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INVESTIGATING THE LONG CYCLES OF CAPITALISM WITH SPECTRAL AND CROSS-SPECTRAL ANALYSIS

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Abstract
The persistent current phase of negative growth has already triggered the awakening of long wave theories. Although long waves are obvious, even with a simple visual observation of the history of the data, doubts as to their existence are expressed by a variety of different theoretical and empirical approaches. However, the increasing number of statistical methods for long wave examination illustrates very clearly that their confirmation, as well as their periodization, depends both on theoretical fixations and / or the use of different empirical methodologies. The present paper uses Spectral Analysis in order to investigate the importance of the long lasting cycles in the periodicity of European Countries' economic evolution. The correlation and timing differences among them are identified with the help of Cross-Spectral analysis.

JEL: C22, E32
Key words: Business Cycles, Long Waves, Spectral analysis, Cross-Spectral Analysis.

1. Introduction

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The financial crisis of 2008 led to one of the longest and most persistent post-war recessions in global economic activity. Similarly to corresponding periods in economic history, it has already generated vigorous debates. Neoclassical growth theory considers this crisis as the stochastic downturn of a common business cycle. On the other hand, the persistent current phase of negative growth triggers the awakening of theories that belong to a different area of economic literature. Traditionally, the theories of long waves come to the fore with the occurrence of persistent long-lasting economic recessions. The long wave tradition asserts that deep recessions, such as the present one or similarly the ones that occurred in the 1930's and 1970's, are the result of an amplified long-lasting downturn, recurring every 40-60 years over the history of capitalism's development.

The initial empirical evidence for long-lasting cyclical economic development leads us back to the first contributions at the end of the 19th century by Jevons (1884), Parvus (1901), Van Gelderen (1913), De Wolff (1924) and the following, statistically more advanced, analysis of Kondratieff (1928).[1] Apart from the familiar business cycles, they emphasized the continuing long waves lasting approximately half a century. Since that time, interesting questions have been raised, concentrating mostly upon the true existence of such economic movements and their theoretical explanation.

The literature on theoretical justification of long waves is quite extensive. Contributions can be divided into three different schools: Marxists (Mandel 1975, 1980, 1981) interpret long waves by the falling course of the rate of profit, which is indisputably a driving force of the system. At the same time, they incorporate various exogenous factors – wars, geographical / sectoral market expansion and technological progress – which avert the systemic downturn and move the economy back to a new phase of expansion.

Close to the Marxian approach, the Social Structure of Accumulation (SSA) School provides an additional argument, offering a framework of continual cyclical movements: the social institutional arrangements such as labour relations, the banking system, the political environment etc., when propitious for the continuity of capital accumulation, assist the transition to the next upswing (Gordon 1980, 1991; Gordon *et al*. 1994; Gordon, Weisskopf & Bowles 1983).

1. Although the literature uses the term "Kondratieff cycles", there are many authors who believe that the credit should be given to earlier works: "*It would, in fact be more appropriate to speak about van Gelderen – De Wolff long waves*" (Kleinknecht, A, 1992, p1).

In contrast to the above, the Schumpeterian/Innovation School focuses on a similar cyclical movement of technological progress. Based on appropriate micro-oriented arguments like entrepreneurial motivations for adapting new ideas, theorists consider the fluctuations of economic activity as the result of innovation clusters (Kleinknecht 1986, 1987; Mensch 1975; Schumpeter 1939).[2]

Despite the different significance attached to the parameter of technological progress, its influence on an economy's long term evolution is undoubtedly accepted. Long fluctuations of economic activity were empirically and chronologically closely related to the occurrence of great technological revolutions. More specifically, the first long wave appears at the end of the 18th century with the beginning of the Industrial Revolution. The second started in the mid- 19th century and was related to the mechanically produced steam engines that became the driving mechanism of production process in many industries and transportation (mechanization, first technological revolution). The direct outcome was the geographical expansion of capitalism. The opening of new markets for the mass produced industrial products occurred within the expanding period of the next, third long wave, which lasted until the end of the Second World War. Nevertheless, this cycle was also related to another (third) technological revolution: electrification, that was accompanied by the expanded use of iron and heavy engineering. The fourth long wave starts after 1940 (in 1945 for Europe), relates to the revolution in natural sciences and is known as the era of atomic energy, oil, automobiles and steel technologies connected with highly structured technology research.

The end of the fourth long wave divides scholars' opinions. Some say that since the 1970's a fifth long wave has begun, associated with the revolution in electronics, telecommunications and informatics (Freeman & Louca 2001; Korotayev & Tsirel 2010; Perez 2010). Some believe that we are still in the longer-lasting downswing of the fourth long wave (Zarotiadis 2012; Wallerstein 1984), while others assume that

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2. In the course of time, various theoretical contributions combined the arguments of the mentioned schools, in order to avoid a mono-causal interpretation of long waves. Kleincknecht (1992) encourages this mixture; neo-Schumpeterians include also SSA-arguments in their discussion (Clark *et al*. 1981; Freeman 1982; Tylecote 1992; Perez 1983, 1985, 2002, 2004, 2010), while other theorist combine the scarcity of natural resources with the emergence of new technologies (Rostow 1975; Volland 1987). Also Van Duijn (1977, 1983) incorporates Schumpeter's theory of innovation and the dynamic system of Forrester (1976) and Sterman (1985, 1986) in his product life cycle approach.

we are now seeing the beginning of the sixth wave, associated with new developments in nano-bio technologies (Lynch 2004). Part of this disparity results not only from using different empirical techniques but also different theoretical arguments.

Truly, the existence of long waves is primarily an empirical exercise. There are both a number of empirical confirmations (Kleinknecht & Bieshaar 1983; Kleinknecht 1986; Korotayev & Tsirel 2010; Van Duijn 1977, 1983; Metz 1992; Reijnders 1992, 2009), as well as many contributions that question the existence of long waves (Garvy 1943; Van der Zwan 1980; Van Ewijk 1981, 1982; Solomou 1990, 1998). As Van Duijn (1983, p. 18) pointed out "*the longer a cycle, the harder it is to prove its existence*". Yet, the confirmation of a long-wave, as well as the exact periodization, depends both on theoretical fixations and/or the use of different empirical methodologies and data. This is what the present paper tries to do. Motivated by the current persistent crisis, it combines alternative methodologies in different countries in order to contribute to answering the following questions:

a. Do economies present cyclical movements that last longer than a common business cycle?
b. Could these movements be considered as periodical?
c. Are their movements related?
d. Is their development synchronised as an international economic phenomenon?

2. Answering questions with new methodology

Until the present the most widespread methodologies for detecting long cycles have been decomposition approaches, with spectral analysis more recently. In the decomposition approach (Kondratieff and Oparin 1928), time series are decomposed between trend and cycles (cyclical components) of different duration. These studies, although useful in revealing long wave patterns, are unable to estimate at the same time the significance of cyclical components of different duration. The recent techniques however, such as spectral analysis, allow for simultaneous estimation of the importance of cycles of different duration, thereby avoiding bias estimations over a specific size of cycle.

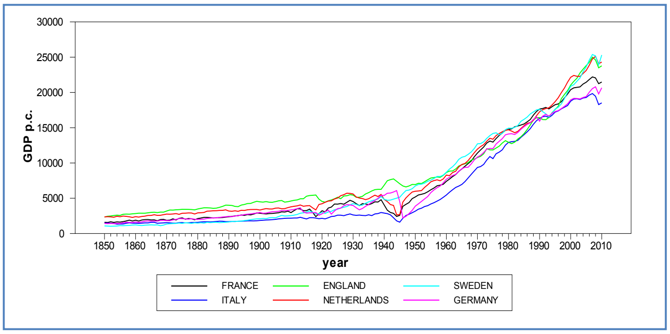
Thus, *Spectral Analysis* or analysis in the *frequency domain* is a helpful methodology for a researcher to see how important are the long lasting cycles relative to cycles of other duration in the periodicity of the series/variable chosen to express economic activity. In this paper, we use spectral analysis to investigate the different periodical movements of 6 economies, France, England, Sweden, Italy, Netherlands and Germany for the period 1850-2010 using the most recent Maddison Project datasets.[3] In order to investigate whether the cycles of the different countries interact or have the same timing and periodicity we take one step further and apply cross-spectral analysis.

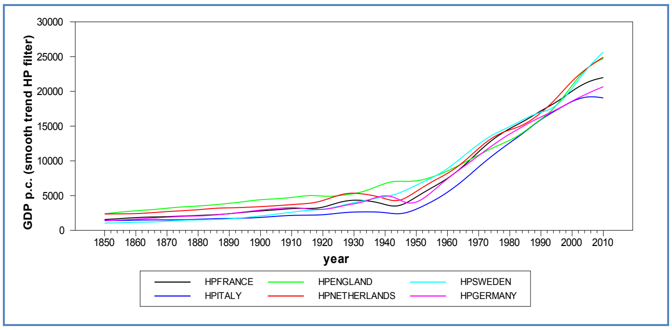
2.1 Answering the first question

Despite the skepticism of some researchers long waves do exist and this is obvious even to the naked eye. The graphs below depict, though not so clearly, long waves occurring from 1850 until the present. Despite the explicable (due to technological progress) upward trend, we can see an expansion phase lasting approximately until approximately 1870 in almost all countries (except Italy and the Netherlands where it is not that obvious). Then, there is a downward movement until approximately 1890 where another expansion phase begins. After 1925, we have a downward movement until 1945. From then, all economies moved closely together upwards, until 1990, where the previously observed convergence starts to vanish. These movements in all 6 countries' GDP become more obvious by smoothing the series with the help of the Hodrick Prescott Filter.

3. Bolt, J. and J. L. van Zanden (2013). The First Update of the Maddison Project; Re-Estimating Growth Before 1820. Maddison Project Working Paper 4. http://www.ggdc.net/maddison/maddison-project/data.htm

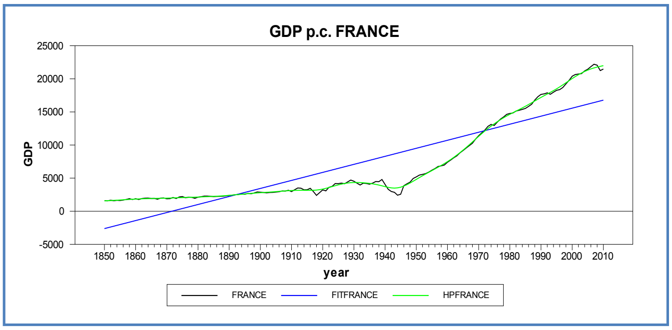
Figure 1. Long Waves of GDP from 1850-2010

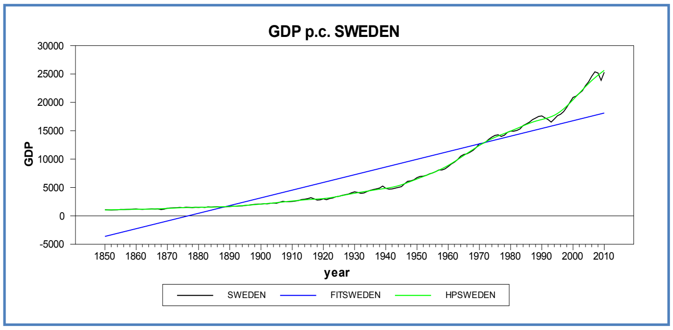


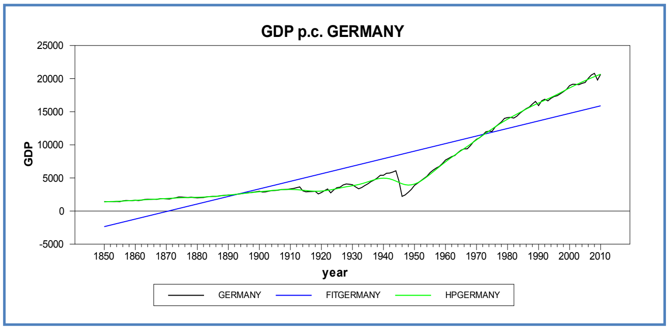


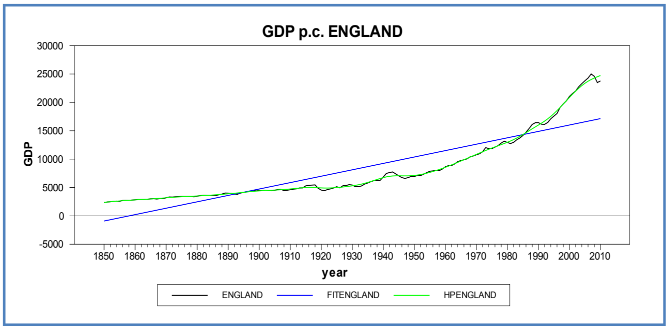
Before discussing the results of spectral analysis, we should mention that there is an obvious difference in the importance of periodicities according to the de-trending technique. Series can become stationary, either by having monotone or polynomial de-trending. Nevertheless, if we choose a polynomial de-trending, fitting on the actual data may be better, but we lose cyclical information, starting from the longer lasting cycles. Generally, monotone trend eliminations maintain longer lasting fluctuations, while, in contrast, polynomial trends, either being of constant or of adjustable degree e.g. Hodrick-Prescott (1997), preserve only shorter cycles. This gives us a great opportunity to repeat something that has been widely noted in the relevant literature: confirming the existence and the duration of a long-wave depends to a great extent on the pre-existing theoretical fixations *"as there are obviously no statistical criteria for choosing the ''true'' trend curve, the existence of long waves depends solely on subjective criteria related to the trend."(Metz 2011, p. 211).*

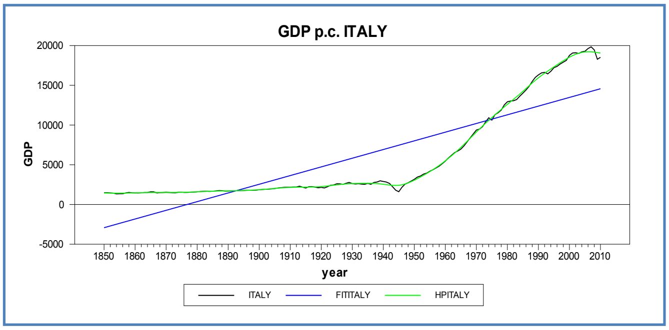
Figure 2. Real series (FRANCE, SWEDEN etc), linear trend estimation (FITFRANCE, FITSWEDEN etc) and smoothing HP trend (HPFRANCE, HPSWEDEN etc.) of each country's GDP

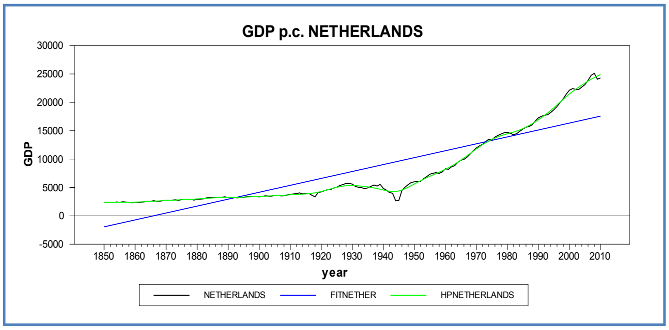







GDP p.c. ENGLAND
GDP
year
ENGLAND
FITENGLAND
HPENGLAND


GDP p.c. ITALY
GDP
year
ITALY
FITITALY
HPITALY


GDP p.c. NETHERLANDS
GDP
year
NETHERLANDS
FITNETHER
HPNETHERLANDS

Above, we depict the course of GDP of each country. As we can see there is an upward movement which is depicted more clearly by estimating a linear trend.[4] However, by taking out of the series the linear trend it is quite obvious that there will remain cyclical components of long duration (in the above graphs we can clearly see three waves up and down the trend line). On the other hand, de-trending the series with HP trend estimation involves the risk of excluding long wave movements. Indeed, if we take the residuals that remain after estimating amore sensitive, flexible trend – for instance by the use of HP – waves of more than 40 years disappear. Does this mean that they do not exist, or that the sensitive trend itself reproduces actually the deeper regularity of longer lasting periodicity? We believe that the second argument is true; that is why we use only de-trending techniques to GDP per capita levels and then to growth rates.

2.2 Answering the second question with Spectral Analysis

Each time series can be expressed as a sum of cosines and sines in case, provided it is stationary. Thus, each time series can be expressed as periodic function that depicts a periodicity at π. This is achieved with Fourier Transformation of the series' auto covariance function. In this manner the series are presented as a function of frequencies ($\theta \in (0,\pi)$) (the number of cycles per period). This means that the series can be plotted upon the points at which the series present a proportion/number of periodical movements (cycles). For example at π we have 0,5 cycle, at 2π one cycle etc. This function is named as power spectral densities function or power spectrum and illustrates the importance of periodic components in the total variance of the series. This is because if we integrate the function for all possible frequencies (from 0 to π), the area under the function is equal to the total variance of the series. For a more detailed analysis of the spectral methodology, see Granger and Hatanaka (1994) and Hamilton (1994), and, for a comprehensive interpretation, Engle (1976). Below, we present the results of the spectral density function estimations of 6 countries, France, England, Sweden, Italy, Netherlandsand Germany for the period 1850-2010. We start with an analysis of GDP per capita annual series, and then proceed with an analysis of GDP growth rates.

4. In all countries GDP p.c. follows a clear exponential path. Therefore, future discussions of the same issue should proceed with exponential de-trending as well in order to capture any possible biases.

Figure 3. Spectral Density Functions of GDP de-trend time series

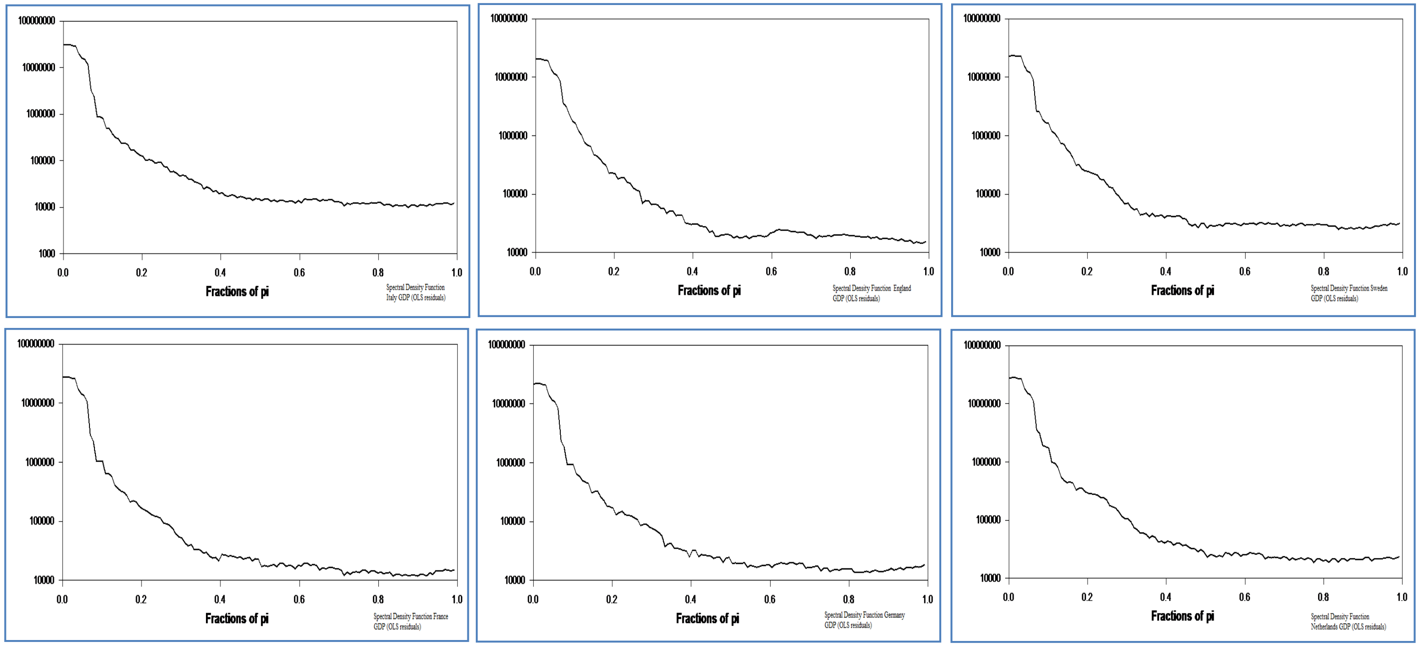


Table1: Spectral Density Estimations, level series.

Frequencies/Fractions of pi		0,02 - 0,065	0,065-0,178	0,178 - 1
Cycle Duration		29- 86 years	11-29 years	2-11 years
Explanation of GDP p.c. series' residual variance (%)	SWEDEN	51%	9%	3%
	NETHERLANDS	51%	8%	3%
	ITALY	53%	5%	1%
	GERMANY	52%	7%	3%
	FRANCE	52%	6%	2%
	ENGLAND	50%	11%	3%

As expected from the above, the spectral density estimations after the elimination of a linear trend depict clearly the presence of long cycles or, otherwise cycles of low frequencies' periodicity. In the horizontal axes we see the frequencies – fractions of π.[5] In the table below our estimations we present how each interval of frequencies of the horizontal axis corresponds to each different length of cycle. Additionally we present the percentages of explanation of the total variance of the series by each type of cycle[6]. As we can see, Kondratieff cycles in the level series of all countries' GDP p.c. explain almost half of the series' total variance. Additionally, we estimated the spectral density functions for annual growth rates, using again the same de-trending procedure. What someone needs to consider when viewing the specific figures is that spectral density functions of the growth rates become more flat than those of the levels for all series. This was expected. Generally, by using stationarity methods such as implementing the first differences in logarithmic series, a danger of excluding long wave movements always exists (Ewijk 1982). By definition in growth rates, every cycle in the series' levels is divided into two sub-cycles. Thus, the small percentages for Kondratieff cycles, in the second table, must not be interpreted to mean that these series don't present long cycles, since when we investigate growth rates, all cycles are being transformed to shorter ones. That is the only reason why, in that case, the business cycles explain almost all the variance of the series.

5. As we mentioned above at π (3,14) the Fourier transformed series depict half periodical movement meaning a half cycle in 1 periods of time (example if we use years as periods' measure units, 1 year) and one full cycle in 2 periods of time, thus 2 years. Thus, π in the horizontal axis corresponds to a full cycle with a periodicity of 2 years. As we move towards the beginning of the axis, the frequencies of the cycles are lower and correspond to cycles of larger duration (ex. π/2 (1,5) corresponds to a cycle of 4 years duration etc.).
6. Note that the sum of total variance for all category of cycles is less than 100%. This is because there is an additional category of cycles covering 100 years (Hegemonic cycles) that we do not present in our table because: 1) we are interested in the Kondratieff cycles and 2) because Hegemonic cycles lack a theoretical background that could give them partly economic meaning

Figure 4. Spectral Density Functions of GDP growth de-trend time series

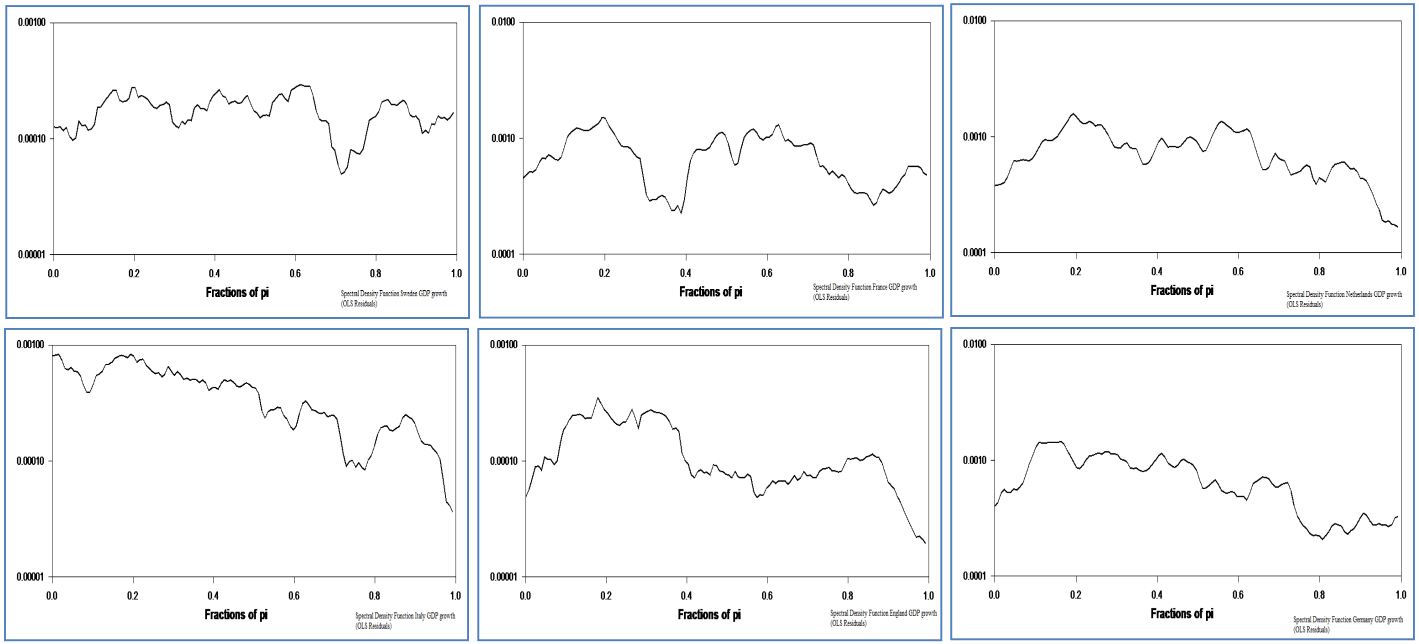


Table 2. Spectral Density Estimations, growth series

Frequencies/Fractions of pi		0,02 - 0,065	0,065-0,178	0,178 - 1
Cycle Duration		29- 86 years	11-29 years	2-11 years
Explanation of GDP p.c. series' residual variance (%)	SWEDEN	3%	13%	83%
	NETHERLANDS	3%	14%	82%
	ITALY	8%	18%	69%
	GERMANY	4%	21%	74%
	FRANCE	4%	17%	78%
	ENGLAND	4%	20%	75%

2.3 Answering the third and the fourth question with Cross-spectral Analysis

Using almost the same methodology, one can examine the periodicity of two variables as they inter-relate. More specifically, it is possible for a researcher to examine how two variables interact or how they are related in the frequency domain. This is achieved with the use of cross-spectral analysis and by estimating the Fourier Transformation of the series' cross-covariance function. However, the presentation of the results of cross-spectral analysis is different than the above. With cross-spectral analysis, we examine mainly two statistics: the coherence (squared) and phase:

The coherence is like a correlation coefficient and takes values between 0, 1. It depicts the correlation between two series in the frequency domain.

The phase depicts whether one variable leads the other. It is measured in fractions of a cycle, hence, as we described before, in fractions of pi.

In the present paper we applied cross-spectral analysis on the same data using GDP p.c. series levels and annual growth rates of GDP p.c. and we present the results in the two figures below (figures 5, 6). For both kinds of series we have estimated the coherence and phase function in all frequencies. The two functions were estimated for pairs of countries. In this manner we can see whether one economy is related to another under the same low frequency, hence, a long cycle. And if it is, which one of the two leads the other. The coherence values are presented in the left-hand axis whereas the phase values are depicted in the right-hand axis. The minimum phase lag is -1π (a half cycle lag) and the maximum phase lead is $+1\pi$ (a half cycle lead). Of course, if we do not have strong coherence (< 0.5), phase estimations are of no importance.

As can be seen in figure 5, all countries' GDP p.c. series appear to have strong linear dependence in all frequencies and thus in all periodicities. In the table below (Table 3) we eliminated only the results of our estimations for cycles lasting between 32-52 years. The same procedure was implemented for the growth series (Table 4). The coherence value is in all cases above 0,5 and extremely close to 1. Moreover, the cycles appear to be almost synchronized since the proportions of cycle lags, especially for the level series, are very limited. However by using only the signs of the phase's values we could reach some conclusion about which country is leading the other during a long cycle of its economic activity. A positive sign of the phase value means that the long cyclical activity of the county on the left vertical axis is ahead of the corresponding cyclical activity of the country on the horizontal axis.

Figure 5: Cross-Spectrum of level series

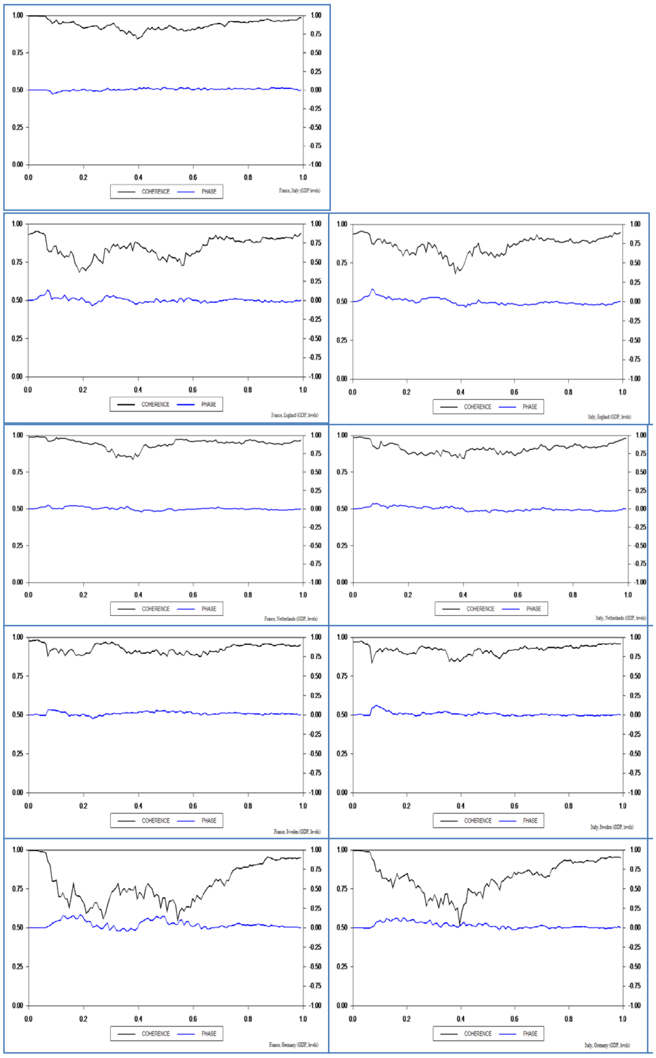


Figure 5: Cross-Spectrum of level series (continued)

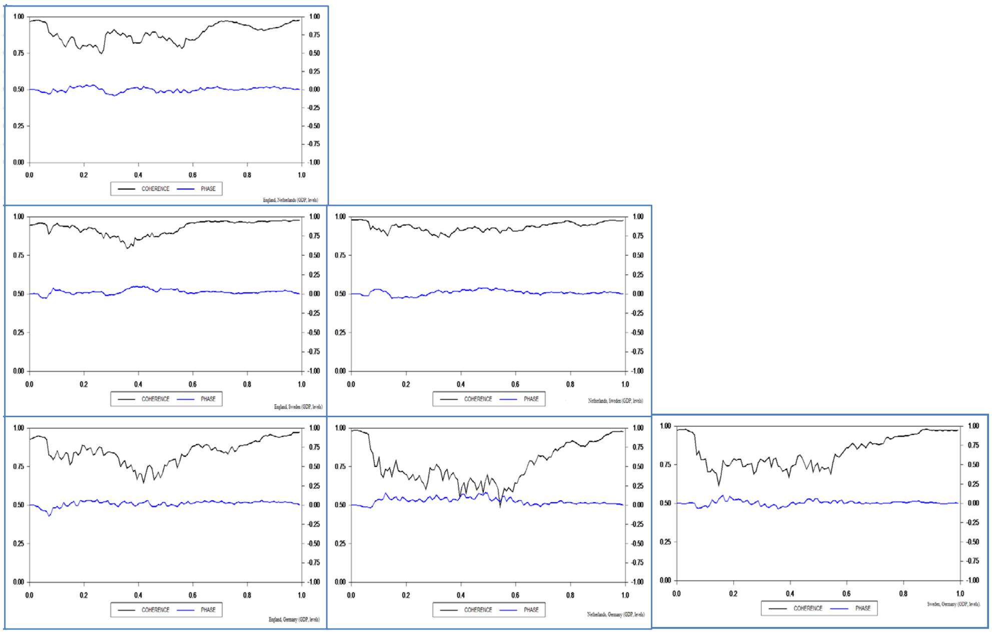


Table 3: Results of cross-spectral analysis on levels

Leader, Follower

Leader(+), Follower (-)

2	1	France				Itally				England				Netherlands				Sweden				Germany			
	Cycle Years	52	43	37	32	52	43	37	32	52	43	37	32	52	43	37	32	52	43	37	32	52	43	37	32
France	Coherence																								
	Phase Values																								
Itally	Coherence	>0,5	>0,5	>0,5	>0,5																				
	Phase Values	+	+	+	+																				
England	Coherence	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5																
	Phase Values	+	+	+	+	+	+	+	+																
Netherlands	Coherence	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5												
	Phase Values	+	+	+	+	+	+	+	+	-	-	-	-												
Sweden	Coherence	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5								
	Phase Values	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
Germany	Coherence	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5				
	Phase Values	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+				

Table 4: Results of cross-spectral analysis on growth

Leader, Follower

Leader(+), Follower (-)

2	1	France				Itally				England				Netherlands				Sweden				Germany			
	Cycle Years	52	43	37	32	52	43	37	32	52	43	37	32	52	43	37	32	52	43	37	32	52	43	37	32
France	Coherence																								
	Phase Values																								
Itally	Coherence	>0,5	>0,5	>0,5	>0,5																				
	Phase Values	+	+	+	+																				
England	Coherence	>0,5	>0,5	>0,5	>0,5	>=0,5	>0,5	>0,5	>0,5																
	Phase Values	+	+	+	+	+	+	+	+																
Netherlands	Coherence	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5												
	Phase Values	-	-	-	-	-	-	-	-	-	-	-	-												
Sweden	Coherence	>0,5	>=0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5								
	Phase Values	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
Germany	Coherence	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>0,5	>=0,5	>0,5				
	Phase Values	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	+	+	+	+				

Figure 6. Cross-Spectrum of growth series

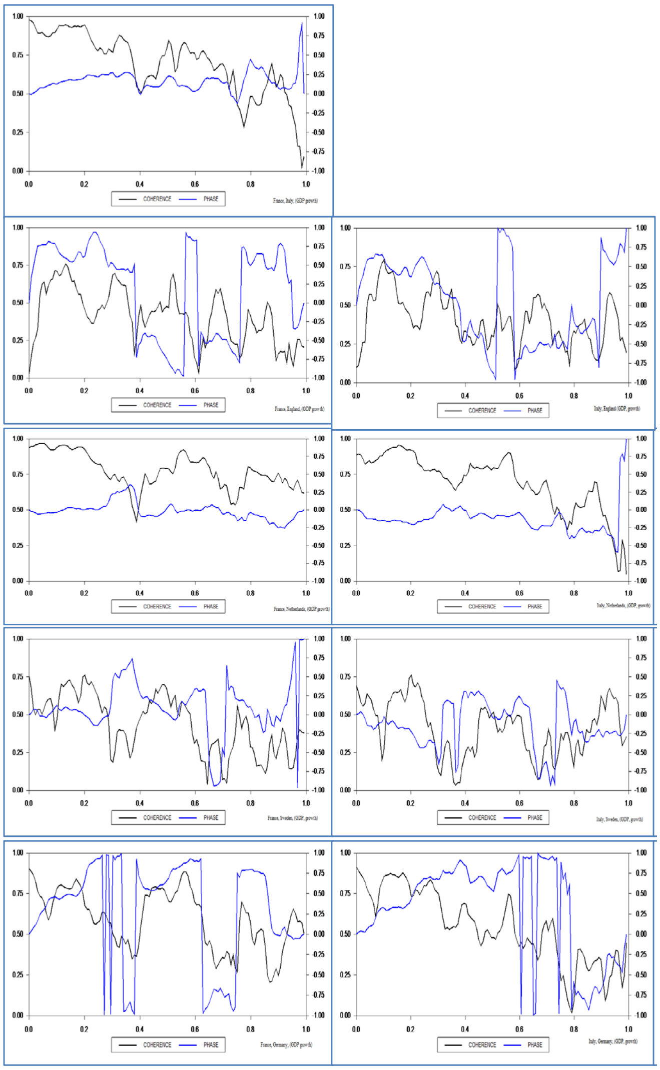
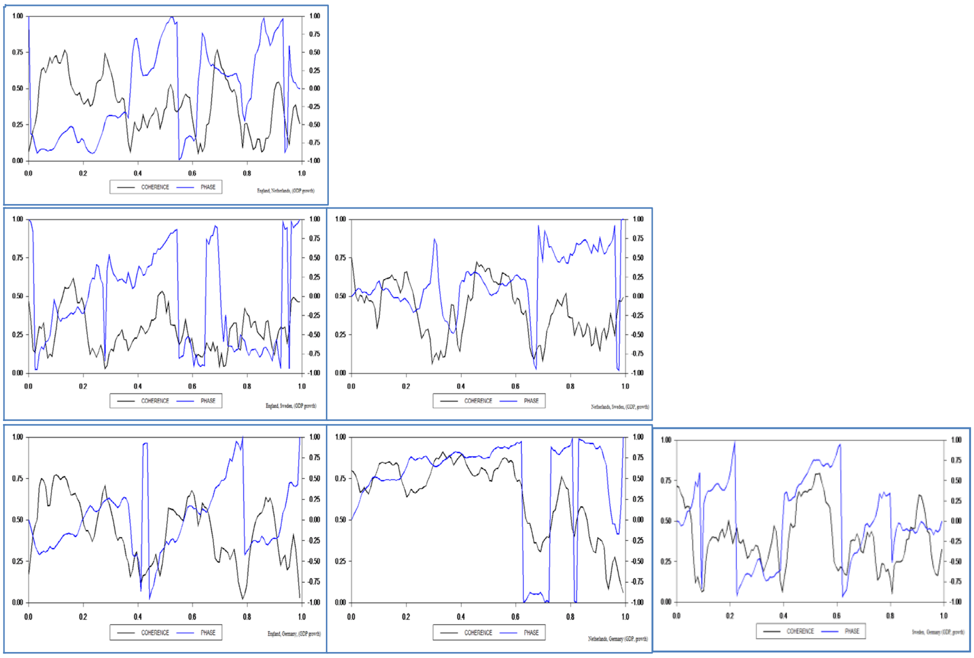


Figure 6. Cross-Spectrum of growth (continued)



Conclusions

Our empirical estimations confirm the long wave's significant contribution in GDP p.c. series. The spectral density estimations after the elimination of a linear trend depicted clearly the presence of long cycles in the series. However, in the case of the GDP p.c. growth rates the results support, apart from long waves, the presence of Juglars, Kuznets and Kitchin cycles in most of the countries. Trying to answer whether these long movements are related with the use of cross-spectral analysis, we found that they have a strong synchronization and a strong linear dependence especially in the GDP p.c. levels. However, the English economy's long cyclical movements are always ahead relatively to other European Countries. This was to be expected, since after the Industrial Revolution, the evolution of capitalism primary influenced England's economy, driving all other countries in the same direction.

Additionally, Germany appears to be a follower especially in three out of the other five countries. This might be due to the fact that its economy was mostly influenced in long economic periods, such as that after the Second World War.

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CDS AND STOCK MARKET: PANEL EVIDENCE UNDER CROSS-SECTION DEPENDENCY

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Abstract
In recent years, the spreads of CDS that are crucial aspects in detecting the financial risk level of countries have been taken more notice of by investors. In this paper, we investigate the relation between CDS spreads and countries' stock indices by using Basher and Westerlund (2009) panel cointegration and Dumitrescu-Hurlin (2012) panel causality tests. Causality from stock market to CDS figures has been detected by the Sequential Panel Selection Method (SPSM) of Chortareas and Kapetanios (2009) for 7 out of 13 G20 countries. Additionally, the study finds a negative correlation between variables with the usage of Common Correlated Effects (CCE) estimator. The positive increasing trend in stock markets causes a decrease in the financial risks that naturally allow low CDS spreads.

JEL Classification: C33, G15
Key words: CDS Spread, Stock Market, Panel Cointegration, Panel Causality, Cross-Section Dependency

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1. Introduction[i]

Financial market instruments distribute flows of funds to finance the investments of market players. Also, these instruments play a vital role in channeling funds from lenders to borrowers. Among them are the credit derivatives that transfer credit risks and yields from one party to another by making forward, future, option and swap contracts (Erdil, 2008: 3). The most commonly used one is credit default swaps (CDS) contracts which promise to promote payment of the credit and provide premium yield in exchange. That is, one party buys the protection with certain remuneration and the other takes the same risk in return for payment. The reasons why CDS have been used can be transferring of credit risk, enhancing the credit limit of a customer, gaining additional income by taking credit risk or portfolio diversification (Karabıyık and Anbar, 2006: 50). The increased importance of CDS contracts since the late 1990's led to efforts to describe the emergence of risk with clear statements. Therefore, the International Swaps and Derivatives Association (ISDA) defined the credit event as emergence of one or more conditions of bankruptcy, failure to pay, obligation acceleration, obligation default, repudiation/moratorium or restructuring (ISDA, 2003: 30). The risk taker recompenses the loss of the protection purchased by the other party. CDS can also be used as a commodity by investors. Any possible change in the risk of the credit debtor is able to alter the CDS prices, revealing new opportunities for investors to make profit. Thus CDS have become a risk indicator in the market. Moreover, CDS inform us regarding the quality of issued bonds of countries or companies and other debt instruments. In this respect, CDS prices use the credit risk information of the reference company, before revision of the bond price of the reference company. Hence the prices of CDS play an essential role for information in credit markets (Tözüm, 2009: 122). The provided knowledge of CDS contributes to detecting the country's risk. During recent years, CDS spreads have become a significant indicator with regard to risk perceptions of countries and companies. Country risk analysts consider that Eurobond yields are not susceptible to more analysis, and therefore they have taken fluctuations of CDS spreads (Ersan and Günay, 2009: 3).

Commodity prices, current deficit and rise in political risk can increase CDS premiums. Recent CDS literature highlights the relationship between CDS prices and the benchmark bond interest rate. While many studies consider that CDS premiums

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[i] We thank the referee for providing constructive comments and help in improving the contents of this paper.

lead to high benchmark bond interest rates, there are limited papers regarding the impact of CDS premiums on the stock exchanges. In this context, the broadly accepted assumption is of a negative relationship between CDS premiums and stock indices. Under this assumption, high CDS premiums affect negatively confidence towards market and stock indices. On the other hand, positive trends on the stock exchange, with the usage of good economic indicators that imply lower country risk, confirm a negative relationship with CDS premiums.

The rest of our paper is organized as four parts. Initially, the study provides a brief overview of the literature. The next part focuses on the explanation of the econometric model. The following section addresses the empirical analysis and lastly the paper contains concluding remarks.

2. Literature Review

Studies of CDS and stock indices used various types to predict the relationship direction between datasets. Therefore, we describe previous studies regarding CDS and indices.

Alexander and Kaeck (2008) examine the effect of theoretical determinants of CDS spreads - interest rates, stock returns and implied volatility on daily changes in the iTraxx Europe indices in the period June 2004 and June 2007, using the Markov switching model. The study reveals that iTraxx Europe indices are sensitive to stock volatility during CDS market turbulence.

Fung *et al*. (2008) provide evidence for the relation between the U.S. stock market and the CDS market from 2001 to 2007. In terms of pricing and volatility, there is mutual feedback for the stock market and the high yield CDS market. They analyse market-wide relations, unlike other studies that use the firm level. Besides, the VAR model shows that the stock market leads both investment grade and high yield CDS markets.

Norden and Weber (2009) claim a negative relationship between stock returns and CDS spreads by taking data that cover 2000-2002 from 58 European and US companies. Also, the study of Demirkan (2011) finds a negative relationship between stock returns of OECD countries and CDS spreads, as well.

Trutwein and Schiereck (2011) focus on the relation between equity and credit markets for major financial institutions. They confirm that there is a strong positive relation between changes in CDS spreads and implied volatility. That is, CDS markets and option implied volatility demonstrate simultaneously adjustment to changes under credit default risk.

The study of Trutwein *et al*. (2011) analyzes the impact of changes in default risk by using CDS spreads on equity returns. Findings of the study support the regime-dependent nature of link between CDS spreads and equity returns. Therefore, the market crisis condition reacts differently for abnormal returns and severe CDS spread movements.

Coronado *et al*. (2012) investigate the link between sovereign CDS and stock indexes for eight European countries (Spain, Portugal, Italy, France, Ireland, United Kingdom, Greece and Germany) during the period 2007-2010 by using VAR and panel data models. The study shows that stock index returns and sovereign CDS spreads changes have significantly negative correlation, and stock index return volatility is related to sovereign CDS spreads movements. Also, the stock market clearly leads the CDS market – which confirms previous results.

Fenech *et al*. (2013) observe correlation between CDS spreads and respective stock prices in Australia by splitting the data pre and post global financial crisis with Archimedean copulas. The study exhibits a negative co-movement for the post-global financial crisis period by including the 2006-2009 period.

Castellano and Scaccia (2013) use the Markov switching model in CDS and stock market index quotes. Daily closing quotes for five years from 2004 to 2010 are analyzed. The basic topic of the research is whether increases in volatility of CDS index changes can be an indicator of stock market turmoil. According to test results, volatility of the CDS market is a reliable instrument for predicting stock market crashes.

Narayan *et al*. (2014) study panel data and conclude that the stock market contributes to price discovery in nine sectors and CDS market contributes to price discovery in only six sectors from 07/02/2004 to 03/30/2012 by converting natural logarithmic forms of data series. Classified firms in terms of sectors and sizes are subjected to panel cointegration and panel VECM in order to estimate price discovery.

Eyssell *et al*. (2013) identify the determinants of levels and changes of sovereign CDS spreads in China. They find that both internal factors, such as the stock market index and interest rate, and global factors had vital impacts on CDS spreads between January 2001 and December 2010. Also, the study reveals that China sovereign CDS spread changes lead stock returns within the Vector Autoregressive model. Therefore, CDS is accepted as a leading economic indicator for cross-market trading and hedging.

Banerji *et al.* (2014) investigate the dynamic relations between external factors, domestic macroeconomic factors with sovereign spreads, debt to GDP ratio, etc. in Asian emerging countries. According to their study, variations in sovereign spreads are mainly driven by external shocks, with the term structure of U.S. interest rates and global risk aversion having the most important role.

Dergiades *et al.* (2013) examine the impact of the volume of activity in social media and web search queries on the sovereign spread between Greece, Ireland, Italy, Portugal, Spain and the German long-term government bond yield during the Greek debt crisis. They use daily time-series data related to the Greek crisis over the period from 20th May 2011 to 9th May 2013. The study suggests that unprocessed data, effortlessly traced in social media, contain valuable information content with respect to the short-run movements of financial markets.

The study analyses the relationship between CDS spreads and stock market prices of 13 out of G20 countries by doing Basher and Westerlund (2009) panel cointegration and Dumitrescu-Hurlin (2012) panel causality tests.

3. Econometric Methodology

Time series analysis investigates relationships separately. However, panel data analysis takes into consideration interaction among countries in order to obtain more advanced results. Thus the use of panel data analysis is more suitable instead of time series analysis for the study. The heterogeneous structure of the panel calls for application of the panel causality test of Dumitrescu and Hurlin (2012). The null hypothesis of the test indicates that there does not exist a Granger causality relationship in the panel, while an alternative hypothesis suggests that there is a causality relation, of at least one, in the cross section. Moreover, Granger causality tests using for time series and panel data analysis is assumed as linear (Alagidede *et al.*, 2011).

The crucial point of the null hypothesis is the possible existing homogeneous relationship, whereas the alternative hypothesis searches for a heterogeneous relationship. The test statistic of basic hypothesis testing is the arithmetic mean of each individual Wald statistic. Additionally, the econometric test method provides reliable results in spite of low data numbers and unbalanced panel data models (Bozoklu and Yılancı, 2013).

According to this model, the null hypothesis is tested by the simple means of the Wald statistic individually. That is:

$$W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,t} \quad \mathbf{(1)}$$

where $W_{i,t}$ denotes the Wald test statistic for country i to test causality.

Dumitrescu and Hurlin (2012) offer an estimated standardized statistic for WHNC by using estimation values of mean and variance of the distribution due to no convergence to the same chi-square of each individual Wald statistics with a small sample for T. This statistical equation is below:

$$Z_{N,T}^{HNC} = \frac{\sqrt{N}\,[W_{N,T}^{Hnc} - \sum_{i=1}^{N} E(W_{i,t}]}{\sqrt{\sum_{i=1}^{N} Var(W_{i,t})}} \qquad \textbf{(2)}$$

where i denotes total number of countries. W and T demonstrate Wald statistics and period numbers. The study of Dumitrescu and Hurlin (2012) explains the details of the model deeply.

4. Data and Empirical Results

In this paper, we analyze the CDS indexes and stock markets of 13 out of G20 countries[1] during the 52 weeks that cover the period 22 April 2013 to 15 April 2014. The countries and stock markets respectively are USA (S&P), Germany (DAX), Argentina (MERVAL), United Kingdom (UK), Brazil (IBOVESPA), France (CAC), South Africa (FTSE JSE), South Korea (KOSPI), Italy (FTSE MIB), Japan (NIKKEI), Mexico (BOLSA), Russia (RTSI) and Turkey (BIST). Descriptive statistics of the series are presented in appendix 1 and appendix 2 respectively for CDS and stock market indices.

Datasets of country stock exchanges and CDS indexes are provided by www.uk.finance.yahoo.com and www.dbresearch.com links. We take logarithms of the series in order to avoid heteroscedasticity problem and normalize series. Appendix 3 demonstrates the related graphics of CDS and stock markets for each countries.

Another significant point is that results of analyses are outcomes from Monte Carlo Simulation 10,000 replications. The structure of the datasets is crucial for the types of the tests in the panel data analysis. In this connection, the status of the variables should be detected as homogeneous or heterogeneous and convenient unit root, cointegration and causality tests should be used. Therefore, initially we detect the structure of the datasets thanks to the Pesaran and Yamagata (2008) slope homogeneity test in Table 1:

[1] The reason why we selecting 13 out of 20 is the avaliability of data sets for our time period.

Table 1: Pesaran and Yamagata (2008) Slope Homogeneity Test Results

	Test Stat.	Prob.
Δ	9.25	0.00*
Δ_{adj}	27.76	0.00*

*indicates significance level in 1%.

According to results, variables are heterogenous at 1% level both Δ and Δ_{adj} statistically. Cross section dependency that is important in the panel data analysis requires us to view time and cross section dimensions. Cross section dependency can be studied by Breusch-Pagan (1980) LM or Pesaran (2004) CD tests.

Breusch Pagan (1980) CD_{LM1}, Pesaran (2004) CD_{LM2} and Pesaran (2004) CD_{LM} test the cross section dependency existence for panel data. When T > N CD_{LM1} and CD_{LM2} tests are considered in respect of cross section dependency. Meanwhile, under N > T condition, CD_{LM} test becomes the cross section dependency estimator.

Table 2 demonstrates the cross section dependency test results via CD_{LM1} and CD_{LM2} tests for CDS and stock markets. The results signify the existence of both CDS and stock market panel cross section dependency.

Table 2: Cross Section Dependency Test Results

	CDS	Stock Market
Cd LM1 (Breusch and Pagan 1980)	227.63 (0.00*)	281.30 (0.00*)
Cd LM2 (Pesaran 2004)	11.98 (0.00*)	16.27 (0.00*)

*indicates significance level in 1%.

Using of cointegration and causality tests that should consider cross section dependency and heterogeneous series are convenient based on test results in Table 1 and Table 2. On the other hand, stationary levels of the series are significant in order to make necessary cointegration and causality tests. Therefore, our study used second generation unit root test panel seemingly unrelated regressions augmented Dickey-Fuller (SURADF) Breuer *et al.* (2001, 2002) due to T > N. According to the SURADF panel unit root test, Table 3 and Table 4 indicate that all series have unit root at their levels. Statistical values are lower than critical values, however series are integrated at their first differences. Also, the SURADF test provides the statistics of each country separately though it analyses panel structures. Therefore, SURADF takes into account not only panel structure of the series but also differences among countries.

Table 3: SURADF Panel Unit Root Test Results for CDS

Countries	Level		First Difference	
	Statistic	Critical Value (%5)	Statistic	Critical Value (%5)
USA_{cds}	-2.781	-7.044	-8.110	-7.593
$Germany_{cds}$	-1.543	-6.874	-9.307	-7.789
$Argentina_{cds}$	-1.912	-7.126	-7.708	-7.643
UK_{cds}	-5.739	-5.802	-9.608	-7.048
$Brazil_{cds}$	-3.722	-5.682	-7.615	-7.098
$France_{cds}$	-7.007	-7.162	-11.45	-7.743
South $Africa_{cds}$	-1.995	-5.909	-7.739	-7.528
South $Korea_{cds}$	-2.742	-5.510	-7.833	-7.291
$Italy_{cds}$	-5.788	-6.048	-8.490	-7.582
$Japan_{cds}$	-3.761	-6.490	-7.994	-6.433
$Mexico_{cds}$	-3.334	-6.363	-9.570	-6.819
$Russia_{cds}$	-2.825	-5.916	-8.504	-7.216
$Turkey_{cds}$	-2.250	-5.734	-8.752	-6.935

Table 4: SURADF Panel Unit Root Test Results for Stock Markets

Countries	Level		First Difference	
	Statistic	Critical Value (%5)	Statistic	Critical Value (%5)
USA_{sm}	-2.781	-7.044	-8.110	-7.593
$Germany_{sm}$	-1.543	-6.874	-9.307	-7.789
$Argentina_{sm}$	-1.912	-7.126	-7.708	-7.643
UK_{sm}	-5.739	-5.802	-9.608	-7.048
$Brazil_{sm}$	-3.722	-5.682	-7.615	-7.098
$France_{sm}$	-7.007	-7.162	-11.45	-7.743
South $Africa_{sm}$	-1.995	-5.909	-7.739	-7.528
South $Korea_{sm}$	-2.742	-5.510	-7.833	-7.291
$Italy_{sm}$	-5.788	-6.048	-8.490	-7.582
$Japan_{sm}$	-3.761	-6.490	-7.994	-6.433
$Mexico_{sm}$	-3.334	-6.363	-9.570	-6.819
$Russia_{sm}$	-2.825	-5.916	-8.504	-7.216
$Turkey_{sm}$	-2.250	-5.734	-8.752	-6.935

Stationary levels [I(1)] of the series are available for testing the cointegration relation between panels. We intend to use the Basher and Westerlund (2009) panel cointegration test in respect of cross section dependency and structural breaks. Existence of cross section dependency validates the bootstrap critical value. If not, asymptotic probability is valid for detection of cointegration relations between variables. The test results are indicated in Table 5. Our analysis takes the critical bootstrap values owing to the existence of cross section dependency for both panels. Calculated test value accepts null hypothesis for existence of panel cointegration. That is, country CDS spreads and stock markets have an integrated structure. Besides, if there is no cross section dependency in the panel, the cointegration relation will be valid anyway according to asymptotic probability. Moreover, any structural break is detected for all countries under the model that allows 5 structural breaks. Weekly and short term data sets can be evaluated as the main reason for this result.

Table 5: Basher and Westerlund (2009) Panel Cointegration Test Results

T Statistic	1.263
Asymptotic Probability	0.103
Bootstrap Critical Value	0.748

*Constant and trend are included in model.

All series are stationary at their first differences and thus the Dumitrescu-Hurlin (2012) panel causality test takes into account the cross section dependency of series. When we look to the results of the Dumitrescu-Hurlin panel causality test in Table 6, there is no causality relation from CDS spreads to stock markets by accepting the null hypothesis. Meanwhile, the causality relation from stock market to CDS spreads is not the same. Initially, the alternative hypothesis which signifies at least one causality relation in the panel is accepted. Sequential Panel Selection Method (SPSM) of Chortareas and Kapetanios (2009) helps to determine which countries have causality relation from CDS spreads to stock market. According to SPSM, the lowest Wald statistic belongs to Russia and we analyze again the same data without Russia. This process lasts till the acceptance of the alternative hypothesis, which is that at least one series in the panel is stationary. Table 6 demonstrates the consequences of the just 1 lag structure in order to not cover more areas.

Table 6: Dumitrescu Hurlin Panel Causality Test Results

Causality from Stock Market to CDS		
Countries	**Wald Statistic**	**Prob.**
Russia	-34.53	0.00*
Italy	-18.14	0.00*
France	-21.49	0.00*
UK	-16.46	0.00*
Argentina	-7.64	0.00*
South Korea	-9.11	0.00*
Germany	-6.12	0.01*
Japan	-3.03	0.11
USA	-1.86	0.17
Turkey	-1.75	0.18
Brazil	-1.00	0.31
South Africa	-0.61	0.43
Mexico	-0.49	0.48
Causality from CDS to Stock Market		
Countries	**Wald Statistic**	**Prob.**
Panel	-0.0082	0.9935

* indicates significance level in 1%.

As a result of the analysis, while the stock exchanges of Russia, Italy, France, UK, Argentina, South Korea and Germany are the causality of the changes of CDS spreads, Japan, USA, Turkey, Brazil, South Africa and Mexico do not have such a relation. Additionally, the results do not alter with 1, 2 and 3 lag structures.

Integration among countries has become more intensive thanks to globalized economic structure and an economic shock in one country can easily spread to other countries. Therefore, Pesaran (2007) designed the Common Correlated Effects (CCE) estimator to provide accurate estimation for long term regression coefficients under cross section dependency (Eratas *et al.*, 2013). We take the stock markets as an independent variable due to causality direction from stock exchange to CDS spreads Table 6. Pesaran's (2007) CCE Mean Group Estimates reveals the results at Table 7 that denote a 0.03459 % decrease in CDS spreads when the stock market increases 1%. The main underlying reason is the decreasing possibility of CDS premiums which are affected by the positive impact of economic indicators and the favorable perception of increasing trend in stock exchange markets by reducing risk.

Table 7: CCE Estimation Results

Dependent Variable	Independent Variable	Coefficient	Standard Dev.	T_{stat}
CDS	Stock Market	-0.03459	0.019450	-1.77870

5. Conclusion and Discussion

In recent years, frequently CDS spreads have been accepted as a critical indicator to measure country risk by market investors. The relation between invested stock exchanges and CDS has attracted numerous academic studies. In this context, we have found that the stock exchanges of 7 out of 13 G20 countries – Russia, Italy, France, UK, Argentina, South Korea and Germany – have direct country-CDS spreads, with the usage of the Dumitrescu-Hurlin (2012) panel causality test. Besides, the Basher and Westerlund (2009) panel cointegration test confirms the co-integrated structure between variables and the CCE estimator verifies that variables affect each other negatively. The facts show that positive trends in stock exchanges enhance the confidence of investors and lead to lower CDS premiums. When CDS premiums are considered as indicators for financial crises, stock exchanges can be accepted as precursor indicator for financial crises.

In the literature, the studies of Fung *et al*. (2008) and Coronado *et al*. (2012) support our results that reveal causality from stock exchange to CDS spreads. Also, papers of Weber (2009), Demirkan (2011), Coronado *et al*. (2012) and Fenech *et al*. (2013) observed a negative cointegration relation between variables as our findings.

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Appendix 1: Descriptive Statistics for CDS

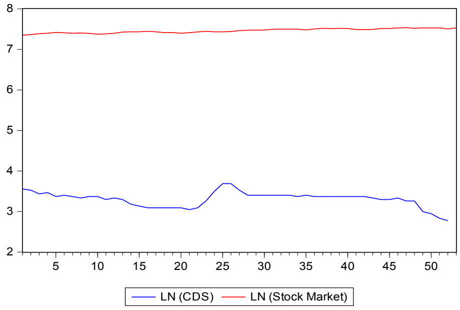
	USA	Germany	Argentina	UK	Brazil	France	S. Africa	S. Korea	Italy	Japan	Mexico	Russia	Turkey
Mean	27.63	26.28	2382	33.32	175.11	61.82	203.19	70.8	206.55	58.38	104.73	179.34	203.44
Median	29	25.00	2371	29.50	180.5	63	203	69	212.5	56	102.5	170.5	208
Maximum	40	35.00	3873	51	214.	81	267	114	286	87	158	270	276
Minimum	16	20.00	1649	23	105	48	148	54	113	39	76	131	117
Std. Dev.	4.90	4.05	580	8.80	26.5	10.05	23.98	10.98	49.69	11.09	18.21	31.07	40.35
Skewness	-0.04	0.69	0.50	0.59	-0.83	0.23	0.02	1.36	-0.18	0.54	0.7	1.07	-0.67
Kurtosis	3.56	2.63	2.38	1.88	3.36	1.72	3.15	6.02	1.66	2.62	3.09	4.12	2.94
Jarque-Bera	0.70	4.45	2.98	5.73	6.34	4.02	0.05	35.98	4.13	2.83	4.3	12.83	3.97
Probability	0.70	0.10	0.22	0.05	0.04	0.13	0.97	0.00	0.12	0.24	0.11	0.00	0.13

Appendix 2: Descriptive Statistics for Stock Market

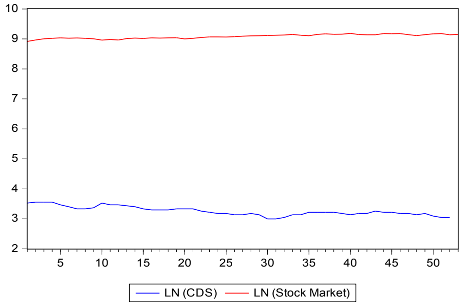
	USA	Germany	Argentina	UK	Brazil	France	S. Africa	S. Korea	Italy	Japan	Mexico	Russia	Turkey
Mean	1737	8809	4766	6577	50901	4127	43651	1954	18325	14494	40845	1347	73667
Median	1744	8865	5241	6583	51186	4165	44017	1957	18304	14462	40863	1348	74258
Maximum	1878	9742	6468	6838	56406	4484	48213	2052	22175	16178	42958	1516	90546
Minimum	1555	7459	2976	6116	44966	3651	37852	1822	15239	12686	37517	1062	61189
Std. Dev.	91.83	614	1095	148	3002	210	2842	53.45	1780	799	1127	96.33	7346
Skewness	-0.11	-0.17	-0.17	-0.81	-0.18	-0.51	-0.31	-0.44	0.16	0.04	-0.41	-0.76	0.50
Kurtosis	1.69	1.84	1.54	3.90	1.99	2.39	2.05	2.73	2.21	2.58	3.35	3.40	2.98
Jarque-Bera	3.85	3.20	4.92	7.69	2.52	3.13	2.87	1.89	1.60	0.40	1.80	5.57	2.27
Probability	0.14	0.20	0.08	0.02	0.28	0.20	0.23	0.38	0.44	0.81	0.40	0.06	0.32

Appendix 3: Graphics of Series (Logarithmic Forms)

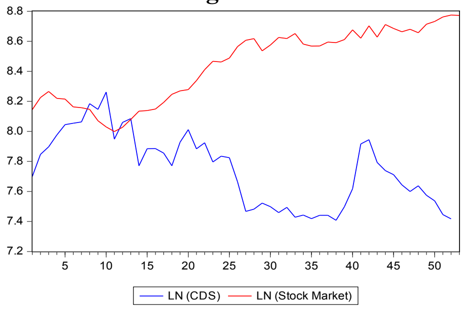
USA



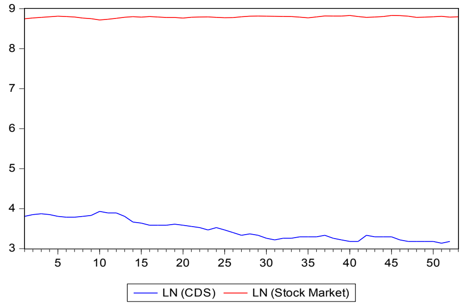
Germany



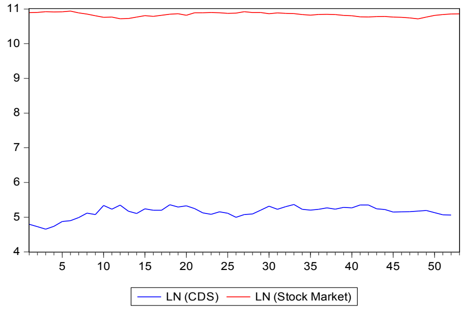
Argentina



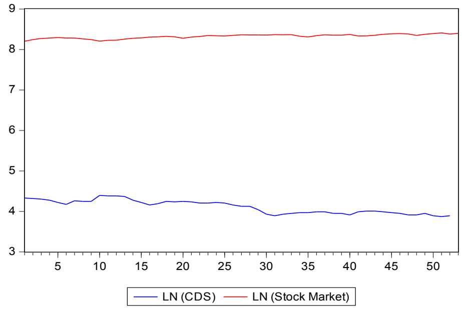
UK

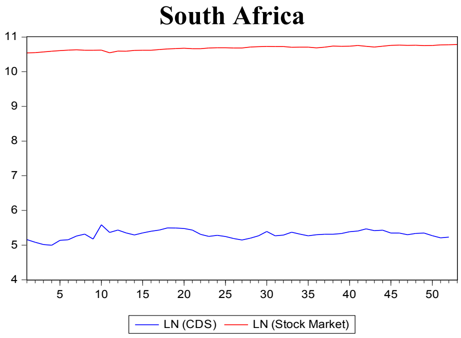


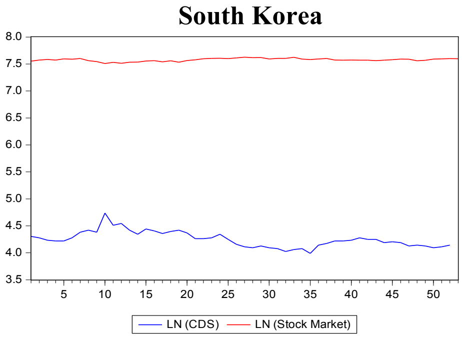
Brasil

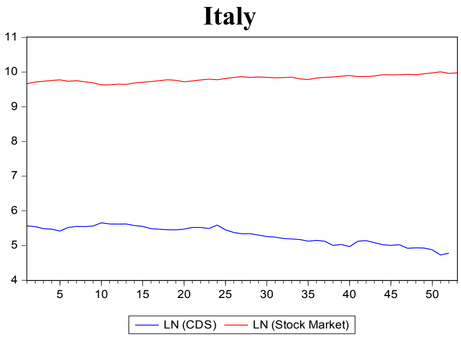


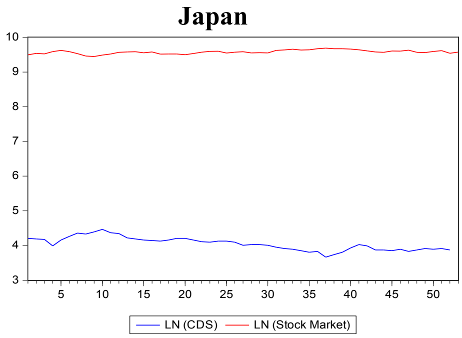
France

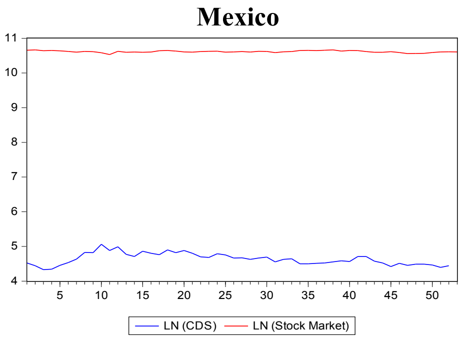


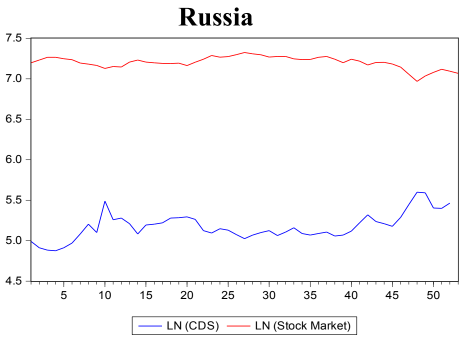

South Africa
LN (CDS)
LN (Stock Market)

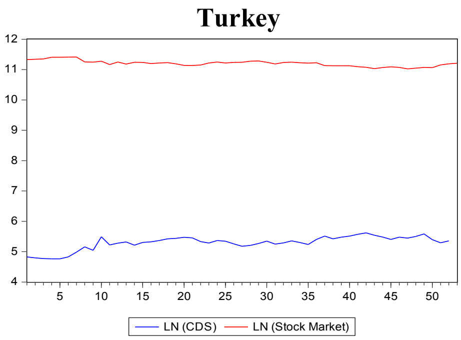

South Korea
LN (CDS)
LN (Stock Market)


Italy
LN (CDS)
LN (Stock Market)


Japan
LN (CDS)
LN (Stock Market)


Mexico
LN (CDS)
LN (Stock Market)


Russia
LN (CDS)
LN (Stock Market)


Turkey
LN (CDS)
LN (Stock Market)

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THE MARKET FOR Ph.D. HOLDERS IN GREECE: PROBIT AND MULTINOMIAL LOGIT ANALYSIS OF THEIR EMPLOYMENT STATUS

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Abstract
The objective of this paper is to investigate the factors influencing the probability that a Ph.D. holder in Greece will work in the academic sector, as well as the probability of his or her choosing employment in various sectors of industry and occupational categories. Probit/multinomial logit models are employed using the 2001 Census data. The empirical results indicate that being young, married, having a Ph.D. in Natural Sciences and/or in Engineering, granted by a Greek university, increases the probability of being employed in the academic sector. Fields of study and the wage rate are the variables that exercise the strongest impact on the predicted probability of choosing employment in various sectors of industry and occupational categories.

JEL Classification: J24, J31
Key words: Ph.D. holder, academic labor market, industry, occupation

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1. Introduction

The number of Ph.D. graduates in Greece has been growing continuously over the last thirty years. Since 1996 the number of Ph.D. graduates has increased by almost 5.5 times, reaching the 1892 mark in 2010, while 58% of them are men and 42% women. Most of the Ph.D. graduates are found in Health Sciences and the Sciences of Engineering, reaching in 2007 almost 70% of the total number of graduates. Regarding their employment status, 31% of Ph.D. holders in 2001 work in academia. With respect to the sectors of industry, most men and women Ph.D. holders are employed in Education, (42.3% and 47%, respectively) and Healthcare (22.4% and 26.2% respectively).

The basic objective of this paper is to analyze the labor market of Ph.D. holders in Greece and to identify the factors that affect the probability of employment in academic and non-academic sectors, as well as the probability of choosing employment in various sectors of economic activity and occupational categories.

Previous research is mostly concentrated on the U.K. and U.S. academic markets and the areas under investigation concern mainly issues regarding earnings differentials among male and female Ph.D. holders and issues of promotion and/or discrimination within the academic sector (Meyer 2005). In Greece, the system of higher education is public, highly concentrated, and the number of the available positions at each university is determined and allocated by the Ministry of Education, Lifelong Learning and Religious Affairs. Each opening of a new employment position is published in the press and the interested individuals submit applications. Furthermore, university salaries are determined by a formal institutional framework, where salaries are mainly related to the tenure status of each position. Consequently, salaries are the same for both males and females and across disciplines, and discrimination in salaries determined by the state is negligible. In addition, the promotion process is also determined by the legal institutional framework depending upon teaching and research requirements and years in a position. No data on these processes are available in order to examine the issues of discrimination in the promotion process among men and women and across disciplines. Given the above institutional framework, our analysis will focus on the factors affecting the probability of employment in the academic and non-academic sector. In other words, the research question concerns factors affecting the "getting in" decision (Meyer 2005), as well as factors affecting the probability of choosing employment in various sectors of industry and occupational categories. As far as we are aware, there is no previous research on the market for Ph.D. holders in

Greece. This paper uses mainly 2001 Census data for Ph.D. holders, data from the Labor Force Survey 2001, as well as the Greek Statistics of Education (1980-2010).

The paper is structured as follows. Section 2 briefly reviews the literature on the academic labor market of Ph.D. holders. Section 3 presents the data and descriptive statistics of the variables used in our analysis. Section 4 presents the results of the econometric analysis. Major findings and conclusions are summarized in Section 5.

2. Review of literature

Research on the market for Ph.D. holders concerns mainly U.K. and U.S. academic markets and focuses on issues regarding earning differentials, promotions and discrimination among male and female Ph.D. holders within the academic sector. Most studies use survey data and control for factors such as the number of published articles, their quality and academic rank. In general, in the U.S., women in academia earn less than their male colleagues, even though the salary gap was closing from the 70's to the 90's (Barbezat 1987; Barbezat 1991; Toutkousian 1998). In particular, in the field of economics, McDowell *et al.*, (2001) and McDowell and Smith (1992) find that women have been disadvantaged in promotions, although the effect seems to be diminishing over time. Ginther and Hayes (2003) and Ginther (2001) examine salaries in the U.S. academic labor market and especially in the field of humanities and find a gender pay gap, although they conclude that this is explained by rank rather than within-rank differentials. Furthermore, McDowell *et al.*, (2001), Long *et al.*, (1993), Kahn (1993, 1995) and Ginther and Kahn (2004) argue that women in academia are less likely to get promoted.

In the U.K. academic sector, salaries are determined within an institutional framework and salary differences are expected to be small, but several studies find a wage gap that is declining over time, as in the U.S. (Dolton and Makepeace 1987; Dolton *et al.*, 1989; McNabb and Wass 1997; Ward 1999). In addition, it seems that women face more promotion difficulties (McDowell *et al.*, 2001; Long *et al.*, 1993; Kahn 1993) and difficulties with editors and referees and thus they are less likely than men to remain in academia after having obtained a doctoral degree (Preston 2004; McDowell *et al.*, 2001; Kahn 1993). In the UK and in the field of economics, Blackaby *et al.*, (2005), find that there is a significant gender promotions gap. In contrast to Ginder and Hayes (2003) and Ward (1999), they also find that there is a significant within-rank pay gap. They also suggest that for given productivity, individual and workplace characteristics, men receive more outside offers than women and those offers are associated with higher earnings. Furthermore, their results are consistent with the "loyal servant" hypothesis, i.e., that women are less likely to leave their current employment, perhaps due to family commitments. Ward (1999) reports an average salary differential of 15-26% for British academics, while Blackaby *et al*., (2005), find an average gender pay gap of 18% for academic economists working in the UK.

In Sweden, Amilon *et al*., (2008) designed cross-sectional logit models explaining the probability of being employed in academia, as well as earnings regressions, and found that women Ph.D. holders are less likely to work in the academic labor market in the fields of natural sciences and medicine, while there are no important differences between men and women in the fields of social sciences and humanities. They also found that Ph.D. holders working in academia are paid less by 24% than those working in the non-academic sector. For both sectors, the gender wage gap is 15%. The gender wage gap varies within the academic and non-academic labor markets, as well as within the fields of study, although women's earnings are always less than men's.

3. Data analysis

3.1 Size and composition of Ph.D. graduates, 1980-2010

This section examines the size and the composition of Ph.D. graduates by gender and field of study. In Greece, during the last 30 years, a continuous increase in the number of Ph.D. graduates has been observed. From 1980 to 2010 the number of Ph.D. graduates has increased by almost six times. During this period the percentage of women Ph.D. graduates has increased and reached the 42% mark. The highest increase was observed in the years 1988-89, 2004-05 and 2006-07 (Table 1, Figure 1).

Figure 2 presents the number of Ph.D. graduates by field of study. The main categories-fields of study are Humanities, Social sciences, Natural sciences, Sciences of Engineering, Earth and Agricultural sciences, Healthcare sciences and Other sciences, including Law and Fine Arts. Overall, the number of Ph.D. graduates has increased, in all fields of study, for both women and men. The biggest increase though in the number of Ph.D. graduates has been observed in the fields of Healthcare sciences and Sciences of Engineering (Table 1 and Figure 2).

Specifically, in the field of Engineering we observe a gradual increase in Ph.D. graduates, especially for men, with several peaks. The most significant peak is observed in the academic year 2004-05, where the number of Ph.D. graduates reached

857 (72.2% of the total number) while 15% of them were women. In Healthcare sciences, peaks are observed in the academic years 1988-89 and 2006-07. In the academic year 1988-89 the number of Ph.D. graduates was 760 (76.5% of the total number) while 35% of them were women. In the academic year 2006-07 the number of Ph.D. graduates reached 1426 individuals (58.5% of the total number) while 41% of them were women. In the field of Humanities, the highest increase is observed in 2001-02, corresponding to 321 graduates (38.2% of the total number), 57% of which were women. In Social and Natural sciences we observe a peak in the academic year 2008-09 which corresponds to 191 graduates (50% of them were women) and 288 individuals (42% of them were women), respectively. In Earth and Agricultural Sciences a significant peak is observed in 2009-10, where the number of Ph.D. graduates reached 159 individuals (8.4% of the total number) while 45% of them were women. Finally, in the field of Other sciences we observe a significant increase in the academic year 2005-06, in which the number of Ph.D. graduates was 67 individuals (6.4% of the total number) and 52% of them were women.

3.2 Census Data and descriptive statistics for Ph.D. holders, 2001

The aforementioned aggregate data are drawn from the Statistics of Education. This data base however does not contain data on individual characteristics. Thus, for estimation purposes we will utilize data from the 2001 Census, a sample corresponding to 10% of the Greek population. This sample consists of 1988 individuals, Ph.D. holders, aged between 28 to 65 years old, (1,395 men and 593 women) (see Table 2). The average Ph.D. holder's age is 41 years old while 66% of them are married. Furthermore, most of the Ph.D. holders in Greece have obtained their degree in the field of Healthcare sciences (502 individuals, 25.3% of the total) followed by Humanities (366 individuals, 18.4% of the total) (see Table 2). Also, 69% of the total number of Ph.D. holders have received their degree from a Greek university.

Table 2 and Figure 3 present the employment status of Ph.D. holders in academic and non-academic sectors in the year 2001, by field of study. As can be seen, 31% of the stock of Ph.D. holders works in the academic sector and 69% in the non-academic one. Most Ph.D. holders working in academia in 2001 have their doctorate in the field of Natural sciences (27.8% of the total number of those working in academia) with the share of women standing at 16%. Also, a significant number of Ph.D. holders working in academia have their doctorate in Humanities (19.8%), where the share of women is 42%.

In the non-academic sector, most Ph.D. holders have their doctorate in Healthcare sciences (30.8%) and in Humanities (17.8%). The former work mostly outside academia (84.3%) and most of them are men, with the share of women reaching the 28% mark. The share of women in Humanities is high relative to other fields, corresponding to 51%. Most Ph.D. holders in this field of study are working outside academia (66.7%) and most of them are women (55%).

Table 3 shows the employment status of Ph.D. holders in Greece, in the year 2001, by sector of industry and by gender. The sectors of industry are divided into five major categories according to NACE Rev1-2D. The first category/sector refers to agriculture, livestock, fishing, retail and manufacturing (Agriculture & Manufacturing). The second category/sector refers to services (Services) which includes commercial activities, food services, transportation and similar activities. The third refers to the sector of public administration (Public Administration), the fourth to Education (Education), and the fifth refers to the sector of the Health care services (Health Care). We observe that most Ph.D. holders in Greece in 2001 were employed in Education (43.6%), and in Healthcare (23.5%). Also, most men and women Ph.D. holders are employed in the sector of Education (42.3% and 47%, respectively), as well as in Health Care (22.4% and 26.2%, respectively) (see Table 3).

Regarding the employment of Ph.D. holders by field of study, it is observed that those who have their doctorate in Humanities (79.6%), Social sciences (35%), Earth and Agricultural sciences (51%), Sciences of Engineering (45%) and Other sciences (39%) work in Education (Figure 4). Most of the Ph.D. holders in Healthcare Sciences work in the Health Care sector (72.6%), (Figure 4). In addition, the share of women working in the sector of Education have a doctorate in the field of Humanities (51%) and in Natural sciences (18%) (Figure 5).

For the purposes of our analysis four main occupation categories have been created based on the ISCO88/STEP92 categorization and according to the education/skills needed for each category. The first category refers to Legislators, Senior officials and Managers, the second to Professionals, the third to Technicians and Associate Professionals and the fourth to the Office and Clerks Related Professionals. Ph.D. holders working in academia are included in the occupational category of Professionals (Table 4). We can see in Figure 6 that most Ph.D. holders in Greece are employed in the "Professional" occupational category (77.4%). This holds for both, men and women (77.2% and 77.8%, respectively).

Data on earnings are derived from the Greek Labor Force Survey (LFS) and refer to the median net earnings of Ph.D. holders in Greece, in 2001, by sector of industry.

The median monthly salary of Ph.D. holders, across all occupations, is about 1,360€, and it varies between 818€ and 1,712€. The median monthly salary of men Ph.D. holders is about 1,345€ and of women is about 1,400€. The highest median monthly salaries are observed in the sector of Health Care (1,487€) and in Education (1,445€), which includes salaries in academia. We observe in Figure 7 that the median monthly salary of Ph.D. holders is higher for the occupational category of professionals, where 80% of them earn a median monthly income between 1,400€-1,599€, followed by Legislators, Senior officials and Managers where 62% of them earn a median monthly income between 1,000€-1,199€.

In conclusion, in 2001, 70% of Ph.D. holders are men, 30% are women and 25% have their Ph.D. degree in Healthcare sciences. The share of women varies among the fields of study, with the highest appearing in Humanities (51%) and the lowest in Sciences of Engineering (14%). Regarding employment, 33% of men and 27% of women work in academia. Most Ph.D. holders are employed in Education and in the sector of Health Care. The highest median net monthly salary for Ph.D. holders is observed in the occupational category of Professionals.

4. Econometric analysis

The first model to be used is a binary probit model explaining the probability of being employed in the academic sector utilizing a set of individual characteristics and family related covariates (Per), a set of field of study related covariates (Fac) and the country (C) where the Ph.D. was obtained:

$$y_i^* = \alpha + \beta Per_i + \gamma Fac_i + \delta C_i + \varepsilon_i \quad \textbf{(1)}$$

where y_i^* takes the value of 1 if the Ph.D. holder works in academia and 0 if he/she works elsewhere. The set of individual characteristics and family related covariates (Per), includes age, as well as, dummies indicating gender, marital status and the country of birth. The set of field of study related covariates (Fac), includes dummies indicating the individual's field of study. The variable (C) is a dummy variable that takes the value of 1 if the Ph.D. holder obtained his/her Ph.D. degree from a Greek university (Table 5).

Multinomial logit models are used in order to analyze the predicted probability of choosing employment in various sectors of industry and in an occupational category for Ph.D. holders (Schmidt and Strauss, 1975). These probabilities are assumed to be affected by individual characteristics and family related covariates (Per), a set of wealth related covariates (W), a set of field of study related covariates (Fac) and the country where the PhD was granted (C):

$$y_i^{**} = \alpha + \beta Per_i + \gamma W + \delta Fac_i + \zeta C_i + \varepsilon_i \quad \textbf{(2)}$$

$$y_i^{***} = \alpha + \beta Wage_i + \gamma Per_i + \delta W_i + \zeta Fac_i + \xi C_i + \varepsilon_i \quad \textbf{(3)}$$

where y_i^{**} is the probability of choosing employment in a particular sector of industry while y_i^{***} is the probability of choosing employment in an occupational category.

The set of individual characteristics and family related covariates (Per), includes variables indicating age, gender, marital status, country of birth, and if he/she lives in the same place where he/she was born. The set of wealth related covariates (W) includes dummies indicating the size of his/her residence (three classes of size, 0-99, 100-199 and greater than 200 square meters), and the ownership status. In equation (3), the median net monthly salary (Wage) of each occupational category is also included. Detailed presentation of the variables used in probit and multinomial logit models are presented at Table 5.

4.1 Empirical results for the probability of working in the academic sector for Ph.D. holders in Greece

Table 6 presents the estimation results of the probit analysis for the probability of working in academia (model 1). Maximum likelihood estimates of the model's parameters, as well as marginal effects, are reported. Most of the variables are statistically significant. Age positively affects the probability of working in academia by 6%, but at a decreasing rate. Also, marriage positively affects the probability by 7%. The gender variable is not statistically significant. The field of study is also a statistically significant factor that positively influences the probability of working in academia. A Ph.D. degree in every field of study increases the probability of working in academia when compared to a Ph.D. degree in Healthcare sciences. For example, an individual who has obtained his/her Ph.D. in Natural sciences has a probability of working in academia of 40.7% compared to someone who has obtained his/her degree in Healthcare sciences. Similarly, having a Ph.D. degree in the field of Earth & Agricultural sciences increases the probability by 35.6%, and in the field of Sciences of Engineering by 32.5%. A Greek Ph.D. degree positively affects the probability of working in academia by 4.2%. Probit results with a gender interaction variable indicate that being female and having a Ph.D. in Humanities and Natural sciences negatively affect the probability of working in the academic sector. In other words, the obtained results show that a young, married Ph.D. holder, who has obtained his/her doctoral degree in Natural sciences, granted by a Greek educational institution, has the highest probability of working in academia.

4.2 Empirical results for the probability of choosing employment in various sectors of industry/occupational categories for Ph.D. holders in Greece

Table 7 presents the estimation results of the multinomial logit analysis for the probability of choosing employment in various sectors of industry (model 2). Maximum likelihood estimates of the model's parameters, as well as relative risk ratios are reported. The empirical results indicate that the field of study seems to have the strongest impact on the probability of choosing employment in the various sectors of industry. In general, a Ph.D. holder in the field of Humanities, Social sciences etc. is more likely to work in the sectors of Services, Public Administration, and Education compared to Ph.D. holders in the field of Healthcare sciences. For example, a Ph.D. holder in the field of Earth & Agricultural sciences and/or Sciences of Engineering is more likely to choose employment in the sector of Agriculture and Manufacturing by 151 and 517 times, respectively, relatively to someone who has his/her Ph.D. in Healthcare sciences and works in the sector of Heath Care. Similarly, a Ph.D. holder in the field of Sciences of Engineering and Other sciences is more likely to work in the Services category, by 1,774 and 2,151 times, respectively, compared to the base category. Also, Ph.D. holders in the fields of Humanities, Social sciences, Natural sciences, Earth & Agricultural sciences, Sciences of Engineering and Other sciences are more likely to work in the sector of Public Administration by a factor of 203, 111, 69, 69, 362 and 152 respectively, compared to the reference category. Lastly, the relative risk ratio of working in the sector of Education is expected to increase for those who have their doctorate degree in the field of Humanities, Sciences of Engineering and Other sciences by a factor of 303, 209 and 125 respectively, compared to the reference category. The coefficient on the gender dummy is negative and statistically significant in all sectors of industry but the sector of Public Administration, although the relative risk ratios are smaller than unity. Women Ph.D. holders are less likely to work in the sectors of Agriculture and Manufacturing, Services and Education by 0.29, 0.49, and 0.65 times respectively, compared to men.

The variables measuring wealth seem to positively affect the probability of choosing employment in various sectors of industry. The results indicate that if the size of the residence is up to 99 square meters and the Ph.D. holder is the sole owner of this residence then he is more likely to choose employment in the sectors of Agriculture

& Manufacturing and in Public Administration, compared to a Ph.D. holder residing in a house larger than 200 square meters. The variable indicating internal mobility (Live where born) appears to negatively affect the probability of choosing employment in the sectors of Services, Public Administration and Education, compared to the reference category, although the relative risk ratios are smaller than unity.

Table 8 presents the estimation results of the multinomial logit analysis for the probability of choosing employment in various occupational categories (model 3). Maximum likelihood estimates of the model's parameters, as well as relative risk ratios are reported. According to the obtained results, the wage variable is a statistically significant one and positively influences the probability that a Ph.D. holder works in the occupational categories of Professionals and Technicians/ Associate Professionals by a factor of 1231 and 420 respectively, compared to the effect that the wage variable has on those working in the occupational category of Office & Clerks related Professionals. Women Ph.D. holders, in comparison to men, are less likely to choose employment in the occupational categories of Legislators, Senior officials & Managers, and Professionals by a factor of 0.24 and 0.37 respectively. If the Ph.D. holder is married, then he/she is more likely to be observed working in the occupational categories of Legislators, Senior officials & Managers and Technicians & Associate Professionals than the occupational category of Office & Clerks Related Professionals. Lastly, the field of study remains a significant factor affecting the probability of choosing employment in a specific occupational category. In particular, if an individual has his/her doctorate in the fields of Humanities, Social sciences, Earth & Agricultural sciences, Sciences of Engineering and Other sciences relative to Healthcare sciences, then he/she is more likely to work in the occupational category of Legislators, Senior officials & Managers by 12, 16, 8, 18 and 8 times respectively, relative to the base category. If an individual has his/her doctorate in the field of Engineering, relative to Healthcare sciences, then he/she is more likely to work in the occupational category of Professionals by a factor of 8. Similarly, if he/she has a doctorate in the field of Natural sciences then he/she is less likely to work in the occupational category of Professionals by a factor of 0,4. The probability of working in the occupational category of Technicians & Associate Professionals is higher for individuals who have their doctorate in the field of Social sciences and Natural sciences.

5. Conclusions

The main objective of this paper was to investigate the factors influencing the probability of a Ph.D. holder in Greece working in the academic sector, as well as the probability of choosing employment in various sectors of economic activity and occupational categories. Probit and multinomial logit models were employed using the 2001 Census data.

Probit analysis results indicate that being young, married and having a Ph.D. in the fields of Natural Sciences, Earth and Agricultural Sciences and Sciences of Engineering, obtained from a Greek University, increases the probability of working in academia.

The empirical results of multinomial logit analysis for the probability of choosing employment in various sectors of industry for Ph.D. holders in Greece indicate that the field of study is the most statistically significant variable. The probability of working in the sector of Agriculture and Manufacturing is higher for those having their Ph.D. in the fields of Earth & Agricultural sciences and Sciences of Engineering. Similarly, the probability of working in the sector of Services is higher for those having their Ph.D. in the fields of Sciences of Engineering and Other sciences. Finally, the probability of working in the sector of Education is higher for individuals with a doctorate in the field of Humanities and Sciences of Engineering. The coefficient on the gender variable is negative and statistically significant in all sectors of industry, with the exception of Public Administration, but relative risk ratios are smaller than unity.

Regarding occupational choice, the obtained results indicate that the wage variable and the field of study are the most important variables affecting the probability of choosing employment in an occupational category. Specifically, wages affect positively the probability of working in the occupational categories of Professionals and Technicians/Associate professionals. The fields of study are important determinants affecting the probability of choosing work in an occupational category. Ph.D. holders in the fields of Humanities, Social sciences, Earth & Agricultural sciences, Sciences of Engineering and Other sciences are more likely to work in the occupational category of Legislators/Senior officials & Managers. Women Ph.D. holders are less likely, compared to men, to choose employment in the occupational category of Legislators/Senior officials & Managers and in the category of Professionals by a factor of 0.24 and 0.37, respectively.

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Table 1: Total number of Ph.D. graduates by field of study, Greece 1981-2010

Academic year	Humanities	Social sciences	Natural sciences	Sciences of Engineering	Earth & Agricultural sciences	Healthcare sciences	Other sciences	Total
1981/1982	29	8	50	25	10	181	11	314
1982/1983	37	16	47	19	11	305	10	445
1983/1984	43	5	40	15	16	109	6	234
1984/1985	50	8	53	31	30	227	15	414
1985/1986	39	12	59	36	36	245	14	441
1986/1987	22	17	30	38	27	220	11	365
1987/1988	49	15	59	49	26	675	11	884
1988/1989	52	18	56	69	28	760	10	993
1989/1990	40	20	69	43	23	270	9	474
1990/1991	47	12	66	112	59	400	16	712
1991/1992	56	36	100	72	39	294	19	616
1992/1993	36	19	74	70	23	305	5	532
1993/1994	57	9	70	98	30	387	18	669
1994/1995	105	36	105	85	28	186	22	567
1995/1996	81	23	102	106	57	182	7	558
1996/1997	93	25	97	108	41	244	25	633
1997/1998	162	34	108	154	55	183	18	714
1998/1999	139	61	130	289	41	145	22	827
1999/2000	175	40	164	158	57	170	18	782
2000/2001	189	33	114	358	96	143	34	967
2001/2002	321	41	109	177	59	96	34	837
2002/2003	314	129	140	205	71	108	26	993
2003/2004	159	59	205	266	80	86	91	946
2004/2005	235	70	131	857	53	221	22	1589
2005/2006	165	105	193	195	57	405	67	1187
2006/2007	259	134	242	252	90	1426	33	2436
2007/2008	197	128	213	313	93	432	28	1404
2008/2009	234	191	288	456	48	549	31	1797
2009/2010	289	185	278	494	159	449	38	1892

Source: Statistics of Education 1980-2010, ESYE Table 2: Employment status of Ph.D. holders in Greece by field of study, 2001.

Table 2: Employment status of Ph.D. holders in Greece by field of study, 2001

	1. Ph.D. holders in Greece in the year 2001			2. Ph.D. holders in Greece, working in academia at the year 2001			3. Ph.D. holders in Greece working in non-academic sector in the year 2001		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
All fields of study	1988	1.395	593 30%	616	456	160 26%	1372	939	433 32%
Humanities	366	180	186 51%	122	71	51 42%	244	109	135 55%
Social Sciences	262	179	83 32%	65	39	26 40%	197	140	57 29%
Natural Sciences	347	264	83 24%	171	143	28 16%	176	121	55 31%
Sciences of Engineering	296	255	41 14%	104	94	10 10%	192	161	31 16%
Earth & Agricultural sciences	102	81	21 21%	41	31	10 24%	61	50	11 18%
Healthcare Sciences	502	362	140 28%	79	58	21 27%	423	304	119 28%
Other Sciences	113	74	39 35%	34	20	14 41%	79	54	25 32%

Source: Greek Census 2001.
Note: The above numbers of Ph.D. holders correspond to 10% of the actual population of Ph.D. holders. Source: Census of Greece 2001.

Table 3: Employment of PhD holders by sector of industry and gender, Greece, 2001

Sectors of industry *		Gender		
		Men	Women	Total
1	Agriculture & Manufacturing	93	11	104
2	Services	294	97	391
3	Public Administration	98	43	141
4	Education	581	264	845
5	Health Care	308	147	455
	Total	1,374	562	1,936

Source: Greek Census 2001.
*Two-digit census industry in five-way grouping.

Table 4: Employment of PhD holders by occupational category, Greece, 2001

Categories of Occupation *		Gender		
		Men	Women	Total
1	Legislators, Senior officials and Managers	149	28	177
2	Professionals	1103	442	1545
3	Technicians and Associate Professionals	113	62	175
4	Office and Clerks Related Professionals	64	36	100
	Total	1429	568	1997

Source: Greek Census 2001.
*Two-digit census occupation in four-way grouping by sex.

Table 5: Variables used for estimation purposes

Variables	
Age	Age
Age^2	Age at square
Female	Dummy variable of sex (1 = woman, 0 = man)
Married	Dummy variable of marital status (1 = married, 0 = non married)
House size 0-99m^2	Dummy variable for residence size (0-99 square meters)
House size 100-199m^2	Dummy variable residence size (100-199 square meters)
House size 200>m^2	Dummy variable for residence size (200- square meters)
House Owner	Dummy variable of ownership status (1 = owner, 0 = not owner)
Lnwage	Natural logarithm of wage
Live Where Born	Dummy variable indicating if the Ph.D. holder lives where he was born (1 = at the same place, 0 = not at the same place)
Country of Birth	Dummy variable indicating if the Ph.D. holder is born in Greece or in another country (1 = Greece, 0 = another country)
Humanities	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in sciences of Humanities
Social Sciences	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in Social sciences
Natural Sciences	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in Natural sciences
Earth & Agricultural Sciences	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in Earth & Agricultural sciences
Sciences of Engineering	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in Sciences of Engineering
Health Care Sciences	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in Healthcare sciences
Other Sciences	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma in Other sciences
Country Studied	Dummy variable indicating if the Ph.D. holder has obtained his/her diploma from a Greek university

Source: Greek Census 2001.
Lnwage: Source LFS 2001.

Table 6: Probit results: probability of working in academia*

Probit results			Probit results with interactions		
Variables	Coefficients (Std. error)	Marginal Effects	Variables	Coefficients (Std. error)	Marginal Effects
Age	0,176***	0,060***	Age	0,175***	0,059***
	(0,0314)			(0,0317)	
Age^2	-0,002***	-0,001***	Age^2	-0,002***	-0,001***
	(0,0003)			(0,0003)	
Female	-0,081	-0,027	Female	0,105	0,036
	(0,0711)			0,1851	
Married	0,206***	0,069***	Married	0,224***	0,075***
	(0,0686)			(0,0850)	
			Married * Female	-0,043	-0,014
				(0,1434)	
Country of Birth	-0,013	-0,004	Country of Birth	0,033	0,006
	(0,1007)			(0,1016)	
Humanities	0,798***	0,297***	Humanities	0,983***	0,367***
	(0,1015)			(0,1289)	
			Humanities* Female	-0,439**	-0,133***
				(0,2093)	
Social Sciences	0,554***	0,201***	Social Sciences	0,482***	0,177***
	(0,1137)			(0,1366)	
			Social Sciences* Female	0,209	0,075
				(0,2400)	
Natural Sciences	1,092***	0,407***	Natural Sciences	1,214***	0,450***
	(0,0984)			(0,1133)	
			Natural Sciences* Female	-0,496**	-0,144***
				(0,2241)	
Earth & Agricultural Sciences	0,933***	0,356***	Earth & Agricultural Sciences	0,867***	0,331***
	(0,1458)			(0,1658)	

			Earth & Agricultural Sciences * Female	0,350	0,129
				(0,3448)	
Sciences of Engineering	0,866***	0,325***	Sciences of Engineering	0,926***	0,348***
	(0,1088)			(0,1198)	
			Sciences of Engineering * Female	-0,259	-0,081
				(0,2840)	
Other Sciences	0,692***	0,263***	Other Sciences	0,577***	0,217***
	(0,1450)			(0,1789)	
			Other Sciences * Female	0,299	0,109
				(0,3053)	
Country Studied	0,124*	0,042*	Country Studied	0,143**	0,047
	(0,069)			(0,070)	
Constant term	-5,846***		Constant term	-5,833***	
	(0,7303)			(0,7384)	
Number of observations: 2005			Number of observations: 2005		
LR $chi^2(12)$: 219,25			LR $chi^2(19)$: 238,78		
Pseudo R^2: 0,089			Pseudo R^2: 0,0965		
Log likelihood = -1127,1945			Log likelihood = -1117,4325		
Level of significance: ***a=1%, **a=5%, *a=10%,					
*Test for endogeneity was rejected by the data, (STATA ivprobit procedure)					

Data source: Greek Census 2001.

Table 7: Multinomial Logit Results: probability of working in sectors of industry for Ph.D. holders in Greece*

	P1/P5		P2/P5		P3/P5		P4/P5	
Variables	Coefficients (Std. error)	Relative Risk Ratios**	Coefficients (Std. error)	Relative Risk Ratios	Coefficients (Std. error)	Relative Risk Ratios	Coefficients (Std. error)	Relative Risk Ratios
Age	0,0477	1,0488	-0,2335**	0,7917	-0,1775	0,8373	-0,0876	0,9191
	(0,176)		(0,124)		(0,136)		(0,108)	
Age^2	-0,0008	0,9991	0,0023*	1,0022	0,0024*	1,0024	0,0011	1,0011
	(0,002)		(0,001)		(0,001)		(0,001)	
Female	-1,2333***	0,2913	-0,7189***	0,4872	-0,1012	0,9037	-0,4272**	0,6523
	(0,405)		(0,259)		(0,294)		(0,217)	
Married	0,2242	1,2513	0,1342	1,1437	-0,2639	0,7679	0,3541	1,4249
	(0,354)		(0,227)		(0,298)		(0,232)	
House size (0-99 m^2)	2,4335***	11,3997	0,7407	2,0974	1,1741*	3,2352	0,4788	1,6143
	(0,688)		(0,385)		(0,465)		(0,312)	
House size (100-199 m^2)	1,2542*	3,5050	0,6424*	1,9011	0,6407	1,8978	0,1897	1,2089
	(0,690)		(0,366)		(0,454)		(0,295)	
House Owner	0,9515***	2,5896	-0,1018	0,9031	0,6119**	1,8440	-0,3179	0,7277
	(0,376)		(0,254)		(0,315)		(0,216)	
Live Where Born	0,1079	1,1140	-0,4398*	0,6441	-0,8386***	0,4323	-0,5449***	0,5799
	(0,351)		(0,244)		(0,276)		(0,205)	
Country of Birth	-1,2342	0,2910	-0,1111	0,8948	0,356	0,9650	0,1159	1,1229
	(0,513)		(0,413)		(0,489)		(0,363)	
Humanities	-10,1842	0,0000	6,1839***	484,9209	5,3143***	203,2331	5,7140***	303,0938
	(688,711)		(0,676)		(0,614)		(0,491)	
Social Sciences	5,0870***	161,9154	5,8051***	331,9929	4,7131***	111,4048	3,3905***	29,6821
	(0,632)		(0,548)		(0,483)		(0,333)	
Natural Sciences	4,3323***	76,1219	5,0937***	162,9895	4,2331***	68,9286	4,1967***	66,4665
	(0,793)		(0,543)		(0,474)		(0,297)	

Earth & Agricultural Sciences	5,0196*** (0,759)	151,3561	5,6597*** (0,675)	287,0671	4,2314*** (0,673)	68,8140	3,8431*** (0,496)	46,6705
Sciences of Engineering	6,2482*** (0,818)	517,0829	7,4807*** (0,750)	1773,61	5,8911*** (0,717)	361,798	5,3427*** (0,611)	209,0837
Other Sciences	3,9475*** (1,339)	51,8076	7,6737*** (0,860)	2150,943	5,0259*** (0,895)	152,3137	4,8304*** (0,745)	125,2703
Country Studied	-0,4028 (0,352)	0,6684	0,5338** (0,271)	0,5863	0,1826 (0,311)	1,2004	0,1874 (0,246)	1,2062
Constant term	-60145 (4,037)		1,7321 (2,898)		-1,6091 (3,225)		-0,2466 (2,564)	
P1 : The probability of working in the sector of Agriculture & Manufacturing								
P2 : The probability of working in the sector of Services								
P3 : The probability of working in the sector of Public Administration								
P4 : The probability of working in the sector of Education								
P5 : The probability of working in the sector of HealthCare (base category)								
Number of observations: 1754								
LR $chi^2(64)$: 1485,25								
Pseudo R^2: 0,3187								
Log likelihood = -1587,4733								
Level of significance: ***a=1%, **a=5%, *a=10%,								
*STATA was used for the estimation of multinomial logit model								
**Standard interpretation for the relative risk ratio is for a unit change in the predictor variable; the relative risk ratio of an outcome relative to the reference group is expected to change by a factor of the respective parameter estimate given the variables in the model are held constant								

Data source: Greek Census 2001.

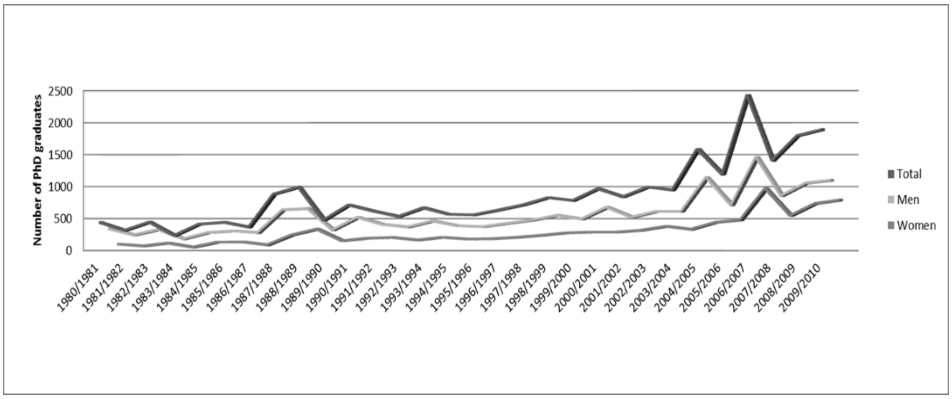
Table 8: Multinomial logit results: probability of working in an occupational category for Ph.D. holders in Greece*

	P1/P4		P2/P4		P3/P4	
Variables	Coefficients (Std. error)	Relative Risk Ratios**	Coefficients (Std. error)	Relative Risk Ratios	Coefficients (Std. error)	Relative Risk Ratios
lnwage	0,7442 (1,411)	2,1048	7,1156*** (1,268)	1230,999	6,0413*** (1,813)	420,4178
Age	-0,1275 (0,232)	00,8803	0,0064 (0,213)	1,0065	-0,5761** (0,251)	0,5621
Age^2	0,0017 (-0,003)	1,0018	0,0002 (-0,002)	1,0002	0,0061** (0,003)	1,0061
Female	-1,4098*** (0,473)	0,2442	-0,9913*** (0,395)	0,3711	0,0307 (0,486)	1,0312
Married	0,7924* (0,454)	2,2087	0,3974 (0,394)	1,4879	1,2544*** (0,513)	3,5057
House size (0-99 m^2)	-0,4113 (0,857)	0,6628	-0,7273 (0,787)	0,4832	0,2875 (0,948)	1,3331
House size (100-199 m^2)	0,6245 (0,909)	1,8673	0,4684 (0,845)	1,5975	1,3389 (0,992)	3,8149
House Owner	-0,2802 0,460	0,7556	-0,0701 (0,407)	0,9323	0,4389 (0,532)	1,5510
Live Where Born	0,6755 (0,497)	1,9650	-0,7745* (0,429)	0,4609	0,4799 (0,563)	1,6160
Country Of Birth	-0,2084 (0,842)	0,8119	0,4872 (0,764)	1,6277	13,6121 (438,422)	815961
Humanities	2,5198*** (0,873)	12,4259	0,9413 (0,703)	2,5634	-0,1022 (0,887)	0,9028
Social Sciences	2,7822*** (0,910)	16,1552	-0,0711 (-0,774)	0,9314	2,0414*** (0,858)	7,7014
Natural Sciences	0,3001 (0,767)	1,3500	-0,8820* (0,549)	0,4139	-1,9772** (0,853)	0,1384

Earth & Agricultural Sciences	2,0553**	7,8090	-0,0121	0,9879	-0,0441	0,9568
	(1,043)		(0,885)		(1,102)	
Sciences of Engineering	2,9206***	18,5534	2,0831**	8,0291	0,4189	1,5204
	(1,075)		(0,936)		(1,247)	
Other Sciences	2,1513*	8,5962	1,2176	3,3793	0,8969	2,4520
	(1,293)		(1,126)		(1,317)	
Country Studied	-0,6726	0,5103	0,9556*	0,3846	-0,8821	0,4139
	(0,568)		(0,532)		(0,619)	
Constant term	-3,3082		-46,9629***		-44,9263	
	(11,643)		(10,499)		(438,645)	
P1 : The probability of working in the occupational category of Legislators, Senior officials & Managers						
P2 : The probability of working in the occupational category of Professionals						
P3 : The probability of working in the occupational category of Technicians & Associate Professionals						
P4 : The probability of working in the occupational category of Office & Clerks related Professionals (base category)						
Number of observations: 1702						
LR $chi^2(51)$: 416,93						
Pseudo R^2: 0,2469						
Log likelihood = -635,89491						
Level of significance: ***a=1%, **a=5%, *a=10%						
*STATA was used for the estimation of multinomial logit model						
**Standard interpretation for the relative risk ratio is for a unit change in the predictor variable; the relative risk ratio of an outcome relative to the reference group is expected to change by a factor of the respective parameter estimate given the variables in the model are held constant.						

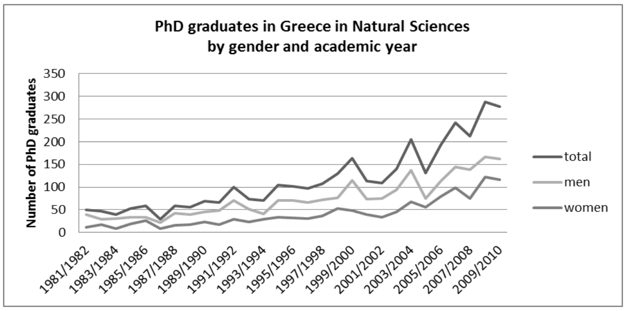
Data source: Greek Census 2001.

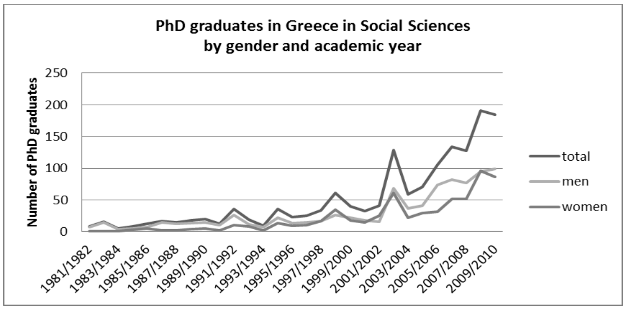
Figure 1: Total number of Ph.D. graduates by academic year and gender, Greece, 1981-2010

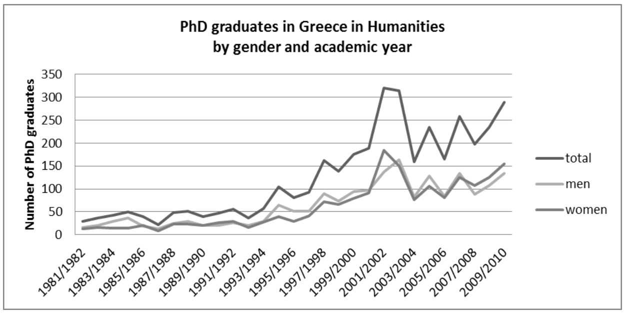


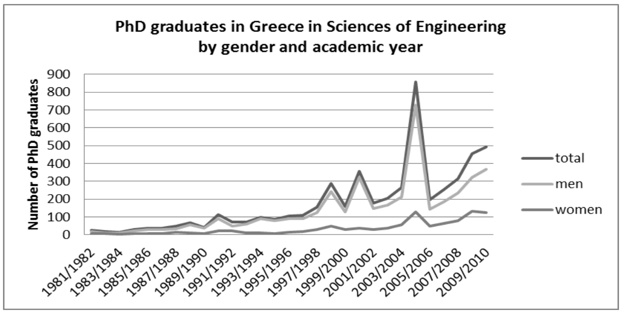
Source: Statistics of Education 1980-2010, ESYE.

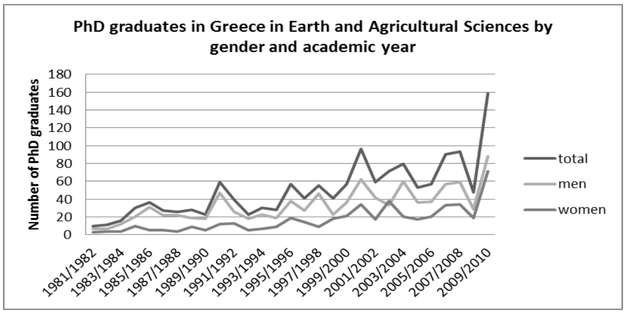
Figure 2: Ph.D. graduates by field of study and gender, Greece, 1981-2010

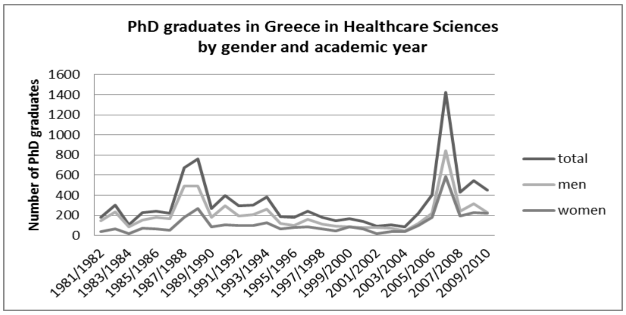


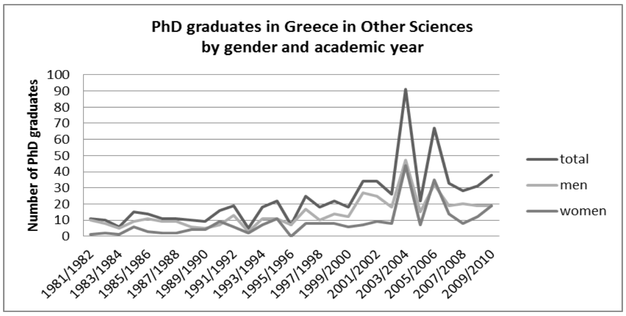



PhD graduates in Greece in Humanities
by gender and academic year
Number of PhD graduates
total
men
women


PhD graduates in Greece in Sciences of Engineering
by gender and academic year
Number of PhD graduates
total
men
women

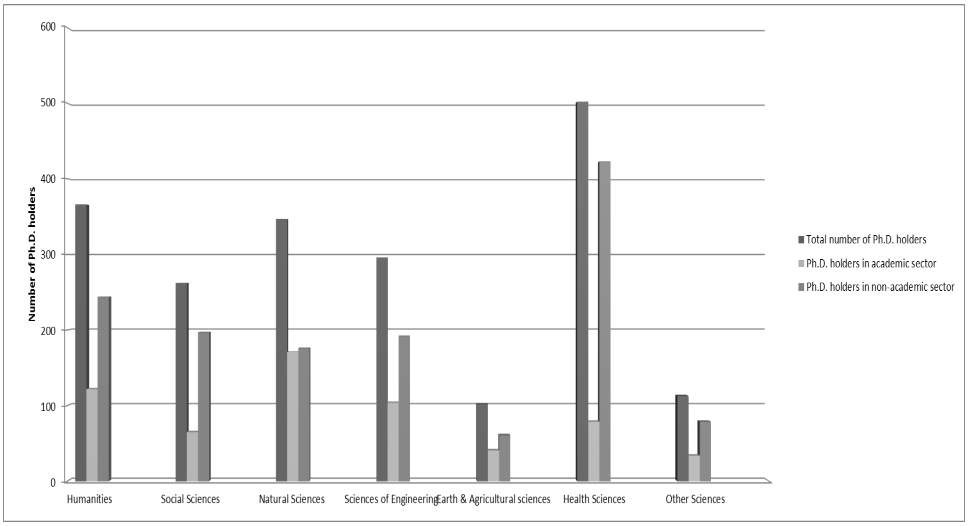

PhD graduates in Greece in Earth and Agricultural Sciences by
gender and academic year
Number of PhD graduates
total
men
women


PhD graduates in Greece in Healthcare Sciences
by gender and academic year
Number of PhD graduates
total
men
women



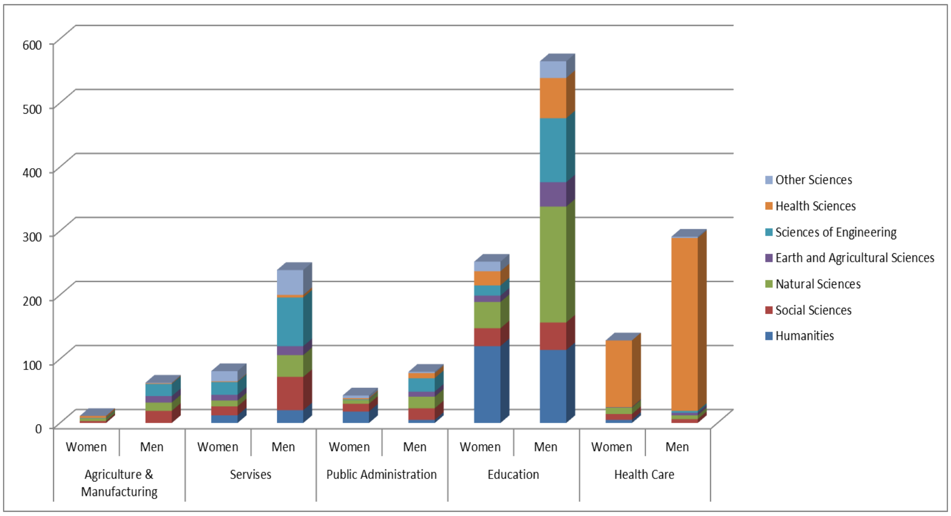
Source: Statistics of Education 1980-2010, ESYE.

Figure 3: Employment of Ph.D. holders in academic and non-academic sectors, by field of study, Greece, 2001



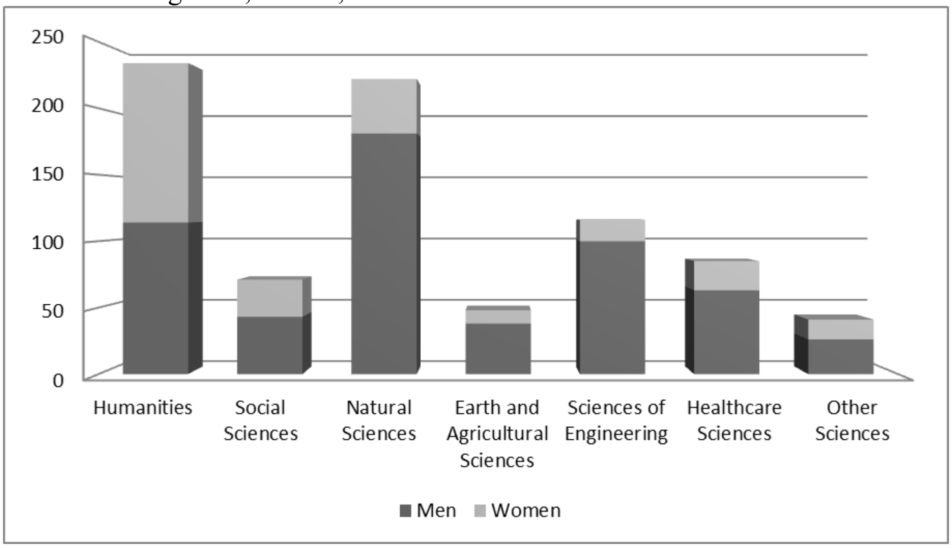
Source: Greek Census 2001 (10% of the Greek population).

Figure 4: Employment of Ph.D. holders in sectors of industry by field of study and gender, Greece, 2001



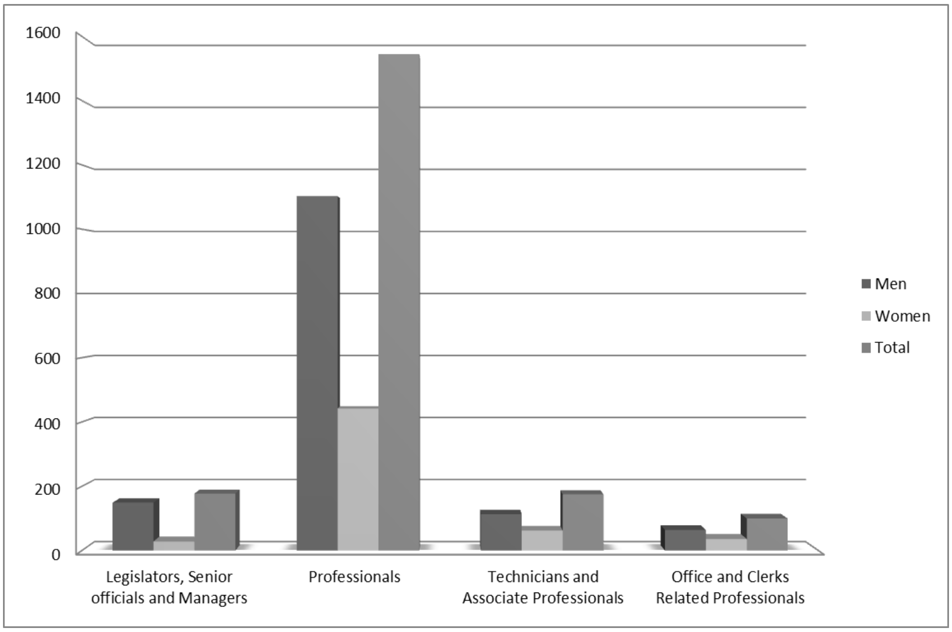
Source: Greek Census 2001.

Figure 5: Employment of Ph.D. holders in the sector of Education by field of study and gender, Greece, 2001



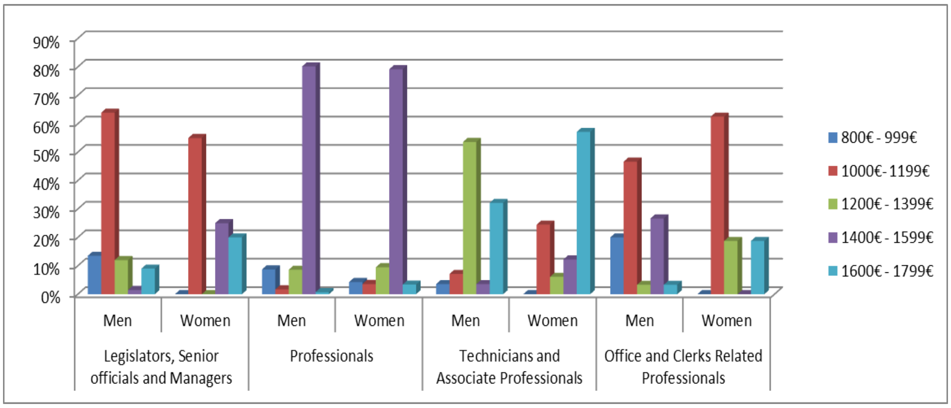
Source: Greek Census 2001.

Figure 6: Employment of Ph.D. holders by occupational category and gender, Greece, 2001



Source: Greek Census 2001.

Figure 7: Median monthly salary for Ph.D. holders by occupational category and gender, Greece, 2001



Source: Greek LFS 2001.

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THE EFFECTS OF FISCAL POLICY ON EMERGING ECONOMIES. A TVP-VAR APPROACH

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Abstract
This study seeks to analyze the effects of government expenditure shock and tax revenue shock on economic activity by applying a time-varying parameter vector autoregressive methodology. The advantage of this approach is that it allows for fiscal policy shocks to vary over time according to the changes in the economic activity and permits us to capture the non-linear nature of the fiscal multiplier's size. This paper provides an evaluation of the effects of fiscal policy in Romania, using quarterly data for three variables: GDP, government expenditure and tax revenues, from 2001q1 to 2013q3. The main results show that fiscal policy has a small effect on economic activity and that for the period considered the estimated coefficients do not show much time variation.

JEL Classification: C32, E62
Key words: fiscal policy, time-varying parameters, Bayesian estimation

1. Introduction

There has always been an interest in analyzing the role of fiscal policy in economic activity, but fiscal policy has received less attention compared to the empirical literature on monetary policy. With the recent economic recession fiscal policy was

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regarded with more interest since it was expected to be effective in economic recovery. Given the limited capacity of monetary policy to provide additional stimulus, fiscal policy has become the most important tool for stabilizing business cycles. The developed economies implemented fiscal stimulus packages as a measure for economic recovery while the developing economies adopted consolidation fiscal measures imposed as a consequence of a pro-cyclical policy adopted before the economic crises.

The empirical studies have not reached a consensus about the effects of fiscal policy (or their magnitude) on macroeconomic variables. Most of the studies on the output effects of fiscal policy, especially before the recent crisis, are based on linear vector autoregressive (VAR) models, with a different scheme of fiscal policy shocks identification. The linear models portray the economy in a simplified way and do not capture the non-linear nature of the multiplier's size. Time-varying para-meter vector autoregressive model (TVP-VAR) −the approach used in this study− allows instead for fiscal policy shocks to vary over time according to the changes in economic activity. Besides TVP-VAR models, there are alternative methodologies that provide evidence for a relationship between the size of the fiscal multiplier and the underlying state of the economy, including threshold VAR models (Baum and Koester 2011, Baum *et al*. 2012) or smooth transition VAR models (Auerbach and Gorodnichenko 2011). There are several studies for developed countries that used the TVP-VAR approach (Kirchner *et al*., 2010, Gerba and Hauzenberger, 2012) but the empirical literature on emerging markets is meagre.

The aim of this paper is to contribute to the analysis of the macroeconomic effects of fiscal policy by providing a range of estimates for fiscal policy effects in Romania. The TVP-VAR model includes quarterly data for government expenditure, GDP and government revenues, from 2001q1 to 2013q3 and is estimated using the Bayesian technique.

The rest of the paper is structured as follows: the next section provides an overview of the related literature, section 3 briefly presents the methodology used for measuring the effects of fiscal policy and describes the data used in the empirical study, section 4 presents the results while section 5 presents the concluding remarks.

2. Literature Review

The most widely used approaches for assessing fiscal policy are the empirical estimates based on vector autoregressive (VAR) models. These approaches have some advantages compared to structural models such as DSGE models because they are unrestricted by a predetermined theoretical construction, but on the other hand VAR estimates of fiscal multipliers are dependent on the type of identification scheme, especially with respect to the output effects of tax changes, as shown by Caldara and Kamps (2008) for the US economy.

A relatively new approach used to assess the effects of fiscal policy shocks on GDP is TVP-VAR. This approach was put forward by Cogley and Sargent (2005) and Primiceri (2005) to evaluate different monetary policy regimes for the US since the post-war period. In particular, the paper focuses on the role of monetary policy in the dynamics of inflation and unemployment. The time variation derives both from the coefficients and the variance covariance matrix of the model's innovations. There is evidence of time variation in the U.S. monetary policy. They observe some deviation in the impulse responses during the oil-shocks and early Volcker period, most of the variation being attributed to the variance of the residuals.

Kirchner *et al*. (2010) have used a TVP-VAR to examine the effect of fiscal policy shocks providing new evidence on the effects of government spending shocks and the fiscal transmission mechanism in the euro area for the period 1980-2008. The results indicate that the effectiveness of spending shocks in stimulating economic activity has decreased for the analyzed period; in particular spending multipliers increased until the late 1980s when they reached values above unity and started to decline to values closer to 0.5 in the current decade. Their results also indicate that higher government debt-to-GDP ratios have negatively affected long-term fiscal multipliers.

Pereira and Lopes (2010) estimate a TVP-VAR for the US over the 1965:q2-2009:q2 period and find that fiscal policy has lost some capacity to stimulate output. What they particularly investigate is whether there has been an increase in policy effectiveness in the course of recessionary episodes, but they find only modest support for it.

Karagyozova (2013) provides a range of estimates for the fiscal multipliers in Bulgaria using linear VAR models with different identification schemes for fiscal shocks and TVP-VAR models. The main findings are that the effectiveness of fiscal policy in stimulating economic activity is generally low, the cumulative government spending multiplier is considerably larger in the years after the introduction of the currency board (0.3) compared to the period just before the 2008 crisis (0.15) but does not exceed 0.4, in line with most of the studies on the emergent EU Member State.

3. Methodology and Data

The method used in this analysis is a TVP-VAR model that allows for variation over time in the estimated coefficients of the model and in the variance-covariance matrix of residuals, following the methodology used by Primiceri (2005). Allowing for time variation both in the coefficients and the variance-covariance matrix leaves it up to the data to determine whether the time variation of the linear structure derives from changes in impulse shock or from changes in the response to impulse shock. This is an advantage over fixed-parameters because it allows us to capture any gradual shift that might occur in the economy.

The following model of lag order k is considered:

$$y_t = C_t + B_{1,t}y_{t-1} + \cdots + B_{k,t-k} + u_t \quad \textbf{(1)}$$

where the vector y_t ($n \times 1$) includes the observed endogenous variables, C_t is an $n \times 1$ vector of time varying coefficients that multiply constant terms, the $B_{i,t}$, i = 1,…k, are matrices of time varying coefficients and u_t are unobservable shocks with variance covariance matrix R_t.

The innovation variance covariance matrix R_t can be decomposed using a triangular factorization of the form:

$$A_t\, R_t A_t' = \sum_t \sum_t' \quad \textbf{(2)}$$

where A_t is lower triangular matrix with ones on the main diagonal and $\sum_t$ is the diagonal matrix.

The first equation becomes:

$$y_t = C_t + B_{1,t}y_{t-1} + \cdots + B_{k,t-k} + \; A_t^{-1}\sum_t e_t, V(e_t) = I_n \quad \textbf{(3)}$$

where I_n is an n-dimensional identity matrix.

The dynamics of the model's time varying parameters are specified as in Primiceri (2005):

$$\beta_t = \beta_{t-1} + \mu_t \quad \textbf{(4)}$$

$$\alpha_t = \alpha_{t-1} + \gamma_t \quad \textbf{(5)}$$

$$\log(\sigma_t) = \log(\sigma_{t-1}) + \eta_t \quad \textbf{(6)}$$

where β_t is the vector of coefficients of the VAR model stacked by rows, α_t is the vector of non-zero and non-one elements of the matrix At stacked by rows and σ_t is the vector of the diagonal elements of the matrix $\sum_t$. The equation 4 and 5 describes a random walk process and standard deviations σ_t in equations 6 are assumed to evolve as geometric random walks. Thus β_t elements, α_t elements and σ_t elements can vary over time, allowing for changes in the contemporaneous relations among the endogenous variables.

All the innovations in the model are assumed to be jointly normally distributed: $[e_t\ \mu_t\ \gamma_t\ \eta_t]$' ~ NID (0, V_t), where V_t is block diagonal with blocks I_n, Q, S and W (Q, S and W are positive definite matrices).

The model is estimated by Bayesian methods, the identification scheme of response impulses being a recursive one. Bayesian technique requires prior distributions to be imposed on the parameters of interest in order to estimate the posterior distribution, given the data. As for the identification scheme of impulse responses, a drawback is the sensitivity to the ordering of variables.

The type of priors[1] is assumed to be independent inverse-Wishart for hyperparameters (Q, S, W) and Normal Distribution for the initial states of the time varying coefficients. The inverse-Wishart prior distribution of the hyperparameters requires degrees of freedom and scale matrices to be set. The degrees of freedom are set as one plus the dimension of each matrix and k_Q, k_S, k_W are calibrated so that the priors obtained are diffuse and uninformative and not flat (k_Q=0.01, k_S =0.1 and k_W= 0.01). The initial values of parameters in the model are set using ordinary least squares estimates over the first 27 observations of data sample.

The choice of endogenous variables follows the empirical literature, thus the vector of endogenous variables consists of variables commonly used to assess the effects of fiscal policy. The variables are government spending (G), GDP (y) and government revenues (T), and are used in estimation as ordered above. The standard data sets used in fiscal VAR models include two more variables-inflation and interest rate, but I choose the minimal set of endogenous variables listed above because the use of TVP-VARs requires a reduced number of endogenous variables and lags to keep the set of parameters manageable. The data are seasonally adjusted with

1. See Primiceri (2005) "Time Varying Structural Vector Autoregressions and Monetary Policy".

Tramo/Seats. Government spending and revenues and GDP are deflated by GDP deflator. The deflated series are then expressed in log. All the variables are used in first differences. Although the Bayesian approach does not necessarily require the data to be stationary, the series used are stationary due to estimation in first differences. Summary statistics for data used in estimation are provided in the first table. A TVP-VAR with two lags is estimated.

The TVP-VAR was estimated in Matlab, based on codes developed by Gary Koop, while the BVAR model was estimated using Dynare.

Table 1. Descriptive Statistics of data

	Y	G	T
Mean	0.007995	0.007619	0.007804
Median	0.012022	0.004600	0.006000
Maximum	0.051824	0.255878	0.031000
Minimum	-0.081267	-0.167013	-0.014000
Std. Dev.	0.020253	0.078834	0.010606
Skewness	-1.503243	0.682152	0.083080
Kurtosis	8.874737	4.678136	2.323435
Jarque-Bera	92.54692	9.939624	1.031368
Probability	0.000000	0.006944	0.597092
Sum	0.407762	0.388584	0.398000
Sum Sq. Dev.	0.020508	0.310741	0.005624

4. Results

Figure 1 reports the estimated impulse responses due to the identified government spending shocks to the three endogenous variables, together with their 10% and 90% probability bands. Figure 2 plots the estimated impulse responses after government revenues shocks with their 10% and 90% probability bands. The main interest is to analyze the impact of a government expenditure shock on an endogenous variable, especially on real output.

As is shown in similar studies, the impact of a government spending shock on emergent economies is small. After positive government expenditure shock real output rises but its intensity is reduced. The fiscal multiplier is very small, less than 1 if it were to be compared with fiscal multipliers obtained in empirical studies, for developed economies. The response of government spending after a positive shock of government spending is not persistent and the effect of the shock is almost zero from the second quarter.

The GDP responds to a tax revenues shock as in the case of government expenditure shock but with greater intensity. The credible intervals accompanying the response of GDP contains zero, thus the reaction of GDP to the spending shock is not estimated precisely, at least for the first periods.

Figure 1. Responses of the variables after a government spending shock

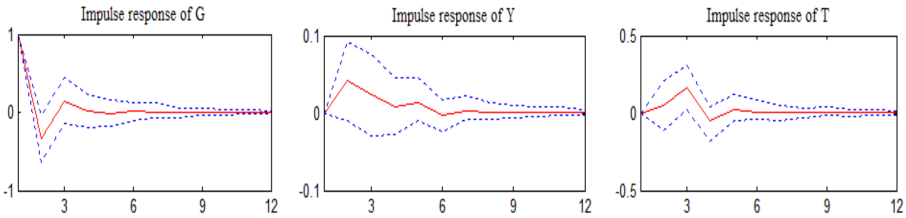
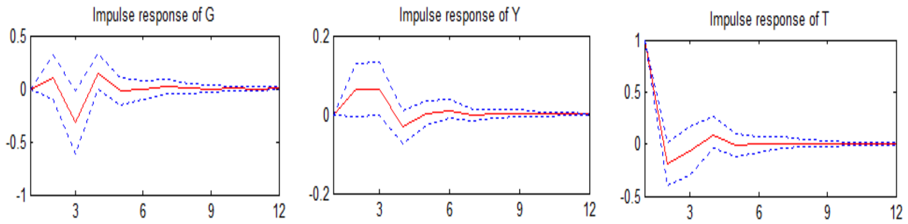
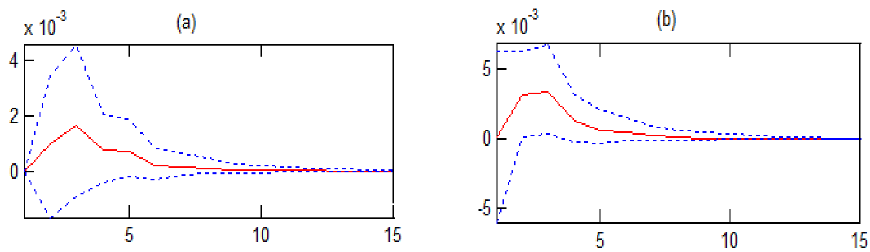


Figure 2. Responses of the variables after a government revenues shock



The response of GDP to fiscal policy shocks is also estimated using Bayesian estimation without time varying specification. Non-informative flat priors were considered. The results of the Bayesian VAR model are presented in the third figure.

Figure 3. (a) Response of GDP after a government spending shock;(b) Response of GDP after a government revenue shock



The effects on GDP of fiscal policy shocks, as has been identified in this approach, are more reduced compared to the previous approach. A high uncertainty is associated with the responses of GDP to a government revenues shock. The effect on GDP is, rather, very weak.

5. Conclusions

This paper estimates the effect of fiscal policy shocks using a TVP-VAR approach. The model is estimated using the Bayesian technique, based on recursive approach as the identification scheme of the structural shocks. The advantage of this approach is that it allows for fiscal policy shocks to vary over time according to changes in economic activity. The specification of the model allows for variation over time in the estimated coefficients and in the variance-covariance matrix of residuals.

According to the impulse response functions I can mention the following: the real output shows a weaker response to fiscal shocks, the fiscal multipliers are positive and small meaning the economic activity is not significantly influenced by fiscal policy in an emergent country. These findings are in line with most of the studies on fiscal policy effects in small open economies. The results obtained using the TVP-VAR approach indicate a larger effect of government spending shock on GDP than the approach without time variation parameters.

In view of the reduced effect of fiscal policy to support economic growth, the fiscal policy makers should concentrate on enhancing the quality of the government expenditure structure. Further investigations closely related to this approach that can improve the results obtained might consist in using different identification sche-mes for the fiscal shock.

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NOWCASTING GDP IN GREECE: A NOTE ON FORECASTING IMPROVEMENTS FROM THE USE OF BRIDGE MODELS

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Abstract
In the recent literature on nowcasting, the use of the so-called bridge models is advocated. These are simple regression models that use data on mixed frequencies, usually with the lower frequency data serving as dependent variables and the higher frequency data as explanatory variables. In this note we investigate whether the use of such models can lead to performance enhancements in forecasting real GDP growth for Greece. This is an interesting and instructive exercise because of the obvious break in Greek real GDP growth during the crisis but also, and more importantly, because of the potential usefulness of such models in forecasting the anticipated recovery in Greek growth. Since many monthly activity indicators are released in advance of GDP growth it is interesting to see how the structure and timing of bridge models can lead to potential improvements in forecasting growth. Our results indicate that by using three of the most important monthly activity indicators such performance enhancements are indeed possible.

JEL Classification: C52, C53, E01, E27
Key words: bridge models, nowcasting, GDP, Greece, growth

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1. Introduction

Decision-makers in different parts of the economy such as business, government, the central bank, financial markets and others, are in need of an accurate and timely assessment of economic growth. The main problem is that since most macroeconomic series of interest are only available at a quarterly frequency and are released three to six weeks after the close of the quarter, many institutions are faced with the problem of using monthly information in order to obtain an early estimate of the last quarter and the current quarter results, as well as a forecast for one quarter ahead.

The aim of this paper is to attempt a nowcasting exercise for the Greek real growth rate by exploiting the particular structure of data on the Greek economy and their release. What makes our exercise particularly interesting is the problems of the data themselves and the importance of growth assessments and forecasts in the context of the deep fiscal crisis faced by the Greek government and productive sectors.

Nowcasting is a relatively new method whose main advantage is the use of new information as it comes in, and the generation of updates at a higher frequency than the frequency of observation of the variable of interest. Until recently, nowcasting had received very little attention in the academic literature, although it was routinely conducted in policy institutions either through a judgmental process or on the basis of simple models. It was first introduced by Evans (2005) for a limited number of time series and evolved by Giannone, Reichlin, and Small (2008) for a larger number of series. In recent years, there have been many applications of this method for several countries and variables thus enhancing and expanding this methodology, such as Antonello *et al*. (2008) for Ireland.

In order to have better forecasts, factor models have proved to be a very useful tool for short-term forecasting of real activity. The use of dynamic factor models has been further improved by recent advances in estimation techniques proposed by Stock and Watson (2002a, 2002b), Forni *et al*. (2004, 2005) or Giannone, Reichlin, and Small (2008), who have put forward the advances in estimation techniques that allow improving their efficiency. This type of model is particularly appealing as it can be applied to large data sets [e.g., Angelini, Camba-Mendez, Giannone, Reichlin, & Rünstler (2011); Barhoumi, Darné, & Ferrara (2010); Schumacher & Breitung (2008); Schumacher (2007)].

The DFMs are based on static and dynamic principal components. The static principal components are obtained as in Stock and Watson (2002a, 2002b). The dynamic principal components are based on either time domain methods, as in Doz, Giannone and Reichlin (2011, 2012), or frequency domain methods, as in Forni *et al.*

(2004, 2005). To the best of our knowledge, Banerjee, Marcellino, and Masten (2005), Banerjee and Marcellino (2006), Antipa *et al*. (2012) are the only studies that compare the forecasting performance of the automatically selected BMs and the DFMs – for Eurozone, US and German GDP growth, respectively. These studies, however, only use factor models following Stock and Watson (2002a, 2002b), for which results are not conclusive in favor of one or the other. DFMs have so far never been used for forecasting Greek GDP growth rates. While the econometric performance of DFMs is very satisfactory, an important caveat of this approach is that the economic content of factors is difficult to interpret from an economic point of view. For that reason we complete this analysis by several bridge models which allow for a more straightforward interpretation of the data used.

An alternative approach to the analysis of time series with mixed frequencies is the mixed data sampling regression (MIDAS) method proposed by Ghysels, Santa-Clara, and Valkanov (2006). The MIDAS method provides linear projections without specifying the dynamics of the regressors. When the model is specified correctly and the parameters are known, the Kalman filter is superior to MIDAS by construction. Otherwise, the question of whether MIDAS or the state space method is superior is still under investigation; see the study of Bai, Ghysels, and Wright (2011), who consider both MIDAS and state space methods. They show the conditions under which the methods are identical and provide evidence that the Kalman filter is slightly more accurate.

The rest of the paper is organized as follows. In section 2 we give a brief summary of the bridge models. In section 3 we discuss the results of our forecasting analysis and section 4 offers some concluding remarks for future research.

2. The bridge model & data, estimation and forecasting

Bridge models are essentially mixed frequency linear regressions. These models "bridge", i.e. link, monthly variables to quarterly ones - hence their name. In this sense they are unrestricted versions of the MIDAS approach (Ghysels, Santa-Clara, and Valkanov (2006)). Such models have been widely considered in the recent literature, and are especially used to forecast GDP growth in national and international institutions (e.g. Diron, 2008; Golinelli & Parigi, 2005; Parigi & Schlitzer, 1995; Rünstler & Sédillot, 2003; Sédillot & Pain, 2003; Zheng & Rossiter, 2006).

To make things specific, let us consider monthly and quarterly variables in the context of our data. The explanatory variables will be monthly economic activity indicators, namely the index of industrial production (IPI), the total turnover of retail sales (RSTOT) and the volume of retail sales (RSVOL). All variables are from seasonally adjusted indices and expressed in real terms as annual growth rates. The dependent variable is obtained from the, seasonally adjusted, quarterly real GDP series and also expressed as annual growth rate. All variables are obtained from the Greek Statistical Authority website (www.statistics.gr) (Table 1). Data availability is from 2001 for real GDP and this dictates the rest of our analysis: we split the data into a training period up to 2007 and use the post-crisis data as our evaluation period.

Table 1. Data series used in our analysis

Data series	Full-sample period	Data collection period/reporting frequency	Number of observations with reporting lag of 1 month or quarter	Number of observations with reporting lag of 2 months
GDP	1 Q 2001-4Q 2013	Quarterly	52	
Industrial production index	Mar 2001-Dec 2013	Monhtly	106	
Volume of Retail Sales	Mar 2001-Dec 2013	Monhtly		106
Total Turnover of Retail Sales	Mar 2001-Dec 2013	Monhtly		106

Source: ELSTAT

The Real GDP Growth rate varies from -0,0894 at the third quarter of 2010, which is the trough, to the peak 0,0754 at the second quarter of 2006. The variable which is most correlated with the GDP is the Volume of Retail Sales of the previous month of examination, followed by the Total Turnover of Retail Sales of the previ-ous month of examination. As can be seen in Table 2 there is a negative skewness between the variables and the values are wider spread around the mean.

Table 2. Summary of statistics

	Average	Std. Dev.	Min	Max	Skewness	Kurtosis	ACF(1)	ACF(2)	Correlation with GDP
Real GDP Growth	0,0024	0,0490	-0,0894	0,0754	-0,4102	1,7875	0,9199	0,8664	1
IPI (0)	-0,0249	0,0470	-0,1312	0,0748	-0,3578	2,5577	0,4260	0,4724	0,5804
IPI (-1)	-0,0273	0,0401	-0,1183	0,0513	-0,2611	2,3279	0,5382	0,4874	0,6085
IPI (-2)	-0,0256	0,0482	-0,1403	0,0654	-0,4734	2,6163	0,4734	0,5342	0,6301
RSTOT (0)	0,0174	0,0941	-0,1791	0,1813	-0,4599	1,9496	0,8105	0,6013	0,8388
RSTOT (-1)	0,0212	0,0838	-0,1627	0,1317	-0,5707	1,9758	0,8189	0,7412	0,8663
RSTOT (-2)	0,0165	0,0931	-0,1702	0,1580	-0,5672	2,0213	0,7360	0,6443	0,7829
RSVOL (0)	-0,0082	0,0848	-0,1900	0,1359	-0,5483	2,2405	0,8335	0,6148	0,8617
RSVOL (-1)	-0,0062	0,0773	-0,1635	0,0952	-0,5385	1,8410	0,7867	0,7361	0,8789
RSVOL (-2)	-0,0115	0,0854	-0,1755	0,1230	-0,4754	1,8701	0,7075	0,6337	0,8175

The variables (0),(-1)(-2) refer to the growth rates of the current month, the previous and two months back, respectively.

The estimation is conducted recursively to fully utilize the relatively small amount of observations available.

The general specification of a bridge model is that of an autoregressive-distributed-lag (ARDL) for q explanatory variables and is given as follows:

$$Y_t = a + \sum_{i=1}^{m} \beta_i Y_{t-i} + \sum_{j=1}^{q}\sum_{i=1}^{k} \delta_{j,i} X_{j,t-1} + \varepsilon_t$$

where m is the number of autoregressive parameters, q is the number of explanatory variables, and k is the number of lags for the explanatory variables. Note that under the restriction that now monthly variables appear above, we see that the equation collapses to a standard autoregression – which thus becomes the natural benchmark to compare forecasting performance. In our analysis we consider models that use each monthly variable, a pair of monthly variables and all three monthly variables together. These models are benchmarked against an AR(1) model and an AR(AIC) model, with maximum lags set to 6.

An important point we should make is that we use our data aligned correctly and taking account of release lags. This is important for making the exercise realistic. For example, we always use a two-month lag on the aligned monthly data: if we are at the end of the 4th quarter we use monthly data for October. So, if the real GDP for the 4th quarter is released, for example, in mid-February and the monthly variable is released in November or December we always use past data correctly in producing the forecasts.

Finally, to evaluate our forecasting results we use the standard measures of mean forecasting error, mean squared error and mean absolute error.

3. Forecasting results

Results in terms of mean error (ME), mean absolute error (MAE), mean-squared error (MSE) and root mean-squared error (RMSE) of the forecasts, as presented in Table 1 as well as the ratio obtained from AR(1) (Ratio1) and AR(AIC) (Ratio 2) benchmarks show that the combination of the IPI, the RSVOL and the RSTOT performed better than the benchmarks. Both Ratio 1 and Ratio 2 showed that almost all models −except for the IPI− perform better than the benchmarks. (Table 2)

Table 3. ME, MAE, MSE, RMSE for the forecast for the period 2008Q3-2013Q4

Model	**AR(1)**	**AR(AIC)**	**RSVOL**	**RSTOT**	**IPI**	**RSVOL & IPI**	**RSTOT & IPI**	**ALL 3**
ME	-0,008	-0,001	-0,003	-0,004	-0,010	-0,005	-0,007	-0,007
MAE	0,018	0,019	0,017	0,018	0,018	0,016	0,017	0,015
MSE	0,001	0,001	0,000	0,000	0,001	0,000	0,000	0,000
RMSE	0,023	0,023	0,021	0,022	0,023	0,020	0,022	0,019
Ratio 1	1,000	1,006	1,085	1,030	0,993	1,117	1,049	1,192
Ratio 2	0,994	1,000	1,079	1,024	0,987	1,111	1,044	1,185

Ratio1 and Ratio2 are computed as the ratios between each RMSE with that obtained from the AR(1) and AR(AIC) models, respectively.

Obviously, simply comparing error-values does not take into account the sample uncertainty underlying observed forecast differences. This is why we also applied the test of equality of forecast performance proposed by Diebold and Mariano (1995). Table 4 includes the results of Diebold–Mariano tests for equality of mean squared errors of each pair of forecasts for each individual series for the reported horizons. As can be seen the results are not as accurate as we would have expected, owing to the small amount of observations. The combination of the three models appears to have the best results over the AR(1) model but to have an accurate result we will surely need another test.

Table 4. Diebold-Mariano tests of the forecast accuracies of different methods with the benchmark AR(1) and AR(AIC)

Model	RSVOL	RSTOT	IPI	RSVOL & IPI	RSTOT & IPI	ALL 3
Benchmark the AR(1)	1,11	0,56	-0,07	1,11	0,43	1,36
Benchmark the AR(AIC)	0,76	0,26	-0,08	0,74	0,27	1,23

4. Concluding remarks

In the preceding analysis we have presented the use of bridge models in order to nowcast the GDP growth rate of Greece. We found that it is possible to get reasonably good estimates of current quarterly GDP growth in anticipation of the official release. Our results showed that changing the BM's equations by including newly available monthly information provides generally more precise forecasts and is preferable to maintaining the same equation over the exercise's horizon.

Comparing the BMs with DFMs and the MIDAS approach is in our research agenda. Moreover, it would be very interesting to expand the number of explanatory variables to include other economic activity indicators, experiment with different lags of the explanatory variables and, more importantly, with the timing of the monthly releases before the GDP quarterly release. Our goal is to produce –from now on– forecasts of the Greek GDP and examine their real time performance.

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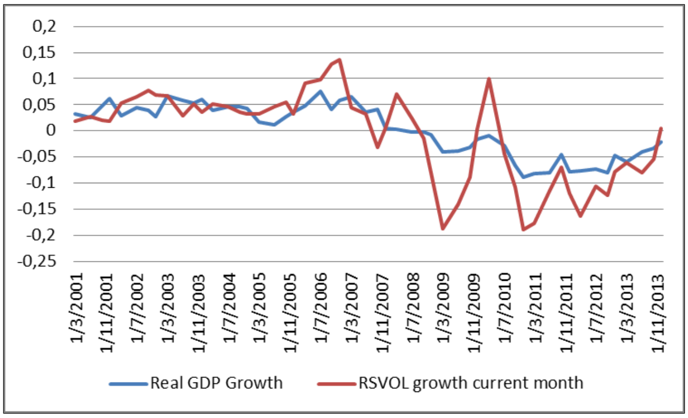
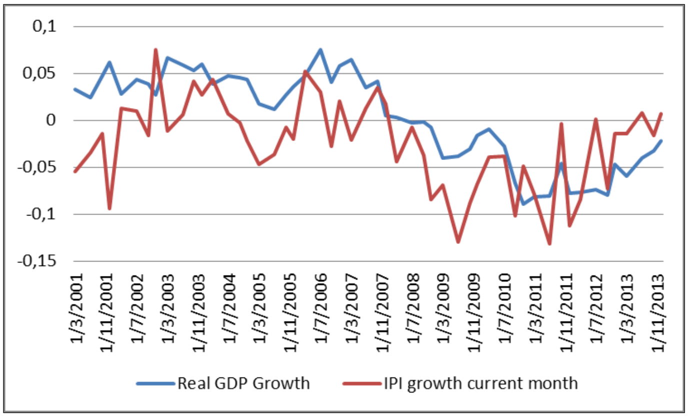
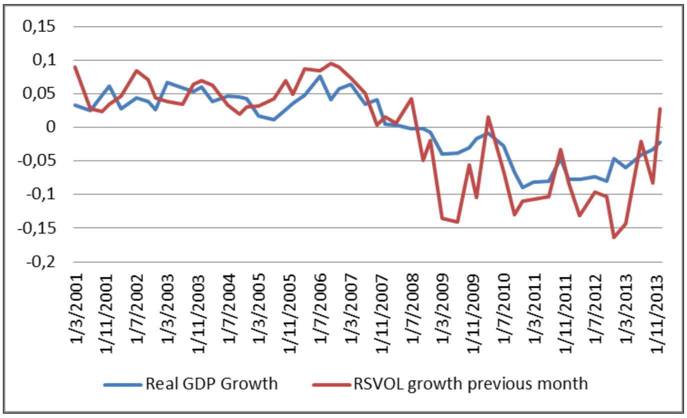
Appendix A.

Graphs of each time series in comparison with the Real GDP Growth.



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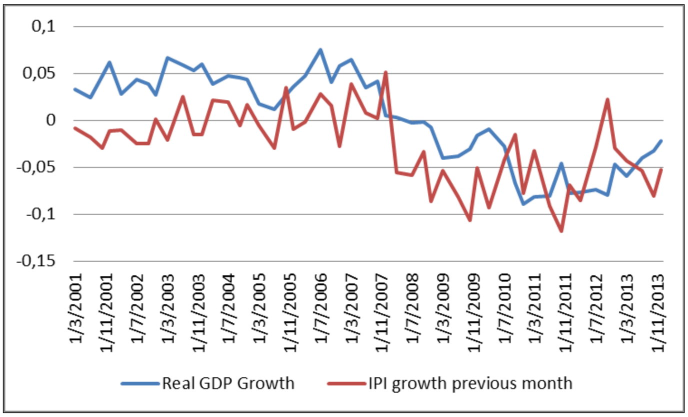
Real GDP Growth
RSVOL growth previous month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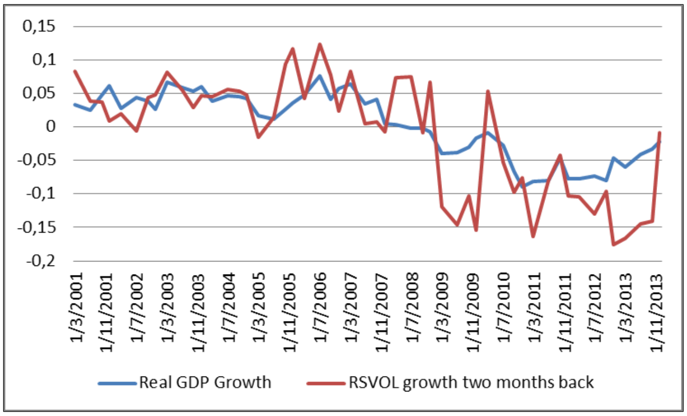
Real GDP Growth
IPI growth previous month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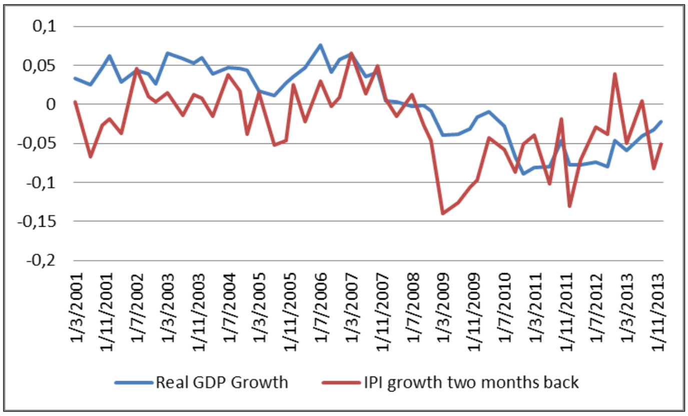
Real GDP Growth
RSVOL growth two months back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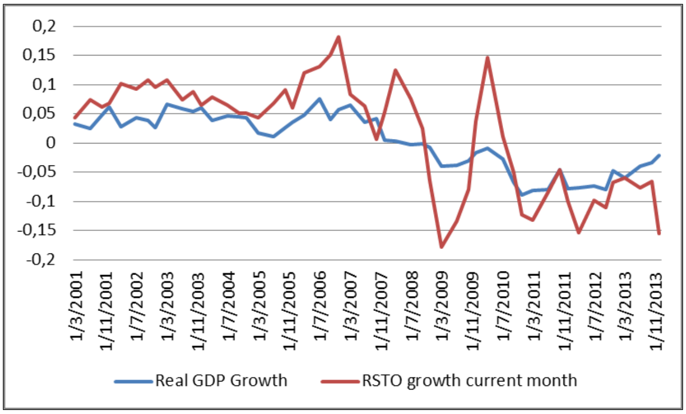
Real GDP Growth
IPI growth two months back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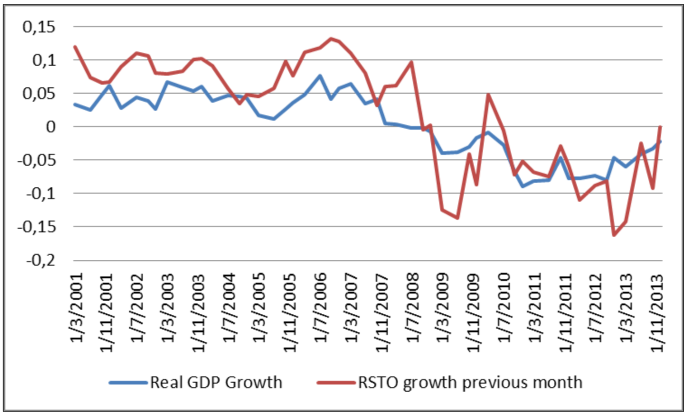
Real GDP Growth
RSTO growth current month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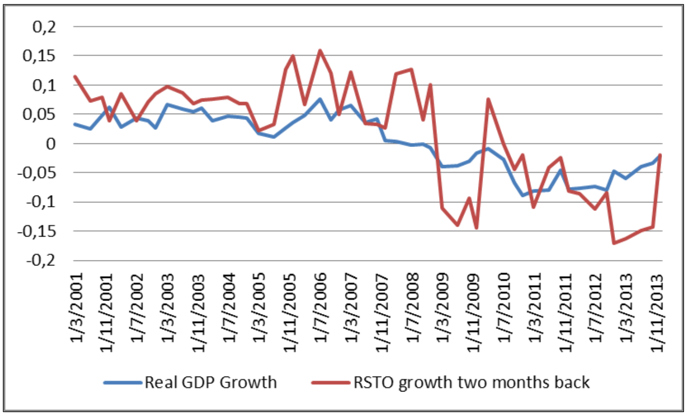
Real GDP Growth
RSTO growth previous month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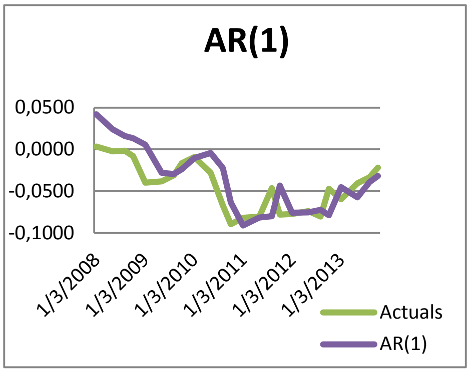
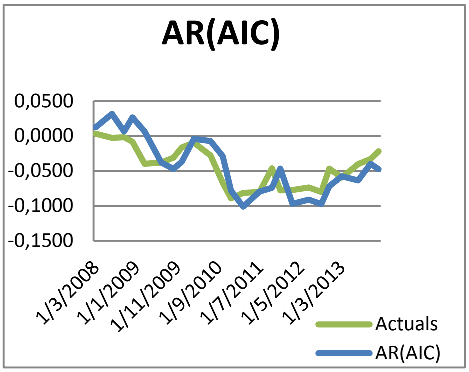
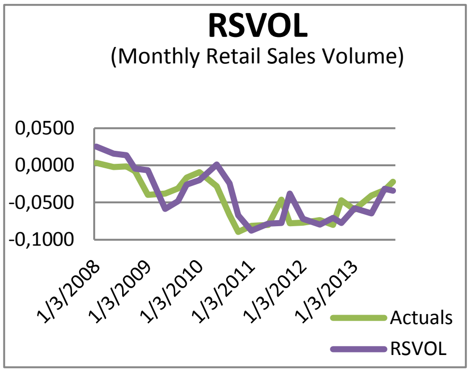
Real GDP Growth
RSTO growth two months back

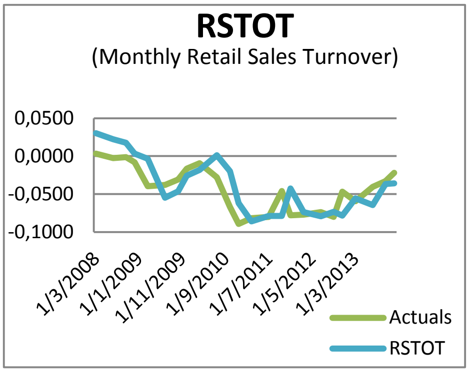
Appendix B.

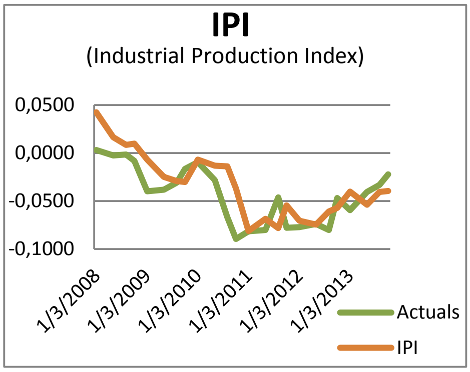
Graphs of each forecast series of each model along with actual values.

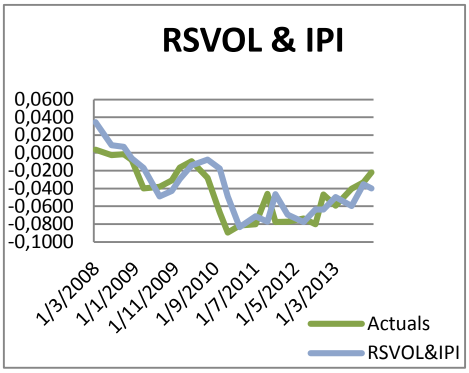


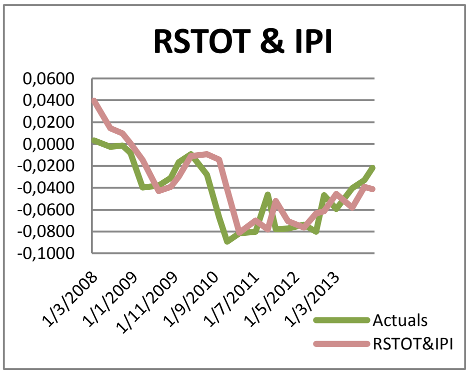








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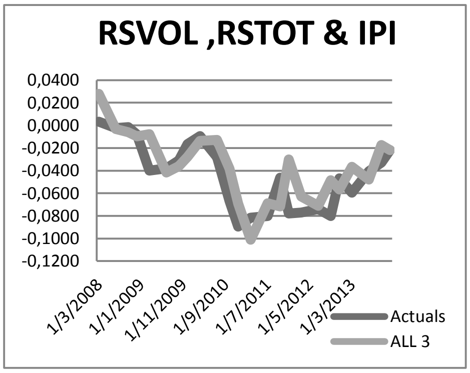
Actuals
RSTOT&IPI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guide for authors

The articles should be written as follows:

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(6) The first page of the manuscript should also contain at least one classification code according to the Classification System for Journal Articles as used by the Journal of Economic Literature; in addition, up to five key words should be supplied.
The classification system used in JEL can be found at:
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(8) Footnotes should be kept to a minimum and numbered consecutively throughout the text with superscript Arabic numerals.

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For monographs
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For contributions to collective works
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For periodicals
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