Purchasing Power Parity and Competitiveness in Portugal: an Empirical Approach

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1. Introduction

The Purchasing Power Parity (PPP) hypothesis is a simple relationship which states that the price levels in two different countries should be the same, when converted to a common currency. Otherwise, large profit opportunities from cross-border trade would arise, and economic agents would engage in arbitrage activities leading to corrections either in prices or nominal exchange rates, or both, until price equalization is attained. To put this differently, while short-run deviations are admissible in light of PPP, the Real Exchange Rate (RER) should be stationary, such that the purchasing power of two different currencies does not deviate permanently from its long-run equilibrium.

The list of empirical studies addressing the PPP hypothesis is vast. From simple univariate unit root tests to long-span data studies, from co-integration to panel tests, PPP has been submitted to almost all types of analysis and scrutiny. However, evidence seems to be mixed at best and characterized by fairly significant levels of persistence, compared to what the theoretical arbitrage relationship would suggest. In a recent paper, Carvalho and Júlio (2010) use several econometric methodologies and conclude that evidence for PPP is in fact very weak. Even nonlinear methods, which have been pointed out in the literature as a potential solution for the PPP puzzle (Taylor and Peel, 2000; Taylor et al., 2001), were unable to provide fair evidence for PPP.

In this article, we provide an empirical coverage of the main and most relevant empirical methods presented in the literature on PPP, taking Portugal as reference country. Our analysis relies on 4 classes of tests – standard univariate unit root tests, standard panel unit root tests, Panel Analysis of Nonstationarity Idiosyncratic and Common components (PANIC), and unit root tests for nonlinear frameworks –, for a dataset consisting of 15 bilateral exchange rates *vis-à-vis* Portugal, and using the Consumer Price Index (CPI) as price measure.[2] In the overall, our results suggest weak evidence supporting the PPP hypothesis.

We also conclude that competitiveness, measured by the RER, is subject to large fluctuations and to very persistent shocks, which last several years. This indicates that Portugal gained competitiveness in some periods, but lost in others, *vis-à-vis* other European countries. However, in the long-run, *i.e.,* ignoring the short and medium term fluctuations in RERs, Portugal lost competitiveness against some of its European partners, such as Belgium, Denmark, France, Luxembourg, Netherlands and Sweden, but maintained or gained competitiveness against others, notably Spain, Greece, Italy and Ireland. These two features – the persistence of shocks and the long-run trend of RERs – may explain, although not justify, the failure of PPP for the Portuguese case.

This article is structured as follows. Section 2 presents the theoretical foundations of PPP. Section 3 introduces the data used in the empirical tests. In Section 4 we describe the methodology. Section 5 presents the results. Section 6 concludes.

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[2] The producer price index, which would also be interesting to analyze, cannot be used in the current study, due to the lack of a sufficient number of observations.

2. Purchasing Power Parity and the Law of One Price

The main building block behind PPP is the Law of One Price (LOP). The LOP, in its absolute version, postulates that the same good should have the same price across countries, if prices are expressed in a common currency. The main idea behind the absolute LOP is frictionless goods arbitrage (Sarno and Taylor, 2002). If goods are seen by consumers as perfect substitutes, then, in the absence of trade barriers and assuming negligible transport costs, price differences across countries originate profit opportunities, which will drive price adjustments until price equalization is attained. The relative version of the LOP postulates a weaker condition, that the relative price of a given good is constant through time when expressed in a common currency. Hence, the domestic prices are allowed to differ from the prices in the foreign country by a given factor. Obviously, the absolute LOP implies its relative version, but the converse is false.

If one assumes that the LOP is verified for each good in a given basket, then it should also be verified for the whole basket. The relationship that results from this aggregation across goods is known as PPP. Absolute PPP is expressed by

$$(1) S_t \cdot P_t^* = P_t$$

where P_t is the weighted average price of the basket of goods at time *t* in the domestic country, P_t^* is the weighted average price of the same basket at time *t* in the foreign country, and S_t denotes the nominal exchange rate, defined as the amount of domestic currency needed to buy one unit of foreign currency. In empirical applications, it is also useful to express the absolute PPP in logarithmic form,

$$(2) s_t + p_t^* - p_t = 0$$

where $s_t = \log S_t$, $p_t^* = \log P_t^*$, and $p_t = \log P_t$. Equation (2) simply states that the purchasing power of one unit of currency is the same in both countries, when converted to the same monetary unit. To put this differently, if absolute PPP holds, then any economic agent can buy the same basket of goods with the same amount of money in both countries. This relationship is supported by stronger assumptions than the ones invoked by the LOP. Namely, the goods that compose the basket should be the same in both countries, the weights used to compute the average price must be the same, and consumer preferences across countries should be similar. These are much stricter conditions, which are unlikely to hold in practice. Despite this, most economists believe that PPP constitutes an anchor for RERs in the long-run, such that any shock to the PPP relationship in (2) eventually dies out.

The relative PPP, expressed in logarithmic form, is

$$(3) s_t + p_t^* - p_t = c$$

where c is a constant. Condition (3) presents two main attractions as compared to (2). Firstly, it is based on the relative LOP, which imposes weaker assumptions by admitting price differences across countries. Secondly, it is much easier to test empirically than its absolute version, since the data collected on prices is based on indices rather than on levels, which creates a wedge between the relative prices of different countries that can only be captured through the parameter c. In empirical applications which use data on price indices, only the relative PPP can be tested.

3. Data

The data we used were gathered from the International Monetary Fund's *International Financial Statistics* (on-line) database. Both quarterly data on bilateral exchange rates of several currencies against the Portuguese *escudo* and on the CPI were collected, for the period 1973:1 – 2009:4. The base year for both price indices is 2005. The analysis comprises 15 countries in the European Union: Austria, Belgium, Cyprus, Denmark, Finland, France, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Spain, Sweden and United Kingdom.[3] From 1999 onwards, the nominal exchange rates of the preceding national

[3] The analysis excludes Germany, due to the German reunification. All other countries in the European Union were excluded due to the lack of reliable data for the considered time frame.

currencies against the Euro were used whenever necessary to make the necessary conversions in the series.[4] All variables were put into natural logarithms before the analysis. In our notation, p_t^* is the log of the CPI in Portugal, p_t is the log of the CPI of the country being tested, and s_t is the log of the amount of currency of the country being tested needed to buy 1 *escudo*.

4. Methodology

We use 4 classes of tests to test the validity of PPP. These methods are extensively discussed in Carvalho and Júlio (2010).

We start by presenting two simple univariate unit root tests – the ADF test and the DF-GLS test – designed to test the null hypothesis of a unit root against the alternative that the process driving RERs is stationary. The latter test has the advantage of allowing for higher power.

Although univariate unit root tests are clearly important, since they are very easy to implement and interpret, there are at least 4 reasons that recommend running additional tests. First, prices and exchange rates are usually non-stationary, which makes the use of standard critical values in univariate tests inappropriate (Philips, 1987). A possible solution is to use co-integration procedures, which allows us to test if a linear combination of two or more non-stationary series is itself stationary. However, we cannot apply this method here, since a majority of our series is not integrated of order 1. More specifically, nominal exchange rates in our sample seem to be stationary, and prices are mostly characterized two unit roots, features that may bias the results of the traditional Johansen's co-integration test. Second, most univariate unit root tests have little power to reject the null hypothesis when it is not true (Sarno and Taylor, 2002). Although the power of the DF-GLS test lies near the asymptotic power envelop, panel procedures may attain large improvements in power by aggregating observations across countries. Third, the RER may be characterized by pervasive components, common to all series, and idiosyncratic components, which are series specific. Conducting unit root tests without taking into account the distinct behaviors of the different components of the series may bias the results (Bai and Ng, 2004). PANIC is able to address this issue, by testing for the presence of unit roots in each of these components separately, even if they are unobservable. Finally, the linear specification assumed by univariate tests (and also by the remaining tests) may not represent correctly the adjustment process faced by RERs, due to frictions in international markets, such as trade barriers and transport costs (Taylor et al., 2001). The solution is to consider nonlinear adjustments in unit root testing, such that different speeds of adjustment can be captured, depending on the misalignment presented by the RER. We now consider the latter three approaches in turn.

The main idea behind panel unit root tests is to pool cross-section data in order to generate more powerful tests; however this may generate additional problems not present in univariate tests, namely contemporaneous correlation between observations. Note that RERs are cross-sectionally dependent by construction, since all of them contain two common components: the Portuguese price index and the value of the *escudo* (prior to the introduction of the Euro).[5] Three standard panel unit root tests are analyzed – the Levin et al. (2002) (henceforth LLC), the Im et al. (2003) (hereinafter IPS) and the Fisher-ADF test (Maddala and Wu, 1999). The LLC test is based on a modified t-statistic from a pooled regression which involves standardized variables, and evaluates the null hypothesis that each RER pair follows a random walk against the alternative hypothesis that all RER pairs are stationary and mean-revert at the same rate. This is one of the main hindrances of this inference process, since the assumption that the same first-order partial autocorrelation is shared by all the cross-section units of the panel under the alternative hypotheses is quite vexatious. Im et al. (2003) develop a more flexible panel unit root testing procedure in which the autoregressive coefficients are allowed to vary across all the cross-section units of the panel. In this test, the null hypothesis that each RER pair follows a random walk is tested against the alternative that a subset of the RER pairs is stationary. The Fisher-ADF test shares the same null and alternative as the IPS test,

[4] To be certain that the creation of the Euro Area does not influence our conclusions, all tests presented here were also run for the period 1973:1 – 1998:4. Since conclusions remained broadly unchanged, we decided to use the longest time span available in order to take advantage of more powerful tests.
[5] See O'Connell (1998) for a discussion.

but is built under more general assumptions and consequently is can perform more reliably in empirical analysis. Observe that a rejection of the null hypothesis in this context is completely uninformative about the identity of the countries in which PPP holds, or even about the number of countries in which we expect to observe a stable RER. The misinterpretation of the null hypothesis in some panel unit root tests is not uncommon in the literature (Sarno and Taylor, 1998; Taylor and Sarno, 1998), and often leads to wrong conclusions.

The results for the factor structure approach developed by Bai and Ng (2004), known as PANIC – Panel Analysis of Non-stationarity in the Idiosyncratic and Common components –, are presented in the sequel. The main idea of this test is to decompose each series into two components – one which is mainly unit specific (idiosyncratic component) and another which is strongly correlated with other series (common factor or pervasive component). While the first may represent specific events for all countries except Portugal, the second may capture any event that affects the Portuguese economy, such as depreciations of the *escudo.* This test procedure has two main advantages. First, it allows the identification of the source of non-stationarity, if any. This presents a significant improvement over other unit root tests, which are not as reliable as PANIC if the series are composed by several components with distinct behaviors. Second, it permits the design of a valid pooled test on the idiosyncratic components, since these are, in principle, independent across the cross-section units of the panel. Hence, PANIC solves the problem posed by the standard panel unit root tests, which, by ignoring cross-sectional dependence, may present serious size distortions that induce over-rejections of the null hypothesis (O'Connell, 1998).

The number of common factors in PANIC is usually selected through an information criterion, along the lines of Bai and Ng (2002), and the decomposition is accomplished by applying principal components to the model. In our analysis, we use the BIC3 criteria, which is more robust to the presence of any residual cross-correlation in the idiosyncratic components. Afterwards, the ADF test is performed on all the individual de-factored series to test for an individual specific unit root. If the common factor is unique, the existence of a common trend is also evaluated through the ADF test. If more than one common factor exists in data, a sequential procedure is applied, which tests the null hypothesis that m common factors are non-stationary, where m is initially equal to the number of common factors. If rejected, the test is performed again, but the number of non-stationary common factors under the null hypothesis is corrected by -1, *i.e.*, we set $m \coloneqq m-1$; otherwise the number of non-stationary common factors is set to m. The test statistics of this sequential procedure are based on modified versions of the Q_f and Q_c statistics (denoted by MQ_f and MQ_c respectively) originally proposed by Stock and Watson (1988). A series is non-stationary if at least one of these two types of components is non-stationary. If at least one common factor is non-stationary but the idiosyncratic component is stationary, then the RER pair will be non-stationary due to a pervasive source. If the opposite is verified, then the non-stationarity of the RER pair is due to a series-specific factor that cannot be endorsed in common grounds. Finally, a valid pooled test of the Fisher-ADF type can be performed on the idiosyncratic components, since these do not depend on the common factor and are therefore independent across the cross-section dimension of the panel.

Lastly, we consider the KSS (Kapetanios et al., 2003) test – a univariate unit root test that is robust to the possibility of nonlinear adjustments in RERs. The idea of nonlinear adjustments in RERs is not new, dating back at least to Cassel (1922), and is based on the idea that transaction costs may create a band of inaction within which deviations from PPP do not create profitability conditions that are the basis of convergence of RERs to their long-run equilibrium. However, once this threshold is breached, profits from international trade arise and RERs become mean-reverting. If one believes that deviations from PPP are characterized by strong nonlinearities, as several models suggest (*e.g.* Dumas, 1992; Sercu et al., 1995), then standard unit root tests will have very low power to reject a potentially false null hypothesis of non-stationarity, as illustrated in Taylor et al. (2001). In the KSS test, the RER is allowed to follow a random walk for small deviations from equilibrium, but becomes increasingly mean-reverting the further away it is from its long-run equilibrium. Hence, rejecting the null hypothesis means that the process is locally non-stationary, but globally nonlinear and stationary.[6].

[6] The KSS test only considers nonlinearities of the ESTAR (Exponential Smooth Transition Autoregressive) type under the alternative hypothesis.

5. Results

Table 1 shows the results of the univariate unit root tests. We observe that the ADF test does not reject the null hypothesis of a unit root for any RER pair at a 5% significance level. The DF-GLS test does not improve the evidence towards PPP significantly, despite its higher power; in fact, only for 4 countries the null hypothesis is rejected at a 5% significance level: Austria, Denmark, Greece and Ireland.

Table 1: Results of univariate unit root tests.

Country	ADF	DF-GLS	Country	ADF	DF-GLS
Austria	-2,71 *	-2,50 **	Italy	-1,62	-1,35
Belgium	-1,48	-1,04	Luxembourg	-1,42	-0,75
Cyprus	-1,35	-0,14	Malta	-1,26	-0,49
Denmark	-2,31	-2,31 **	Netherlands	-1,16	-1,06
Finland	-1,06	-1,08	Spain	-2,12	-1,75 *
France	-0,81	-0,28	Sweden	-0,17	0,95
Greece	-2,64 *	-2,63 ***	United Kingdom	-1,72	-1,76 *
Ireland	-2,03	-2,02 **			
			Number of rejections *	2	6
			Number of rejections **	0	4
			Number of rejections ***	0	1

Notes: *, ** and *** represent rejections at 10, 5 and 1 percent significance levels, respectively. The ADF and DF-GLS tests consider an intercept, but no trend in data. Both use the Akaike Information Criteria to select the lag length (an upper bound of 8 lags was imposed). The critical values for the ADF t-statistic are approximately *-2.58* at 10 percent, *-2.88* at 5 percent, and *-3.48* at 1 percent significance levels, while the critical values for the DF-GLS t-statistic are approximately *-1.62* at 10 percent, *-1.94* at 5 percent, and *-2.58* at 1 percent significance levels (MacKinnon, 1996).

The results for the LLC, IPS, and Fisher-ADF tests are presented in Table 2. All these tests fail to reject the random walk behavior of RERs, which suggests that all RERs pairs are non-stationary and therefore they do not mean-revert to their hypothetical long-run equilibrium. This evidence is in line with the findings of univariate unit root tests, and supports the conclusion that the Portuguese economy faced permanent changes in competitiveness *vis-à-vis* other European countries. The issue of competitiveness is analyzed in Section 6.

Table 2: Results of panel unit root tests under the assumption of cross-sectional dependence.

LLC		IPS		Fisher-ADF	
τ_ρ	p-v	W_{tbar}	p-v	Z_{stat}	p-v
0,43	0,67	-0,53	0,30	30,31	0,55

Notes: The number of lags was automatically selected according to the Akaike Information Criteria (an upper bound of 8 lags was imposed) in the tests which rely on lags to correct for serial correlation. Results do not change substantially under alternative lag selection criteria. For the LLC test, the Bartlett kernel method was used, and bandwidth selection was made according to the Newey-West criteria.

Table 3 provides the results of PANIC. First of all, observe that the variability of each series that is explained by the common factors is above 50 percent for all series except Sweden, and in 3 cases it even above 90%. This reveals the importance of factor analysis in developing and understanding the co-movements of contemporaneously related series. According to the BIC3 criterion and the MQ_f and MQ_c statistics, our panel has two non-stationary common factors (*i.e.,* common trends). Additionally, the unit root tests on the idiosyncratic error components show that, for all countries except Italy, specific shocks are endowed with infinite memory. Furthermore, the panel test yields the same conclusion of the standard panel unit root tests of Table 2. Hence, PANIC suggests that pervasive sources, related to the Portuguese economy, and idiosyncratic shocks, contribute together to the non-stationarity of RERs. All these conclusions carry through if one considers the presence of a unique common factor.[7]

Table 3: Results of PANIC.

Country	ADF^{ϵ}	R_1	Country	ADF^{ϵ}	R_1
Austria	0,17	0,11	Italy	-2,29 **	0,39
Belgium	-0,81	0,09	Luxembourg	-0,05	0,09
Cyprus	0,10	0,25	Malta	0,13	0,25
Denmark	-0,21	0,11	Netherlands	-1,67 *	0,09
Finland	-1,02	0,38	Spain	-0,10	0,47
France	0,70	0,19	Sweden	0,49	0,51
Greece	-0,06	0,48	United Kingdom	-0,56	0,22
Ireland	-0,19	0,27			
Number of common factors (BIC3)				2	
MQf(2)				-1,51	
Number of common trends (MQf)				2	
MQc(2)				-3,11	
Number of common trends (MQc)				2	
Pooled test (P)				-0,54	

Notes: ADF^{ϵ} is the ADF test on the idiosyncratic component. $\mathbf{R_1}$ is a measure of the relative importance of the idiosyncratic factor in the series, and is computed as the ratio between the variance of the first difference of the idiosyncratic error term and the variance of the first difference of the series. The critical values for the ADF t-statistic are approximately *-1.61* at 10 percent, *-1.94* at 5 percent and *-2.59* at 1 percent significance levels, for the case of no constant (MacKinnon, 1996). The critical values for $MQ_{c,f}(2)$ are approximately *-19.9* at 10 percent, *-23.5* at 5 percent, and *-31.6* at 1 percent significance levels (Bai and Ng, 2004).

Finally, Table 4 presents the results of the KSS test. These results seem to broadly corroborate the main conclusions of the previous tests: there is no evidence for a wide-ranging PPP relationship in the case of the Portuguese economy. In fact, only in 4 cases the null hypothesis of a random walk was rejected in favor of a globally stable RER at a 5% significance level: Austria, Denmark, Spain and United Kingdom.

Table 4: Results of the KSS test.

Country	KSS		Country		KSS	
Austria	-2,98	**	Italy		-2,30	
Belgium	-1,29		Luxembourg		-1,31	
Cyprus	-2,09		Malta		-1,75	
Denmark	-2,92	**	Netherlands		-1,97	
Finland	-1,73		Spain		-3,23	**
France	-0,99		Sweden		-0,25	
Greece	-2,28		United Kingdom		-3,33	**
Ireland	-2,62	*				
				*	5	
			Number of rejections	**	4	
				***	0	

Notes: *, ** and *** represent rejections at 10, 5 and 1 percent significance levels, respectively. The KSS test considers an intercept, but no trend in the data. The number of lags was selected according to the Akaike Information Criteria (an upper bound of 8 lags was imposed). Monte Carlo simulations were performed to derive the critical values for the KSS t-statistic, with a total number of 148 observations (the dimension of our time series) and 50 000 replications. We obtained (approximately) the following critical values: *-2.61* at 10 percent, *-2.88* at 5 percent, and *-3.42* at 1 percent significance levels. These values are similar to the ones obtained by Kapetanios et al. (2003).

[7] Since these results are similar to the ones in Table 3, we do not present this case here.

In sum, some evidence of a stable RER seems to exist between Portugal and the following countries: Austria, Denmark, Greece, Ireland, Spain and the United Kingdom; however, this evidence is unconvincing and insufficient to highlight PPP as a wide-ranging relationship for the Portuguese case.

6. Conclusions and Implications

In this article, we conducted several tests to test the validity of PPP, using Portugal as reference country. Each test specifically addressed a particular feature or trait of the data, but all suggested that evidence for PPP as a wide-ranging relationship is non-existent. Only in some particular cases the PPP hypothesis was, to some extent, supported by the data, although the evidence cannot be classified as compelling.

The failure of PPP has several economic implications. For instance, Rogoff (1996) and Sarno and Taylor (2002) point out that, if shocks to the RER are highly persistent, then they must be originated from the real side (*e.g.* technology shocks), while, if shocks to the RER show little persistence, then they must be originated by aggregate demand (*e.g.* monetary policy). PPP is also used to compare national income levels (Sarno and Taylor, 2001), and this only makes sense if the relative purchasing power of two currencies does not change over time.

However, PPP is also useful to undertake conclusions regarding competitiveness between two countries. Since the RER measures the relative price of a given basket of goods, when these are expressed in a common currency, permanent changes in its level can be linked to changes in competitiveness. In this sense, an appreciation or depreciation of the RER is associated to a decrease or increase in competitiveness, respectively. Although the CPI is not the best suited measure to evaluate this, since it includes some non-tradable goods, it is often used in practice due to the lack of sufficient information for alternative price measures.

These changes in competitiveness can be evaluated through a graphical inspection of the series, which are presented in the Appendix. Most of the series are characterized by episodes of real appreciations and by episodes of real depreciations of the *escudo,* indicating that shocks to the RER are very persistent and have not only a short-run effect, but also a medium-run impact. This is a first cause of the failure of PPP for many RER pairs.[8]

Furthermore, the RER is characterized by a positive long-run trend for Austria, Belgium, Denmark, France, Luxembourg, Netherlands and Sweden, and by a positive structural break around the early 90's for Cyprus, Finland and Malta. This suggests a fall in the competitiveness of the Portuguese economy against these countries. On the other hand, Portugal maintained or even gained competitiveness against Greece, Ireland, Italy and Spain. The existence of long-run trends in RERs is another cause of the failure of PPP.

It is also worthwhile to analyze the series for the period after the early 90's, since the behavior of RERs changed with the adoption of the convergence criteria that lead to the creation of the Euro Area. While Portugal lost competitiveness against Austria, Belgium, Denmark, Finland, France, Luxembourg, Netherlands, Sweden and the United Kingdom, it maintained or gained competitiveness against Cyprus, Greece, Ireland, Italy, Malta and Spain.

7. References

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[8] It is well known that, if the RER is very persistent, but stationary, unit root tests have low power to reject a false null hypothesis.

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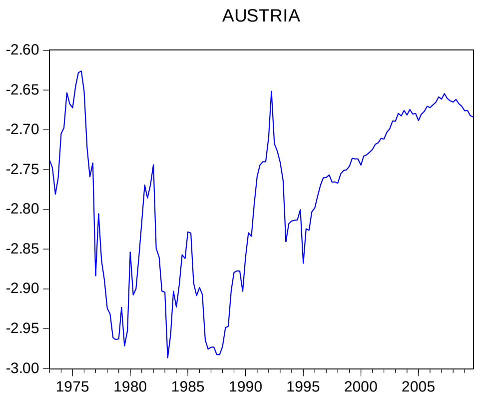
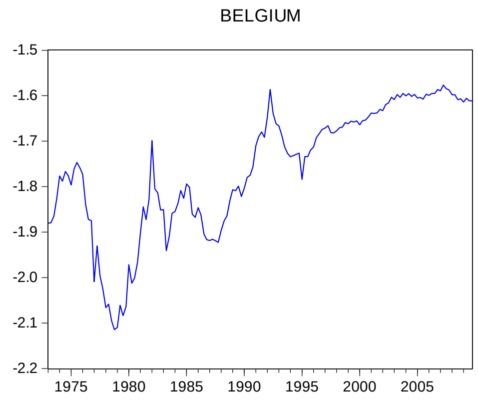
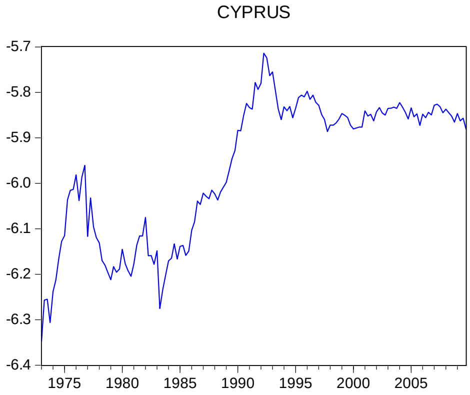
8. Appendix






CYPRUS
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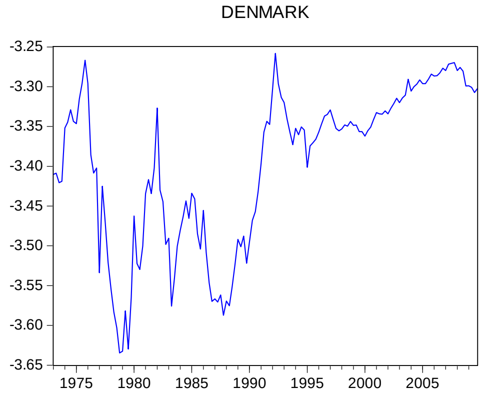
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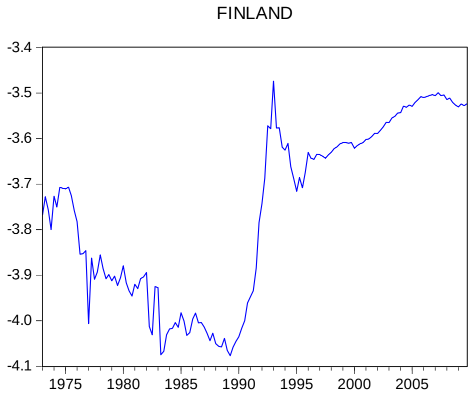
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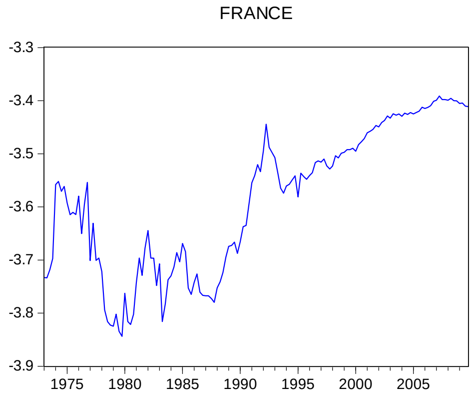
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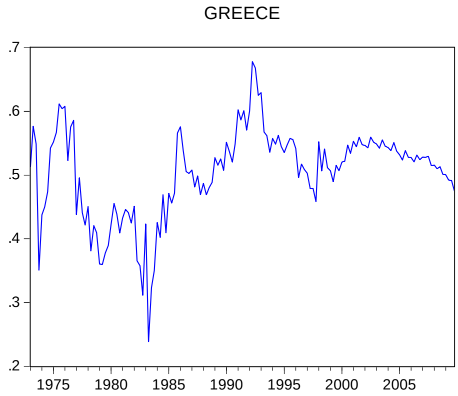
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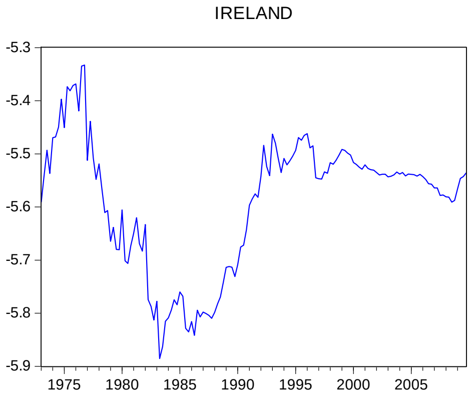
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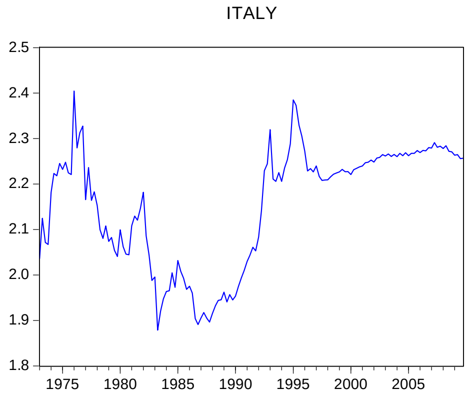
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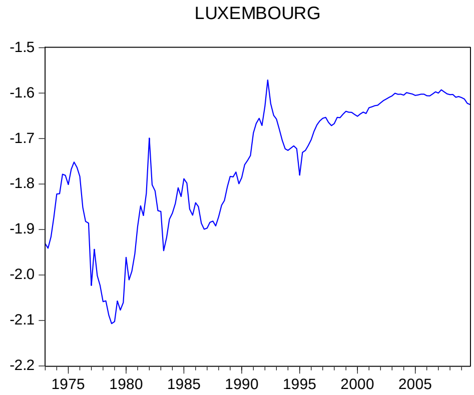
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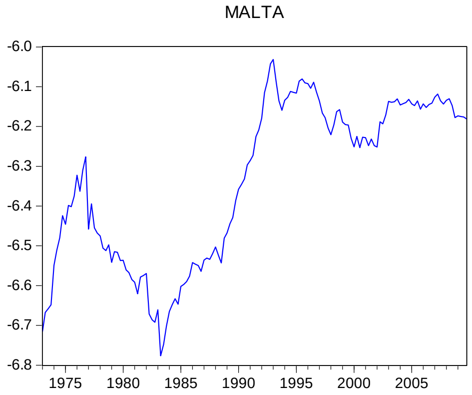
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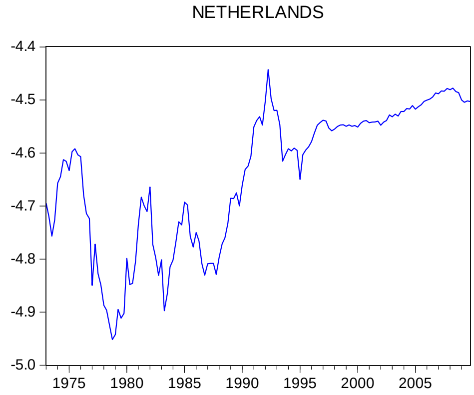
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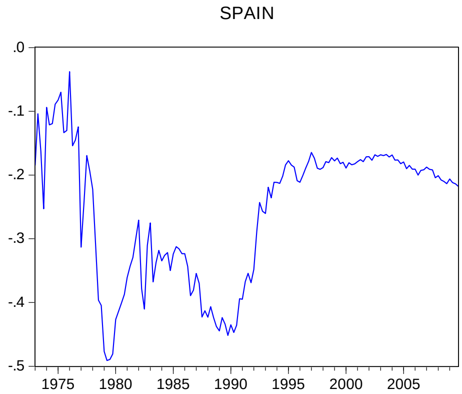
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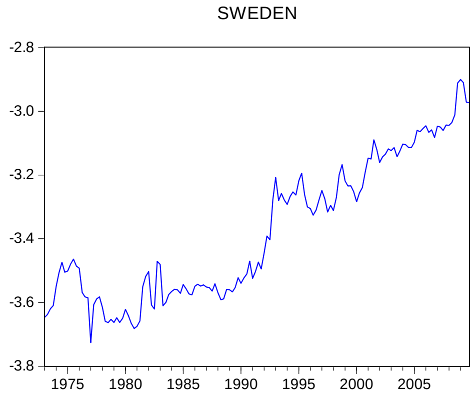
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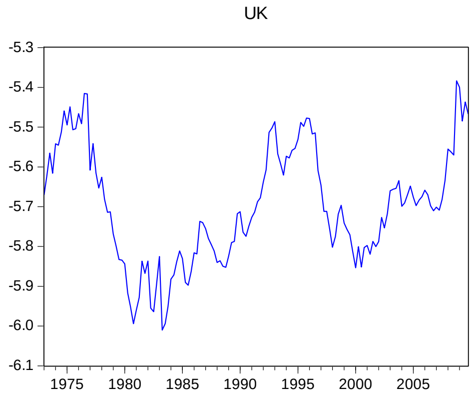
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