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SEASONAL UNIT ROOTS IN QUARTERLY TURKISH DATA

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ABSTRACT

In this study, the seasonal unit root test developed by HEGY (1990) is applied to some quarterly macroeconomic data of Turkey to find out whether the series is characterized by a deterministic seasonal pattern or a stochastic seasonal pattern. The test results indicate that deterministic seasonal pattern is more common than stochastic seasonal pattern, although there are some seasonal unit roots.

1. Introduction

Whether the macroeconomic time series can be represented by difference-stationary(DS) or trend -stationary(TS) processes (i.e., whether they are stationary around a stochastic trend or stationary around a deterministic trend) has been the central issue in the literature for the last decade[1]. Particularly, following the Nelson and Plosser (1982)'s work, many empirical studies have tested for a unit root at the long run. One of the aspects of the economic time series when working with quarterly or monthly data involves seasonality. In general, seasonality is treated as a deterministic phenomenon, hence it is either represented by dummy variables, ignoring the possibility of stochastic seasonality, or as Kunst (1993) states that "seasonality is viewed as a sort of nuisance to be gotten rid of by adjustment methods". However, treating seasonality as deterministic while the series have stochastic seasonals may cause misspecification, just as the case with spurious detrending(see Ghysels, Lee and Siklos (1993), and Ghysels and Perron (1993).

Deterministic seasonality implies that the seasonal pattern remains constant over time. However, the alternative to this is stochastic seasonality which allows the seasonal pattern to change and vary. Hylleberg *et al.* (1993) provides some examples of the reasons for the change in the seasonal patterns. Stochastic seasonality that allows for changes in the seasonal pattern is approximated by a time series model with seasonal unit roots. In addition, the choice between a process with seasonal unit roots (i. e., a seasonally integrated process) and a process with deterministic seasonality (i. e., a seasonal dummy representation) depends on the extent to which the seasonal patern varies and changes (Hylleberg et al., 1993)

Hylleberg, Engle Granger and Yoo (1990) [henceforth HEGY] develops a test for seasonal unit roots in quarterly data. The HEGY test is designed to detect seasonal unit roots against the alternative of stationary movements

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around a deterministic pattern. In this paper , the seasonal unit root tests propesed by HEGY (1990) will be applied to some quarterly macroeconomic data of Turkey, to investigate empirically whether the quarterly series have unit roots at the seasonal frequencies. Recently, Selçuk (1993) applied both classical unit root tests and the Bayesian (Sims) test to some monthly (seasonally adjusted) Turkish aggregated data to find out whether the series contain a unit root at zero frequency (long run). Therefore our study can be considered as an extension of Selçuk (1993) in the sense that our test procedure will detect unit roots at the seasonal frequencies as well as at the zero frequency, but, of course we shall use unadjusted (raw) data.

The organization of the paper is as follows. In section 2, the concept of seasonal integration, and seasonal unit root tests developed by HEGY (1990) will be explained. These tests will be applied to the quarterly wholesale price index (WPI), consumer price index (CPI), industrial production index (IPI), money supply (MI), exports (X), imports (M), trade deficit (X-M) and the $/ TL exchange rate series in section 3. Finally, in section 4 the results of the test will be discussed briefly.

2. TESTS FOR SEASONAL INTEGRATION

In the absent of seasonality, the standard definition of integration as defined by Engle and Granger (1987) is: "if a series is required to take d-times differences to make it stationary, the series is said to be integrated of order d. Seasonal integration, on the other hand, is defined by Osborn *et al.* (1988) as" a non-deterministic series is said to be integrated of order (d, D), if the series has a stationary, invertible ARMA representation after one-period differencing d-times and seasonally differencing (D-times". Seasonal differencing for quarterly series can be illustrated as $x_t - x_{t-4} = \Delta_4 x_t$.

For a series to be integrated at all frequencies, it should have unit roots at all seasonal frequencies as well as at the zero (long run) frequency. The seasonal frequencies quarterly data are 1/2 and 1/4 of a cycle (2π), corresponding to periods of two-quarters (biannual) and four-quarters (annual). A univariate model that allows for seasonal integration at seasonal frequencies as well as at the zero frequency can be written as

$$(1-L^4)\, x_t = \varepsilon_t \tag{1}$$

where L is the lag operator (i.e., $L^i x_t = x_{t-i}$). The lag polynomium $(1-L^4)$ can be factorized as

$$\begin{aligned}(1\ L^4) &= (1 - L) (1 + L + L^2 + L^3) \\ &= (1 - L) (1 + L) (1 + iL^2) \\ &= (1 - L) (1 + L) (1 - iL) (1 + iL)\end{aligned}$$

Thus, $(1 - L^4) = 0$ has four roots: one at the zero frequency (L = 1), one at the biannual (1/2) frequency (L = -1), and a pair of complex roots at the annual (1/4, 3/4) frequency (L = ±1). The HEGY test is based on the auxiliary regression

$$y_{4t} = \left(1 - L^4\right) = \pi_1 \, y_{1t-1} + \pi_2 \, y_{2t-1} + \pi_3 \, y_{3t-2} + \pi_4 \, y_{3t-1} + \varepsilon t \qquad (2)$$

where

$$y_{1t} = \left(1 + L + L^2 + L^3\right) x_t \qquad y_{3t} = -\left(1 - L^2\right) x_t$$

$$y_{2t} = -\left(1 - L + L^2 - L^3\right) x_t \qquad y_{4t} = \left(1 - L^4\right) x_t$$

In (2), the fransformed series y_{1t} preserves a unit root at the zero frequency and remove the seasonal unit roots, y_{2t} preserves a unit root at the biannual (1/2) frequency and removes the unit roots at the other frequencies, and y_{3t} preserves complex conjugate roots at the annual -four quarter- (1/4 and 3/4) frequencies and removes the roots at the other frequencies.

The test procedure is as follows. To test the null hypothesis of $\pi_1 = 0$ (and $\pi_2 = 0$) against the alternative $\pi_1 < 0$ (and $\pi_2 < 0$) the t-ratios of the corresponding parameters are compared to the critical values tabulated by Fuller (1976), The test for unit roots at the frequencies 1/4 and 3/4 are based on an "F" test on $\pi_3 \cap \pi_4 = 0$ against the alternative $\pi_3 \cup \pi_4 \neq 0$. However the critical values are those tabulated by HEGY (1990), since under the null, F - statistic has a nonstandard distribution. In addition, conditional on $\pi_4 = 0$, a t-test of π_3, that is a test for a unit root at frequency 1/4, can be performed but in this case the critical values are those tabulated by Dickey, Hasza and Fuller (1984).

Equation (2) can be augmented by the lagged values of y_{4t} to whiten the residuals, as is the case with the Dickey-Fuller unit root tests. The distribution of the test statistic is not affected by the augmentation. However, as Engle, Granger, Hylleberg and Lee (hereafter, EGHL) (1993) states that "the power and the size of the test may depend critically on the 'right' augmentation being used". In addition, equation (2) can be extended by including deterministic components such as an intercept, a trend, and seasonal dummies, but these change the distribution of the test statistic. HEGY (1990) provides the critical values for each case.

3. DATA AND TESTING PROCEDURE

The quarterly data were obtained either from the "Bulletins" of the Central Bank of Turkey, or from the "data-base" of the Central Bank provided on the *internet.* The beginning date of 1981. 1 is especially chosen to represent the policy shift towards liberalization. The base years of the indexes are shown on the corresponding tables below. All the series were, first, transformed to natural logarithms, then each series were transformed to y_{it}'s (i=1,2,3,4) in order to remove unit roots at the frequencies other than the one we are interested in. Then the transformed series are used in the estimation of the auxiliary regression of (2). To determine the lag length (the order of augmentation) of the dependent variable, first we started with a maximum lag length of 4, then we dropped the terms that are below 10% significance level. By keeping only the statistically significant lags (if there is any), we reestimated equation (2). This kind of approach that allows gaps (holes) in the lag distribution is adopted by EGHL (1993) with the rationale for "whitening the residuals at the cost of minimum number of parameters". In other words, this approach trades off the loss of power that results from including unnecessary lags against the bias that results from excluding necessary lags (Beaulieu and Miron, 1993).

Equation (2) is estimated for four different combination of deterministic components such as an intercept, seasonal dummy variables and a trend, for each regression. The lag order of each regression is determined by the approach outlined above.

The empirical results of the HEGY test can be interpreted as follows. For the log of wholesale price index (Table 1), consumer price index (Table 2), industrial production index (Table 3), exchange rate (Table 4), exports (Table 5), trade deficit (Table 7) and M1 (Table 8) series, a unit root at zero frequency cannot be rejected (i.e., they are all integrated at the long run). However, the log of imports series (Table 6) seems to have a trend-stationary process rather than an integrated process, since inclusion of a trend in the model makes the imports series stationary at long run.

In case of seasonal unit roots, only the log of exchange rate series contains a unit root at the annual (1/4, 3/4) frequency based on an F-test. The log of WPI, CPI[2] and (X-M) series do not have any seasonal unit roots at any seasonal frequency at all. The rest of the series have seasonal unit roots, but it seems that a seasonal deterministic pattern is more likely rather than a changing and varying seasonal (i.e., a stochastic seasonal) pattern, because seasonal unit roots are rejected when seasonal dummies are included, whereas seasonal unit roots cannot be rejected when the seasonal dummies are excluded[3].

4. CONSLUSION

In this study, the seasonal unit root test developed by HEGY (1990) is applied to some quarterly macroeconomic time series of Turkish economy to investigate whether the series contain a seasonal unit root (i.e., whether the series has a changing and varying seasonal pattern). This kind of information would be useful in proper specification of the modelling of economic time series. Particulary, when a cointegration relationship between variables are detected, knowing that the series contain seasonal unit roots will be important for the specification of the cointegrating regression. If the cointegrating relationship is thought to be a long-run relation while the series contain seasonal unit roots, then the cointegrating regression will yield inconsistent estimates (see HEGY (1990) and EGHL (1993)).

The empirical results in this study indicate that some of the macroeconomic time series of Turkish economy, do have a seasonal pattern, but this pattern is more likely to be a deterministic one, despite seasonal unit roots found at seasonal frequencies. The strongest evidence for a seasonal unit root is found in the exchange rate series in which there is a seasonal unit root at the annual frequency. These findings may be contrary to those of Hylleberg *et al.* (1993) who found that changing and varying seasonal pattern is a common phenomenon among many macroeconomic data for several countries.

Since quarterly aggregate macroeconomic data, such as GNP, consumption, investment, etc., prior to 1987 are not available for Turkey, we were unable to test them, since the HEGY test requires at least 50 or more observations. A further study would investigate seasonal unit roots in monthly Turkish data.

Table 1. Test for seasonal unit roots in the log of WPI (1981=100), 1981.1 - 1995.1

		t-values				F-values
Deterministic Part[a]	Augmentation	π_1	π_2	π_3	π_4	$\pi_3 \cap \pi_4$
I, S, T	-	0.01*	-3.68	-4.40	-3.61	27.40
I, S	-	1.93*	-3.72	-4.51	-3.67	28.47
I,T	-	0.51*	-4.23	-3.91	-3.19	18.89
I	-	2.36*	-4.36	-4.05	-3.22	19.69

(*) indicates that a unit root cannot be rejected at a 5 per cent significance level.
(a) I=intercept, S= seasonal dummies, T=trend.

Table 2. Test for seasonal unit roots in the log of CPI (1978-1979=100), 1981.1 - 1995.1

		t-values				F-values
Deterministic Part[a]	Augmentation	π_1	π_2	π_3	π_4	$\pi_3 \cap \pi_4$
I, S, T	-	-0.30*	-3.73	-4.90	-3.06	26.13
I, S	-	2.25*	-3.74	-4.90	-3.13	26.40
I,T	-	0.01*	-3.90	-4.28	-2.85	18.30
I	-	2.97*	-3.91	-4.32	-2.89	18.67

(*) indicates that a unit root cannot be rejected at a 5 per cent significance level
(a) I =intercept, S = seasonal dummies, T = trend.

Table 3. Test for seasonal unit roots in the log of IPI (1984=100), 1981.1-1994.3

Deterministic part[a]	Augmentation	't' values π1	π2	π3	π4	'F'values π3 ∩ π4
I,S,T	-	-2.35*	-3.38*	-4.89	-2.50	19.57
I,S	-	-1.02*	-3.12*	-4.36	-2.40	16.25
I,T	1,2,4	-0.89*	-1.00*	-0.36*	-0.02	0.07*
I	1,4	-0.93*	-0.66*	-0.74*	-0.02	0.27*

(*) indicates that a unıt root cannot be rejected at a 5 per cent significance level.
(a) I = intercept, S = seasonal dummies, T = trend.

Table 4. Test for seasonal unit roots in the log of Exchange Rate ($/TL), 1981.1-1994.4

Deterministic Part[a]	Augmentation	't' values π1	π2	π3	π4	'F' values π3 ∩ π4
I,S,T	4	1.22*	-3.58	-2.30	-1.27	4.63*
I,S	-	1.61*	-3.17	-2.60	-2.08	9.90
I,T	-	1.53*	-4.17	-2.16	-0.78	3.16
I	-	1.67*	-3.74	-2.76	-1.57	7.95

(*) indicates that a unıt root cannot be rejected at a 5 per cent significance level.
(a) I =intercept,S =seasonal dummies, T=trend

Table 5. Test for sesonal unit roots in the log of Exports (in U.S.$), 1981.1- 1995.1

Deterministic Part[a]	Augmentation	t- values π1	π2	π3	π4	F- values π3 ∩ π4
I , S , T	-	-2.77*	-3.27	-3.94	-2.94	17.23
I , S	4	-0.58*	-2.74*	-2.65	-3.40	12.25
I ,T	1,4	-1.94*	-1.45*	-1.42*	-0.75	1.29*
I	1,4	-0.76*	-1.48*	-1.25*	-1.02	1.30*

(*) indicates that a unit root cannot be rejected at a 5 per cent significance level.
(a) I = intercept, S = seasonal dummies, T= trend.

Table 6 Test for seasonal unit roots in roots in the log of Imports (in U.S$) 1981.1 -1995. 1

Deterministic parta	Augmentation	t - values π1	π2	π3	π4	F- values π3∩ π4
I ,S ,T	4	-3.86	-4.67	-4.16	-3.48	22.17
I ,S	-	-0.73*	-3.78	-2.65	-4.04	15.79
I, T	1	-3.98	-1.90*	-1.86*	-1.12	2.35*
I	1	0.01*	-1.50*	-0.69*	-1.53	1.31*

(*) indicates that a unit root cannot be rejected at a 5 per cent signifi cance level

(a) I = intercept, S = seasonal dummies ,T= trend.

Table 7. Test for seasonal unit roots in the log of Trade Deficit, (X-M) 1981.1 - 1995 .

Deterministic parta	Augmentation	t- values π1	π2	π3	π4	F -values π3 ∩ π4
I ,S ,T	-	-2.83*	-4.09	-3.89	-2.34	12.90
I, S	-	-2.42*	-3.94	-3.52	-2.37	11.32
I, T	-	-2.74*	-4.21	-3.82	-2.34	12.35
I	–	-2.13*	-4.08	-3.53	-2.40	11.17

(*) indicates that a unit root cannot be rejected at a 5 per cent significance level.

(a) I = intercept , S = seasonal dummies, T =trend.

Table .8 Test for seasonal unit roots in the log of M1 1981. 1 -1995.2

Deterministic Parta	Augmentation	t-values π1	π2	π3	π4	F- values π3 ∩ π4
I ,S ,T	-	-0.84*	-3.85	-4.02	-0.33	8.39
I ,S	-	3.00*	-3.79	-4.00	-0.43	8.40
I,T	1.4	-0.71*	-1.35*	-2.35	0.80	3.12
I	1.4	-3.45*	-1.33*	-2.28	0.76	2.91*

(*) indicates that a unit root cannot be rejected at a 5per cent significance level.

(a) I = intercept, S = seasonal dummies, T= trend.

ÖZET

Bu çalışmada, HEGY (1990) tarafından geliştirilen mevsimsel birim kök testi, Türkiye ekonomisine ait bazı makroekonomik zaman serilerine uygulanarak üçer aylık (quarterly) verilerin deterministik mevsimsel hareketle mi? yoksa stokastik mevsimsel hareketle mi? daha iyi temsil edilebileceği araştırılmıştır. Test sonuçları sözkonusu serilerin daha çok deterministik mevsimsel bileşeni içerdiği yönündedir.

NOTES

1. An alternative specification between DS and TS processes is the segmented trend (i. e. , a trend having one or more breaks) specification. Some econometricians claim that some of the aggregate data may be better represented by the segmented trends (see Rappaport and Reichlin (1989), Perron (1989) and Simkins (1994).

2. The WPI (1963=100) and Istanbul cost of living index (1963= 100) series that cover the period from 1964.1 to 1988.1 were also checked for seasonal unit roots. However, the same results were obtained.

3. One exception is the log of X series in which a seasonal unit root at the bi-annual (1/2) frequency cannot be rejected. However, the graphs of the transformed y_{2t} series for exports exhibit a deterministic movement. Hylleberg et al. (1993) advocates the use of graphs of y_{2t} and y_{3t} series to ensure that the series has a stochastic seasonal pattern, in addition to the HEGY test. We have also used the level of exports, imports and trade deficit, instead of the log of exports, etc. In the HEGY test. The results of the HEGY test for exports favored the deterministic pattern. The results for imports and trade deficit were the same as those with log levels.

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