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Purchasing Power Parity
A Different Approach

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CONTENTS

1. Introduction

Historically, Purchasing Power Parity (henceforth PPP) provides the simplest explanation of long-run exchange rate determination, according to which the equilibrium exchange rate between domestic and foreign currencies equals the ratio between domestic and foreign prices. In other words:

$$s_t = p_t^* - p_t \tag{1.1}$$

where s_t is the logarithm of the nominal exchange rate (the foreign price of domestic currency) and p_t and p_t^* are the domestic and foreign price levels, respectively. Here we are referring to absolute rather than relative PPP according to which

$$\Delta s_t = \Delta p_t^* - \Delta p_t \tag{1.2}$$

A few years ago, PPP validity theory seemed like a fairly dull research topic. On the one hand the unavoidable effects of floating exchange rates made it obvious to even its most stubborn defenders, that PPP is not a short-run relationship; depreciation or appreciation of a product does not cancel out exchange rate movements on a monthly or even annual basis. On the other hand, there where neither sufficient time spans of floating rate data nor adequate econometric techniques for testing PPP theory as a long-run relationship. Fortunately, things are quite different nowadays and, by means of modern econometric techniques, important results have emerged.

Section 2 of this thesis reviews the huge literature testing simple PPP from naive static tests of PPP, to modern unit-root approaches for testing whether real exchange rates are stationary and to cointegration techniques, the most recent phase of PPP testing. Because convergence to PPP is relatively slow, it is not easy to empirically distinguish between a random-walk real exchange rate and a stationary real exchange rate that reverts very slowly. This is particularly problematic when looking at highly volatile floating exchange rates. One of the major innovations has been to look at longer historical data sets, incorporating fixed as well as floating rate periods. There are some obvious problems in mixing regimes, though these have been addressed to some extent recently.

Section 3, briefly covers the theoretical framework this study is based at. In particular, in this section we describe all the theoretical matters that introduce relevant with econometrics readers, to the results of our thesis. We try to be brief because, the main point of the study is the results we came up with and not the theory that lies beneath. Yet, theory needs to be analyzed for reading comprehension reasons. We analyze both Dickey-Fuller and Augmented Dickey-Fuller tests for unit roots conducted in our time series (RER), and we proceed with Time Varying Coefficient AR(p) models and their dynamic differences compared with the equivalent constant coefficient ones. Lastly, we present a method for examining the stability of the coefficients of an econometric model, namely Variable Parameter Regression.

Section 4, describes our data. We tabulate starting and ending year of our original series (both price indexes and Nominal Exchange Rates), for all the countries we study, and some rules of thumb that we followed while rearranging our data.

In section 5, our work is presented. In particular we reveal our original motives for this kind of research, proceed with the dynamic complications that came up, present our efforts towards overcoming the difficulties and point out the main points of every step. Firstly, we exhibit the formula we followed in constructing the basic time series, Real Exchange Rate (RER), then we tabulate our results on unit roots testing on this series and underline critical results. Thereinafter, we accentuate our concerns on t-statistic's behavior and attempt to answer possible questions on this matter. Lastly, we present our system of equations that models RER as a series, and estimations on the parameters of interest.

Section 6 concludes the thesis; References and Appendices follow.

Frenkel (1978) ran regressions of the form

$$s_t = \alpha + \beta(p_t - p_t^*) + e_t \tag{2.2}$$

for major hyperinflationary countries. He was interested in whether the slope coefficient β equals one. He found estimates of β quite close to one and argued that PPP should be an important "building block" of any model of exchange rate determination. Except for Frenkel's study on the aforementioned group of countries, most early researchers strongly rejected PPP with β estimates far from one (there where cases of estimates close to 2.5 or even negative ones). Yet, they were claiming that PPP still holds in the long-run even though short-run results where contradicting.

Another problem in equation (2.2) is that both exchange rates and price levels are simultaneously determined. Krugman (1978) dealt with the endogeneity problem and although his β estimates using instrumental variables where closer to one than under OLS, one could still reject PPP.

Conclusively, most early seventies tests fail to take into account the possible non stationarity of the relative series in equation (2.2). Today we know that if e_t in (2.2) is non stationary then hypothesis tests of β = 1 are invalid. Yet researchers helped us realize that PPP does not hold continuously, and should only be tested as a long-run theory.

2.2 *Real Exchange Rate as a Random Walk*

In the beginning of eighties opinion turned to another direction. Researchers decided to impose rather than estimate the hypothesis that β = 1, and test rather than impose the hypothesis that the real exchange rate (henceforth RER)

$$q_t = s_t - p_t + p_t^* \tag{2.3}$$

is stationary (all series in logs).

Examples are the studies of Darby (1983), Adler and Lehman (1983), Hakkio (1984), Frankel (1986), Edison (1987), Huizinga (1987) and Meese and Rogoff (1988).

The main problem of these tests is low power. Knowing that exchange rates (especially the floating period data) are extremely volatile, it is very difficult to distinguish between slowly mean reverting and random walk behavior of RER. This issue is more thoroughly tested nowadays using broader data sets and modern statistical methods.

An interesting discussion on the Random Walk hypothesis of RER evolved shortly after Roll's (1979) arguments. According to Roll, RER changes should not be predictable if foreign exchange markets are efficient. Yet, neither RER are traded assets and therefore subject to the usual efficient markets hypothesis, nor Nominal Exchange Rates (NER) follow a Random Walk if there are risk premia.

The Random Walk hypothesis of RER should better be explained by means of macroeconomic theories. A number of studies deal with the above mentioned matters, and try to explain PPP theory using more fundamental factors such as productivity and government spending. Balassa and Samuelson for example, argue that technological progress has historically been faster in the traded goods sector than in the non traded goods sector. More importantly, this bias is greater in high income countries, and as a consequence, CPI levels tend to be higher in wealthy countries. This rise in productivity will cause an unavoidable rise in the entire economy's wages and, producers of non traded goods will only be able to meet the higher wages if there is a rise in the relative price of those goods.

2.2.1 *Existence of unit roots in Real Exchange Rates (RER)*

In the modern literature there are three (3) main techniques for testing the unit root hypothesis in RER. The most commonly used is the Dickey-Fuller and augmented Dickey-Fuller tests. Later on in our study we briefly discuss on this matter theoretically. Tests for unit roots can be performed using the analysis of Phillips (1987) which allows for conditional heteroskedasticity of the residual. Perron (1989) extends Phillips' Z test, to allow for one time changes in the constant and the trend by including dummy variables. The formula for both the above mentioned tests involves a regression of the RER q_t, on a constant, a time trend q_{t-1} and lagged changes in q_{t-1} :

$$q_t = \alpha_0 + \alpha_1 t + \alpha_2 q_{t-1} + \Phi(L) q_{t-1} + e_t \qquad (2.4)$$

where L is the lag operator, $\Phi(L)$ is a p-th order polynomial in L, with coefficients φ_1, φ_2, φ_3, ..., φ_p and e_t is a white noise error term. Under the null hypothesis that q_t follows a random walk (or more generally has a unit root component, since, if the RER has one unit root, then its first difference is stationary though not necessarily serially uncorrelated as in the Random Walk model), $\alpha_2 = 1$. Alternatively if PPP holds in the long run, then $\alpha_1 = 0$ and $\alpha_2 < 1$.

The two other techniques are namely "*variance ratios*" and "*fractional integration*". More on this matters and on estimation techniques generally, are outside the objectives of this study. One can find further information on Diebold, Husted and Rush (1991).

Meese and Rogoff (1988), were unable to reject the unit root hypothesis in RER using floating rate monthly data for dollar/pound, dollar/Yen and dollar/DM exchange rates and applying Dickey-Fuller tests. Basically, empirical literature as a whole, argues that one cannot reject the unit root null if using industrialized countries monthly data for floating rates.

If one uses fixed instead of floating rates data, then the evidence is more mixed. Chowdhury and Sdogati (1993) strongly reject the unit root null for bilateral rates of various European currencies against the Deutsche Mark using data from the 1979-1990 period during which the EMS was in place. Their results for the US dollar are not so straightforward.

As already mentioned, the major concern with this kind of tests is that they lack sufficient power to reject unit root hypothesis in RER against persistent alternatives. The tests give very little information on the aforementioned matter. Frankel (1986, 1990) calibrated a simple autoregression using post Bretton-Woods data, and argued that this sample period is far too short to reliably reject the unit root/random walk null.

According to most of the researcher's conclusions, one needs to either look at a number of currencies simultaneously or look at longer horizon data sets consisting of both pre and post Bretton-Woods data.

2.2.2 Cross Sections Tests

Hakkio (1984) was the first to suggest using cross section data to gain power. He employed GLS estimator to allow for cross exchange rate correlation in the residuals in four exchange rates against the US dollar. According to simple calibration results, he needed eighteen years of monthly data. Although power on his tests was strengthened, he too was unable to reject the random walk model.

Abuaf and Jorion (1990) run autoregressions in levels using GLS estimator for ten countries' currencies against the US dollar over the period 1973-1987. Their rejections of the unit root null were the weakest ones; at the 10% significance level using one sided tests.

Recently, Cumby (1993) made clever use of the "*Economists Hamburger Standard*" which each year reports the dollar price of McDonald's Big Mac hamburger in up to twenty-five countries. By means of only seven years of data (1987-1993) he detects substantial reversion towards the *law of one price*. More importantly, deviations from the relevant Parity exhibit remarkably little persistence, with only 30% of the deviation of one year persisting to the next. Of course in Cumby's study there exist some irregularities. Firstly, relatively few of the currency pairs in his sample are actually floating against each other and convergence appears easier to detect in fixed rather than floating data. Finally, McDonald's pricing policies for their relevant products across the world, may differ from that in a broader price index.

2.2.3 *Tests using Longer Horizon data sets*

By extending data period one might be able to strengthen power in this kind of unit root tests. Frankel (1986) used 116 years of data (1869-1984) for the dollar/pound RER. He found that a simple first-order autoregression yields a coefficient of 0,86, implying that PPP deviations decrease roughly 14% a year and have a half life of 4,6 years. He rejects the unit root null in the 5% confidence level using Dickey-Fuller confidence intervals.

Edison (1987) looks at the US dollar/pound data for the years 1890-1978. He uses the following error-correction mechanism

$$\Delta s_t = \alpha_0 + \alpha_1[\Delta(p - p^*)_t] + \alpha_2(s - p + p^*)_{t-1} \qquad (2.5)$$

where Δs_t is the change in the nominal exchange rate, $\Delta(p - p^*)_t$ is the contemporaneous change in the relative prices and $(s - p + p^*)_{t-1}$ is the lagged RER, (all series in logs). He estimates $\alpha_2 = 0{,}09$ meaning that the NER converges towards PPP at a statistically significant 9% a year (implied half life of 7,3 years). Similarly Johnson (1990) rejects the random walk null hypothesis using 120 years of data for Canadian dollar/US dollar exchange rate. He estimates the half life of PPP deviations to be 3,1 years.

Abuaf and Jorion (1990) are also able to reject the random walk null using time series data from 1901-1972 for eight currencies. Their point estimates suggest a half life of PPP deviations of 3,3 years.

Lothian and Taylor (1994) is an interesting attempt to cast some light on this issue. Using annual data spanning two centuries for dollar/pound (1791-1990) and French franc/pound (1803-1990) RER, they find strong evidence of mean reverting RER behavior. According to their study, simple stationary first-order autoregressive models estimated on pre float data ending in 1973, easily outperform non stationary RER models in dynamic forecasting exercises over the recent float, in that they produce better forecasts of the actual RER. This forecasting superiority increases with the time horizon, which is as it should be if RER are in fact slowly mean reverting. The aforementioned models are capable of explaining some 80% of the variation in the dollar/pound RER and 60 % of the variation in the FF/pound RER during the past two centuries. Additionally, they find that the process of mean reversion is very slow, with estimated half lives of PPP deviations 6 years for the dollar/pound and a little under 3 years for the FF/pound RER. Yet, they are unable to reject the unit root null using only post Bretton-Woods data, and also the hypothesis of no structural change.

Conclusively, they argue that PPP as an equilibrium condition remains a useful empirical first approximation in the long run. Nevertheless, they do not make any finer distinctions with regard to model selection, they simply wonder whether PPP deviations is a result of either real or monetary influences.

Very recently Cuddington and Liang (2000), reexamine the PPP hypothesis for the dollar/pound RER using the data set constructed by Lothian and Taylor, find the time series non stationary for the whole sample period and conclude towards the opposite direction. Yet their method is seriously questionable, since they impose implausible lag lengths of 14 years. Why would anyone entertain the idea of adjustment lags in RER spreading over such a long period, some 15 years ?

Lastly we wish to mention an issue that Roggoff has raised. The countries for which very long run PPP series are easily available, are those few who have continuously been among the world's wealthiest nations. Countries that grew very fast from a low level (e.g. China), and countries that were once rich but are no longer so (e.g. Argentina) have not been studied extensively. But these are precisely the countries for which one can reasonably expect the relative price of goods to have changed dramatically, and for which tests for long run PPP are most likely to fail.

2.3 Cointegration tests on PPP

The motivation for the employment of cointegration methods for testing for PPP is simple: All the commonly employed unit root tests fail to reject the null hypothesis that both the exchange rate and relative prices contain unit roots. Cointegration techniques ask whether a group of non stationary variables (NER and relative prices in our case) can be combined to produce a stationary variable. If so the non stationary variables are said to be cointegrated.

Early cointegration methods of testing PPP where based on a three step procedure. Firstly, one tests the relative time series for unit roots, applying both Dickey-Fuller and augmented Dickey-Fuller tests that have been mentioned earlier. If not rejecting the unit root null, one estimates the following cointegrating relation using for example OLS.

That means

$$s_t = \mu p_t + \mu^* p_t^* + e_t \quad (2.6)$$

and imposing μ = -μ = 1.

Since in case of cointegration the error term in eq. (2.6) is stationary, one uses the OLS residuals of eq. (2.6), runs the Dickey-Fuller regression as described in eq. (2.4) but with the time trend omitted and tests the hypothesis that $\alpha_2 = 1$. In this case, prices and exchange rates are not cointegrated under the null, whereas they are cointegrated under the alternative $\alpha_2 < 1$. More thorough studies, use Johansen's (1991) technique or even Horvath and Watson's (1993) to correct for some inefficiencies in the above methodology.

Enders (1988), Mark (1990), Fisher and Park (1991), Cheung and Lai (1993) and others are examples of cointegration testing studies.

Kim (1990) examines long run PPP in the bilateral exchange rates of the dollar vis-à-vis five countries' currencies, namely Canada, France, Italy, Japan and the United Kingdom. He uses both Wholesale Price

Index (WPI) for the period 1900-1987 and Consumer Price Index (CPI) for the period 1914-1987, so as to test whether the choice of the price index matters.

According to Kim, the NER is cointegrated with both the WPI and the CPI ratios, except for the Canadian dollar which is cointegrated with neither. The relevant coefficient is close to one in cases of cointegration. Thereinafter, the hypothesis that RER follows a random walk is rejected in seven out of ten cases. Finally, each set of exchange rates and relative prices shares no common trends. Thus PPP seems to hold in general. Lastly he claims that NER is more strongly cointegrated with the WPI than with the CPI, either because of real shocks and subsequent changes in the price of non traded goods relative to traded ones, or because of major differences in economic growth among the five countries he examines.

There do exist some common findings in all the previous studies. Firstly, with floating currency pairs one rejects the no-cointegration hypothesis less frequently than with fixed currency pairs. Also tests based on WPI tend to reject more easily than tests based on CPI as Kim explained. Finally rejections of the no cointegration null are easier for trivariate systems (p, p^* enter separately) than for bivariate systems ($p-p^*$ treated as one time series). The problem is that although the environment appears ideal for cointegration techniques, the estimates on the cointegration vector do not seem to be in the vicsinity of unity. Some researchers find estimates of μ and μ^* in eq. (2.6) as great as 25.4 for CPIs, or as great as 11 for WPIs, using only post Bretton-Woods data, with no apparent economic explanation at all. More meaningful studies that apply broader data sets, seem to agree that the point estimate of this parameter is less than one (see for example, Taylor and McMahon 1988, Canarella 1990, Cheung and Lai 1993, Culver and Papell 1999). Interestingly, this piece of evidence seems to be robust to the choice of the cointegration estimator.

If the cointegrating vector between the nominal exchange rate and the relative price is not [1, -1], then the real exchange rate is not identical to the cointegration error. This is not as innocuous as it might look at first sight. If the nominal exchange rate and the relative price are cointegrated, with the unique cointegrating vector being [1, -θ], then the vector [1, -1] is not a cointegrating one, which implies that the real exchange rate is not stationary. In other words, the validity of the PPP theory, under the assumption that the nominal exchange rate and relative price contain unit roots, critically depends on whether $\theta = 1$.

Judging as a whole, cointegration studies have not yet provided some benefits over previous techniques. On the contrary their results are rather misleading, maybe because of the sample bias. More work on the future might prove helpful.

2.3.1 Disbelief against cointegration techniques

A question that immediately arises and was the motive for a different approach in PPP theory by Elliot (1998) and Christou and Pittis (2000), is whether it is appropriate to directly apply integration/cointegration techniques, solely in terms of the results from unit root testing. This is because these tests are notorious to have very low power for near-to-unit root alternatives. In view of this, it is highly plausible that both exchange rates and relative prices do not possess exact unit roots, which in turn raises serious questions on the appropriateness of cointegration methods in this particular context.

Elliott (1998) demonstrates that commonly applied hypothesis tests on the parameters of interest suffer from severe size distortions, when slowly mean reverting processes are approximated by unit roots. Christou and Pittis (2000) extend Elliott's analysis, by exploring the impact of near-to-unit roots on the weak exogeneity status of conditioning variables for the parameters of interest. They show that the major difference between exact and near-to-unit roots lies in the presence (or absence) of weak exogeneity of the regressors in the conditional model. In particular, in the case that regressors almost have unit roots, weak exogeneity of the regressor collapses as the parameter of interest can no longer be identified from the conditional model alone. In such a case, all the single-equation cointegration estimators, such as the Hendry-type Autoregressive Distributed Lag (ADL) or the Phillips - Hansen's Fully Modified Least Squares (FMLS) estimators are doomed to be inconsistent. It is worth emphasizing that these adverse effects are not exhausted in the context of single equation cointegration methods. The simulation results of Christou and Pittis clearly show that system-based estimators, such as the Johansen estimator, also produce inconsistent estimates when near-to-unit roots are approximated by exact unit roots.

Christou and Pittis have dealt with the above matter in a much greater detail. In a very recent study they focus on the reasons that are likely to be responsible for the evidence against cointegration parameter being unity. They also argue that these reasons might be relevant for the PPP puzzle as well.

Let ζ_t and u_t be two bivariate processes, with $\zeta_t=[x_t, y_t]^T$ and $u_t=[u_{1t}, u_{2t}]^T$. Also assume that u_t is an I(0) process and the generating mechanism for y_t is given by the system:

$$y_t=\theta x_t + u_{1t} \qquad (2.7)$$

$$x_t=p x_{t-1} + u_{2t} \qquad (2.8)$$

The extent to which this system is cointegrated depends on the value of parameter p. In particular, if p=1, equations yield the triangular representation of cointegration, put forward by Phillips (1988). On the other hand, if p<1 then the system is stationary. Of particular interest is the case where p is less than but very close to unity.

Next, assume that u_t follows a bivariate VAR(1) process,

$$\begin{pmatrix} u_{1t} \\ u_{2t} \end{pmatrix} \equiv \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix} \begin{pmatrix} u_{1t-1} \\ u_{2t-1} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \qquad (2.9)$$

and

$$\begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \rightarrow IN\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix} \begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{pmatrix}\right] \qquad (2.10)$$

Both eigen-values of the matrix $A=[\alpha_{ij}], i,j=1,2$ are assumed to be less than one in modulus and $\Sigma=[\sigma_{ij}], i,j=1,2$ is positive definite.

According to Christou and Pittis it is possible the accumulated evidence on $\theta<1$ arises from the fact that the cointegration estimators are applied on time series that contain near-to-unit roots. Indeed, it is possible that the rejection of the PPP hypothesis is attributable merely to inconsistency of the employed estimators, provided that the asymptotic bias, $\tilde{\theta}$, is negative and such that $\hat{\theta} - 1 = \tilde{\theta}$. PPP holds remarkably well under the assumption that nominal exchange rates and relative prices contain roots equal to 0,9 a value that standard unit root tests fail to detect. They also argue that the presence of long-run correlation between the regression error and the error that drives the relative price is likely to affect the estimates of half-lives of PPP deviations. This is because these estimates are usually obtained in the context of univariate models for the real exchange rate, thus ignoring any possible feedbacks between the real exchange rate and the error that drives the relative price. Their results from the estimation and hypothtesis testing on θ, combined with the Monte Carlo results on the direction and magnitude of the bias, leave very little doubts on the validity of the second condition (θ=1) for the PPP hypothesis.

3. Theoretical Issues

In our study there are several theoretical matters that need to be explained. Therefore we proceed with the necessary brief discussion on the theoretical framework that covers our study in a broader sense. We intend to reveal the theory that lies beneath our computation/calculation methods. For that we trust a few scientific papers that analyze the relevant information, and lectures in the class by Prof. Pittis in our Post Graduate program.

3.1 Dickey-Fuller, Augmented Dickey-Fuller Tests

3.1.1 Dickey-Fuller (DF) Tests

Let's consider an AR(1) process:

$$y_t = \mu + \rho y_{t-1} + e_t \qquad (3.1)$$

where μ and ρ are coefficients and e_t is assumed to be white noise.
The process is stationary if $-1 < \rho < 1$. If $\rho = 1$, y_t is a non stationary time series (a random walk with drift) or more generally has a unit root component. If the absolute value of ρ is greater than one, the series is explosive.

Therefore, the hypothesis of a stationary time series can be evaluated by testing whether the absolute value of the coefficient ρ is strictly less than one, that is to test the null hypothesis Ho: $\rho = 1$, against the one-sided alternative H_1: $\rho < 1$, since explosive series do not contribute much to empirically testing economic issues/theories.

The test is carried out by estimating the following equation:

$$\Delta y_t = \mu + \beta y_{t-1} + e_t \qquad (3.2)$$

where $\beta = \rho - 1$, (y_{t-1} has been subtracted from both sides of the AR(1) model).

The null and alternative hypotheses are:

Ho: $\beta=0$

H_1: $\beta<0$.

This test cannot be carried out by performing a t-test on the estimated β, because the t-statistic under the null hypothesis of a unit root does not have the conventional t-distribution. Dickey and Fuller (1979) showed that the distribution under the null hypothesis is non-standard, and simulated the critical values for selected sample sizes. More recently, MacKinnon (1991) has implemented a much larger set of simulations than those tabulated by Dickey and Fuller. In addition, MacKinnon estimates the response surface using the simulation results, permitting the calculation of Dickey-Fuller critical values for any sample size and for any number of right-hand variables. E-Views v.3.1 reports these MacKinnon critical values for unit root tests.

3.1.2 Augmented Dickey-Fuller (ADF) test

The simple unit root test described above is valid only if the series is an AR(1) process. If the series is correlated at higher order lags, the assumption of white noise disturbances is violated. The ADF test makes a parametric correction for higher-order correlation by assuming that the time series in discussion follows an AR(p) process and adjusting the test methodology.

The ADF approach controls for higher-order correlation by adding lagged difference terms of the dependent variable y to the right-hand side of the regression:

$$\Delta y_t = \mu + \beta y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_2 \Delta y_{t-2} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + e_t \quad (3.3)$$

This augmented specification is then used to test:

H_o: $\beta = 0$

H_1: $\beta < 0$

in this regression. An important result obtained by Fuller is that the asymptotic distribution of the t-statistic on β is independent of the number of lagged first differences included in the ADF regression. Moreover, while the parametric assumption that y_t follows an auto-regressive process may seem restrictive, Said and Dickey (1984) demonstrate that the ADF test remains valid even when the series has a moving average (MA) component, provided that enough lagged difference terms are added to the regression.

Apart from specifying the number of lagged differences, one has to decide whether to include a constant, a trend or both in the augmented regression. Also, one can use both the Schwartz Information (SIC) and Akaike information (AIC) criteria in order to determine the optimal lag-length of the ADF regression equation. The model he will select will be the one with the smallest information criteria. The notion of an information criterion is to provide a measure of information that strikes a balance between this measure of goodness of fit and parsimonious specification of the model. The various information criteria differ in how to strike this balance.

Definitions

Akaike info criterion (AIC) : $-\ 2\lambda\ /\ n\ +\ 2k\ /\ n$

Schwarz criterion (SC) : $-\ 2\lambda\ /\ n\ +\ k\ \log\ n\ /\ n$

where k is the number of estimated parameters, n is the number of observations, and l is the value of the log likelihood function using the k estimated parameters. The various information criteria are all based on minus 2 times the average log likelihood function, adjusted by a penalty function.

The null hypothesis of a unit root is rejected against the one-sided alternative if the t-statistic is less than (lies to the left of) the critical value.

3.2 *Autoregressive Process with Time Varying Coefficient*

Varying Coefficient models have received regular attention in the econometric literature. An example is Nicholls and Pagan (1983) and the references listed in their paper, although these studies do not include lags of the dependent variable, the RER in our case. Hence, the stability of the process depends only on the "coefficient equation". Andel (1971, 1976), Nicholls and Quinn (1983) and Ledolter (1979, 1980) appeared to have studied processes with lagged dependent variables, although not in a thorough detail. Granger and Andersen (1978) managed to join the properties of a "Bilateral Process" with time varying processes, only in special cases where one is able to obtain conditions for stability.

This last approach was studied in great detail in a study by Andrew A. Weiss (1985) for an AR(1) process with AR(1) coefficient. The basic process he considers is

$$\begin{aligned} y_t &= \beta_0 y_{t-1} + \beta_t y_{t-1} + e_t \\ \beta_t &= M \varphi_{t-1} + u_t \end{aligned} \qquad (3.4)$$

where e_t and u_t are Gaussian white noise with

- $E(e_t) = E(u_t) = 0$,
- $E(e_t u_s) = 0$ for all s, t (3.5)
- $E(e_t^{\,2}) = 1$
- $E(u_t^{\,2}) = Q$

This AR(1) process, in which the coefficient of y_{t-1} also follows an AR(1) process, is an extension of the constant coefficient AR(1) process and is the basic member of the class of varying coefficient ARMA processes. The difference between constant coefficient and time varying coefficient AR(1) models, lies in the dynamic complication of the latter's analytics. Correlation in the "error term" in eq. (3.4)a is introduced, when $M \neq 0$ and we allow for a lagged dependent variable.

The basic requirement for this process to be useful in econometrics (meaning consistency and Asymptotic Normality of the relevant estimates and therefore second order stationarity) is

$$E(y_t^{\,2}) < \infty$$

In the usual AR(1) process (equations (3.4) with $M = Q = 0$), $\beta_t = 0$ for all t, and the condition reduces to $|\beta_0| < 1$. One could suppose the relevant condition ($|\beta_t| < 1$) on the time varying model. However, as Weiss states "we cannot impose such an absolute condition on β_t because of the interaction between the two equations and the stochastic nature of β_t".

It is true that the basic process Weiss considers (equations (3.4)), is not identical to the time varying model we are willing to estimate. In particular, we wish to allow for a constant in equation (3.4)a because generally in Economics, RER are considered to be time series with non zero mean value. Therefore we want a model that could describe RER data under all circumstances. If it were the case such that $|\beta_0| < 1$ and β_t stationary with zero mean, then obviously we attempt to model RER through a set of equations that describes series with zero mean value. Yet, allowing for a constant in eq. (3.4)a does not dramatically change the general conclusions of Weiss analysis for cases such as ours with RER series. After all, one can reasonably assume that the basic process in eq (3.4)a, y_t equals the sum of RER and a constant y_0. Therefore :

$$Y_t = RER + y_0 \qquad (3.6)$$

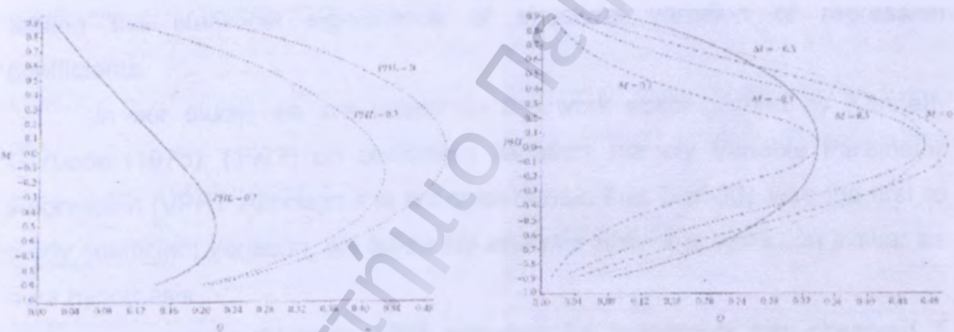
Continuing the discussion above, Weiss obtains a sufficient condition for the stability of the AR(1) process with an AR (1) coefficient. He claims that a process $\{y_t,\ t = 0, 1, \dots\}$ is stable (meaning that both its first and second conditional moments $E\{y_t / y_o\}$ and $E\{y_t\, y_s / y_o\}$ for fixed $s = 0, 1, \dots$ converge to fixed values not depending upon the initial value y_o) if

$$R + S^2(\infty) < 1 \qquad (3.7)$$

where:

- $\overline{B}_t = \beta_0 + \beta_t$
- $R = E(\overline{B}_t^2) = \beta_o^2 + Q/(1 - M^2)$
- $S^2(\infty) = var(\overline{B}_t^2) + 2\lim(\sum_{j=1}^{n} \frac{n-j}{n} cov(\overline{B}_t^2, \overline{B}_{t-j}^2))$

and according to Weiss it is easy to tabulate values of β_0, M and Q such that condition (3.7) holds for any large n. Weiss has given us some examples in the following figures:



Figures 3.1 – 3.2

The basic result of both the figures earlier reported is that, for certain values of some of the parameters of the model in discussion, one can argue stability for the series he studies if the point estimates of the remaining parameters lie in the concave of the above figures.

Moreover, as Weiss claims, equation (3.7) limits the correlation between terms in the $\overline{\beta_t}$, so that if the process becomes explosive $(|\beta_t| \geq 1)$, the expectation is that it is quickly brought back to stability.

More thorough details on studies concerning time varying coefficient models are outside the purpose of this thesis, yet there are some listed topics on our references section.

3.3 *A method for examining the Stability of Regression Coefficients*

When applying statistical techniques and performing empirical studies, econometricians, usually are able to justify the choice of a model based on theoretical arguments. However, when discussing the stability of the model's coefficients things are not as easy. Some researchers have tried to work in those fields of econometric theory. Quant (1958) for example, has estimated the location from a shift from one regression to another and Quant (1960) and Chow (1960) have tested the null hypothesis of a shift at a particular point in time. Also Brown, Durbin and Evans (1975) have proposed two methods for testing the statistical significance of structural variation of regression coefficients.

In our study, we are based on the work accomplished by Kenneth Garbade (1975), (1977) on coefficient variation, namely Variable Parameter Regression (VPR). Although it is not quite certain that Garbade was the first to study coefficient variation, we follow his analysis since it is based on similar as ours hypothesis.

According to Garbade, VPR assumes the researcher has observed T ordered scalar observations $\{y_1, y_2, \ldots, y_T\}$ generated by the model :

$$y_t = x_t\beta_t + u_t \qquad t = 1, \ldots, T \qquad (3.8)$$

$$u_t \sim N(o, \sigma^2)$$

where x_t is a n-dimensional vector of known exogenous regressors and β_t is a n-dimensional vector of unknown coefficients. Furthermore Garbade assumes the β vector follows a random walk with zero drift through time:

$$\beta_t = \beta_{t-1} + p_t \qquad t = 2, \ldots, T \qquad (3.9)$$

$$p_t \sim N(0, \sigma^2 P)$$

where $\sigma^2 P$ is the stationary covariance matrix of the innovation p_t.

If P = 0, then VPR reduces to the ordinary stationary coefficient linear regression problem. The variance term σ^2 is the same in both equations. This is so for expositional convenience reasons. The "error terms" u_t, p_t are serially uncorellated.

Garbade claims that the simple form retained here (equations (3.8), (3.9)), is appropriate since researchers are not concerned with estimating a particular stochastic process generating the β's. Instead, they wish to examine the stability of the β's, and a possible pattern of any indicated variation. In the case of rejection of the hypothesis of constant coefficients, they might consider structural explanations of the β's as functions of additional exogenous variables, rather than develop more complicated models of stochastically evolving coefficients.

Obviously, the model introduced through eq. (3.8), (3.9), is more specific than the AR(1) model with time varying coefficients of the same order (AR(1)) we earlier analyzed. Yet, the method examined for its validity under Garbade's work, applies to our hypothesis as well.

Garbade proceeds with explaining how estimation takes place. He describes the mechanism that revises original estimates of β_t' s, gives analytical formulas for computing and estimating, thoroughly explains certain hypothesis needed for the validity of the aforementioned method and tests the resultant filtered estimates. He uses estimates that maximize log likelihood function

$$L^*(P) = -(T - n)\ln(\hat{\sigma}) - \frac{1}{2}\sum_{t=n+1}^{T}\ln(E_t) \qquad (3.10)$$

for the parameters of interest, in particular σ^2 and mainly P, where $\hat{\sigma}$ and E_t are both implicit functions of P.

Then, based on Monte Carlo experiments, he provides us with the empirical distribution of the relevant statistic:

$$-2\ln(\lambda) = -2\,[\,L^*(P_0) - L^*(P)\,] \qquad (3.11)$$

Accordingly, he provides us with the means to test whether the maximum likelihood estimate of the coefficient variance is statistically different from an hypothesized value (zero in our case), and to produce important results on the stability of the coefficients of RER in our study.

Kendall and Stuart (1973) say that for non zero variances in eq. (3.9) the statistic has asymptotically a chi-square distribution with one degree of freedom. Garbade proves that the likelihood statistic will be more concentrated toward the origin than a chi-square, because maximum likelihood estimates less than zero are set to zero. Thus, using a chi-square distribution to determine critical values of the statistic, would have led to a conservative test for the stability of the β_t coefficients.

Finally, VPR as a whole provides the researcher with a graphical representation of the estimated evolving coefficients based on the full set of observations, and with standard errors for those estimates. This is useful for judging the quantitative as well as the statistical importance of those estimates, and for someone who wishes to identify some patterns or structural breaks in the Data Generating Mechanism.

4. Data set description

Empirical tests of long run relationships require considerable amounts of data. Although in econometric studies, more observations are always preferable to less, Hendry (1986) points out that increasing the sample size by "simple disaggregation" (from years to months say) is not likely to reveal such long run relationships. Isaard (1983) estimates that two to five years are required for PPP to be reestablished after a disturbance, while Frankel (1986) claims that ten or more years might be required. High frequency data (e.x. monthly data) over a short horizon may not be able to detect convergence that takes this much time. In this study, we follow Frankel (1986) who argues that long run PPP is most accurately tested using annual data over a long period.

The data set we shall use consists of annual observations of 39 countries' currencies against the US dollar exchange rates and the Wholesale and Consumer Price Indexes of those countries and United States. In some cases the data span a little more than 30 years ending in 1997/1998 and in others more than two centuries beginning around 1800. This is because the exchange rate and relative prices require considerable time before they assume sizable proportions.

This sample offers a uniquely rich body of data for studying exchange rate behavior. For the major countries we study, exchange arrangements varied considerably over the sample period ranging from the pure gold standard to wartime controls of varying intensity and episodes of floating rate and flat money.

Confrontation with data spanning more than two centuries in length has both benefits and costs. On the benefit side, it is, of course, the fact that a possible mean reversion of the regression error is allowed to appear and the fact that more stringent tests can be accomplished. On the cost side, it is the potential problem of regime changes and parameter instability.

In Table 4.1 all 40 countries are shown alphabetically along with relevant information concerning the beginning-ending year of our data. Both Price indexes are tabulated.

Table 4.1

A/A	COUNTRY	WPI DATA		CPI DATA	
		START YEAR	END YEAR	START YEAR	END YEAR
1.	Argentina	1913	1998	1913	1998
2.	Australia	1901	1998	1861	1998
3.	Austria	1924	1998	1919	1998
4.	Belgium	1927	1998	1835	1998
5.	Brazil	1937	1998	1912	1998
6.	Canada	1900	1998	1910	1998
7.	Chile	1928	1998	1913	1998
8.	Colombia	1948	1998	1923	1998
9.	Costa Rica	1937	1998	1937	1998
10.	Denmark	1900	1997	1864	1998
11.	Egypt	1913	1997	1915	1998
12.	Finland	1920	1997	1920	1998
13.	France	1900	1998	1840	1998
14.	Germany	1800	1998	1820	1998
15.	Greece	1930	1997	1923	1998
16.	India	1914	1997	1921	1998
17.	Iran	1936	1997	1936	1998
18.	Ireland	1946	1997	1922	1998
19.	Israel	1968	1998	1922	1998
20.	Italy	1910	1997	1861	1998
21.	Japan	1868	1998	1900	1998
22.	Mexico	1887	1998	1900	1998
23.	Morocco	1939	1997	1939	1998
24.	Netherlands	1901	1998	1880	1998
25.	New Zealand	1913	1997	1915	1998
26.	Norway	1880	1998	1835	1998
27.	Pakistan	1961	1998	1950	1998
28.	Philippines	1935	1997	1937	1998
29.	South Africa	1910	1998	1900	1998
30.	South Korea	1930	1998	1948	1998
31.	Spain	1814	1998	1914	1998
32.	Sweden	1860	1998	1830	1998
33.	Switzerland	1816	1998	1890	1998
34.	Taiwan	1949	1997	1951	1998
35.	Thailand	1947	1998	1948	1998
36.	Tunisia	1940	1997	1938	1998
37.	Turkey	1930	1998	1922	1998
38.	United Kingdom	1790	1998	1820	1998
39.	United States	1720	1998	1820	1998
40.	Venezuela	1900	1997	1933	1998

As regards the nominal exchange rates, we have used bilateral NER of the country' s currency against the US dollar (e.x. Pound/US dollar in the case of United Kingdom). In all cases, the data for the NER begun earlier on in the past compared to the price indexes. Obviously, one of the two countries in discussion in each case was the United States of America. This is so for comparison reasons.

4.1 Rearranging Data

The original data set was three different MS-Excel files, each with a specific time series for several countries. Two of the files contained the two different Price data, namely CPI and WPI in an index format. The base year was unknown in each country's indexes. The latter file contained the Nominal Exchange Rates for almost two hundred of currencies of different countries against the US dollar.

Firstly we have chosen the 40 aforementioned countries for which the data were adequate for calculations. Our rule was "at least 30 years of constant data in each of the time series in discussion". Then, the NER time series was transformed to an index format. Thereinafter, for each set of time series (e.x. NER of pound/US dollar, UK WPI and USA WPI) we made sure that data begin in the same year which was chosen to be the new base year. This latter procedure is called "rebasing" of the data.

The data set is kindly donated to us by University of Cyprus.

5. Methodology - Results

5.1 Real Exchange Rates creation – DF, ADF tests

The data set for each of the 39 countries, as imported in E-Views v.3.1, was three different time series in an index format and with the same base year. E-views v.3.1 was used for all the calculations since, being a statistical software, it is more accurate than MS-Excel. The series were the following, using "WPI United Kingdom" workfile as an example:

- Nominal Exchange Rate pound/US dollar: (NER)
- WPI for the United Kingdom: (UKIDX)
- WPI for the United States: (USAIDX)

Real Exchange Rate (RER), as a time series, was created through the formula :

$$\text{Log (RER)} = \text{Log(NER)} - \text{Log(UKIDX)} + \text{Log(USAIDX)} \quad (5.1)$$

Our motive was tests for unit roots in the RER time series. For that we conducted both Dickey-Fuller, and Augmented Dickey-Fuller with one lag, tests for unit roots in the series. Both tests conducted on LEVEL. We chose not to model the series through AR models of a higher order guided by, both the Information Criteria mentioned in section 3.1.2, and our intuition. We argue that the RER as a stochastic process is by its nature describable through AR(1) or AR(2) models at most. The results of these tests are shown in table 5.1 for each country using WPI data, and in table 5.2 for each country using CPI data. The series tested for stationarity is, as already mentioned, RER as stated in eq (5.1). Unit root tests are DF tests (equivalently ADF with 0 lags), and ADF tests with 1 lag as proposed by the information criteria for each case.

Table 5.1 (WPI DATA used)

A/A	COUNTRY	STATIONARY (95% level)	NON STATIONARY (95% level)	REMARKS
1.	Argentina		X	
2.	Australia		X	
3.	Austria	X (1 lag)	X (0 lag)	
4.	Belgium		X	In the limit
5.	Brazil		X	In the limit
6.	Canada	X		
7.	Chile		X	
8.	Colombia	X (0 lag)	X (1 lag)	
9.	Costa Rica	X		
10.	Denmark	X (1 lag(	X (0 lag)	
11.	Egypt		X	
12.	Finland		X	In the limit
13.	France	X		
14.	Germany		X	
15.	Greece		X	
16.	India	X		
17.	Iran		X	
18.	Ireland		X	
19.	Israel		X	
20.	Italy	X		
21.	Japan	X (0 lag)	X (1 lag)	
22.	Mexico	X		
23.	Morocco	X		
24.	Netherlands	X		
25.	New Zealand		X	
26.	Norway	X		
27.	Pakistan	X		
28.	Philippines	X		
29.	South Africa	X		
30.	South Korea	X		
31.	Spain		X	
32.	Sweden		X	In the limit
33.	Switzerland		X	
34.	Taiwan	X		
35.	Thailand	X		
36.	Tunisia	X		
37.	Turkey	X (0 lag)	X (1 lag)	
38.	United Kingdom	X		
39.	Venezuela	X (0 lag)	X (1 lag)	In the limit

MacKinnon critical value for rejection of hypothesis of a unit root in the 95% confidence level : -2.8755

Table 5.2 (CPI DATA used)

A/A	COUNTRY	STATIONARY (95% level)	NON STATIONARY (95% level)	REMARKS
1.	Argentina		X	
2.	Australia		X	In the limit
3.	Austria	X (1 lag)	X (0 lag)	In the limit
4.	Belgium		X	
5.	Brazil		X	
6.	Canada		X	
7.	Chile		X	
8.	Colombia		X	
9.	Costa Rica		X	In the limit
10.	Denmark	X (1 lag)	X (0 lag)	In the limit
11.	Egypt		X	
12.	Finland		X	In the limit
13.	France	X		
14.	Germany		X	
15.	Greece		X	
16.	India		X	
17.	Iran		X	
18.	Ireland		X	In the limit
19.	Israel		X	
20.	Italy	X		
21.	Japan		X	In the limit
22.	Mexico	X		
23.	Morocco	X		
24.	Netherlands		X	In the limit
25.	New Zealand		X	
26.	Norway	X		
27.	Pakistan		X	
28.	Philippines	X		
29.	South Africa	X		
30.	South Korea	X		
31.	Spain	X (1 lag)	X (0 lag)	
32.	Sweden	X		
33.	Switzerland		X	
34.	Taiwan		X	In the limit
35.	Thailand	X		
36.	Tunisia		X	
37.	Turkey		X	
38.	United Kingdom		X	
39.	Venezuela		X	

MacKinnon critical value for rejection of hypothesis of a unit root in the 95% confidence level : -2.8755

It is rather obvious that things are not as easy as one might expect. Our results are summarized as follows:

Table 5.1

- In table 5.1 there are 16 countries for which the RER using WPI data, is a non stationary of the unit root type series, among them Argentina, Australia, Brazil, Canada, Germany, Greece, Spain and Switzerland.
- There are 6 countries, namely Austria, Colombia, Denmark, Japan, Turkey and Venezuela, for which the results are confusing meaning that RER is either stationary or not, depending on the order of the AR model. In any case the stationarity status is in the limit, meaning that the reported t-statistic is very close to the DF critical value in the 95% confidence level.
- The remaining 17 countries' RER, is a stationary series according to the DF and ADF tests, on the models examined. Among these countries is France, India, Italy, Mexico, South Africa and United Kingdom.
- There are cases (e.x. Sweden), where the stationarity status of the series is the same under both Df and ADF tests, but is in the limit.

Table 5.2

- In table 5.2 there are 26 countries for which the RER using CPI data, is a non stationary of the unit root type series, among them Belgium, Chile, Egypt, Israel, New Zealand, Turkey and Venezuela.
- There are only 3 countries, namely Austria, Denmark and Spain, for which the results are confusing meaning that RER is either stationary or not, depending on the order of the AR

model. In any case the stationarity status is in the limit, meaning that the reported t-statistic is very close to the DF critical value in the 95% confidence level.

- Only 10 countries, among them France, Italy, Mexico and South Korea, for which RER is a stationary series according to the DF and ADF tests, on the models examined.
- There are cases (e.x. Taiwan), where the stationarity status of the series is the same under both Df and ADF tests, but is in the limit.

Table 5.1 – 5.2

- If one looks closer to the examples in both tables, he shall find out that for some countries the results on the stationarity status of the RER are different depending on the certain Price Indexes used. Take United Kingdom for example. The data sets cover more than two centuries in the past for both WPI and CPI as reported in table 4.1. Therefore the results are plausible to say the least. If one uses WPI data, then RER is clearly a stationary series and the validity of the PPP theory is strongly reinforced. Yet, judging by the CPI data for the same country, the PPP theory collapses. United Kingdom is a major and stable economy of the world, traditionally among the wealthiest nations and this result is not so easily justified by the differences of the two price indexes, especially with more than two hundred years of constant data. Serious questions about the appropriateness of the whole methodology chosen, or even of the family of models used arise.

  In table 5.3, lie the results of all the unit root tests conducted for the United Kingdom data sets, reported for both price data. We choose United Kingdom, mainly because most other researchers have studied the same data and supported their results on either the validity or not, of the PPP theory, using the same methodology.

Table 5.3

Dickey-Fuller Test Equation in RER using WPI data.			
Dependent Variable: D(REALEXR) Sample(adjusted): 1791 1998 Included observations: 208 after adjusting endpoints			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
REALEXR(-1)	-0.188727	0.041518	-4.54568
C	0.902105	0.198789	4.537999
DF Test Statistic	-4.54568		
Augmented Dickey-Fuller Test Equation in RER using WPI data.			
Dependent Variable: D(REALEXR) Sample(adjusted): 1792 1998 Included observations: 207 after adjusting endpoints			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
REALEXR(-1)	-0.194097	0.044099	-4.40143
D(REALEXR(-1))	0.017735	0.070409	0.251888
C	0.928161	0.211184	4.395043
ADF Test Statistic	-4.401427		
Dickey-Fuller Test Equation in RER using CPI data.			
Dependent Variable: D(REALEXR) Sample(adjusted): 1821 1998 Included observations: 178 after adjusting endpoints			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
REALEXR(-1)	-0.039384	0.019889	-1.98014
C	0.206595	0.10246	2.016355
DF Test Statistic	-1.980143		
Augmented Dickey-Fuller Test Equation in RER using CPI data.			
Dependent Variable: D(REALEXR) Sample(adjusted): 1822 1998 Included observations: 177 after adjusting endpoints			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
REALEXR(-1)	-0.041707	0.020201	-2.06462
D(REALEXR(-1))	0.067344	0.075369	0.893533
C	0.218272	0.104077	2.097229
ADF Test Statistic	-2.064624		

Note : REALEXR ≡ Real Exchange Rate (RER)

*MacKinnon critical values for rejection of hypothesis of a unit root.	
1% Critical Value*	-3.4631
5% Critical Value	-2.8755
10% Critical Value	-2.5741

5.2 *Erratic Behavior of the t-statistic*

As described in the thesis proposal our first ideas for the series in discussion, and the basic motive for our study at first place, was completely different. Our first thoughts were as follows.

The Data Generation Processes (DGP's) defined in most studies that test PPP validity theory, cover thoroughly exact and near-to-unit roots territory. In both cases the results are rather convincing as regards the work that has been accomplished. Additionally, the antithesis in other researcher's results was pointing to an important issue that needs to be examined. In particular, how possible it could be that all the parameters in the models have remained constant over a long period of time? And if parameter instability is present, then how does it affect the properties of the estimators and test statistics? In particular how do the various cointegration estimators, namely OLS, JOH, ADL, AADL and various versions of FMLS behave under both the above cases when structural breaks in either the exchange rate or the relative prices or both are introduced?

At this moment it is natural to explain what we mean by the phrase "structural breaks are introduced". Common logic says that long data sets that are needed for the relevant series to become sizeable proportions, more probably arise out of not completely identical Data Generation Processes. There might be a radical change in the fundamentals of the relevant economies, or there might be a long lasting war (World War II for example), that altered the correlation or the dependence between the series. Therefore it is necessary to test how the estimators and test statistics behave if we suppose that our data set comes not from one but from a few different DGPs and conduct Monte Carlo simulations using different coefficients for the models that we were planning to study. This were our first thoughts and for that we proceed as follows in the next subsection.

5.2.1 t-statistic constructed as a series

Naturally, we thought it could be a good start to try to identify this kind of breaks in our data. The methodology was simple, yet it allowed us to create a new time series in our workfiles for all the countries in discussion, namely "TSTAT", which is the computed t-statistic from the recursive estimation of the coefficients of the model. The model in each case, was either AR(1) or AR(2) as implied by the Information Criteria (AIC, SC) we explained earlier (section 3.1.2).

Analytically, suppose for example that, judging by the criteria, the best representation of RER in the case that follows, is an AR(1) model. We allow for a constant as already explained. The model for the time series in discussion, namely RER, is (using first differences):

$$\Delta y_t = \beta_0 + \beta_1 y_{t-1} + u_t \qquad (5.2)$$

where y_t is the log of the Real Exchange Rate (eq. (5.1)), and u_t is a white noise "error term".

E-views v.3.1 automatically performs recursive estimation of the coefficients of the model in eq. (5.2). The relevant equation is estimated repeatedly, using ever larger subsets of the sample data. If there are k coefficients to be estimated in the model, then the first k observations are used to form the first estimate. The next observation is then added to the data set and k+1 observations are used to compute the second estimate. This process is repeated until all the T sample points have been used, yielding T-k+1 estimates of the coefficients. At each step the last estimate can be used to predict the next value of the dependent variable. This view enables us to trace the evolution of estimates for any coefficient as more and more of the sample data are used in the estimation. It also provides a plot of selected coefficients in the equation for all feasible recursive estimations. Also shown are the standard error of the estimated coefficients.

If the coefficient displays significant variation as more data is added to the estimating equation, it is a strong indication of instability. Coefficient plots will sometimes show dramatic jumps as the postulated equation tries to digest a structural break.

Thereinafter, using the recursive estimates on the β_1 and its standard error, namely "β_1SE", we computed the t-statistics (eq. (5.3) and saved the results as series.

$$t - stat = \beta_1 / \beta_1 SE \qquad (5.3)$$

5.2.2 Erratic behavior

Our aim was to find out the behavior of the statistic as more and more data were added in the sample. If there were big jumps in either the rejection or the acceptance region, or if there was a jump from one region to the other, especially after omitting the first few calculations to avoid small sample effects, then the relevant year would be a strong sign of a structural break in the Data Generation Process. The figures below are just a few from the 78 t-statistic plots that were totally created (39 countries and two RER time series -using both WPI and CPI- for each country).

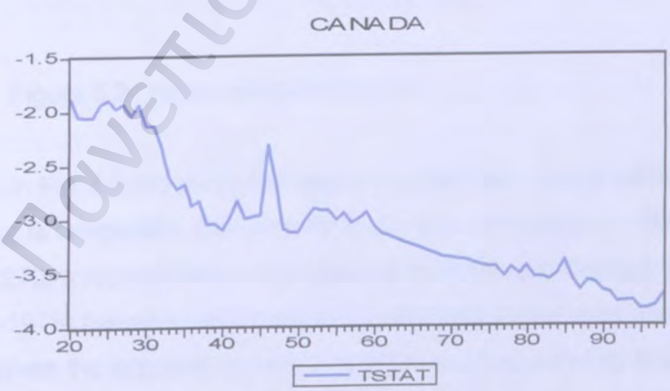


Figure 5.1 : t-stat using WPI DATA

Take figure 5.1 for example. Our WPI data for Canada begin in 1900. Things look quite ordinary hear and by examining the more recent part of the graph, one would reasonably argue that RER is stationary series since the computed t-statistic for the years after 1955 lays in the rejection region (greater than –2.8755). Nevertheless, the fact that one needs over 55 observations to reject the unit root null in the RER is suspicious to say the least. If a researcher would consider testing for unit roots in RER, using data until 1954 he would have accepted the null hypothesis of a unit root in the time series.

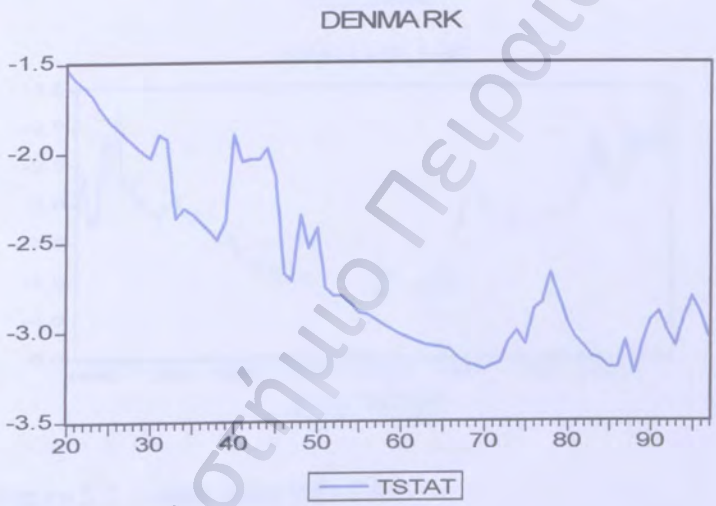


Figure 5.2 : t-stat using WPI DATA

In Fig. 5.2 the problems become quite clear. The erratic behavior of the t-statistic is inarguable. Our data for Denmark, also begin in 1900. By using data until 1970, a researcher would have rejected the unit root null. A few years later (1976-1978) the same empirical study with only a few more observations, would have given the opposite results. And by examining carefully the very last part of the graph (years until almost nowadays) we observe that the computed t-statistic "jumps" from the rejection to the acceptance region and vice versa almost every year!

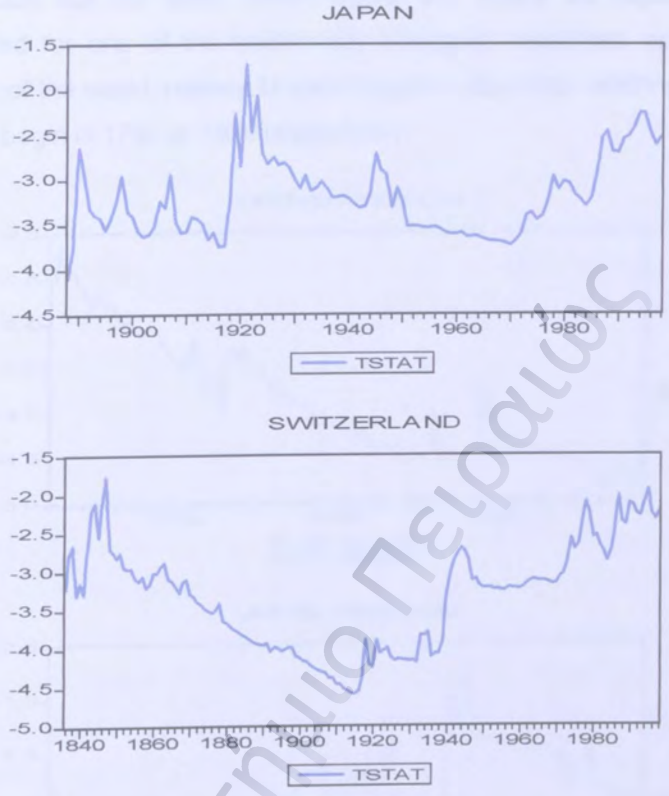


Figure 5.3 : t-stats using WPI DATA

A wary reader, would probably argue that either the data set is not adequate, or Danish economy is not among the strongest ones in the world. The two graphs presented in figure 5.3 convincingly answer these questions. The same characteristics in the behavior of the computed t-statistic appear in Japan's graph, which is among the wealthiest nations of the world through most of the 20th Century. In Switzerland, data begin in 1816 and the general picture remains unaltered. A researcher in 1980 would have rejected the unit root null for Switzerland's RER, while the same researcher nowadays would have had strong arguments against the validity of the PPP theory, since the results would have pointed towards non stationary RER.

Last but not least comes figure 5.4. There we represent t-statistic computed for one of the traditionally strongest, wealthiest and more stable nations of the world, namely United Kingdom. Our data referring to either WPI or CPI, begin in 1790 or 1820 respectively.

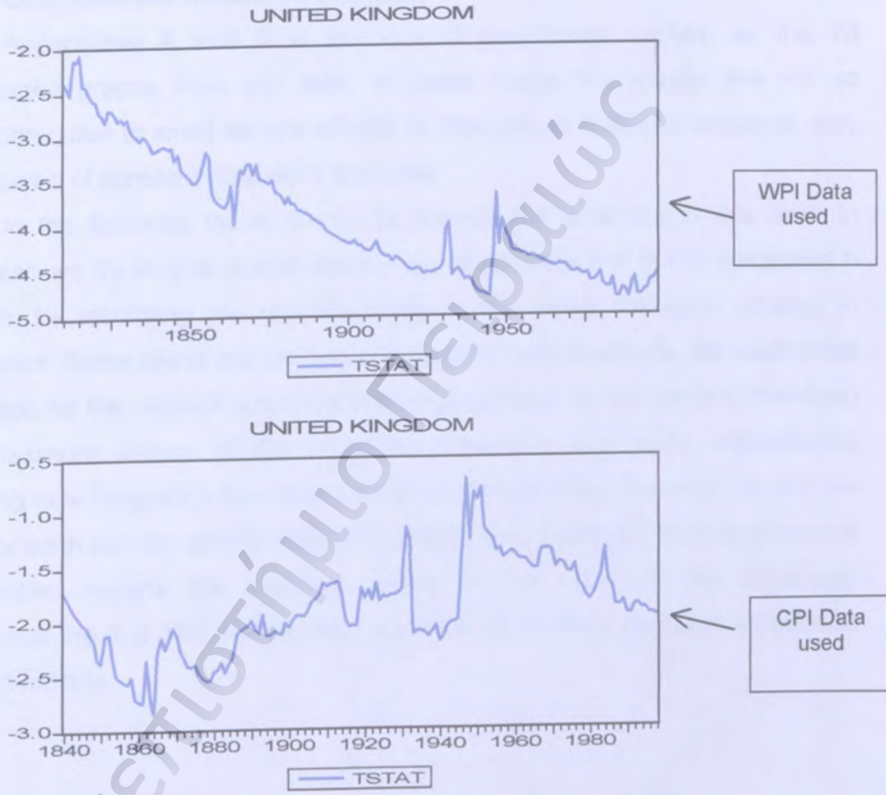


Figure 5.4 : t-statistic using both price Indexes

Judging by the first in row plot, validity of the PPP theory becomes stronger as time goes by and the behavior of the computed t-statistic is desirable. However, if one were to examine whether PPP holds under CPI Data, his results would have been quite vague, even after applying DF and ADF tests to almost two centuries of constant data. The more recent part of the plot is in the acceptance of the unit root null region, although there is an obvious downward sloping trend, while the former part is in the same region but with an upward sloping trend. There is no clear indication about the value of the computed t-statistic in the near future.

5.2.3 Concentrated Results in this field

Appendices A and B in the end of our thesis, contain all the 78 constructed graphs from our data. In some cases the results are not so trustworthy, due to small sample effects. In Pakistan or Israel for example, only 30 35 years of constant data were available.

In the following tables we try to present our analytics in this field. In particular, we try to give a brief description of the behavior of the computed t-statistic, by tabulating the characteristics of the series for each country in discussion. Some cases are omitted due to small sample effects, although there is a graph for the relevant countries in the Appendices. In this context, minimum and maximum values of the computed t-statistic, and some percentages counting how frequently one would either accept or reject the unit root null on RER for each country and for each price index, are reported. The last column of both tables reports the included values of the t-statistic. As previously mentioned the first 20-25 computed values were omitted because calculation was not reliable.

Table 5.4 **t-statistic constructed using WPI Data rejection-acceptance of the unit root null**
(figures in percentages)

A/A	COUNTRY	min	max	Reject	Accept	Included values
1	Argentina	-2.593156	0.801409	0.00	100.00	66
2	Australia	-1.876889	-0.730228	0.00	100.00	78
3	Austria	-5.113683	-0.048478	81.82	18.18	55
4	Belgium	-2.034557	-0.975184	0.00	100.00	52
5	Brazil	-3.133791	-0.796151	13.09	86.90	42
6	Canada	-3.857462	-1.887767	70.27	29.73	79
7	Chile	-2.098575	5.689692	1.96	98.04	51
8	Colombia	-3.360670	-2.492834	----	----	31
9	Costa Rica	-3.062579	-0.945214	13.09	86.91	42
10	Denmark	-3.245583	-1.536834	42.95	57.05	78
11	Egypt	-2.978684	-1.136404	3.08	96.93	65
12	Finland	-2.673814	0.202008	0.00	100.00	58
13	France	-6.432343	-1.761559	75.95	83.54	79
14	Germany	-3.944147	7.064546	39.66	60.34	179
15	Greece	-2.188404	-0.307602	0.00	100.00	48
16	India	-3.506518	-1.374391	57.03	42.97	64
17	Iran	-2.178923	-0.533416	0.00	100.00	42
18	Ireland	-2.111597	-0.851580	----	----	32
19	Israel	-3.942107	-1.005742	----	----	31
20	Italy	-4.384168	-0.288080	86.03	23.97	68
21	Japan	-4.102111	-1.724355	76.13	23.88	111
22	Mexico	-4.772369	3.025973	88.59	11.51	92
23	Morocco	-5.111530	-3.241656	100.00	0.00	39
24	Netherlands	-3.351127	-1.072232	41.67	58.33	78
25	New Zealand	-3.661808	-0.247772	15.85	84.15	82
26	Norway	-3.986351	2.525665	62.63	37.37	99
27	Pakistan	-7.997596	0.269614	----	----	35
28	Philippines	-4.294062	-2.516634	83.72	16.28	43
29	South Africa	-3.950689	0.986797	33.72	66.28	86
30	South Korea	-4.087580	0.570713	80.30	19.70	66
31	Spain	-4.396700	-0.610428	38.79	61.22	165
32	Sweden	-2.357897	0.417801	0.00	100.00	119
33	Switzerland	-4.594699	-1.770049	73.61	26.37	163
34	Taiwan	-3.795742	-2.606908	----	----	29
35	Thailand	-5.082751	-2.992951	----	----	32
36	Tunisia	-4.906163	-2.800108	98.69	1.32	38
37	Turkey	-3.001658	-0.253814	11.23	88.78	49
38	United Kingdom	-4.819653	-2.067212	88.62	11.38	189
39	Venezuela	-3.408960	-1.387555	28.85	71.16	78

Table 5.5 **t-statistic constructed using CPI Data rejection-acceptance of the unit root null**
(figures in percentages)

A/A	COUNTRY	min	max	Reject	Accept	Included values
1	Argentina	-1.972835	1.098986	0.00	100.00	83
2	Australia	-3.089019	-1.107768	10.17	89.83	118
3	Austria	-3.413603	-0.462087	67.86	32.14	70
4	Belgium	-3.758214	-0.809269	1.74	98.27	144
5	Brazil	-3.536895	1.081939	24.63	75.37	67
6	Canada	-2.839532	-1.324015	0.00	100.00	49
7	Chile	-2.785189	1.366304	0.00	100.00	66
8	Colombia	-2.515900	-0.858742	0.00	100.00	56
9	Costa Rica	-2.953682	0.208567	4.76	95.24	42
10	Denmark	-3.647591	-0.734849	54.79	45.22	115
11	Egypt	-3.249777	-0.177722	7.04	92.97	64
12	Finland	-2.871973	-1.586164	9.32	90.68	59
13	France	-3.830632	-0.842721	47.49	52.52	139
14	Germany	-6.267398	-0.050101	35.22	64.78	159
15	Greece	-1.547278	1.343823	0.00	100.00	55
16	India	-2.172269	-0.465396	0.00	100.00	58
17	Iran	-2.572532	-0.966815	0.00	100.00	42
18	Ireland	-2.780042	-1.507877	0.00	100.00	57
19	Israel	-2.438153	0.289468	0.00	100.00	57
20	Italy	-4.767455	-0.995177	65.26	34.75	118
21	Japan	-3.858847	1.653698	8.86	91.14	79
22	Mexico	-5.944510	-3.031820	100.00	0.00	79
23	Morocco	-4.776129	-3.120343	100.00	0.00	39
24	Netherlands	-3.060580	-0.465837	11.11	88.89	99
25	New Zealand	-2.877810	-1.096950	0.00	100.00	64
26	Norway	-3.842237	-1.748967	54.87	45.14	144
27	Pakistan	-2.270215	0.895201	----	----	29
28	Philippines	-3.493756	-2.342029	48.81	51.19	42
29	South Africa	-2.405929	-0.774406	0.00	100.00	79
30	South Korea	-4.918407	-2.990607	----	----	31
31	Spain	-4.213459	-2.097741	39.24	60.77	65
32	Sweden	-4.322134	-1.114777	58.73	41.28	149
33	Switzerland	-2.803370	-0.423694	0.00	100.00	89
34	Taiwan	-3.660185	-2.346762	----	----	28
35	Thailand	-3.490004	-2.413228	----	----	31
36	Tunisia	-1.577743	-0.510187	0.00	100.00	41
37	Turkey	-1.989010	2.009997	0.00	100.00	57
38	United Kingdom	-2.850033	0.703906	0.32	99.69	159
39	Venezuela	-2.185100	0.712927	0.00	100.00	46

5.3 *On modeling Real Exchange Rates*

Our efforts now turn to modeling our time series. In particular we wish to find a certain system of equations, that could under certain restrictions, describe all the so far mentioned families of statistical models. This system of equations should be able to encompass the constant coefficient AR(p) models both under stationarity and unit roots, and models that describe non stationarity of an unknown type. Therefore it needs to be dynamic, meaning that the coefficient of the lagged regressor of the basic equation need to be stochastic.

Dynamic systems can be represented in a general form known as the state space form. Many time series models, including the classical linear regression model and ARIMA models, can be written and estimated as special cases of a state space specification.

There are two main benefits to representing a dynamic system in state space form. First, the state space allows unobserved variables (known as the state variables) to be incorporated into, and estimated along with, the observable model. Second, state space models can be estimated using a powerful recursive algorithm known as the Kalman filter. The Kalman filter is used both to evaluate the likelihood function and to forecast and smooth the unobserved state variables.

State space models have been applied in the econometrics literature to model unobserved variables such as (rational) expectations, measurement errors, missing observations, permanent income, unobserved components (cycles and trends), and the natural rate of unemployment. The Kalman filter algorithm has been used to compute exact, finite sample forecasts for Gaussian ARMA models, multivariate (vector) ARMA models, MIMIC (multiple indicators and multiple causes), Markov switching models, and time varying (random) coefficient models. Extensive surveys of applications of state space models in econometrics can be found in Hamilton (1994a, chapter 13; 1994b) and Harvey (1989, chapters 3, 4).

The general model we are willing to suppose for our time series, Real Exchange Rates, belongs to the family of Time Varying Coefficient models.

Specifically, it is an AR(1) time varying model with a constant and an AR(1) coefficient (equations (5.4) - (5.6)). In Section 3, and especially subsection 3.2, we briefly describe theoretical matters on these models. In particular we briefly explain some of their properties, derive important results on the stability of the generated time series they describe, and reveal some patterns on expectations about stability.

In particular let y_t be a univariate stochastic process such that :

$$y_t = c(1) + c(2)y_{t-1} + \beta_t y_{t-1} + e_t \qquad (5.4)$$

$$\beta_t = c(3)\beta_{t-1} + v_t \qquad (5.5)$$

where y_t is the log of the Real Exchange Rate as defined in equation (5.1). Next assume that the "error terms" are such that :

$$\begin{pmatrix} e_t \\ v_t \end{pmatrix} \rightarrow IN\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & \sigma_v \end{pmatrix}\right] \qquad (5.6)$$

where $\Sigma=[\sigma_{ij}]$, i,j = 1,2 is positive definite. Also suppose that $\sigma_e^2 = 1$.

Obviously, the extend to which the system is a constant coefficient AR(1) model, depends on the value of the parameter σ_v. In particular if σ_v is considered so small that it practically equals zero, and accordingly the variance of the coefficient equation (henceforth, state equation) is practically zero, then the system is a well known member of the AR(p) family of models with known properties both under stationarity and unit roots. This is so because :

- If c(3) in equation (5.5) equals unity, then

  $$\beta_t = \beta_{t-1} = \ldots = \beta_0$$

  the initial condition. Equation (5.4) could be rewritten as

  $$y_t = c(1) + y_{t-1} + e_t \qquad (5.7)$$

and obviously RER is modeled as a series with a unit root component.

- If c(3) in equation (5.5) is not in the vicinity of unity, then β_t would be zero in the limit. Equation (5.4) could be rewritten as

$$y_t = c(1) + c(2)y_{t-1} + e_t \qquad (5.8)$$

and RER is modeled through a usual AR(1) model with constant.

On the other hand, if σ_v and accordingly the variance of the state equation, is not small enough to be ignored, then the system is a member of the Time Varying family of models and Weiss' analysis (section 3.2) could be of use. Further research could be performed in the future, studying the properties of these models in a much greater detail, and reaching to certain conclusions about stability of the series they describe.

Therefore a test needs to be performed on our time series, test on whether the value of the parameter in discussion, in particular σ_v, equals zero. For that we shall use the method described in section 3.3, namely Variable Parameter Regression, and Log Likelihood function' statistic as the relevant statistic. According to the analysis of section 3.3, this statistic's distribution is slightly different than the chi-square with as many degrees of freedom, as the number of restrictions we impose on the model.

In our workfiles, we have performed this kind of test, for all the countries in discussion and for both RER we have created for each country. The unrestricted model is equations (5.4) – (5.6) and on that we impose the restriction that

$$\sigma_v = \sigma_\beta = 0$$

Table 5.6 RER for United Kingdom (WPI Data used)

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1791 1998			
Included Observations: 205			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	1.091936	0.327891	3.330179
C(2)	0.215785	0.083129	2.595782
C(3)	1.004889	0.004989	201.4017
VAR (y_t)	1.93E-08	11201.56	1.72E-12
VAR (β_t)	0.001188	0.159906	0.007427
Final β_t estimated (unrestricted)	0.533625	0.034462	15.4846
Log Likelihood		15.42631	
SSpace: **RESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1791 1998			
Included Observations: 205			
Variance of observation equations: Diagonal			
Variance of state equations: 0.000000000001			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	-0.111749	2.240804	-0.04987
C(2)	1.017318	0.473679	2.147692
C(3)	-0.001572	1.072184	-0.00147
VAR (y_t)	0.204419	0.011986	17.05507
Final β_t estimated (restricted)	1.66E-16	1.00E-06	1.66E-10
Log Likelihood		-82.3363	

Table 5.6 reports our results , using RER constructed under WPI data for United Kingdom.

The statistic we use, is Log likelihood statistic, (equation (3.11) or :

$$-2\ln(\lambda) = -2\,[\,L^*(P_0) - L^*(P)\,]$$

where L*( ), is the Log Likelihood function (equation (3.10)), and P is the parameter on which we impose the restrection.

The hypothesis are:

$H_0: \quad \sigma_v = \sigma_\beta = 0$

$H_1: \quad \sigma_v = \sigma_\beta > 0$

Garbade in section 3.3, proves that the likelihood statistic will be more concentrated toward the origin than a chi-square, because maximum likelihood estimates less than zero are set to zero. Thus, using a chi-square distribution to determine critical values of the statistic, would have led to a conservative test for the stability of the β_t coefficients.

Our computed statistic for the above example is:

$$-2\ln(\lambda) = -2\,[\,L^*(P_0) - L^*(P)\,] =$$
$$-2\,[\,-82.3363 - 15.42631\,] = 195.52522$$

The null hypothesis that we are dealing with a constant coefficient model is strongly rejected. We note that the critical values of even the chi-square dstribution with one degree of freedom, in several confident levels, are as follows:

0,005	0,025	0,05	0,9	0,95	0,975	0,99	0,995
0,0000393	0,000982	0,00393	2,706	3,841	5,024	6,635	7,879

Table 5.6 also tabulates the estimated values of the parameters of the model (equations (5.4) – (5.6)). Judging by the estimates of the unrestricted Sspase, c(3) lies in the vicinity of unity, therefore it could be stated that we are dealing with an AR(1) time varying model with random walk coefficient. Yet, this last result is not convincing, since further and more stringent tests are necessary.

Tables 5.7 and 5.8 report our results of the above mentioned test, for all countries and for both time series (RER using WPI and CPI data). The null hypothesis of constant coefficients is vastly rejected, and the non stationarity of the series, is beyond any doubts.

Table 5.7: Time-varying (AR(1)) *vs* Constant (AR(1)) using WPI Data

A/A	COUNTRY	Unrestricted	Restricted	Likelihood statistic	Reject (95% level)	Accept (95% level)
1.	Argentina					
2.	Australia	31.011740	-73.393240	208.809960	√	
3.	Austria	0.778190	-62.791550	127.139480	√	
4.	Belgium	-23.170100	-63.701360	81.062520	√	
5.	Brazil	6.089527	-59.729730	131.638514	√	
6.	Canada	155.063700	-67.657640	445.442680	√	
7.	Chile					
8.	Colombia	2.793951	-48.528610	102.645122	√	
9.	Costa Rica	-15.048150	-54.996920	79.897540	√	
10.	Denmark	13.402890	-70.315270	167.436320	√	
11.	Egypt	-7.949401	-71.329990	126.761178	√	
12.	Finland	10.159780	-62.899470	146.118500	√	
13.	France	-8.897238	-76.228080	134.661684	√	
14.	Germany	-220.050600	-258.305200	76.509200	√	
15.	Greece					
16.	India	-18.351500	-66.274010	95.845020	√	
17.	Iran					
18.	Ireland	43.990110	-46.249170	180.478560	√	
19.	Israel	-3.900243	-34.904060	62.007634	√	
20.	Italy	-1.689295	-70.269100	137.159610	√	
21.	Japan	15.460050	-70.515990	171.952080	√	
22.	Mexico	-49.699330	-83.654850	67.911040	√	
23.	Morocco	-12.362970	-52.070330	79.414720	√	
24.	Netherlands	24.729040	-72.436660	194.331400	√	
25.	New Zealand	39.452080	-64.185640	207.275440	√	
26.	Norway	-13.416630	-76.830040	126.826820	√	
27.	Pakistan	2.002236	-41.313320	86.631112	√	
28.	Philippines	-13.508720	-61.484970	95.952500	√	
29.	South Africa	30.824910	-64.225660	190.101140	√	
30.	South Korea	-38.859550	-70.666720	63.614340	√	
31.	Spain	8.910312	-71.853050	161.526724	√	
32.	Sweden	65.664450	-72.731160	276.791220	√	
33.	Switzerland	36.754190	-97.384180	268.276740	√	
34.	Taiwan	28.248520	-47.326050	151.149140	√	
35.	Thailand	22.157460	-47.738180	139.791280	√	
36.	Tunisia	-18.202630	-51.087290	65.769320	√	
37.	Turkey	-37.761340	-65.335150	55.147620	√	
38.	United Kingdom	15.426310	-82.336280	195.525180	√	
39.	Venezuela	2.023159	-71.932310	147.910938	√	

Critical values of X^2 with one (1) degree of freedom

0,005	0,025	0,05	0,9	0,95	0,975	0,99	0,995
0,0000393	0,000982	0,00393	2,706	3,841	5,024	6,635	7,879

Table 5.8: Time-varying (AR(1)) *vs* Constant (AR(1)) using CPI Data

A/A	COUNTRY	Unrestricted	Restricted	Likelihood statistic	Reject (95% level)	Accept (95% level)
1.	Argentina					
2.	Australia	-32.768280	-85.323600	105.110640	√	
3.	Austria	-2.031305	-64.172170	124.281730	√	
4.	Belgium	-1.676397	-97.973390	192.593986	√	
5.	Brazil					
6.	Canada	128.043400	-66.293270	388.673340	√	
7.	Chile					
8.	Colombia	-39.076320	-57.935900	37.719160	√	
9.	Costa Rica	-22.312750	-55.095140	65.564780	√	
10.	Denmark	89.385720	-77.750410	334.272260	√	
11.	Egypt	-31.882340	-58.126540	52.488400	√	
12.	Finland	-9.265346	-59.578900	100.627108	√	
13.	France	12.255880	-87.791110	200.093980	√	
14.	Germany					
15.	Greece	-226.869000	-338.004800	222.271600	√	
16.	India	-37.594450	-58.019300	40.849700	√	
17.	Iran					
18.	Ireland	27.254210	-61.402070	177.312560	√	
19.	Israel	-41.412110	-68.371810	53.919400	√	
20.	Italy	0.710485	-94.138800	189.698570	√	
21.	Japan	5.355796	-76.808110	164.327812	√	
22.	Mexico	-23.140830	-66.213360	86.145060	√	
23.	Morocco	-13.579370	-50.784490	74.410240	√	
24.	Netherlands	60.601780	-72.981960	267.167480	√	
25.	New Zealand	43.473060	-63.813360	214.572840	√	
26.	Norway	103.510100	-85.111150	377.242500	√	
27.	Pakistan	13.147670	-48.208350	122.712040	√	
28.	Philippines	-19.199650	-66.804670	95.210040	√	
29.	South Africa	50.404010	-68.492860	237.793740	√	
30.	South Korea	-9.137911	-56.044500	93.813178	√	
31.	Spain	-1.923157	-61.868220	119.890126	√	
32.	Sweden	143.312400	-93.029950	472.684700	√	
33.	Switzerland	86.144780	-67.611520	307.512600	√	
34.	Taiwan	28.089770	-41.360900	138.901340	√	
35.	Thailand	38.544050	-49.870460	176.829020	√	
36.	Tunisia	-57.973780	-82.390940	48.834320	√	
37.	Turkey	-2.320364	-62.676390	120.712052	√	
38.	United Kingdom	123.876900	-91.962580	431.678960	√	
39.	Venezuela	19.334110	-61.750030	162.168280	√	

Critical values of X^2 with one (1) degree of freedom

0,005	0,025	0,05	0,9	0,95	0,975	0,99	0,995
0,0000393	0,000982	0,00393	2,706	3,841	5,024	6,635	7,879

In Appendix C, we report our estimates for the parameters of the unrestricted model, namely c(1), c(2), c(3), their standard errors and the relevant t-statistics. We also report the variances of the time series of our model (equations (5.4 – (5.6)), namely RER and β_t. The results are for all countries in discussion using WPI Data so as to construct our time series (RER).

In Appendix D, we report our estimates for the parameters of the unrestricted model, namely c(1), c(2), c(3), their standard errors and the relevant t-statistics. We also report the variances of the time series of our model (equations (5.4 – (5.6)), namely RER and β_t. The results are for all countries in discussion using CPI Data so as to construct our time series (RER).

Obviously, some reported values are statistically insignificant. However, we choose to report estimates for all the parameters, since we are dealing with Time Varying models and the theoretical framework that lies beneath, is still quite vague. Further research on these issues, is by all means necessary, yet it is outside the objectives of this study.

6. Conclusions

Undoubtedly, research on Purchasing Power Parity has enjoyed a rebirth over the last ten to fifteen years. This is so, partly due to the development of modern econometric techniques and partly to the synthesis of more broader data sets that cover both pre and post Bretton Woods periods. The main positive result is that progress has been accomplished. Researchers have accepted PPP theory at least as a starting point in their analysis.

However, disagreements do exist on the behavior of the time series the researchers test, namely Real Exchange Rates (RER). This, according to our opinion, is either caused by the inappropriateness of traditional econometric models to explain the stationarity or not status of RER, or by the lack of in depth studies on the new approaches.

In our study, we try to understand and model RER behavior through Time Varying models. Yet, our knowledge on this matters is still incomplete and our results are based on a certain approach. The "image" could be altered dramatically, under a more thorough study.

Under our approach, RER is considered as a series with a certain kind of non stationarity that p-th order AR models with constant coefficients fail to accommodate. More importantly, for our time series, RER, stability as defined in Weiss work cannot be stated. All the estimates shown in the Appendices C and D for the parameters of interest in equations (5.4) – (5.6), are such that their combination as defined in equation (3.7) and presented in figures (3.1) and (3.2) does not imply stability. We remind the reader, that stability could be accomplished if certain combinations of the parameters of interest lie in the concave of the previously stated figures (3.1) and (3.2).

We claim that the kind of non stationarity we are facing here, is of an unknown kind. Take the model defined in equations (6.1) for example, model introduced by Prof. Pittis and defined as "Separable non Stationarity". For simplicity reasons suppose that $\sigma^2(\ ) = \sigma(\ )$.

$$\begin{pmatrix} y_t \\ y_{t-1} \end{pmatrix} \rightarrow IN\left[\begin{pmatrix} \mu t \\ \mu(t-1) \end{pmatrix}\begin{pmatrix} \sigma(0)t & \sigma(1)(t-1) \\ \sigma(1)(t-1) & \sigma(0)(t-1) \end{pmatrix}\right] \quad (6.1)$$

The unconditional moments of the stochastic process y_t are non stationary since they are t-dependent.

Yet, under the joint Normality hypothesis, the conditional moments are as theory says:

$$E(y_t \,/\, y_{t-1}) = \beta_0 + \beta_1 y_{t-1} \quad (6.2)$$

$$Var(y_t \,/\, y_{t-1}) = \sigma(0)t - \frac{\sigma(1)(t-1)}{\sigma(0)(t-1)} \quad (6.3)$$

where:

$$\beta_1 = \frac{\sigma(1)(t-1)}{\sigma(0)(t-1} = \frac{\sigma(1)}{\sigma(0)} \quad (6.4)$$

$$\beta_0 = \mu t - \beta_1\mu(t-1) \quad (6.5)$$

The orthogonal decomposition of the model is:

$$y_t = E(y_t \,/\, y_{t-1}) + u_t = \beta_0 + \beta_1 y_{t-1} + u_t \quad (6.7)$$

conditional variance as stated in eq. (6.3) and a white noise error term.

Suppose that the series we are studying (y_t), has a unit root, according to some unit root tests. Under this model (eq. (6.7)), $\beta_1 = 1$ and as equation (6.4) states

$$\sigma(0) = \sigma(1)$$

Obviously, the parameters of interest on this model (equation (6.1)) are no longer t-dependent since $\beta_0 = \mu$ = constant and only heteroskedasticity that can be studied is present. Therefore time series with this kind of non stationarity, namely "separable non stationarity" can be studied.

However, our time series, RER, exhibits a non stationarity status of a different kind, still unknown according to our knowledge.

It could perhaps be the system of equations that follow:

$$\begin{pmatrix} y_t \\ y_{t-1} \end{pmatrix} \rightarrow D\left[\begin{pmatrix} \mu_t \\ \mu_{t-1} \end{pmatrix}\begin{pmatrix} \sigma(0)_t & \sigma(1)_{t-1} \\ \sigma(1)_{t-1} & \sigma(0)_{t-1} \end{pmatrix}\right] \qquad (6.8)$$

where all the unconditional moments of the series y_t or equivalently RER, are unknown functions of time. Additionally, the distribution of the time series in discussion could be such that no moments exist. This kind of non stationarity and its dynamic implications are more general and still quite vague to econometricians.

Conclusively, PPP theory and its dynamics are still a quite intriguing subject for study and our efforts introduce a different approach to Real Exchange Rate behavior. More thorough research on these matters might be fruitful in the future.

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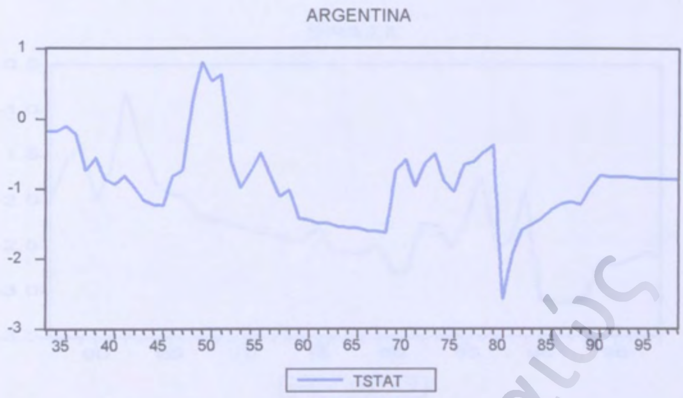
APPENDIX A

T-statistic graphs using WPI Data in RER construction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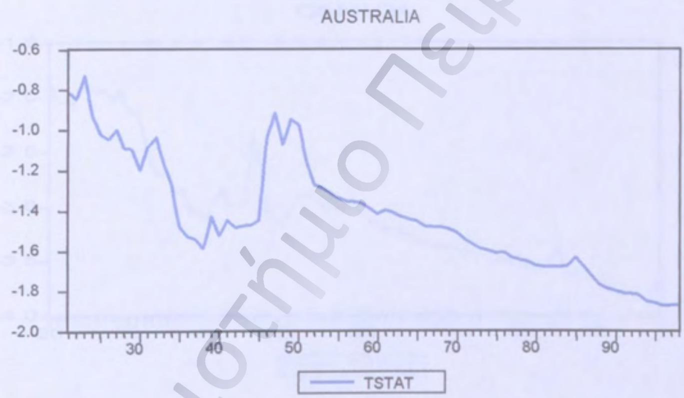
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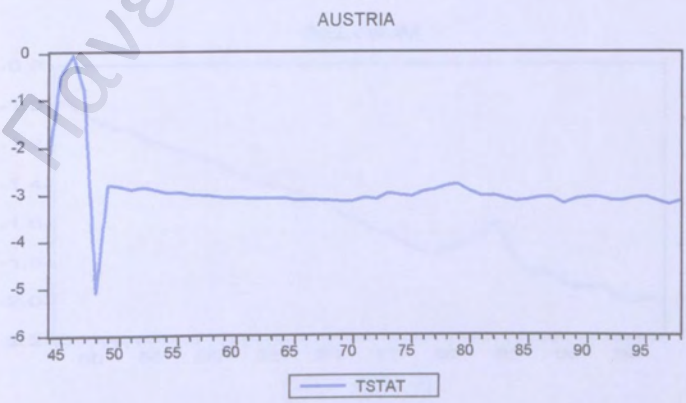
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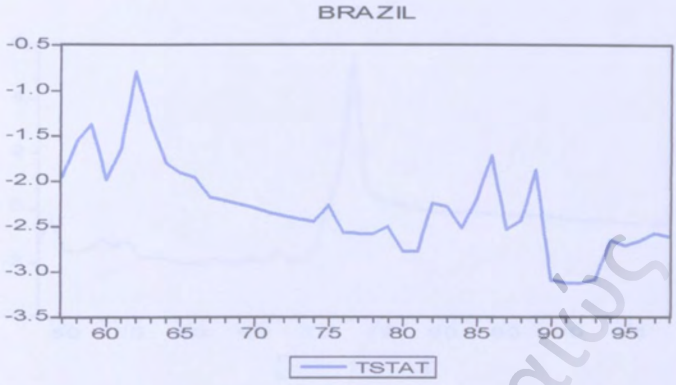
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TSTAT


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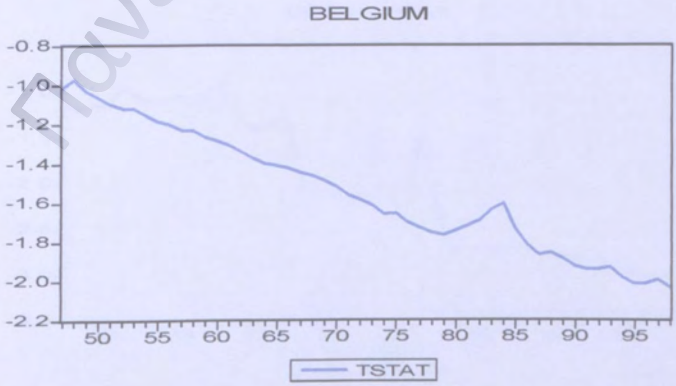
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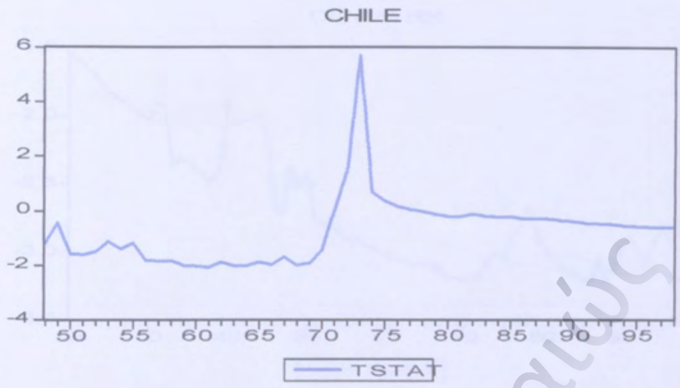
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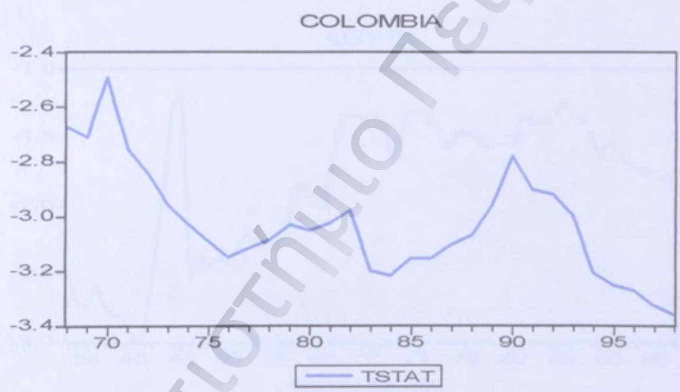
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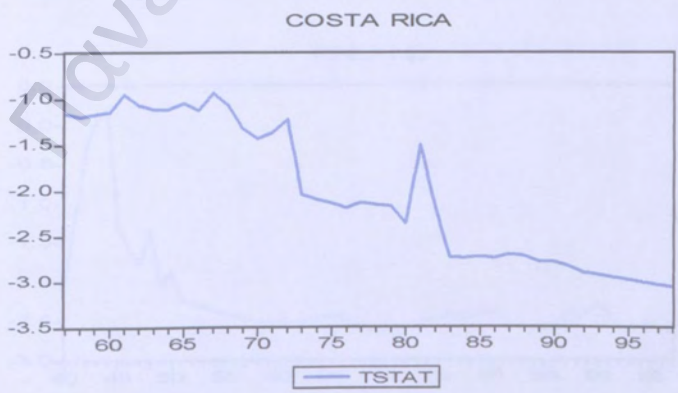
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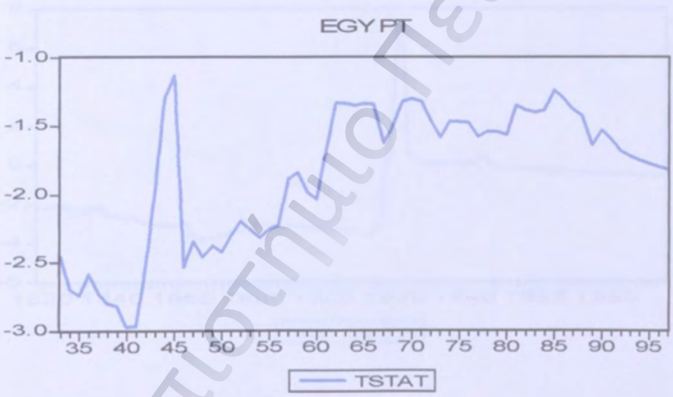
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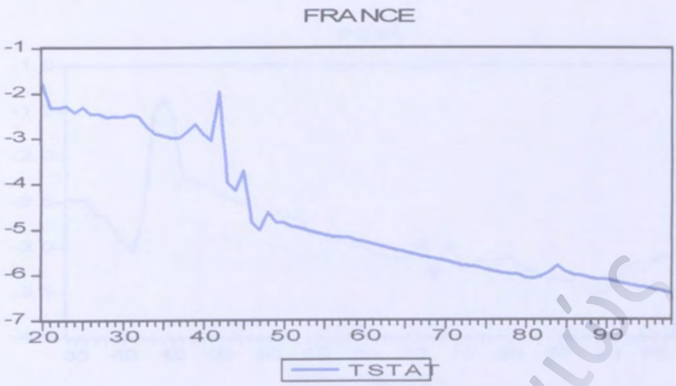
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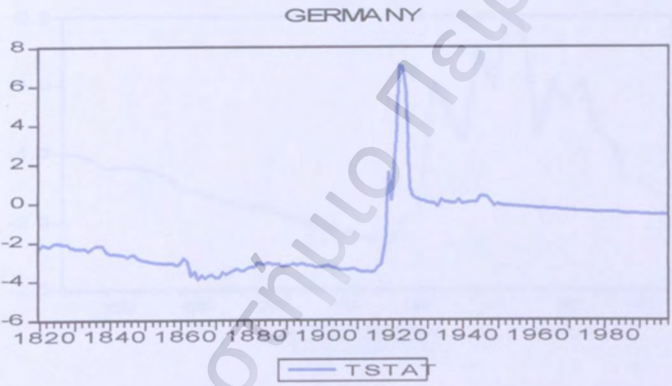
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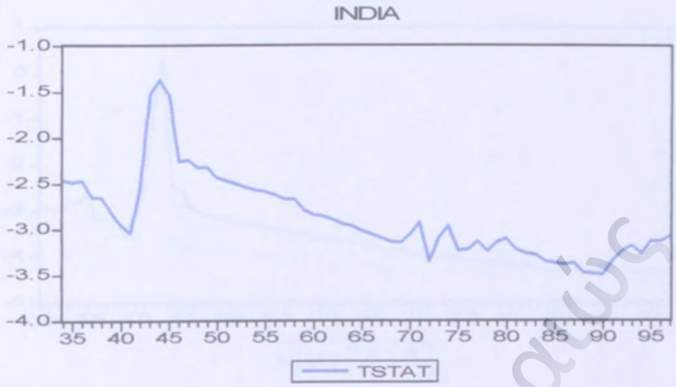
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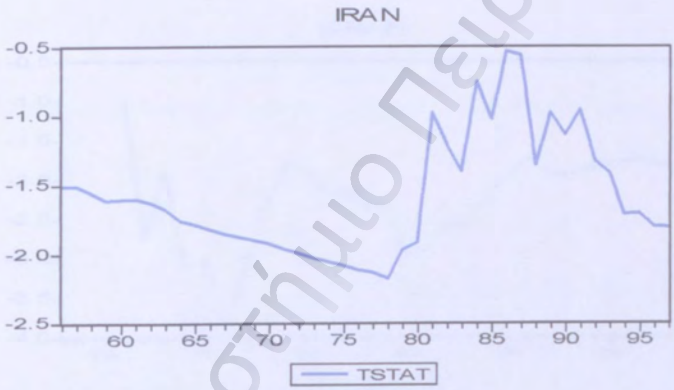
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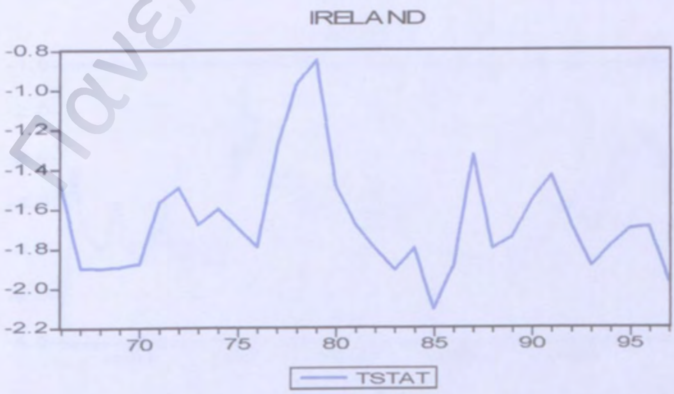
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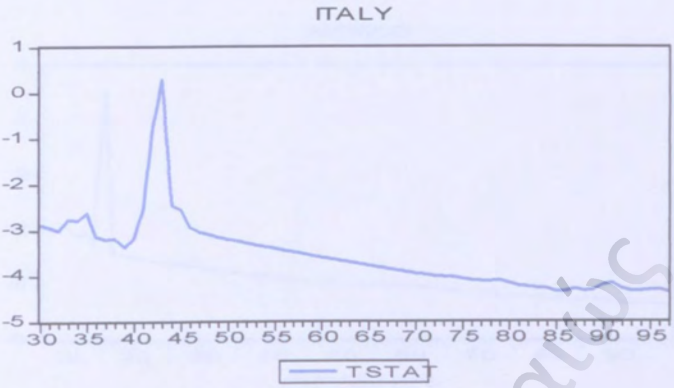
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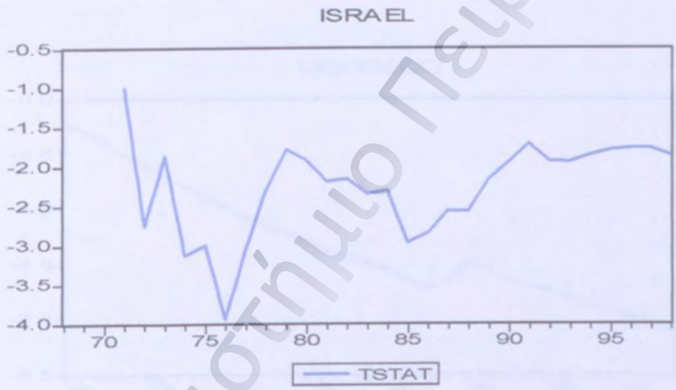
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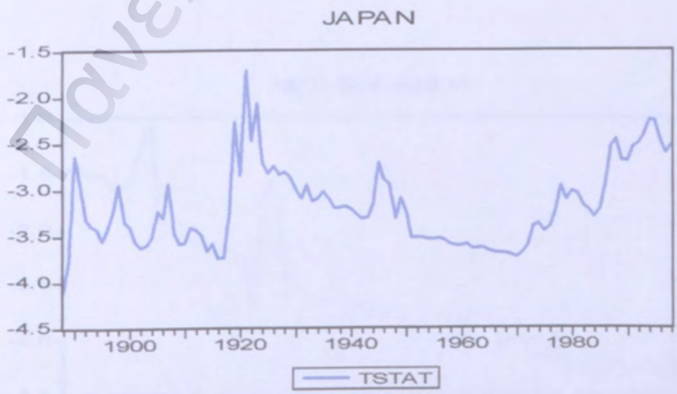
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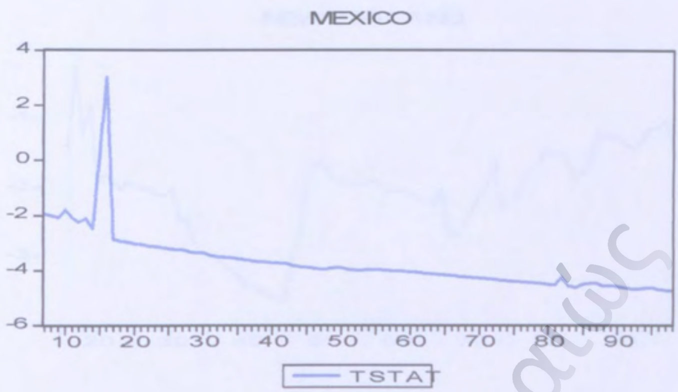
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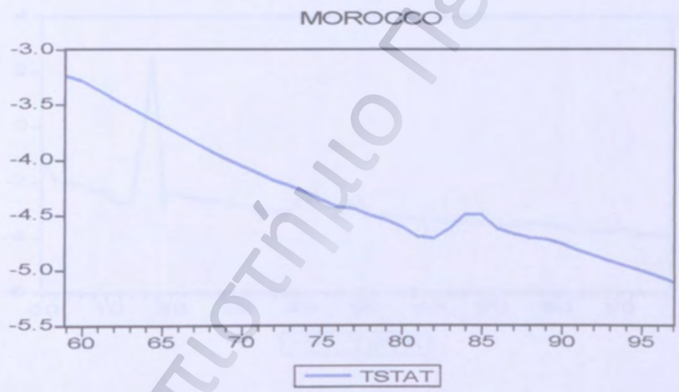
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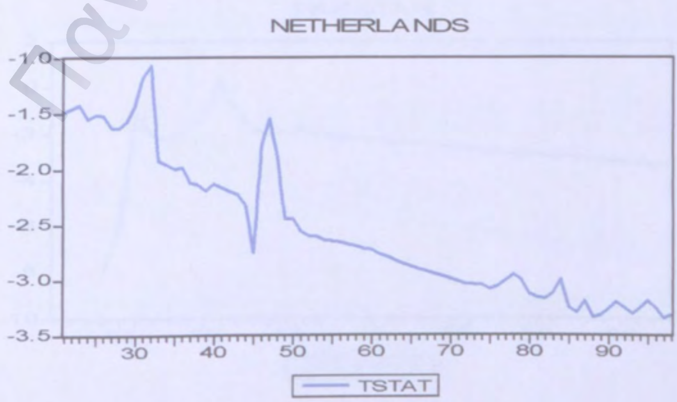
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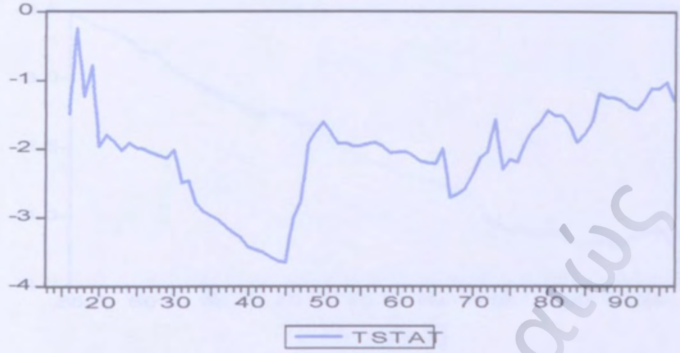

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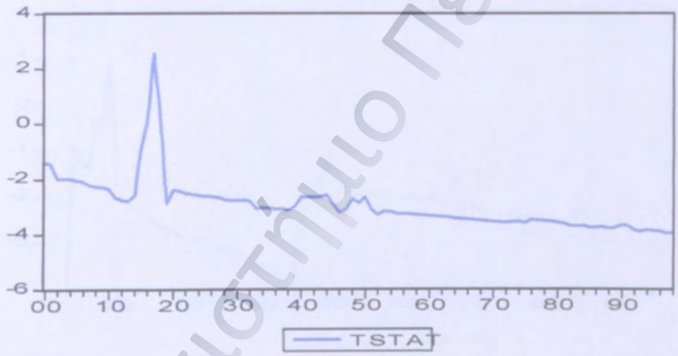

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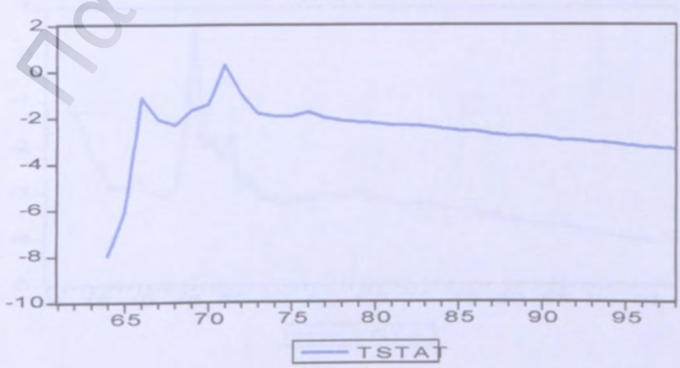

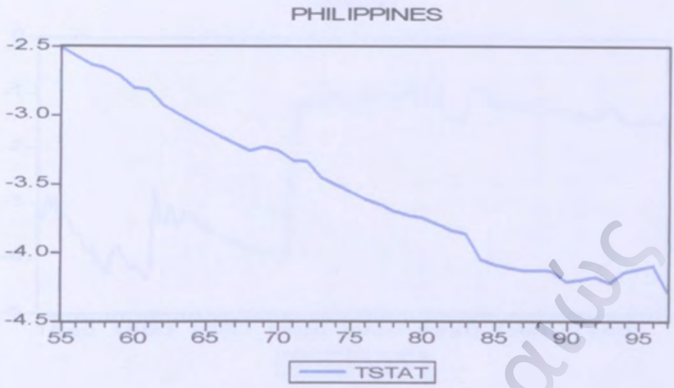
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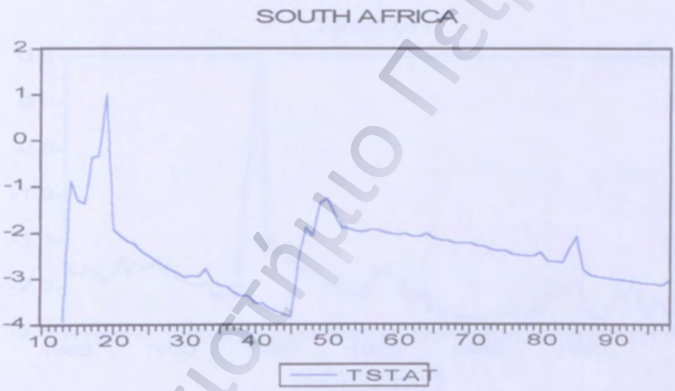
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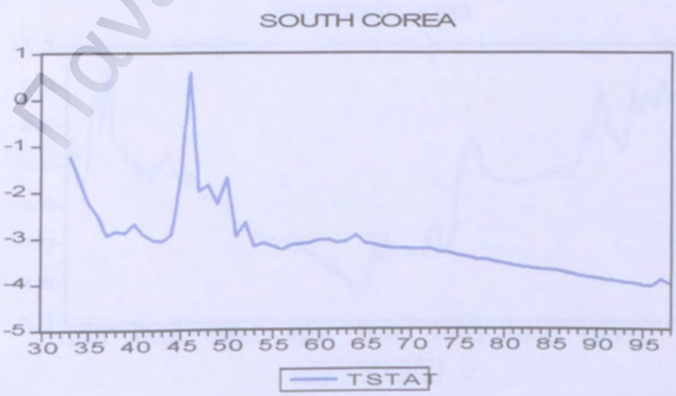
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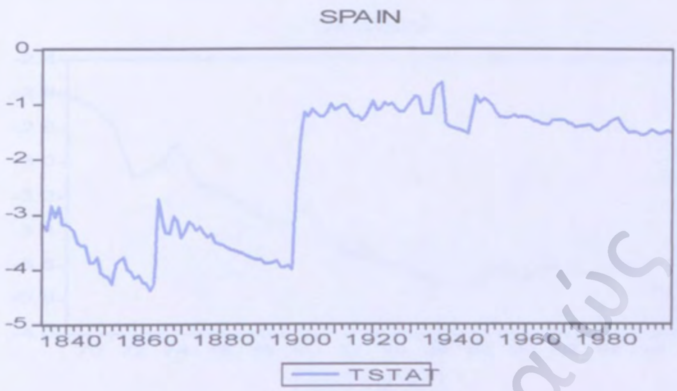
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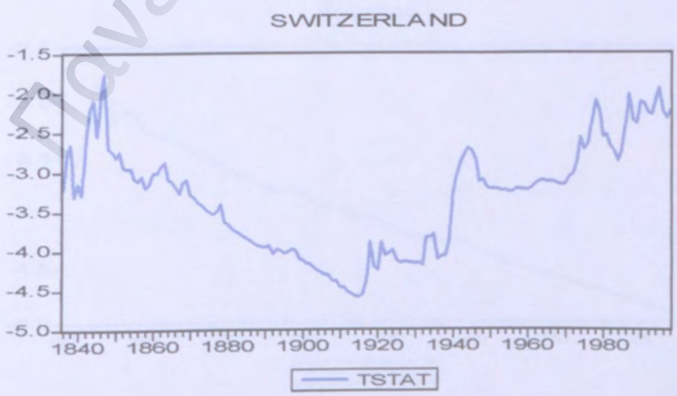
1980
TSTAT


SWITZERLAND
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-2.0
-2.5
-3.0
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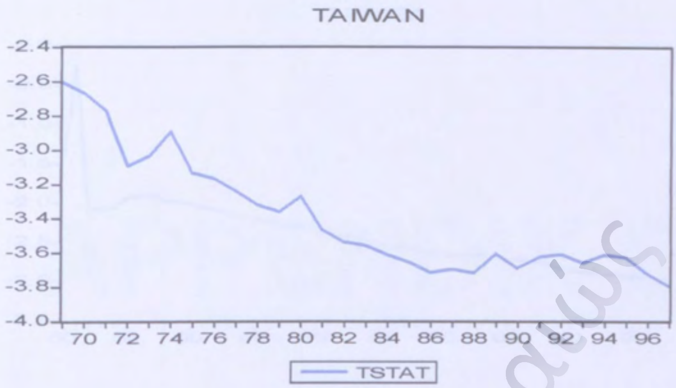
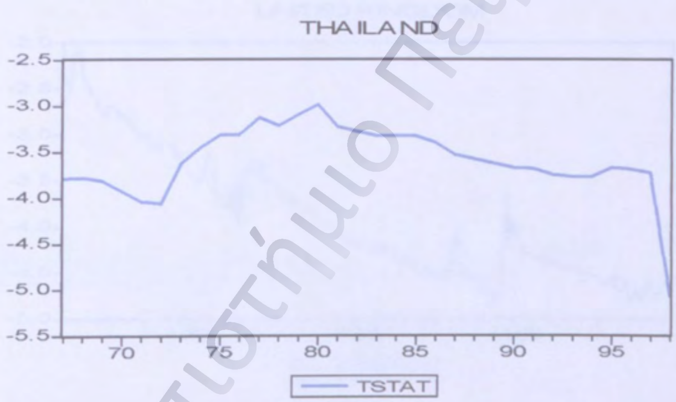
-4.0
-4.5
-5.0
1840
1860
1880
1900
1920
1940
1960
1980
TSTAT


TAIWAN
-2.4
-2.6
-2.8
-3.0
-3.2
-3.4
-3.6
-3.8
-4.0
70 72 74 76 78 80 82 84 86 88 90 92 94 96
TSTAT


THAILAND
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-3.0
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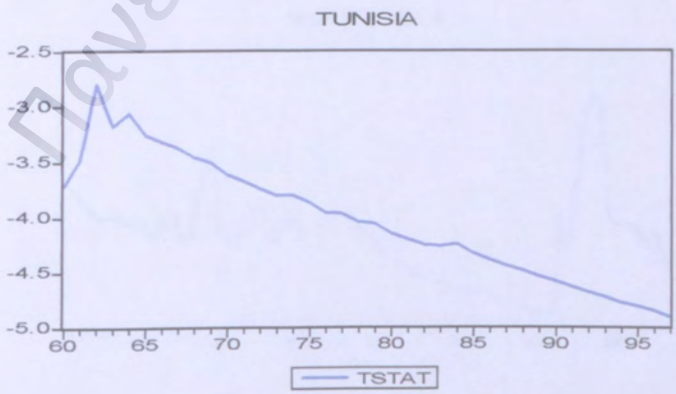
-4.0
-4.5
-5.0
-5.5
70 75 80 85 90 95
TSTAT


TUNISIA
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-3.0
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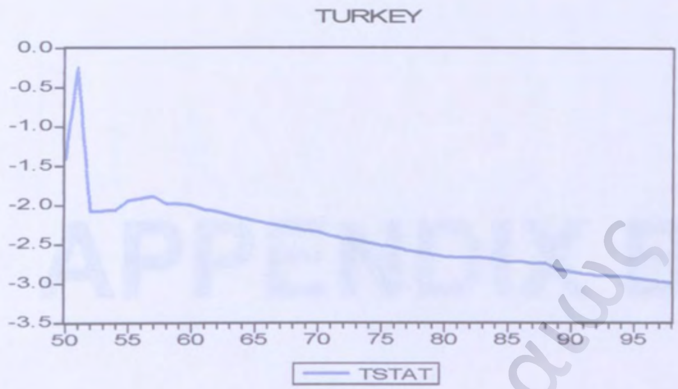
-4.0
-4.5
-5.0
60 65 70 75 80 85 90 95
TSTAT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-3.0
-3.5
50
55
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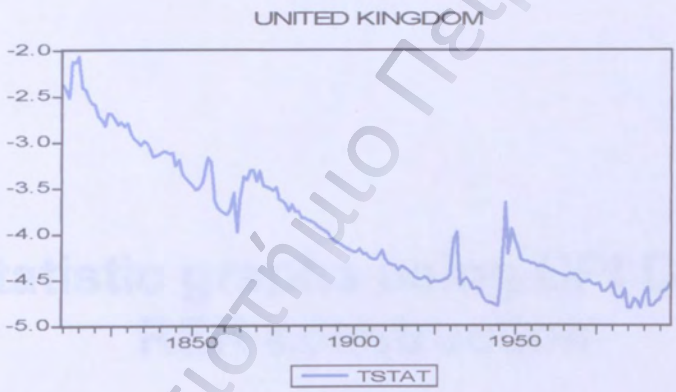
65
70
75
80
85
90
95
TSTAT


UNITED KINGDOM
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-4.0
-4.5
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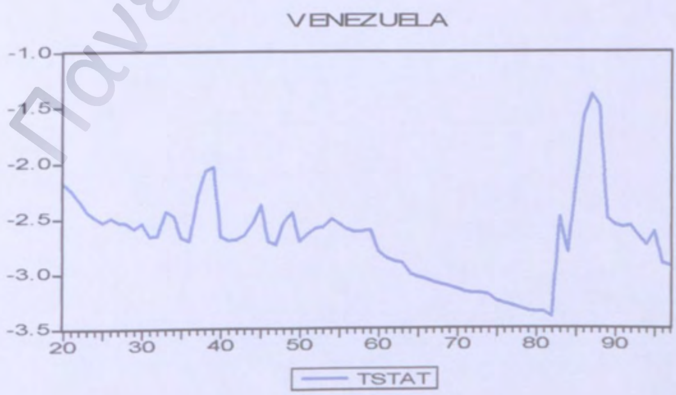
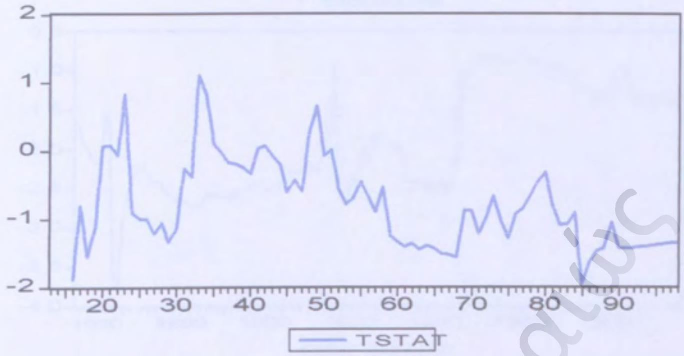
1850
1900
1950
TSTAT


VENEZUELA
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
20
30
40
50
60
70
80
90
TSTAT

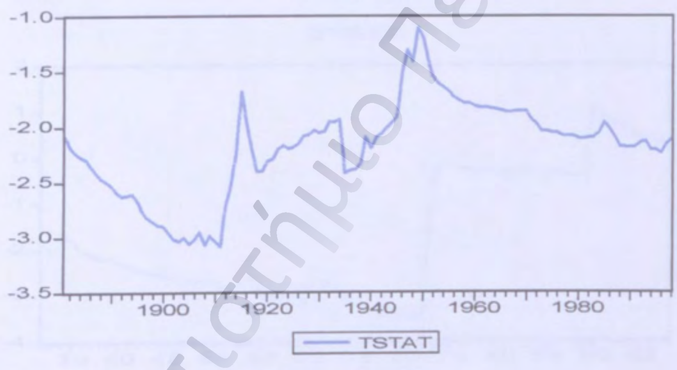
APPENDIX B

T-statistic graphs using CPI Data in RER construction

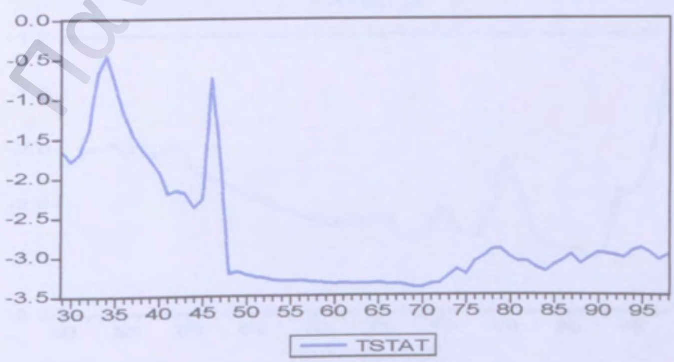
ARGENTINA

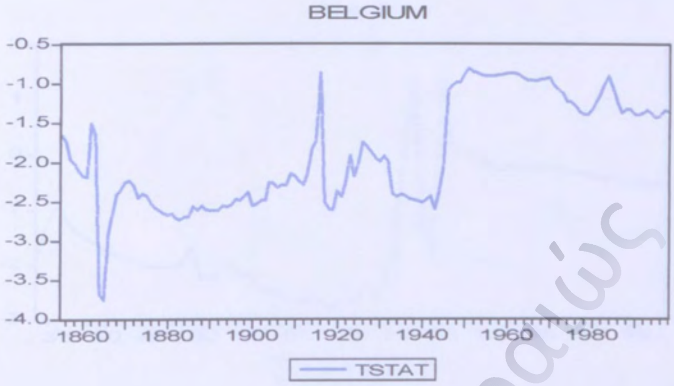


AUSTRALIA



AUSTRIA




BELGIUM
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-1.0
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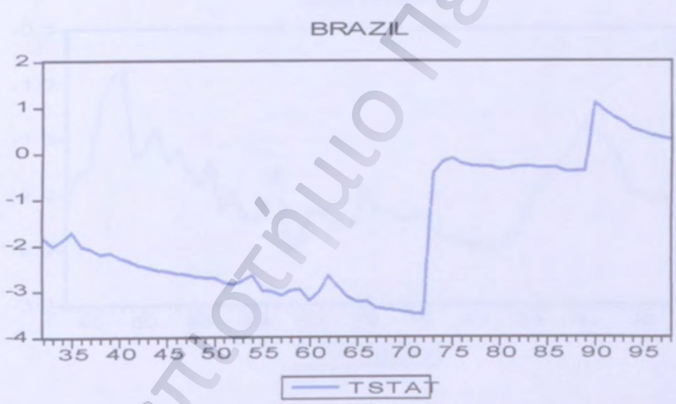
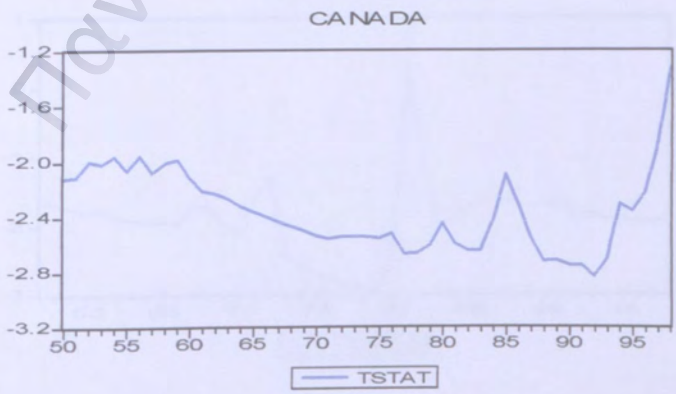
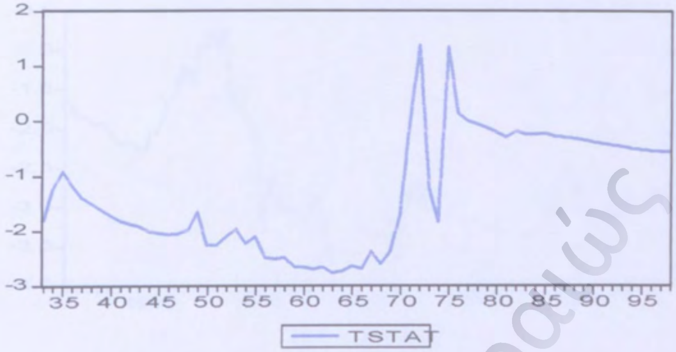
-3.0
-3.5
-4.0
1860
1880
1900
1920
1940
1960
1980
TSTAT

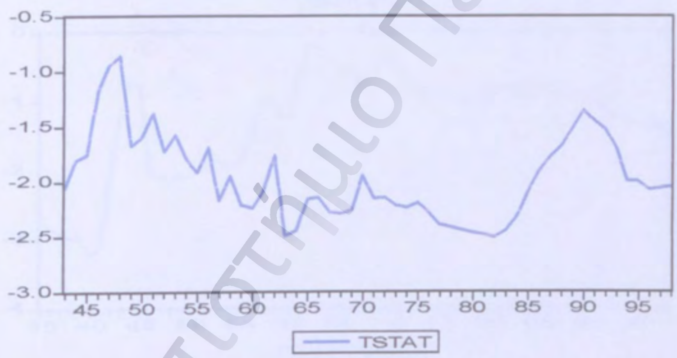

BRAZIL
2
1
0
-1
-2
-3
-4
35
40
45
50
55
60
65
70
75
80
85
90
95
TSTAT


CANADA
-1.2
-1.6
-2.0
-2.4
-2.8
-3.2
50
55
60
65
70
75
80
85
90
95
TSTAT

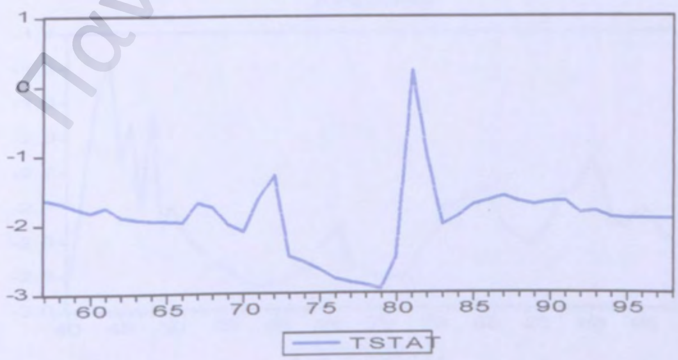
CHILE

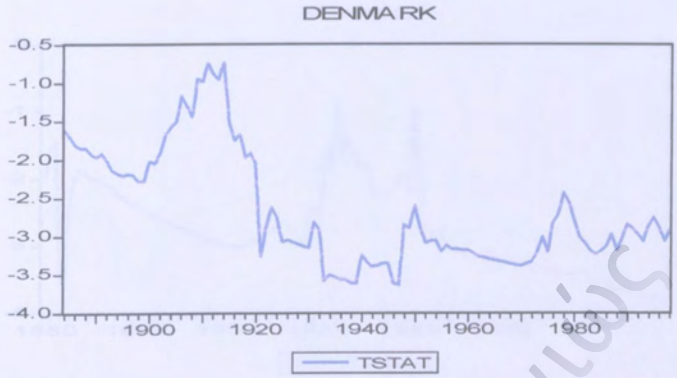


COLOMBIA



COSTA RICA




DENMARK
-0.5
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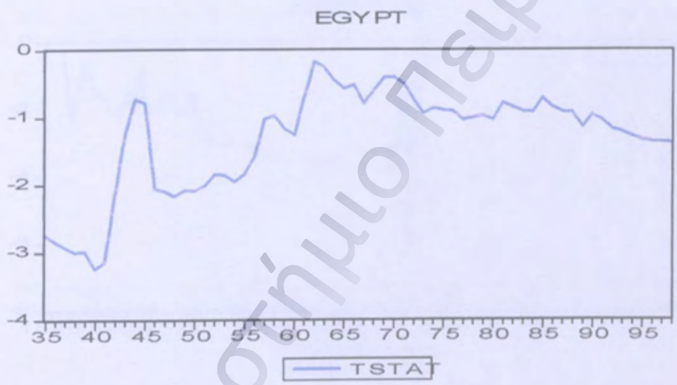
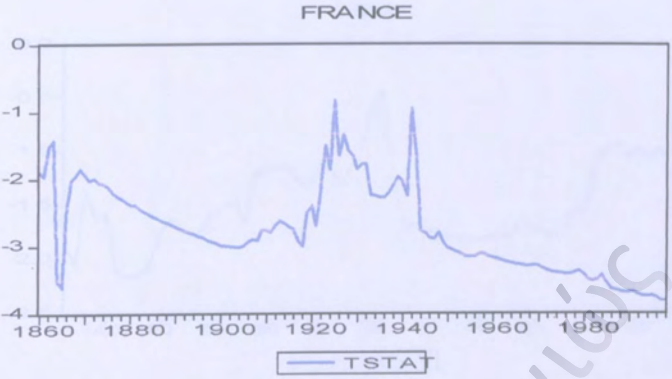
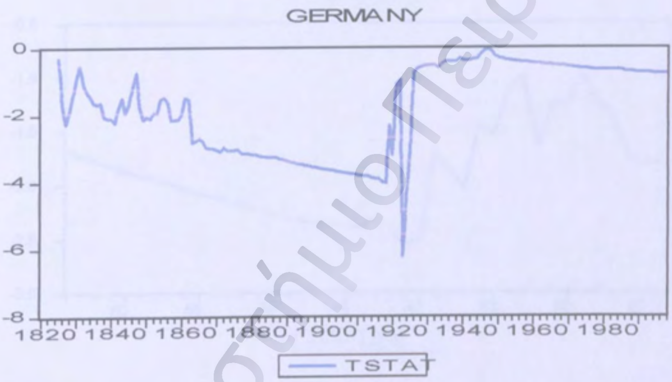
-2.5
-3.0
-3.5
-4.0
1900
1920
1940
1960
1980
TSTAT


EGYPT
0
-1
-2
-3
-4
35 40 45 50 55 60 65 70 75 80 85 90 95
TSTAT


FINLAND
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
40 45 50 55 60 65 70 75 80 85 90 95
TSTAT


FRANCE
0
-1
-2
-3
-4
1860 1880 1900 1920 1940 1960 1980
TSTAT


GERMANY
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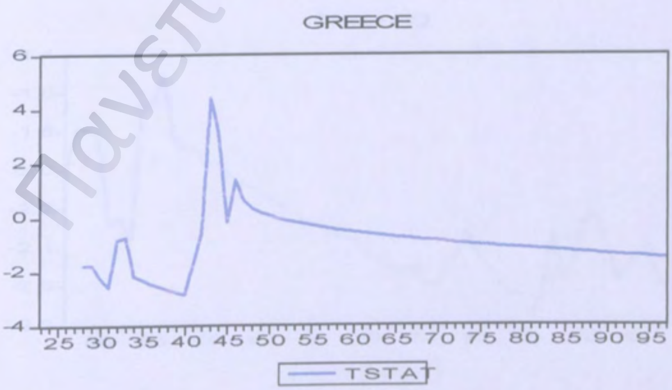
-2
-4
-6
-8
1820 1840 1860 1880 1900 1920 1940 1960 1980
TSTAT


GREECE
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2
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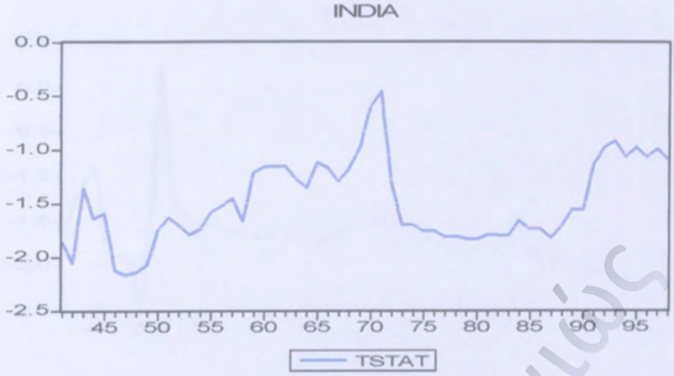
-2
-4
25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
TSTAT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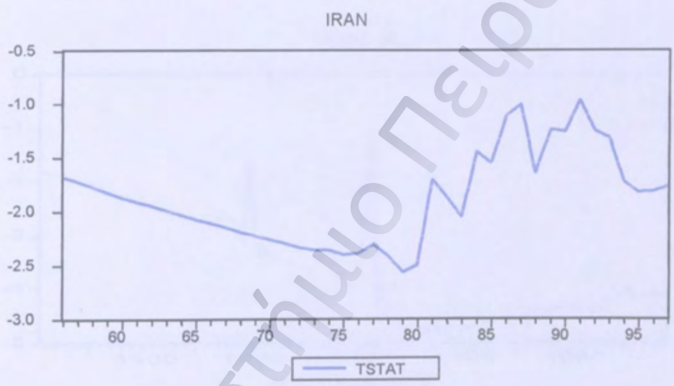
-2.5
45 50 55 60 65 70 75 80 85 90 95
TSTAT


IRAN
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-2.5
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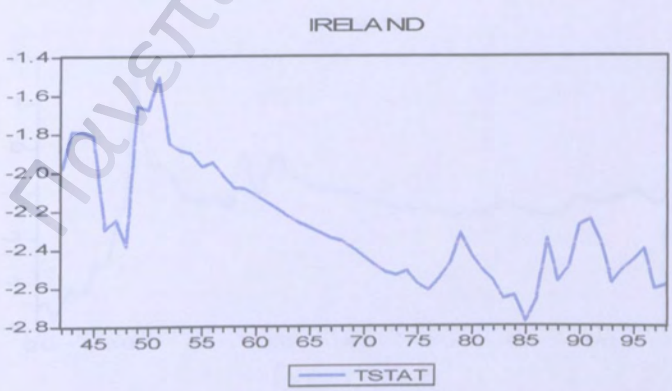
60 65 70 75 80 85 90 95
TSTAT


IRELAND
-1.4
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-2.2
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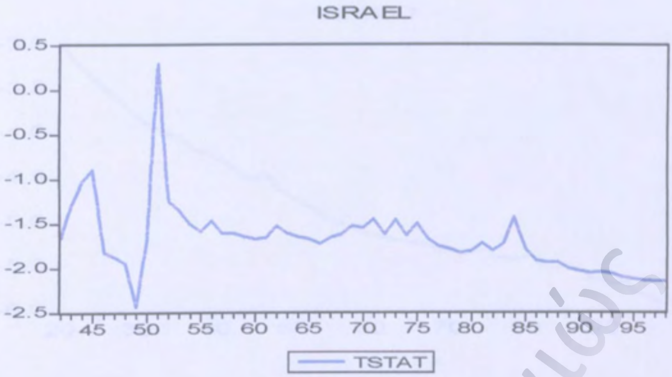
-2.6
-2.8
45 50 55 60 65 70 75 80 85 90 95
TSTAT


ISRAEL
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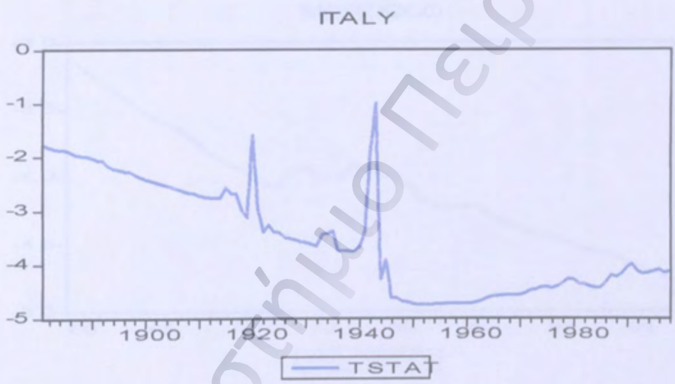
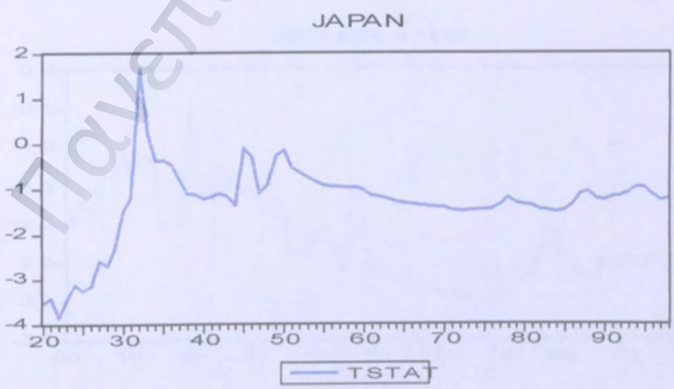
-2.5
45 50 55 60 65 70 75 80 85 90 95
TSTAT


ITALY
0
-1
-2
-3
-4
-5
1900 1920 1940 1960 1980
TSTAT


JAPAN
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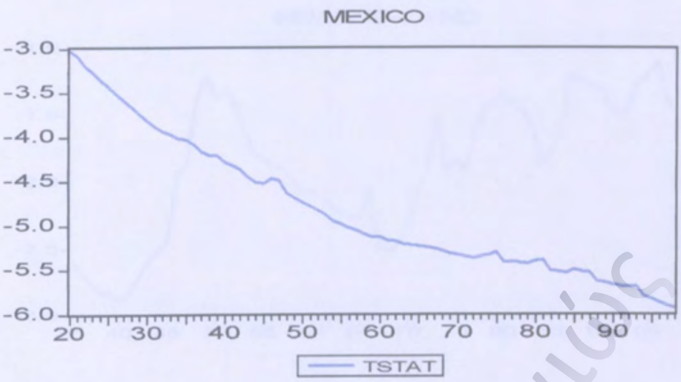
-1
-2
-3
-4
20 30 40 50 60 70 80 90
TSTAT


MEXICO
-3.0
-3.5
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-4.5
-5.0
-5.5
-6.0
20
30
40
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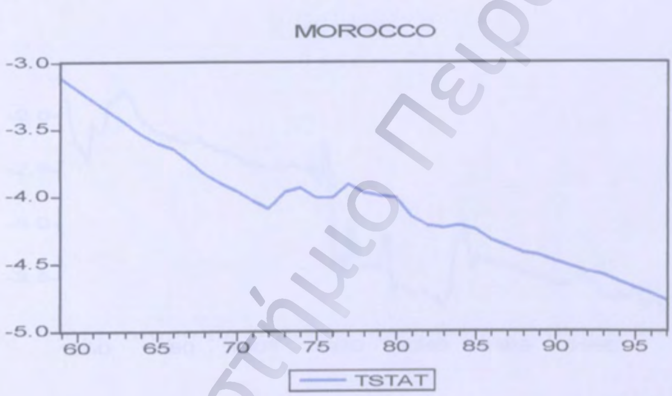
60
70
80
90
TSTAT


MOROCCO
-3.0
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-4.0
-4.5
-5.0
60
65
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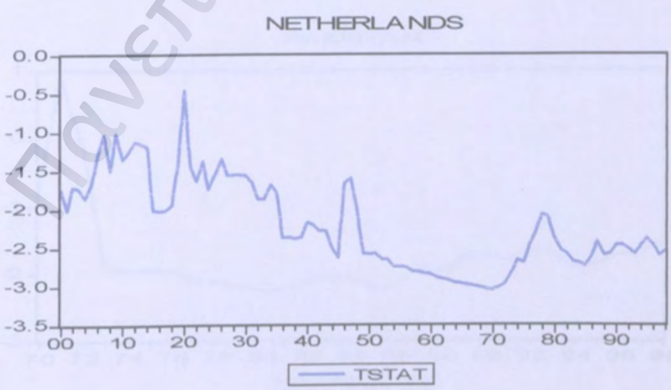
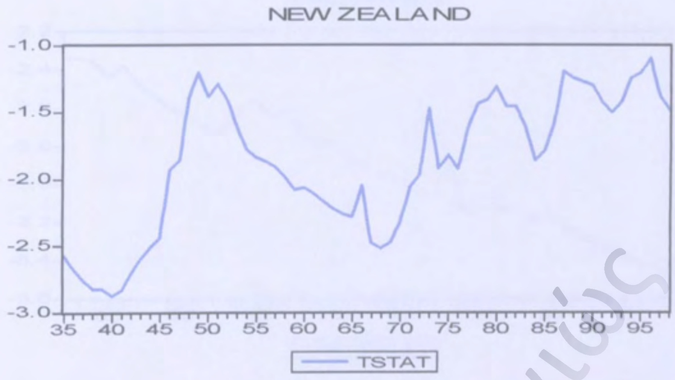
75
80
85
90
95
TSTAT


NETHERLANDS
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
00
10
20
30
40
50
60
70
80
90
TSTAT


NEW ZEALAND
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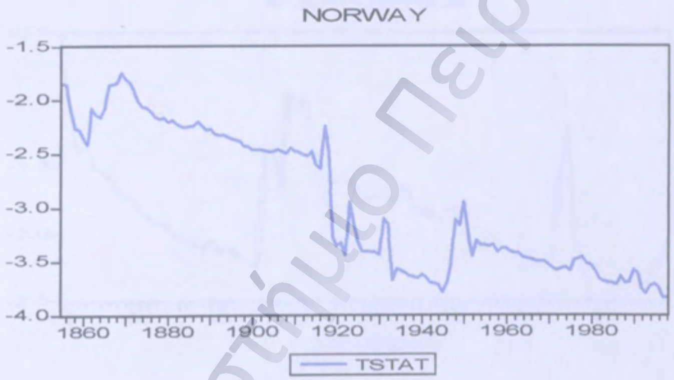
-2.5
-3.0
35 40 45 50 55 60 65 70 75 80 85 90 95
TSTAT


NORWAY
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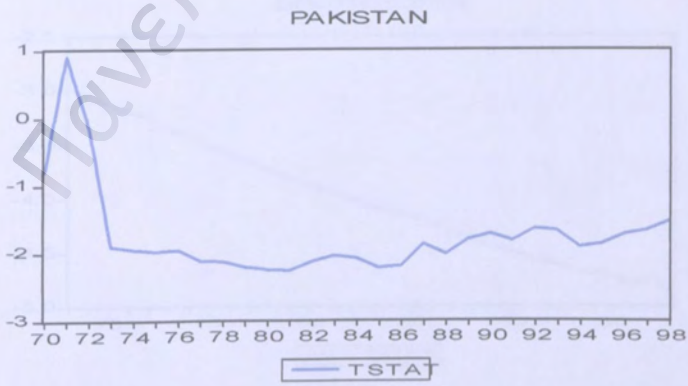
1860 1880 1900 1920 1940 1960 1980
TSTAT


PAKISTAN
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0
-1
-2
-3
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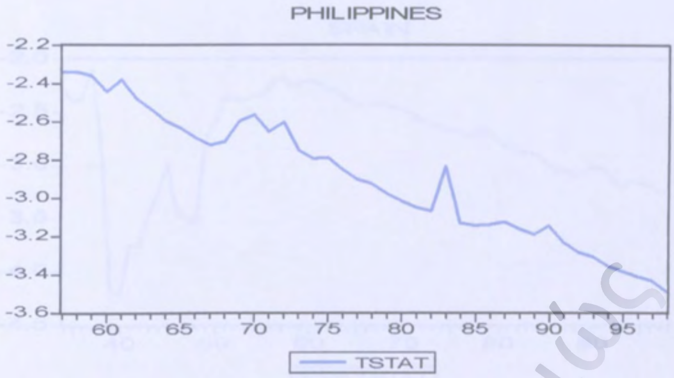
TSTAT


PHILIPPINES
-2.2
-2.4
-2.6
-2.8
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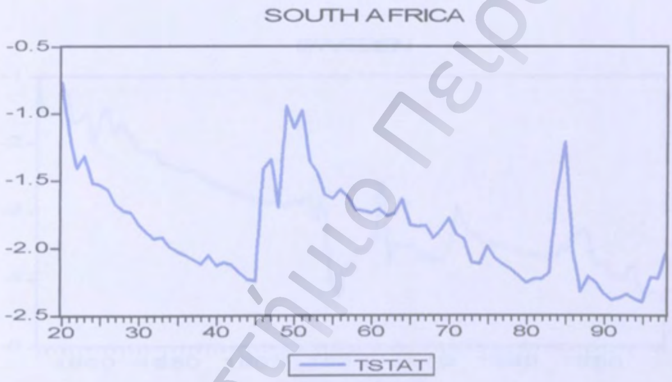
-3.2
-3.4
-3.6
60
65
70
75
80
85
90
95
TSTAT


SOUTH AFRICA
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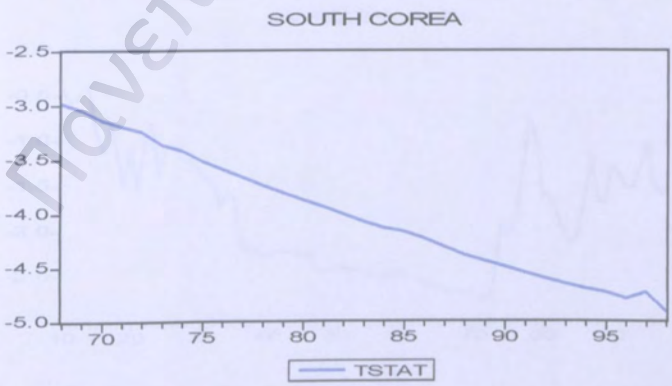
90
TSTAT


SOUTH COREA
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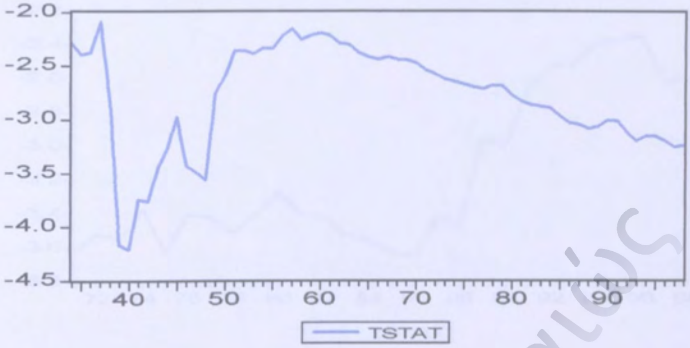
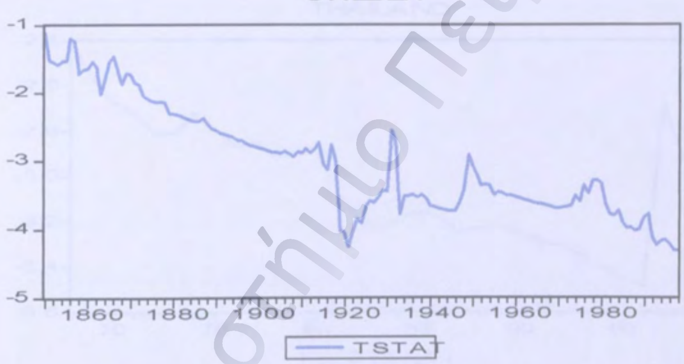
-4.5
-5.0
70
75
80
85
90
95
TSTAT

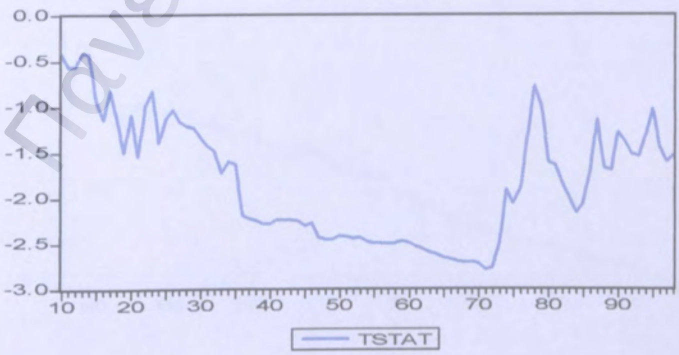
SPAIN

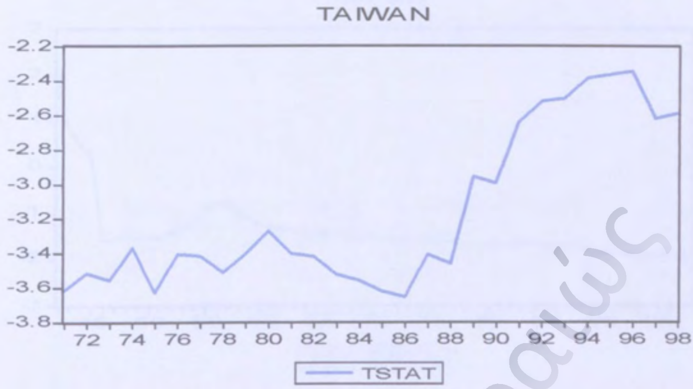


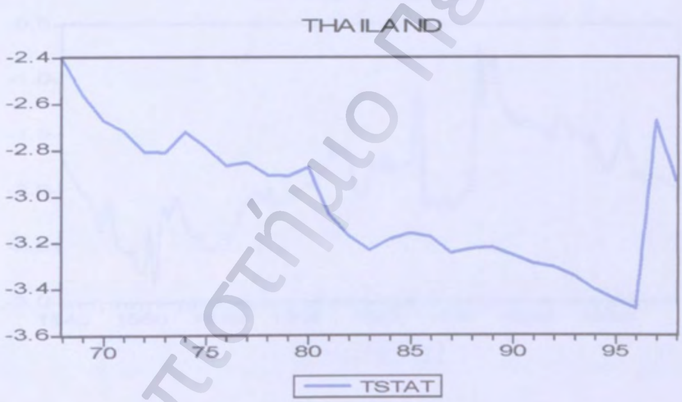
SWEDEN

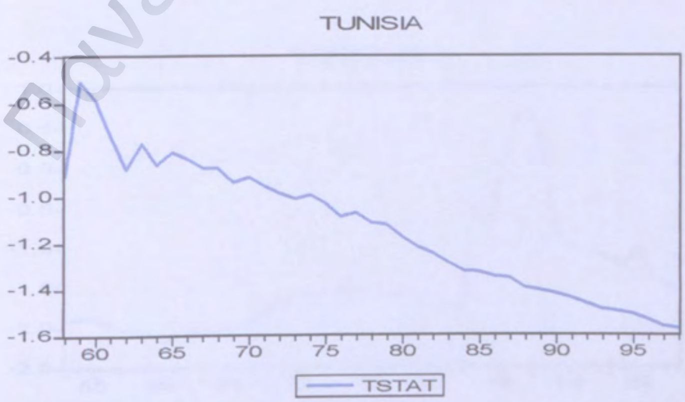


SWITZERLAND




TAIWAN
-2.2
-2.4
-2.6
-2.8
-3.0
-3.2
-3.4
-3.6
-3.8
72 74 76 78 80 82 84 86 88 90 92 94 96 98
TSTAT


THAILAND
-2.4
-2.6
-2.8
-3.0
-3.2
-3.4
-3.6
70 75 80 85 90 95
TSTAT


TUNISIA
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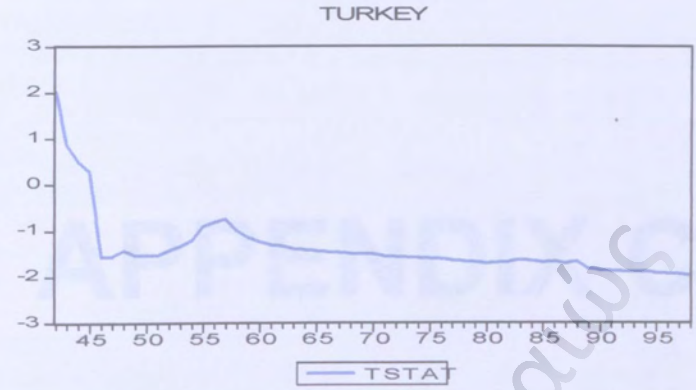
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
60 65 70 75 80 85 90 95
TSTAT


TURKEY
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-1
-2
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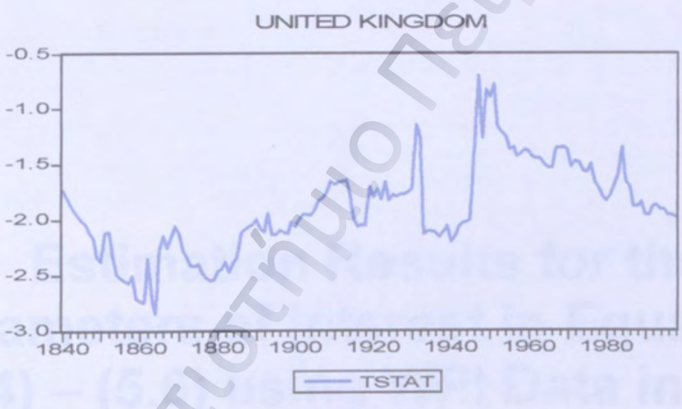
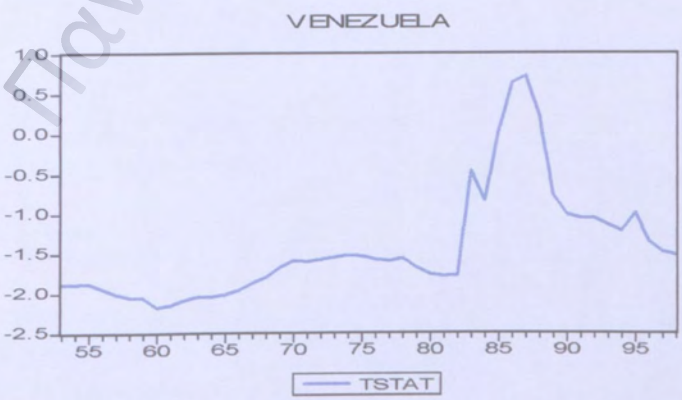
45
50
55
60
65
70
75
80
85
90
95
TSTAT


UNITED KINGDOM
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
1840
1860
1880
1900
1920
1940
1960
1980
TSTAT


VENEZUELA
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
55
60
65
70
75
80
85
90
95
TSTAT

APPENDIX C

Estimation Results for the parameters of interest in Equations (5.4) – (5.6) using WPI Data in RER construction

AUSTRALIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1902 1998			
Included Observations: 94			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.245531	0.266465	12.17994
C(2)	-0.626703	0.060674	-10.32908
C(3)	0.998980	0.005061	197.3978
Var (y_t)	1.86E-18	4.35E+13	4.27E-32
Var (β_t)	0.001346	0.052852	0.025467
Final β_t estimated (unrestricted)	0.937425	0.036687	25.55168
Log Likelihood		31.01174	

AUSTRIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1925 1998			
Included Observations: 71			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.655207	0.191172	19.11995
C(2)	-0.734156	0.043499	-16.87772
C(3)	0.983582	0.002431	404.5248
Var (y_t)	2.33E-09	46774.33	4.98E-14
Var (β_t)	0.000634	0.113730	0.005575
Final β_t estimated (unrestricted)	0.789010	0.025181	31.33392
Log Likelihood		0.778190	

BELGIUM

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1928 1998			
Included Observations: 68			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.352067	0.421733	10.31948
C(2)	-0.934491	0.906572	-1.030797
C(3)	1.004386	0.014237	70.54874
Var (y_t)	3.95E-08	3525.674	1.12E-11
Var (β_t)	0.002377	0.050444	0.047113
Final β_t estimated (unrestricted)	1.211852	0.048750	24.85865
Log Likelihood		-23.17010	

BRAZIL

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1938 1998			
Included Observations: 58			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.800220	0.511049	11.34964
C(2)	-1.183130	0.111173	-10.64227
C(3)	1.000580	0.005161	193.8695
Var (y_t)	1.58E-07	2100.050	7.51E-11
Var (β_t)	0.001512	0.204052	0.007408
Final β_t estimated (unrestricted)	0.806011	0.038879	20.73146
Log Likelihood		6.089527	

CANADA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1998			
Included Observations: 95			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.314484	0.340873	9.723524
C(2)	-0.700395	0.075479	-9.279316
C(3)	0.999756	0.000937	1067.527
Var (y_t)	2.71E-08	31010.74	8.73E-13
Var (β_t)	8.94E-05	7.507076	1.19E-05
Final β_t estimated (unrestricted)	0.998420	0.009458	105.5668
Log Likelihood		155.0637	

COLOMBIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1949 1998			
Included Observations: 47			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.035170	0.282966	14.26027
C(2)	-0.761244	0.061860	-12.30593
C(3)	0.995926	0.002083	478.2165
Var (y_t)	5.93E-08	6097.386	9.72E-12
Var (β_t)	0.000378	0.773006	0.000489
Final β_t estimated (unrestricted)	0.968507	0.019433	49.83818
Log Likelihood		2.793951	

COSTA RICA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1938 1998			
Included Observations: 58			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.025749	0.164999	24.39868
C(2)	-0.737103	0.036650	-20.11205
C(3)	1.003598	0.001980	506.8934
Var (y_t)	1.45E-07	1610.839	8.99E-11
Var (β_t)	0.000393	0.458774	0.000856
Final β_t estimated (unrestricted)	0.872063	0.019814	44.01336
Log Likelihood		-15.04815	

DENMARK

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1997			
Included Observations: 94			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.818268	0.139829	20.15512
C(2)	-0.463739	0.030151	-15.38053
C(3)	1.005952	0.001931	521.0475
Var (y_t)	3.13E-08	4702.500	6.66E-12
Var (β_t)	0.000450	0.252022	0.001787
Final β_t estimated (unrestricted)	0.811852	0.021221	38.25704
Log Likelihood		13.40289	

EGYPT

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1914 1997			
Included Observations: 81			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.782229	0.146440	32.65652
C(2)	-0.965468	0.032044	-30.12910
C(3)	0.987392	0.002292	430.8865
Var (y_t)	1.53E-07	1394.667	1.10E-10
Var (β_t)	0.000514	0.291745	0.001763
Final β_t estimated (unrestricted)	1.042616	0.022678	45.97394
Log Likelihood		-7.949401	

FINLAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1921 1997			
Included Observations: 74			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.943140	0.281298	10.46272
C(2)	-0.640934	1.015017	-0.631451
C(3)	1.000090	0.007178	139.3299
Var (y_t)	2.28E-15	4.19E+10	5.45E-26
Var (β_t)	0.002146	0.043823	0.048966
Final β_t estimated (unrestricted)	0.956428	0.046323	20.64690
Log Likelihood		-10.15978	

FRANCE

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1998			
Included Observations: 95			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	8.440599	0.195269	43.22547
C(2)	-1.781001	0.365705	-4.870046
C(3)	1.005891	0.005208	193.1616
Var (y_t)	3.79E-08	3059.005	1.24E-11
Var (β_t)	0.002187	0.046134	0.047408
Final β_t estimated (unrestricted)	1.050992	0.046767	22.47315
Log Likelihood		-8.897238	

GERMANY

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1801 1998			
Included Observations: 195			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.216132	0.397800	10.59861
C(2)	-0.829219	0.097697	-8.487701
C(3)	1.001515	0.006340	157.9706
Var (y_t)	5.51E-14	7.54E+08	7.30E-23
Var (β_t)	0.003827	0.005516	0.693916
Final β_t estimated (unrestricted)	1.673793	0.061866	27.05496
Log Likelihood		-220.0506	

INDIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1915 1997			
Included Observations: 80			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.373664	0.300949	11.21010
C(2)	-0.448573	0.068986	-6.502389
C(3)	1.005594	0.003728	269.7152
Var (y_t)	2.54E-07	1434.138	1.77E-10
Var (β_t)	0.000727	0.422737	0.001719
Final β_t estimated (unrestricted)	0.755526	0.026957	28.02694
Log Likelihood		-18.35150	

IRELAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1947 1997			
Included Observations: 48			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.614396	0.607924	5.945473
C(2)	-0.691240	0.130672	-5.289881
C(3)	0.997359	0.003793	262.9417
Var (y_t)	4.26E-08	20478.46	2.08E-12
Var (β_t)	0.000415	1.780059	0.000233
Final β_t estimated (unrestricted)	0.830952	0.020363	40.80700
Log Likelihood		43.99011	

ISRAEL

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1969 1998			
Included Observations: 27			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.314020	0.629271	5.266441
C(2)	-0.612958	0.139074	-4.407431
C(3)	1.013710	0.005000	202.7514
Var (y_t)	2.11E-06	606.5451	3.48E-09
Var (β_t)	0.000715	1.477623	0.000484
Final β_t estimated (unrestricted)	0.862752	0.026740	32.26491
Log Likelihood		-3.900243	

ITALY

SSpace: **UNRESTRICTED**
Estimation Method: Maximum Likelihood
Model: Time-Varying Coefficient Model
Sample(adjusted): 1911 1997
Included Observations: 84
Variance of observation equations: Diagonal
Variance of state equations: Diagonal

	Coefficient	Std. Error	t-Statistic
C(1)	5.211771	0.188980	27.57847
C(2)	-1.130117	0.137028	-8.247369
C(3)	0.986579	0.005541	178.0364
Var (y_t)	4.69E-10	235936.8	1.99E-15
Var (β_t)	0.002563	0.043803	0.058514
Final β_t estimated (unrestricted)	0.845940	0.050627	16.70913
Log Likelihood		-1.689295	

JAPAN

SSpace: UNRES
Estimation Method: Maximum Likelihood
Model: Time-Varying Coefficient Model
Sample(adjusted): 1869 1998
Included Observations: 127
Variance of observation equations: Diagonal
Variance of state equations: Diagonal

	Coefficient	Std. Error	t-Statistic
C(1)	7.695938	0.367925	20.91716
C(2)	-2.088969	0.088333	-23.64868
C(3)	0.997394	0.005518	180.7518
Var (y_t)	1.39E-17	4.39E+12	3.16E-30
Var (β_t)	0.002311	0.024051	0.096079
Final β_t estimated (unrestricted)	0.744186	0.048071	15.48110
Log Likelihood		15.46005	

MEXICO

SSpace: **UNRESTRICTED**
Estimation Method: Maximum Likelihood
Model: Time-Varying Coefficient Model
Sample(adjusted): 1888 1998
Included Observations: 108
Variance of observation equations: Diagonal
Variance of state equations: Diagonal

	Coefficient	Std. Error	t-Statistic
C(1)	5.834358	0.149319	39.07301
C(2)	-1.180315	0.036523	-32.31690
C(3)	0.993416	0.002886	344.2516
Var (y_t)	1.60E-08	5167.254	3.10E-12
Var (β_t)	0.001541	0.032366	0.047618
Final β_t estimated (unrestricted)	1.044210	0.039258	26.59835
Log Likelihood		-49.69933	

MOROCCO

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1940 1997			
Included Observations: 55			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.763943	0.622232	7.656221
C(2)	-1.449105	183.7463	-0.007886
C(3)	1.001408	0.232823	4.301161
Var (y_t)	5.99E-09	46137.64	1.30E-13
Var (β_t)	0.006090	0.056749	0.107321
Final β_t estimated (unrestricted)	1.152130	0.078041	14.76322
Log Likelihood		-12.36297	

NETHERLANDS

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1902 1998			
Included Observations: 94			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	6.535761	0.227717	28.70127
C(2)	-1.350837	0.050269	-26.87209
C(3)	0.991771	0.002458	403.4998
Var (y_t)	1.28E-07	1436.510	8.94E-11
Var (β_t)	0.000577	0.244945	0.002355
Final β_t estimated (unrestricted)	0.888846	0.024015	37.01155
Log Likelihood		24.72904	

NEW ZEALAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1914 1997			
Included Observations: 81			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	6.139293	0.298386	20.57504
C(2)	-1.233205	0.065632	-18.78962
C(3)	0.994496	0.003307	300.6945
Var (y_t)	7.43E-10	296287.7	2.51E-15
Var (β_t)	0.000810	0.251899	0.003217
Final β_t estimated (unrestricted)	0.596879	0.028467	20.96705
Log Likelihood		39.45208	

NORWAY

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1881 1998			
Included Observations: 115			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.363097	0.095047	24.86238
C(2)	-0.324669	0.020888	-15.54342
C(3)	1.004637	0.001472	682.6743
Var (y_t)	2.85E-07	713.5727	3.99E-10
Var (β_t)	0.000347	0.458687	0.000756
Final β_t estimated (unrestricted)	0.802920	0.018623	43.11422
Log Likelihood		-13.41663	

PAKISTAN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1962 1998			
Included Observations: 34			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.192213	0.674545	4.732391
C(2)	-0.528293	0.149413	-3.535802
C(3)	0.993718	0.005681	174.9096
Var (y_t)	7.79E-08	9575.731	8.14E-12
Var (β_t)	0.000738	0.866953	0.000851
Final β_t estimated (unrestricted)	0.846076	0.027163	31.14766
Log Likelihood		2.002236	

PHILIPPINES

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1936 1997			
Included Observations: 59			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.301195	0.190920	22.52881
C(2)	-0.878317	0.055418	-15.84907
C(3)	0.988604	0.006922	142.8155
Var (y_t)	1.27E-06	128.9849	9.87E-09
Var (β_t)	0.002129	0.056359	0.037776
Final β_t estimated (unrestricted)	0.913873	0.046142	19.80565
Log Likelihood		-13.50872	

SOUTH AFRICA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1911 1998			
Included Observations: 85			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.268998	0.411305	10.37914
C(2)	-0.805612	0.092997	-8.662815
C(3)	1.002421	0.002309	434.0916
Var (y_t)	5.14E-08	5060.880	1.02E-11
Var (β_t)	0.000457	0.456623	0.001000
Final β_t estimated (unrestricted)	0.974939	0.021372	45.61725
Log Likelihood		30.82491	

SOUTH KOREA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1931 1998			
Included Observations: 65			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.027368	0.190367	26.40876
C(2)	-0.923591	0.150559	-6.134411
C(3)	0.993944	0.008625	115.2391
Var (y_t)	1.16E-08	9142.874	1.27E-12
Var (β_t)	0.004954	0.021065	0.235159
Final β_t estimated (unrestricted)	1.036353	0.070382	14.72469
Log Likelihood		-38.85955	

SPAIN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1815 1998			
Included Observations: 181			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.900255	0.153321	25.43850
C(2)	-0.788393	0.038924	-20.25445
C(3)	1.003418	0.002833	354.1597
Var (y_t)	2.02E-10	307475.9	6.56E-16
Var (β_t)	0.001046	0.040841	0.025599
Final β_t estimated (unrestricted)	1.129728	0.032334	34.93889
Log Likelihood		8.910382	

SWEDEN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1861 1998			
Included Observations: 135			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	1.965769	0.257542	7.632800
C(2)	-0.141759	0.055470	-2.555619
C(3)	1.003055	0.003782	265.2082
Var (y_t)	1.36E-08	15928.84	8.51E-13
Var (β_t)	0.000787	0.235708	0.003338
Final β_t estimated (unrestricted)	0.676946	0.028048	24.13507
Log Likelihood		65.66445	

SWITZERLAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1817 1998			
Included Observations: 179			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.821276	0.125435	30.46409
C(2)	-0.582476	0.027323	-21.31834
C(3)	1.004431	0.001722	583.1980
Var (y_t)	1.20E-07	1094.194	1.10E-10
Var (β_t)	0.000408	0.248066	0.001644
Final β_t estimated (unrestricted)	0.578595	0.020193	28.65395
Log Likelihood		36.75419	

TAIWAN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1950 1997			
Included Observations: 45			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.568033	0.501415	9.110289
C(2)	-0.970396	0.118297	-8.203010
C(3)	0.996893	0.004546	219.2803
Var (y_t)	5.91E-08	12643.76	4.68E-12
Var (β_t)	0.000565	1.119364	0.000505
Final β_t estimated (unrestricted)	0.963869	0.023778	40.53557
Log Likelihood		28.24852	

THAILAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1948 1998			
Included Observations: 48			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.515413	0.398912	13.82614
C(2)	-1.081127	0.089734	-12.04809
C(3)	0.994352	0.004789	207.6527
Var (y_t)	6.98E-08	5546.829	1.26E-11
Var (β_t)	0.000669	0.479990	0.001395
Final β_t estimated (unrestricted)	0.826372	0.025875	31.93766
Log Likelihood		22.15746	

TUNISIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1941 1997			
Included Observations: 54			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	7.440054	0.603831	12.32141
C(2)	-1.907445	5.184849	-0.367888
C(3)	1.003647	0.017904	56.05733
Var (y_t)	1.01E-07	1360.550	7.44E-11
Var (β_t)	0.003809	0.032325	0.117845
Final β_t estimated (unrestricted)	1.303230	0.061720	21.11525
Log Likelihood		-18.20263	

TURKEY

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1931 1998			
Included Observations: 65			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.197166	0.411455	12.63118
C(2)	-1.217762	3.193006	-0.381384
C(3)	0.998470	0.014526	68.73891
Var (y_t)	2.34E-27	2.61E+22	8.97E-50
Var (β_t)	0.008376	0.008828	0.948706
Final β_t estimated (unrestricted)	1.131792	0.091518	12.36683
Log Likelihood		-37.76134	

UNITED KINGDOM

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1791 1998			
Included Observations: 205			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	1.091936	0.327891	3.330179
C(2)	0.215785	0.083129	2.595782
C(3)	1.004889	0.004989	201.4017
Var (y_t)	1.93E-08	11201.56	1.72E-12
Var (β_t)	0.001188	0.159906	0.007427
Final β_t estimated (unrestricted)	0.533625	0.034462	15.48460
Log Likelihood		15.42631	

VENEZUELA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1997			
Included Observations: 94			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.536084	0.282710	16.04501
C(2)	-0.732951	0.059752	-12.26657
C(3)	0.993450	0.003854	257.7943
Var (y_t)	3.82E-07	510.2064	7.49E-10
Var (β_t)	0.000737	0.194484	0.003788
Final β_t estimated (unrestricted)	0.754828	0.027143	27.80963
Log Likelihood		2.023159	

APPENDIX D

Estimation Results for the parameters of interest in Equations (5.4) – (5.6) using CPI Data in RER construction

AUSTRALIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1862 1998			
Included Observations: 134			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.761960	0.113299	33.20391
C(2)	-0.517666	0.022984	-22.52248
C(3)	1.011439	0.001500	674.1455
Var (y_t)	3.49E-08	3033.429	1.15E-11
Var (β_t)	0.000357	0.180642	0.001977
Final β_t estimated (unrestricted)	0.858155	0.018898	45.40916
Log Likelihood		-32.76828	

AUSTRIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1920 1998			
Included Observations: 76			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	1.154240	0.251458	4.590184
C(2)	-0.264145	0.120191	-2.197704
C(3)	0.997766	0.004632	215.4254
Var (y_t)	0.033610	0.004959	6.777710
Var (β_t)	0.000637	0.108385	0.005878
Final β_t estimated (unrestricted)	0.859705	0.044031	19.52493
Log Likelihood		-2.031305	

BELGIUM

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1836 1998			
Included Observations: 160			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	8.935447	0.076908	116.1830
C(2)	-1.782796	0.021264	-83.84021
C(3)	1.001189	0.003240	308.9741
Var (y_t)	8.97E-07	154.8764	5.79E-09
Var (β_t)	0.001675	0.063610	0.026328
Final β_t estimated (unrestricted)	1.345465	0.040924	32.87732
Log Likelihood		-1.676397	

CANADA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1911 1998			
Included Observations: 85			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.142080	0.238231	13.18923
C(2)	-0.683382	0.053255	-12.83223
C(3)	1.000524	0.000757	1321.541
Var (y_t)	8.83E-08	7453.649	1.18E-11
Var (β_t)	6.39E-05	8.100924	7.88E-06
Final β_t estimated (unrestricted)	1.071163	0.007991	134.0449
Log Likelihood		128.0434	

COLOMBIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1924 1998			
Included Observations: 72			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.619307	0.298842	12.11110
C(2)	-0.528882	0.074733	-7.076994
C(3)	1.006201	0.003153	319.1675
Var (y_t)	9.30E-07	470.5941	1.98E-09
Var (β_t)	0.000706	0.504577	0.001399
Final β_t estimated (unrestricted)	0.825868	0.026572	31.08054
Log Likelihood		-39.07632	

COSTA RICA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1938 1998			
Included Observations: 58			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.635994	0.143781	25.28835
C(2)	-0.650780	0.032070	-20.29225
C(3)	1.006925	0.002482	405.7369
Var (y_t)	4.59E-07	489.2838	9.38E-10
Var (β_t)	0.000467	0.347467	0.001343
Final β_t estimated (unrestricted)	0.923092	0.021599	42.73703
Log Likelihood		-22.31275	

DENMARK

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1865 1998			
Included Observations: 131			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.097668	0.233629	13.25893
C(2)	-0.652429	0.053889	-12.10689
C(3)	0.998538	0.001880	531.0254
Var (y_t)	1.24E-08	12135.83	1.02E-12
Var (β_t)	0.000481	0.250460	0.001921
Final β_t estimated (unrestricted)	0.893960	0.021937	40.75150
Log Likelihood		89.38572	

EGYPT

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1916 1998			
Included Observations: 80			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.497810	0.286532	8.717373
C(2)	-0.271505	0.065969	-4.115651
C(3)	1.004094	0.002339	429.2373
Var (y_t)	1.96E-07	1525.096	1.28E-10
Var (β_t)	0.000425	0.561181	0.000758
Final β_t estimated (unrestricted)	0.797555	0.020619	38.68135
Log Likelihood		-31.88234	

FINLAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1921 1998			
Included Observations: 75			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.593848	0.176018	26.09878
C(2)	-1.160026	0.040877	-28.37811
C(3)	0.997965	0.002708	368.5304
Var (y_t)	9.37E-10	104499.0	8.96E-15
Var (β_t)	0.000780	0.085080	0.009172
Final β_t estimated (unrestricted)	1.022043	0.027935	36.58587
Log Likelihood		-9.265346	

FRANCE

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1841 1998			
Included Observations: 155			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	7.417643	0.184979	40.09993
C(2)	-1.500239	0.043730	-34.30704
C(3)	0.993835	0.003297	301.4205
Var (y_t)	7.38E-08	1522.548	4.85E-11
Var (β_t)	0.001369	0.064881	0.021095
Final β_t estimated (unrestricted)	0.959424	0.036995	25.93386
Log Likelihood		12.25588	

GREECE

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1924 1997			
Included Observations: 71			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.356077	4.207983	0.797550
C(2)	0.881924	0.423285	2.083524
C(3)	-0.417019	1.392513	-0.299472
Var (y_t)	31.70923	9.607279	3.300542
Var (β_t)	0.013922	0.029530	0.471440
Final β_t estimated (unrestricted)	-0.002098	0.125380	-0.016734
Log Likelihood		-226.8690	

INDIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1922 1998			
Included Observations: 74			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.519067	0.262366	9.601337
C(2)	-0.317123	0.060973	-5.200999
C(3)	1.002855	0.002155	465.3698
Var (y_t)	1.01E-07	3615.229	2.80E-11
Var (β_t)	0.000394	0.761849	0.000518
Final β_t estimated (unrestricted)	0.870977	0.019861	43.85463
Log Likelihood		-37.59445	

IRELAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1923 1998			
Included Observations: 73			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.112925	0.284105	10.95695
C(2)	-0.570361	0.062248	-9.162688
C(3)	1.003513	0.002065	486.0684
Var (y_t)	1.56E-07	1775.802	8.81E-11
Var (β_t)	0.000427	0.518791	0.000822
Final β_t estimated (unrestricted)	0.869295	0.020652	42.09216
Log Likelihood		27.25421	

ISRAEL

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1923 1998			
Included Observations: 73			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.330714	0.102427	52.04423
C(2)	-1.183646	0.025749	-45.96935
C(3)	0.994556	0.001599	621.9784
Var (y_t)	1.12E-07	1510.662	7.38E-11
Var (β_t)	0.000532	0.222891	0.002386
Final β_t estimated (unrestricted)	1.216653	0.023064	52.75194
Log Likelihood		-41.41211	

ITALY

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1862 1998			
Included Observations: 134			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.835078	0.115885	50.35248
C(2)	-1.024112	0.026770	-38.25654
C(3)	0.983577	0.003542	277.7041
Var (y_t)	1.37E-08	6598.686	2.08E-12
Var (β_t)	0.001530	0.046807	0.032678
Final β_t estimated (unrestricted)	0.666432	0.039110	17.04010
Log Likelihood		0.710485	

JAPAN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1998			
Included Observations: 95			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	9.449483	0.461871	20.45915
C(2)	-1.998314	0.104035	-19.20803
C(3)	0.997772	0.005085	196.2230
Var (y_t)	1.72E-11	5817216.	2.96E-18
Var (β_t)	0.001720	0.052655	0.032656
Final β_t estimated (unrestricted)	0.845232	0.041467	20.38327
Log Likelihood		5.355796	

MEXICO

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1998			
Included Observations: 95			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.096474	0.202482	25.16996
C(2)	-1.135744	0.634625	-1.789631
C(3)	0.991359	0.006951	142.6261
Var (y_t)	1.32E-11	5421872.	2.43E-18
Var (β_t)	0.003461	0.018513	0.186939
Final β_t estimated (unrestricted)	0.988376	0.058829	16.80082
Log Likelihood		-23.14083	

MOROCCO

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1940 1997			
Included Observations: 55			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.376544	0.521895	10.30197
C(2)	-1.598314	1.969073	-0.811709
C(3)	1.000628	0.015314	65.33863
Var (y_t)	3.87E-09	22867.62	1.69E-13
Var (β_t)	0.004854	0.014035	0.345849
Final β_t estimated (unrestricted)	1.078093	0.069670	15.47418
Log Likelihood		-13.57937	

NETHERLANDS

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1881 1998			
Included Observations: 115			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.414326	0.414562	13.06036
C(2)	-1.099392	0.089870	-12.23316
C(3)	1.001994	0.002830	354.0596
Var (y_t)	6.95E-08	2364.995	2.94E-11
Var (β_t)	0.000676	0.193652	0.003492
Final β_t estimated (unrestricted)	0.902361	0.026004	34.70149
Log Likelihood		60.60178	

NEW ZEALAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1916 1998			
Included Observations: 80			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.756112	0.403578	11.78487
C(2)	-0.888734	0.086232	-10.30626
C(3)	0.997263	0.002819	353.7611
Var (y_t)	5.01E-11	3841456.	1.30E-17
Var (β_t)	0.000590	0.285959	0.002062
Final β_t estimated (unrestricted)	0.819402	0.024285	33.74133
Log Likelihood		43.47306	

NORWAY

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1836 1998			
Included Observations: 160			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.405306	0.195188	12.32305
C(2)	-0.491255	0.046723	-10.51423
C(3)	1.001029	0.001867	536.0936
Var (y_t)	4.32E-10	277179.3	1.56E-15
Var (β_t)	0.000544	0.186284	0.002919
Final β_t estimated (unrestricted)	0.954662	0.023318	40.94051
Log Likelihood		103.5101	

PAKISTAN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1951 1998			
Included Observations: 45			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.570691	0.382565	6.719625
C(2)	-0.441681	0.083334	-5.300109
C(3)	0.999618	0.002556	391.0649
Var (y_t)	4.08E-08	10516.60	3.88E-12
Var (β_t)	0.000404	0.877299	0.000461
Final β_t estimated (unrestricted)	0.974465	0.020103	48.47474
Log Likelihood		13.14767	

PHILIPPINES

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1938 1998			
Included Observations: 58			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.747015	0.221391	16.92491
C(2)	-0.807994	0.347704	-2.323801
C(3)	0.988881	0.008864	111.5582
Var (y_t)	2.33E-07	542.2850	4.30E-10
Var (β_t)	0.002510	0.037650	0.066672
Final β_t estimated (unrestricted)	0.989674	0.050102	19.75322
Log Likelihood		-19.19965	

SOUTH AFRICA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1901 1998			
Included Observations: 95			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.151307	0.462974	8.966616
C(2)	-0.742930	0.102095	-7.276817
C(3)	1.002522	0.002483	403.8315
Var (y_t)	4.49E-08	9311.346	4.82E-12
Var (β_t)	0.000415	0.822056	0.000505
Final β_t estimated (unrestricted)	1.028390	0.020382	50.45618
Log Likelihood		50.40401	

SOUTH KOREA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1949 1998			
Included Observations: 47			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.827097	0.223273	21.61974
C(2)	-1.048074	0.162712	-6.441269
C(3)	1.007280	0.005213	193.2090
Var (y_t)	2.72E-10	664295.9	4.09E-16
Var (β_t)	0.001566	0.110398	0.014189
Final β_t estimated (unrestricted)	1.273509	0.039578	32.17738
Log Likelihood		-9.137911	

SPAIN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1915 1998			
Included Observations: 81			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.864127	0.437483	8.832641
C(2)	-0.775433	0.100298	-7.731255
C(3)	0.995961	0.003134	317.8178
Var (y_t)	1.11E-07	1343.057	8.24E-11
Var (β_t)	0.000892	0.118016	0.007560
Final β_t estimated (unrestricted)	0.981140	0.029869	32.84766
Log Likelihood		-1.923157	

SWEDEN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1831 1998			
Included Observations: 165			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.435843	0.263481	9.244862
C(2)	-0.492679	0.055806	-8.828396
C(3)	1.000846	0.001680	595.5818
Var (y_t)	1.52E-08	16699.05	9.10E-13
Var (β_t)	0.000416	0.508886	0.000818
Final β_t estimated (unrestricted)	0.980648	0.020398	48.07678
Log Likelihood		143.3124	

SWITZERLAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1891 1998			
Included Observations: 105			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.370137	0.285093	11.82120
C(2)	-0.727236	0.077430	-9.392205
C(3)	0.999259	0.001889	529.0975
Var (y_t)	1.64E-10	1394786.	1.17E-16
Var (β_t)	0.000424	0.467192	0.000907
Final β_t estimated (unrestricted)	0.924334	0.020586	44.90192
Log Likelihood		86.14478	

TAIWAN

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1952 1998			
Included Observations: 44			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.632769	0.318412	11.40901
C(2)	-0.700400	0.073108	-9.580332
C(3)	0.993793	0.002291	433.8372
Var (y_t)	6.81E-07	1201.020	5.67E-10
Var (β_t)	0.000306	2.161428	0.000141
Final β_t estimated (unrestricted)	0.841867	0.017481	48.15883
Log Likelihood		28.08977	

THAILAND

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1949 1998			
Included Observations: 47			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	5.315305	0.394307	13.48012
C(2)	-1.193543	0.085389	-13.97779
C(3)	1.001382	0.004592	218.0743
Var (y_t)	2.06E-07	2140.716	9.63E-11
Var (β_t)	0.000407	0.876107	0.000465
Final β_t estimated (unrestricted)	1.050520	0.020186	52.04109
Log Likelihood		38.54405	

TUNISIA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1939 1998			
Included Observations: 57			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	-0.308243	0.280136	-1.100331
C(2)	0.860172	0.077043	11.16482
C(3)	-0.024471	0.539362	-0.045371
Var (y_t)	5.04E-34	1.14E+29	4.43E-63
Var (β_t)	0.085555	0.013830	6.186047
Final β_t estimated (unrestricted)	-0.000189	0.292499	-0.000647
Log Likelihood		-57.97378	

TURKEY

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1923 1998			
Included Observations: 73			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	3.194530	0.317572	10.05922
C(2)	-0.698037	0.559340	-1.247966
C(3)	1.003313	0.006889	145.6343
Var (y_t)	2.49E-21	2.62E+16	9.52E-38
Var (β_t)	0.002000	0.025811	0.077469
Final β_t estimated (unrestricted)	1.004320	0.044716	22.45974
Log Likelihood		-2.320364	

UNITED KINGDOM

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1821 1998			
Included Observations: 175			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	2.778303	0.245912	11.29798
C(2)	-0.590552	0.054079	-10.92012
C(3)	1.000079	0.001552	644.2329
Var (y_t)	2.05E-11	6927316.	2.97E-18
Var (β_t)	0.000454	0.267857	0.001695
Final β_t estimated (unrestricted)	1.072156	0.021308	50.31641
Log Likelihood		123.8769	

VENEZUELA

SSpace: **UNRESTRICTED**			
Estimation Method: Maximum Likelihood			
Model: Time-Varying Coefficient Model			
Sample(adjusted): 1934 1998			
Included Observations: 62			
Variance of observation equations: Diagonal			
Variance of state equations: Diagonal			
	Coefficient	**Std. Error**	**t-Statistic**
C(1)	4.688512	0.564718	8.302392
C(2)	-1.034944	0.179434	-5.767810
C(3)	0.998490	0.006010	166.1417
Var (y_t)	1.72E-08	11930.84	1.44E-12
Var (β_t)	0.001220	0.142040	0.008592
Final β_t estimated (unrestricted)	1.054869	0.034934	30.19613
Log Likelihood		19.33411	