IJEFI

INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCIAL ISSUES

EJ EconJournals

ISSN: 2146-4138

International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2016, 6(2), 503-507.

EJ EconJournals

Regime Nonstationarity and Nonlinearity in the Turkish Output Level

Ozge Kandemir Kocaaslan*

Department of Economics, Faculty of Economics and Administrative Sciences, Hacettepe University, Beytepe Campus, 06800 Cankaya, Ankara, Turkey. *Email: ozge.kandemir@hacettepe.edu.tr

ABSTRACT

In this paper, we investigate the nonlinearity and nonstationarity of Turkish output series applying a Markov regime switching augmented Dickey Fuller unit root test. We document that the output series are characterized by a two-regime Markov switching unit root process. We show that output series is stationary in one regime and nonstationary in the other one. Moreover, we observe that the nonstationary regime corresponds to the recessionary periods in the Turkish economy. That is, the shocks to output are highly persistent in the recession regime, but they are transitory in the expansion regime. In addition, the time period in which the output series is found as stationary is longer than the one in which the output series has a unit root.

Keywords: Unit Root, Markov Regime Switching Model, Output
JEL Classifications: C22, C24, E23

1. INTRODUCTION

Ever since the influential work of Hamilton (1989) who models the U.S. business cycle, numerous studies have examined the macroeconomic fluctuations using Markov regime switching models. These studies document that if the macroeconomic time series show nonlinearities, asymmetries and regime shifts, then the standard models with constant parameters are likely to yield misleading results. In this regard, Markov regime switching models are one of the most appropriate econometric models not only to examine the dynamic nature of the variables of concern but also to analyze how these variables behaved previously and how their behavior may change hereafter.

Researchers have adapted Markov regime switching methodology to different models such as vector autoregressive models (see Krolzig (1997), Warne (2000), Ehrmann et al. (2003)), autoregressive conditionally heteroscedastic (ARCH)/generalized ARCH models (Hamilton and Susmel (1994), Cai (1994), Gray (1996)) and panel data models (Asea and Blomberg (1998)). Following these advances in nonlinear time series analysis, Markov switching extension of the augmented Dickey Fuller (ADF) test has been developed (see, Hall et al. (1999)). The main motivation of this approach is the low power of the standard ADF unit root test proposed by Dickey and Fuller (1979) in distinguishing between an I(1) and I(0) process when the true data generating process of the underlying series has structural breaks and embedded nonlinearities. For instance, Perron (1989) documents that structural breaks in time series can affect the results of the standard tests of the unit root. Perron (1989) suggests that if the breaks are known the unit root testing strategy can be extended by including dummy variables to account for structural breaks in the ADF regression. However, Zivot and Andrews (1992) propose a test where the structural break should be estimated endogenously instead of treating the break as fixed. However, there could be more than one break in the underlying series. Lumsdaine and Papell (1997) and Lee and Strazicich (2003) extend the work of Zivot and Andrews (1992) by developing unit root tests which allow for two endogenous structural breaks in the data. These recent studies point out that the identification of the break dates cannot be considered as independent of the data, and the standard unit root tests which do not take account this fact may yield substantial size distortions and tend to over reject the null hypothesis of unit root.

By allowing the ADF regression parameters to switch values between different regimes, Markov switching ADF (MSADF)

Table 1: Hansen test results for *y*

Standardized likelihood ratio		3.589							
M=0	[0.007]	M=1	[0.010]	M=2	[0.012]	M=3	[0.018]	M=4	[0.042]

P-values in square brackets. The P-values are calculated according to the method described in Hansen (1992), using 10,000 random draws from the relevant limiting Gaussian processes and bandwidth parameter M=0, 1,..., 4; see Hansen (1992) for further details

regression does not make any a priori assumption of stationarity or nonstationarity of either regime. It is possible for both regimes to be locally stationary or one to be locally stationary and the other locally nonstationary. What is more, as this model does not require the researcher to divide the sample period into different subsamples or to predetermine the regime dates, any prior information of the number and the location of the breaks is not needed[1].

Our interest in this issue is due to the observation that empirical evidence on the stationarity properties of Turkish output level is contradictory. Several researchers have investigated the stationarity properties of Turkish output for various purposes over different periods. It can be inferred from this empirical literature that the standard unit root tests which does not take account of structural breaks and recent tests which can allow one or two structural breaks at the most yield different conclusions regarding the stationarity of output. The most possible reason behind the little consensus in the empirical studies is the presence of regime shifts and structural breaks in the output series. For this reason, in this study we apply the MSADF unit root test to examine the stationarity dynamics of the Turkish output series. The main contribution of our study to this literature is to provide fresh evidence about the time series properties of the Turkish output series by using a regime dependent unit root test.

The remainder of the paper is organized as follows. Section 2 presents the data, MSADF regression methodology and the empirical model. The empirical results are discussed in Section 3 and Section 4 concludes the paper.

2. DATA AND ECONOMETRIC METHODOLOGY

2.1. Data

We carry out our empirical investigation using the log of Turkish quarterly real gross domestic product (GDP) index (2010 = 100), y_t, for the period from 1987:Q1 to 2015:Q2. Data are obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF).

To test for the presence of regime shifts in the output series, we implement Hansen (1992; 1996) test. Standard likelihood ratio test cannot be used to test the null of linearity against the alternative of Markov regime switching model. The reason is that under the null of linearity the parameters of the transition probabilities are unidentified as the scores with respect to the parameters of interest are equal to zero and the information matrix is singular. Thus, we implement the test proposed by Hansen (1992; 1996) which overcomes this problem. The results of the Hansen test are presented in Table 1. The results show that the Hansen test rejects the null of linearity for quarterly output series. As a result of this investigation, we implement MSADF unit root test which accommodates the presence of regime shifts in the output series, y_t.

2.2. Econometric Methodology

Before committing the MSADF unit root test to analyze the stationarity property of the Turkish GDP series we first focus on the ADF unit root test proposed by Dickey and Fuller (1979) as follows:

$$\Delta y_t = \mu + \lambda y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \varepsilon_t \tag{1}$$

where y_t is the log of real GDP, Δ is the first difference operator, μ is the constant term, ε_t is i.i.d. $N(0, \sigma^2)$ and p is the lag order of the model. Here, the unit root test corresponds to testing of the null hypothesis of a unit root (H_0: $\lambda = 0$) against stationarity (H_0: $\lambda < 0$). The nonrejection of the null hypothesis of a unit root implies that GDP has a stochastic trend then any shock has a permanent effect until the next shock occurs. That is, shocks to the GDP cannot be considered as transitory and GDP is likely to exhibit a non-mean reverting process.

For the ADF test, the optimal lag length is chosen based on general to specific approach to ensure that the residuals of the unit root regression are white noise in the ADF test. We find that 4 lags are sufficient to render residuals white noise in the ADF test. The ADF test statistic is −0.199, which is greater than McKinnon critical values, and thus we cannot reject the null hypothesis of a unit root. The ADF test results suggest that output series is an I(1) process and any shocks to output are persistent and thereby output series does not have mean reverting properties. However, the ADF unit root test has low power in distinguishing between an I(1) and I(0) process when the true data generating process of the underlying series has structural breaks and regime shifts.

In this study, observing that the underlying output series embodies regime shifts, we investigate the issue of non-stationarity of output series by applying the following MSADF regression:

$$\Delta y_t = \mu(s_t) + \lambda(s_t) y_{t-1} + \sum_{j=1}^{p} \beta(s_t) \Delta y_{t-j} + \varepsilon_t, \quad \varepsilon_t \sim N\left(0, \sigma^2(s_t)\right), \tag{2}$$

where, Δy_t is the first difference of the real GDP. s_t is the latent state variable and it indicates the regime which the economy is

1 Several researchers have used MSADF methodology for different variables as real exchange rates (Kanas and Genius, 2005, Kanas, 2006; 2009, Holmes, 2008; 2010, Lee and Yoon, 2013), stock prices (Chen, 2008, Shen and Holmes, 2014), short-term interest rates (Chua and Suardi, 2007), external debt (Takeuchi, 2010), inflation rate (Chen, 2010), current account deficits (Chen, 2011), real GDP (Camacho, 2011), unemployment rate (Cevik and Dibooglu, 2013), international art market prices (Cevik et al., 2013).

Table 2: Parameter estimates of the MSADF regression

Regime 1			Regime 2		
Parameter	Estimate	Standard error	Parameter	Estimate	Standard error
μ_1	0.074	0.019	μ_2	0.146	0.074
λ_1	−0.031	0.010	λ_2	−0.090	0.043
β_{11}	−0.448	0.093	β_{21}	−0.549	0.164
β_{12}	−0.539	0.088	β_{22}	−0.578	0.181
β_{13}	−0.409	0.091	β_{23}	−0.620	0.155
β_{14}	0.375	0.080	β_{24}	0.392	0.198
σ_1	0.009	0.001	σ_2	0.017	0.003
p_{11}	0.917	0.033	p_{22}	0.780	0.101
MSADF test results					
H_0: λ_1=0	−4.087		H_0: λ_2=0	−1.649	
	[0.083]			[0.175]	

Figures in square brackets are simulated P-values. MSADF: Markov switching augmented Dickey Fuller

in at time t. $\mu(s_t)$, $\lambda(s_t)$ and $\beta_1(s_t), \ldots, \beta_p(s_t)$ are regime dependent parameters. ε_t is the innovation process with a regime dependent variance-covariance matrix $\sigma^2(s_t)$. For the MSADF test, the lag length, p, is also chosen based on the general to specific approach and 4 lags are found to be sufficient to ensure that the residuals of the unit root regression are white noise in the ADF test.

Following Hamilton (1989) regime switches are assumed to be directed by a first-order, two state Markov process with the following fixed transition probabilities[2]:

$$\begin{aligned} P[s_t = 1 \mid s_{t-1} = 1] &= p \\ P[s_t = 2 \mid s_{t-1} = 1] &= 1-p \\ P[s_t = 2 \mid s_{t-1} = 2] &= q \\ P[s_t = 1 \mid s_{t-1} = 2] &= 1-q \end{aligned} \tag{3}$$

MSADF regression methodology allows the variance of the output series to switch across regimes following a first-order Markov chain. Moreover, the autoregressive parameters in the ADF regression are also allowed to change as the regimes shift, and hence they are regime dependent. The advantage of this model is that no a priori assumption regarding the (non) stationarity of either regime is required. More specifically, this model allows both regimes to be locally stationary or one to be locally stationary and the other locally nonstationary.

MSADF regression in Equation (2) is estimated using the maximum likelihood procedure[3]. In this framework, we test the unit root in each regime based on the t-tests of the null hypotheses $\lambda_1 = 0$ and $\lambda_2 = 0$ against the respective one-sided alternatives $\lambda_1 < 0$ and $\lambda_2 < 0$. However, as the distribution under the null hypothesis is unknown in MSADF model, we perform Monte Carlo simulations to obtain the P-values of the t-tests of the null hypotheses against the respective one-sided alternatives. To do so, in the first step we estimate regression (2) under the null $\lambda_i = 0$ for $i = 1, 2$. Second, we generate a sample of size equal to the data series that follows the estimated data generating process in the first step[4]. In the third step, we fit regression in Equation (2) to each realization of the sample and obtain the two t-statistics for the parameter λ, one for the first regime and the other for the second regime. We next repeat the second step and the third step 10 000 times and store the two series of t-statistics. In the final step, we calculate the resulting P-values by expressing the percentage of the generated t-ratios that are below the t-values from the estimated model under the alternative hypothesis (Chua and Suardi, 2007).

3. EMPIRICAL RESULTS

We now focus on the empirical evidence from the maximum likelihood estimation of the parameters of the MSADF regression described in Equation (2). The upper panel of Table 2 reports the estimates of the parameters of the MSADF regression and the related standard errors.

$$\Delta y_t = \mu(s_t) + \lambda(s_t) y_{t-1} + \sum_{j=1}^{p} \beta(s_t) \Delta y_{t-j} + \varepsilon_t, \quad \varepsilon_t \sim N\left(0, \sigma^2(s_t)\right),$$

The estimates of the transition probabilities p_{11} and p_{22} are 0.917 and 0.780, respectively, which implies the presence of strong persistence of both regimes. However, Regime 1 is more persistent than Regime 2. In particular, given the transition probabilities, the mean duration of Regime 1 and Regime 2 are 12 quarters and 5 quarters respectively[5].

The lower panel of Table 2 presents the simulated t-statistics and corresponding simulated P-values. The P-value of the test statistic rejects the null of nonstationarity in Regime 1 while the P-value of the test statistic fails to reject the null of nonstationarity in Regime 2. This result suggests that output series has mean-reverting properties only in Regime 1. By contrast, the null hypothesis of unit root cannot be rejected in Regime 2. That is, any shock to output has a permanent effect until the next shock

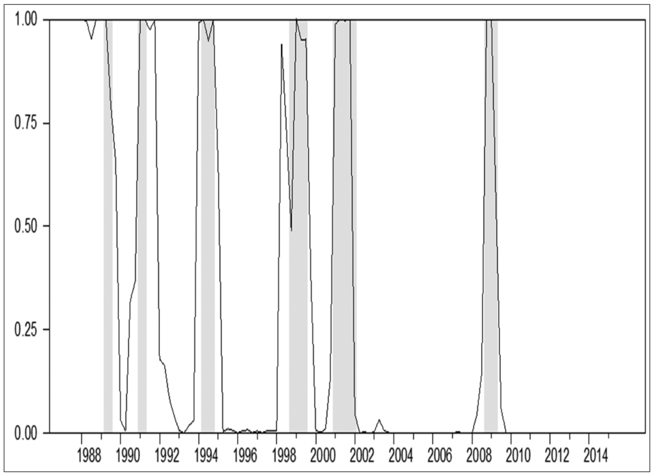
2 For instance, if the economy is in the first state in the previous period ($s_{t-1} = 1$), p is the probability of switching to the first state in the present period ($s_t = 1$).

3 See Hamilton (1994) for details of the estimation procedure.

4 The estimated transition probabilities in the first step are used while generating the artificial data.

5 The average duration of each regime i is calculated using the formula $1/(1-p_{ii})$ where p_{ii} is the probability of the transition from regime i to regime i.

Figure 1: Smoothed probabilities of Regime 2 (nonstationary regime)



occurs and output series does not have mean-reverting properties in Regime 2.

We then plot the estimated smoothed probabilities for Regime 2 in Figure 1. The shaded areas in Figure 1 are the recession periods for Turkey determined by Altug and Bildirici (2010). We see that during the sample period being analyzed, the Turkish economy experienced six recessionary episodes. When we can compare the estimated smoothed probabilities of Regime 2 (nonstationary regime) that we infer from the Markov regime switching model with the recession dates provided by Altug and Bildirici (2010) we observe a match. Put simply, the estimated smoothed probabilities of Regime 2 in Figure 1 clearly correspond to the dates of Turkish recessions. Hence Regime 2 can be identified as recession regime and Regime 1 can be identified as expansion regime. This is an interesting finding which implies that Turkish output series are mean reverting in the expansion regime but nonstationary in the recession regime. Thus, shocks to output series are highly persistent in the recession regime while they are transitory and they have finite lives in the expansion regime.

4. CONCLUSION

In this paper, we examine the stationarity properties of the Turkish output series for the period between 1987:Q1 and 2015:Q2. In doing so, we account for the regime shifts in the output series by implementing a Markov regime switching unit root test. Given the results of the Hansen test which suggests that output series exhibits regime shifts, we argue that MSADF regression is more appropriate to test the stationarity dynamics of the Turkish output level.

Our findings show that the output series has mean reverting properties only in Regime 1, while the null hypothesis of unit root cannot be rejected in Regime 2. Furthermore, we observe a match between the implied dates for Regime 2 that we infer from the MSADF regression with the dates of the recessions in the Turkish economy. This is an interesting finding and has not been shown in the existing empirical literature: Turkish output series are mean reverting in the expansion regime (Regime 1) but nonstationary in the recession regime (Regime 2). Hence, shocks to output series are quite persistent in the recession regime while they are transitory and they have finite lives in the expansion regime. Although the standard unit root test which does not take account of the structural breaks and regime shifts in the output series cannot reject the null hypothesis of a unit root, we find a regime-dependent nonstationarity in the output level by using MSADF unit root test. One should therefore be cautious before using the standard tests which do not allow regime shifts when examining and discussing the stationarity properties of series which has regime shifts and embedded nonlinearities. Moreover, from a policy standpoint, the existence of a unit root in the recession regime indicates that any shock has a permanent effect in this regime until the next shock and thereby to go out of the recession there is a need for a policy action in this regime.

REFERENCES

Altug, S., Bildirici, M. (2010), Business Cycles around the Globe: A Regime-Switching Approach. CEPR Discussion Papers, No. 7968.

Asea, P.K., Blomberg, B. (1998), Lending cycles. Journal of Econometrics, 83(1), 89-128.

Cai, J. (1994), A markov model of switching-regime ARCH. Journal of Business & Economic Statistics, 12(3), 309-316.

Camacho, M. (2011), Markov-switching models and the unit root hypothesis in real US GDP. Economics Letters, 112(2), 161-164.

Cevik, E.I., Atukeren, E., Korkmaz, T. (2013), Nonlinearity and nonstationarity in international art market prices: Evidence from markov-switching ADF unit root tests. Empirical Economics, 45(2), 675-695.

Cevik, E.I., Dibooglu, S. (2013), Persistence and non-linearity in US unemployment: A regime-switching approach. Economic Systems, 37(1), 61-68.

Chen, S.W. (2008), Non-stationarity and non-linearity in the stock prices: Evidence from the OECD countries. Economics Bulletin, 3(11), 1-11.

Chen, S.W. (2010), Regime non-stationarity and non-linearity in inflation rates: Evidence from OECD countries. International Research Journal of Finance and Economics, 463, 47-57.

Chen, S.W. (2011), Current account deficits and sustainability: Evidence from the OECD countries. Economic Modelling, 28(4), 1455-1464.

Chua, C.L., Suardi, S. (2007), Markov-switching mean reversion in short-term interest rates: Evidence from East Asian Economies. Economic Record, 83(263), 383-397.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a), 427-431.

Ehrmann, M., Ellison, M., Valla, N. (2003), Regime-dependent impulse response functions in a Markov-switching vector autoregression model. Economics Letters, 78(3), 295-299.

Gray, S. (1996), Modeling the conditional distribution of interest rates as a regime-switching process. Journal of Financial Economics, 42(1), 27-62.

Hall, S.G., Psaradakis, Z., Sola, M. (1999), Detecting periodically collapsing bubbles: A Markov-switching unit root test. Journal of Applied Econometrics, 14(2), 143-154.

Hamilton, J.D. (1989), A new approach to the economic analysis of nonstationary time series and the business cycle. Econometrica: Journal of the Econometric Society, 57(2), 357-384.

Hamilton, J.D., (1994), Time Series Analysis. Princeton, NJ: Princeton University Press.

Hamilton, J.D., Susmel, R. (1994), Autoregressive conditional heteroscedasticity and changes in regime. Journal of Econometrics, 64(1), 307-333.

Hansen, B.E. (1992), The likelihood ratio test under nonstandard conditions: Testing the Markov switching model of GNP. Journal of Applied Econometrics, 7(S1), 61-82.

Hansen, B.E. (1996), Erratum: The likelihood ratio test under nonstandard conditions: Testing the Markov switching model of GNP. Journal of Applied Econometrics, 11(2), 195-198.

Holmes, M.J. (2008), Real exchange stationarity in latin America and relative purchasing power parity: Regime switching approach. Open Economics Review, 19(2), 261-275.

Holmes, M.J. (2010), Are Asia-Pacific real exchange rates stationary? A regime-switching perspective. Pacific Economic Review, 15(2), 189-203.

Kanas, A. (2006), Purchasing power parity and Markov regime switching. Journal of Money, Credit, and Banking, 38, 1669-1687.

Kanas, A. (2009), Real exchange rate, stationarity, and economic fundamentals. Journal of Economics and Finance, 33(4), 393-409.

Kanas, A., Genius, M. (2005), Regime (non)stationarity in the US/UK real exchange rate. Economics Letters, 87(3), 407-413.

Krolzig, H. (1997), Markov-Switching Vector Autoregressions: Modelling, Statistical Inference, and Application to Business Cycle Analysis. Berlin: Springer.

Lee, H.T., Yoon, G. (2013), Does purchasing power parity hold sometimes? Regime switching in real exchange rates. Applied Economics, 45(16), 2279-2294.

Lee, J., Strazicich, M.C. (2003), Minimum lagrange multiplier unit root test with two structural breaks. The Review of Economics and Statistics, 85(4), 1082-1089.

Lumsdaine, R.L., Papell, D.H. (1997), Multiple trend breaks and the unit root hypothesis. The Review of Economics and Statistics, 79(2), 212-218.

Perron, P. (1989), The great crash, the oil price shock, and the unit root hypothesis. Econometrica, 57, 1361-1401.

Shen, X., Holmes, M.J. (2014), Do Asia-Pacific stock prices follow a random walk? A regime-switching perspective. Applied Economics Letters, 21(3), 189-195.

Takeuchi, F. (2010), US external debt sustainability revisited: Bayesian analysis of extended Markov switching unit root test. Japan and the World Economy, 22(2), 98-106.

Warne, A. (2000), Causality and Regime Inference in a Markov Switching VAR. Working Paper Series, 118, Sveriges Riksbank, (Central Bank of Sweden).

Zivot, E., Andrews, D.W.K. (1992), Further Evidence on the Great Crash, the Oil-Price Shock and the Unit Root Hypothesis. Journal of Business and Economic Statistics, 10(3), 251-270.