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TESTING FOR UNIT ROOTS WITH STRUCTURAL CHANGE: AN APPLICATION OF THE PERRON ADDITIVE OUTLIER TEST TO THE TURKISH MACROECONOMIC TIME-SERIES DATA (*)

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ABSTRACT

A structural break in the mean level is a sort of exogenous intervention to the series, and thus, can change the order of integration of the series by, i.e., creating spurious unit roots. This paper applies the Perron Additive Outlier test for unit roots with structural change to the Turkish macroeconomic time-series data on the one hand. It also provides the standard Dickey-Fuller test results and compare the two on the other. The results are significant not only in macroeconometric modelling and forecasting processes but also in policy making.

1. INTRODUCTION

Testing for unit roots has attracted a remarkable amount of work in the statistics and economics literature. Traditional unit root tests such as the Dickey-Fuller test, (Dickey and Fuller, 1979 and 1981) however, have some important shortcomings: i.e. a) low power of the alternative of a root close to but below unity, b) due to the nature of the standard hypothesis testing procedure, one cannot reject the null hypothesis unless there is a strong evidence against it, c) possible autocorrelation and also existence of some Moving Average (MA) components, d) possible structural changes, e) seasonality.

In this direction, it has recently been argued (esp. Perron, 1989, 1990 and 1994) that structural breaks can change the order of integration of the series by, i.e., creating spurious unit roots. In short, a structural break in the mean level is a sort of exogenous intervention to the series. This approach follows the "intervention analysis" of Box and Tiao (1975) in the sense that the structural change is being considered as exogenous and as occurring at a known date. That is, a structural break in the mean level is a type of exogenous intervention to the series. Perron (1990) argues that ignoring these effects can lead to inadequate model specifications, spurious unit roots, poor forecasts and improper policy implications. Perron (1990 and 1994) and Perron and Vogelsang (1992a), in the same direction, propose a test for integration level for structural break known the 'Perron test' (hereafter) and

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provide the appropriate critical values. In a recent work, Perron and Vogelsang (1992b) apply the test in the spirit of (1990) to analyse the issue of PPP. What the test is that it removes a particular break from the noise function and add it to the deterministic part of the series. The noise function is then analysed without the effect of the break (i.e. application of the standard unit root testing).

The test should be seen as an improvement in the direction of searching and creating more informative economic time-series. In fact, by employing the Perron test, one is not testing the presence of a structural break. Instead, whether or not the integration level of the series is changed by the structural change, is tested. In contrast to Christiano (1992), the Perron method determines the break data exogenously.

This paper also provides some applications of the traditional Dickey-Fuller and the Perron tests for unit roots by using some annual (1955-1995) Turkish macroeconomic time-series data and compare the results of the two. The remainder of the paper is organised as follows. Section II sets out the econometric methodology used. The data and empirical results are presented in Section III. The final Section offers some implications of the results.

II. ON METHODOLOGY

In the light of our previus discussion, we now set out the econometric methodology in brief. Let us first outline the standard Dickey-Fuller test procedure. In practice, the following model is estimated by OLS:

$$\Delta y_t = \beta + \alpha t + \delta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + e_t \quad (1)$$

where t, Δ, β and e_t represent the time trend, the first-difference operator, the constant term and a sequence of uncorrelated stationary error terms with zero mean and constant variance respectively. An easy and appropriate method of testing the order of integration of a series, say y_t, is suggested by Dickey and Fuller. The DF test consists of testing the negativity of δ in regression (1). Rejection of the null hypothesis $\delta=0$ in favour of the alternative $\delta<0$ implies that y_t is stationary (i.e. integrated of order zero, $y_t \sim I(0)$). For equation (1), the t and F distrubutions are not appropriate (due to nonstationarity) for testing the null. Corrected critical value tables of the t statistic in the ADF (augmented Dickey Fuller) regression of (1) are reported by Fuller (1976), Guilkey and Schmidt (1989), MacKinnon (1991), and Charemza and Deadman (1992). Since the distribution of the t statistic in this case is not known precisely, it should be obtained by simulation, and thus the critical values are subject to some error. The null is rejected if the value of the t statistic has a larger negative value than the corresponding critical value. In practice, it is not clear whether one should use the ADF regression (1) with or without intercept term and time trend. Charemza and Deadman (1992, 134) argue that regression with intercept term sometimes produce results that are rather difficult to interpret. In the next Section, we report the results with intercept and time trend. But, to ensure the robustness of the results we also checked for the test results without intercept which are in line with our reported test results. We believe that in practice most macroeconomic data have mixed underlying processes (i.e. a mixture of 'deterministic) (TSP) and 'stochastic' (DSP) processes). Perhaps, a more reasonable explanation would be that in many cases we have DSP (difference stationary process) dominant mixed process. This is why we include thet time trend in the ADF equation as long as it is significant.

As regards the Perron test for order of intergration, Perron (1989, 1990 and 1994) and Perron and Vogelsang (1992a) suggest two types of model, namely, the 'additive' outlier model (AOM)' and the 'innovational outlier model (IOM)'. The first one is recommended for 'sudden' changes while the second one would be more appropriate for 'gradual' changes. Due to sudden nature of most structural changes and also considering Turkey's confirming experience in the 1980's, in the next Section, the AOM version of the Perron test is preferred.[1] A brief description of the AOM version of the Perron test for intergration level for structural break is as follows. This is a two-step procedure (Perron, 1990, 1994; Perron and Vogelsang, 1992a):

1st step: let y_t be the residuals from a regression (by employing OLS method of estimation) of Y_t on an intercept term, time trend and DU_t where $DU_t = 1$ if $t > T_b$ and 0 otherwise.

2nd step: run the following modified regression (by OLS) and test the negativity of α by using appropriate critical values in Perron (1990, Table 4) or alternatively in Rybinski (1994).

$$\Delta y_t = \alpha y_{t-1} + \sum_{j=0}^{k} d_j D(TB)_{t-j} + \sum_{i=0}^{k} \alpha_i \Delta y_{t-i} + u_t \qquad (2)$$

where $D(TB)_t = 1$ if $t = T_b + 1$ and 0 otherwise. T_b is the break year.

(1) For a comprehensive study on nonstationarity and structural breaks in economic time-series, see Noriega-Muro (1993).

III. DATA AND EMPIRICAL RESULTS

In the light of the econometric methodology presented in the previous Section, we now apply and compare the results of the standard ADF test and the Perron test by employing some annual (1950-1995) Turkish macroeconomic time-series data including exports (X), imports (M), GNP deflator (DEF), wholeasale price index (P), money stock (M1), saving deposits (time) (SD), nominal exchange rates (NER), real GNP (YN) and fixed capital investments (FCI) (for data definitions and sources, see Appendix). We especially chose those data which seemed to have a structural break to see whether or not the order of integration is changed by the effect of it. We use the natural logarithm of the relevant variables. To ensure that our hypothesised break years are correctly chosen, we also calculate the split-sample ADF statistics. Our split-sample ADF test results confirm the validity of our choices for break years (available on request). Break years are chosen 1980 for five of the variables including exports, imports, GNP deflator, wholesale price index and money stock. The rest is as follows. 1981 for saving deposits, 1970 for nominal exchange retas, 1979 for both real and nominal GNP, and 1978 for fixed capital investments. Please note that we use recently tabulated critical values for small samples from Rybinski (1994).

Table 1 and Table 2 suggest that all variables are nonstationary in levels. Table 1 also shows that according to standard ADF test the variables are intergrated of order one (i.e. differencing once is sufficient to make them stationary) with the exception of fixed capital investments. However, when the Perron test is applied (i.e. stuctural change is taken into account) the evidence is mixed. There is little doubt that various structural changes are rather effective on the series. Evidence suggest that for three variables out of ten, structural changes do not change the integration level of the series in hand, i.e. exports, imports and real GNP. A body of evidence (seven out of ten), shows that structural breaks change the order of integration (see Table 1 and Table 2). Since, in this case, the effects of various one-time breaks are significant, then any practitioner using these data might need Box and Tiao (1975) type of 'intervention analysis' to get rid of the significant effects of the outliers before proceeding further in any sensible modelling.

IV. SOME IMPLICATIONS

We provide some evidence that breaks in a series can change the time series properties of the data. This will naturally lead to improper modelling and estimating procedure. There is also little doubt that the Perron test provides a useful tool for practitioners of econometrics working on the time-series modelling of nonstationary macroeconomic data. The results are especially crucial for those who are dealing with the Turkish macroeconomic time-series data. An improtant shortcoming of the test is that it can allow one-time break only.

TABLE 1: The ADF Test

VARIABLES	TEST STATISTIC LEVELS	1ST DIFF.	2DN DIFF.	CRITICAL VALUE
X	-2.07(1)	-4.75(1)	------	-3.51
M	-2.17(1)	-4.89(1)	------	-3.51
DEF	3.41(2)	-3.77(1)	------	-3.51
P	3.22(1)	-3.60(0)	------	-3.51
M1	4.33(1)	-4.69(0)	------	-3.51
SD	2.53(1)	-5.05(0)	------	-3.51
NER	3.26(1)	-4.96(0)	------	-3.51
YR	-2.22(0)	-7.11(0)	------	-3.51
YN	3.54(1)	-3.58(0)	------	-3.51
FCI	-2.12(1)	-2.51(3)	-5.82(0)	-3.60

COMMENT: The reported critical values are obtained from MacKinnon (1991), and correspond to 43 number of observations at 5% significance level. (25 number of observations for FCI). The intercept term and the time trend (when necessary) are included in the ADF equations. Numbers in parentheses show the order of augmentation sufficient to secure lack of autocorrelation of the error terms. The variables are expressed in natural logarithms.

TABLE 2: The Perron Test

VARIABLES	TEST STATISTIC LEVELS	1ST DIFF.	2DN DIFF.	CRITICAL VALUE
X	-2.32(3)	-4.95(1)	------	-3.44(0.7)
M	-1.76(1)	-4.49(1)	------	-3.44(0.7)
DEF	-1.08(1)	0.04(2)	-7.03(3)	-3.44(0.7)
P	-0.68(2)	0.80(2)	-5.90(2)	-3.44(0.7)
M1	-2.72(4)	0.51(2)	-6.42(2)	-3.44(0.7)
SD	-1.31(1)	-2.80(1)	-7.92(1)	-3.44(0.7)
NER	-0.57(1)	-2.61(1)	-6.02(2)	-3.59(0.5)
YR	-2.81(0)	-7.86(0)	------	-3.44(0.7)
YN	-0.74(2)	0.49(2)	-5.71(2)	-3.44(0.7)
FCI	-3.95(3)	-4.28(0)	------	-3.51(0.6)

COMMENT: We use the small sample critical values (45 num.of obs.) tabulated by Rybinski (1994) at 5% significance level instead of original critical values reported by Perron (1990) and Perron and Vogelsang (1992a). The corresponding break fractions are calculated as $\delta = T_b/T$ where T_b and T represent the number of observations until the break year (inclusive) and the whole sample size respectively. Numbers in parantheses in the test statistic columns show the order of augmentation sufficient to secure lack of autocorrelation of the error terms while numbers in parentheses in the critical value column show the corresponding calculated break fractions for each variable. The variables are expressed in natural logarithms.

APPENDIX

Definitions and sources:

The data used in this study are annual for the period of 1950-1995 and are taken from the sources of either State Instite of Statistics (SIS) or State Planning Organisation (SPO).

1) X: exports, in US$; SIS.

2) M: imports, in US$; SIS.

3) DEF: GNP deflator, (1968=100); SIS.

4) P: consumer price index, (1968=100); SIS.

5) M1: money supply (narrow definition), in millions of TL; SIS.

6) SD: saving deposits (time), in millions of TL; SIS.

7) NER: nominal effective exchange rates index, (1968=100); SIS.

8) YR: GNP at constant prices, in millions of TL; SIS.

9) YN: GNP at current prices, in millions of TL; SIS.

10) FCI: fixed capital investments at 1994 prices, in millions of TL; 1968-1994 (annual); SPO.

ÖZET

Ortalama düzeyinde ortaya çıkan yapısal değişim serinin zaman serisi özelliklerini değiştirerek sahte birim köke yol açabilir. Bu nedenle birim kök testinde (durağanlık testi) bu yapısal değişimin de hesaba katılması gereklidir. Bu makale yapısal değişimin olduğu durumlar için önerilen Perron birim kök testini Türkiye makroekonomisi serilerine uygulamaktadır. Uygulama ayrıca standart birim kök testleri için de yapılmakta ve heriki sonuç karşılaştırılmaktadır. Sonuçlar özellikle makroekonometrik modelleme, öngörümleme ve ekonomi politikası yapım süreçleri açısından önemlidir.

REFERENCES

Box, G.E.P. and Tiao, G.C. (1975), "Intervention Analysis with applications to Economic and Environmental Problems", **Journal of the American Statistical Association**, 70, 70-9.

Charemza, W.W. and Deadman, D.F. (1992). **New Directions in Econometric Practice**, Adward elgar, UK.

Christiano, L.J. (1992), "Searching for Breaks in GNP", **Journal of Business and Economic Statistics**, 10, 237-50.

Dickey, D.A. and Fuller, W.A. (1979), "Distribution of the Estimators for

Autoregressive Time Series with a Unit Root", **Journal of the American Statistical Association**, 74, 427-31.

Dickey, D.A. and Fuller, W.A. (1981), "Likelihood Ratio Statistics for autoregressive Time Series with a Unit Root", **Econometrica**, 49 (4), 1057-73.

Fuller, W.A. (1976), **Introduction to Statistical Time Series**, J.Wiley & Sons, Inc., New York.

Guilkey, D.K. and Schmidt, P (1989), "Extended Tabulations for Dickey-Fuller Tests", **Economics Letters**, 31, 355-7.

MacKinnon, J.G. 519917, "Critical Values for cointegration Tests", in Engle, R.F. and Granger, C.W.J. (edes.), **Long-run Economic Relationships**, Oxford University Press, Oxford.

Noriega-Muro, A.E. (1993), **Nonstationarity and Structural Breaks in Economic Time Series: Asymptotic Theory and Monte Carlo Simulations**, Avebury, UK.

Perron, P. (1989), "The great crash, the Oil Price Shock and the Unit Root Hypothesis", **Econometrica**, 57, 1361-1401.

Perron, P. (1990), "Testing for a unit Root in a Time Series with a Changing Mean", **Journal of Business and Economic Statistics**, 8, 153-162.

Perron, P. and Vogelsang, T.J. (1992a), "Testing for a Unit Root in a Time Series with a Changing Mean': Corrections and Extensions", **Journal of Business and Economic Statistics**, 10, 467-70.

Perron, P. and Vogelsang, T.J. (1992b), "Nonstationarty and Level Shifts with an Application to PPP", **Journal of Business and Economic Statistics**, 10, 301-20.

Perron, P. (1994), "Trend, Unit Root and Structural Change in Macroeconomic Time Series", in **Cointegration for the Applied Economist**, B.B. Rao (ed.), The Macmillan, UK, 113-46.

Rybinski, K. (1994), **Extended Tabulations for Perron Additive Outlier Test**, Mimeo, University of Gdansk.

Utkulu, U. (1994), "Cointegration analysis: an Introductory Survey with Applications to Turkey", , **I. Ulusal Ekonometri ve İstatistik Sempozyumu Bildirileri** içerisinde, 11-12, Nov., M. Güneş, Ş. Üçdoğruk and V. Pazaralıoğlu (eds), İzmir, 303-24.