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Non-Linearities and Unit Roots in G7 Macroeconomic Variables

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Non-Linearities and Unit Roots in G7 Macroeconomic Variables*

Yunus Aksoy and Miguel A. Leon-Ledesma

Abstract

We carry out a meta-analysis on the frequency of unit-roots in macroeconomic time series with a dataset covering 249 variables for the G7 countries. We use linear tests and the three popular non-linear tests (TAR, ESTAR and Markov Switching). In general, the evidence in favour of the random walk hypothesis is weaker than in previous studies. This evidence against unit roots is stronger for real and nominal asset prices. Our results show that rejection of the null of a unit root in the macro dataset is substantially higher for non-linear than linear models. Finally, the results from a Monte Carlo experiment show that rejection frequencies are very close to the nominal size of the test when the DGP is a linear unit root process. This leads us to reject the hypothesis that overfitting deterministic components explains the higher rejection frequencies of nonlinear tests.

KEYWORDS: overfitting, nonlinear models, unit root

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1. Introduction

Ever since Nelson and Plosser's (1982) work on trends and random walks in macroeconomic time series, stationarity testing has become a cornerstone feature of the applied time series literature. Both from the econometrics and macroeconomics literature, discussion about the stationarity properties of time series has become part of the core of analysis. Unit roots (UR) are very important for macroeconomic modelling due to the well known spurious regression problem analyzed by Newbold and Granger (1974). Also, the permanent vs. transitory nature of shocks is relevant for theory models that aim at being consistent with the actual data generating process of macroeconomic time series.[1] Finally, for finance professionals and policy-makers, Diebold and Kilian (2000) show that pre-testing for unit roots before implementing forecasts yield superior forecasting performance to the alternatives of working always with differenced series or working always with level series.

The literature is very large. It ranges from attempts at alleviating the low power properties of traditional ADF tests (see Elliott et al., 1996 and Ng and Perron, 2001) to the impact of structural breaks on inference about unit roots in Perron (1989) and the literature thereafter (e.g. Andrews and Ploberger, 1994, Vogelsang and Perron, 1998).[2] To date, there is a consensus view that in the presence of structural breaks the standard linear unit root tests tend to under-reject the null of a unit root. A recent strand of the literature, however, has become very popular. It deals with the effect of potential non-linearities in the underlying DGP on unit root testing. Since the work of Neftci (1984), testing for non-linearities and structural instabilities has gained a major importance in applied work. Stock and Watson (1996), for instance, carry out a comprehensive study of parameter instability in a large macroeconomic dataset and find that the tests indicate widespread instability in univariate and bivariate autoregressive models. Enders and Granger (1998) show that if these non-linearities are prevalent under the alternative of stationarity, linear tests for UR suffer from lack of power. This has led to the recent appearance of a variety of tests that account for non-linear DGPs in the data.

In principle, any economic time series could be fitted with a sufficiently non-linear functional form. However, economic interpretability and "parsimony"

[1] Contrary to this viewpoint, Christiano and Eichenbaum (1990), argue that there is little relevance in the stationarity properties of GNP for modelling purposes.

[2] A particular issue of interest is the presence of outliers. Kilian and Ohanian (2002) show that in the presence of outliers (temporary large shocks) ADF tests tend to overreject the null of a unit root. For per capita GDP in several industrialized countries Darne and Diebolt (2004) show that the statistically significant outliers were major events such as the First and Second World Wars, German hyperinflation, and the Great Depression.

requires particular forms of non-linearity. Three of these particular forms that have been widely applied in the literature are Threshold Autoregressive (TAR) models, Smooth Transition Autoregressive (STAR) models, and Markov Switching models (MS). A complete analysis of unit roots within the context of TAR models[3] has been developed in Caner and Hansen (2001). In their paper they build on Enders and Granger (1998) and develop a test for unit roots when the series behaves as a momentum-TAR (M-TAR) variable under the alternative of stationarity. That is, the parameters of the ADF-type equation are different if lagged changes in the variable are above or below a particular threshold. A test for unit roots within the second class of models is developed in Kapetanios et al (2003). The variable follows an Exponential-STAR (ESTAR) process under the alternative and a linear unit root under the null. The ESTAR model assumes that there is a middle and two outer (symmetric) regimes. The series is then assumed to be non-stationary in the middle regime but mean reverting in the outer regimes under the alternative. Finally, although not yet as developed as the previous two classes of models, Hall et al (1999) present a test for unit roots when the variable is subject to Markov Switching changes in the parameters with two regimes.[4] In principle, MS models would encompass most forms of structural breaks analysed in the literature[5] and hence this is a very general model of structural instability for the parameters of an ADF-type equation.

The applied literature on unit roots has used these and related tests very intensively in the last few years. Although they are not the only potential forms of non-linearity nor the only tests developed for these non-linear functions, we will focus on them because they are both pioneering works that develop full testing procedures and have been widely used in recent years in applied work.

Our purpose in this paper is twofold. First, we present evidence on unit roots tests for a large macroeconomic dataset for the G7 countries using linear tests and the three popular non-linear tests mentioned above. This will help comparing rejection frequencies for actual data of linear and non-linear tests and further the evidence on trends and random walks pioneered by Nelson and Plosser (1982). In this sense, our paper provides a meta-analysis of non-linear unit root tests using 249 macroeconomic time series, roughly half of them being real and the other half nominal/financial variables. This will allow us to analyse whether the results are consistent with some theory priors about the stationarity properties of the series. Given the large nature of the database, our study does not pay special attention to a detailed modelling of particular time series. However, it does

[3] More particularly Momentum-TAR (MTAR) models.

[4] Properly speaking the Hall et al (1999) test was developed to account for periodically collapsing bubbles and hence allowed for the existence of an explosive regime.

[5] See Nelson et al (2001) for an analysis of the impact of Markov Switching on linear unit root tests.

provide broad evidence on the frequency of unit-roots in macroeconomic series that can serve as both a useful guide and as food for thought for further analysis for the applied macroeconomist. To our knowledge, a broad study of this nature using both linear and non-linear tests and different kinds of macro time series has not been presented previously in the literature.

Second, given that our results show, as expected, higher rejection frequencies for actual data, we pose the question of whether this is the result of non-linear tests "over-fitting" underlying deterministic components or simply because the available data actually presents some form of non-linearity.[6] As mentioned before, a sufficiently non-linear model could be able to perfectly fit any economic time series. For example, one could think of a Markov Switching in mean model in which, by imposing m states in the data, the fit artificially captures N structural breaks for each state m even if the underlying process is a stochastic linear one. To this end, we perform a Monte Carlo experiment to analyse the rejection frequencies of these tests when the actual DGP is a linear unit root.

Our results show that, in general, the evidence in favour of the random walk hypothesis is weaker than in previous studies. Rejection of the null of a unit root in the macro dataset is substantially higher for non-linear than linear models (roughly, 10% versus 20%). The ESTAR test of Kapetanios et al (2003) and the Markov Switching model with switches in the intercept reject most frequently the null. In a few cases we reject the null of a unit root for some macroeconomic variables that a priori are expected to follow a random walk, (e.g. in some money supply series or price indices). The results from a Monte Carlo experiment show that rejection frequencies are very close to the nominal size of the test, leading us to reject the over-fitting explanation. This is always the case for sample sizes that are roughly similar to those used in most economic applications.

The paper is organised as follows. In section 2 we present and discuss the non-linear unit root tests. Section 3 presents the results for the large macroeconomic dataset. In Section 4 we perform the Monte Carlo experiments for rejection frequencies and Section 5 concludes.

2. Non-linear unit root tests

2.1. TAR unit root tests: Caner and Hansen (2001)

Caner and Hansen (2001) (CH) propose a test based on an ADF-type equation that follows an asymmetric M-TAR structure. For a stochastic process y_t with $t = 1,\ldots,T$, the M-TAR model can be written as

[6] Our use the term "overfitting" refers to the idea that non-linear functional forms, being more flexible, will usually fit the (non-linear) mean of the series closer to its actual values than linear forms.

$$\Delta y_t = I_t\left[y_{t-1}\theta_1 + \sum_{j=1}^{p}\gamma_{1j}\Delta y_{t-j} \right] + (1-I_t)\left[y_{t-1}\theta_2 + \sum_{j=1}^{p}\gamma_{2j}\Delta y_{t-j} \right] + \zeta_t\,, \tag{1}$$

where $y_{t-1} = (1\ \ t\ \ y_{t-1})$, ζ_t is an iid error, and I_t is the indicator function that takes the form

$$I_t = \begin{cases} 1 & if \quad z_{t-1} < \lambda \\ 0 & if \quad z_{t-1} \geq \lambda \end{cases}.$$

where λ is a threshold and the variable z_t is any stationary variable that would determine the change of regime. As in most economic applications we can set $z_t = y_t - y_{t-m}$. That is, we assume that y_t behaves differently depending on whether past *changes* in y_t have been higher or lower than a certain threshold λ. This is a self-exciting M-TAR model with two regimes as in Enders and Granger (1998). The lag length m for the changes in y is determined by the data as is the search for the optimal threshold λ. The parameter vectors θ_1 and θ_2 can be partitioned as

$$\theta_1 = \begin{pmatrix} \mu_1 \\ \delta_1 \\ \rho_1 \end{pmatrix}, \qquad \theta_2 = \begin{pmatrix} \mu_2 \\ \delta_2 \\ \rho_2 \end{pmatrix},$$

where μ_i is an intercept, δ_i is the parameter of the deterministic trend, and ρ_i is the autoregressive parameter with $i = 1, 2$. In order to search for the optimal threshold λ, CH follow Chan (1993) and obtain λ as the value of Δy_{t-m} that minimises the residual sum of squares of the OLS estimation of (1).[7]

In order to test for the existence of asymmetry in the adjustment under both regimes they test the null hypothesis $H_o : \theta_1 = \theta_2$ on the OLS estimation of (1), making use of a Wald statistic (W_T). The null of a unit root would imply H_o: $\rho_1 = \rho_2 = 0$. This is tested making use of another Wald statistic R1.[8] R1 is constructed as the sum of the squared values of the individual one sided t-statistics for ρ_1 and ρ_2. Finally, they also propose to choose m to minimise the residual sum of squares of (1). Given that the Wald test of asymmetry is a monotonic function of the residual variance, m is chosen as the value which maximizes the Wald test of asymmetry.

[7] In practice, outliers are eliminated by trimming the series for the highest and lowest values of Δy_{t-m}.

[8] R1 is the one sided Wald test for a unit root, whereas they also propose a two-sided Wald test which they call R2.

The unit root hypothesis involves testing for H_o: $\rho_1 = \rho_2 = 0$. There are two possible alternatives: H_1: $\rho_1 < 0$ *and* $\rho_2 < 0$ and

$$H_2 : \begin{cases} \rho_1 < 0 \quad and \quad \rho_2 = 0 \\ or \\ \rho_1 = 0 \quad and \quad \rho_2 < 0 \end{cases}$$

The first alternative corresponds to the stationary case, whilst the second implies stationarity in only one of the regimes, which implies overall non-stationarity but a different behaviour from the classic unit-root. CH develop asymptotic theory for the distribution of this unit-root test. However, for finite samples they recommend the use of bootstrapping. As the distribution of the test statistic will depend on whether or not a threshold effect exists, p-values obtained through the bootstrap are not unique. Monte Carlo experiments show that this unit root test has substantial power gains against the linear ADF test as threshold effects become larger. In order to discriminate between the two alternatives in H_2, CH recommend looking at the individual *t*-statistics for ρ_1 and ρ_2.

The economic interpretation of this model would be that, for certain macroeconomic variables, positive and negative shocks – or shocks above or below a certain threshold – may have different effects on the mean and speed of convergence of the data.[9] A typical example, which is also the focus of CH's empirical example, is the unemployment series. Due to hysteretic elements in the labour market, large shocks may shift unemployment from low unemployment equilibrium to high unemployment equilibrium and vice versa (see Blanchard and Summers, 1986). Another example could be the impact of recessions and expansions on the trend rate of growth of an economy.[10]

2.2. STAR unit root tests: Kapetanios et al (2003).

The non linear form of an ADF equation corresponding to the class of STAR models is

$$\Delta y_t = \rho_1 y_{t-1} + \rho_2 y_{t-1} G(z_t; \phi, \lambda) + \varepsilon_t , \qquad (2)$$

[9] See the seminal work of Balke and Fomby (1997) for the analysis of cointegration relations subject to TAR adjustment dynamics. In their case, the threshold is determined by the size of the lagged error correction mechanism.
[10] For applications of this test see, amongst several others, Arestis et al (2004) for budget deficits, Kuo and Enders (2004) for the term structure, Henry and Shields (2004) for inflation and Ferreira and León-Ledesma (2007) for real interest rate parity.

where G is a transition function, ε_t is an $iid(0, \sigma^2)$ error, z_t is a state variable, ϕ is the speed of transition variable, and λ is a threshold. The transition function can take several forms such as a logistic function (LSTAR), a quadratic logistic function (QLSTAR), or an exponential function (ESTAR). Because of the particularly interesting properties of ESTAR models for economic applications, Kapetanios et al (2003) (KSS), focus on tests for a unit root when the DGP follows an ESTAR process under the alternative.[11] In this case we have that (2) becomes:

$$\Delta y_t = \rho_1 y_{t-1} + \rho_2 y_{t-1}[1 - \exp(-\phi(z_t - \lambda)^2] + \varepsilon_t \,. \qquad (3)$$

As KSS assume that y_t is a mean-zero stochastic process, one can set $\lambda = 0$. Further they set the state variable $z_t = y_{t-1}$, i.e. a self-exciting ESTAR model. This makes $G = 1 - \exp\{-\phi y_{t-1}^2\}$. As $y_{t-1} \to \pm\infty$, $G \to 1$, and as $y_{t-1} \to 0$, $G \to 0$. Hence, the process shows three regimes, a middle regime when y_{t-1} is close to zero and two symmetric outer regimes when y_{t-1} becomes large (either positive or negative). The smoothness of the transition between these regimes depends on parameter ϕ.

KSS further impose the assumption that $\rho_1 = 0$. The reason is that, in some economic contexts it is reasonable to assume that the variable displays a mean reverting behaviour towards an attractor when it is sufficiently far away from it, but a random walk representation in the neighbourhood of the attractor. In this case, we have that

$$\Delta y_t = \rho_2 y_{t-1}[1 - \exp(-\phi y_{t-1}^2)] + \varepsilon_t \,. \qquad (4)$$

The test for the *joint* null hypothesis of linearity and a unit root can be achieved by testing H_0: $\phi = 0$ against H_1: $\phi > 0$. Using a first order Taylor series approximation to (1), one can obtain

$$\Delta y_t = \varphi y_{t-1}^3 + error \,. \qquad (5)$$ [12]

[11] See Michael et al (1997) for a related work, van Dijk et al (2002) for a survey on recent developments in STAR modelling and Granger and Terasvirta (1993) for a complete coverage of STAR models.

[12] It is possible to augment this regression with lagged first differences of y_t to allow for possible residual serial correlation.

The unit root test is based on the t-statistic for the null $\varphi = 0$ against the alternative $\varphi < 0$ from the OLS estimate of φ ($\hat{\varphi}$). The asymptotic distribution of this test (t_{NL}) is non-standard and KSS derive it and provide asymptotic critical values.

When the process y_t is not mean zero, they propose the use of transformations of the data. For the case of a non-zero mean, i.e. $x_t = \mu + y_t$, they propose the use of demeaned data $y_t^* = x_t - \bar{x}$, where $\bar{x}$ is the sample mean. For the case of a non-zero mean and a non-zero deterministic trend, i.e. $x_t = \mu + \delta t + y_t$ they propose the use of the demeaned and de-trended data $y_t^* = x_t - \hat{\mu} - \hat{\delta} t$, where $\hat{\mu}$ and $\hat{\delta}$ are the OLS estimators of μ and δ. This procedure allows carrying out the test using (5) with the demeaned/de-trended data.

The appeal of the ESTAR model is clear when one thinks of arbitrage in goods or assets markets in which transaction costs create a band of inactivity. Within the transactions cost band, arbitrage will not take place and the variable does not revert to its equilibrium value. For too high or too low values of the variable, arbitrage forces will lead to mean reversion. That is why this model is popular in modelling real exchange rate behaviour (and the PPP hypothesis) such as in Sercu et al (1995), Michael et al (1997) and Taylor et al (2001).[13]

Note that, although some particular functional forms of STAR models such as the LSTAR nest the TAR model discussed in the previous section when the speed of adjustment tends to ∞, the ESTAR model of KSS does not nest the M-TAR model of CH. This is because the M-TAR model assumes two regimes whereas the ESTAR assumes three, the state variable is different and, finally, with an infinite adjustment speed the ESTAR model becomes linear.

2.3. Unit root tests with Markov Switching.

The Markov Switching model (MS), put forward by Hamilton (1989), has been the focus of much empirical work in the area of business cycles analysis. The MS model proposes a functional form for dynamic equations in which parameter values may change between a predetermined M number of states. Hence, this model can be seen as a generalisation of structural break models that allow for M breaks in the series and where changes between states can occur several times and not just as a one-off change in the parameters. The general representation of a Markov Switching ADF equation (MS-ADF) is as follows:

[13] For applications of the KSS test see, for instance, Chortareas and Kapetanios (2004), and Chortareas et al (2004).

$$\Delta y_t = \mu_0(1-s_t) + \mu_1(s_t) + [\rho_0(1-s_t) + \rho_1(s_t)]y_{t-1} + \sum_{i=1}^{l}[\varphi_{0i}(1-s_t) + \varphi_{1i}(s_t)]\Delta y_{t-i} + e_t \quad (6)$$

where s_t is the unobservable realisation of the state that is governed by a discrete-time, discrete-state Markov stochastic process. This process is defined by the transition probabilities:

$$\Pr(s_{t+1} = j \mid s_t = i) = p_{ij}, \sum_{j=1}^{M} p_{ij} = 1, \forall i. \quad (7)$$

In our case we will consider the most common case in which $M = 2$, that is, the variable is allowed to switch between two different states $s_t = 0$ and $s_t = 1$. μ is the deterministic trend part of the ADF equation and can be a constant or constant and a trend ($\mu = \eta + \theta t$). One can also consider that $e_t \sim N(0, \sigma^2(s_t))$, i.e. the residual variance of (6) is state-dependent.

Several studies such as Hall et al (1999), Nelson et al (2001), Psaradakis (2001, 2002), and Cavaliere (2002), have analysed the effect of MS on linear tests for unit roots. The general findings of this literature are that, firstly, if there is MS in the trend component of the series (i.e. intercept and/or trend), traditional UR tests (ADF, PP, GLS-ADF, KPSS) suffer from a very large loss of power. Secondly, when there are changes in the mean of the series due to business cycle effects, UR tests remain useful once an appropriate lag augmentation is chosen. This is because MS of this kind introduces autocorrelation in the errors. Finally, MS variances, again, do not affect the power of traditional UR tests. Hence, structural changes in deterministic components in the form of MS, may have important effects on linear UR tests.

The main test for UR allowing for MS changes in regression parameters in an ADF equation was developed in Hall et al (1999). Although their test was originally designed to test for bubbles in macroeconomic time series, its extension to unit root testing is straightforward.[14] Given the computational burden of these tests, especially for the Monte Carlo experiments in Section 4, we limit our analysis to three MS models derived from (6).

Model i: $\Delta y_t = \eta_0(1-s_t) + \eta_1(s_t) + \rho y_{t-1} + \sum_{i=1}^{l}\varphi_i \Delta y_{t-i} + e_t$.

[14] See León-Ledesma and McAdam (2004) for unemployment applications of this test.

Model ii: $\Delta y_t = \eta_0(1-s_t) + \eta_1(s_t) + [\theta_0(1-s_t) + \theta_1(s_t)]t + \rho y_{t-1} + \sum_{i=1}^{l} \varphi_i \Delta y_{t-i} + e_t$.

Model iii: $\Delta y_t = \eta_0(1-s_t) + \eta_1(s_t) + [\rho_0(1-s_t) + \rho_1(s_t)]y_{t-1} + \sum_{i=1}^{l} \varphi_i \Delta y_{t-i} + e_t$.

In Model i we consider the case in which only the intercept switches between states. In Model ii we allow both intercept and time trend to switch. Finally, in model iii, we allow both intercept and the autoregressive coefficient to switch. These three cases cover a sufficiently wide range of possible break models.

For Models i and ii, the null hypothesis is H_0: $\rho = 0$ against the alternative H_1: $\rho < 0$, and can be analysed by using the t-ratios of the estimated coefficient $\hat{\rho}$.[15] The distribution of this t-ratio under the null, however, is unknown. Hall et al (1999) recommend the use of bootstrapped critical values. In Model iii the null corresponds to Ho: $\rho_0 = 0$ and $\rho_1 = 0$, which can be tested again using the individual t-ratios. In this case, however, we can consider two alternatives. The first is that both $\rho_i < 0$. In this case the variable would behave as a MS classical stationary variable. The second is that $\rho_i < 0$ and $\rho_j = 0$ for $i,j = 0,1$. In this case, the variable is mean reverting in one state but a unit root in the other. We will call the former Criterion 1 and the latter Criterion 2. It is straightforward to see that Criterion 1 is more restrictive than 2, and we would expect to see more rejections of the null in the latter. We also carried out a test similar to the R2 test in the TAR model of CH based on a Wald statistic. This Wald statistic is calculated as:

$$W = t_{\rho 1}^2 + t_{\rho 2}^2 \qquad (8)$$

As in the previous two cases, as we do not know the asymptotic distribution of the test, we use bootstrapped critical values for *W*. In all our applications we use 260 bootstraps of the MS regression under the null to obtain the critical values at the 5% level.

3. Unit root tests for the G7 macroeconomic variables

Data: We study the data reported in Stock and Watson (2004) (SW hereafter). The SW dataset covers up to 43 quarterly time series for Canada, France,

[15] The estimation of the coefficients is carried out using the Expectations Maximization (EM) algorithm.

Germany, Italy, Japan, the U.K. and the U.S. over the period 1959 to 1999. In total we have 249 time series at our disposal. Broadly, the dataset consists of measures of real economic activity, prices, monetary variables and several asset prices. As we are only interested on the unit root properties of the data we do not engage in the transformations implemented by SW. We replicate the SW data definitions in the Appendix.

Results for Unit Root Tests: We implemented both linear and non-linear unit root tests to our dataset. We used three different linear UR tests together with the three nonlinear tests described earlier. The first linear test is the standard ADF test of the null of a unit root that is known to have low power against alternatives close to a unit root. The second test is the Modified Phillips-Perron test with GLS de-trending of Ng and Perron (2001) for the null of a unit root. We report both the MZ_{α}^{GLS} and MZ_t statistics. Finally, we implement Elliott et al's (1996) (ERS hereafter) most powerful DF-GLS test for the null of a unit root. The lag augmentation was chosen using the Ng and Perron (2001) Modified Information Criteria (MIC).[16] This method reduces substantially size distortions.[17] The tests are carried out using a constant term and a constant and a deterministic trend.

As described in Section 2, the first non-linear unit root test is based on the TAR unit root test of Caner and Hansen. When testing for unit roots we treat the threshold as unidentified. In this case the bootstrap is based on a linear AR model.[18] This test is implemented by choosing the estimated delay parameter *m* that minimizes the residual variance. We report the Wald statistic (W_T) for the threshold effect (for nonlinearity) and the threshold unit root test using both asymptotic and bootstrapped p-values (for nonstationarity). The second test is the ESTAR unit root test of KSS. Note that here it is sufficient to report the t-statistics for the nonlinear term, as the KSS test is a test for the joint hypothesis of linearity and unit roots. Finally, we implement the unit root tests with the Markov switching. For consistency with the linear models, all the nonlinear tests are carried out using a constant term and a constant and a deterministic trend. Results of the empirical implementation are presented in Tables 1 to 14. We use a 5% significance level for all the tests. The results for the Markov Switching test are

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[16] The results using other information methods such as AIC or a general to specific method (GTS) did not change the conclusions about unit-roots.

[17] Note, however, that Darne and Diebolt (2004) recently show that in the presence of outliers the Modified Phillips-Perron test is more robust to size distortions than the ERS test. As the local asymptotic power of the modified Philllips-Perron test is quite similar to ERS test we only report in the Tables results of modified Phillips-Perron test. The ERS test results are available upon request.

[18] The alternative is to treat the threshold as identified, and to base the bootstrap on simulations from a unit root TAR process. CH show Monte-Carlo evidence that suggests the unidentified threshold bootstrap test suffers from less size distortions than the identified threshold test or a test based on the asymptotic critical values for possible threshold nonlinearities.

reported on separate tables as the number of variables for which the test achieved convergence is substantially smaller than in the other two tests.[19]

We find that the hypothesis of a unit root is rejected for 49.4% (123/249) of the series considered in this study by at least one of the linear or nonlinear tests.[20] In Table 1 we report global rejection frequencies for all unit root tests. Overall it is clear that the nonlinear unit root tests tend to reject more often than any of the three linear unit root tests. Out of 249 series being tested linear tests reject unit root hypothesis for about 9% (ADF-test) to 17% of cases (Modified PP-test), whereas the TAR tests reject the unit root in 17% to 21% of cases (using bootstrapped p-values) and the ESTAR test of KSS rejects the unit root in 24% to 31% of the cases. The ESTAR tests reject unit roots more frequently than any other linear and nonlinear tests considered here. Finally, as Tables 6 and 7 report, the MS-ADF test also presents high rejection frequencies, especially for the case of Model i and Model iii using criterion 2. These results, however, are biased upwards, because most series considered are asset prices as we can see from Table 7. Given that asset prices have a higher rejection frequency of the null, the MS-ADF test appears to have higher rejection frequencies overall.

Table 2 presents tests results for the rejection of the hypothesis of unit roots for each variable/country pair irrespective of the assumption on the data generating process. That is, here we report whether the null hypothesis is rejected at least once by one of the linear or nonlinear tests. We find that the unit root hypothesis can be rejected for about 50% of the series. Lower rejection rates are found for Canada and the UK (in the order of 40-45%) and higher rejection rates are found for the US and France (in the order of 55-60%).

In Table 3 we report global unit root rejection frequencies for linear versus nonlinear tests irrespective of the type of test in the case of linear tests, and irrespective of the particular type of data generating process assumption in the case of nonlinear tests. Here it is very clear that, globally, nonlinear unit root tests reject (at least once) the null of a unit root much more frequently than the linear tests. In the case of linear tests, the global rejection frequencies for each individual country are about 10%. The rejection frequency increases to roughly 30% in the case of Canada and 54% in the case of Germany when nonlinear unit root tests are considered altogether.

In Table 4 we provide global rejection frequencies for variables that are grouped under the headings of 1) nominal and real asset prices, that include various interest rates, exchange rates, stock, dividend, house, gold and silver

[19] Note also that, as we will see later, most results obtained for the MS-ADF test refer to real and nominal asset prices, and hence average rejection frequencies are not directly comparable.

[20] Higher rejection frequencies are to be expected, however, as the number of tests used increases. For this reason, the overall rejection frequency of the combined tests should be interpreted with caution.

prices; 2) macroeconomic fundamentals that include GDP, industrial production, capacity utilization, employment/unemployment figures and aggregate price indices; 3) Nominal and real wages, goods and commodity prices, that include earnings, oil and commodity prices; and, finally, 4) money, that includes various nominal and real monetary aggregates. Here we take into account all linear and nonlinear subtest criteria in the calculation of the rejection frequencies.

It is clear that in all subcategories, as compared to linear unit root tests, non-linear tests reject the unit root hypothesis much more frequently. In the case of asset prices linear unit root tests are unable to reject the null in several variables, whereas non-linear tests reject the null for all variables but house prices at least once (on aggregate 19% for linear tests and 30% rejection rate for nonlinear tests). Short term nominal interest rates are found to be stationary in at least one non-linear specification whereas linear unit root tests cannot reject the null of a unit root for most of the interest rates. Rejection frequencies of linear tests for real interest rates are higher than in non-linear tests.

Similarly, in the case of macroeconomic activity variables, non-linear tests do reject the hypothesis of a unit root more frequently than the linear tests (4% under linear tests and 13% under non-linear tests). There are several instances where random walks in capacity utilization are rejected under linear and non-linear functional specifications as expected. Both sets of tests cannot reject the hypothesis of a unit root for real GDP, employment and unemployment. Uncomforting however, in some instances nonlinear tests seem to reject the unit root in variables such as industrial production, CPI and PPI indices that are a priori unlikely to be I(0).

For wages, goods and commodity prices rejection of the null is much higher in the non-linear tests. This is especially the case for nominal and real commodity prices for which rejection rates for non-linear tests are on average 38% as opposed to 6% for linear tests.

The fourth set of results concerns nominal and real monetary aggregates. Here, none of the linear tests rejects the null whereas nonlinear tests reject in several instances the unit root hypothesis (13%, substantially above the nominal rejection rate of 5%).

In Table 5 we report rejection frequencies for TAR and ESTAR unit root tests. TAR unit root tests reject the null more frequently for macroeconomic activity and monetary aggregates (17% and 18% respectively) than ESTAR tests (6% and 5%) whereas ESTAR unit root tests reject the null more frequently for asset prices (48%) than the TAR tests (20%). For wages, goods and commodity prices rejection frequencies in both sets of tests are similar.

For the Markov Switching tests reported in Tables 6 to 7, note that due to convergence problems for a large number of series we only report results for a maximum of 110 series, mainly asset prices, under different assumptions about regime switching. In Table 6 we report global rejection frequencies of the null of a unit root by country and model. Overall, the null is rejected for a maximum of 35% of the series available using Model iii and criterion 2. Also Model i (with a switch in the constant only) rejects the null for 33% of the variables. Using Criterion 1 for Model iii yields a very low 1% rejection frequency (1 variable), which is well below the 5% nominal size of the test. The highest rejection frequencies by variable can be found for asset prices in Models i and ii.[21] Model iii using Criterion 2 of the W test rejects most frequently for economic activity variables. However, the number of variables is too small for a meaningful comparison.

For the sake of completeness we report throughout Tables 8 to 14 individual test results for each country. The first column of the tables indicates whether the hypothesis of unit root has been rejected at least once. The first column of the TAR tests also reports the W_T test for linearity described in Section 2.1. It is worth pointing out that, in the overwhelming majority of cases, whenever non-linearity was found, the unit root hypothesis was rejected and vice versa. This is an expected result, as the null of a unit root implies that $\rho_1 = \rho_2 = 0$, which also implies no threshold effect in the AR coefficient.

For many countries' asset prices, particularly nominal and real interest rates, it is possible to reject at least once the hypothesis of a unit root when linear and non-linear tests are jointly taken into account (exceptions are nominal house prices).

There are mixed results for economic activity and wages, goods and price variables and finally monetary aggregates. For none of the countries do we reject the null of a unit root for the case of real GDP. However, in the case of the industrial production index in Canada, for example, TAR unit root tests with a constant and a trend rejects the null. In Germany, the ESTAR test with a constant and a trend, and in the UK both sets of TAR unit root tests reject the unit root hypothesis. A similar picture emerges in some price level variables. Just to mention some examples, the unit root hypothesis for the CPI index is rejected for Canada with the ESTAR unit root test with a constant and a trend, in France and Japan with the TAR unit root test with a constant and the ESTAR unit root test with a constant and a trend, and in the U.S. with the TAR test with a constant and a trend. In the case of monetary aggregates, nonlinear unit root tests reject the null in a few cases. This is the case mainly for TAR unit root tests with a constant and a trend.

Overall, it is clear that the linear unit root tests reject the null much less frequently than those of nonlinear tests. ESTAR unit root tests tend to reject the unit root hypothesis most often as compared to alternative nonlinear tests. In some

[21] Mostly rejections of the unit root for real and nominal interest rates. Details by variable are available on request.

instances, the tests reject the unit root hypothesis for variables that we would expect a priori to have a unit root such as some monetary aggregates, industrial production or some aggregate price indices. This may simply be reflecting that their DGP is indeed of a specific nonlinear functional form captured by the ESTAR, TAR or MS models. Alternatively, this may as well be due to some degree of over-fitting of the deterministic components by the nonlinear functional form. In order to analyse this hypothesis, in Section 4 we assess the rejection frequencies of the nonlinear tests based on Monte-Carlo simulations.

4. Monte Carlo experiments for rejection frequencies

We address the possible over-fitting explanation for the higher rejection frequencies of non-linear tests by carrying out a size experiment. In all cases we will assume that the DGP is a linear unit root process of the following form:

$$y_t = \alpha y_{t-1} + (1-\alpha) y_{t-2} + u_t \text{ with } u_t \sim \text{iid } N(0,1). \quad (8)$$

We analyse several cases for α = {-0.5, 1, 0.5} and the sample size T = {50, 100, 200, 500}.[22] We will use a nominal size in all experiments of 5%. If the over-fitting explanation is important, we would expect rejection frequencies well above 5%.

4.1. TAR unit root tests.

As in the previous section, in all cases we use the "unidentified case" (i.e. assuming no threshold effect under the alternative) following CH's recommendations. We provide two sets of results. In the first set we use asymptotic critical values from CH, and in the second we used bootstrapped critical values. For the asymptotic critical values we used 10,000 Monte Carlo draws, and for the bootstrapped case 1,000 draws with 500 bootstrap replications. We also provide results for both the R1 and R2 tests. In CH a similar experiment is carried out when analysing size distortions of the test for the case of no threshold under the null[23] and for T = 100. In our case we extend this analysis for different T's.

The results are reported in Table 15. The size of the CH test is very close to the nominal size in all cases. Only in the case of T = 50 can we observe slightly higher rejection frequencies. As T grows this problem disappears and in most

[22] We also carried out experiments using other values for α, and different lag structures for the original series. The results, however, remained essentially the same and are not reported here to save space.
[23] See CH Table IV.

cases we are close to the 5% rejection frequencies. There is no substantial difference between the R1 and R2 tests and both the asymptotic and bootstrapped critical values seem to work equally well. There is a slight tendency to under-reject as T becomes large when using asymptotic critical values.

From these results we can conclude that there is no evidence that the CH test tends to over-reject the null of a unit root when it is true, and we can discard the over-fitting explanation of the results in the previous Section.

4.2. ESTAR unit root tests

Given that in the KSS the null hypothesis is a joint hypothesis of a unit root and linearity, our size experiment is equivalent to that carried out by KSS. Here, we just replicate these experiments adding the case of T =500 and α = -0.5 to those analysed by KSS. We used 10,000 Monte Carlo draws from (8). Given that the results are essentially the same, we report only the results from the Monte Carlo without de-meaning.

We can see from Table 16 that our results are very close to those of KSS. In all cases, the empirical size is very close to the nominal size of 5%. In this case, this is true also for short sample sizes (T = 50), and for any form of the dynamic adjustment parameter α. As in the TAR model, we can comfortably reject the hypothesis that a high rejection frequency in the data is due to over-fitting.

4.3. Markov Switching unit roots

We carry out the Monte Carlo experiment for the Hall et al (1999) MS-ADF model for each of the three models used in the previous section. Given that we used 260 bootstrap replications, 1,000 Monte Carlo draws, and that the EM estimation requires several iterations for achieving convergence, the experiment becomes very large and computationally intensive. For this reason, we limit ourselves to the cases of T = {100, 200} and α = 1. We still used a lag augmentation of one in the MS-ADF regression as MS shifts introduce error autocorrelation (Psaradakis, 2001). So far, we do not know of any similar attempt at analysing size properties of this test.

Table 17 reports the rejection frequencies found using the simulated series (8). For Model iii we report rejection frequencies using both criteria. For T = 100, Models i and ii both tend to over-reject very slightly, but not sufficiently to explain the high rejection frequencies of these tests in the data. As T increases, size distortions are reduced and become quite close to the nominal size. For T = 200, both models have very good rejection frequencies. In the case of Model iii, we can observe that using Criterion 2, there is a slight over-rejection of the null (7.7%) but only for T = 100. The other way around happens with Criterion 1. In this case the test grossly under-rejects the null. This may be due to the fact that MS changes in the autoregressive coefficient ρ may be capturing some turning points where the data is accelerating its divergence from the initial condition and hence it is difficult to reject the null in both states. However, if we relax the alternative hypothesis as in Criterion 2, the test tends to reject the null at levels close to the nominal size especially as T increases. In the case of the *W* test, rejection frequencies are close to 5% for both sample sizes.

From these results we can conclude that the MS-ADF model overall would not tend to over-reject the null of a unit root, rejecting yet again the over-fitting explanation. Modelling changes in the autoregressive parameter poses more difficulties as, depending on the alternative, the test may under-reject. This is a likely explanation for the results obtained in Section 4 where rejection frequencies in Model iii using Criterion 1 were very low (1%).

In general, the Monte Carlo experiments reveal that the hypothesis of over-fitting in the three non-linear unit root tests is not supported. The tests seem to behave quite well even if the actual DGP is a linear unit-root process. This points out that the larger rejection frequencies of the unit root hypothesis found in the macroeconomic data may be due to the existence of some forms of non-linearity that are captured well by the different functional forms postulated in these tests. A way of reading our results could be that, notwithstanding power properties, non-linear unit roots tests can be used even for series that a priori we do not expect to be non-linear.

The question is then, given that there are some variables for which the three tests reject the unit root hypothesis, how to discriminate between alternative forms of non-linearity.[24] This is important, as once a rejection of the unit root hypothesis has been established, the modelling and forecasting of a series will be different depending on the particular functional form that represents it best. This, however, goes beyond the scope of this paper. It is worth noting, however, that recent developments in Giordani, Kohn and van Dijk (2005) offer a unified approach for representing these three forms of non-linearity simultaneously in a state-space form.[25] These developments can offer a convenient way of simultaneously testing for unit roots and the form of non-linearity. Another promising avenue is that of Hamilton (2001), in which the author proposes a framework for determining whether non-linearieties exist, what they look like and whether they can be adequately represented by a particular parametric model. An extension of this work to possibly non-stationary series or vectors of series could also be fruitful.

[24] Kilic (2005) recommends that unit root tests be carried out before non-linearity tests. Although his arguments are derived from a completely different perspective, they point out at similar conjecture to ours.

[25] See also Lundbergh et al (2003) for an analysis of STAR models with time varying coefficients.

5. Conclusions

In this paper we have presented new evidence on the unit root hypothesis for a large macroeconomic dataset of 249 macroeconomic series of the G7 countries using linear and three different non-linear unit roots tests. These are Threshold Autoregressive, Exponential Smooth Transition Autoregressive, and Markov Switching ADF models. Our evidence shows that nonlinear unit root tests tend to reject the null of a unit root more frequently than linear unit root tests. The support for the unit root hypothesis in macroeconomic time series is thus found to be weaker than in the earlier literature. Nevertheless, we still cannot reject the null of a unit root for a large fraction of available series. The results, however, vary depending on the type of series analysed. For asset prices, especially real interest rates, we find less support of the UR hypothesis. For most of the monetary aggregates, prices and economic activity variables, in general, we cannot reject the hypothesis of a unit root; however there are notable exceptions to this finding, in particular some price indices and monetary aggregates.

Secondly, a series of Monte Carlo experiments suggest that the over-fitting of the deterministic components potentially arising with the application of nonlinear models can be ruled out. That is, we found little evidence for the fact that, as non-linear models tend to fit deterministic components closer to the actual series, the rejection of the unit root null is made easier.

Our results invite further research. First, if some of the data generating process can be well approximated by nonlinear functional forms, and the unit root hypothesis can be rejected, there is an issue whether some linear macro-econometric models can be appropriately used. Second, bearing in mind the findings of Diebold and Kilian (2000) in the presence of some nonlinear stationary processes there may be a case for reassessing the forecast performance of alternative data manipulations such as first differencing or other transformations.

Table 1: Unit root rejection frequencies

		Linear Unit Root Tests						Non-linear Unit Root Tests					
								TAR				ESTAR	
		Constant			Constant and Trend			Constant		Constant and Trend		Constant	Constant and Trend
Country	**# of series**	**ADF**	**MZ_α^{GLS}**	**MZ_t**	**ADF**	**MZ_α^{GLS}**	**MZ_t**	**Boot. p-values**	**Asym. p-values**	**Boot. p-values**	**Asym. p-values**	**ESTAR- t_{NL}**	**ESTAR1- t_{NL}**
Canada	37	8%	14%	14%	3%	8%	8%	3%	3%	12%	12%	24%	24%
France	32	9%	13%	16%	6%	9%	13%	30%	33%	26%	30%	22%	19%
Germany	35	11%	11%	23%	14%	14%	14%	27%	27%	30%	37%	34%	31%
Italy	36	3%	8%	14%	0%	6%	6%	18%	24%	21%	18%	39%	33%
Japan	37	8%	8%	13%	5%	8%	11%	25%	31%	25%	25%	32%	32%
UK	30	7%	7%	17%	7%	7%	10%	7%	11%	26%	33%	28%	20%
US	42	17%	17%	24%	12%	12%	17%	8%	10%	13%	21%	38%	31%
Total # series	249												
Weighted Average		**9%**	**11%**	**17%**	**7%**	**9%**	**11%**	**16%**	**20%**	**21%**	**25%**	**31%**	**24%**

Table 2: Global rejection of the UR at least by one test. Linear and Nonlinear Tests Combined

	Canada	France	Germany	Italy	Japan	UK	US
rovnght	no	yes	yes	no	yes	yes	yes
rtbill	no	no	yes	no	na	no	yes
rbnds	na	na	na	yes	na	na	yes
rbndm	na	na	na	no	na	na	yes
rbndl	yes	no	yes	no	no	yes	yes
rrovnght	no	yes	yes	yes	yes	yes	yes
rrtbill	yes	no	yes	yes	na	yes	yes
rrbnds	na	na	na	yes	na	na	yes
rrbndm	na	na	na	yes	na	na	yes
rrbndl	yes	yes	yes	yes	yes	yes	yes
rspread	yes	yes	yes	yes	yes	no	yes
exrate	no	yes	yes	no	no	no	na
rexrate_a	no	yes	yes	no	no	no	yes
stockp	no	no	no	no	yes	no	no
rstockp	no	no	no	yes	yes	no	no
divpr	yes	yes	yes	yes	yes	yes	yes
house	no	na	na	na	no	no	no
rhouse	yes	na	na	na	no	no	no
gold	yes	yes	yes	yes	yes	no	yes
rgold	yes	yes	yes	yes	yes	no	yes
silver	yes	yes	yes	yes	yes	yes	yes
rsilver	yes	yes	yes	yes	yes	yes	yes
rgdp	no	no	no	no	no	no	no
ip	yes	no	no	no	no	yes	no
capu	yes	no	yes	yes	yes	na	yes
emp	no	no	no	na	no	no	no
unemp	no	no	no	no	no	no	yes
pgdp	no	yes	no	no	yes	yes	yes
cpi	no	yes	no	no	yes	no	yes
ppi	no	na	no	no	yes	no	no
earn	yes	no	no	na	no	yes	yes
oil	no	yes	yes	yes	no	yes	no
roil	no	no	no	no	no	no	no
comod	no	yes	yes	no	yes	yes	no
rcomod	yes	yes	yes	yes	no	yes	yes
mon0	na	na	na	na	no	na	no
mon1	no	no	no	no	no	na	yes
mon2	yes	yes	no	no	yes	na	yes
mon3	no	na	no	yes	yes	na	yes
rmon0	na	na	na	na	no	na	no
rmon1	no	no	no	yes	no	na	no
rmon2	no	na	yes	yes	no	na	no
rmon3	no	yes	no	na	yes	na	no
Rejections	15	18	19	19	19	14	26
Total	37	32	35	36	37	30	42
Rejection %	40.54%	56.25%	54.29%	52.78%	51.35%	46.66%	61.90%

Note: '*yes*' indicates that at least one test is able to reject the unit root whereas '*no*' indicates that none of the tests implemented were able to reject the null. '*na*' indicates the unavailability of data series or in some cases lack of variation in the data series such that tests could not be implemented.

Table 3: Global rejection of the unit root at least by one test: linear versus nonlinear models

	Canada		**France**		**Germany**		**Italy**		**Japan**		**UK**		**US**	
	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear
rovnght	no	no	no	yes	no	yes	no	no	no	yes	no	no	no	yes
rtbill	no	no	no	no	no	yes	no	no	na	na	no	yes	no	yes
rbnds	na	na	na	na	na	na	no	yes	na	na	na	na	no	yes
rndm	na	na	na	na	na	na	no	no	na	na	na	na	no	no
rbndl	no	yes	no	no	no	yes	no	no	no	no	no	yes	no	no
rrovnght	no	no	yes	no	yes	yes	no	yes	yes	yes	no	no	yes	no
rrtbill	yes	no	no	no	yes	yes	no	yes	na	na	yes	no	yes	yes
rrbnds	na	na	na	na	na	na	no	yes	na	na	na	na	yes	yes
rrbndm	na	na	na	na	na	na	yes	yes	na	na	na	na	yes	no
rrbndl	yes	no	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
rspread	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes
exrate_a	no	no	no	yes	no	yes	no	no	no	no	no	no	na	na
rexrate_a	no	no	no	yes	no	yes	no	no	no	no	no	no	no	yes
stockp	no	no	no	no	no	no	no	no	no	yes	no	no	no	no
rstockp	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
divpr	no	yes	no	yes	no	yes	es	yes	no	yes	no	yes	no	no
house	no	no	na	na	na	na	na	na	no	no	no	no	no	no
rhouse	no	yes	na	na	na	na	na	na	no	no	no	no	no	no
gold	no	yes	no	yes	no	yes	no	yes	no	yes	no	no	no	yes
rgold	no	yes	no	yes	no	yes	no	yes	no	yes	no	no	no	yes
silver	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
rsilver	no	yes	no	yes	no	yes	yes	yes	no	yes	no	yes	no	yes
rgdp	no	no	no	no	no	no	no	no	no	no	no	no	no	no
ip	no	yes	no	no	no	no	no	no	no	no	no	yes	no	no
capu	yes	no	no	no	no	yes	no	yes	no	yes	na	na	yes	yes
emp	no	no	no	no	no	no	na	na	no	no	no	no	no	no
unemp	no	no	no	no	no	no	no	no	no	no	no	no	no	no

Table 3 (continued)

	Canada		France		Germany		Italy		Japan		UK		US	
	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear
pgdp	no	no	no	yes	no	no	no	no	no	yes	no	yes	no	yes
cpi	no	no	no	yes	no	no	no	no	no	yes	no	no	no	yes
ppi	no	no	na	na	no	no	no	no	no	yes	no	no	no	no
earn	no	yes	no	no	no	no	na	na	no	no	no	yes	no	no
oil	no	no	no	yes	no	yes	no	yes	no	no	no	yes	no	no
roil	no	no	no	no	no	no	no	no	no	no	no	no	no	no
comod	no	no	no	yes	no	yes	no	no	no	yes	no	yes	no	no
rcomod	no	yes	no	yes	yes	yes	no	yes	no	no	no	yes	no	yes
mon0	na	na	na	na	na	na	na	na	no	no	na	na	no	no
mon1	no	no	no	no	no	no	no	no	no	no	na	na	no	yes
mon2	no	yes	No	yes	no	no	no	no	no	yes	na	na	no	no
mon3	no	no	Na	na	no	no	no	yes	no	yes	na	na	no	yes
rmon0	na	na	Na	na	na	na	na	na	no	no	na	na	no	no
rmon1	no	no	No	no	no	no	no	yes	no	no	na	na	no	no
rmon2	no	no	Na	na	no	yes	no	yes	no	no	na	na	no	no
rmon3	no	no	No	yes	no	no	na	na	no	yes	na	na	no	no
#Rejectn	4	11	3	16	5	19	5	19	3	19	2	12	7	18
Total	37	37	32	32	35	35	36	36	37	37	30	30	42	42
% Rejection	10.81%	29.73%	9.38%	50.00%	14.29%	54.29%	13.89%	52.78%	8.11%	51.35%	6.67%	40.00%	16.67%	42.86%

Note: '*yes'* indicates that at least one test is able to reject the unit root whereas '*no'* indicates that none of the tests implemented were able to reject the null of unit root. '*na*' indicates the unavailability of data series or in some cases lack of variation in the data series such that tests could not be implemented.

Table 4: Unit root rejection frequencies (variable based)

	Total			Linear Unit Root Tests			Nonlinear Unit Root Tests		
	Rejections	# of Tests	Percentage	Rejections	# of Tests	Percentage	Rejections	# of Tests	Percentage
				Asset Prices					
rovnght	15	84	18%	2	42	5%	13	42	31%
rtbill	7	68	10%	0	36	0%	7	32	22%
rbnds	4	24	17%	0	12	0%	4	12	33%
rbndm	1	24	4%	0	12	0%	1	12	8%
rbndl	9	80	11%	1	42	2%	8	38	21%
rrovnght	37	78	47%	25	42	60%	12	36	33%
rrtbill	31	72	43%	23	36	64%	8	36	22%
rrbnds	9	24	38%	6	12	50%	3	12	25%
rrbndm	8	24	33%	6	12	50%	2	12	17%
rrbndl	51	84	61%	38	42	90%	13	42	31%
rspread	55	84	65%	30	42	71%	25	42	60%
exrate_a	6	72	8%	0	36	0%	6	36	17%
rexrate_a	12	84	14%	0	42	0%	12	42	29%
stockp	6	84	7%	0	42	0%	6	42	14%
rstockp	6	84	7%	0	42	0%	6	42	14%
divpr	18	84	21%	2	42	5%	16	42	38%
house	0	38	0%	0	24	0%	0	14	0%
rhouse	2	44	5%	0	24	0%	2	20	10%
gold	18	84	21%	0	42	0%	18	42	43%
rgold	20	84	24%	1	42	2%	19	42	45%
silver	20	84	24%	2	42	5%	18	42	43%
rsilver	21	84	25%	5	42	12%	16	42	38%
Subtotal	**356**	**1472**	**24%**	**141**	**750**	**19%**	**215**	**722**	**30%**
				Activity					
rgdp	0	84	0%	0	42	0%	0	42	0%
ip	8	78	10%	0	36	0%	8	42	19%
capu	21	52	40%	13	36	36%	8	16	50%
emp	0	74	0%	0	42	0%	0	32	0%
unemp	1	58	2%	1	42	2%	0	16	0%
pgdp	9	84	11%	0	42	0%	9	42	21%
cpi	6	78	8%	0	36	0%	6	42	14%
ppi	2	68	3%	0	36	0%	2	32	6%
Subtotal	**47**	**576**	**8%**	**14**	**312**	**4%**	**33**	**264**	**13%**
				Wages, Goods and Commodity Prices					
earn	5	70	7%	0	42	0%	5	28	18%
oil	14	78	18%	0	36	0%	14	42	33%
roil	0	84	0%	0	42	0%	0	42	0%

Table 4 (continued)

	Total			Linear Unit Root Tests			Nonlinear Unit Root Tests		
	Rejections	# of Tests	Percentage	Rejections	# of Tests	Percentage	Rejections	# of Tests	Percentage
comod	13	84	15%	0	42	0%	13	42	31%
rcomod	24	84	29%	5	42	12%	19	42	45%
Subtotal	**56**	**400**	**14%**	**5**	**204**	**2%**	**51**	**196**	**26%**
				Money					
mon0	0	28	0%	0	18	0%	0	10	0%
mon	2	72	3%	0	36	0%	2	36	6%
mon2	8	62	13%	0	30	0%	8	32	25%
mon3	6	40	15%	0	18	0%	6	22	27%
rmon0	0	24	0%	0	12	0%	0	12	0%
rmon1	2	60	3%	0	24	0%	2	36	6%
rmon2	6	54	11%	0	24	0%	6	30	20%
rmon3	4	62	6%	0	30	0%	4	32	13%
Subtotal	**28**	**402**	**7%**	**0**	**192**	**0%**	**28**	**210**	**13%**
Overall	487	2850	17%	160	1458	11%	327	1392	23%

Table 5: Unit root rejection frequencies (nonlinear tests by variable)

	TAR			ESTAR		
	Rejections	# of Tests	Percentage	Rejections	# of Tests	Percentage
			Asset Prices			
rovnght	6	28	21%	7	14	50%
rtbill	2	20	10%	5	12	42%
rbnds	2	8	25%	2	4	50%
rbndm	0	8	0%	1	4	25%
rbndl	1	24	4%	7	14	50%
rrovnght	8	24	33%	4	12	33%
rrtbill	4	24	17%	4	12	33%
rrbnds	0	8	0%	3	4	75%
rrbndm	0	8	0%	2	4	50%
rrbndl	8	28	29%	5	14	36%
rspread	15	28	54%	10	14	71%
exrate_a	6	24	25%	0	12	0%
rexrate_a	11	28	39%	1	14	7%
stockp	4	28	14%	2	14	14%
rstockp	2	28	7%	4	14	29%
divpr	5	28	18%	11	14	79%
house	0	8	0%	0	6	0%
rhouse	0	12	0%	2	8	25%

Table 5 (continued)

	TAR			ESTAR		
	Rejections	**# of Tests**	**Percentage**	**Rejections**	**# of Tests**	**Percentage**
gold	10	28	36%	8	14	57%
rgold	7	28	25%	12	14	86%
silver	4	28	14%	14	14	100%
rsilver	2	28	7%	14	14	100%
Subtotal	**97**	**476**	**20%**	**118**	**246**	**48%**
			Activity			
rgdp	0	28	0%	0	14	0%
ip	8	28	29%	0	14	0%
capu	2	6	33%	6	10	60%
emp	0	20	0%	0	12	0%
unemp	0	4	0%	0	12	0%
pgdp	9	28	32%	0	14	0%
cpi	6	28	21%	0	14	0%
ppi	2	20	10%	0	12	0%
Subtotal	**27**	**162**	**17%**	**6**	**102**	**6%**
			Wages, Goods and Commodity Prices			
earn	4	16	25%	1	12	8%
oil	14	28	50%	0	14	0%
roil	0	28	0%	0	14	0%
comod	10	28	36%	3	14	21%
rcomod	8	28	29%	11	14	79%
Subtotal	**36**	**128**	**28%**	**15**	**68**	**22%**
			Money			
mon0	0	6	0%	0	4	0%
mon	1	24	4%	1	12	8%
mon2	7	20	35%	1	12	8%
mon3	6	14	43%	0	8	0%
rmon0	0	8	0%	0	4	0%
rmon1	2	24	8%	0	12	0%
rmon2	4	20	20%	2	10	20%
rmon3	4	20	20%	0	12	0%
Subtotal	**24**	**136**	**18%**	**4**	**74**	**5%**

Table 6: Rejection frequencies of the MS-ADF test by country

	Model i		**Model ii**		**Model iii**			
						Crit 1	Crit 2	W
Country name	# of vars	% Rejections	# of vars	% Rejections	# of vars	% Rejections	% Rejections	% Rejections
Canada	16	31%	19	21%	12	8%	50%	17%
France	17	47%	16	27%	13	0%	23%	15%
Germany	11	27%	13	38%	10	0%	50%	20%
Italy	11	27%	12	8%	10	0%	30%	10%
Japan	5	20%	9	22%	5	0%	20%	0%
UK	13	31%	18	29%	13	0%	38%	38%
US	17	35%	23	22%	10	0%	10%	0%
TOTAL	**90**	**33%**	**110**	**24%**	**73**	**1%**	**35%**	**16%**

Table 7: Rejection frequencies of the MS-ADF test by type of variable

	Model i		**Model ii**		**Model iii**			
						Crit 1	Crit 2	W
Type of variable	# vars	% Rejection	# vars	% Rejection	# vars	% Rejection	% Rejection	% Rejection
Asset Prices	70	37%	67	30%	55	2%	29%	9%
Econ Activity	4	25%	19	5%	3	0%	33%	33%
Wages and Commodity Prices	12	17%	16	25%	11	0%	64%	45%
Money	4	25%	8	13%	4	0%	50%	0%
TOTAL	**90**	**33%**	**110**	**24%**	**73**	**1%**	**36%**	**16%**

Table 8: Tests results Canada

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
rovnght	**N**	-1.66	-6.18	-1.63	-1.91	-9.21	-1.83	2.77	0.61	0.84	3.44	0.67	0.94	-1.52	-1.77
rtbill	**Y**	-1.85	-8.92	-1.81	-2.15	-9.37	-2.08	6.85	0.28	0.36	4.96	0.63	0.82	**-3.20***	-3.13
rbndl	**Y**	-1.14	-4.72	-1.12	-1.37	-4.78	-1.34	1.93	0.70	0.92	1.10	0.97	1.00	**-3.84***	**-3.69***
rrovnght	**Y**	-1.63	**-17.58***	-1.58	-2.73	-19.50	-2.58	11.60	0.08	0.07	9.44	0.25	0.37	-2.05	-1.71
rrtbill	**Y**	-2.70	**-22.84***	**-2.61***	-3.09	**-28.02***	**-2.96***	4.02	0.46	0.69	3.71	0.74	0.92	-1.49	-1.60
rrbndl	**Y**	**-2.93**	**-19.71***	**-2.79***	-3.13	**-24.85***	**-2.98***	5.97	0.30	0.45	6.76	0.51	0.64	-1.54	-1.65
rspread	**Y**	**-3.05**	**-16.17***	**-2.72***	-3.19	-17.31	-2.81	**38.00***	**0.00***	**0.00***	**19.70***	**0.01***	**0.01***	0.11	0.10
exrate_a	**N**	0.34	-0.80	0.42	-1.69	-5.48	-1.64	2.39	0.68	0.87	7.22	0.40	0.59	-1.69	-2.22
rexrate_a	**N**	0.32	-0.55	0.37	-1.39	-3.92	-1.37	3.41	0.49	0.76	7.73	0.53	0.53	-1.57	-2.12
stockp	**N**	2.83	4.09	2.90	-0.22	1.60	-0.03	0.00	0.99	1.00	0.19	1.00	1.00	0.89	-0.35
rstockp	**N**	-0.08	-2.68	-0.07	-1.66	-6.75	-1.62	7.67	0.19	0.28	7.57	0.37	0.55	-1.08	-1.69
divpr	**Y**	-1.93	-8.23	-1.86	-2.23	-11.71	-2.10	1.77	0.72	0.93	2.23	0.86	0.98	**-4.54***	**-4.79***
house	**N**	1.44	0.45	1.59	-1.52	-4.86	-1.48	0.00	0.99	1.00	1.67	0.82	0.99	-1.55	-3.31
rhouse	**Y**	-0.44	-2.95	-0.39	-1.63	-6.07	-1.57	4.51	0.40	0.62	4.57	0.67	0.86	**-3.41***	**-3.77***
gold	**Y**	-0.64	-2.81	-0.62	-2.09	-9.70	-2.11	5.41	0.30	0.51	4.46	0.62	0.86	**-4.09***	**-5.09***
rgold	**Y**	-1.58	-7.94	-1.58	-2.16	-10.02	-2.17	3.66	0.52	0.73	4.16	0.76	0.89	**-4.91***	**-4.87***
silver	**Y**	-1.78	-9.25	-1.73	-2.25	-9.85	-2.16	2.03	0.76	0.91	3.29	0.76	0.94	**-8.30***	**-8.28***
rsilver	**Y**	-2.32	-10.02	**-2.22***	-2.38	-10.80	-2.28	1.12	0.88	0.97	1.37	0.90	1.00	**-8.21***	**-8.26***
rgdp	**N**	4.06	1.41	5.03	-1.76	-14.29	-1.89	2.28	0.75	0.88	10.60	0.08	0.28	1.68	1.35
ip	**N**	2.67	1.34	2.90	-2.57	-15.09	-2.62	0.49	0.86	0.99	18.50	**0.04***	**0.02***	0.86	0.75
capu	**Y**	**-3.16***	**-31.14***	**-3.26***	**-3.57***	**-31.47***	**-3.58***	-	-	-	-	-	-	-1.83	-1.80
emp	**N**	3.05	0.96	3.47	-2.00	-8.01	-2.00	8.57	0.15	0.21	12.50	0.18	0.16	0.26	0.94
unemp	**N**	-1.57	-5.62	-1.58	-1.93	-10.04	-2.01	-	-	-	-	-	-	-2.50	-2.88
pgdp	**Y**	2.40	0.69	2.99	-0.78	-2.02	-0.76	3.63	0.61	0.73	6.70	0.52	0.64	0.12	-1.98

Table 8 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
cpi	**Y**	1.61	0.28	2.09	-0.87	-2.60	-0.86	8.03	0.37	0.25	15.40	0.18	0.07	-0.03	-3.27
ppi	**Y**	2.29	0.75	2.53	-1.01	-3.83	-1.04	3.81	0.53	0.71	13.90	0.11	0.11	0.43	-1.83
earn	**Y**	4.10	1.08	4.78	-0.58	-1.30	-0.56	1.99	0.68	0.91	7.05	0.52	0.61	0.08	**-4.27***
oil	**N**	-0.82	-4.70	-0.80	-2.38	-10.62	-2.30	7.66	0.21	0.28	11.10	0.25	0.24	-2.33	-2.55
roil	**N**	-1.50	-6.48	-1.47	-1.91	-7.16	-1.87	2.85	0.58	0.83	15.10	0.10	0.07	-2.17	-2.14
comod	**Y**	0.20	-0.90	0.24	-1.93	-7.95	-1.88	0.24	0.94	0.99	14.00	0.08	0.10	-1.69	-2.85
rcomod	**Y**	-1.96	-8.69	-1.97	-2.37	-12.97	-2.35	2.81	0.59	0.83	35.60	**0.00***	**0.00***	**-4.40***	**-4.68***
mon1	**N**	10.91	4.08	11.19	1.82	5.19	1.71	0.00	0.99	1.00	0.00	1.00	1.00	4.50	3.51
mon2	**Y**	2.24	0.11	2.33	-0.78	-3.41	-1.00	0.00	0.95	1.00	23.00	**0.04***	**0.00***	0.85	-2.49
mon3	**N**	2.35	0.21	2.44	-0.74	-3.16	-0.96	-	-	-	-	-	-	0.65	-2.71
rmon1	**N**	4.39	4.80	4.86	0.27	2.77	0.17	1.92	0.76	0.92	0.29	0.98	1.00	2.01	1.23
rmon2	**N**	2.58	0.63	2.78	-1.66	-5.67	-1.60	5.32	0.31	0.52	6.21	0.56	0.70	-0.59	-1.85
rmon3	**N**	2.70	0.67	2.91	-1.57	-5.01	-1.51	0.75	0.85	0.98	9.82	0.39	0.34	-0.81	-2.02

Table 9: Tests results France

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
rovnght	**Y**	-1.80	-8.87	-1.75	-1.94	-8.82	-1.87	2.64	0.67	0.85	2.27	0.88	0.98	**-3.42***	-3.39
rtbill	**N**	-1.53	-5.92	-1.49	-1.98	-7.99	-1.91	1.69	0.72	0.93	4.12	0.70	0.89	-2.73	-3.19
rbndl	**N**	-1.26	-4.63	-1.26	-1.34	-4.48	-1.34	5.50	0.26	0.50	4.77	0.59	0.84	-2.01	-1.82
rrovnght	**Y**	**-2.96***	**-16.11***	**-2.83***	-3.28	**-21.68***	**-3.10***	7.63	0.16	0.28	9.48	0.25	0.36	-1.96	-2.08
rrtbill	**N**	-2.62	-13.18	-2.51	-3.02	-18.21	-2.83	4.36	0.41	0.64	7.39	0.40	0.57	-1.39	-1.54
rrbndl	**Y**	**-3.07***	**-17.52***	**-2.95***	**-3.53***	**-27.73***	**-3.36***	7.84	0.12	0.27	11.20	0.11	0.24	-1.35	-1.32

Table 9 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant&Trend
		ADF	MZ_a^{GLS}	MZ_t	ADF	MZ_a^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR- t_{NL}	ESTAR- t_{NL}
rspread	**Y**	**-3.86***	**-29.76***	**-3.64***	**-4.15***	**-30.31***	**-3.87***	**21.00***	**0.02***	**0.00***	**20.70***	0.05	**0.01***	**-4.99***	**-4.97***
exrate_a	**Y**	-1.43	-6.16	-1.37	-1.87	-6.73	-1.81	**14.90***	**0.03***	**0.02***	**21.70***	**0.02***	**0.01***	-2.31	-2.30
rexrate_a	**Y**	-1.69	-5.95	-1.64	-1.75	-6.01	-1.70	**25.50***	**0.00***	**0.00***	**25.40***	**0.02***	**0.00***	-2.11	-2.07
stockp	**N**	4.48	9.70	4.64	0.84	9.74	0.87	0.00	0.98	1.00	1.52	0.90	1.00	4.62	4.21
rstockp	**N**	1.75	7.50	1.79	0.29	5.00	0.30	0.55	0.91	0.99	0.61	0.98	1.00	3.34	2.93
divpr	**Y**	-1.29	-3.55	-1.27	-1.60	-6.68	-1.51	4.66	0.48	0.61	**113.00***	**0.00***	**0.00***	**-4.10***	**-4.42***
gold	**Y**	-0.42	-1.76	-0.40	-1.41	-4.21	-1.41	**28.20***	**0.00***	**0.00***	**27.50***	**0.01***	**0.00***	-2.15	-2.28
rgold	**Y**	-1.44	-5.38	-1.44	-1.66	-5.91	-1.67	7.14	0.32	0.33	**28.30***	**0.00***	**0.00***	**-3.18***	-3.13
silver	**Y**	-1.59	-7.64	-1.55	-2.00	-8.00	-1.93	5.02	0.36	0.56	6.23	0.46	0.69	**-7.70***	**-7.65***
rsilver	**Y**	-2.28	-9.98	-2.19	-2.51	-11.87	-2.39	1.92	0.81	0.92	3.73	0.75	0.92	**-7.68***	**-7.76***
rgdp	**N**	3.36	1.22	3.99	-1.68	-8.47	-1.69	8.96	0.14	0.19	7.44	0.60	0.56	-0.33	-0.52
ip	**N**	2.43	0.86	2.58	-1.37	-5.28	-1.36	1.36	0.77	0.95	6.83	0.50	0.63	-0.46	0.20
capu	**Y**	-1.46	**-16.62***	-1.57	-2.42	-16.58	-2.36	-	-	-	-	-	-	-2.11	-2.07
emp	**N**	0.47	-9.67	-0.17	-1.89	-17.79	-2.33	-	-	-	-	-	-	0.11	-0.21
unemp	**N**	-0.33	-1.71	-0.13	-1.28	-12.21	-1.98	-	-	-	-	-	-	-1.55	-0.56
pgdp	**Y**	1.16	0.09	1.52	-0.29	-0.06	-0.50	15.40	0.16	**0.02***	1.01	0.96	1.00	-1.19	2.76
cpi	**Y**	0.64	-1.39	0.65	-1.31	-4.82	-1.31	**21.60***	**0.04***	**0.00***	2.54	0.97	0.98	-0.35	-1.73
oil	**Y**	-0.82	-4.03	-0.81	-1.96	-7.32	-1.91	**48.80***	**0.00***	**0.00***	**67.40***	**0.00***	**0.00***	-1.73	-1.81
roil	**N**	-1.70	-6.84	-1.67	-1.93	-7.18	-1.88	5.54	0.39	0.50	6.53	0.63	0.66	-1.70	-1.66
comod	**Y**	-0.42	-2.66	-0.42	-2.02	-8.08	-1.97	**14.80***	**0.04***	**0.02***	**27.70***	**0.00***	**0.00***	-2.58	-3.14
rcomod	**Y**	-0.82	-6.60	-0.82	-3.10	-17.10	**-2.92***	0.22	0.98	1.00	11.20	0.21	0.23	**-3.57***	**-4.31***
mon1	**N**	2.01	0.84	2.62	-0.95	-1.86	-0.89	2.51	0.53	0.86	1.59	0.95	0.99	-0.84	-0.13
mon3	**Y**	1.48	0.70	2.30	-0.95	-2.69	-0.87	-	-	-	-	-	-	-1.22	**-6.71***
rmon1	**N**	0.12	-0.06	0.14	-1.11	-3.15	-1.07	1.53	0.78	0.94	2.29	0.94	0.98	-0.71	-1.29
rmon3	**Y**	1.77	0.40	2.13	-0.92	-3.86	-1.06	**15.50***	**0.00***	**0.02***	3.48	0.78	0.93	-1.87	-0.97

Table 10: Tests results Germany

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_{α}^{GLS}	MZ_t	ADF	MZ_{α}^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
ovnght	**Y**	-2.24	-10.85	**-2.17***	-2.33	-10.81	-2.24	9.51	0.07	0.16	15.00	0.16	0.08	**-4.01***	**-3.98***
rtbill	**Y**	-1.94	-7.93	-1.94	-2.07	-8.87	-2.05	-	-	-	-	-	-	**-3.50***	**-3.72***
rbndl	**Y**	-2.02	-13.12	**-2.02***	-2.25	-13.66	-2.24	-	-	-	-	-	-	**-3.42***	**-3.57***
rrovnght	**Y**	**-3.73***	**-44.31***	**-3.50***	**-4.40***	**-50.32***	**-4.03***	**20.80***	**0.00***	**0.00***	**29.00***	**0.00***	**0.00***	**-3.78***	**-3.82***
rrtbill	**Y**	**-3.16***	**-35.42***	**-2.92***	**-4.47***	**-36.57***	**-3.89***	19.00*	0.03*	0.00*	**18.50***	0.12	**0.02***	**-3.00***	-2.94
rrbndl	**Y**	**-5.66***	**-62.96***	**-4.79***	**-6.39***	**-63.83***	**-5.25***	18.60*	0.01*	0.00*	14.80	0.07	0.08	**-3.31***	-3.32
rspread	**Y**	**-3.43***	**-23.61***	**-3.30***	**-3.80***	**-28.42***	**-3.63***	8.90	0.15	0.19	**22.30***	**0.01***	**0.01***	**-4.79***	**-4.88***
exrate_a	**Y**	-0.84	-4.43	-0.78	-1.83	-7.46	-1.75	12.20	0.05	0.06	**18.10***	**0.04***	**0.02***	-2.69	-2.62
rexrate_a	**Y**	-1.77	-6.32	-1.71	-1.82	-6.41	-1.77	**15.90***	**0.02***	**0.01***	**18.20***	**0.02***	**0.02***	-2.18	-2.15
stockp	**Y**	4.17	9.60	4.33	1.07	7.87	1.62	0.00	0.95	1.00	0.00	1.00	1.00	1.01	0.36
rstockp	**Y**	2.99	8.67	3.09	0.37	5.08	0.68	0.00	0.98	1.00	0.80	0.97	1.00	0.37	-0.35
divpr	**Y**	-1.14	-3.56	-1.12	-2.30	-14.98	-2.15	3.80	0.45	0.71	17.60	**0.04***	**0.03***	-2.70	**-3.92**
gold	**Y**	-0.86	-3.34	-0.86	-1.62	-5.57	-1.63	**25.90***	**0.01***	**0.00***	9.41	0.38	0.37	**-3.10***	-3.16
rgold	**Y**	-1.58	-6.04	-1.58	-1.75	-6.46	-1.75	**15.90***	**0.04***	**0.01***	15.60	0.12	0.06	**-3.60***	**-3.56***
silver	**Y**	-2.19	-9.78	**-2.11***	-2.26	-9.84	-2.17	9.59	0.27	0.15	**27.90***	**0.03***	**0.00***	**-8.53***	**-8.55***
rsilver	**Y**	-2.16	-9.95	**-2.08***	-2.57	-12.04	-2.44	3.66	0.52	0.73	**23.10***	0.06	**0.00***	**-8.24***	**-8.33***
rgdp	**N**	4.96	1.36	5.15	-2.02	-8.14	-2.00	0.00	0.98	1.00	2.95	0.87	0.96	-0.25	-0.96
ip	**Y**	1.79	0.37	1.84	-1.43	-8.31	-1.42	1.77	0.74	0.93	9.02	0.34	0.41	-1.18	-1.09
capu	**Y**	-1.33	-10.84	-1.31	-1.76	-11.03	-1.74	-	-	-	-	-	-	**-4.13***	**-4.31***
emp	**N**	-0.38	-1.36	-0.38	-1.61	-9.47	-1.62	0.00	0.99	1.00	12.70	0.18	0.15	-0.96	-1.90
unemp	**N**	-0.46	-2.50	-0.31	-2.72	-17.56	-2.87	-	-	-	-	-	-	-1.62	-2.73
pgdp	**N**	4.34	1.08	5.81	-0.76	-1.40	-0.69	0.91	0.80	0.98	10.40	0.37	0.29	-1.18	-2.03
cpi	**N**	3.02	0.93	3.98	-0.98	-3.58	-0.96	1.34	0.77	0.96	5.61	0.60	0.76	-0.05	-1.36
ppi	**N**	1.17	0.07	1.24	-1.37	-5.03	-1.39	0.32	0.96	0.99	1.30	0.95	1.00	-0.40	-1.30
earn	**N**	5.26	1.39	6.35	-0.81	-3.20	-0.74	-	-	-	-	-	-	0.18	-2.86

Table 10 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	**MZ_{α}^{GLS}**	**MZ_t**	**ADF**	**MZ_{α}^{GLS}**	**MZ_t**	**W_T**	**Boot. p-value**	**Asym. p-value**	**W_T**	**Boot. p-value**	**Asym. p-value**	**ESTAR-t_{NL}**	**ESTAR-t_{NL}**
oil	**Y**	-1.11	-4.83	-1.09	-1.84	-6.50	-1.80	**15.50***	**0.04***	**0.02***	10.30	0.26	0.29	-1.82	-1.85
roil	**N**	-1.68	-6.35	-1.65	-1.84	-6.55	-1.80	3.53	0.55	0.75	6.83	0.51	0.63	-1.80	-1.78
comod	**Y**	-1.83	-10.21	-1.79	-2.60	-12.65	-2.49	**18.70***	**0.01***	**0.00***	**25.90***	**0.01***	**0.00***	-2.12	-2.12
rcomod	**Y**	-0.06	-2.49	-0.03	**-3.83***	**-25.07***	**-3.51***	0.59	0.92	0.99	**41.60***	**0.00***	**0.00***	-1.82	**-3.72***
mon1	**N**	6.69	3.44	9.63	1.28	2.62	0.93	0.00	0.99	1.00	0.00	1.00	1.00	4.43	2.52
mon2	**N**	3.30	1.64	3.47	-0.19	-2.32	-0.64	6.76	0.33	0.36	11.80	0.17	0.20	1.02	-1.79
mon3	**N**	3.74	1.14	5.51	0.34	-0.33	-0.10	4.17	0.39	0.67	1.24	0.96	1.00	3.74	0.74
rmon1	**N**	5.21	3.19	6.25	0.58	1.74	0.34	0.00	1.00	1.00	0.00	1.00	1.00	3.60	1.59
rmon2	**Y**	2.62	1.18	2.54	-1.08	-5.12	-1.32	0.00	0.99	1.00	**22.50***	**0.04***	**0.00***	-0.19	-2.65
rmon3	**N**	4.01	1.65	4.85	-0.91	-3.94	-1.12	0.03	1.00	1.00	0.95	0.96	1.00	1.78	0.37

Table 11: Tests results Italy

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	**MZ_{α}^{GLS}**	**MZ_t**	**ADF**	**MZ_{α}^{GLS}**	**MZ_t**	**W_T**	**Boot. p-value**	**Asym. p-value**	**W_T**	**Boot. p-value**	**Asym. p-value**	**ESTAR-t_{NL}**	**ESTAR-t_{NL}**
rovnght	N	-1.36	-5.83	-1.32	-1.47	-6.84	-1.40	7.62	0.19	0.29	3.43	0.94	0.81	-0.99	-1.51
rtbill	N	-1.11	-3.67	-1.08	-2.09	-11.77	-1.93	2.52	0.80	0.86	9.99	0.32	0.28	-0.67	-1.24
rbnds	Y	-1.08	-3.17	-1.05	-1.31	-6.44	-1.18	**23.80***	**0.03***	**0.00***	8.76	0.43	0.37	-1.42	-2.98
rbndm	N	-1.14	-3.74	-1.13	-1.13	-3.39	-1.14	3.56	0.61	0.74	3.35	0.94	0.79	-1.61	-1.34
rbndl	N	-1.20	-4.38	-1.19	-1.24	-4.15	-1.25	5.78	0.41	0.47	6.96	0.62	0.49	-2.03	-1.83
rrovnght	Y	-2.05	-7.92	-1.98	-2.23	-11.63	-2.16	3.38	0.52	0.76	**14.70***	0.08	0.05	**-3.16***	-3.37
rrtbill	Y	-1.64	-9.61	-1.60	-2.41	-11.98	-2.20	10.80	0.09	0.10	6.11	0.71	0.48	**-3.07***	-2.63
rrbnds	Y	-1.84	-9.06	-1.79	-2.43	-11.78	-2.28	10.10	0.09	0.13	8.76	0.43	0.33	**-3.28***	-2.99
rrbndm	Y	-2.75	**-16.47***	**-2.66***	-2.89	-19.90	-2.78	7.79	0.16	0.27	3.35	0.94	0.80	**-3.10***	-3.14

Table 11 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant&Trend
		ADF	MZ_a^{GLS}	MZ_t	ADF	MZ_a^{GLS}	MZ_t	W_T	Boot.	Asym.	W_T	Boot.	Asym.	ESTAR- t_{NL}	ESTAR- t_{NL}
rrbndl	Y	**-3.06***	**-19.62***	**-2.94***	-3.19	**-22.49***	**-3.04***	7.17	0.28	0.33	6.96	0.62	0.50	**-3.54***	**-3.57***
rspread	Y	-2.88	**-22.74***	**-2.68***	-3.43	**-22.78***	**-3.09***	**19.50***	**0.01***	**0.00***	8.82	0.42	0.40	**-4.14***	**-4.39***
exrate_a	N	0.07	-2.13	0.07	-2.10	-9.19	-2.09	5.19	0.37	0.54	13.90	0.11	0.11	-1.50	-2.07
rexrate_a	N	-1.83	-6.64	-1.77	-1.84	-6.64	-1.77	6.67	0.29	0.37	8.28	0.48	0.40	-2.18	-2.12
stockp	N	2.68	5.07	2.84	-0.17	0.67	-0.27	0.06	0.98	1.00	2.97	0.96	0.86	0.04	-0.52
rstockp	Y	-1.32	-4.27	-1.30	-1.40	-4.32	-1.37	0.77	0.94	0.98	2.48	0.98	0.93	**-4.53***	**-4.37***
gold	Y	0.24	-0.59	0.27	-1.45	-4.39	-1.42	**14.60***	**0.04***	**0.02***	14.60	0.08	0.06	-1.99	**-3.70***
rgold	Y	-1.41	-5.21	-1.41	-1.61	-5.56	-1.61	4.29	0.49	0.65	5.58	0.76	0.60	**-3.87***	**-3.83***
silver	Y	-1.24	-6.50	-1.20	-2.10	-8.54	-2.03	8.06	0.23	0.25	**22.40***	**0.01***	**0.02***	**-7.04***	**-7.06***
rsilver	Y	-2.21	-9.30	**-2.13***	-2.39	-10.97	-2.28	1.49	0.84	0.95	1.03	1.00	0.97	**-7.79***	**-7.85***
rgdp	N	3.19	0.92	3.68	-2.31	-13.65	-2.31	5.76	0.36	0.47	12.10	0.18	0.15	-1.20	-0.55
ip	Y	1.91	0.48	2.01	-1.78	-10.38	-1.72	4.88	0.39	0.58	**22.70***	**0.00***	**0.00***	-1.27	-0.75
capu	Y	-1.66	-14.09	-1.63	-2.27	-14.12	-2.21	0.00	0.98	1.00	-	-	-	**-3.79***	**-3.8***
unemp	N	-0.07	-0.83	-0.06	-1.53	-7.66	-1.52	-	-	-	-	-	-	-1.2	-2.43
pgdp	Y	1.80	0.45	2.60	-0.51	-1.57	-0.54	7.16	0.40	0.33	17.80	**0.03***	**0.08***	-0.64	-3.20
cpi	N	0.60	-4.16	0.54	-1.06	-3.46	-1.15	13.00	0.14	0.05	3.47	0.93	0.90	-0.03	-2.62
ppi	N	1.03	-0.59	0.75	-1.98	-12.92	-2.00	4.30	0.57	0.65	10.60	0.28	0.29	-2.68	-2.18
oil	Y	-0.35	-2.82	-0.33	-2.17	-9.40	-2.10	**31.10***	**0.00***	**0.00***	**45.10***	**0.00***	**0.01***	-1.80	-2.10
roil	N	-1.60	-6.10	-1.57	-1.80	-6.31	-1.76	4.21	0.54	0.66	7.17	0.59	0.56	-1.83	-1.80
comod	Y	0.33	-0.73	0.33	-2.03	-9.76	-1.97	0.60	0.96	0.99	15.80	0.06	0.12	-1.91	**-4.05***
rcomod	Y	-0.86	-5.54	-0.86	-2.40	-10.85	-2.32	2.50	0.69	0.86	**59.80***	**0.00***	**0.00***	**-3.78***	**-4.50***
mon1	N	6.31	2.25	8.18	0.64	0.70	0.65	0.00	0.99	1.00	2.98	0.96	0.84	1.77	-0.87
mon2	Y	2.63	0.88	3.20	-1.61	-5.31	-1.61	0.08	0.96	1.00	**31.90***	**0.00***	**0.01***	-0.29	-0.32
rmon1	Y	1.37	0.13	1.38	-1.50	-5.06	-1.47	**17.70***	**0.02***	**0.01***	6.70	0.64	0.55	-0.40	0.04
rmon2	Y	-0.73	-8.33	-0.79	-1.81	-9.62	-1.79	**14.80***	**0.03***	**0.02***	10.40	0.29	0.35	**-4.12***	**-4.10***

Table 12: Tests results Japan

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_{α}^{GLS}	MZ_t	ADF	MZ_{α}^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
rovnght	Y	-1.37	-7.83	-1.37	-3.10	-19.96	-3.00*	24.20*	0.01*	0.00*	32.70*	0.01*	0.00*	-6.92*	-8.89*
rbndl	N	-0.39	-1.41	-0.38	-1.65	-7.46	-1.59	4.80	0.40	0.59	12.30	0.18	0.17	-1.18	-2.26
rrovnght	Y	-3.26*	-35.10*	-3.04*	-4.32*	-35.28*	-3.85*	22.20*	0.02*	0.00*	21.70*	0.03*	0.01*	-2.92	-2.91
rrbndl	Y	-3.07*	-23.13*	-2.83*	-3.44*	-24.70*	-3.12*	14.80*	0.03*	0.02*	13.90	0.10	0.11	-3.26*	-3.30
rspread	Y	-3.25*	-20.02*	-3.01*	-3.39	-21.41*	-3.11*	36.10*	0.00*	0.00*	35.00*	0.00*	0.00*	-3.67*	-3.76*
exrate_a	N	-0.10	-1.38	-0.08	-1.99	-7.87	-1.91	3.17	0.51	0.79	6.35	0.52	0.68	-1.38	-2.09
rexrate_a	N	-0.52	-3.27	-0.47	-2.07	-8.18	-1.99	3.85	0.52	0.71	4.43	0.72	0.87	-2.83	-3.43*
stockp	Y	-0.19	-1.62	-0.20	-1.63	-5.55	-1.60	15.70*	0.04*	0.02*	25.70*	0.04*	0.00*	-3.12*	-3.59*
rstockp	Y	-0.73	-3.38	-0.76	-2.00	-8.10	-1.98	10.50	0.09	0.11	26.00*	0.04*	0.00*	-3.17*	-3.42*
divpr	Y	-0.46	-1.92	-0.19	-1.80	-7.64	-1.72	6.95	0.31	0.35	4.78	0.67	0.84	-6.92*	-6.20*
house	N	0.21	-0.67	0.36	-1.15	-7.00	-1.56	-	-	-	-	-	-	-2.39	-1.88
rhouse	N	-0.90	-4.84	-0.86	-2.05	-12.60	-2.30	8.52	0.29	0.22	1.79	0.94	0.99	-2.29	-2.16
gold	Y	-1.41	-6.20	-1.40	-1.81	-7.37	-1.84	16.30*	0.04*	0.01*	14.10	0.14	0.10	-4.47*	-4.40*
rgold	Y	-2.11	-10.14	-2.13*	-2.24	-10.41	-2.25	12.90	0.05	0.05*	24.40*	0.02*	0.00*	-4.71*	-4.68*
silver	Y	-2.31	-10.59	-2.22*	-2.38	-11.15	-2.27	5.36	0.36	0.52	6.01	0.58	0.72	-8.96*	-8.99*
rsilver	Y	-1.89	-10.35	-1.82	-2.94	-15.15	-2.75	3.97	0.49	0.69	6.26	0.45	0.69	-8.53*	-8.66*
rgdp	N	4.45	0.99	5.29	-1.22	-3.14	-1.20	1.11	0.80	0.97	5.28	0.73	0.79	-1.29	-2.13
ip	N	1.29	0.05	1.35	-2.00	-10.70	-2.05	4.03	0.48	0.69	2.79	0.78	0.97	-1.33	-1.02
capu	Y	-0.89	-7.55	-0.86	-2.46	-12.98	-2.42	-	-	-	-	-	-	-3.31*	-3.80*
emp	N	3.81	0.82	4.20	-0.85	-2.67	-0.83	7.16	0.18	0.33	5.70	0.61	0.75	-2.34	-2.79
unemp	N	0.63	2.71	0.74	-0.28	-2.75	-0.23	6.95	0.27	0.35	7.87	0.40	0.52	-0.42	-1.08
pgdp	Y	1.77	0.27	1.98	-0.27	0.43	-0.32	28.90*	0.00*	0.00*	2.42	0.83	0.98	-0.93	2.33
cpi	Y	1.61	0.31	1.96	-0.60	-1.00	-0.75	23.80*	0.02*	0.00*	7.87	0.55	0.52	-0.77	1.96
ppi	Y	-0.36	-1.73	-0.33	-1.22	-3.83	-1.28	16.00*	0.03*	0.01*	2.75	0.87	0.97	-1.18	-0.59
earn	Y	2.68	0.67	3.33	-0.64	-0.68	-0.65	24.00*	0.07	0.00*	6.64	0.72	0.65	-0.52	0.45

Table 12 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
oil	**N**	-1.33	-4.96	-1.31	-1.62	-5.32	-1.59	5.55	0.36	0.50	1.90	0.88	0.99	-2.35	-2.30
roil	**N**	-1.94	-7.42	-1.90	-1.98	-7.59	-1.94	2.17	0.66	0.89	2.29	0.90	0.98	-2.19	-2.18
comod	**Y**	-1.36	-4.67	-1.34	-1.36	-4.69	-1.34	5.02	0.33	0.56	7.78	0.36	0.53	**-4.96***	**-4.92***
rcomod	**N**	0.85	-0.46	0.90	-2.17	-13.45	-2.09	3.32	0.53	0.77	5.22	0.60	0.80	-1.44	-1.64
mon0	**N**	4.51	0.97	6.20	1.36	1.41	-0.23	0.00	0.97	1.00	0.45	0.94	1.00	4.93	4.46
mon1	**N**	6.27	3.02	9.93	1.00	4.88	1.07	0.00	0.99	1.00	4.34	0.69	0.87	3.46	2.47
mon2	**Y**	1.29	-0.36	1.77	-1.28	-5.11	-1.27	1.77	0.84	0.93	**25.70***	**0.03***	**0.00***	-0.21	-2.21
mon3	**Y**	2.12	0.34	3.02	-0.68	-1.70	-0.63	0.00	0.97	1.00	**26.20***	**0.02***	**0.00***	0.48	-1.49
rmon0	**N**	4.93	2.64	6.10	0.90	1.83	-0.12	0.66	0.80	0.99	0.03	0.97	1.00	4.57	3.87
rmon2	**N**	2.00	0.60	2.38	-1.75	-6.86	-1.76	0.00	0.98	1.00	4.31	0.69	0.88	-0.60	-2.54
rmon3	**Y**	2.94	0.99	3.72	-1.07	-3.14	-0.98	0.00	0.97	1.00	**26.70***	**0.01***	**0.00***	1.17	-1.53

Table 13: Tests results UK

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
rovnght	**Y**	-1.84	-9.99	-1.77	-2.11	-9.94	-2.00	11.80	0.07	0.07	**20.20***	**0.04***	**0.01***	-1.64	-1.37
rtbill	**N**	-1.57	-9.34	-1.53	-1.90	-9.29	-1.83	-	-	-	-	-	-	-2.31	-2.24
rbndl	**Y**	-1.03	-3.40	-1.01	-0.91	-3.07	-0.89	**13.10***	0.06	**0.04***	13.00	0.13	0.14	**-3.98***	**-3.79***
rrovnght	**Y**	-2.14	-9.90	**-2.10***	-2.89	-16.76	-2.73	7.76	0.24	0.27	9.59	0.25	0.35	-1.95	-1.94
rrtbill	**Y**	**-3.28***	**-19.22***	**-3.08***	-3.58	-23.60	-3.33	4.11	0.45	0.67	6.38	0.51	0.68	-2.41	-2.44
rrbndl	**Y**	**-3.12***	**-38.98***	**-2.97***	-3.91	-41.27	-3.66	5.41	0.37	0.51	5.41	0.55	0.78	**-3.32***	-3.32
rspread	**N**	-1.70	-6.63	-1.66	-2.29	-10.47	-2.22	5.31	0.34	0.52	2.14	0.85	0.99	-1.96	-2.19
exrate_a	**N**	-1.14	-5.49	-1.09	-1.86	-7.62	-1.78	10.10	0.11	0.13	11.30	0.25	0.23	-2.27	-2.19

Table 13 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
rexrate_a	**Y**	-1.66	-7.32	-1.61	-2.22	-8.99	-2.12	12.10	0.06	0.06	**16.70***	0.13	**0.04***	-2.73	-2.70
stockp	**N**	4.04	4.08	4.14	0.35	1.83	0.38	5.03	0.37	0.56	6.98	0.43	0.61	2.30	1.15
rstockp	**N**	0.46	-0.03	0.48	-1.18	-3.39	-1.16	5.20	0.50	0.54	0.01	0.99	1.00	-0.39	-1.16
divpr	**Y**	-2.41	-11.87	**-2.28***	-2.67	-15.51	-2.48	5.33	0.43	0.52	11.50	0.38	0.22	**-7.42***	**-7.78***
house	**N**	1.81	0.95	2.20	-1.66	-7.04	-1.63	-	-	-	-	-	-	-0.72	-3.38
rhouse	**Y**	-0.63	-4.55	-0.59	-2.45	-12.38	-2.46	9.70	0.13	0.15	27.10*	0.02*	0.00*	**-4.30***	**-4.90***
gold	**N**	-0.36	-1.53	-0.34	-1.40	-4.15	-1.38	3.79	0.49	0.71	10.60	0.24	0.28	-2.17	-2.74
rgold	**Y**	-1.33	-4.68	-1.31	-1.45	-4.69	-1.43	2.15	0.66	0.90	4.45	0.66	0.87	**-3.27***	-3.15
silver	**Y**	-1.63	-8.81	-1.59	-2.18	-9.56	-2.10	7.86	0.29	0.27	10.80	0.22	0.26	**-7.22***	**-7.17***
rsilver	**Y**	-2.17	-9.98	**-2.09***	-2.67	-13.19	-2.53	0.33	0.90	0.99	26.50	0.08	0.00	**-6.54***	**-6.62***
rgdp	**N**	5.07	1.85	5.94	-0.87	-2.00	-0.86	1.62	0.77	0.94	3.71	0.76	0.92	1.21	0.14
ip	**Y**	1.83	0.62	1.92	-2.39	-14.16	-2.30	**14.00***	**0.02***	**0.03***	**28.10***	**0.04***	**0.00***	-0.60	-0.90
emp	**N**	0.18	-2.37	0.07	-1.99	-9.32	-2.07	4.68	0.54	0.60	6.21	0.55	0.70	-1.20	-2.11
unemp	**N**	-1.46	-6.89	-1.44	-2.32	-16.27	-2.58	-	-	-	-	-	-	-1.84	-1.54
pgdp	**Y**	3.10	1.17	4.37	-0.37	-1.17	-0.33	5.05	0.51	0.56	**28.30***	**0.00***	**0.00***	0.30	-2.02
cpi	**N**	2.18	0.67	2.94	-0.60	-2.10	-0.64	2.99	0.67	0.81	1.48	0.93	1.00	0.46	-2.46
ppi	**N**	1.92	0.59	2.54	-0.78	-2.28	-0.76	2.31	0.78	0.88	7.05	0.50	0.61	0.06	-2.69
earn	**Y**	4.35	1.47	6.42	0.42	-0.21	0.17	6.38	0.30	0.40	**45.70***	**0.00***	**0.00***	2.09	-0.77
oil	**Y**	-0.77	-4.07	-0.75	-2.17	-8.94	-2.11	**41.60***	**0.00***	**0.00***	**52.80***	**0.00***	**0.00***	-1.78	-1.92
roil	**N**	-1.73	-7.27	-1.70	-1.93	-7.44	-1.89	3.79	0.61	0.71	9.47	0.34	0.36	-1.78	-1.71
comod	**Y**	-0.09	-1.30	-0.07	-1.98	-8.46	-1.93	1.94	0.74	0.91	**22.00***	**0.02***	**0.01***	-1.83	-3.10
rcomod	**Y**	-0.98	-5.58	-0.99	-2.97	-19.16	-2.94	4.19	0.51	0.67	6.94	0.41	0.62	**-3.82***	**-4.38***

Table 14: Tests results US

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
rovnght	**Y**	-1.82	-11.66	-1.81	-2.34	-12.11	-2.31	2.22	0.75	0.89	1.77	0.97	0.99	**-5.39***	**-5.35***
rtbill	**Y**	-1.74	-11.05	-1.73	-2.29	-11.57	-2.25	9.30	0.17	0.17	8.27	0.30	0.48	**-4.72***	**-4.68***
rbnds	**Y**	-1.66	-9.14	-1.64	-2.09	-9.55	-2.07	7.97	0.20	0.26	3.29	0.80	0.94	**-4.77***	**-4.75***
rbndm	**Y**	-1.27	-6.05	-1.26	-1.67	-6.49	-1.67	1.89	0.75	0.92	2.46	0.83	0.98	**-3.30***	-3.25
rbndl	**Y**	-1.16	-5.18	-1.14	-1.56	-5.58	-1.53	1.60	0.75	0.94	1.58	0.93	1.00	**-3.10***	-3.01
rrovnght	**Y**	**-4.01***	**-27.83***	**-3.69***	**-4.08***	**-30.04***	**-3.74***	5.87	0.28	0.46	7.14	0.35	0.60	**-3.04***	-3.06
rrtbill	**Y**	**-3.85***	**-27.84***	**-3.57***	**-3.96***	**-29.66***	**-3.66***	**11.50***	**0.04***	0.08	13.30	0.06	0.13	**-3.75***	**-3.79**
rrbnds	**Y**	**-3.47***	**-23.96***	**-3.27***	**-3.60***	**-25.64***	**-3.37***	3.69	0.47	0.73	3.13	0.85	0.95	**-3.48***	**-3.52**
rrbndm	**Y**	**-3.10***	**-19.00***	**-2.97***	-3.19	-21.02	**-3.04***	7.30	0.21	0.31	10.30	0.25	0.30	**-3.23***	-3.28
rrbndl	**Y**	**-3.05***	**-17.76***	**-2.93***	-3.13	-20.07	**-3.00***	**25.20***	**0.00***	**0.00***	**27.80***	**0.01***	**0.00***	**-2.93***	-2.97
rspread	**Y**	**-3.77***	**-26.59***	**-3.57***	**-3.82***	**-27.39***	**-3.61***	5.25	0.49	0.53	9.59	0.39	0.35	**-6.84***	**-6.84***
rexrate_a	**Y**	-1.67	-5.86	-1.68	-1.94	-7.74	-1.91	**13.80***	0.06	**0.03***	**18.30***	0.05	**0.02***	-2.57	-2.60
stockp	**N**	9.08	8.58	9.38	2.17	8.49	2.15	0.00	0.98	1.00	0.00	1.00	1.00	1.68	1.99
rstockp	**N**	4.84	8.34	4.99	1.04	5.66	1.00	0.00	0.98	1.00	0.00	1.00	1.00	1.90	1.52
divpr	**Y**	-2.20	-10.72	**-2.13***	-2.25	-10.58	-2.16	3.73	0.53	0.72	3.90	0.67	0.91	-2.64	-2.55
rhouse	**N**	0.14	-1.69	0.19	-2.18	-9.62	-2.13	7.72	0.12	0.28	12.20	0.16	0.18	-2.28	-2.88
gold	**Y**	-0.83	-3.52	-0.82	-2.05	-9.27	-2.07	3.88	0.48	0.70	13.90	0.11	0.11	**-4.58***	**-5.05***
rgold	**Y**	-1.62	-7.66	-1.61	-2.01	-8.80	-2.01	5.14	0.39	0.55	4.28	0.67	0.88	**-4.87***	**-4.82***
silver	**Y**	-1.88	-9.50	-1.82	-2.20	-9.65	-2.12	3.81	0.45	0.71	4.23	0.68	0.88	**-7.94***	**-7.94***
rsilver	**Y**	-2.24	-9.51	**-2.16***	-2.37	-10.85	-2.27	1.65	0.74	0.94	2.52	0.86	0.98	**-7.46***	**-7.51***
rgdp	**N**	5.60	2.07	7.45	0.28	1.23	0.08	0.00	0.99	1.00	0.00	1.00	1.00	2.99	1.82
ip	**N**	3.27	1.89	3.68	-1.72	-9.79	-1.89	0.61	0.89	0.99	1.76	0.95	0.99	1.59	0.90
capu	**Y**	**-3.38***	**-22.13***	**-3.28***	**-3.52***	**-23.85***	**-3.44***	**12.90***	**0.01***	**0.05***	15.70	0.10	0.06	**-3.70***	**-3.71***
emp	**N**	4.37	1.31	5.26	-1.65	-10.91	-1.62	3.04	0.60	0.80	7.73	0.43	0.53	0.76	-0.14
unemp	**N**	-2.39	-12.03	**-2.35***	-2.41	-12.24	-2.39	-	-	-	-	-	-	-2.42	-2.32
pgdp	**Y**	0.97	-1.53	1.18	-1.05	-3.51	-1.05	7.15	0.28	0.33	**23.50***	**0.01***	**0.00***	-0.35	-0.82
cpi	**Y**	2.02	0.28	2.74	-0.64	-2.35	-0.71	6.22	0.31	0.42	**27.90***	**0.01***	**0.00***	0.80	-1.22

Table 14 (continued)

	Reject	Linear Tests w. Constant			Linear Tests w. Constant&Trend			TAR test w. Constant			TAR test w. Constant&Trend			ESTAR Constant	ESTAR Constant &Trend
		ADF	MZ_α^{GLS}	MZ_t	ADF	MZ_α^{GLS}	MZ_t	W_T	Boot. p-value	Asym. p-value	W_T	Boot. p-value	Asym. p-value	ESTAR-t_{NL}	ESTAR-t_{NL}
ppi	**Y**	2.29	0.67	2.55	-0.98	-2.47	-0.97	-	-	-	-	-	-	-0.30	-2.48
oil	**N**	-1.04	-5.50	-1.02	-2.32	-10.09	-2.25	5.18	0.37	0.54	7.33	0.54	0.58	-2.33	-2.43
roil	**N**	-1.66	-7.11	-1.62	-1.95	-7.49	-1.90	2.74	0.57	0.84	7.99	0.34	0.51	-1.93	-1.89
comod	**Y**	-0.35	-2.15	-0.34	-2.18	-10.71	-2.19	4.46	0.39	0.63	5.28	0.60	0.79	-1.86	-3.24
rcomod	**Y**	-1.33	-6.23	-1.35	-2.39	-12.72	-2.38	3.95	0.48	0.69	**67.30***	**0.00***	**0.00***	**-4.24***	**-4.64***
mon0	**N**	2.02	-7.91	0.15	1.18	-14.14	-1.53	0.00	0.99	1.00	-	-	-	4.84	5.27
mon1	**Y**	2.26	0.77	2.19	-0.84	-3.50	-1.01	0.00	0.98	1.00	**16.30***	0.09	**0.05***	-0.96	**-3.62***
mon2	**Y**	3.73	1.41	5.72	0.14	-0.98	-0.14	0.00	0.96	1.00	**16.80***	0.09	**0.04***	2.17	0.54
mon3	**Y**	3.49	-0.56	4.46	0.61	-9.97	-1.42	0.00	0.98	1.00	**23.20***	**0.02***	**0.00***	2.39	1.75
rmon0	**N**	3.88	0.82	3.30	1.05	-11.06	-2.26	0.00	0.96	1.00	0.42	0.97	1.00	4.82	4.72
rmon1	**N**	-0.32	-2.65	-0.47	-2.00	-8.22	-2.00	5.03	0.34	0.56	4.68	0.68	0.85	-2.22	-2.63
rmon2	**N**	1.58	0.33	1.67	-2.13	-10.99	-2.12	3.15	0.55	0.79	5.10	0.73	0.81	-0.92	-0.99
rmon3	**N**	2.21	0.36	1.96	-2.09	-13.40	-2.50	9.06	0.20	0.18	14.90	0.28	0.08	0.13	-0.61

Table 15:Monte Carlo simulations: rejection frequencies for the CH test

	Using asymptotic critical values					
	R1			R2		
	α = -0.5	α = 1	α = 0.5	α = -0.5	α = 1	A = 0.5
T=50	6.2	6.6	7.5	6.4	6.7	7.4
T=100	4.5	4.8	5.3	4.6	4.7	5.1
T=200	4.1	4.4	4.6	4.4	4.5	4.5
T=500	3.7	3.9	4.2	3.7	4.0	3.9
	Using bootstrapped critical values					
T=50	8.2	5.4	6.7	8.2	5.4	6.2
T=100	5.0	3.9	4.0	4.8	3.7	4.3
T=200	5.6	4.7	6.4	5.3	4.6	6.1
T=500	5.7	6.0	4.3	5.8	5.9	4.6

Note: see text for details on the experiment. The nominal size is 5%.

Table 16: Monte Carlo simulations: rejection frequencies for the KSS test

	α = 0.5	**α = 1.0**	**α = -0.5**
T = 50	4.5	4.6	3.6
T = 100	5.1	4.6	4.4
T = 200	5.0	4.8	4.6
T = 500	4.7	4.8	5.0

Note: see text for details on the experiment. The nominal size is 5%.

Table 17: Monte Carlo simulations: rejection frequencies for the MS-ADF

	T = 100			T = 200		
Model i	6.5			4.5		
Model ii	7.0			6.4		
	Criterion 1	Criterion 2	Wald	Criterion 1	Criterion 2	Wald
Model iii	1.2	7.7	5.9	1.1	5.9	4.6

Note: In all experiments we have used α = 1 and 1000 Monte Carlo replications using 260 bootstraps for the unit root test. Nominal size is 5%. The model estimated is a MS-ADF(1). This is because Markov Level shifts in y would introduce residual autocorrelation in the DF regression.

Appendix: Stock and Watson Dataset, variables definition

rovnght	**Interest rate: overnight**
rtbill	**Interest rate: short term Government Bills**
rbnds	**Interest rate: short term Government Bonds**
rbndl	**Interest rate: long term Government Bonds**
rrovnght	**Real overnight rate: rovnght-CPI Inflation**
rrtbill	**Real short term bill rate: rtbill-CPI Inflation**
rrbnds	**Real short term bond rate: rbnds-CPI Inflation**
rrbndl	**Real long term bond rate: rbndl- CPI Inflation**
rspread	**Term spread: rbndl-rovnght**
exrate	**Nominal exchange rate**
rexrate	**Real exchange rate**
stockp	**Stock price index**
rstockp	**Real stock price index**
divpr	**Dividend price index**
house	**House price index**
rhouse	**Real house price index**
gold	**Gold prices**
rgold	**Real gold prices**
silver	**Silver prices**
rsilver	**Real silver prices**
rgdp	**Real GDP**
ip	**Index of industrial production**
capu	**Index of capacity utilization**
emp	**Employment**
unemp	**Unemployment rate**
pgdp	**GDP deflator**
cpi	**Consumer price index**
ppi	**Producer price index**
earn	**Wages**
commod	**Commodity price index**
oil	**Oil prices**
roil	**Real oil prices**
rcommod	**Real commodity price index**
m0	**Money: M0 or monetary base**
m1	**Money:M1**
m2	**Money:M2**
m3	**Money:M3**
rm0	**Real money: M0**
rm1	**Real money: M1**
rm2	**Real money: M2**
rm3	**Real money: M3**

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