Long-Run PPP: The Case of Greece: Towards the Transition to the Euro: A Maximum Likelihood Cointegration Approach[1]

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ABSTRACT

In this paper one will test for the existence of long-run PPP for seven drachma bilateral exchange rates, using monthly data from 1966m01 to 2007m12. The countries include the USA, UK, Germany, Italy, Spain, Japan and France. PPP will be tested using maximum likelihood estimation of cointegrating vectors, proposed by Johansen [1988]. One will essentially test whether potential long-run cointegrating relationships between nominal exchange rates and price levels correspond to *strong-form* PPP, suggested by economic theory. One finds that prior to the Euro, *strong-form* PPP held for Greece with Germany and the UK, while when focusing on the post-Euro era, *strong-form* PPP was established between Greece and all Euro-zone countries in the sample and the UK.

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I. INTRODUCTION

Purchasing Power Parity is the fundamental principle underlying international macroeconomics. Based on the law of one price, “the purchasing power parity exchange rate is one between two currencies which would equate the two national price levels, if expressed in a common currency, so that the purchasing power of a unit of currency will be the same in both economies. When PPP holds, the real exchange rate is constant so any fluctuations to it represent deviations from PPP.”[2] The concept was articulated by scholars of the Salamanca school in 16th century Spain, but its modern origins trace to post World War I, when Gustav Cassel promoted the use of the concept as a means of setting relative parities.[3]

Generally, “while few empirically literate economists take PPP seriously as a short-term proposition, due to “transaction costs, imperfect competition and foreign exchange market interventions”[4], most instinctively believe in some variant of PPP as an anchor for long-run real exchange rates.”[5] Thus, estimates of PPP are considered important for purposes such as “determining the degree of exchange rate misalignment and the appropriate policy responses, the setting of exchange rate parities, and the international comparison of national income levels.”[6] It is therefore evident why such an immense literature has been solely devoted on empirically analyzing, testing and predicting the movements of exchange rates and price levels in the pre and post Bretton Woods periods. The importance of the concept to macroecononomic policy making was the main reason that inspired the author’s research.

In this paper, one will use cointegration techniques to test for the existence of PPP between Greece and its main trading partners, before and after the transition to the Euro. One will explain the merits that arise when PPP holds and suggest policy implications. Hypotheses will be tested “within the framework provided by the maximum likelihood estimation technique of cointegrating vectors suggested by Johansen [1988]”.[7] The innovative aspects of this paper are the following:

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[2] Taylor M. P., Sarno L., “The economics of exchange rates”, Cambridge University Press, 4th Edition, 2006, page 51

[3] Rogoff K, “The Purchasing Power Parity Puzzle”, *Journal of Economic Literature*, Volume 34, 1996, pages 648

[4] Baum C. F., Barkoulas J. T., Caglayan M., “Nonlinear adjustment to purchasing power parity in the post-Bretton Woods era”, *Journal of International Money and Finance*, Volume 20, 2001, page 380

[5] Rogoff K, “The Purchasing Power Parity Puzzle”, *Journal of Economic Literature*, Volume 34, 1996, pages 647

[6] Taylor M. P., Peel D. A., Sarno L., “Non-linear mean reversion in real exchange rates: towards a solution to the Purchasing Power Parity puzzles”, *International Economic Review,* Volume 42, Number 4, November 2001, page 1015

[7] Georgoutsos D.A. and Kouretas G. P., “ Long-run purchasing power parity in the 1920’s: the Greek experience”, *Applied Economics,* Volume 24, 1992, page 1301

Although Greece has been negligibly dealt with as a benchmark country of analysis, no paper has used such a vast data span, with attention usually restricted to no more than two decades, albeit suggestions for large datasets as a means of establishing co-movement between exchange rates and prices. Additionally, unlike similarly targeted papers, emphasis will be given to pre and post-Euro eras, potentially investigating the effect of transition on existence of PPP.

The paper is organized as follows: In section II, one presents the relevant literature, followed by data examination and preliminary statistical analysis, in section III. In section IV one outlines the theoretical methodology employed. In section V one presents the empirical results for pre and post Euro periods, along with comparisons to existing literature. In section VI one highlights limitations. Finally, in section VII, one concludes with relevant policy implications.

II. LITERATURE REVIEW

Perhaps the most controversial topic in international macroeconomics, "the empirical support of PPP has waxed and waved over the years".[8] Its empirical testing has undergone several stages, starting from unit root tests on the real exchange rate, preceded by multivariate and panel cointegration techniques and peaking with recently developed non-linear methodologies. Therefore, the "sophistication of the testing procedures, have developed *pari passu* with advances in econometric techniques".[9] What follows, portrays the most imperative studies, presents the dynamic development of empirical testing on PPP and underlines some weaknesses of previous methodologies.

The early consensus in testing for PPP, involved estimates of the form: $e_t = \theta_0 + \theta_1 p + \theta_2 p^* + \omega_t$, with restrictions: $\theta_0 = 0$, $\theta_1 = 1$ and $\theta_2 = -1$; Frenkel [1978]. The main problem with such estimation methods however is that stationarity of the estimated errors is not acknowledged, something essential in establishing a valid long-run relationship. Consequently, the next step was to correct for the issue of non-stationarity. The methodology involved testing for a unit root in the real exchange rate, with stationarity suggesting mean reversion and validity of PPP.[10] The literature has been rather controversial.

One the one hand, scholars like Adler and Lehmann [1983] argued that the real exchange rate follows a random walk, questioning the feasibility of cointergation. Using annual and monthly data, targeted on fixed and floating rate regimes, the authors were unable to reject the hypothesis of a random walk of the real exchange rate, for a series of industrialized countries, suggesting violation of the theory. Similar findings were also suggested by Roll [1979]. Furthermore, Corbae and Ouliaris [1988], applied cointegration techniques to test for a co-movement between nominal exchange rates and prices of industrialized countries including the USA, UK and Canada. The authors were unable to reject the hypothesis of no cointegration, suggesting that regressions involving domestic and foreign price levels plus spot exchange rates were spurious.

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[8] Taylor A., "A century of purchasing power parity", *The Review of Economics and Statistics,* Volume 84, Issue 1, February 2002, page 139

[9] Taylor M. P., Sarno L., "The economics of exchange rates", Cambridge University Press, 4th Edition, 2006, page 58

[10] Ibid, Taylor M. P., Sarno L., "The economics of exchange rates", page 59

Similar findings were suggested by Karfakis and Moschos [1989] using two decades of data, for the case of Greece under the current float. This rejection of cointegration led many to criticize PPP because of "murky concepts rather than differences in data."[11], and led to the "widespread belief that it was of little or no use empirically".[12] In fact, "this might be thought of as the first PPP puzzle".[13] Additionally, the validity of the concept was also criticized in periods of severe volatility. Frenkel [1981] argued; "during the 1970's, exchange rate movements, bore little relationship to short-run inflation differentials, making divergences from PPP cumulative".

On the other hand, some scholars argued that a "possible rationalization of the failure to reject the hypothesis of non-stationary real exchange rates, lays on the lack of long available data to provide any reasonable degree of test power."[14] Lothian and Taylor [1996], used data spanning two centuries for dollar-sterling and franc-sterling real exchange rates and outperformed non-stationarity in the real exchange rate despite high short-run persistence following shocks in the real exchange rates. Similar analysis was undertaken by Abuaf and Jorion [1990] and Kim [1990], who concluded that evidence against PPP, was "mainly because of lack of power of tests used, rather than actual evidence against the concept"[15].

Frankel and Rose [1996], Pedroni [1995] and Lothian [1997], applied panel cointegration techniques and found strong evidence of PPP alongside Cheung and Lai [1993], who introduced the notion of fractional cointegration and found evidence of long-run PPP, using historical data for 1914-1989. Additionally, Pippenger, Geppert [1997] re-formulated the general model including the presence of transaction costs and tested for univariate co-integration using the trace statistic proposed by Johansen. The authors suggest existence of PPP, also for Greece, as in "only three out of eighteen cases, did the trace statistic indicate more than one cointegrating vector". Similar findings for Greece were suggested by Baum, Barkoulas and Caglayan [2001], testing within the framework of maximum likelihood, as well as Dockery and Georgellis [1994].

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[11] Darby M., "Does Purchasing Power Parity Work?" Academic *Conference Proceedings*, *Federal Reserve Bank of San Francisco*, 1982 San Francisco, CA

[12] Dornbusch, R., "Purchasing power parity". In: Eatwell, J., Milgate, M. and Newman, P., Editors, 1987. *The New Palgrave: A Dictionary of Economics*, Stockton, New York, pp. 1075–1085.

[13] Taylor M. P., Peel D. A., Sarno L., "Non-linear mean reversion in real exchange rates: towards a solution to the Purchasing Power Parity puzzles", *International Economic Review,* Volume 42, Number 4, November 2001, page 1016

[14] Taylor M, Sarno L, "The Behaviour of Real Exchange Rates during the Post-Bretton Woods Period", *Journal of International Economics*, Volume 46, 1998, pages 282

[15] Abuaf, N. and Jorion, P., "Purchasing power parity in the long run", *Journal of Finance*, Volume 45, 1990, page 157

Finally, even further developments in econometric techniques have laid the foundations in using non-linear time series estimations to capture mean reversion of real exchange rates. Current literature has led to strong acceptance of the hypothesis of mean reverting behaviour. Taylor, Sarno and Peel [2001], found strong non-linear mean reversion for the cases of UK, Germany, France and Japan, with similar results suggested in Serletis and Gogas [2000], Sarno [2000] for the case of Turkey and Baum, Barkoulas and Caglayan [2001], with strong non-linear mean reversion for the Greek case.

Nevertheless, all the above studies, have taken place before the formation of a common European currency area. In fact, "remarkably few empirical studies test the hypothesis of purchasing power parity for the Euro-zone."[16] This constitutes the author's reason for expanding the analysis into the post-Euro era. Koedijk, Tims and van Dijk [2004] tested for the existence of PPP using a span of data from 1973-2003 for a panel of real exchange rates vis-à-vis the German deutschmark and found evidence supportive of PPP for the full panel. For small European countries, evidence was weak but existent. Similar findings were suggested by Papell [1997], suggesting "evidence against the unit root hypothesis of the real exchange rate is stronger for larger than smaller panels, for monthly rather than quarterly data and when the German mark rather than the US dollar was the base currency." Notably, Greece belongs to the panel where evidence of long-run PPP is strong.

Arguably however, "a very serious problem with panel unit root tests, highlighted by Monte Carlo evidence of Taylor and Sarno [1998], is that the null hypothesis in such cases is that all of the series are generated by unit-root processes, so that the probability of rejection of the null hypothesis may be quite high when as few as one of the series of interest is a realisation of a stationary process".[17]

Additionally, Lopez and Papell [2007] argue: "While we would expect that, following the adoption of the Euro, long-run PPP would hold within the Euro-zone, issues involving the transition to the Euro are not so obvious". The evidence on PPP they found is stronger for countries within the Euro-zone compared to Euro-zone vis-à-vis other ones and for the larger Euro countries rather than the smaller ones. They also argue that convergence towards PPP starts in 1992 and not upon the currency transition.

[16] Koedijk K. G., Tims B., van Dijk M., "Purchasing Power Parity and the Euro Area", *Journal of International Money and Finance*, Volume 23, 2004, pages 1081-1107
[17] Taylor M. P., Sarno L., "The economics of exchange rates", Cambridge University Press, 4th Edition, 2006, page 86

To conclude, although some literature has dealt with the case of Greece there has been no paper that exclusively focuses on the Greek economy before and after the transition to the Euro. This thesis, aims to cover this empirical deficiency, using the relatively efficient and statistically powerful econometric methodology of cointegrating vectors.

III. DATA ANALYSIS AND PRESENTATION

The dataset used contains monthly observations of consumer price indices (CPI) for Greece, USA, France, UK, Spain, Germany, Japan and Italy along with end-of-period bilateral nominal exchange rates for UK sterling, German mark, Italian lira, Spanish peseta, US dollar, Japanese yen and French franc against the Greek drachma.[18] Nominal exchange rates are defined as the domestic price of foreign currency such that an increase is associated with depreciation. As suggested in Lopez and Papell [2007], for countries, which adopted the Euro, one has constructed the exchange rates, by converting in-currency by dollar using the prefixed exchange rates.[19]

All the variables belong to the period 1966m01-2007m12 with no missing observations. A key concern was the choice of the price index, which varies among researchers, with the CPI and WPI (wholesale price index) being the most popular ones. In many cases, researchers use both and compare results. It is commonly argued that "WPI places heavier weight on tradable goods than CPI and tends to yield more favourable test results to PPP. The use of WPI however is sometimes under the criticism that the relationship between traded goods, prices and exchange rates comes close to a truism."[20]

One chose the CPI for two reasons. Firstly, because of complete data availability and secondly, because the actual formulation of the PPP hypothesis by Cassell was based on the CPI. Remarkably, it has been found that the choice of price index might often lead to different conclusions (Kim [1990]).

In terms of sources, one used the International Monetary Fund's, International Financial Statistics, extracted from the Statistical Yearbook 2008 and some supplementary data from Thomson DataStream. These databases are internationally known for their availability and accuracy of data.

[18] The choice of trading partners was based on OECD's profile on Greece www.oecd.org/greece, suggesting the countries used the most important trading partners in terms of imports and exports, with Greece.

[19] This has been done as follows: One collected data for the nominal exchange rates of each currency of interest against the US dollar. Even for countries, which switched to the euro, data on the exchange rate of their former currencies against the dollar still exist in statistical datasets. The conversion back to the pre euro currencies however still enclosed the dynamic volatility of the exchange rates that was required, meaning that the adoption of the euro was treated as a break/shock to the system and thus the sample was divided accordingly.

[20] Cheung Y and Lai K. S., "A Fractional Cointegration Analysis of Purchasing Power Parity", *Journal of Business & Economic Statistics*, Vol. 11, No. 1, January 1993, page 104

The IMF's dataset, which was the core of the analysis, has been extremely popular and used in papers like Taylor, Sarno and Steel [2001], Taylor [1988], Baum, Barkoulas and Caglayan [2001], while studies such as Coakley and Fuertes [1997] and MacDonald [1993], have used DataStream.

Notably, due to the fact that not all nominal bilateral exchange rates were available, some exchange rate series had to be created. One calculated the nominal exchange rates between Greece and Italy, Spain, France, Germany and Japan as follows:

$\frac{drachma}{dollar} / \frac{currency_i}{dollar} = \frac{drachma}{currency_i}$, for i= France, Germany, Italy, Spain and Japan. This methodology might present slight inaccuracies, but is the only available methodology for not so popular currencies such as the drachma. To the author's knowledge, reported values are as accurate as possible.

Additionally, one also computed the logarithmic expressions of all series; the reason being the following: Formally, the absolute version of PPP is defined as:

$$\sum_{i=1}^{N} \alpha_i P_{i,t} = E_t \sum_{i=1}^{N} \alpha_i P^*_{i,t}$$

where the weights in summation satisfy $\sum_{i=1}^{N} \alpha_i = 1$. If the price indices are constructed using a geometric index then we must form the weighted sum after taking logarithms:

$$\sum_{i=1}^{N} \gamma_i p_{i,t} = e_t + \sum_{i=1}^{N} \gamma_i p^*_{i,t}$$

where again geometric weights sum to unity and lower-case letters denote logarithmic expressions. Therefore, if national price levels and bilateral nominal exchange rates are logarithmically transformed then the popular absolute PPP condition that is used in the literature takes the form:

$$e_t = p_t - p^*_t \quad [21]$$

which is more convenient in terms of estimation.

Our preliminary analysis dictated testing for potential unit roots in the series. The reason for doing this was to ensure that all variables were integrated of the same order before applying cointegration techniques.

[21] Taylor M. P., Sarno L., "The economics of exchange rates", Cambridge University Press, 4th Edition, 2006, pages 52-53

According to the Granger representation theorem, if $x_t \sim I(1)$ and $y_t \sim I(1)$ then $a x_t + b y_t \sim I(1)$ unless x and y are cointegrated, meaning that $u_t \sim I(0)$; i.e. if $z_t = a x_t + b y_t \sim I(0)$, then x and y are cointegrated as the non-stationarity of both series offsets exactly offset each other out. The components of a $k \times 1$ vector, y_t, are said to be cointegrated of order d and b, denoted $y_t \sim CI(d,b)$ if all the components of the y_t vector are $I(d)$ and if there exists a non-zero vector β such that $z_t = \beta' y_t \sim I(d-b)$.[22]

Formally, one tested for the presence of a unit root in all series using Augmented Dickey Fuller (ADF) and Phillips-Perron unit root tests. The ADF test is of the form:

$$\Delta q_t = \mu + \gamma t + \alpha q_{t-1} + \sum_{j=1}^{p*} \varphi_j \Delta q_{t-j} + \varepsilon t$$

where $p* = p-1$ is determined by minimizing certain information criteria and the null hypothesis is $\alpha = 0$, suggesting the presence of a unit root, versus the alternative of $\alpha < 0$.

The Phillips-Perron test, which arguably has more power than the ADF, by accounting for error heterogeneity, takes the form:

$$Z(t_a) = \frac{\tilde{S}}{\sigma_{T\omega}} t_a - \frac{T^3}{4\sqrt{3}D_x^{1/2}\tilde{\sigma}_{T\omega}} (\tilde{\sigma}_{T\omega}{}^2 - \tilde{S}^2)$$

where $\tilde{\sigma}_{t\omega} = T^{-1} \sum_{t=1}^{T} u_t^2 + 2T^{-1} \sum_{s=1}^{1} \sum_{t=s+1}^{T} u_t u_{t-s}$, $D_x = \det[X'X]$ = determinant of regressor X and $\tilde{S}$ = regression standard error. Here again the null hypothesis is one of a unit root versus the alternative of stationarity.[23]

Table 1 presents the results of both tests for all the logarithmic transformations of the series in levels and first differences, including a constant and a time trend.

[22] Engle R.F. and Granger C.W.J, "Co-integration and error correction: representation, estimation and testing," *Econometrica,* Volume 5, 1987, pages 251-276

[23] For more information about the methodology refer to, Phillips C. B., Perron P, "Testing for a unit root in time series regression," *Biometrkika*, Volume 75, Issue 2, 1988, pages 335-346 and Golic N., "Econometrics of Exchange Rate Movements: Cointegration Approach", VDM Verlag Dr. Muller, 2007, pages 45-46

Table 1: ADF and Philipps-Perron tests for the presence of unit roots in the series[1]

Variables	ADF		Phillips Perron	
	Levels	1st differences	Levels	1st differences
Lncpigreece	-0.91177	-3.18053	0.10542	-21.4845
	[0.9526]	[0.0896]	[0.9973]	[0.0000]
Lncpifrance	-0.85604	-3.65028	0.52454	-18.4384
	[0.9586]	[0.0267]	[0.9994]	[0.0000]
Lncpigermany	-2.12416	-2.48700	-0.11284	-18.8864
	[0.5305]	**[0.3345]**	[0.9946]	[0.0000]
Lncpiitaly	-0.92155	-2.91147	0.79517	-17.2562
	[0.9515]	**[0.1597]**	[0.9998]	[0.0000]
Lncpispain	-1.66381	-2.22969	0.83403	-21.8758
	[0.7658]	**[0.4715]**	[0.9998]	[0.0000]
Lncpijapan	-1.71500	-3.48672	-0.82364	-18.7039
	[0.7434]	[0.0419]	[0.9617]	[0.0000]
Lncpiuk	-1.25411	-3.27927	0.15821	-19.3106
	[0.8973]	[0.0709]	[0.9977]	[0.0000]
Lncpiusa	-1.70030	-3.05351	0.10217	-16.6114
	[0.7500]	**[0.1189]**	[0.9973]	[0.0000]
Lngrffr	-1.06789	-28.2735	-1.15702	-28.5231
	[0.9320]	[0.0000]	[0.9169]	[0.0000]
Lngrdem	0.49717	-34.7769	0.43461	-35.5927
	[0.9993]	[0.0000]	[0.9991]	[0.0000]
Lngritl	-1.44251	-16.3195	-1.33347	-16.0750
	[0.8474]	[0.0000]	[0.8783]	[0.0000]
Lngrspp	-1.41393	-18.1657	-1.38160	-18.1760
	[0.8561]	[0.0000]	[0.8654]	[0.0000]
Lngrjpy	0.65587	-20.0226	0.25311	-20.2252
	[0.9996]	[0.0000]	[0.9983]	[0.0000]
Lngrusd	0.10255	-17.1978	0.18106	-17.2716
	[0.9973]	[0.0000]	[0.9979]	[0.0000]
Lngrgbp	-1.62612	-17.1659	-1.62164	-17.0802
	[0.7816]	[0.0000]	[0.7834]	[0.0000]

1: p-values are reported in brackets

These results come to confirm what economic theory and empirical studies suggest; i.e. the existence of a unit root in the levels of the series and no unit root when the series are first differenced. These results are crucial, as in order to establish a stationary cointegrating relationship between two or more series; it is necessary that all variables be integrated of the same order. For four variables, highlighted in bold, the ADF test was unable to reject the hypothesis of a unit root in the differenced series, suggesting $I(2)$ variables. Nevertheless, the ADF has arguably lower power compared to the Philipps-Perron test and thus, for those series the results suggested by the later test are more satisfactory. For all other variables, the same conclusions are reached using both tests.

Having done this, one also divided the variables in seven groups with each group containing the CPI of Greece and its trading partner as well as the nominal exchange rate. The series were plotted over time. In all cases, variables seemed to be trending together suggesting potential cointegrating relationship(s).[24]

[24] These graphs can be seen in appendix 2. Nevertheless, one had to formally test for the presence of cointegrating relationships.

IV. THEORETICAL METHODOLOGIES AND ISSUES[25]

One will use the methodology suggested by Johansen [1988] to test for the existence of cointegrating vectors in a multivariate context, by examining “nonstationary vector autoregressive (VAR) processes, which are $I(1)$ and generated by independently and identically distributed Gaussian errors”.[26] “The Johansen method employs a VAR framework which incorporates both the short and long-run dynamics of the system, using a reduced rank regression technique.”

Earlier cointegration studies on PPP employed the two-step Engle and Granger [1987] procedure by applying an Augmented Dickey Fuller test on the residuals of a long-run estimated model of the form: $e_t = \theta_0 + \theta_1(p_t - p_t^*) + \omega_t$. Essentially, the test was on the real exchange rate defined as: $q_t = e_t - p_t + p^*_t$. The hypothesis of mean reverting behaviour of the real exchange rate implied co-movement of e_t, p_t and p^*_t and was established when ω_t was stationary.

This approach however tends to be particularly inefficient, because it typically assumes that a unique cointegrating vector exists. It may be the case that more than one relationship exists, in which case OLS would typically estimate a linear combination of them. The low power of this test tends to over-reject the PPP hypothesis. To correct for this, a sophisticated econometric technique, based on maximum likelihood estimation, was suggested by Johansen and will be the fundamental tool of this paper.

The analysis starts with a VAR of the form:

$$\vec{X}_t = \Theta_1 \vec{X}_{t-1} + \dots + \Theta_k \vec{X}_{t-k} + \mu + \vec{\varepsilon}_t \quad (1)$$

$\vec{X}_t$ is allowed to be non-stationary. In our context all series are $I(1)$ and Johansen defines an impact matrix as: $A(z) = \Pi = I - \Theta_1 - \dots - \Theta_k$ with rank $r < p$. This matrix determines the long-run properties of $\vec{X}_t$, which is a vector of $I(1)$ variables, such that $\Delta \vec{X}_t$ is stationary. If this impact matrix is expressed as $\Pi = \alpha \beta'$, where both α and β are $p \times r$ dimensional, then although $\Delta \vec{X}_t$ is stationary and $\vec{X}_t$ is non-stationary, the linear combinations $z_t = \beta' \vec{X}_t$, will be stationary.

[25] All of section IV, is based on the paper: Johansen S, “Statistical Analysis of Co-integrating Vectors”, *Journal of Economic Dynamics and Control*, Volume 12, 1988, pages 231-254

β is the matrix of co-integrating vectors and α represents the matrix of weights with which each co-integrating vector enters each of the $\vec{X}_t$ equations. The Johansen procedure involves estimating the space spanned by β from observations $\vec{X}_t$, given the restriction that $rank(\Pi) \le r$ or alternatively, $\Pi = \alpha\beta'$.

Essentially, one is testing for the rank of the long-run matrix Π, which is equivalent to testing that the smallest latent root of Π is zero, corresponding to the number of cointegrating relationships in the system. To do so, the proposed VAR model is re-written such that Π enters the model explicitly.

$$\Delta\vec{X}_t = \Gamma_1\Delta\vec{X}_{t-1} + \dots + \Gamma_{k-1}\Delta\vec{X}_{t-k+1} + \Pi\vec{X}_{t-1} + \vec{\varepsilon}_t \qquad (2)$$

where $\Gamma_i = -I + \Theta_1 + \dots + \Theta_i$. Having presented this re-formulation, the procedure suggested by Johansen involves the following: Firstly, regressing $\Delta\vec{X}_t$ and $\vec{X}_{t-k+1}$ on lagged differences of $\Delta\vec{X}_t$ and obtaining the set of residuals R_{0t} and R_{kt}. Secondly, deriving and ranking, in terms of magnitude, the eigenvalues λ_i of $S_{k0}S_{00}^{-1}S_{0k}$ in the metric S_{kk}, such that $\lambda_1 \ge \lambda_2 \ge \dots \ge \lambda_k$. This essentially means solving the equation: $|\lambda S_{kk} - S_{k0}S_{00}^{-1}S_{0k}| = 0$, corresponding to solving $\left|\lambda - S_{k0}S_{00}^{-1}S_{0k}S_{kk}^{-1}\right| = 0$. Having done so, Johansen proposes two likelihood ratio tests for the existence of cointegration: The trace statistic for the hypothesis that there are at most r cointegrating vectors:

$$-2\ln(\vec{X}) = -T\sum_{i=r+1}^{p}\ln(1-\hat{\lambda}_i)$$

with $\hat{\lambda}_i$ corresponding to the $p-r$ smallest eigenvalues and the maximum eigenvalue statistic of testing that there exist r versus $r+1$ cointegrating vectors:

$$-2\ln\{\vec{X} : r/r+1\} = -T(1-\hat{\lambda}_{r+1})$$

Having established at least one cointegrating vector, Johansen proved how to test for linear restrictions on the estimated cointegrating vector(s) of the form: $H_0 : \beta = H\varphi$, where H is a $p \times s$ matrix and φ is a $s \times r$ matrix incorporating the restrictions on the values of the eigenvectors. This is done in the Vector Error Correction Model, which is of the form:

$$\Delta\vec{X}_t = \mu + \Gamma_1\Delta\vec{X}_{t-1} + \dots + \Gamma_{k-1}\Delta\vec{X}_{t-k+1} + \alpha\beta'\vec{X}_{t-1} + \vec{\varepsilon}_t$$

In our context, the test is whether the cointegrating vector of parameters β', of the system $(e_t, p_t, p_t{*})$ corresponds to $(1,-1,1)$, suggested by economic theory.

V. EMPIRICAL ANALYSIS AND RESULTS

One will use the suggested methodology to test the desired hypotheses and compare the results to existing literature. As the analysis includes seven countries other than Greece, seven unrestricted VAR models had to be estimated using maximum likelihood, with Greece being the benchmark country. One also split the sample into two sub-samples; namely 1966m01-2000m12 and 2001m01-2007m12 to capture pre and post-Euro effects.[27] The VAR models were defined as:

$$\Delta \vec{X}_t = \Gamma_1 \Delta \vec{X}_{t-1} + \ldots + \Gamma_{k-1} \Delta \vec{X}_{t-k+1} + \Pi \vec{X}_{t-1} + \mu + \vec{\varepsilon}_t$$

$\vec{X}_t$ is defined as $\vec{X}_t = \left(e_t, p_t, p_t{}^*\right)'$, representing the logarithm of the nominal bilateral exchange rate of the drachma and each of the seven other currencies in turn, the logarithm of the CPI of Greece and the logarithm of the CPI of each trading partner country. μ and ε_t are 3×1 vectors and $\Pi = \alpha \beta'$, is a 3×3 matrix.

The first issue of consideration was the optimal lag length of each VAR. The literature suggests several different ways in which this value can be determined. Usually, the choice is based on the minimization of information criteria like the Schwarz (SIC) or the Akaike (AIC). Alternatively, the optimal lag length can be determined based on removing serial correlation from the error vector. Notably, it is the case that the performance of a VAR is rather sensitive to the lag length selected. Although the SIC will be asymptotically consistent as $T \rightarrow \propto$, it generally suggests a small lag length, which is arguably problematic, as it ignores most of the dynamics of high frequency data. Using Monte Carlo simulations, Cheung and Lai [1993] suggested that under-parameterisation of the model results in falsification of the tests, whereas an overparametarized model does not. Additionally, Gonzalo [1994] showed that under-parameterisation would produce biases in the estimated vectors along with high autocorrelation. [28]

Having said this, one chose the optimal lag length in each VAR based on the minimization of the AIC, allowing for a maximum of 12 lags, to capture any effects from seasonality as from the monthly-frequented data.

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[27] The sample is split in such a way in order to acknowledge the fact that Greece officially adopted the euro in January 2001. This is not the case for the other euro countries. Upon calculation of exchange rates against the Greek drachma this has been taken into account.

[28] MacDonald R., Marsh I., "Exchange Rate Modelling: Advanced Studies in Theoretical and Applied Econometrics", Kluwer Academic Publishers, *Springer,* 1999, page 149

Additionally, one also tested whether serial correlation was present at the chosen lag, in which case, more lags were included to correct for serially correlated vector residuals.[29]

V(A). PRE-EURO ERA ANALYSIS

After having established seven VAR models, which present no biases in the estimated vectors or any form of autocorrelation, one tested for cointegration of the series using both trace and maximum eigenvalue tests.[30] Usually, both tests are expected to pinpoint the same number of cointegrating relationships (if any). Otherwise, one chose the trace statistic due to its superior power.[31] Table 2 presents the tests for cointegration for the pre-Euro era.

[29] This methodology has been suggested by Baum, Barkoulas, and Caglayan [2001], Strauss [1996], Cheung, Fung and Lai [1995] and MacDonald and Marsh [1999]. The tests of optimal VAR lag lengths as well as of serial correlation can be found in appendix 3a. The null hypothesis of the Lagrangean Multiplier (LM) test found in the appendix is of no serially correlated errors at the specified lag.

[30] Notably the Likelihood ratio test of Johansen (JLR): $-T\ln(1-\lambda_i)$ was shown by Johansen and Juselius [1990] to being weakly converging to a function of Brownian motion: $JLR \Rightarrow \left[\int_0^1 (t-1/2)dB\right]^2 / \int_0^1 (t-1/2)^2 dt$, where B is a standard Brownian motion, in which case the JLR is $\chi^2(1)$

[31] Suggested in: Helmut Lutkepohl, Pentti Saikkonen and Carsten Trenkler, "Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process", *Econometrics Journal,* Volume 4, 2001, pages 287-310

Table 2: Johansen Cointegration tests for the validity of PPP hypothesis: pre-Euro era [a]

		Trace statistic $H_0: r \le r_0$ vs. $H_1: r > r_0$				Max Eigenvalue statistic $H_0: r \le r_0$ vs. $H_1: r = r_0 + 1$			
Countries	k	eigenvalue	$H_0:r = 0$ $H_0:r \le 1$ $H_0:r \le 2$ λ_{trace} stat	0.05 c.v.	p-value	eigenvalue	$H_0: r = 0$ $H_0: r \le 1$ $H_0: r \le 2$ λ_{max} stat	0.05 c.v.	p-value
Germany	13	0.04555	38.1651	35.1928	0.0232*	0.04555	18.9284	22.2996	0.1385
		0.02953	19.2367	20.2618	0.0687	0.02953	12.1680	15.8921	0.1764
		0.01726	7.06871	9.16455	0.1228	0.01726	7.0687	9.1645	0.1228
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **no cointegrating eqn (s)** at 5%			
France	7	0.06078	46.7293	24.2760	0.0000*	0.06078	25.8326	17.7973	0.0025*
		0.04758	20.8967	12.3209	0.0015*	0.04758	20.0846	11.2248	0.0011*
		0.00197	0.81207	4.12991	0.4236	0.00197	0.81207	4.12991	0.4236
λ_{trace} indicates **2 cointegrating eqn (s)** at 5%						λ_{max} indicates **2 cointegrating eqn (s)** at 5%			
Italy	7	0.07062	50.1851	35.1928	0.0006*	0.07062	30.1721	22.2996	0.0032*
		0.03440	20.0130	20.2618	0.0541	0.03440	14.4226	15.8921	0.0838
		0.01348	5.59043	9.16455	0.2258	0.01348	5.59043	9.16455	0.2248
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
Spain	9	0.07886	52.0640	35.1928	0.0003*	0.07886	33.6778	22.2996	0.0009*
		0.02964	18.3862	20.2618	0.0887	0.02964	12.3345	15.8921	0.1674
		0.01465	6.05168	9.16455	0.1868	0.01465	6.05168	9.16455	0.1868
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
UK	7	0.06458	51.9044	35.1928	0.0006*	0.06458	27.5039	22.2996	0.0086*
		0.03698	24.4006	20.2618	0.0541	0.03698	15.5243	15.8921	0.0570
		0.02131	8.87630	9.16455	0.2248	0.02131	8.87630	9.16455	0.0567
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
USA	7	0.07768	59.1386	35.1928	0.0000*	0.07768	33.3134	22.2996	0.0010*
		0.04907	25.8251	20.2618	0.0077*	0.04907	20.7275	15.8921	0.0080*
		0.01230	5.09765	9.16455	0.2729	0.01230	5.09765	9.16455	0.2729
λ_{trace} indicates **2 cointegrating eqn (s)** at 5%						λ_{max} indicates **2 cointegrating eqn (s)** at 5%			
Japan	13	0.04146	28.9831	24.2760	0.0119*	0.04146	17.1904	17.7973	0.0615
		0.02534	11.7927	12.3209	0.0612	0.02534	10.4215	11.2248	0.0690
		0.00337	1.37120	4.12991	0.2827	0.00337	1.37120	4.12991	0.2827
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **no cointegrating eqn (s)** at 5%			

a: The system variables $\vec{X}_t = (e_t, p_t, p_t*)'$ are used in all seven VAR models. k is the optimal lag length, which has been chosen for each VAR model based on the minimization of the AIC and on non-serially correlated errors. Additionally, * denotes rejection of the hypothesis at the 0.05 level. The critical values used are asymptotic based on MacKinnon, Haug and Michelis [1999].

At least one cointegrating relationship existed between Greece and all its trading partners, with a unique relationship established for Germany, Italy, Spain, UK and Japan. These relationships need not necessarily coincide with PPP however. In order to test for the existence of *strong-form* PPP, one had to impose a linear restriction of the form $H_0: \beta = H\varphi$, corresponding to $H_0: \beta^{'} = (1,-1,1)$, known as the *"proportionality and symmetry assumption"*[32]. This was undertaken in the Vector Error Correction Model (VECM), where all series were stationary and disequilibria were corrected. For the cases of USA and France, 2 cointegrating relationships were suggested by both tests. This is not astonishing, as up to $n-1$ cointegrating vectors may indeed exist.

What is generally meant by *strong-form* PPP is a situation where "there is at least one cointegrating vector between an exchange rate and the corresponding relative prices *and* the proportionality restrictions are satisfied. In many cases these may not be satisfied due measurement errors or transportation costs."[33] Often, empirical studies emphasize on *weak-form* PPP, established upon existence of cointegration. Nonetheless, one will focus on *strong-form.*

One run separate VECM's of the form: $\Delta \vec{X}_t = \mu + \Gamma_1 \Delta \vec{X}_{t-1} + ... + \Gamma_{k-1} \Delta \vec{X}_{t-k+1} + \alpha\beta^{'} \vec{X}_{t-1} + \vec{\varepsilon}_t$, imposing the hypothesis: $H_0: \beta^{'} = (1,-1,1)$. Notably, the lag length of the VECM is defined as $k^* = k-1$, the reason being that all series were first differenced to achieve stationary. Also the VECM residuals had to be stationary, which was established.[34] The results for testing *strong-form* PPP together with the estimated parameters and adjustment coefficients are presented below:

[32] MacDonald R., "Long-run purchasing power parity: Is it for real?", *The Review of Economics and Statistics*, Volume 75, Number 4, November 1993, page 691
[33] Ibid, MacDonald R., "Long-run purchasing power parity: Is it for real?", page 692
[34] Joint unit tests on the residuals of each VECM were undertaken to guarantee stationary residuals. Stationary residuals were indeed established suggesting valid results. These results can be seen in appendix 3b.

Table 3: VECM and hypothesis of strong-form PPP: pre-Euro era [b]

Countries	k^*	β'	$H_0 : \beta' = (1,-1,1)$	$(\alpha_e, \boldsymbol{\alpha_p}, \alpha_{p*})'$	
Germany	12	(1, -1.006, 0.743)	5.611 [0.0605]*	**0.0192 {1.128}**	
				0.0177 {2.492}	
				0.0040 {3.493}	
France	6	(1, 0.000, -0.868)	15.445 [0.000]	**-0.0412 {-4.447}**	**0.0102 {2.649}**
		(0.000, 1, -0.925)		-0.0116 {-2.310}	0.0048 {2.284}
				0.0005 {0.665}	-0.0012 {-3.824}
Italy	6	(1, -3.256, 4.372)	13.788 [0.001]	**0.0058 {3.745}**	
				0.0068 {4.426}	
				0.0007 {1.900}	
Spain	8	(1, -1.536, 1.604)	14.280 [0.000]	**0.0195 {3.033}**	
				-0.0260 {-4.807}	
				0.0053 {2.335}	
UK	6	(1, 0.000, -0.424)	2.4533 [0.117]*	**0.0047 {1.214}**	**-0.0105 {-2.157}**
		(0.000, 1, -1.674)		0.0073 {2.285}	-0.0186 {-4.642}
				-0.0033 {-3.009}	0.0013 {0.093}
USA	6	(1, 0.000, -1.482)	16.011 [0.000]	**-0.0113 {-1.586}**	**-0.0076 {-1.488}**
		(0.000, 1, -2.870)		-0.0034 {-0.561}	-0.0146 {-3.402}
				-0.0047 {-5.424}	0.0020 {3.250}
Japan	12	(1, -1.178, 0.982)	10.340 [0.006]	**-0.0121 {-1.117}**	
				0.0196 {3.786}	
				0.0004 {0.223}	

b: The cointegrating vector β' has been normalized with respect to the nominal exchange rates. The LR statistic used imposes the hypothesis that $H_0 : \beta' = (1,-1,1)$ and is asymptotically distributed as a χ^2 with 2 degrees of freedom. P-values are given in [ ] and t-statistics in {}. The test statistic if defined as $-T \sum_{i=r+1}^{n} [\ln(1-\hat{\lambda}_i^*) - \ln(1-\hat{\lambda}_i)]$ and obtained by solving: $|\lambda H' S_{kk} H - H' S_{k0} S_{00}^{-1} S_{0k} H| = 0$ [35].

A * denotes accepting the hypothesis of long-run PPP and the subscript in the $\alpha' s$ defines the adjustment coefficient of each series.

[35] Where, the characteristic roots of the unrestricted matrix Π are $\hat{\lambda}_1, \ldots \hat{\lambda}_n$ and the characteristic roots of the model in the cointegrating vector(s) are $\hat{\lambda}_1^*, \ldots \hat{\lambda}_n^*$

Strong-form PPP was only established for Greece with Germany and the UK, with the later also suggested by Dockery and Georgellis [1994], arguing that PPP held between Greece and countries, which were not constrained by the Exchange Rate Mechanism. Intuitively, the existence of PPP between Greece and the two economies arises because both are Greece's major European trading partners.

For the five remainder countries, the existence of *strong-form* PPP with Greece was rejected at any significance level. These results contradict Pippenger, and Geppert [1997], who established existence of PPP between Greece and the USA, enhancing the importance of the US economy as a global economic power but coincide with Karfakis and Moschos [1989], as: "shocks which affect the discrepancy between domestic and foreign prices are not reflected in the nominal exchange rate movement".

Nevertheless, for countries like the USA or Japan, the non-existence of PPP can be explained due to the differences in macroeconomic policies relative to Greece. For the cases of Italy and Spain the non-establishing of PPP is surprising. According Dornbusch [1985]; Studies of inflation episodes, offer support for PPP in that they show close cumulative movements of prices and exchange rates. Arguably, the 1970's-1980's found these Mediterranean countries with increased inflationary volatility mainly due to the oil crises and unstable macroeconomic policies. A similar argument was proposed by Sarno [2000], for the case of Turkey during the 80's and 90's, providing strong evidence of PPP. Nevertheless, *weak-form* PPP was established in all cases, yielding similar results with other studies of the post Bretton Woods period such as MacDonald [1993], Abuaf, Jorion [1990] and Kim [1990].

Additionally, one estimated the speeds of adjustment of each system back to equilibrium, captured by the coefficients of matrix α, "interpreted as the weights with which PPP disequilibrium is corrected in each of the equations."[36] The speeds of adjustment vary across countries, with some estimated adjustment coefficients of the exchange rates being significantly negative, correcting for disequilibrium of month $t-1$ in t. Taking the UK as example, 1.05% of deviation from PPP is corrected in t.

[36] MacDonald R., "Long-run purchasing power parity: Is it for real?", *The Review of Economics and Statistics*, Volume 75, Number 4, November 1993, page 694

V(B). POST-EURO ERA ANALYSIS

One undertook the same analysis for the post-Euro era.[37] As suggested by Koedijk, Tims and van Dijk [2004]: "The transition of the Euro-zone countries towards a single currency forms a unique opportunity to test the PPP hypothesis. Its importance is based on the fact that convergence of price levels within the European Monetary Union would be an important issue for public policy makers and is rather interesting from the perspective of asset pricing and portfolio management, in terms of the underlining risk associated with volatile exchange rate." Table 4 presents the tests for cointegration.

[37] Again the same analysis was followed. The tests for the VAR lengths, serially correlated errors and stationary vector errors of the VECM can be seen in appendices 4a and 4b.

Table 4: Johansen Cointegration tests for the validity of PPP hypothesis: post-Euro era

		Trace statistic H_0: $r \le r_0$ vs. H_1: $r > r_0$				Max Eigenvalue statistic H_0: $r \le r_0$ vs. H_1: $r = r_0 + 1$			
Countries	k	eigenvalue	H_0:r = 0 H_0:r ≤ 1 H_0:r ≤ 2 λ_{trace} stat	0.05 c.v.	p-value	eigenvalue	H_0: r = 0 H_0: r ≤ 1 H_0: r ≤ 2 λ_{max} stat	0.05 c.v.	p-value
Germany	12	0.32977	51.4881	35.1928	0.0004*	0.32977	33.6110	22.2996	0.0009*
		0.16621	17.8771	20.2618	0.1031	0.16621	15.2687	15.8921	0.1764
		0.03058	2.60863	9.16455	0.6560	0.03058	2.6086	9.1645	0.6560
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
France	12	0.28854	45.1481	35.1928	0.0031*	0.28854	28.5966	22.2996	0.0058*
		0.14572	16.5514	20.2618	0.1502	0.14572	13.2301	15.8921	0.1253
		0.03877	3.32136	9.16455	0.5224	0.03877	3.32136	9.16455	0.5224
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
Italy	12	0.18842	27.2688	24.2760	0.0204*	0.18842	17.5369	17.7973	0.0546*
		0.10683	9.73187	12.3209	0.1307	0.10683	9.49007	11.2248	0.0994
		0.00288	0.24180	4.12991	0.6816	0.00288	0.24180	4.12991	0.6816
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **no cointegrating eqn (s)** at 5%			
Spain	12	0.34472	49.5005	35.1928	0.0008*	0.34472	35.5065	22.2996	0.0004*
		0.11517	13.9940	20.2618	0.2898	0.11752	10.5014	15.8921	0.2909
		0.04073	3.49266	9.16455	0.4929	0.04073	3.49266	9.16455	0.4929
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
UK	13	0.23304	47.5596	35.1928	0.0015*	0.23304	22.2868	22.2996	0.0502
		0.21133	25.2728	20.2618	0.0093*	0.21133	19.9418	15.8921	0.011*
		0.61492	5.33096	9.16455	0.2491	0.06149	5.33096	9.16455	0.2491
λ_{trace} indicates **2 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
USA	12	0.26703	43.3854	35.1928	0.0053*	0.26703	26.0946	22.2996	0.0140*
		0.13354	17.2908	20.2618	0.1220	0.13354	12.0408	15.8921	0.1836
		0.06059	5.25001	9.16455	0.2571	0.60587	5.25001	9.16455	0.2571
λ_{trace} indicates **1 cointegrating eqn (s)** at 5%						λ_{max} indicates **1 cointegrating eqn (s)** at 5%			
Japan	12	0.17938	30.4654	35.1928	0.1480	0.17938	16.6060	22.2996	0.2573
		0.12429	13.8594	20.2618	0.2992	0.12429	11.1488	15.8921	0.2410
		0.03175	2.71063	9.16455	0.6360	0.03175	2.71063	9.16455	0.6360
λ_{trace} indicates **no cointegrating eqn (s)** at 5%						λ_{max} indicates **no cointegrating eqn (s)** at 5%			

After the adoption of the Euro, some form of cointergating relationships held between Greece and all countries except for Japan. This result of no co-integration, suggests that $e_t \sim I(1)$, $p_t \sim I(1)$, $p^*_t \sim I(1)$ but $\alpha\, e_t + \beta\, p_t + \kappa\, p^*_t \sim I(1)$. Thus *weak-form* PPP was established for all cases apart from the case Japan. Testing for *strong-form* PPP:

Table 5: VECM and hypothesis of strong-form PPP: post-Euro era

Countries	k^*	β'	$H_0 : \beta' = (1,-1,1)$	$(\alpha_e, \alpha_p, \alpha_{p*})'$	
Germany	11	(1, 0.605, -1.267)	4.998 [0.082]*	**-0.0178 {-0.444}**	
				-0.1994 {-5.987}	
				-0.0570 {-2.163}	
France	11	(1, -0.153, 0.278)	6.468 [0.039]*	**-0.2607 {-1.965}**	
				-0.7980 {-5.841}	
				-0.0589 {-0.804}	
Italy	11	(1, -0.798, 1.162)	4.592 [0.101]*	**-0.0449 {-0.726}**	
				-0.2683 {-4.334}	
				-0.0351 {-1.883}	
Spain	11	(1, -0.473, 0.464)	2.373 [0.305]*	**-0.4011 {-2.557}**	
				0.6638 {4.870}	
				0.0587 {0.638}	
UK	12	(1, 0.000, 10.894)	1.407 [0.236]*	**-0.1206 {-1.460}**	**-0.4941 {-1.484}**
		(0.000, 1, -3.733)		0.0076 {0.423}	0.0268 {0.371}
				0.0345 {3.283}	0.1383 {3.261}
USA	11	(1, 4.179, -3.473)	16.011 [0.000]	**-0.0900 {-2.512}**	
				0.0411 {7.575}	
				0.0020 {0.433}	

Interestingly, the results are encouraging. After the adoption of the Euro and the development of a concrete European economic system, *strong-form* PPP was established between Greece and all its European trading partners including the UK. Additionally, the speeds of adjustment towards mean reversion were bigger in absolute values, indicating greater corrections of disequilibria and faster convergence to the proposed parity condition, although some were insignificant.

These results overlap with the findings of Koedijk, Tims and van Dijk [2004] and Lopez and Papell [2007] and Papell [1997] as in their analyses, Greece belonged to the panel of countries where PPP was established. The establishment of *strong-form* PPP between Greece and the UK and Germany, suggests trading patterns did not change even after the adoption of the Euro. Also, the establishment of PPP between Greece and all the Euro-zone countries in the sample is intuitive in the sense that all these countries are refrained in terms of monetary policy, which is primarily controlled by the European Central Bank. Thus, these countries follow similar inflationary targets and face the same base interest rates. Finally, for the case of the USA, although a unique cointegrating relationship was established, one was unable to establish *strong-form* PPP. This is explained by means of excess transportation costs and fundamental policy differences.

VI. LIMITATIONS OF ANALYSIS

In this paper, one addressed issues of spurious regressions and low power econometric techniques, by using the Johansen methodology, accounting for dynamic effects of the system variables and allowing for multiple cointegrating vectors. Nonetheless, more powerful techniques have been recently developed and applied to testing for PPP.

PPP has been recently tested within a dynamic non-linear framework, where the expected mean reverting behavior, follows a non-linear pattern. This methodology allows for "frictions in international trade"[38], captured potentially by structural breaks, which have been ignored, although one would anticipate their existence during the 70's and mid 80's following severe volatility from the two oil crises. The most common characterization of non-linear adjustment is in terms of a smooth transition autoregressive (STAR) model, proposed by Granger and Teräsvirta [1993] of the form:

$$\left[q_t - \mu\right] = \sum_{j=1}^{p} \beta_j \left[q_{t-j} - \mu\right] + \left[\sum_{j=1}^{p} \beta_j^* \left[q_{t-j} - \mu\right]\right] \Phi\left[\theta; q_{t-d} - \mu\right] + \varepsilon_t$$

q_t is a stationary, ergodic process, $\varepsilon_t \sim iid(0, \sigma^2)$ and $(\theta, \mu) \in \{\Re^+ \times \Re\}$. The transition function $\Phi\left[\theta; q_{t-d} - \mu\right]$ determines the degree of mean reversion and is governed by θ, which determines the speed of reversion and μ, which is the equilibrium level of q_t.[39]

Recent literature has shown that such methodologies will lead to strong acceptance of mean reverting behaviour, (Taylor, Sarno and Peel [2001]). In general, this framework "is particularly attractive, as the strength of the equilibrating force is increasing in the magnitude of the degree of disequilibrium."[40] Nevertheless, it can be argued that the Johansen methodology is still considered the "second best".

Another issue concerned the data used in the analysis. As mentioned in section III, it was the case that some series were manually constructed.

[38] Baum C. F., Barkoulas J. T., Caglayan M., "Nonlinear adjustment to purchasing power parity in the post-Bretton Woods era", *Journal of International Money and Finance*, Volume 20, 2001, page 379

[39] Taylor M. P., Peel D. A., Sarno L., "Non-linear mean reversion in real exchange rates: towards a solution to the Purchasing Power Parity puzzles", *International Economic Review,* Volume 42, Number 4, November 2001, page 1020

[40] Baum C. F., Barkoulas J. T., Caglayan M., "Nonlinear adjustment to purchasing power parity in the post-Bretton Woods era", *Journal of International Money and Finance*, Volume 20, 2001, page 383

This may have presented minor discrepancies, although in theory, the way in which the exchange rates were calculated, should hold. Since the sources from which data was extracted are internationally recognized, the values reported are, to the author's knowledge, the accurate ones.

Finally, another potential problem was the loss of degrees of freedom due to large valued lag lengths. Nevertheless, results reported were consistent and free from problems of autocorrelation and non-stationary errors. This "conflict" between parsimony and efficiency is often present in empirical work, with the events usually being mutually exclusive. Nonetheless, the size of the samples was still large enough to make valid statistical inferences. However, Johansen's asymptotic critical values are valid when the sample asymptotically tends to infinity, which was arguably not the case for the second sample. This could have been solved by computing the appropriate critical values, through Monte Carlo simulations.

VII. CONCLUDING REMARKS AND POLICY IMPLICATIONS

To conclude, this paper has shown that although prior to the adoption of the Euro, PPP for Greece existed only with the UK and Germany, after the transition to the Euro it held for all Euro-zone countries plus the UK. Additionally, deviations from parity were corrected much faster compared to the pre-Euro era. The established results are very encouraging. The fact that PPP was established enables us to argue that, in theory, the uncertainty associated with predicting the movements of volatile exchange markets, is minimized to a certain extent, capturing the inflation differential between the countries and leading to less frictions, stimulating healthier trade prospects for Greece and its trading partners. As the European Union is Greece’s major partner, primarily consisting of most countries used in the sample, the mere existence of PPP enhances the prospect of FDI from countries such as Germany and France into Greece, stimulating growth.

Additionally, given Greece’s historical macroeconomic instability, the existence of PPP, would in theory, signal the existence of “tight” and stable domestic macroeconomic policy and invigorate appropriate policy responses to correct any short-run deviations. Finally, the existence of PPP suggests dynamic convergence of national incomes, as the exchange rate simply portrays the difference in inflation differentials, acclaiming Greece’s decision to join the Euro-zone in 2001, despite the loss of independent monetary policy.[41]

[41] As a final comment the author would like to stress the fact that the above are potential policy implications arising from the validity of PPP as a long-run equilibrium. In light of the current financial crisis however, which arguably did not yet reveal its full effects when the sample of the author ended; i.e. 2007m12, it is true that most of these arguments will not hold due to the consequences of the financial turmoil experienced by the world economy. Nevertheless, under a non-extreme scenario, the implications suggested are meaningful and useful to policy makers.

APPENDIX 1

Variable descriptions

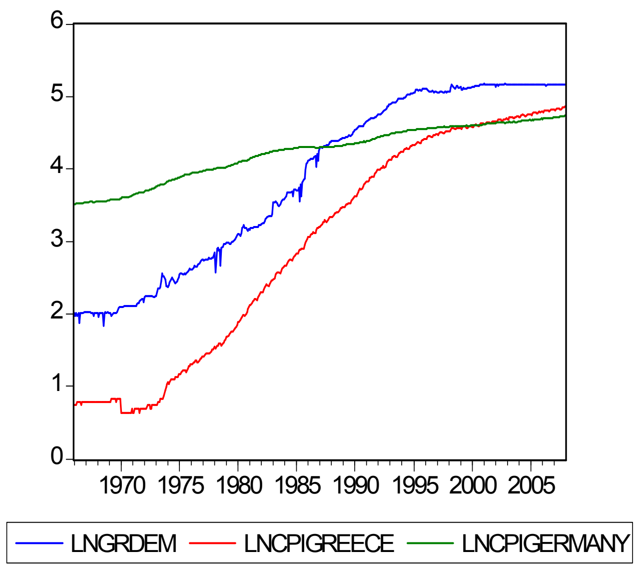
Sample: 1966m01 – 2007m12, 504 observations
Data Sources: IMF International Financial Statistics, Thomson DataStream
All exchange rates are end of period data market rates

Lncpigreece	Natural logarithm of Consumer Price Index of Greece (urban areas: averages)
Lncpifrance	Natural Logarithm of Consumer Price Index of France (averages)
Lncpigermany	Natural Logarithm of Consumer Price Index of Germany (unified Germany + pre unification data, averages)
Lncpiitaly	Natural Logarithm of Consumer Price Index of Italy (all Italy, averages)
Lncpiusa	Natural Logarithm of Consumer Price Index of USA (averages)
Lncpiuk	Natural Logarithm of Consumer Price Index of UK (averages)
Lncpijapan	Natural Logarithm of Consumer Price Index of Japan (all Japan, averages)
Lncpispain	Natural Logarithm of Consumer Price Index of Spain (averages)
Lngrffr	Natural Logarithm of nominal exchange rate of Greek drachma versus French franc
Lngrdem	Natural Logarithm of nominal exchange rate of Greek drachma versus German mark
Lngritl	Natural Logarithm of nominal exchange rate of Greek drachma versus Italian lira
Lngrspp	Natural Logarithm of nominal exchange rate of Greek drachma versus Spanish peseta
Lngrjpy	Natural Logarithm of nominal exchange rate of Greek drachma versus Japanese yen
Lngrgbp	Natural Logarithm of nominal exchange rate of Greek drachma versus UK sterling
Lngrusd	Natural Logarithm of nominal exchange rate of Greek drachma versus US dollar

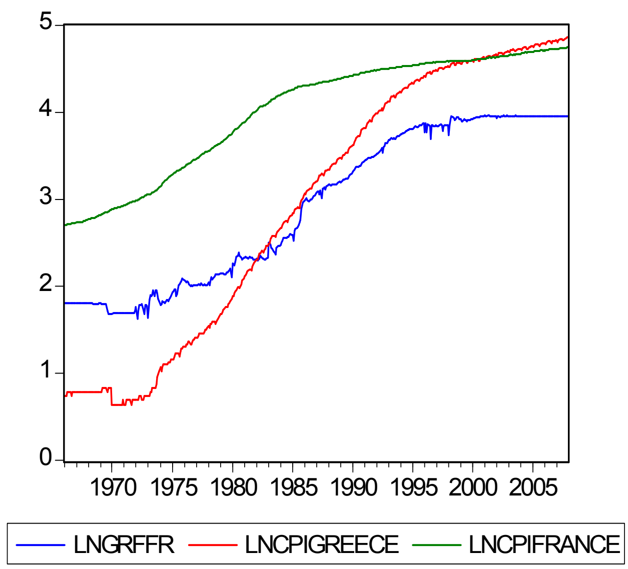
APPENDIX 2

Plots of group series over time

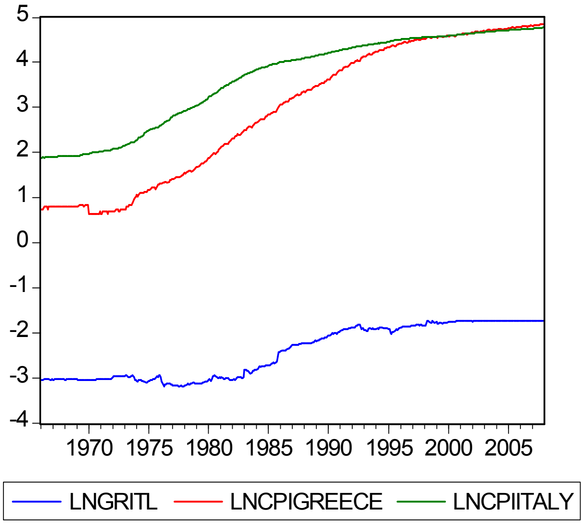
Greece-Germany



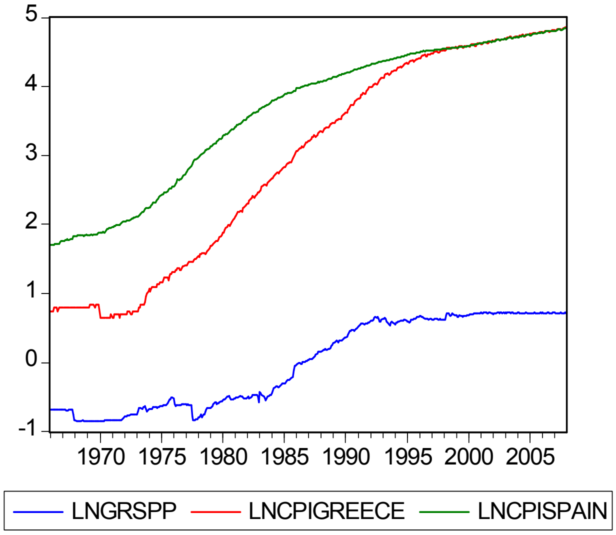
Greece-France



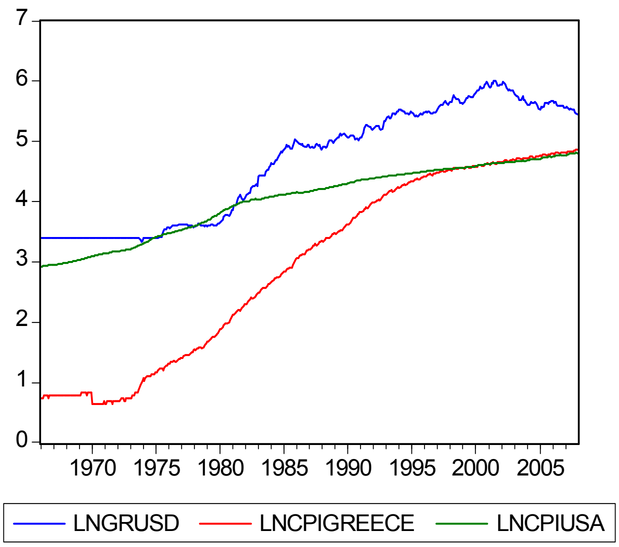
Greece-Italy



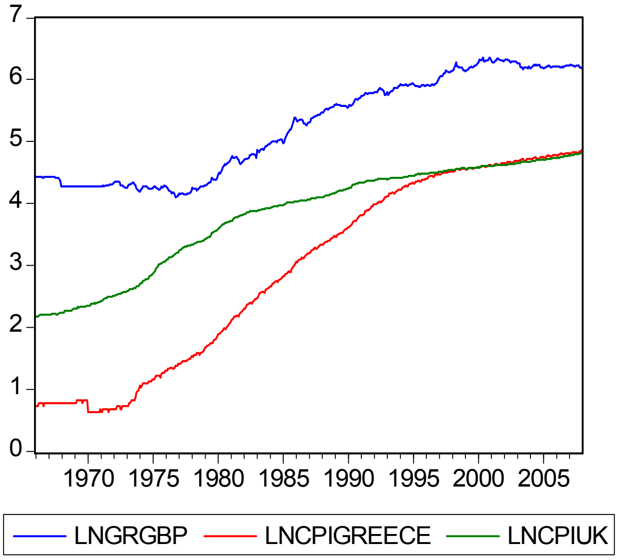
Greece-Spain



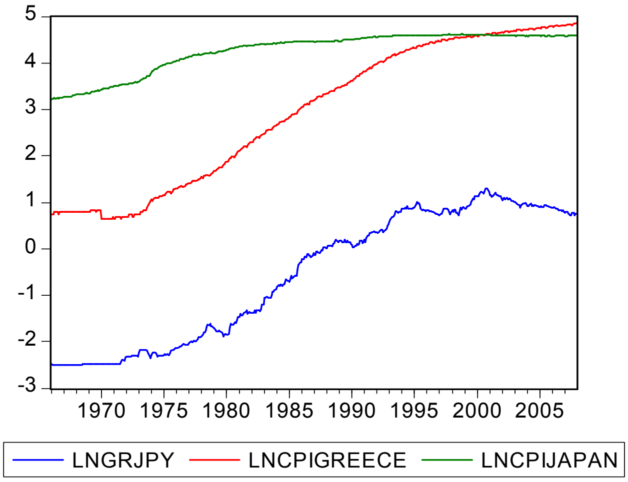
Greece-USA



Greece-UK



Greece-Japan



APPENDIX 3

a) Determination of optimal VAR lag lengths and tests for serially correlated errors for period 1966-2000

VAR (lngrdem, lncpigreece, lncpigermany) 1966-2000

Lag	LogL	AIC
0	99.35193	-0.472313
1	3555.298	-17.36911
2	3624.265	-17.66306
3	3630.867	-17.65131
4	3634.824	-17.62659
5	3654.092	-17.67692
6	3663.410	-17.67848
7	3684.289	-17.73671
8	3692.510	-17.73289
9	3703.818	-17.74421
10	3710.243	-17.73158
11	3718.834	-17.72958
12	**3735.537**	**-17.76734***

Lags	LM-Stat	Prob
1	70.03000	0.0000
2	31.50301	0.0002
3	15.94876	0.0680
4	18.63663	0.0285
5	14.18116	0.1160
6	27.73388	0.0011
7	26.74892	0.0015
8	13.94201	0.1244
9	17.02893	0.0483
10	9.134914	0.4249
11	15.63141	0.0750
12	33.40221	0.0001
13	**7.214550**	**0.6148**

VAR (lngrffr, lncpigreece, lncpifrance) 1966-2000

Lag	LogL	AIC
1	3655.842	-17.86197
2	3688.047	-17.97572
3	3713.196	-18.05488
4	3729.723	-18.09178
5	3761.123	-18.20158
6	3777.464	-18.23757
7	**3813.423**	**-18.36972***
8	3816.406	-18.34022
9	3825.024	-18.33835
10	3833.098	-18.33381
11	3845.356	-18.34978
12	3847.792	-18.31761

Lags	LM-Stat	Prob
1	7.581374	0.5768
2	6.038127	0.7361
3	9.635185	0.3808
4	21.95118	0.0090
5	6.160071	0.7238
6	50.90746	0.0000
7	**9.671392**	**0.3777**

VAR (lngritl, lncpigreece, lncpiitaly) 1966-2000

Lag	LogL	AIC
1	3685.176	-18.00576
2	3733.242	-18.19726
3	3749.468	-18.23268
4	3762.270	-18.25133
5	3789.146	-18.33895
6	3798.592	-18.34114
7	**3820.273**	**-18.40330***
8	3827.693	-18.39555
9	3833.118	-18.37803
10	3840.442	-18.36981
11	3847.120	-18.35843
12	3855.520	-18.35549

Lags	LM-Stat	Prob
1	13.13313	0.1567
2	17.52842	0.0411
3	13.48210	0.1420
4	17.37208	0.0432
5	20.52854	0.0149
6	53.61088	0.0000
7	**3.345346**	**0.9490**

VAR (lngrspp, lncpigreece, lncpispain) 1966-2000

Lag	LogL	AIC
0	-315.8656	1.563067
1	3528.053	-17.23556
2	3542.899	-17.26421
3	3550.133	-17.25556
4	3552.852	-17.22476
5	3573.913	-17.28389
6	3577.362	-17.25668
7	3604.222	-17.34422
8	3607.863	-17.31795
9	**3623.075**	**-17.34841***
10	3628.927	-17.33298
11	3639.298	-17.33970
12	3642.644	-17.31198

Lags	LM-Stat	Prob
1	14.55990	0.1038
2	12.49763	0.1867
3	4.080742	0.9060
4	21.42775	0.0109
5	29.50593	0.0005
6	36.59596	0.0000
7	16.43423	0.0583
8	31.42916	0.0002
9	**5.602727**	**0.7789**

VAR (lngrusd, lncpigreece, lncpiusa) 1966-2000

Lag	LogL	AIC
0	-170.3746	0.849875
1	3872.795	-18.92546
2	3899.879	-19.01411
3	3910.781	-19.02344
4	3915.015	-19.00008
5	3928.961	-19.02432
6	3940.690	-19.03770
7	**3963.941**	**-19.10755***
8	3971.495	-19.10046
9	3981.116	-19.10351
10	3988.026	-19.09326
11	3993.475	-19.07586
12	3997.079	-19.04941

Lags	LM-Stat	Prob
1	15.50453	0.0780
2	16.43604	0.0583
3	3.815640	0.9231
4	4.512695	0.8746
5	3.679778	0.9312
6	37.66869	0.0000
7	**6.486127**	**0.6904**

VAR (lngrgbp, lncpigreece, lncpiuk) 1966-2000

Lag	LogL	AIC
0	-302.7637	1.498842
1	3536.635	-17.27762
2	3570.427	-17.39915
3	3583.356	-17.41841
4	3596.197	-17.43724
5	3609.697	-17.45930
6	3631.868	-17.52386
7	**3652.312**	**-17.57996***
8	3657.630	-17.56191
9	3669.614	-17.57654
10	3679.201	-17.57942
11	3686.484	-17.57100
12	3689.917	-17.54371

Lags	LM-Stat	Prob
1	12.03124	0.2116
2	28.32350	0.0008
3	16.57420	0.0558
4	18.26058	0.0323
5	5.034691	0.8313
6	46.31828	0.0000
7	**1.937662**	**0.9924**

VAR (lngrjpy, lncpigreece, lncpijapan) 1966-2000

Lag	LogL	AIC	Lags	LM-Stat	Prob
0	-403.9159	1.994686	1	66.80087	0.0000
1	3342.459	-16.32578	2	64.78306	0.0000
2	3354.634	-16.34134	3	17.22904	0.0452
3	3370.441	-16.37471	4	50.68019	0.0000
4	3377.254	-16.36399	5	27.72819	0.0011
5	3410.808	-16.48435	6	27.91815	0.0010
6	3419.702	-16.48384	7	12.86726	0.1687
7	3458.616	-16.63047	8	43.71592	0.0000
8	3467.086	-16.62787	9	10.28468	0.3279
9	3495.917	-16.72508	10	20.48816	0.0151
10	3500.869	-16.70524	11	8.214957	0.5126
11	3514.032	-16.72565	12	26.58887	0.0016
12	**3523.959**	**-16.73019***	**13**	**6.206702**	**0.7191**

b) Joint Testing for a unit root in the residuals of the VECM for 1966-2000[42]

VECM (Dlngrdem, Dlncpigreece, Dlncpigermany) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-46.0607	**0.0000**	3	1218
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-38.3344	**0.0000**	3	1218
ADF - Fisher Chi-square	475.772	**0.0000**	3	1218
PP - Fisher Chi-square	475.772	**0.0000**	3	1218

VECM (Dlngrffr, Dlncpigreece, Dlncpifrance) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-44.4875	**0.0000**	3	1236
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-38.3365	**0.0000**	3	1236
ADF - Fisher Chi-square	477.852	**0.0000**	3	1236
PP - Fisher Chi-square	477.912	**0.0000**	3	1236

[42] The p-values for the Fisher tests are computed using an asymptotic χ^2 distribution. All other tests assume asymptotic normality

VECM (Dlngritl, Dlncpigreece, Dlncpiitaly) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-44.7558	**0.0000**	3	1236
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-38.5295	**0.0000**	3	1236
ADF - Fisher Chi-square	478.231	**0.0000**	3	1236
PP - Fisher Chi-square	478.249	**0.0000**	3	1236

VECM (Dlngrspp, Dlncpigreece, Dlncpispain) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-45.6985	**0.0000**	3	1230
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-38.1720	**0.0000**	3	1230
ADF - Fisher Chi-square	477.121	**0.0000**	3	1230
PP - Fisher Chi-square	477.037	**0.0000**	3	1230

VECM (Dlngrusd, Dlncpigreece, Dlncpiusa) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-44.8982	**0.0000**	3	1236
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-38.0515	**0.0000**	3	1236
ADF - Fisher Chi-square	477.629	**0.0000**	3	1236
PP - Fisher Chi-square	477.629	**0.0000**	3	1236

VECM (Dlngrgbp, Dlncpigreece, Dlncpiuk) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-33.4847	**0.0000**	3	1225
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-26.8841	**0.0000**	3	1225
ADF - Fisher Chi-square	333.064	**0.0000**	3	1225
PP - Fisher Chi-square	478.101	**0.0000**	3	1236

VECM (Dlngrjpy, Dlncpigreece, Dlncpijapan) 1966-2000

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-45.3500	**0.0000**	3	1218
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-37.5788	**0.0000**	3	1218
ADF - Fisher Chi-square	474.254	**0.0000**	3	1218
PP - Fisher Chi-square	474.401	**0.0000**	3	1218

APPENDIX 4

a) Determination of optimal VAR lag lengths and tests for serially correlated errors for period 2001-2007

VAR (lngrdem, lncpigreece, lncpigermany) 2001-2007

Lag	LogL	AIC
0	763.5098	-18.10738
1	985.8670	-23.18731
2	996.8255	-23.23394
3	1008.274	-23.29224
4	1019.773	-23.35174
5	1051.417	-23.89087
6	1068.284	-24.07818
7	1093.099	-24.45474
8	1114.044	-24.73914
9	1120.239	-24.67235
10	1133.055	-24.76321
11	1155.418	-25.08138
12	**1170.632**	**-25.22934***

Lags	LM-Stat	Prob
1	28.16182	0.0009
2	25.72281	0.0023
3	14.34293	0.1106
4	11.55424	0.2396
5	11.13406	0.2666
6	11.47934	0.2443
7	10.99034	0.2764
8	12.22078	0.2011
9	17.68275	0.0390
10	12.13033	0.2061
11	4.466942	0.8781
12	**5.027653**	**0.8319**

VAR (lngrffr, lncpigreece, lncpifrance) 2001-2007

Lag	LogL	AIC
0	785.9133	-18.64079
1	1022.278	-24.05425
2	1036.146	-24.17013
3	1051.973	-24.33269
4	1058.788	-24.28066
5	1091.034	-24.83413
6	1112.589	-25.13307
7	1121.551	-25.13218
8	1127.776	-25.06610
9	1132.856	-24.97276
10	1139.186	-24.90918
11	1160.310	-25.19787
12	**1187.047**	**-25.62016***

Lags	LM-Stat	Prob
1	30.40875	0.0004
2	22.92345	0.0064
3	17.11451	0.0470
4	12.58401	0.1824
5	7.019841	0.6351
6	6.290094	0.7106
7	11.39389	0.2497
8	8.761172	0.4596
9	3.302232	0.9511
10	18.00999	0.0351
11	5.194856	0.8170
12	**7.384638**	**0.5971**

VAR (lngritl, lncpigreece lncpiitaly) 2001-2007

Lag	LogL	AIC
0	764.0986	-18.12140
1	1074.436	-25.29610
2	1089.308	-25.43591
3	1093.354	-25.31796
4	1107.129	-25.43164
5	1122.613	-25.58602
6	1141.534	-25.82223
7	1155.832	-25.94838
8	1159.520	-25.82191
9	1163.802	-25.70957
10	1173.095	-25.71654
11	1184.064	-25.76342
12	**1221.091**	**-26.43073***

Lags	LM-Stat	Prob
1	43.47490	0.0000
2	15.65939	0.0743
3	14.32958	0.1111
4	10.04232	0.3471
5	12.30238	0.1968
6	17.17818	0.0460
7	6.809165	0.6570
8	11.97404	0.2148
9	6.729092	0.6653
10	11.68525	0.2316
11	8.797173	0.4562
12	**13.02595**	**0.1614**

VAR (lngrspp, lncpigreece, lncpispain) 2001-2007

Lag	LogL	AIC
0	752.5466	-17.84635
1	969.7598	-22.80380
2	978.2252	-22.79108
3	997.3819	-23.03290
4	1044.973	-23.95175
5	1076.545	-24.48916
6	1088.657	-24.56326
7	1107.105	-24.78821
8	1116.459	-24.79665
9	1124.877	-24.78279
10	1140.157	-24.93231
11	1162.256	-25.24419
12	**1183.112**	**-25.52648***

Lags	LM-Stat	Prob
1	26.42393	0.0017
2	19.18554	0.0237
3	4.604224	0.8674
4	13.07352	0.1593
5	7.557363	0.5793
6	5.111168	0.8245
7	8.222744	0.5119
8	18.62948	0.0285
9	9.333752	0.4071
10	9.300868	0.4100
11	3.189203	0.9563
12	**13.59341**	**0.1375**

VAR (lngrusd, lncpigreece lncpiusa) 2001-2007

Lag	LogL	AIC
0	484.0003	-11.45239
1	821.7924	-19.28077
2	835.6388	-19.39616
3	846.8453	-19.44870
4	851.2549	-19.33940
5	876.5432	-19.72722
6	903.6601	-20.15857
7	917.4853	-20.27346
8	923.0506	-20.19168
9	933.1452	-20.21774
10	936.9152	-20.09322
11	950.9722	-20.21362
12	**989.6119**	**-20.91933***

Lags	LM-Stat	Prob
1	19.34117	0.0224
2	14.54663	0.1042
3	10.04219	0.3471
4	9.500791	0.3924
5	7.142746	0.6223
6	5.934053	0.7465
7	13.72770	0.1323
8	6.928211	0.6446
9	8.121616	0.5219
10	7.561896	0.5788
11	4.286180	0.8916
12	**10.95107**	**0.2791**

VAR (lngrgbp, lncpigreece lncpiuk) 2001-2007

Lag	LogL	AIC
0	543.0700	-12.85881
1	874.1729	-20.52793
2	895.2248	-20.81488
3	911.8388	-20.99616
4	917.7974	-20.92375
5	957.5166	-21.65516
6	970.5933	-21.75222
7	979.5314	-21.75075
8	984.5471	-21.65588
9	991.1536	-21.59890
10	998.7357	-21.56514
11	1024.699	-21.96901
12	**1045.335**	**-22.24606***

Lags	LM-Stat	Prob
1	8.186501	0.5155
2	11.33914	0.2532
3	14.52402	0.1049
4	9.535603	0.3894
5	5.259973	0.8111
6	7.923976	0.5418
7	8.017749	0.5324
8	6.111656	0.7287
9	7.564863	0.5785
10	7.188612	0.6175
11	8.775210	0.4583
12	18.01397	0.0350
13	**5.578330**	**0.7813**

VAR (lngrjpy, lncpigreece, lncpijapan) 2001-2007

Lag	LogL	AIC
0	606.3241	-14.36486
1	853.1734	-20.02794
2	860.1999	-19.98095
3	868.6602	-19.96810
4	874.2260	-19.88633
5	902.0331	-20.33412
6	931.4369	-20.81993
7	957.8919	-21.23552
8	973.4221	-21.39100
9	980.6724	-21.34934
10	987.7047	-21.30249
11	1001.218	-21.40995
12	**1025.409**	**-21.77165***

Lags	LM-Stat	Prob
1	18.69751	0.0279
2	12.21235	0.2016
3	9.733980	0.3724
4	21.35444	0.0112
5	11.97634	0.2146
6	4.657495	0.8631
7	8.284140	0.5058
8	4.064263	0.9071
9	5.552940	0.7837
10	7.591217	0.5758
11	6.438504	0.6954
12	**10.38572**	**0.3202**

b) Joint Testing for a unit root in the residuals of the VECM for 2001-2007

VECM (Dlngrdem, Dlncpigreece, Dlncpigermany) 2001-2007

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-16.1658	**0.0000**	3	249
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-13.9528	**0.0000**	3	249
ADF - Fisher Chi-square	98.3749	**0.0000**	3	249
PP - Fisher Chi-square	98.0346	**0.0000**	3	249

VECM (Dlngrffr, Dlncpigreece, Dlncpifrance) for 2001-2007

Method	Statistic	Prob.**	C.sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-16.5268	**0.0000**	3	249
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-13.8694	**0.0000**	3	249
ADF - Fisher Chi-square	98.0689	**0.0000**	3	249
PP - Fisher Chi-square	98.3491	**0.0000**	3	249

VECM (Dlngritl, Dlncpigreece, Dlncpiitaly) for 2001-2007

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-15.9092	**0.0000**	3	249
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-14.1394	**0.0000**	3	249
ADF - Fisher Chi-square	79.0976	**0.0000**	3	249
PP - Fisher Chi-square	78.7452	**0.0000**	3	249

VECM (Dlngrspp, Dlncpigreece, Dlncpispain) for 2001-2007

Method	Statistic	Prob.**	Cross sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-15.9603	**0.0000**	3	249
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-14.2237	**0.0000**	3	249
ADF - Fisher Chi-square	95.7831	**0.0000**	3	249
PP - Fisher Chi-square	95.8145	**0.0000**	3	249

VECM (Dlngrusd, Dlncpigreece, Dlncpiusa) for 2001-2007

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-13.2700	**0.0000**	3	249
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-14.1708	**0.0000**	3	249
ADF - Fisher Chi-square	94.3533	**0.0000**	3	249
PP - Fisher Chi-square	94.7467	**0.0000**	3	249

VECM (Dlngrgbp, Dlncpigreece, Dlncpiuk) for 2001-2007

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-13.7336	**0.0000**	3	249
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-14.6723	**0.0000**	3	249
ADF - Fisher Chi-square	98.4777	**0.0000**	3	249
PP - Fisher Chi-square	98.2273	**0.0000**	3	249

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