>0.0483</td>
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<tr>
<td>D(EDEX(-1))</td>
<td>3.181582</td>
<td>0.069643</td>
<td>-45.86441</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-2))</td>
<td>-3.928338</td>
<td>0.221674</td>
<td>-17.72125</td>
<td>0.0000</td>
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<tr>
<td>D(EDEX(-3))</td>
<td>2.374302</td>
<td>0.314383</td>
<td>7.552288</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-4))</td>
<td>-2.520105</td>
<td>0.320048</td>
<td>-7.847153</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-5))</td>
<td>5.741464</td>
<td>0.347955</td>
<td>16.50058</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-6))</td>
<td>-6.855688</td>
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<td>-14.47016</td>
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<tr>
<td>D(EDEX(-7))</td>
<td>3.957641</td>
<td>0.490741</td>
<td>8.056026</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-8))</td>
<td>-2.222886</td>
<td>0.379099</td>
<td>-5.683605</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-9))</td>
<td>3.779979</td>
<td>0.357298</td>
<td>10.57933</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-10))</td>
<td>-4.420727</td>
<td>0.386866</td>
<td>-11.42701</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-11))</td>
<td>2.420698</td>
<td>0.304522</td>
<td>7.949174</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX(-12))</td>
<td>0.509202</td>
<td>0.103304</td>
<td>-4.929142</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>437420.4</td>
<td>401539.6</td>
<td>1.089358</td>
<td>0.2774</td>
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</tbody>
</table>

R-squared: 0.998382  
Adjusted R-squared: 0.998270  
S.E. of regression: 3.45E+15  
S.D. of dependent var: 33.44007  
Mean dependent var: 24093148  
Schwarz criterion: 33.66857
Null Hypothesis: EDEX has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th>Test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test</td>
<td>-6.336023</td>
<td>0.0000</td>
</tr>
<tr>
<td>statistic</td>
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</tr>
<tr>
<td>Test critical values</td>
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</tr>
<tr>
<td>1% level</td>
<td>-3.574446</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-2.923780</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.599925</td>
<td></td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EDEX)
Method: Least Squares
Date: 09/07/15   Time: 00:18
Sample (adjusted): 1967 2014
Included observations: 48 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDEX(-1)</td>
<td>-0.262483</td>
<td>0.041427</td>
<td>-6.336023</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(EDEX)</td>
<td>0.279868</td>
<td>0.113497</td>
<td>2.465873</td>
<td>0.0181</td>
</tr>
<tr>
<td>D(EDEX)</td>
<td>0.442697</td>
<td>0.122673</td>
<td>3.606759</td>
<td>0.0008</td>
</tr>
<tr>
<td>D(EDEX)</td>
<td>0.458668</td>
<td>0.202692</td>
<td>2.262876</td>
<td>0.0291</td>
</tr>
<tr>
<td>D(EDEX)</td>
<td>0.327571</td>
<td>0.197087</td>
<td>1.662064</td>
<td>0.1043</td>
</tr>
<tr>
<td>D(EDEX)</td>
<td>1.156290</td>
<td>0.296846</td>
<td>3.895257</td>
<td>0.0004</td>
</tr>
<tr>
<td>D(EDEX)</td>
<td>1.846994</td>
<td>0.327477</td>
<td>5.640068</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>17594100</td>
<td>47764369</td>
<td>3.683522</td>
<td>0.7146</td>
</tr>
</tbody>
</table>

R-squared | 0.723879 | Mean dependent var | 95336657 |
Adjusted R-squared | 0.675558 | S.D. dependent var | 4.20E+08 |
S.E. of regression | 2.38E+08 | Akaike info criterion | 41.57329 |
Sum squared resid | 2.29E+18 | Schwarz criterion | 41.88516 |
Log likelihood | -989.7590 | Hannan-Quinn criterion | 41.69115 |
F-statistic | 14.98059 | Durbin-Watson stat | 1.882189 |
Prob(F-statistic) | 0.000000 | | |

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic based on AIC, MAXLAG=14)

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.934031</td>
<td>0.9958</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.452574
- 5% level: -2.975608
- 10% level: -2.574346


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 09/07/15 Time: 00:24
Sample (adjusted): 1963Q2 2013Q4
Included observations: 203 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP(-1)</td>
<td>4.27E-05</td>
<td>4.57E-05</td>
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<td>0.3515</td>
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<tr>
<td>D(GDP(-1))</td>
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<td>0.223382</td>
<td>-18.94063</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-2))</td>
<td>-2.742060</td>
<td>0.331945</td>
<td>8.260591</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-3))</td>
<td>2.367032</td>
<td>0.353289</td>
<td>-6.701690</td>
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<tr>
<td>D(GDP(-4))</td>
<td>-4.722988</td>
<td>0.372115</td>
<td>12.69229</td>
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</tr>
<tr>
<td>D(GDP(-5))</td>
<td>-5.804192</td>
<td>0.437528</td>
<td>-13.26536</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-6))</td>
<td>3.652744</td>
<td>0.441201</td>
<td>8.279084</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-7))</td>
<td>-1.817287</td>
<td>0.376621</td>
<td>-4.825237</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-8))</td>
<td>2.291263</td>
<td>0.357900</td>
<td>6.401972</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-9))</td>
<td>-2.713425</td>
<td>0.342381</td>
<td>-7.925152</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-10))</td>
<td>1.628640</td>
<td>0.239608</td>
<td>6.797101</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(GDP(-11))</td>
<td>-4.402257</td>
<td>0.075756</td>
<td>-5.249691</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.584404</td>
<td>0.387575</td>
<td>1.507844</td>
<td>0.1333</td>
</tr>
</tbody>
</table>

R-squared: 0.999475
Mean dependent var: 79.70796
S.E. of regression: 0.999439
Akaike info criterion: 3.802952
S.E. of regression: 3.802952
Schwarz criterion: 5.804401

Doctoral Dissertation Sophia A. Kassapi
Σελίδα 266
Null Hypothesis: GDP has a unit root  
Exogenous: Constant  
Lag Length: 10 (Automatic based on AIC, MAXLAG=10)  

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test critical values:</td>
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</tr>
<tr>
<td>1% level</td>
<td>-2.902298</td>
<td>0.0532</td>
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<tr>
<td>5% level</td>
<td>-3.588509</td>
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</tr>
<tr>
<td>10% level</td>
<td>-2.603064</td>
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</table>


Augmented Dickey-Fuller Test Equation  
Dependent Variable: D(GDP)  
Method: Least Squares  
Date: 09/07/15 Time: 00:16  
Sample (adjusted): 1971 2014  
Included observations: 44 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP(-1)</td>
<td>-0.101433</td>
<td>0.034949</td>
<td>-2.902298</td>
<td>0.0067</td>
</tr>
<tr>
<td>D(GDP(-2))</td>
<td>0.786493</td>
<td>0.182932</td>
<td>4.267270</td>
<td>0.0002</td>
</tr>
<tr>
<td>D(GDP(-3))</td>
<td>0.296195</td>
<td>0.224213</td>
<td>1.321046</td>
<td>0.1959</td>
</tr>
<tr>
<td>D(GDP(-4))</td>
<td>-0.058511</td>
<td>0.218876</td>
<td>-0.267327</td>
<td>0.7909</td>
</tr>
<tr>
<td>D(GDP(-5))</td>
<td>0.043024</td>
<td>0.241939</td>
<td>0.177830</td>
<td>0.8600</td>
</tr>
<tr>
<td>D(GDP(-6))</td>
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<td>0.228921</td>
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<td>0.3150</td>
</tr>
<tr>
<td>D(GDP(-7))</td>
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<td>0.312770</td>
<td>0.636162</td>
<td>0.5292</td>
</tr>
<tr>
<td>D(GDP(-8))</td>
<td>-0.340043</td>
<td>0.295804</td>
<td>-1.149558</td>
<td>0.2588</td>
</tr>
<tr>
<td>D(GDP(-9))</td>
<td>0.356892</td>
<td>0.266961</td>
<td>1.336867</td>
<td>0.1907</td>
</tr>
<tr>
<td>D(GDP(-10))</td>
<td>0.546200</td>
<td>0.496305</td>
<td>1.100532</td>
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<tr>
<td>C</td>
<td>118.2303</td>
<td>77.27568</td>
<td>1.529981</td>
<td>0.1358</td>
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</table>

R-squared     0.835639  Mean dependent var  367.2436  
Adjusted R-squared 0.779139  S.D. dependent var  674.1485  
S.E. of regression  316.8215  Akaike info criterion  14.58155  
Sum squared resid  3212027  Schwarz criterion  15.06815  
Log likelihood -306.7942  Hannan-Quinn criterion  14.75201  
F-statistic  14.79027  Durbin-Watson stat  2.100692
Null Hypothesis: $H$ has a unit root  
Exogenous: Constant  
Lag Length: 5 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th></th>
<th>t-Statistic</th>
<th>Prob. $^*$</th>
</tr>
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<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
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<td>0.9384</td>
</tr>
<tr>
<td>Test critical values:</td>
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</tr>
<tr>
<td>1% level</td>
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</tr>
<tr>
<td>5% level</td>
<td>-2.922449</td>
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</tr>
<tr>
<td>10% level</td>
<td>-2.599224</td>
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Augmented Dickey-Fuller Test Equation  
Dependent Variable: D($H$)  
Method: Least Squares  
Date: 09/07/15   Time: 00:13  
Sample (adjusted): 1965-2014  
Included observations: 49 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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</thead>
<tbody>
<tr>
<td>$H(-1)$</td>
<td>-0.002605</td>
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</tr>
<tr>
<td>D($H(-1)$)</td>
<td>0.374550</td>
<td>0.149437</td>
<td>2.506400</td>
<td>0.0162</td>
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<tr>
<td>D($H(2)$)</td>
<td>0.271994</td>
<td>0.163800</td>
<td>1.660461</td>
<td>0.1043</td>
</tr>
<tr>
<td>D($H(-3)$)</td>
<td>-0.030288</td>
<td>0.171982</td>
<td>-0.178113</td>
<td>0.8611</td>
</tr>
<tr>
<td>D($H(-4)$)</td>
<td>-0.113525</td>
<td>0.166311</td>
<td>-0.682606</td>
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<tr>
<td>D($H(-5)$)</td>
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<td>0.2721</td>
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</table>

R-squared 0.402178  Mean dependent var 2647.531  
Adjusted R-squared 0.315775  S.D. dependent var 5283.262  
S.E. of regression 4367.007  Akaike info criterion 19.73311  
Sum squared resid 8.01E+08  Schwarz criterion 20.00337  
Log likelihood -476.4611  Hannan-Quinn criterion 19.83564  
F-statistic 4.700180  Durbin-Watson stat 1.973112  
Prob(F-statistic) 0.000951
Null Hypothesis: P has a unit root  
Exogenous: Constant  
Lag Length: 12 (Automatic based on AIC, MAXLAG=14)  

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.462574</td>
<td>0.4360</td>
</tr>
<tr>
<td>5% level</td>
<td>-2.875608</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.574346</td>
<td></td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation  
Dependent Variable: D(P)  
Method: Least Squares  
Date: 09/07/15, Time: 00:19  
Sample (adjusted): 1963Q4 2013Q4  
included observations: 203 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(-1)</td>
<td>-0.000338</td>
<td>0.000200</td>
<td>-1.689598</td>
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</tr>
<tr>
<td>D(P(-1))</td>
<td>3.226160</td>
<td>0.069953</td>
<td>46.11919</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-2))</td>
<td>-4.185962</td>
<td>0.224388</td>
<td>-18.65501</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-3))</td>
<td>2.783927</td>
<td>0.340809</td>
<td>8.168572</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-4))</td>
<td>-2.393858</td>
<td>0.369710</td>
<td>-6.474966</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-5))</td>
<td>4.609716</td>
<td>0.385855</td>
<td>11.86281</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-6))</td>
<td>-5.672559</td>
<td>0.453687</td>
<td>-12.80328</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-7))</td>
<td>3.618238</td>
<td>0.464356</td>
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<td>0.0000</td>
</tr>
<tr>
<td>D(P(-8))</td>
<td>-1.885164</td>
<td>0.408643</td>
<td>-4.610977</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-9))</td>
<td>-2.470623</td>
<td>0.391193</td>
<td>-6.315617</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-10))</td>
<td>-2.872474</td>
<td>0.378631</td>
<td>-7.586480</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-11))</td>
<td>1.853259</td>
<td>0.286734</td>
<td>6.152034</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(P(-12))</td>
<td>-0.371478</td>
<td>0.087489</td>
<td>-4.245983</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>56.944558</td>
<td>27.98512</td>
<td>2.034816</td>
<td>0.0433</td>
</tr>
</tbody>
</table>

R-squared 0.996372  Mean dependent var 519.8001  
Adjusted R-squared 0.996122  S.D. dependent var 1348.517  
S.E. of regression 83.97164  Akaike info criterion 11.76531  
Sum squared resid 1332684  Schwarz criterion 11.99380

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

Null Hypothesis: H has a unit root
Exogenous: Constant
Lag Length: 13 (Automatic based on AIC, MAXLAG=14)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-0.401091</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.462737
- 5% level: -2.875680
- 10% level: -2.574305


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(H)
Method: Least Squares
Date: 09/07/15 Time: 00:22
Sample (adjusted): 1953Q3 2013Q4
Included observations: 202 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(-1)</td>
<td>-5.00E-05</td>
<td>0.000125</td>
<td>-0.401091</td>
<td>0.6888</td>
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<tr>
<td>D(H(-1))</td>
<td>-3.067678</td>
<td>0.072058</td>
<td>-42.84974</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-2))</td>
<td>-3.689423</td>
<td>0.240800</td>
<td>-15.32151</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-3))</td>
<td>2.072793</td>
<td>0.369182</td>
<td>5.614551</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-4))</td>
<td>-1.919473</td>
<td>0.371913</td>
<td>-5.161077</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-5))</td>
<td>4.400782</td>
<td>0.371920</td>
<td>11.83228</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-6))</td>
<td>-5.136141</td>
<td>0.493180</td>
<td>-10.41433</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-7))</td>
<td>2.585494</td>
<td>0.611771</td>
<td>4.226244</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-8))</td>
<td>-0.891114</td>
<td>0.516877</td>
<td>-1.724033</td>
<td>0.0864</td>
</tr>
<tr>
<td>D(H(-9))</td>
<td>1.790728</td>
<td>0.379695</td>
<td>4.716229</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-10))</td>
<td>-2.228718</td>
<td>0.371991</td>
<td>-5.991317</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(H(-11))</td>
<td>0.913150</td>
<td>0.381407</td>
<td>2.394160</td>
<td>0.0176</td>
</tr>
<tr>
<td>D(H(-12))</td>
<td>0.197297</td>
<td>0.261925</td>
<td>0.753256</td>
<td>0.4522</td>
</tr>
<tr>
<td>D(H(-13))</td>
<td>-0.207400</td>
<td>0.080523</td>
<td>-2.575675</td>
<td>0.0100</td>
</tr>
<tr>
<td>C</td>
<td>21.17232</td>
<td>15.29096</td>
<td>1.384630</td>
<td>0.1678</td>
</tr>
</tbody>
</table>

R-squared   0.997974    Mean dependent var  899.1772
Adjusted R-squared 0.997822   S.D. dependent var  1360.160
S.E. of regression 63.47227      Akaike info criterion  11.21044

Doctoral Dissertation Sophia A. Kassapi
Null Hypothesis: P has a unit root  
Exogenous: Constant  
Lag Length: 1 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th>Test critical values:</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% level</td>
<td>-2.267630</td>
<td>0.1860</td>
</tr>
<tr>
<td>5% level</td>
<td>-3.560019</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.917650</td>
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</tr>
<tr>
<td></td>
<td>-2.598689</td>
<td></td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation  
Dependent Variable: D(P)  
Method: Least Squares  
Date: 09/06/15  Time: 23:47  
Sample (adjusted): 1962 2014  
Included observations: 53 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(-1)</td>
<td>-0.042195</td>
<td>0.018867</td>
<td>-2.267630</td>
<td>0.0277</td>
</tr>
<tr>
<td>D(P(-1))</td>
<td>0.260348</td>
<td>0.132404</td>
<td>1.966318</td>
<td>0.0548</td>
</tr>
<tr>
<td>C</td>
<td>6956.695</td>
<td>2509.852</td>
<td>2.775341</td>
<td>0.0077</td>
</tr>
</tbody>
</table>

R-squared: 0.194451  
Adjusted R-squared: 0.162229  
S.E. of regression: 4679.975  
Sum squared resid: 1.10E+09  
Log likelihood: -521.5652  
F-statistic: 6.034739  
Prob(F-statistic): 0.004491

Mean dependent var: 2228.189  
S.D. dependent var: 5113.060  
Akaike info criterion: 19.79491  
Schwarz criterion: 19.90644  
Hannan-Quinn criter.: 19.83780  
Durbin-Watson stat: 2.015120
Null Hypothesis: S has a unit root
Exogenous: Constant
Lag Length: 13 (Automatic based on AIC, MAXLAG=14)

<table>
<thead>
<tr>
<th></th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-1.830838</td>
<td>0.3648</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.462737
- 5% level: -2.875689
- 10% level: -2.574385


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(S)
Method: Least Squares
Date: 09/07/15 Time: 00:21
Sample (adjusted): 1963Q3 2013Q4
Included observations: 202 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S(-1)</td>
<td>-0.000624</td>
<td>0.000341</td>
<td>-1.830838</td>
<td>0.0687</td>
</tr>
<tr>
<td>D(S(-1))</td>
<td>3.061578</td>
<td>0.073749</td>
<td>41.51338</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-2))</td>
<td>-9.300632</td>
<td>0.237374</td>
<td>-15.29500</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-3))</td>
<td>2.024856</td>
<td>0.347865</td>
<td>5.82086</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-4))</td>
<td>-1.875566</td>
<td>0.332741</td>
<td>-5.63671</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-5))</td>
<td>4.249609</td>
<td>0.324648</td>
<td>13.08990</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-6))</td>
<td>-4.927582</td>
<td>0.443312</td>
<td>-11.15538</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-7))</td>
<td>2.543296</td>
<td>0.542891</td>
<td>4.684729</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-8))</td>
<td>-1.090670</td>
<td>0.447902</td>
<td>-2.435067</td>
<td>0.0158</td>
</tr>
<tr>
<td>D(S(-9))</td>
<td>2.058711</td>
<td>0.325325</td>
<td>6.320178</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-10))</td>
<td>-2.448161</td>
<td>0.325802</td>
<td>-7.424497</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(S(-11))</td>
<td>1.119033</td>
<td>0.347164</td>
<td>3.223301</td>
<td>0.0015</td>
</tr>
<tr>
<td>D(S(-12))</td>
<td>0.014145</td>
<td>0.240605</td>
<td>0.058793</td>
<td>0.9532</td>
</tr>
<tr>
<td>D(S(-13))</td>
<td>-0.126754</td>
<td>0.076392</td>
<td>-1.659253</td>
<td>0.0997</td>
</tr>
<tr>
<td>C</td>
<td>405.4434</td>
<td>223.3790</td>
<td>1.815047</td>
<td>0.0711</td>
</tr>
</tbody>
</table>

R-squared: 0.996420
Adjusted R-squared: 0.996152
S.E. of regression: 499.6803


"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεά Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."
Null Hypothesis: S has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on AIC, MAXLAG=10)

<table>
<thead>
<tr>
<th></th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-2.619939</td>
<td>0.0953</td>
</tr>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.557472</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-2.916566</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.596116</td>
<td></td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(S)
Method: Least Squares
Date: 09/07/15    Time: 00:10
Sample (adjusted): 1981 2014
Included observations: 54 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S(-1)</td>
<td>-0.076253</td>
<td>0.029105</td>
<td>-2.619939</td>
<td>0.0115</td>
</tr>
<tr>
<td>C</td>
<td>50804.64</td>
<td>17887.87</td>
<td>2.840174</td>
<td>0.0064</td>
</tr>
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</table>

R-squared 0.116609 Mean dependent var 5130.667
Adjusted R-squared 0.099621 S.D. dependent var 31033.98
S.E. of regression 29447.63 Akaike info criterion 23.45495
Sum squared resid 4.51E+10 Schwarz criterion 23.52861
Log likelihood -631.2836 Hannan-Quinn citer. 23.48336
F-statistic 6.864081 Durbin-Watson stat 1.682365
Prob(F-statistic) 0.011501
COINTEGRATION TESTS- SAMPLE 216 OBSERVATIONS

Τα Μακροπρόθεσμα Αποτέλεσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.190768</td>
<td>134.7809</td>
<td>95.75366</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.139337</td>
<td>90.11873</td>
<td>69.81889</td>
<td>0.0005</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.125598</td>
<td>58.45773</td>
<td>47.85613</td>
<td>0.0037</td>
</tr>
<tr>
<td>At most 3 *</td>
<td>0.080225</td>
<td>30.13841</td>
<td>29.79707</td>
<td>0.0457</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.050315</td>
<td>12.49338</td>
<td>15.49471</td>
<td>0.1347</td>
</tr>
<tr>
<td>At most 5</td>
<td>0.007556</td>
<td>1.600454</td>
<td>3.841466</td>
<td>0.2058</td>
</tr>
</tbody>
</table>

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
** Mackinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.190768</td>
<td>44.66219</td>
<td>40.07757</td>
<td>0.0142</td>
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<tr>
<td>At most 1</td>
<td>0.139337</td>
<td>31.66100</td>
<td>33.87587</td>
<td>0.0899</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.125598</td>
<td>28.31932</td>
<td>27.58434</td>
<td>0.0402</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.080225</td>
<td>17.64503</td>
<td>21.13612</td>
<td>0.1437</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.050315</td>
<td>10.89293</td>
<td>14.26460</td>
<td>0.1596</td>
</tr>
<tr>
<td>At most 5</td>
<td>0.007556</td>
<td>1.600454</td>
<td>3.841466</td>
<td>0.2058</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
** Mackinnon-Haug-Michelis (1999) p-values

Doctoral Dissertation Sophia A. Kassapi
Pairwise Granger Causality Tests

Date: 09/07/15   Time: 00:31

Sample: 1960Q1 2013Q4

Lags: 2

<table>
<thead>
<tr>
<th>Null Hypothesis:</th>
<th>Obs</th>
<th>F-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(E) does not Granger Cause D(P)</td>
<td>213</td>
<td>0.374899954</td>
<td>0.687821548</td>
</tr>
<tr>
<td>D(P) does not Granger Cause D(E)</td>
<td></td>
<td>0.136903381</td>
<td>0.872132993</td>
</tr>
<tr>
<td>D(S) does not Granger Cause D(P)</td>
<td>213</td>
<td>0.345768188</td>
<td>0.708082496</td>
</tr>
</tbody>
</table>

### Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Lags</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(P) does not Granger Cause D(S)</td>
<td>5.119000596</td>
<td>0.00675815</td>
<td></td>
</tr>
<tr>
<td>D(H) does not Granger Cause D(P)</td>
<td>0.144931518</td>
<td>0.865168819</td>
<td></td>
</tr>
<tr>
<td>D(P) does not Granger Cause D(H)</td>
<td>0.951603155</td>
<td>0.38795968</td>
<td></td>
</tr>
<tr>
<td>D(EDEX) does not Granger Cause D(P)</td>
<td>1.906846904</td>
<td>0.151135786</td>
<td></td>
</tr>
<tr>
<td>D(P) does not Granger Cause D(EDEX)</td>
<td>3.235862063</td>
<td>0.041314486</td>
<td></td>
</tr>
<tr>
<td>D(GDP) does not Granger Cause D(P)</td>
<td>3.867607281</td>
<td>0.022428414</td>
<td></td>
</tr>
<tr>
<td>D(P) does not Granger Cause D(GDP)</td>
<td>4.579007626</td>
<td>0.011321319</td>
<td></td>
</tr>
<tr>
<td>D(S) does not Granger Cause D(E)</td>
<td>0.683787654</td>
<td>0.505832573</td>
<td></td>
</tr>
<tr>
<td>D(E) does not Granger Cause D(S)</td>
<td>0.806711438</td>
<td>0.447714844</td>
<td></td>
</tr>
</tbody>
</table>

---

**Doctoral Dissertation Sophia A. Kassapi**

Σελίδα 277
D(H) does not Granger Cause D(E)  | 213  | 5.268731045  | 0.005859948
D(E) does not Granger Cause D(H)  | 3.955655659  | 0.020603725

D(EDEX) does not Granger Cause D(E)  | 213  | 0.206214255  | 0.813824872
D(E) does not Granger Cause D(EDEX)  | 0.362957273  | 0.69605843

D(GDP) does not Granger Cause D(E)  | 213  | 3.361815824  | 0.036566473
D(E) does not Granger Cause D(GDP)  | 2.522255069  | 0.082731461

D(H) does not Granger Cause D(S)  | 213  | 4.277183553  | 0.015122529
D(S) does not Granger Cause D(H)  | 0.775034158  | 0.462013785

D(EDEX) does not Granger Cause D(S)  | 213  | 1.306674232  | 0.272931698
<table>
<thead>
<tr>
<th></th>
<th>D(S) does not Granger Cause D(EDEX)</th>
<th>D(GDP) does not Granger Cause D(S)</th>
<th>D(S) does not Granger Cause D(GDP)</th>
<th>D(EDEX) does not Granger Cause D(H)</th>
<th>D(H) does not Granger Cause D(EDEX)</th>
<th>D(GDP) does not Granger Cause D(H)</th>
<th>D(H) does not Granger Cause D(GDP)</th>
<th>D(GDP) does not Granger Cause D(EDEX)</th>
<th>D(EDEX) does not Granger Cause D(GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.325772305</td>
<td>0.31805505</td>
<td>3.707755257</td>
<td>0.448780927</td>
<td>0.484868339</td>
<td>0.21632492</td>
<td>1.795927697</td>
<td>157.3266716</td>
<td>40.16784591</td>
</tr>
<tr>
<td></td>
<td>0.03786596</td>
<td>0.727915945</td>
<td>0.026168685</td>
<td>0.639022628</td>
<td>0.6164725</td>
<td>0.805654532</td>
<td>0.168537431</td>
<td>2.42303E-42</td>
<td>1.77481E-15</td>
</tr>
<tr>
<td></td>
<td>213</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST
**VALENTYN PANCHENKO MODIFIED**

<table>
<thead>
<tr>
<th>Series length=213, embedding dimension=2, bandwidth=1.500000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: Edex.txt does not cause E.txt</td>
</tr>
<tr>
<td>T statistics=-2.992, p-value=0.99862</td>
</tr>
<tr>
<td>Null hypothesis: E.txt does not cause Edex.txt</td>
</tr>
<tr>
<td>T statistics=-2.101, p-value=0.98217</td>
</tr>
<tr>
<td>Null hypothesis: Edex.txt does not cause GDP.txt</td>
</tr>
<tr>
<td>T statistics=2.555, p-value=0.00530</td>
</tr>
<tr>
<td>Null hypothesis: GDP.txt does not cause Edex.txt</td>
</tr>
<tr>
<td>T statistics=1.741, p-value=0.04084</td>
</tr>
</tbody>
</table>
Null hypothesis: Edex.txt does not cause H.txt
T statistics=-0.179, p-value=0.57089

Null hypothesis: H.txt does not cause Edex.txt
T statistics=-1.748, p-value=0.95977

Null hypothesis: Edex.txt does not cause P.txt
T statistics=1.921, p-value=0.02737

Null hypothesis: P.txt does not cause Edex.txt
T statistics=0.727, p-value=0.23376
Null hypothesis: Edex.txt does not cause S.txt
T statistics=1.326,
p-value=0.09240

Null hypothesis: S.txt does not cause Edex.txt
T statistics=1.013,
p-value=0.15553

Null hypothesis: E.txt does not cause H.txt
T statistics=-0.090,
p-value=0.53584

Null hypothesis: H.txt does not cause E.txt
T statistics=1.717,
p-value=0.04297

Null hypothesis: GDP.txt does not cause E.txt

Null hypothesis: E.txt does not cause GDP.txt
<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP.txt does not cause P.txt</td>
<td>-2.128</td>
<td>0.98335</td>
</tr>
<tr>
<td>Null hypothesis:</td>
<td>-0.904</td>
<td>0.81691</td>
</tr>
<tr>
<td>GDP.txt does not cause S.txt</td>
<td>0.406</td>
<td>0.34252</td>
</tr>
<tr>
<td>Null hypothesis:</td>
<td>1.274</td>
<td>0.10132</td>
</tr>
<tr>
<td>P.txt does not cause GDP.txt</td>
<td>0.244</td>
<td>0.40357</td>
</tr>
<tr>
<td>Null hypothesis:</td>
<td>0.693</td>
<td>0.24406</td>
</tr>
</tbody>
</table>
Null hypothesis: 
GDP.txt does not cause H.txt

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP.txt does not cause H.txt</td>
<td>H.txt does not cause GDP.txt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.296,</td>
<td>0.61638</td>
</tr>
</tbody>
</table>

Null hypothesis: 
S.txt does not cause H.txt

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.txt does not cause H.txt</td>
<td>H.txt does not cause S.txt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.161,</td>
<td>0.12284</td>
</tr>
</tbody>
</table>

Null hypothesis: 
P.txt does not cause E.txt

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.txt does not cause E.txt</td>
<td>E.txt does not cause P.txt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.866,</td>
<td>0.19334</td>
</tr>
<tr>
<td>T statistics</td>
<td>p-value</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>-0.320</td>
<td>0.62563</td>
</tr>
<tr>
<td><strong>Null hypothesis:</strong></td>
<td></td>
</tr>
<tr>
<td>P.txt does not cause H.txt</td>
<td></td>
</tr>
<tr>
<td>-0.502</td>
<td>0.69219</td>
</tr>
<tr>
<td><strong>Null hypothesis:</strong></td>
<td></td>
</tr>
<tr>
<td>P.txt does not cause S.txt</td>
<td></td>
</tr>
<tr>
<td>0.850</td>
<td>0.19755</td>
</tr>
</tbody>
</table>
ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST
On var residuals
Series length=213, embedding dimension=2, bandwidth=0.600000
VALENTYN PANCHENKO MODIFIED

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edex.txt does not cause GDP.txt</td>
<td>GDP.txt does not cause Edex.txt</td>
</tr>
<tr>
<td>T statistics=2.047, p-value=0.02034</td>
<td>T statistics=1.739, p-value=0.04099</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edex.txt does not cause E.txt</td>
<td>E.txt does not cause Edex.txt</td>
</tr>
</tbody>
</table>

### Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>Null hypothesis: Edex.txt does not cause H.txt</th>
<th>Null hypothesis: H.txt does not cause Edex.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>T statistics = -1.129, p-value = 0.87061</td>
<td>T statistics = -0.203, p-value = 0.58047</td>
</tr>
<tr>
<td>T statistics = 0.523, p-value = 0.30045</td>
<td>T statistics = 0.603, p-value = 0.27328</td>
</tr>
<tr>
<td>Null hypothesis: Edex.txt does not cause P.txt</td>
<td>Null hypothesis: P.txt does not cause Edex.txt</td>
</tr>
<tr>
<td>T statistics = -0.252, p-value = 0.59941</td>
<td>T statistics = -0.759, p-value = 0.77594</td>
</tr>
<tr>
<td>Null hypothesis: Edex.txt does not cause S.txt</td>
<td>Null hypothesis: S.txt does not cause Edex.txt</td>
</tr>
<tr>
<td>T statistics = 0.523, p-value = 0.30045</td>
<td>T statistics = 0.603, p-value = 0.27328</td>
</tr>
</tbody>
</table>

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>Null hypothesis: GDP.txt does not cause P.txt</th>
<th>Null hypothesis: P.txt does not cause GDP.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>T statistics = -0.516, p-value = 0.69697</td>
<td>T statistics = 1.850, p-value = 0.03213</td>
</tr>
<tr>
<td>T statistics = -0.665, p-value = 0.74682</td>
<td>T statistics = -0.633, p-value = 0.73648</td>
</tr>
<tr>
<td>Null hypothesis: GDP.txt does not cause E.txt</td>
<td>Null hypothesis: E.txt does not cause GDP.txt</td>
</tr>
<tr>
<td>T statistics = -0.243, p-value = 0.59604</td>
<td>T statistics = 0.325, p-value = 0.37270</td>
</tr>
</tbody>
</table>

Doctoral Dissertation Sophia A. Kassapi
Null hypothesis: GDP.txt does not cause H.txt
T statistics = 0.379, p-value = 0.35229

Null hypothesis: H.txt does not cause GDP.txt
T statistics = -0.521, p-value = 0.69886

Null hypothesis: GDP.txt does not cause S.txt
T statistics = -0.147, p-value = 0.55849

Null hypothesis: S.txt does not cause GDP.txt
T statistics = 2.203, p-value = 0.01379

Null hypothesis: E.txt does not cause H.txt
Null hypothesis: H.txt does not cause E.txt
<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.txt does not cause S.txt</td>
<td>-0.253</td>
<td>0.60003</td>
</tr>
<tr>
<td>S.txt does not cause E.txt</td>
<td>2.041</td>
<td>0.02065</td>
</tr>
<tr>
<td>E.txt does not cause S.txt</td>
<td>1.623</td>
<td>0.05229</td>
</tr>
<tr>
<td>S.txt does not cause E.txt</td>
<td>0.260</td>
<td>0.39746</td>
</tr>
<tr>
<td>P.txt does not cause E.txt</td>
<td>-0.474</td>
<td>0.68230</td>
</tr>
<tr>
<td>E.txt does not cause P.txt</td>
<td>1.284</td>
<td>0.09961</td>
</tr>
<tr>
<td>Null hypothesis:</td>
<td>Null hypothesis:</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>P.txt does not cause H.txt</td>
<td>H.txt does not cause P.txt</td>
<td></td>
</tr>
<tr>
<td>T statistics=-1.113,</td>
<td>T statistics=-0.297,</td>
<td></td>
</tr>
<tr>
<td>p-value=0.86707</td>
<td>p-value=0.61683</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.txt does not cause S.txt</td>
<td>S.txt does not cause P.txt</td>
</tr>
<tr>
<td>T statistics=0.958,</td>
<td>T statistics=1.149,</td>
</tr>
<tr>
<td>p-value=0.16906</td>
<td>p-value=0.12519</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Null hypothesis:</th>
<th>Null hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.txt does not cause H.txt</td>
<td>H.txt does not cause S.txt</td>
</tr>
</tbody>
</table>
T statistics=0.932, p-value=0.17573

T statistics=1.103, p-value=0.13496

ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST
On VAR residuals
Series length=213, embedding dimension=2, bandwidth=1.319
VALENTYN PANCHENKO MODIFIED

Series length=213, embedding dimension=2, bandwidth=1.319000
Null hypothesis: Edex.txt does not cause GDP.txt
T statistics=2.429, p-value=0.00758

Null hypothesis: GDP.txt does not cause Edex.txt
T statistics=1.727, p-value=0.04206

| Series length=213, embedding dimension=2, bandwidth=1.319000 | Null hypothesis: Edex.txt does not cause P.txt
T statistics=1.095, p-value=0.13678 |
|---|---|
| Null hypothesis: P.txt does not cause Edex.txt
T statistics=0.723, p-value=0.23495 |

| Series length=213, embedding dimension=2, bandwidth=1.319000 | Null hypothesis: Edex.txt does not cause E.txt
T statistics=-2.245, p-value=0.98762 |
|---|---|
| Null hypothesis: E.txt does not cause Edex.txt
T statistics=-2.165, p-value=0.98481 |

| Series length=213, embedding dimension=2, bandwidth=1.319000 | Null hypothesis: Edex.txt does not cause S.txt
T statistics=1.148, p-value=0.12550 |
|---|---|
| Null hypothesis: S.txt does not cause Edex.txt
T statistics=1.751, p-value=0.03994 |
### Null hypothesis: Edex.txt does not cause H.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.413</td>
<td>0.33982</td>
</tr>
</tbody>
</table>

### Null hypothesis: H.txt does not cause Edex.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.194</td>
<td>0.42315</td>
</tr>
</tbody>
</table>

### Null hypothesis: GDP.txt does not cause P.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.198</td>
<td>0.57830</td>
</tr>
</tbody>
</table>

### Null hypothesis: P.txt does not cause GDP.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.197</td>
<td>0.11558</td>
</tr>
</tbody>
</table>

### Null hypothesis: GDP.txt does not cause E.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.235</td>
<td>0.89165</td>
</tr>
</tbody>
</table>

### Null hypothesis: E.txt does not cause GDP.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.465</td>
<td>0.67919</td>
</tr>
</tbody>
</table>

### Null hypothesis: GDP.txt does not cause S.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.596</td>
<td>0.27567</td>
</tr>
</tbody>
</table>

### Null hypothesis: S.txt does not cause GDP.txt

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.321</td>
<td>0.09332</td>
</tr>
</tbody>
</table>
Null hypothesis: GDP.txt does not cause H.txt
T statistics=-0.244, p-value=0.59643

Null hypothesis: H.txt does not cause GDP.txt
T statistics=-1.493, p-value=0.93231

Series length=213, embedding dimension=2, bandwidth=1.319000

Null hypothesis: P.txt does not cause E.txt
T statistics=0.088, p-value=0.46493

Null hypothesis: E.txt does not cause P.txt
T statistics=-0.884, p-value=0.81156

Series length=213, embedding dimension=2, bandwidth=1.319000

Null hypothesis: P.txt does not cause S.txt
T statistics=1.701, p-value=0.04447

Null hypothesis: S.txt does not cause P.txt
T statistics=0.563, p-value=0.28661

Series length=213, embedding dimension=2, bandwidth=1.319000

Null hypothesis: P.txt does not cause H.txt
T statistics=-0.049, p-value=0.51936

Null hypothesis: H.txt does not cause P.txt
### T-statistics and p-values

<table>
<thead>
<tr>
<th>Series Length</th>
<th>Embedding Dimension</th>
<th>Bandwidth</th>
<th>T-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>213</td>
<td>2</td>
<td>1.319000</td>
<td>-1.769</td>
<td>0.96156</td>
</tr>
</tbody>
</table>

Null hypothesis: E.txt does not cause S.txt

T-statistic = 1.361, p-value = 0.08671

Null hypothesis: S.txt does not cause E.txt

T-statistic = 0.240, p-value = 0.40501

<table>
<thead>
<tr>
<th>Series Length</th>
<th>Embedding Dimension</th>
<th>Bandwidth</th>
<th>T-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>213</td>
<td>2</td>
<td>1.319000</td>
<td>0.710</td>
<td>0.23870</td>
</tr>
</tbody>
</table>

Null hypothesis: E.txt does not cause H.txt

T-statistic = 1.157, p-value = 0.12368

Null hypothesis: S.txt does not cause H.txt

T-statistic = 1.157, p-value = 0.12368

Null hypothesis: H.txt does not cause E.txt

T-statistic = 1.499, p-value = 0.06695

Null hypothesis: H.txt does not cause S.txt

T-statistic = 1.212, p-value = 0.11283
ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST
On var residuals

Series length=213, embedding dimension=2, bandwidth=0.33

Cees Diks & Marcin (2012) Wolski MODIFIED

<table>
<thead>
<tr>
<th>Series length</th>
<th>embedding dimension</th>
<th>bandwidth</th>
<th>Null hypothesis: Edex.txt does not cause GDP.txt</th>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>213</td>
<td>2</td>
<td>0.33</td>
<td>GDP.txt does not cause Edex.txt</td>
<td>1.619</td>
<td>0.05275</td>
</tr>
<tr>
<td>213</td>
<td>2</td>
<td>0.33</td>
<td>P.txt does not cause Edex.txt</td>
<td>2.345</td>
<td>0.00950</td>
</tr>
</tbody>
</table>

Null hypothesis: GDP.txt does not cause Edex.txt
T statistics=2.345, p-value=0.00950
Null hypothesis: P.txt does not cause Edex.txt
null hypothesis: Edex.txt does not cause E.txt
T statistics=-0.527, p-value=0.70088
null hypothesis: E.txt does not cause Edex.txt
T statistics=1.322, p-value=0.09313

null hypothesis: Edex.txt does not cause S.txt
T statistics=0.002, p-value=0.49917
null hypothesis: S.txt does not cause Edex.txt
T statistics=1.783, p-value=0.03733

null hypothesis: Edex.txt does not cause H.txt
T statistics=0.493, p-value=0.31110
null hypothesis: H.txt does not cause Edex.txt
T statistics=0.627, p-value=0.26542
<table>
<thead>
<tr>
<th>Series length=213, embedding dimension=2, bandwidth=0.330000</th>
<th>T statistics=0.569, p-value=0.28469</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: GDP.txt does not cause P.txt</td>
<td>Null hypothesis: P.txt does not cause GDP.txt</td>
</tr>
<tr>
<td>T statistics=1.282, p-value=0.09987</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=213, embedding dimension=2, bandwidth=0.330000</th>
<th>T statistics=0.530, p-value=0.29815</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: GDP.txt does not cause E.txt</td>
<td>Null hypothesis: E.txt does not cause GDP.txt</td>
</tr>
<tr>
<td>T statistics=1.744, p-value=0.04061</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=213, embedding dimension=2, bandwidth=0.330000</th>
<th>T statistics=-0.270, p-value=0.60659</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: GDP.txt does not cause S.txt</td>
<td>Null hypothesis: S.txt does not cause GDP.txt</td>
</tr>
<tr>
<td>T statistics=2.186, p-value=0.01441</td>
<td></td>
</tr>
</tbody>
</table>
bandwidth=0.330000

<table>
<thead>
<tr>
<th>Null hypothesis: GDP.txt does not cause H.txt</th>
<th>Null hypothesis: H.txt does not cause GDP.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>T statistics=-0.328, p-value=0.62846</td>
<td>T statistics=0.555, p-value=0.28941</td>
</tr>
</tbody>
</table>

series length=213, embedding dimension=2,
bandwidth=0.330000

<table>
<thead>
<tr>
<th>Null hypothesis: P.txt does not cause E.txt</th>
<th>Null hypothesis: E.txt does not cause P.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>T statistics=0.341, p-value=0.36667</td>
<td>T statistics=0.789, p-value=0.21506</td>
</tr>
</tbody>
</table>

series length=213, embedding dimension=2,
bandwidth=0.330000

<table>
<thead>
<tr>
<th>Null hypothesis: P.txt does not cause S.txt</th>
<th>Null hypothesis: S.txt does not cause P.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>T statistics=0.505, p-value=0.30675</td>
<td>T statistics=0.506, p-value=0.30653</td>
</tr>
</tbody>
</table>

series length=213, embedding dimension=2,
bandwidth=0.330000

<table>
<thead>
<tr>
<th>Null hypothesis: P.txt does not cause H.txt</th>
<th>Null hypothesis: H.txt does not cause P.txt</th>
</tr>
</thead>
</table>

series length=213, embedding dimension=2,
bandwidth=0.330000

### “Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.”

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.143</td>
<td>0.44307</td>
</tr>
</tbody>
</table>

**Series length=213, embedding dimension=2, bandwidth=0.330000**

Null hypothesis: E.txt does not cause S.txt

T statistics=1.357, p-value=0.08739

Null hypothesis: S.txt does not cause E.txt

T statistics=0.161, p-value=0.43592

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.859</td>
<td>0.80480</td>
</tr>
</tbody>
</table>

### Series length=213, embedding dimension=2, bandwidth=0.330000

Null hypothesis: E.txt does not cause H.txt

T statistics=0.466, p-value=0.32060

Null hypothesis: H.txt does not cause E.txt

T statistics=0.491, p-value=0.31178

<table>
<thead>
<tr>
<th>T statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.385</td>
<td>0.08299</td>
</tr>
</tbody>
</table>

### Series length=213, embedding dimension=2, bandwidth=0.330000

Null hypothesis: S.txt does not cause H.txt

T statistics=1.385, p-value=0.08299

Null hypothesis: H.txt does not cause S.txt

T statistics=0.744, p-value=0.22836

---

*Doctoral Dissertation Sophia A. Kassapi*
ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST
On EGARCH FILTERED RESIDUALS
Series length=214, embedding dimension=2, bandwidth=1.319
VALENTYN PANCHENKO MODIFIED

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=1.319000</th>
<th>Series length=214, embedding dimension=2, bandwidth=1.319000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: EDEXF EGARCH.txt does not cause GDPF EGARCH.txt</td>
<td>Null hypothesis: GDPF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=2.312, p-value=0.01039</td>
<td>T statistics=2.282, p-value=0.01123</td>
</tr>
<tr>
<td>Null hypothesis: EDEXF EGARCH.txt does not cause PF EGARCH.txt</td>
<td>Null hypothesis: PF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>T statistics=1.415, p-value=0.07858</td>
<td>T statistics=-1.468, p-value=0.92891</td>
</tr>
<tr>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
</tr>
<tr>
<td>Null hypothesis: EDEXF EGARCH.txt does not cause SF EGARCH.txt</td>
<td>Null hypothesis: SF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=1.083, p-value=0.13937</td>
<td>T statistics=1.484, p-value=0.06895</td>
</tr>
<tr>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
</tr>
<tr>
<td>Null hypothesis: EDEXF EGARCH.txt does not cause HF EGARCH.txt</td>
<td>Null hypothesis: HF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=-1.278, p-value=0.89929</td>
<td>T statistics=-0.612, p-value=0.72977</td>
</tr>
<tr>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
</tr>
<tr>
<td>Null hypothesis: GDPF EGARCH.txt does not cause PF EGARCH.txt</td>
<td>Null hypothesis: GDPF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=-1.278, p-value=0.89929</td>
<td>T statistics=-0.612, p-value=0.72977</td>
</tr>
<tr>
<td>EGARCH.txt</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>T statistics=0.344, p-value=0.3656</td>
<td></td>
</tr>
<tr>
<td>Null hypothesis: GDPF EGARCH.txt does not cause SF EGARCH.txt</td>
<td></td>
</tr>
<tr>
<td>T statistics=0.063, p-value=0.47487</td>
<td></td>
</tr>
<tr>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
<td></td>
</tr>
<tr>
<td>Null hypothesis: GDPF EGARCH.txt does not cause HF EGARCH.txt</td>
<td></td>
</tr>
<tr>
<td>T statistics=-0.612, p-value=0.72967</td>
<td></td>
</tr>
</tbody>
</table>

| Null hypothesis: PF EGARCH.txt does not cause GDPF EGARCH.txt             |
| T statistics=0.680, p-value=0.24819                                       |

<table>
<thead>
<tr>
<th>EGARCH.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
</tr>
<tr>
<td>Null hypothesis: SF EGARCH.txt does not cause GDPF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=0.950, p-value=0.17105</td>
</tr>
</tbody>
</table>

| Null hypothesis: HF EGARCH.txt does not cause GDPF EGARCH.txt               |
| T statistics=-1.226, p-value=0.88990                                      |
Series length=214, embedding dimension=2, bandwidth=1.319000

| Null hypothesis: PF EGARCH.txt does not cause EF GARCH.txt |
|---------------------------------|---------------------------------|
| T statistics=0.077, p-value=0.46934 |

| Null hypothesis: EF GARCH.txt does not cause PF EGARCH.txt |
|---------------------------------|---------------------------------|
| T statistics=-1.969, p-value=0.97554 |

Series length=214, embedding dimension=2, bandwidth=1.319000

| Null hypothesis: PF EGARCH.txt does not cause SF EGARCH.txt |
|---------------------------------|---------------------------------|
| T statistics=0.326, p-value=0.37228 |

| Null hypothesis: SF EGARCH.txt does not cause PF EGARCH.txt |
|---------------------------------|---------------------------------|
| T statistics=-1.114, p-value=0.86735 |

Series length=214, embedding dimension=2, bandwidth=1.319000

| Null hypothesis: PF EGARCH.txt does not cause HF EGARCH.txt |
|---------------------------------|---------------------------------|
| T statistics=-1.126, p-value=0.86997 |

| Null hypothesis: HF EGARCH.txt does not cause PF EGARCH.txt |
|---------------------------------|---------------------------------|
\[ T \text{ statistics} = -2.358, \ p\text{-value} = 0.99081 \]

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=1.319000</th>
<th>T statistics=-2.358, p-value=0.99081</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: EF GARCH.txt does not cause SF EGARCH.txt</td>
<td>Null hypothesis: SF EGARCH.txt does not cause EF GARCH.txt</td>
</tr>
<tr>
<td>T statistics=0.423, p-value=0.33597</td>
<td>T statistics=0.296, p-value=0.38373</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=1.319000</th>
<th>T statistics=-0.661, p-value=0.74556</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: EF GARCH.txt does not cause HF EGARCH.txt</td>
<td>Null hypothesis: HF EGARCH.txt does not cause EF GARCH.txt</td>
</tr>
<tr>
<td>T statistics=-0.355, p-value=0.63853</td>
<td>T statistics=0.608, p-value=0.27143</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=1.319000</th>
<th>T statistics=0.608, p-value=0.27143</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: SF EGARCH.txt does not cause HF EGARCH.txt</td>
<td>Null hypothesis: HF EGARCH.txt does not cause SF EGARCH.txt</td>
</tr>
</tbody>
</table>

Doctoral Dissertation Sophia A. Kassapi
<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=1.319000</th>
<th>T statistics=1.067, p-value=0.14289</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: GDPF EGARCH.txt does not cause EF GARCH.txt</td>
<td>Null hypothesis: EF GARCH.txt does not cause GDPF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=-2.335, p-value=0.99022</td>
<td>T statistics=-0.747, p-value=0.77241</td>
</tr>
<tr>
<td>Series length=214, embedding dimension=2, bandwidth=1.319000</td>
<td></td>
</tr>
<tr>
<td>Null hypothesis: EDEXF EGARCH.txt does not cause EF GARCH.txt</td>
<td>Null hypothesis: EF GARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=-0.843, p-value=0.80032</td>
<td>T statistics=-3.220, p-value=0.99936</td>
</tr>
</tbody>
</table>

**ASYMPTOTIC NONLINEAR GRANGER CAUSALITY TEST**

**On EGARCH FILTERED RESIDUALS**

_Document as read:_


Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

Series length=214, embedding dimension=2, bandwidth= 0.33

DIKS AND WOLSKI MODIFIED

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Null hypothesis:</strong> EDEXF EGARCH.txt does not cause GDPF EGARCH.txt</td>
<td><strong>Null hypothesis:</strong> GDPF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=2.618, p-value=0.00442</td>
<td>T statistics=2.716, p-value=0.00330</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Null hypothesis:</strong> EDEXF EGARCH.txt does not cause PF EGARCH.txt</td>
<td><strong>Null hypothesis:</strong> PF EGARCH.txt does not cause EDEXF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=0.464, p-value=0.32150</td>
<td>T statistics=-0.950, p-value=0.82899</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
<th></th>
</tr>
</thead>
</table>
Null hypothesis: EDEXF EGARCH.txt does not cause EF GARCH.txt
T statistics=0.985, p-value=0.16240

Null hypothesis: EDEXF EGARCH.txt does not cause SF EGARCH.txt
T statistics=0.207, p-value=0.41818

Null hypothesis: EDEXF EGARCH.txt does not cause HF EGARCH.txt
T statistics=0.800, p-value=0.21192

Null hypothesis: EF GARCH.txt does not cause EDEXF EGARCH.txt
T statistics=-0.078, p-value=0.53119

Null hypothesis: SF EGARCH.txt does not cause EDEXF EGARCH.txt
T statistics=-0.439, p-value=0.66982

Null hypothesis: HF EGARCH.txt does not cause EDEXF EGARCH.txt
T statistics=0.523, p-value=0.30055

Series length=214, embedding dimension=2, bandwidth=0.330000

Series length=214, embedding dimension=2, bandwidth=0.330000

Series length=214, embedding dimension=2, bandwidth=0.330000

Series length=214, embedding dimension=2, bandwidth=0.330000
Null hypothesis: GDPF EGARCH.txt does not cause PF EGARCH.txt  
T statistics=0.867, p-value=0.19293

Null hypothesis: PF EGARCH.txt does not cause GDPF EGARCH.txt  
T statistics=0.270, p-value=0.39370

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
</tr>
</thead>
</table>

Null hypothesis: GDPF EGARCH.txt does not cause EF GARCH.txt  
T statistics=1.305, p-value=0.09594

Null hypothesis: EF GARCH.txt does not cause GDPF EGARCH.txt  
T statistics=0.970, p-value=0.16602

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
</tr>
</thead>
</table>

Null hypothesis: GDPF EGARCH.txt does not cause SF EGARCH.txt  
T statistics=-1.484, p-value=0.93113

Null hypothesis: SF EGARCH.txt does not cause GDPF EGARCH.txt  
T statistics=-1.644, p-value=0.94988

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
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</thead>
</table>
Null hypothesis: GDPF EGARCH.txt does not cause HF EGARCH.txt  
T statistics=0.742, p-value=0.22913

Null hypothesis: HF EGARCH.txt does not cause GDPF EGARCH.txt  
T statistics=-0.656, p-value=0.74410

Series length=214, embedding dimension=2, bandwidth=0.330000

Null hypothesis: PF NEW GARCH.txt does not cause SF EGARCH.txt  
T statistics=1.596, p-value=0.05522

Null hypothesis: SF EGARCH.txt does not cause PF NEW GARCH.txt  
T statistics=-0.432, p-value=0.66697

Series length=214, embedding dimension=2, bandwidth=0.330000

Null hypothesis: PF NEW GARCH.txt does not cause HF EGARCH.txt  
T statistics=0.845, p-value=0.19899

Null hypothesis: HF EGARCH.txt does not cause PF NEW GARCH.txt  
T statistics=0.111, p-value=0.45581

Series length=214, embedding dimension=2, bandwidth=0.330000

Doctoral Dissertation Sophia A. Kassapi

Σελίδα 311
<table>
<thead>
<tr>
<th>Null hypothesis: SF EGARCH.txt does not cause HF EGARCH.txt</th>
<th>T statistics=1.334, p-value=0.09102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: HF EGARCH.txt does not cause SF EGARCH.txt</td>
<td>T statistics=1.194, p-value=0.11624</td>
</tr>
<tr>
<td>Null hypothesis: PF NEW GARCH.txt does not cause EF GARCH.txt</td>
<td>T statistics=1.112, p-value=0.13301</td>
</tr>
<tr>
<td>Null hypothesis: EF GARCH.txt does not cause PF NEW GARCH.txt</td>
<td>T statistics=0.241, p-value=0.40495</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=0.330000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: EF GARCH.txt does not cause SF EGARCH.txt</td>
</tr>
<tr>
<td>Null hypothesis: SF EGARCH.txt does not cause EF GARCH.txt</td>
</tr>
</tbody>
</table>

Series length=214, embedding dimension=2, bandwidth=0.330000
Null hypothesis: EF GARCH.txt does not cause HF EGARCH.txt
T statistics=0.500, p-value=0.30847

Null hypothesis: HF EGARCH.txt does not cause EF GARCH.txt
T statistics=1.055, p-value=0.14578

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=2, bandwidth=1.500000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: GDPF EGARCH.txt does not cause SF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=-0.489, p-value=0.68743</td>
</tr>
</tbody>
</table>

Null hypothesis: SF EGARCH.txt does not cause GDPF EGARCH.txt
T statistics=1.004, p-value=0.15779

<table>
<thead>
<tr>
<th>Series length=214, embedding dimension=7, bandwidth=1.500000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis: GDPF EGARCH.txt does not cause SF EGARCH.txt</td>
</tr>
<tr>
<td>T statistics=0.086, p-value=0.46578</td>
</tr>
</tbody>
</table>

Null hypothesis: SF EGARCH.txt does not cause GDPF EGARCH.txt
T statistics=1.331, p-value=0.09164
**BOOTSTRAPPED NONLINEAR GRANGER**

**DP**

**DIKS & PANCHENKO MODIFIED**

\(E=0.6\) embed. Dim.=2 Realizations=1000

<table>
<thead>
<tr>
<th>C:\Users\sophi_000&gt;desktop\D1\grangers1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Input file 1: desktop\D1\e1.txt</td>
<td></td>
</tr>
<tr>
<td>214 data read</td>
<td></td>
</tr>
<tr>
<td>Input file 2: desktop\D1\e2.txt</td>
<td></td>
</tr>
<tr>
<td>214 data read</td>
<td></td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>l=-5 p-value = 0.770000</td>
<td></td>
</tr>
<tr>
<td>l=-4 p-value = 0.860000</td>
<td></td>
</tr>
<tr>
<td>l=-3 p-value = 0.780000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>0.860000</td>
</tr>
<tr>
<td>-1</td>
<td>0.780000</td>
</tr>
<tr>
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</tr>
<tr>
<td>1</td>
<td>0.970000</td>
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<tr>
<td>2</td>
<td>0.820000</td>
</tr>
<tr>
<td>3</td>
<td>0.410000</td>
</tr>
<tr>
<td>4</td>
<td>0.650000</td>
</tr>
<tr>
<td>5</td>
<td>0.690000</td>
</tr>
</tbody>
</table>

C:sophi_000>desktop
Input file 1: desktop\D1\e1=EDEX
214 data read
Input file 2: desktop\D1\e3=GDP
214 data read
seed:1
l=-5 p-value = 0.310000
l=-4 p-value = 0.160000
l=-3 p-value = 0.130000
### Parameter and Nonparametric Approach

<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
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</tr>
<tr>
<td>-1</td>
<td>0.020000</td>
</tr>
<tr>
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<td>0.020000</td>
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<tr>
<td>1</td>
<td>0.020000</td>
</tr>
<tr>
<td>2</td>
<td>0.090000</td>
</tr>
<tr>
<td>3</td>
<td>0.150000</td>
</tr>
<tr>
<td>4</td>
<td>0.110000</td>
</tr>
<tr>
<td>5</td>
<td>0.140000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D1\grangers1
Input file 1: desktop\D1\e1.txt
214 data read

Input file 2: desktop\D1\e4.txt
214 data read

seed: 1

<table>
<thead>
<tr>
<th>l</th>
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</thead>
<tbody>
<tr>
<td>-5</td>
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</tr>
<tr>
<td>-4</td>
<td>0.640000</td>
</tr>
<tr>
<td>-3</td>
<td>0.690000</td>
</tr>
<tr>
<td>-2</td>
<td>0.460000</td>
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</tbody>
</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.360000</td>
</tr>
<tr>
<td>1</td>
<td>0.880000</td>
</tr>
<tr>
<td>2</td>
<td>0.960000</td>
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<tr>
<td>3</td>
<td>0.850000</td>
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<tr>
<td>4</td>
<td>0.750000</td>
</tr>
<tr>
<td>5</td>
<td>0.820000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D1\grangers1
Input file 1: desktop\D1\e1.txt
214 data read
Input file 2: desktop\D1\e6.txt
214 data read
seed: 1
<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
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</tr>
<tr>
<td>-4</td>
<td>0.570000</td>
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<tr>
<td>-3</td>
<td>0.630000</td>
</tr>
<tr>
<td>-2</td>
<td>0.680000</td>
</tr>
<tr>
<td>-1</td>
<td>0.850000</td>
</tr>
<tr>
<td>0</td>
<td>0.850000</td>
</tr>
</tbody>
</table>

**Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.**

<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
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</tr>
<tr>
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<td>0.700000</td>
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<tr>
<td>4</td>
<td>0.860000</td>
</tr>
<tr>
<td>5</td>
<td>0.900000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000\desktop\D1\grangers1

- Input file 1: desktop\D1\e2.txt
- 214 data read
- Input file 2: desktop\D1\e3.txt
- 214 data read
- seed: 1

<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
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<tr>
<td>-2</td>
<td>0.660000</td>
</tr>
<tr>
<td>-1</td>
<td>0.990000</td>
</tr>
<tr>
<td>0</td>
<td>0.990000</td>
</tr>
<tr>
<td>1</td>
<td>0.950000</td>
</tr>
</tbody>
</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.570000</td>
</tr>
<tr>
<td>4</td>
<td>0.620000</td>
</tr>
<tr>
<td>5</td>
<td>0.620000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000\desktop\D1\grangers1
Input file 1: desktop\D1\e2.txt
214 data read
Input file 2: desktop\D1\e5.txt
214 data read
seed:1
<table>
<thead>
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<tbody>
<tr>
<td>-5</td>
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</tr>
<tr>
<td>-4</td>
<td>0.300000</td>
</tr>
<tr>
<td>-3</td>
<td>0.350000</td>
</tr>
<tr>
<td>-2</td>
<td>0.150000</td>
</tr>
<tr>
<td>-1</td>
<td>0.880000</td>
</tr>
<tr>
<td>0</td>
<td>0.880000</td>
</tr>
<tr>
<td>1</td>
<td>0.670000</td>
</tr>
<tr>
<td>2</td>
<td>0.200000</td>
</tr>
<tr>
<td>3</td>
<td>0.330000</td>
</tr>
</tbody>
</table>

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

| l=4 | p-value = 0.420000 |
| l=5 | p-value = 0.130000 |

C:\Users\sophi_000\desktop\D1\grangers1
Input file 1: desktop\D1\e2.txt
214 data read
Input file 2: desktop\D1\e6.txt
214 data read
seed:1

| l=-5 | p-value = 0.100000 |
| l=-4 | p-value = 0.550000 |
| l=-3 | p-value = 0.200000 |
| l=-2 | p-value = 0.090000 |
| l=-1 | p-value = 0.210000 |
| l=0  | p-value = 0.210000 |
| l=1  | p-value = 0.570000 |
| l=2  | p-value = 0.320000 |
| l=3  | p-value = 0.290000 |
| l=4  | p-value = 0.470000 |
```

l=5 p-value = 0.320000
C:\Users\sophi_000>desktop\D1\grangers1
Input file 1: desktop\D1\e3.txt
214 data read
Input file 2: desktop\D1\e4.txt
214 data read
seed: 1
l=-5 p-value = 0.680000
l=-4 p-value = 0.650000
l=-3 p-value = 0.480000
l=-2 p-value = 0.110000
l=-1 p-value = 0.380000
l=0 p-value = 0.380000
l=1 p-value = 0.420000
l=2 p-value = 0.210000
l=3 p-value = 0.380000
l=4 p-value = 0.280000
l=5 p-value = 0.140000
```

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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C:\Users\sophi_000>desktop\D1\grangers1
Input file 1: desktop\D1\e4.txt
214 data read
Input file 2: desktop\D1\e5.txt
214 data read
seed:1
l=−5 p-value = 0.300000
l=−4 p-value = 0.190000
l=−3 p-value = 0.610000
l=−2 p-value = 0.590000
l=−1 p-value = 0.460000
l=0 p-value = 0.460000
l=1 p-value = 0.120000
l=2 p-value = 0.400000
l=3 p-value = 0.160000

| l=4 p-value = 0.410000 |
| l=5 p-value = 0.120000 |
| C:sophi_000>desktop\D1\grangers1 |
| Input file 1: desktop\D1\e4.txt |
| 214 data read |
| Input file 2: desktop\D1\e6.txt |
| 214 data read |
| seed:1 |
| l=-5 p-value = 0.190000 |
| l=-4 p-value = 0.500000 |
| l=-3 p-value = 0.480000 |
| l=-2 p-value = 0.450000 |
| l=-1 p-value = 0.530000 |
| l=0 p-value = 0.530000 |
| l=1 p-value = 0.200000 |
| l=2 p-value = 0.130000 |
| l=3 p-value = 0.320000 |
| l=4 p-value = 0.300000 |

### Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>l=5 p-value</th>
<th>0.320000</th>
</tr>
</thead>
<tbody>
<tr>
<td>C:\Users\sophi_000\desktop\D1\grangersl</td>
<td></td>
</tr>
<tr>
<td>Input file 1: desktop\D1\e5.txt</td>
<td></td>
</tr>
<tr>
<td>214 data read</td>
<td></td>
</tr>
<tr>
<td>Input file 2: desktop\D1\e6.txt</td>
<td></td>
</tr>
<tr>
<td>214 data read</td>
<td></td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>l=-5 p-value</td>
<td>0.710000</td>
</tr>
<tr>
<td>l=-4 p-value</td>
<td>0.540000</td>
</tr>
<tr>
<td>l=-3 p-value</td>
<td>0.260000</td>
</tr>
<tr>
<td>l=-2 p-value</td>
<td>0.230000</td>
</tr>
<tr>
<td>l=-1 p-value</td>
<td>0.500000</td>
</tr>
<tr>
<td>l=0 p-value</td>
<td>0.500000</td>
</tr>
<tr>
<td>l=1 p-value</td>
<td>0.490000</td>
</tr>
<tr>
<td>l=2 p-value</td>
<td>0.260000</td>
</tr>
<tr>
<td>l=3 p-value</td>
<td>0.210000</td>
</tr>
<tr>
<td>l=4 p-value</td>
<td>0.500000</td>
</tr>
<tr>
<td>l=5 p-value</td>
<td>0.500000</td>
</tr>
</tbody>
</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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<table>
<thead>
<tr>
<th>(l)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>0.387097</td>
</tr>
<tr>
<td>-1</td>
<td>0.903226</td>
</tr>
<tr>
<td>0</td>
<td>0.903226</td>
</tr>
<tr>
<td>1</td>
<td>0.774194</td>
</tr>
<tr>
<td>2</td>
<td>0.903226</td>
</tr>
</tbody>
</table>

```
C:\Users\sophi_000>desktop\D2\grangers2
Input file 1: desktop\D2\e1.txt
214 data read
Input file 2: desktop\D2\e5.txt
214 data read
seed:1
l=2 p-value = 0.548387
l=1 p-value = 0.612903
l=0 p-value = 0.612903
l=1 p-value = 0.870968
l=2 p-value = 0.967742
C:\Users\sophi_000>desktop\D2\grangers2
```

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

<table>
<thead>
<tr>
<th>Input file 1: desktop\D2\e1.txt</th>
<th>214 data read</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input file 2: desktop\D2\e6.txt</td>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>l=-2 p-value = 0.838710</td>
<td></td>
</tr>
<tr>
<td>l=-1 p-value = 0.903226</td>
<td></td>
</tr>
<tr>
<td>l=0 p-value = 0.903226</td>
<td></td>
</tr>
<tr>
<td>l=1 p-value = 0.580645</td>
<td></td>
</tr>
<tr>
<td>l=2 p-value = 0.935484</td>
<td></td>
</tr>
</tbody>
</table>

C:sophi_000\desktop\D2\grangers2

<table>
<thead>
<tr>
<th>Input file 1: desktop\D2\e2.txt</th>
<th>214 data read</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input file 2: desktop\D2\e3.txt</td>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>l=-2 p-value = 0.741935</td>
<td></td>
</tr>
<tr>
<td>l=-1 p-value = 0.935484</td>
<td></td>
</tr>
</tbody>
</table>

Doctoral Dissertation Sophia A. Kassapi

Σελίδα 332

**Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

<table>
<thead>
<tr>
<th>l=0</th>
<th>p-value = 0.935484</th>
</tr>
</thead>
<tbody>
<tr>
<td>l=1</td>
<td>p-value = 0.935484</td>
</tr>
<tr>
<td>l=2</td>
<td>p-value = 1.000000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D2\grangers2

Input file 1: desktop\D2\e2.txt
214 data read

Input file 2: desktop\D2\e4.txt
214 data read

seed:1

l=-2 p-value = 0.225806
l=-1 p-value = 0.838710
l=0 p-value = 0.838710
l=1 p-value = 0.838710
l=2 p-value = 0.580645

C:\Users\sophi_000>desktop\D2\grangers2

Input file 1: desktop\D2\e2.txt
214 data read

Input file 2: desktop\D2\e5.txt
214 data read

seed: 1

\( l=-2 \ p\text{-value} = 0.129032 \)
\( l=-1 \ p\text{-value} = 0.838710 \)
\( l=0 \ p\text{-value} = 0.838710 \)
\( l=1 \ p\text{-value} = 0.612903 \)
\( l=2 \ p\text{-value} = 0.161290 \)

C:\Users\sophi_000>desktop\D2\grangers2
Input file 1: desktop\D2\e2.txt
214 data read
Input file 2: desktop\D2\e6.txt
214 data read

seed: 1

\( l=-2 \ p\text{-value} = 0.161290 \)
\( l=-1 \ p\text{-value} = 0.225806 \)
\( l=0 \ p\text{-value} = 0.225806 \)
\( l=1 \ p\text{-value} = 0.741935 \)
\( l=2 \ p\text{-value} = 0.258065 \)

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

C:\Users\sophi_000>desktop\D2\grangers2

Input file 1: desktop\D2\e3.txt
214 data read

Input file 2: desktop\D2\e4.txt
214 data read

seed:1

l=-2 p-value = 0.096774
l=-1 p-value = 0.387097
l=0 p-value = 0.387097
l=1 p-value = 0.548387
l=2 p-value = 0.354839

C:\Users\sophi_000>desktop\D2\grangers2

Input file 1: desktop\D2\e3.txt
214 data read

Input file 2: desktop\D2\e5.txt
214 data read

seed:1

l=-2 p-value = 0.806452

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

<table>
<thead>
<tr>
<th>l=1 p-value</th>
<th>l=0 p-value</th>
<th>l=2 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.741935</td>
<td>0.741935</td>
<td>0.903226</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D2\grangers2
Input file 1: desktop\D2\e3.txt
214 data read
Input file 2: desktop\D2\e6.txt
214 data read
seed:1
<table>
<thead>
<tr>
<th>l=-2 p-value</th>
<th>l=-1 p-value</th>
<th>l=0 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.903226</td>
<td>1.000000</td>
<td>1.000000</td>
</tr>
<tr>
<td>l=1 p-value</td>
<td>l=2 p-value</td>
<td></td>
</tr>
<tr>
<td>0.677419</td>
<td>0.935484</td>
<td></td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D2\grangers2
Input file 1: desktop\D2\e4.txt
214 data read

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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<table>
<thead>
<tr>
<th>l=2 p-value = 0.064516</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Input file 1: desktop\D2\e5.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D2\e6.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
</tr>
<tr>
<td>l=-2 p-value = 0.290323</td>
</tr>
<tr>
<td>l=-1 p-value = 0.548387</td>
</tr>
<tr>
<td>l=0 p-value = 0.548387</td>
</tr>
<tr>
<td>l=1 p-value = 0.580645</td>
</tr>
<tr>
<td>l=2 p-value = 0.258065</td>
</tr>
</tbody>
</table>

BOOTSTRAPPED NONLINEAR GRANGER

DP

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Input file 2: desktop\D3\e3.txt</td>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>l=-2 p-value = 0.130000</td>
<td></td>
</tr>
<tr>
<td>l=-1 p-value = 0.060000</td>
<td></td>
</tr>
<tr>
<td>l=0 p-value = 0.060000</td>
<td></td>
</tr>
<tr>
<td>l=1 p-value = 0.020000</td>
<td></td>
</tr>
<tr>
<td>l=2 p-value = 0.120000</td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>C:\Users\sophi_000&gt;desktop\D3\grangers3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input file 1: desktop\D3\e1.txt</td>
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<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D3\e4.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>seed:</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>l=-2 p-value = 0.510000</td>
</tr>
<tr>
<td>l</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>-1</td>
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<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
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</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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\[
\begin{array}{l}
l=-2 \ p-value = 0.150000 \\
l=-1 \ p-value = 0.370000 \\
l=0 \ p-value = 0.370000 \\
l=1 \ p-value = 0.520000 \\
l=2 \ p-value = 0.200000 \\
\end{array}
\]

C:\Users\sophi_000>desktop\D3\grangers3
Input file 1: desktop\D3\e3.txt
214 data read
Input file 2: desktop\D3\e4.txt
214 data read
seed:1
\[
\begin{array}{l}
l=-2 \ p-value = 0.160000 \\
l=-1 \ p-value = 0.390000 \\
l=0 \ p-value = 0.390000 \\
l=1 \ p-value = 0.420000 \\
l=2 \ p-value = 0.260000 \\
\end{array}
\]

C:\Users\sophi_000>desktop\D3\grangers3
Input file 1: desktop\D3\e3.txt

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."
Input file 1: desktop\D3\e1.txt
214 data read

Input file 2: desktop\D3\e5.txt
214 data read

seed:1

l=-2 p-value = 0.440000
l=-1 p-value = 0.330000
l=0 p-value = 0.330000
l=1 p-value = 0.910000
l=2 p-value = 0.880000

BOOTSTRAPPED NONLINEAR GRANGER

DP

DIKS & PANCHENKO MODIFIED
Epsilon=1.319  embed.dim=2  n=214  lags=2

1000 realizations

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Input file 1: desktop\D4\e1.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D4\e2.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
</tr>
<tr>
<td>l=-2 p-value = 0.857000</td>
</tr>
<tr>
<td>l=-1 p-value = 0.850000</td>
</tr>
<tr>
<td>l=0 p-value = 0.850000</td>
</tr>
<tr>
<td>l=1 p-value = 0.947000</td>
</tr>
<tr>
<td>l=2 p-value = 0.826000</td>
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</tbody>
</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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<tbody>
<tr>
<td>Input file 2: desktop\D4\e3.txt</td>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>l=-2 p-value = 0.125000</td>
<td></td>
</tr>
<tr>
<td>l=-1 p-value = 0.016000</td>
<td></td>
</tr>
<tr>
<td>l=0 p-value = 0.016000</td>
<td></td>
</tr>
<tr>
<td>l=1 p-value = 0.029000</td>
<td></td>
</tr>
<tr>
<td>l=2 p-value = 0.084000</td>
<td></td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D4\grangers4

<table>
<thead>
<tr>
<th>Input file 1: desktop\D4\e1.txt</th>
<th>214 data read</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input file 2: desktop\D4\e4.txt</td>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
<td></td>
</tr>
<tr>
<td>l=-2 p-value = 0.446000</td>
<td></td>
</tr>
<tr>
<td>l=-1 p-value = 0.835000</td>
<td></td>
</tr>
</tbody>
</table>

Doctoral Dissertation Sophia A. Kassapi Σελίδα 350
<table>
<thead>
<tr>
<th>l=0</th>
<th>p-value = 0.835000</th>
</tr>
</thead>
<tbody>
<tr>
<td>l=1</td>
<td>p-value = 0.704000</td>
</tr>
<tr>
<td>l=2</td>
<td>p-value = 0.910000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D4\grangers4
Input file 1: desktop\D4\e1.txt
214 data read
Input file 2: desktop\D4\e5.txt
214 data read
seed:1
l=-2 p-value = 0.384000
l=-1 p-value = 0.386000
l=0 p-value = 0.386000
l=1 p-value = 0.897000
l=2 p-value = 0.924000

C:\Users\sophi_000>desktop\D4\grangers4
Input file 1: desktop\D4\e1.txt
214 data read
Input file 2: desktop\D4\e6.txt
<table>
<thead>
<tr>
<th>214 data read</th>
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</thead>
<tbody>
<tr>
<td>seed:1</td>
</tr>
<tr>
<td>l=-2 p-value = 0.735000</td>
</tr>
<tr>
<td>l=-1 p-value = 0.821000</td>
</tr>
<tr>
<td>l=0 p-value = 0.821000</td>
</tr>
<tr>
<td>l=1 p-value = 0.507000</td>
</tr>
<tr>
<td>l=2 p-value = 0.954000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D4\grangers4
Input file 1: desktop\D4\e2.txt
214 data read
Input file 2: desktop\D4\e3.txt
214 data read
seed:1
l=-2 p-value = 0.678000
l=-1 p-value = 0.983000
l=0 p-value = 0.983000
l=1 p-value = 0.920000
l=2 p-value = 0.964000

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Input file 1: desktop\D4\e2.txt</td>
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<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D4\e4.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>seed:1</td>
</tr>
<tr>
<td>l=-2 p-value = 0.238000</td>
</tr>
<tr>
<td>l=-1 p-value = 0.811000</td>
</tr>
<tr>
<td>l=0 p-value = 0.810000</td>
</tr>
<tr>
<td>l=1 p-value = 0.668000</td>
</tr>
<tr>
<td>l=2 p-value = 0.398000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C:\Users\sophi_000&gt;desktop\D4\grangers4</th>
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</thead>
<tbody>
<tr>
<td>Input file 1: desktop\D4\e2.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D4\e5.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
</tbody>
</table>

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.

seed:1
l=-2 p-value = 0.149000
l=-1 p-value = 0.868000
l=0 p-value = 0.868000
l=1 p-value = 0.691000
l=2 p-value = 0.243000

C:\Users\sophi_000\desktop\D4\grangers4
Input file 1: desktop\D4\e2.txt
214 data read
Input file 2: desktop\D4\e6.txt
214 data read
seed:1
l=-2 p-value = 0.138000
l=-1 p-value = 0.209000
l=0 p-value = 0.208000
l=1 p-value = 0.613000
l=2 p-value = 0.216000

C:\Users\sophi_000\desktop\D4\grangers4

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

<table>
<thead>
<tr>
<th>Input file 1: desktop\D4\e3.txt</th>
</tr>
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<tbody>
<tr>
<td>214 data read</td>
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<table>
<thead>
<tr>
<th>Input file 2: desktop\D4\e4.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>214 data read</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>seed:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>l=-2 p-value = 0.150000</td>
</tr>
<tr>
<td>l=-1 p-value = 0.458000</td>
</tr>
<tr>
<td>l=0 p-value = 0.458000</td>
</tr>
<tr>
<td>l=1 p-value = 0.410000</td>
</tr>
<tr>
<td>l=2 p-value = 0.258000</td>
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<table>
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<th>C:\Users\sophi_000&gt;desktop\D4\grangers4</th>
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<table>
<thead>
<tr>
<th>Input file 1: desktop\D4\e3.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>214 data read</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Input file 2: desktop\D4\e5.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>214 data read</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>seed:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>l=-2 p-value = 0.842000</td>
</tr>
<tr>
<td>l=-1 p-value = 0.694000</td>
</tr>
</tbody>
</table>
l=0 p-value = 0.694000
l=1 p-value = 0.519000
l=2 p-value = 0.912000

C:\Users\sophi_000>desktop\D4\grangers4
Input file 1: desktop\D4\e3.txt
214 data read
Input file 2: desktop\D4\e6.txt
214 data read
seed:1
l=-2 p-value = 0.937000
l=-1 p-value = 0.901000
l=0 p-value = 0.901000
l=1 p-value = 0.679000
l=2 p-value = 0.962000

C:\Users\sophi_000>desktop\D4\grangers4
Input file 1: desktop\D4\e4.txt
214 data read
Input file 2: desktop\D4\e5.txt

| 214 data read |
| seed:1 |
| l=-2 p-value = 0.588000 |
| l=-1 p-value = 0.439000 |
| l=0 p-value = 0.439000 |
| l=1 p-value = 0.160000 |
| l=2 p-value = 0.345000 |

C:\Users\sophi_000\desktop\D4\grangers4

Input file 1: desktop\D4\e4.txt
214 data read

Input file 2: desktop\D4\e6.txt
214 data read

seed:1
l=-2 p-value = 0.384000
l=-1 p-value = 0.491000
l=0 p-value = 0.491000
l=1 p-value = 0.244000
l=2 p-value = 0.106000

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."
BOOTSTRAPPED NONLINEAR GRANGER

DP

DIKS & WOLSKI MODIFIED

epsilon=0.33 embed.dim=2 n=214 lags=2

10,000 realizations

C:\Users\sophi_000>desktop\D5\grangers5
Input file 1: desktop\D5\e1.txt
214 data read
Input file 2: desktop\D5\e2.txt
214 data read
seed:1
l=-2 p-value = 0.857000
| l=−1 p-value | 0.850000 |
| l=0 p-value | 0.850000 |
| l=1 p-value | 0.947000 |
| l=2 p-value | 0.826000 |

```
C:\Users\sophi_000\desktop\D5\grangers5
Input file 1: desktop\D5\e1.txt
214 data read
Input file 2: desktop\D5\e3.txt
214 data read
seed:1
l=−2 p-value = 0.125000
l=−1 p-value = 0.016000
l=0 p-value = 0.016000
l=1 p-value = 0.029000
l=2 p-value = 0.084000
```

```
C:\Users\sophi_000\desktop\D5\grangers5
Input file 1: desktop\D5\e1.txt
214 data read
```

Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση.»

<table>
<thead>
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<tbody>
<tr>
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</tr>
<tr>
<td>l=-2 p-value = 0.446000</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>l=0 p-value = 0.835000</td>
<td></td>
</tr>
<tr>
<td>l=1 p-value = 0.704000</td>
<td></td>
</tr>
<tr>
<td>l=2 p-value = 0.910000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C:\Users\sophi_000&gt;desktop\D5\grangers5</th>
<th>Input file 1: desktop\D5\e1.txt</th>
</tr>
</thead>
<tbody>
<tr>
<td>214 data read</td>
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<tr>
<td>Input file 2: desktop\D5\e5.txt</td>
<td>214 data read</td>
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<tr>
<td>seed:1</td>
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</tr>
<tr>
<td>l=-2 p-value = 0.384000</td>
<td></td>
</tr>
<tr>
<td>l=-1 p-value = 0.386000</td>
<td></td>
</tr>
<tr>
<td>l=0 p-value = 0.386000</td>
<td></td>
</tr>
<tr>
<td>l=1 p-value = 0.897000</td>
<td></td>
</tr>
</tbody>
</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."
| seed:1 | l=-2 p-value = 0.678000  |
|       | l=-1 p-value = 0.983000  |
|       | l=0 p-value = 0.983000   |
|       | l=1 p-value = 0.920000   |
|       | l=2 p-value = 0.964000   |

C:\Users\sophi_000>desktop\D5\grangers5
Input file 1: desktop\D5\e2.txt
214 data read
Input file 2: desktop\D5\e4.txt
214 data read
seed:1
l=-2 p-value = 0.238000
l=-1 p-value = 0.811000
l=0 p-value = 0.810000
l=1 p-value = 0.668000
l=2 p-value = 0.398000
C:\Users\sophi_000>desktop\D5\grangers5

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."

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<table>
<thead>
<tr>
<th>l=0</th>
<th>p-value = 0.208000</th>
</tr>
</thead>
<tbody>
<tr>
<td>l=1</td>
<td>p-value = 0.613000</td>
</tr>
<tr>
<td>l=2</td>
<td>p-value = 0.216000</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>C:\Users\sophi_000&gt;desktop\D5\grangers5</th>
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</thead>
<tbody>
<tr>
<td>Input file 1: desktop\D5\e3.txt</td>
</tr>
<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D5\e6.txt</td>
</tr>
<tr>
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<td>seed:1</td>
</tr>
<tr>
<td>l=-2 p-value = 0.937000</td>
</tr>
<tr>
<td>l=-1 p-value = 0.901000</td>
</tr>
<tr>
<td>l=0  p-value = 0.901000</td>
</tr>
<tr>
<td>l=1  p-value = 0.679000</td>
</tr>
<tr>
<td>l=2  p-value = 0.962000</td>
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</tbody>
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<tbody>
<tr>
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<tr>
<td>214 data read</td>
</tr>
<tr>
<td>Input file 2: desktop\D5\e5.txt</td>
</tr>
</tbody>
</table>

"Τα Μακροπρόθεσμα Αποτελέσματα των Δημοσίων Επενδύσεων: Οικονομική Ανάπτυξη και Δημόσια Δωρεάν Παιδεία. Ελλάδα 1960-2015. Μία Παραμετρική και Μη-Παραμετρική Ανάλυση Προσέγγιση."  

<table>
<thead>
<tr>
<th>l=-2 p-value</th>
<th>l=-1 p-value</th>
<th>l=0 p-value</th>
<th>l=1 p-value</th>
<th>l=2 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.842000</td>
<td>0.694000</td>
<td>0.694000</td>
<td>0.519000</td>
<td>0.912000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D5\grangers5
Input file 1: desktop\D5\e3.txt
214 data read
Input file 2: desktop\D5\e4.txt
214 data read

seed:1
l=-2 p-value = 0.150000
l=-1 p-value = 0.458000
l=0 p-value = 0.458000
l=1 p-value = 0.410000
l=2 p-value = 0.258000

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<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>0.491000</td>
</tr>
<tr>
<td>0</td>
<td>0.491000</td>
</tr>
<tr>
<td>1</td>
<td>0.244000</td>
</tr>
<tr>
<td>2</td>
<td>0.106000</td>
</tr>
</tbody>
</table>

C:\Users\sophi_000>desktop\D5\grangers5

Input file 1: desktop\D5\e5.txt
214 data read

Input file 2: desktop\D5\e6.txt
214 data read

seed:1

<table>
<thead>
<tr>
<th>l</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>0.245000</td>
</tr>
<tr>
<td>-1</td>
<td>0.468000</td>
</tr>
<tr>
<td>0</td>
<td>0.468000</td>
</tr>
<tr>
<td>1</td>
<td>0.576000</td>
</tr>
<tr>
<td>2</td>
<td>0.233000</td>
</tr>
</tbody>
</table>
APPENDIX A.2  PROGRAMMING CODES IN C LANGUAGE

CODE 1:

#include <stdio.h>
#include <stdlib.h>
#include <math.h>

#define max(a,b) a>b?a:b

int B=1000;          /* number of bootstrap replications + 1 */
int mmax=2;         /* maximum emb. dim. */
double prob=0.05;   /* stationary bootstrap probability */

/* determine the log of ratios of correlation integrals */

double redun(double *x, double *y, int N, int m, int mmax, double epsilon)
{

    int i, j, k, Cx1=0, Cxy1=0, Cx2=0, Cxy2=0;
    double disx, disy, redun;

    for (i=mmax;i!=N-1;i++)
    {
        for (j=i+1;j!=N;j++)
        {
            disx = disy = 0.0;
            for (k=1;k!=m+1;k++)
            {
                disy = max(fabs(y[i-k]-y[j-k]),disy);
            }
            disy = max(fabs(y[i-k]-y[j-k]),disy);
        }
    }

    return 0;
}
for (k=1;k!=mmax+1;k++)
{
    disx = max(fabs(x[i-k]-x[j-k]),disx);
}

if (disx <= epsilon)
{
    Cx1++;
    if (disy <= epsilon)
        Cxy1++;
}

disx = max(fabs(x[i]-x[j]),disx);

if (disx <= epsilon)
{
    Cx2++;
    if (disy <= epsilon)
        Cxy2++;
}

redun = (double)Cxy2/(double)Cxy1-(double)Cx2/(double)Cx1;

return(redun);
/* normalize the time series to unit std. dev. */

void normalise(double *x, int N)
{
  int i;
  double mean=0.0, var=0.0;

  for (i=0;i!=N;i++)
  {
    mean += x[i];
    var += x[i]*x[i];
  }

  mean /= (double)(N);
  var /= (double)(N);
  var -= mean*mean;

  for (i=0;i!=N;i++)
    x[i] = (x[i]-mean)/sqrt(var);

  return;
}

double rand01(void)
{
  return ((double)(rand())/(double)(RAND_MAX));
int main()
{
    char filename[128];
    double x[10803], y[10803], x1[10803], y1[10803], t, tmp, epsilon=0.6, *r,
            p=0.0;
    int i, m, index, b, count, ties, *size, run, N, seed;
    FILE *infil;

    size = (int *)malloc((2*mmax+1)*sizeof(int));
    for (m=-mmax;m!=mmax+1;m++)
        size[m+mmax] = 0;

    r = (double *) malloc(B*sizeof(double));

    if (r==NULL) {fprintf(stderr,"Malloc failed..."); exit(1); }

    printf("Input file 1: "); scanf("%s", filename);

    if ( (infil=fopen(filename,"r"))== NULL)
        {fprintf(stderr,"Error: unable to open file. Exiting...");
            exit(1);
        }

    "}
i = 0;
while (fscanf(infil,"%lf", &tmp) != EOF)
{
    x[i] = tmp;
    i++;
}

N = i;

printf("%d data read\n", i);

printf("Input file 2: "); scanf("%s", filename);

fclose(infil);

if ( (infil=fopen(filename,"r") == NULL)
{
    fprintf(stderr,"Error: unable to open file. Exiting...\n");
    exit(1);
}

i = 0;
while (fscanf(infil,"%lf", &tmp) != EOF)
{
    y[i] = tmp;
    i++;
}
fclose(infil);

printf("%d data read\n", i);

if (i!=N)
{
  fprintf(stderr,"Error: data number mismatch. Exiting...
");
  exit(1);
}

printf("seed:"); scanf("%d",&seed);

srand(seed);

printf("Mmax=%d\n",mmax);
for (m=-mmax;m!=mmax+1;m++)
{
  printf("%d\n",m);
  for (b=0;b!=B;b++)
  {
    if (b==0)
    {
      for (i=0;i!=N;i++)
      {
        x1[i] = x[i];
        y1[i] = y[i];
      }
    }
  }
}
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```
else {
    index = (int)(N*rand01());
    for (i=0;i!=N;i++)
    {
        if (rand01() > prob)
        {
            index++;
            if (index>N-1) index = 0;
        }
        else
            index = (int)(N*rand01());
    }
    else
        index = (int)(N*rand01());
    if (m>0)
    {
        y1[i] = y[index];
        x1[i] = x[i];
    }
    else if(m<0)
    {
        x1[i] = x[index];
        y1[i] = y[i];
    }
}

normalise(x1, N);
```
normalise(y1, N);

if (m<0)
    r[b] = redun(y1,x1,N,-m,-m,epsilon);
else if (m>0)
    r[b] = redun(x1,y1,N,m,m,epsilon);
}

count = ties = 0;
p = 0.0;
for (b=1;b!=B;b++)
{
    if (r[b] > r[0])
        count++;
    else
        if (r[b] == r[0])
            ties++;
}

/* determine p-value (randomized in case ties > 1) */

p = count + (int)((double)(ties+1)*rand01()) + 1;
p /= (double)(B);

fprintf(stderr,"l=%d p-value = %f\n", m,p);
}

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CODE 2:

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>

#define max(a,b) a>b?a:b

int B=1000;          /* number of bootstrap replications + 1 */
int mmax=2;         /* maximum emb. dim. */
double prob=0.05;   /* stationary bootstrap probability */

/* determine the log of ratios of correlation integrals */

double redun(double *x, double *y, int N, int m, int mmax, double epsilon)
{
    int i, j, k, Cx1=0, Cxy1=0, Cx2=0, Cxy2=0;
    double disx, disy, redun;

    for (i=mmax;i!=N-1;i++)
    {
        for (j=i+1;j!=N;j++)
        {
```
disx = disy = 0.0;
for (k=1;k!=m+1;k++)
{
  disy = max(fabs(y[i-k]-y[j-k]),disy);
}
for (k=1;k!=mmax+1;k++)
{
  disx = max(fabs(x[i-k]-x[j-k]),disx);
}

if (disx <= epsilon)
{
  Cx1++;
  if (disy <= epsilon)
    Cxy1++;
}

disx = max(fabs(x[i]-x[j]),disx);

if (disx <= epsilon)
{
  Cx2++;
  if (disy <= epsilon)
    Cxy2++;
}
}

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\[
\text{redun} = \frac{(\text{double})\text{Cxy2}}{(\text{double})\text{Cxy1}} - \frac{(\text{double})\text{Cx2}}{(\text{double})\text{Cx1}};
\]

return(redun);
}

/* normalize the time series to unit std. dev. */

void normalise(double *x, int N)
{
    int i;
    double mean=0.0, var=0.0;
    for (i=0;i!=N;i++)
    {
        mean += x[i];
        var += x[i]*x[i];
    }
    mean /= (double)(N);
    var /= (double)(N);
    var -= mean*mean;
    for (i=0;i!=N;i++)
    \text{x}[i] = (\text{x}[i]-\text{mean})/\sqrt{\text{var}};

    return;
}

double rand01(void)
{
    return ((\text{double})\text{rand()})/(\text{double})(\text{RAND\_MAX}));

int main()
{
    char filename[128];
    double x[10803], y[10803], x1[10803], y1[10803], t, tmp, epsilon=1.5, *r,
    p=0.0;
    int i, m, index, b, count, ties, *size, run, N, seed;
    FILE *infil;
    size = (int *)malloc((2*mmax+1)*sizeof(int));
    for (m=-mmax;m!=mmax+1;m++)
        size[m+mmax] = 0;
    r = (double *) malloc(B*sizeof(double));
    if (r==NULL) {fprintf(stderr,"Malloc failed...
"); exit(1); }

    printf("Input file 1: "); scanf("%s", filename);
    if ( (infil=fopen(filename,"r")) == NULL)
      {fprintf(stderr,"Error: unable to open file. Exiting...
"); exit(1); }

    i = 0;
    while (fscanf(infil,"%lf", &tmp) != EOF)
    {
    }

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printf("%d data read\n", i);

if (i!=N)
{
    fprintf(stderr,"Error: data number mismatch. Exiting...\n");
    exit(1);
}

printf("seed:"); scanf("%d",&seed);

srand(seed);

for (m=-mmax;m!=mmax+1;m++)
{
    for (b=0;b!=B;b++)
    {
        if (b==0)
        {
            for (i=0;i!=N;i++)
            {
                x1[i] = x[i];
                y1[i] = y[i];
            }
        }
        else
        {
            index = (int)(N*rand01());
        }
    }
}

printf("\n");
for (i=0;i!=N;i++)
{
    if (rand01() > prob)
    {
        index++;
        if (index>N-1) index = 0;
    }
    else
    {
        index = (int)(N*rand01());
    }
    if (m>0)
    {
        y1[i] = y[index];
        x1[i] = x[i];
    }
    else if(m<0)
    {
        x1[i] = x[index];
        y1[i] = y[i];
    }
}
normalise(x1, N);
normalise(y1, N);
if (m<0)
    r[b] = redun(y1,x1,N,-m,-m,epsilon);
else if (m>0)
    r[b] = redun(x1,y1,N,m,m,epsilon);

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count = ties = 0;
p = 0.0;
for (b=1;b!=B;b++)
{
    if (r[b] > r[0])
        count++;
    else
        if (r[b] == r[0])
            ties++;
}
/* determine p-value (randomized in case ties > 1) */

    p = count + (int)((double)(ties+1)*rand01()) + 1;
p /= (double)(B);
    fprintf(stderr,"l=%d p-value = %f\n", m,p);
}
    system("pause");
    return(0);
}

CODE 3:
#include <stdio.h>
#include <stdlib.h>
#include <math.h>

#define max(a,b) a>b?a:b
int B=1000;       /* number of bootstrap replications + 1 */
int mmax=2;        /* maximum emb. dim. */
double prob=0.05;  /* stationary bootstrap probability */

/* determine the log of ratios of correlation integrals */

double redun(double *x, double *y, int N, int m, int mmax, double epsilon)
{
    int i, j, k, Cx1=0, Cxy1=0, Cx2=0, Cxy2=0;
    double disx, disy, redun;

    for (i=mmax;i!=N-1;i++)
    {
        for (j=i+1;j!=N;j++)
        {
            disx = disy = 0.0;
            for (k=1;k!=m+1;k++)
            {
                disy = max(fabs(y[i-k]-y[j-k]),disy);
            }
            for (k=1;k!=mmax+1;k++)
            {
                disx = max(fabs(x[i-k]-x[j-k]),disx);
            }
        }
    }

    return redun;
}
if (disx <= epsilon)
{
    Cx1++;
    if (disy <= epsilon)
        Cxy1++;
}

disx = max(fabs(x[i]-x[j]),disx);

if (disx <= epsilon)
{
    Cx2++;
    if (disy <= epsilon)
        Cxy2++;
}
}

redun = (double)Cxy2/(double)Cxy1-(double)Cx2/(double)Cx1;

return(redun);
}

/* normalize the time series to unit std. dev. */

void normalise(double *x, int N)
{
    int i;

    /* normalize the time series to unit std. dev. */
double mean=0.0, var=0.0;

for (i=0;i!=N;i++)
{
    mean += x[i];
    var += x[i]*x[i];
}

mean /= (double)(N);
var /= (double)(N);
var -= mean*mean;

for (i=0;i!=N;i++)
    x[i] = (x[i]-mean)/sqrt(var);

return;

}

double rand01(void)
{
    return ((double)(rand()))/(double)(RAND_MAX));
}

int main()
{
    char filename[128];
double x[10803], y[10803], x1[10803], y1[10803], t, tmp, epsilon=0.33, *r, p=0.0;
int i, m, index, b, count, ties, *size, run, N, seed;
FILE *infil;

size = (int *)malloc((2*mmax+1)*sizeof(int));
for (m=-mmax;m!=mmax+1;m++)
    size[m+mmax] = 0;

r = (double *) malloc(B*sizeof(double));

if (r==NULL) {fprintf(stderr,"Malloc failed...
"); exit(1); }

printf("Input file 1: "); scanf("%s", filename);

if ( (infil=fopen(filename,"r")) == NULL)
    {fprintf(stderr,"Error: unable to open file. Exiting...
"); exit(1);
    }

i = 0;
while (fscanf(infil,"%lf", &tmp) != EOF)
    {
        x[i] = tmp;
        i++;
    }
N = i;

printf("%d data read\n", i);

printf("Input file 2: "); scanf("%s", filename);

fclose(infil);

if ( (infil=fopen(filename,"r")) == NULL)
{
    fprintf(stderr,"Error: unable to open file. Exiting...
");
    exit(1);
}

i = 0;
while (fscanf(infil,"%lf", &tmp) != EOF)
{
    y[i] = tmp;
    i++;
}

fclose(infil);

printf("%d data read\n", i);

if (i!=N)

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{ 
    fprintf(stderr,"Error: data number mismatch. Exiting...
    exit(1);

    printf("seed:"); scanf("%d",&seed);

    srand(seed);

    for (m=-mmax;m!=mmax+1;m++)
    {
        for (b=0;b!=B;b++)
        {
            if (b==0)
            {
                for (i=0;i!=N;i++)
                {
                    x1[i] = x[i];
                    y1[i] = y[i];
                }
            }
            else
            {
                index = (int)(N*rand01());
                for (i=0;i!=N;i++)
                {
                    if (rand01() > prob)

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```c
{ 
  index++;
  if (index>N-1) index = 0;
}
else
  index = (int)(N*rand01());
if (m>0)
  { 
    y1[i] = y[index];
    x1[i] = x[i];
  }
else if(m<0)
  { 
    x1[i] = x[index];
    y1[i] = y[i];
  }
}

normalise(x1, N);
normalise(y1, N);

if (m<0)
  r[b] = redun(y1,x1,N,-m,-m,epsilon);
else if (m>0)
  r[b] = redun(x1,y1,N,m,m,epsilon);
}
```
count = ties = 0;
p = 0.0;
for (b=1;b!=B;b++)
{
    if (r[b] > r[0])
        count++;
    else
        if (r[b] == r[0])
            ties++;
}

/* determine p-value (randomized in case ties > 1) */

p = count + (int)((double)(ties+1)*rand01()) + 1;
p /= (double)(B);

fprintf(stderr,"l=%d p-value = %f\n", m,p);
}
system("pause");
return(0);

---

**CODE 4:**

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
```

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#define max(a,b) a>b?a:b

int B=1000; /* number of bootstrap replications + 1 */
int mmax=2; /* maximum emb. dim. */
double prob=0.05; /* stationary bootstrap probability */

/* determine the log of ratios of correlation integrals */

double redun(double *x, double *y, int N, int m, int mmax, double epsilon)
{
    int i, j, k, Cx1=0, Cxy1=0, Cx2=0, Cxy2=0;
    double disx, disy, redun;

    for (i=mmax;i!=N-1;i++)
    {
        for (j=i+1;j!=N;j++)
        {
            disx = disy = 0.0;
            for (k=1;k!=m+1;k++)
            {
                disy = max(fabs(y[i-k]-y[j-k]),disy);
            }
            for (k=1;k!=mmax+1;k++)
            {
                disx = max(fabs(x[i-k]-x[j-k]),disx);
            }
        }
    }

    return redun;
}
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if (i!=N)
{
    fprintf(stderr,"Error: data number mismatch. Exiting...\n");
    exit(1);
}

printf("seed:"); scanf("%d",&seed);

srand(seed);

for (m=-mmax;m!=mmax+1;m++)
{
    for (b=0;b!=B;b++)
    {
        if (b==0)
        {
            for (i=0;i!=N;i++)
            {
                x1[i] = x[i];
                y1[i] = y[i];
            }
        }
        else
        {
            index = (int)(N*rand01());
            for (i=0;i!=N;i++)
        }

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{  
if (rand01() > prob)  
{  
index++;  
if (index>N-1) index = 0;  
}  
else  
index = (int)(N*rand01());  
if (m>0)  
{  
y1[i] = y[index];  
x1[i] = x[i];  
}  
else if(m<0)  
{  
x1[i] = x[index];  
y1[i] = y[i];  
}  
}  
}

normalise(x1, N);
normalise(y1, N);

if (m<0)  
r[b] = redun(y1,x1,N,-m,-m,epsilon);  
else if (m>0)
r[b] = redun(x1,y1,N,m,m,epsilon);

count = ties = 0;
p = 0.0;
for (b=1;b!=B;b++)
{
    if (r[b] > r[0])
        count++;
    else
        if (r[b] == r[0])
            ties++;
    }

/* determine p-value (randomized in case ties > 1) */

p = count + (int)((double)(ties+1)*rand01()) + 1;
p /= (double)(B);

fprintf(stderr,"l=%d p-value = %f\n", m,p);
}

#include <stdio.h>

CODE 5:
#include <stdlib.h>
#include <math.h>

#define max(a,b) a>b?a:b

int B=10000;       /* number of bootstrap replications + 1 */
int mmax=2;        /* maximum emb. dim. */
double prob=0.05;  /* stationary bootstrap probability */

/* determine the log of ratios of correlation integrals */

double redun(double *x, double *y, int N, int m, int mmax, double epsilon) {

    int i, j, k, Cx1=0, Cxy1=0, Cx2=0, Cxy2=0;
    double disx, disy, redun;

    for (i=mmax;i!=N-1;i++)
    {
        for (j=i+1;j!=N;j++)
        {
            disx = disy = 0.0;
            for (k=1;k!=m+1;k++)
            {
                disy = max(fabs(y[i-k]-y[j-k]),disy);
            }    
            for (k=1;k!=mmax+1;k++)
            {
            }
        }
    }
}

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```c
{ 
    disx = max(fabs(x[i-k]-x[j-k]),disx);
}

if (disx <= epsilon) 
{ 
    Cx1++;
    if (disy <= epsilon)
        Cxy1++;
} 

disx = max(fabs(x[i]-x[j]),disx);

if (disx <= epsilon) 
{ 
    Cx2++;
    if (disy <= epsilon)
        Cxy2++;
} 
}
}
redun = (double)Cxy2/(double)Cxy1-(double)Cx2/(double)Cx1;

return(redun);
}

/* normalize the time series to unit std. dev. */
void normalise(double *x, int N)
{
    int i;
    double mean=0.0, var=0.0;

    for (i=0;i!=N;i++)
    {
        mean += x[i];
        var += x[i]*x[i];
    }

    mean /= (double)(N);
    var /= (double)(N);
    var -= mean*mean;

    for (i=0;i!=N;i++)
        x[i] = (x[i]-mean)/sqrt(var);

    return;
}

double rand01(void)
{
    return ((double)(rand())/(double)(RAND_MAX));
}
int main()
{
    char filename[128];
    double x[10803], y[10803], x1[10803], y1[10803], t, tmp, epsilon=0.33,
    *r, p=0.0;
    int i, m, index, b, count, ties, *size, run, N, seed;
    FILE *infil;

    size = (int *)malloc((2*mmax+1)*sizeof(int));
    for (m=-mmax;m!=mmax+1;m++)
        size[m+mmax] = 0;

    r = (double *) malloc(B*sizeof(double));

    if (r==NULL) {fprintf(stderr,"Malloc failed...\n"); exit(1); }

    printf("Input file 1: "); scanf("%s", filename);

    if ( (infil=fopen(filename,"r")) == NULL)
    {
        fprintf(stderr,"Error: unable to open file. Exiting...
");
        exit(1);
    }

    i = 0;
    while (fscanf(infil,"%lf", &tmp) != EOF)

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printf("%d data read\n", i);

if (i!=N)
{
    fprintf(stderr,"Error: data number mismatch. Exiting...\n");
    exit(1);
}

printf("seed: "); scanf("%d",&seed);

srand(seed);

for (m=-mmax;m!=mmax+1;m++)
{
    for (b=0;b!=B;b++)
    {
        if (b==0)
        {
            for (i=0;i!=N;i++)
            {
                x1[i] = x[i];
                y1[i] = y[i];
            }
        }
        else
        {
            // code...
        }
    }
}

else
{
  // code...
}
index = (int)(N*rand01());
for (i=0;i!=N;i++)
{
    if (rand01() > prob)
    {
        index++;
        if (index>N-1) index = 0;
    }
    else
        index = (int)(N*rand01());
    if (m>0)
    {
        y1[i] = y[index];
        x1[i] = x[i];
    }
    else if(m<0)
    {
        x1[i] = x[index];
        y1[i] = y[i];
    }
}

normalise(x1, N);
normalise(y1, N);

if (m<0)
r[b] = redun(y1,x1,N,-m,-m,epsilon);
else if (m>0)
    r[b] = redun(x1,y1,N,m,m,epsilon);
}

count = ties = 0;
p = 0.0;
for (b=1;b!=B;b++)
{
    if (r[b] > r[0])
        count++;
    else
        if (r[b] == r[0])
            ties++;

    /* determine p-value (randomized in case ties > 1) */

    p = count + (int)((double)(ties+1)*rand01()) + 1;
    p /= (double)(B);

    fprintf(stderr,"l=%d p-value = %f\n", m,p);
}

system("pause");
return(0);
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Figure 3. Greek debt in comparison to Eurozone average 1999-2016, retrieved from http://www.eurostat.com.

Figure 4. Greek crisis in contrast to the recession of 1929. The size of GDP during the first 5 years of the recession. Data for US from U.S. Department of Commerce: Bureau of Economic Analysis, data for Greece from OECD Main Economic Indicators, retrieved from http://www.valeofinancial.com.

Figure 5. European commission economic Indicators 2011. Data retrieved from http://www.derspiegel.com

Figure 6. Greece economic indicators 2013, data retrieved from http://www.afponline.org

Figure 7. Minimum wage in 2015, at PPP. Data reprinted from World Economic Forum blog, retrieved from http://www.weforum.org

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Figure 8. Minimum wage levels EU and US in 2014 (before taxes and ssc). Data reprinted from Statista Charts and Eurostat, retrieved by http://www.statista.com

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Figure 11. European countries and minimum wages. Data taken from eurostat, retrieved from http://www.afponline.org


Figure 13. Minutes worked for a Big Mac. Data retrieved from International Business Times 2013, http://www.ibtimes.com


Figure 16. Evolution by region of destination in the number of students enrolled outside the country of citizenship. (2000 to 2009). Retrieved from OECD EAG 2011.
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Figure 18. Percentage of foreign tertiary students enrolled in each country of destination, retrieved from OECD and Unesco institute for statistics, from OECD eag 2011.

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Table 26. Time organization of teachers.(2009 indicative). Note: Data from OECD, eag, 2011..

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Table 39. Nonlinear Granger causality test- eGarch residuals.

Table 40. Bootstrapped Nonlinear Granger Causality test results.
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