Convergence to Purchasing Power Parity at the Commencement of the Euro

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We investigate convergence towards Purchasing Power Parity (PPP) within the Euro Zone and between the Euro Zone and its main partners using panel data methods that incorporate serial and contemporaneous correlation. We find strong rejections of the unit root hypothesis, and therefore evidence of PPP, in the Euro Zone for different numeraire currencies, as well as in the Euro Zone plus the United States, with the US dollar as the numeraire currency, starting between 1996 and 1999. The process of convergence towards PPP, however, begins earlier, generally in 1992 or 1993 following the adoption of the Maastricht Treaty.

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1.   Introduction

The European Union's (EU) efforts towards monetary and economic stabilization culminated with the commencement of the Euro in January 1999. But, as in the academic sense, the "commencement" involved an end as well as a beginning. Since the abandonment of the Bretton-Woods System in 1971, the EU tried several alternatives (the "Snake" and the European Monetary System) before reaching its goal. As delineated by the Treaty of Maastricht, membership in the Euro required the achievement of five criteria, including inflation convergence and nominal exchange rate stability within its member states.

The Purchasing Power Parity (PPP) hypothesis considers a proportional relation between the nominal exchange rate and the relative price ratio, which implies that the real exchange rate is constant over time. The most common way to test for PPP consists in investigating unit roots in real exchange rates. If the unit root can be rejected in favor of level stationarity, then deviations from parity are temporary and PPP is said to hold in long run. The literature on testing for PPP has become voluminous in recent years.

Since inflation convergence plus nominal exchange rate stability implies real exchange rate convergence, the commencement of the Euro created an almost ideal case study for the PPP hypothesis. 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. Did PPP hold within the Euro Zone during the EMS period, or was there convergence to PPP? If there was convergence to PPP, did it occur following the Maastricht Treaty, at the time of the irrevocable fixing of exchange rates, or elsewhere? Does PPP, or a transition to PPP, hold between the Euro Zone countries and other European, industrialized, and negotiating countries?

The basic problem with testing for PPP in the post-Bretton Woods period is that the lack of power of univariate unit root tests with 30 years of data makes the results obtained unreliable. Since extending the span of the data is not an option, Abuaf and Jorian (1990) and Levin, Lin and Chu (2002) propose the use of panels to exploit the cross-sectional information.[1] The attraction of these tests is that they have good power with the time series and cross section dimensions of available data. Panel unit root tests

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[1] Another promising alternative is to use stationary covariates, as in Elliott and Pesevanto (2001).

have been used to investigate the hypothesis of long run PPP by Frankel and Rose (1996), Wu (1996), Mac Donald (1996), Oh (1996), Jorion and Sweeney (1996), and Papell (1997). More recent work, including O'Connell (1998), Taylor and Sarno (1998), Papell and Theodoridis (2001) and Wu and Wu (2001), allows for contemporaneous correlation of real exchange rates under both the null and alternative hypotheses.

We investigate the behavior of real exchange rates, both within Euro area and between the Euro area and a number of its trading partners, during the 1973-2001 post-Bretton Woods time period. We use a finite-sample panel unit root procedure that accounts for country-specific serial correlation and data-specific contemporaneous correlation, assumes the same speed of mean reversion across countries under the alternative hypothesis, and allows for the results to change depending on the numeraire currency.[2] We generate critical values using Monte Carlo methods.[3]

The central result of this paper is that there is a sharp distinction between finding statistical *evidence* of PPP and finding *convergence* towards PPP. Within the Euro zone, strong rejections of unit roots in real exchange rates, and thus statistical evidence of PPP, starts to hold between 1996 and 1999 depending on the numeraire currency. The beginning of convergence, however, occurs in 1992 or 1993. While the achievement of PPP generally occurs after the actions taken by countries to satisfy the criteria for membership in the Euro, convergence towards PPP is linked to the Maastricht Treaty on European Union signed in 1992.

We also investigate PPP between the countries of the Euro zone and a number of different countries, using the currency of the non-Euro countries as the numeraire. The pattern between the United States and the Euro countries closely follows the pattern among the Euro countries, convergence starting in 1992 and achievement of PPP starting in 1997. Among European countries that are not in the Euro zone, only Denmark exhibits strong evidence of PPP, while Greece, Sweden, and the United Kingdom do not. Among the countries negotiating to join the Euro, the strongest evidence of PPP is for Malta and Hungary.

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[2] Papell and Theodoridis (2001) discuss the rationale for the latter two assumptions.

2.   The Euro

The Economic and Monetary Union (EMU) resulted from a long and slow process, starting in 1954 with the Treaty of Rome. We focus, however, on the last and most successful aspect, resulting in the advent of the Euro. The Treaty of Maastricht in 1992 established the timetable of achievements, along with the five convergence criteria defining the access to the single currency.[4] For the purpose of investigating the behavior of real exchange rates, the two most important criteria were that the rate of inflation for each country could not exceed the average rates of inflation of the three Member States with the lowest inflation by more than 1.5% and that the national currency could not have been devaluated during the two previous years and must have remained within the EMS 2.25% margin of fluctuation.

The Members States had to achieve the economic convergence during a transitional period of four years, 1994 to 1998. In this effort of cohesion, the European Monetary Institute (EMI) was created to facilitate and reinforce the coordination of their monetary policies, to promote the use of the ECU (European Currency Unit) and to prepare for the creation of the European Central Bank (ECB).[5] Finally, in May 1998, the European Council defined the list of countries joining the new exchange rate mechanism (ERM II). Those are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. Greece joined the Euro in January 2001. Exchange rates were fixed in January 1999, followed by circulation of the coins and notes in January 2002.

The almost ten years of efforts toward the establishment of the Euro creates an unprecedented opportunity for PPP analysis. Since the Euro resulted from preset nominal exchange rates and inflation convergence within the EMS, the long process towards its creation offers many candidates for both convergence and achievement of PPP. Three of

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[3] The critical values available either do not account for contemporaneous correlation or do not correspond to the size of our panels.
[4] The other three criteria were:
- long-term interest rates shall not vary by more than 2% in relation to the average interest rates of the three Member States with the lowest interest rates
- national budget deficits must be close to or below 3% of the GNP
- public debt may exceed 60% of GNP only if the trend is declining toward this level
[5] Created in 1999, the ECB is independent of national governments and manages the monetary policies of all the Members States joining the single currency.

these are 1992-1993 as a direct response to the Treaty of Maastricht, 1997-1998 when the criteria are observed and 1999 with the switch from the semi-flexible to the fixed exchange rate regime.

3. The Model and Test Procedure

Let e and p be the nominal exchange rate and the consumer price index of the studied country and e* and p* be the nominal exchange rate and the consumer price index of the country-base. The real exchange rate q (in logarithms) is calculated as:

$$q = e - e^* + p^* - p \tag{1}$$

As stipulated earlier, PPP is said to hold if the process q does not contain any unit root, then the process is defined as stationary. For a single real exchange rate between two countries, we could test for PPP by using univariate Augmented-Dickey-Fuller (ADF) tests:

$$\Delta q_t = \mu + \alpha q_{t-1} + \sum_{i=1}^{k} c_i \Delta q_{t-1} + \varepsilon_t \,. \tag{2}$$

The null hypothesis of a unit root in the real exchange rate would be rejected in favor of the alternative hypothesis of level stationarity (PPP) if α is significantly less than 0. The problem with these tests is that they have low power for the span of post-Bretton Woods data.

One method to increase power is to exploit the cross-section dimension of the data. Suppose we have N real exchange rates. A panel version of the ADF test for the real exchange rate of country j at time t, q_{jt}, is defined by the following equation:

$$\Delta q_{jt} = \mu_j + \alpha q_{jt-1} + \sum_{i=1}^{k} c_{ij} \Delta q_{jt-1} + \varepsilon_{jt} \tag{3}$$

where j=1,…,N indexes the countries and i=1,…,k the number of lags. We allow for heterogeneous intercepts (μ_j) and serial correlation ($\sum_{i-1}^{k} c_{ij} \Delta q_{jt-1}$). Equation (3) is estimated using feasible GLS (FGLS) to account for contemporaneous correlation with the lag length k set equal to the value chosen by univariate estimation (we use the recursive t-test procedure proposed by Campbell and Perron (1991) because of its size

and power properties (Hall (1994), Ng and Perron (1995)).[6] We consider that PPP holds only if the entire panel is stationary. This definition leads us to use the Levin, Lin and Chu (2000) homogeneous alternative (H1: $\alpha_j = \alpha < 0$) instead of the Im, Peseran and Shin (1997) heterogeneous alternative (H1: $\alpha_j < 0$). The latter one implies the stationarity of at least one series in the panel while the first one implies the stationarity of each series, that is the entire panel.[7] As a result, we reject the null hypothesis of a unit root in favor of the alternative of level stationarity (PPP) if α is significantly less than zero.

We calculate critical values using Monte Carlo methods. First, we generate data specific empirical distributions. For each panel and each span of data, we estimate the real exchange rate using univariate ADF tests. We treat the estimated parameters as true values, defining the data generating process for the errors in each of the series. Then, using the residuals, we construct real exchange rate innovations and calculate the covariance matrix Σ, which allows us to produce pseudo samples based on the estimated process with iid N $(0,\Sigma)$ innovations. The size of the generated samples equals the actual size of our series (from 88 to 166 observations). We then take partial sums so that the generated real exchange rates have a unit root by construction.

The finite sample critical values are calculated from the generated data. Using the recursive t-statistic procedure with the univariate estimation, we define the number of lags (k) needed for each series. We estimate equation (3) five thousand times, sort the resultant t-statistics and deduce the critical values for each panel and for each time period that we consider. We analyze twenty-three panels constructed from 5 groups of countries. We also consider different periods of time, which implies a variation in the span of data from 88 to 166 observations. For each panel and time period, we need to generate a different set of critical values (around 450 sets in total).

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[6] The maximum number of lags considered is $k_{max} = 12$ with a selection at 10%.

[7] Furthermore, with univariate tests, the processes are highly persistent and the α's are negative but generally not significantly different from 0. Bowman (1999) shows that there is a loss of power of the IPS test, relative to the LLC test, when α is equal across members of the panel. He also shows that size adjusted power falls much faster for the LLC test than for the IPS test when only a subset of the members of a panel is stationary. Since rejection of the unit root null is normally interpreted as evidence that all real exchange rates are stationary, even though the alternative hypothesis of the tests is that at least one element is stationary, we view this as an advantage of the LLC test.

Because of the number of panels and periods considered, we report our critical values as graphs instead of tables. We first illustrate the general behavior of the real exchange rates. Then, if convergence to PPP occurs, we focus on the last seven years of the period and offer a more detailed approach, plotting the t-statistics on α from estimating Equation (3) and the 1%, 5% and 10% critical values of the unit root test.

4. Empirical Investigation

4. a. The Data

We use quarterly, nominal exchange rates in US dollars and Consumer Price Indexes for 23 countries from 1973(1) to 2001(4).[8] For the countries switching to the Euro, we collect the nominal exchange rate currency by Dollar from 1973 to 1998, then the Euro by Dollar exchange rate from 1999 to 2001 and convert in currency by Dollar using the prefixed exchange rates.

Our analysis is based on the following groups:

Euro Zone: The Member States as of 1998 are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain. Luxembourg is excluded because of its currency union with Belgium.

Europe: Greece, Denmark, Sweden and United Kingdom. Greece is considered in the second category because it did not join the Euro until 2000. The other three countries, while not part of the Euro, belong to the European Union (EU).

Negotiating Countries: Cyprus, Hungary, and Poland start negotiating to become members in 1998 while Malta waited until 2000. Several aids have been created to facilitate the economic and social transition of prospective Member States, and to put them in a position to join the Union.

Industrialized Countries: The United States and Japan are the two main trading partners of the European Union, while Switzerland is a direct neighbor of the Euro Zone.

Mediterranean Countries: Morocco and Turkey were included because geographical proximity, strong historical and cultural links, and the possibility of achieving a Euro-Mediterranean free trade area by 2010 makes those countries important partners.

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[8] The source of the data is International Financial Statistics, CD-ROM for 03/2002.

4. b.   PPP Within the Euro Zone

Since the abandonment of the Bretton Woods system of fixed exchange rates pegged to the US dollar in 1971, exchange rates and inflation stabilization have been policy goals of European countries. We focus on the post-Maastricht period of the European Monetary System (1992-1997) and the advent of the single currency (1999-2001).

For the 10 countries in the Euro Zone, we conduct panel unit root tests on the resultant 9 real exchange rates, using each country's currency as a numeraire. For each panel, we first conduct a panel unit root test for the period 1973(1) – 1980(1). We then add observations quarter-by-quarter, ending with the period 1973(1) - 2001(4). The critical values for the tests reflect both the increasing span of the data and the different numeraire currencies. The p-values from the unit root tests from panels ending between 1980 and 2001 are graphed in *Figure 1a* while the Dickey-Fuller t-statistics and appropriate critical values are depicted in *Figure 1b*.

We obtain 10 graphs with a mostly common pattern. The years 1992 and 1993 symbolize the start of convergence towards PPP that leads (in most cases) to a strong rejection of the unit root hypothesis. The statistical rejections themselves, however, mostly occur between 1996 and 1999. While the establishment of the convergence criteria (1992), the Single European Market (1993), and the year for achieving the criteria to join the Euro (1997) are strongly associated with the convergence process, the "actual" switch to the irrevocably fixed regime (1999 - 2001) does not have a strong influence on the real exchange rates behavior. In most of the cases, PPP holds before this benchmark. This is consistent with the original vision for European Monetary Union: exchange rate and inflation stability followed by a single currency.

Strong evidence of convergence to PPP occurs with the three largest members of the Euro Zone, France, Germany, and Italy, as the numeraire currency. The results for France and Germany are remarkably similar. There is no evidence of PPP before 1992, with the p-values being over .40 at the start of that year. Beginning in 1992, there is rapid convergence to PPP, with significant rejections (at the 5% level) starting in 1996. For

Italy, the process of convergence starts at the same time but is much more rapid, with significant rejections occurring as early as 1993.

The pattern of convergence extends to the smaller countries in the Euro Zone. Austria, Belgium, Finland, Ireland, Netherlands, Portugal, and Spain all start converging to PPP in 1992 or 1993. The final result, however, varies among the countries. Finland follows the pattern described above, with strong rejections starting in 1997. Austria, Netherlands, and Portugal do not achieve strong rejections until 2000 or 2001. Belgium and Ireland have weak rejections (at the 10% level) starting between 1999 and 2001. Finally, the unit root null is never rejected for Spain.

4. c.   PPP Between the Euro Zone and Other Countries

We proceed to investigate the pattern of convergence to and achievement of PPP between members of the Euro Zone and a number of other countries. For each "external" country, we construct panels of 10 real exchange rates, with the currency of the external country being the numeraire. The results for several Western European countries are depicted in *Figure 2*. These countries were chosen because they all took part in at least one effort of stabilization of their real exchange rates with the Euro Zone countries (Snake, ERM or ERMII).

The pattern of convergence to PPP for Denmark mirrors that of the Euro Zone countries. The convergence process begins in 1993 and statistically significant rejections occur starting in 1995. This should not be surprising since Denmark successfully took part in the EMU's two first stages but decided to opt out of the third stage. The United Kingdom, which decided to not join the EMU after the second stage, also displays convergence towards PPP starting in 1993. The evidence is weaker, however, with the only (weak) rejection occurring at the end of 2001. Sweden also displays convergence towards PPP starting in 1993, but the evidence never comes close to even a weak rejection of the unit root hypothesis. Greece, which entering the Euro Zone in 2001, does not display evidence of either convergence towards or achievement of PPP.

A number of countries are currently negotiating to join the Euro Zone. Based on availability of data, we focus on four candidates: Cyprus, Hungary, Malta and, Poland. The results for these countries are illustrated in Figure 3. Convergence towards PPP is

observed for all four countries, with the convergence starting in 1992 or 1993 for Cyprus, Hungary, and Malta and in 1995 for Poland. The end result, however, varies considerably among the countries. Strong evidence of PPP (rejections at the 5% level) is found for Hungary starting in 1996 and for Malta starting in 2000. Evidence of PPP is not found for Cyprus or Poland.

The evidence of convergence for several industrialized countries is depicted in *Figure 4*. The pattern when the United States dollar is the numeraire currency mimics the pattern within the Euro Zone. The process of convergence to PPP starts in 1992 with a rejection of the unit root hypothesis at the 5% level beginning in 1997.[9] It is interesting to note that the similar pattern observed between France, Germany, Italy and the United States coincides with a non-orchestrated harmonization of their policies. The inflation rate and the budget deficit for the United States were reduced starting in 1991-1992 and the appreciation of the US dollar against most of the Euro Zone currencies began in 1994-1996. The results for Japan and Switzerland are much weaker. Although convergence towards PPP appears to begin for both countries in 1995, there are no strong rejections of the unit root hypothesis.

We also investigated convergence for two Mediterranean countries, Turkey and Morocco. The results for these countries are shown in *Figure 5*. Convergence towards PPP for Turkey starts around 1992 and begins to strengthen in 1996, coinciding with the start of its customs union with the EU. Convergence toward towards PPP for Morocco also begins in 1992. Neither country, however, displays strong rejections of the unit root hypothesis.

5. **Conclusions**

The purpose of this paper is to analyze the impact of the Euro on the purchasing power parity hypothesis when analyzed within Europe and with its closest partners. We focus on two questions. First, is the evidence of PPP stronger within the Euro Zone than the evidence between the Euro Zone and a number of other countries? Second, did convergence to PPP occur with its adoption in 1999, or did the process start earlier?

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[9] Papell (2003) finds a similar pattern of unit root rejections for a panel of 21 industrialized countries with the United States dollar as the numeraire currency.

The evidence of PPP is clearly stronger within the Euro Zone than between the Euro Zone and other European, negotiating, industrialized, and Mediterranean countries. Even within the Euro Zone, however, the choice of numeraire currency makes a considerable difference. The evidence of PPP is stronger for the largest countries in the Euro Zone, France, Germany, and Italy, than for the smaller members. There is one important exception, and that is the United States. The timing and strength of the evidence of PPP when the US dollar is the numeraire currency, strong rejections of the unit root hypothesis starting in 1997, is typical for the panels that are comprised solely of Euro Zone countries.

Our other major result is that there is a sharp distinction between the start of convergence towards PPP and statistical evidence of PPP. Both within the Euro Zone and between the Euro Zone and other countries, strong rejections of the unit root hypothesis, when they occur, generally start between 1996 and 1999. The process of convergence towards PPP, in contrast, begins earlier, generally in 1992 or 1993. We conclude that there has been a two-stage process of convergence towards PPP. The process started with the adoption of the Maastricht Treaty in 1992 and culminated, in the form of statistically significant evidence, with the achievement of convergence criteria in 1997 and 1998 and the adoption of the Euro in 1999.

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Figure1.a: **EURO-ZONE**
P-values

Austria

Belgium

Finland

France

Germany

Ireland

Italy

Netherlands

Portugal

Spain
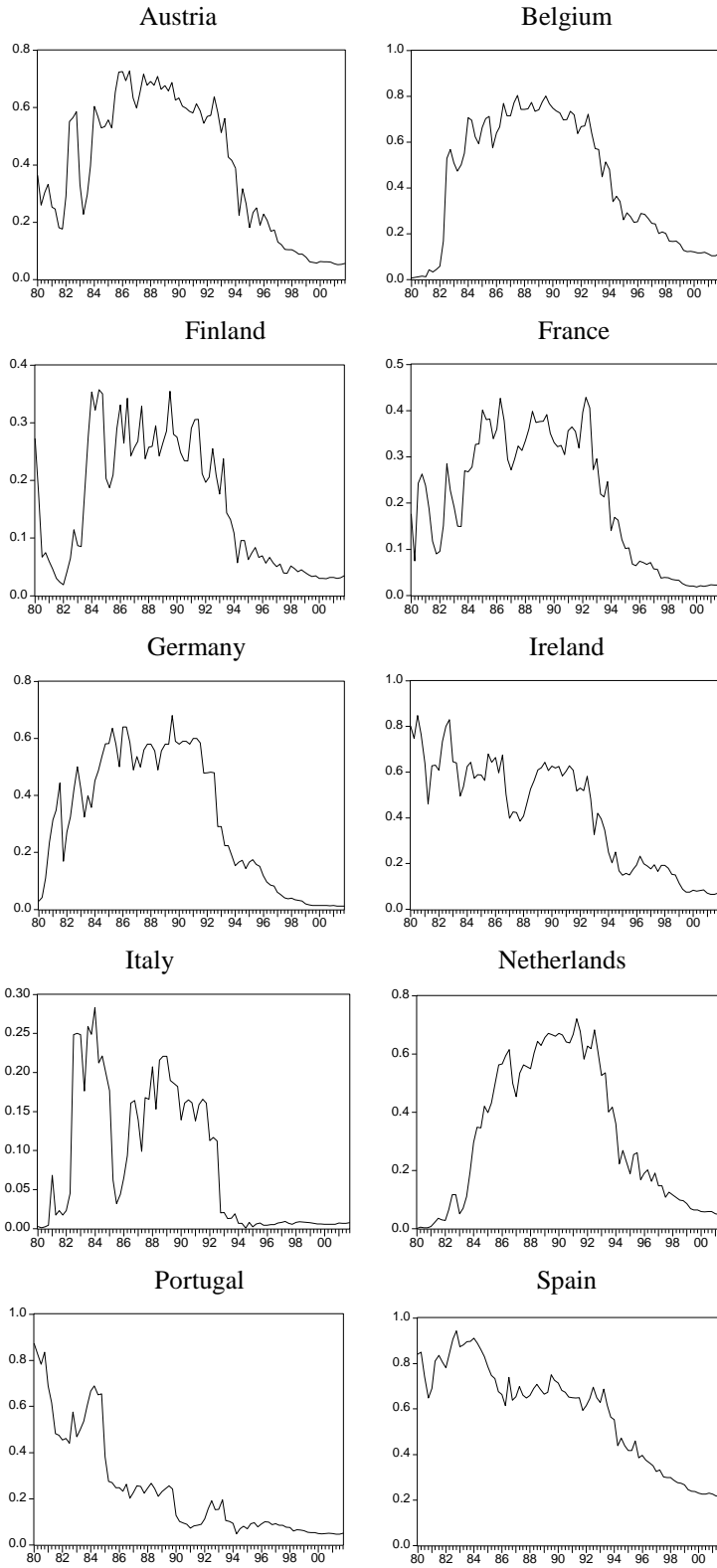
Figure 1.b: **EURO-ZONE**
DF-statistic and 1%, 5%, 10% critical values

Austria

Belgium

Finland

France

Germany

Ireland

Italy

Netherlands

Portugal

Spain
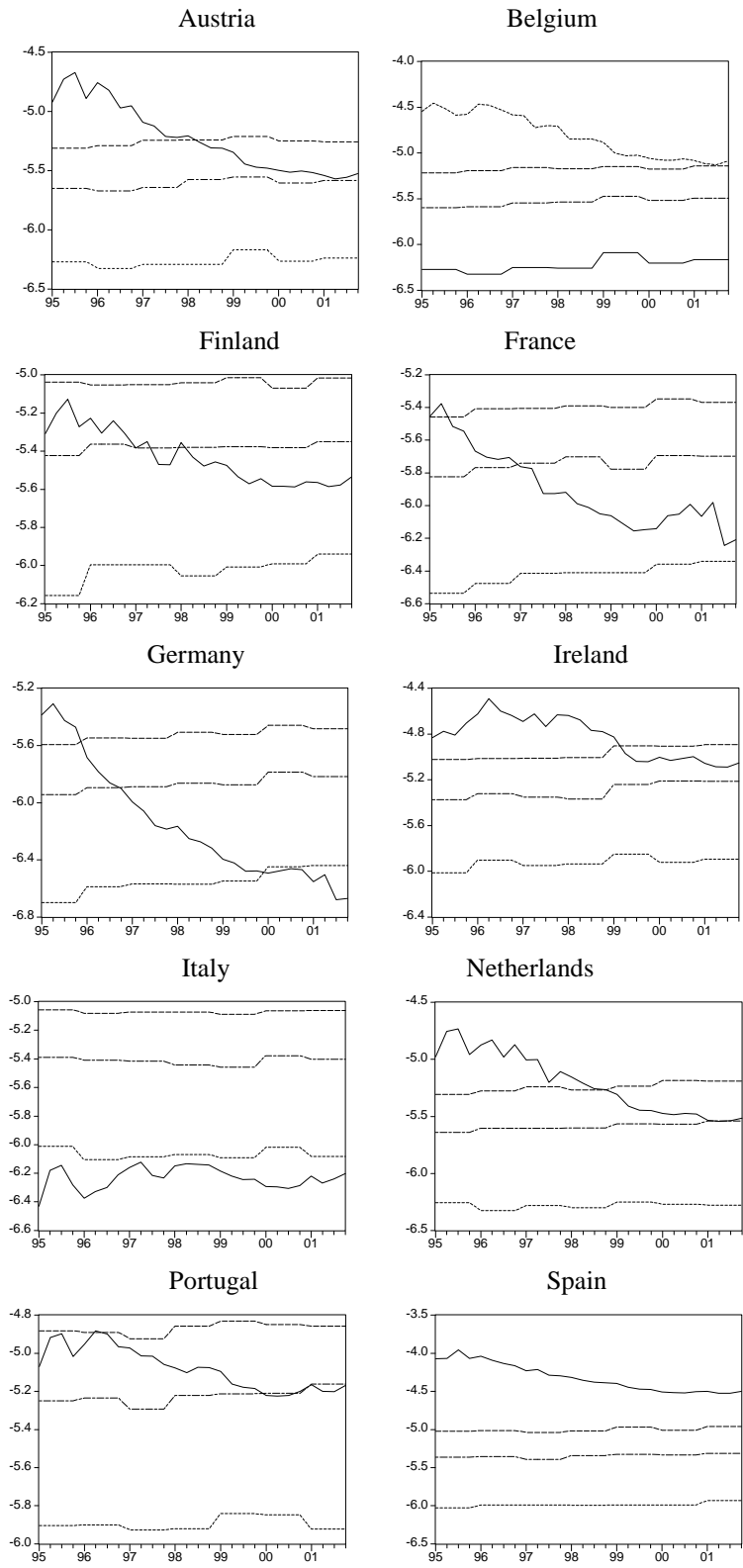
Figure 2.a: **EUROPE**
P-values

Denmark

Greece

Sweden

United Kingdom
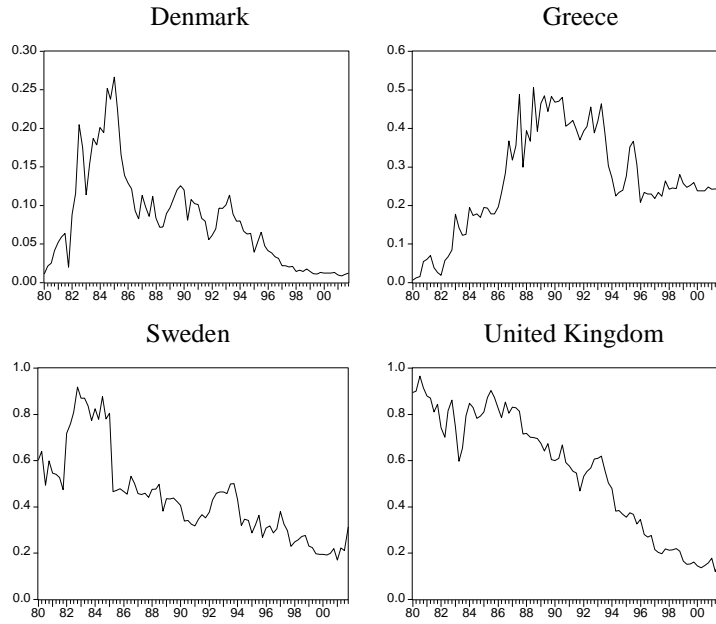
Figure 2.b: **EUROPE**
DF-statistic and 1%, 5%, 10% critical values

Denmark

Greece

Sweden

United Kingdom

15
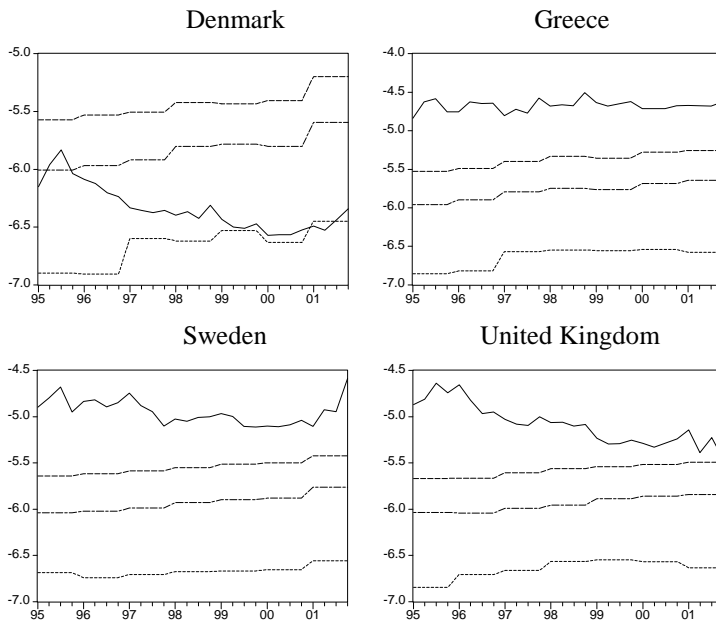
Figure 3.a: **NEGOCIATING COUNTRIES**
P-values

Cyprus

Hungary

Malta

Poland
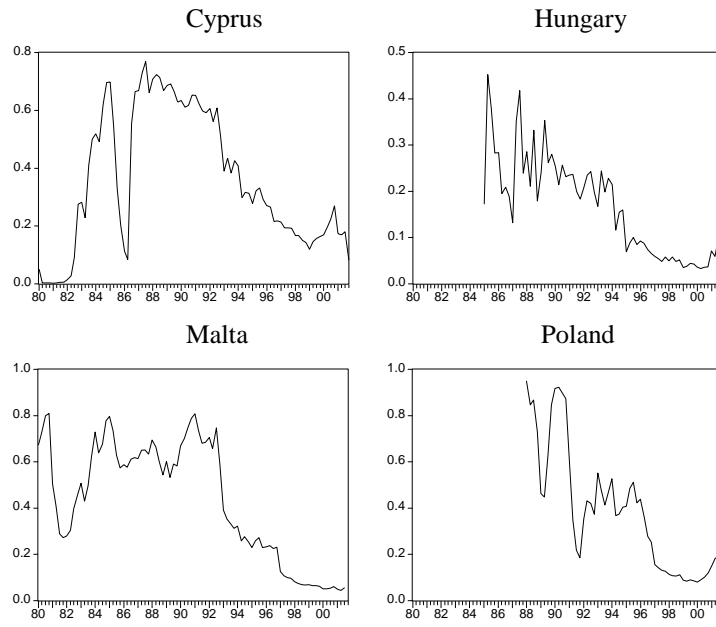
Figure 3.b: **NEGOCIATING COUNTRIES**
DF-statistic and 1%, 5%, 10% critical values

Malta

Hungary

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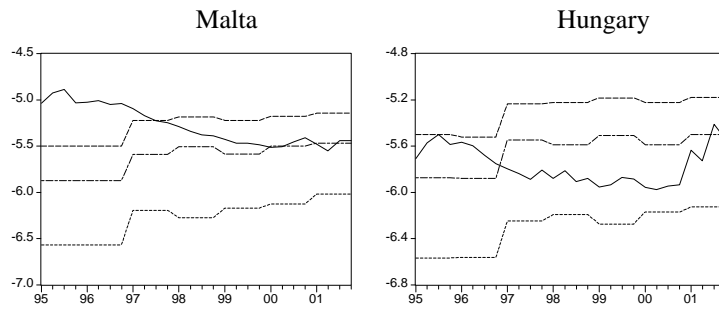
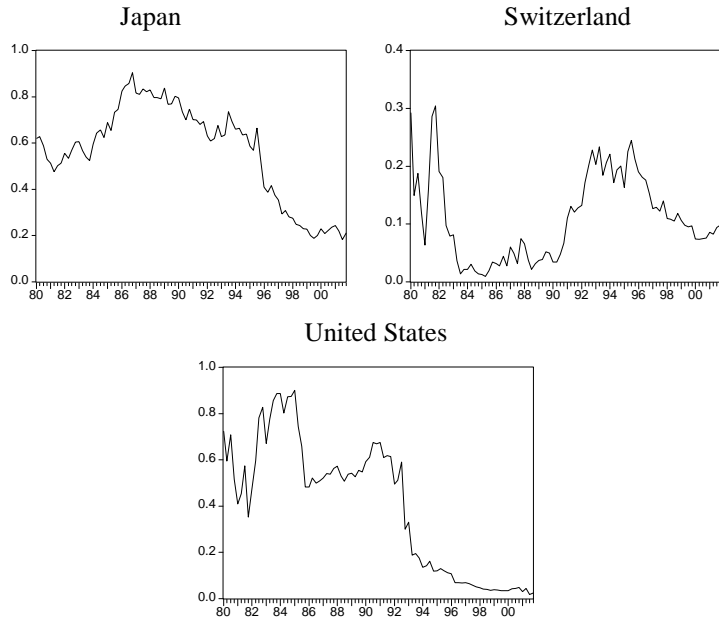Figure 4.a: **INDUSTRIALIZED COUNTRIES**
P-values

Japan

Switzerland

United States

Figure 4.b: **INDUSTRIALIZED COUNTRIES**
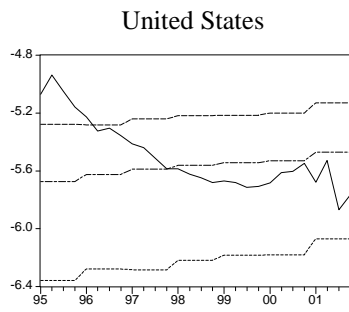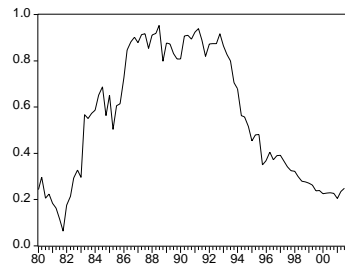DF-statistic and 1%, 5%, 10% critical values

United States

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Figure 5: **MEDITERRANEAN COUNTRIES**
P-values

Morocco

Turkey