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Persistency of Output Fluctuations: The Case of Turkey

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Abstract

According to the conventional view, fluctuations in real gross national product (GNP) represent temporary changes of economic output from its long-term trend that treats real GNP as a trend stationary rather than unit root process. Examination of this conventional view is crucial since the properties of the fluctuations has an important role in estimation, forecasting and consequently for the evaluation of the economic relationships. The aim of this study is to investigate the persistency of output fluctuations in Turkey. For this purpose two widely used methods are applied. One of them uses parametric approach for measuring the persistency and the other uses non-parametric approach. Results of these two approaches show that fluctuations of output are not transitory completely as it was presumed by conventional macroeconomic view.

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1. Introduction

Economic growth is one of the key macroeconomic variables that measures the robustness and prosperity of the economy. For this reason, the issue of economic growth has long been a central concern of nations. There are many theories and studies concerning characteristics, sources and the pattern of the economic growth. In macroeconomics, it is common to decompose economic output, which is measured by real gross national product (GNP) into secular and cyclical components. According to the conventional view, fluctuations in real gross national product (GNP) that is to say cyclical component represents temporary changes of output from its long-term trend that treats real GNP as a trend stationary rather than unit root process. Treating fluctuations in real GNP as stationary implies any long run or permanent movement is necessarily attributed to the secular component. In other words, any shock to the economy has transitory effect on output and the level of the real GNP will revert to its trend in a short period. On the other hand, when the real GNP is assumed to have a unit root, the effect of a shock have a permanent effect which leads the level of real GNP to diverge from its long run trend. As it can be recognized, examination of this conventional view is important not only for econometricians but also for the economists and the policy makers. Knowing the persistency of the fluctuations enables to obtain more precise statistical results that lead more precise evaluation of the economic developments. For post war US data, this conventional view has been examined by many researchers such as (Nelson and Plosser 1982), (Campbell and Mankiw 1987 a, b) and (Cochrane 1988).

Nelson and Plosser used unobserved components approach to estimate the persistence and Campbell and Mankiw used ARIMA model approach. These studies concluded that for the fluctuations in output, it is hard to reject the view that post-war real GNP is persistent as a random walk with drift. However, (Cochrane 1988) argued in his paper that low-order ARMA approach of Campbell and Mankiw and the unobserved components approach of Nelson and Plosser can not match the short-run dynamics and the small random walk component in the long run dynamics at the same time. So they can capture the short-run dynamics and incorrectly imply large random walk component. Hence he proposed non-parametric approach to measure the persistency of the fluctuations and concluded that the random walk component in the US real GNP data is small.

The purpose of this study is to investigate the persistency of output fluctuations in Turkey using both ARIMA and non-parametric approach given by Campbell-

Mankiw and Cochrane respectively. In the first approach, general ARMA models for real GNP growth are estimated. From the parameter estimates, impulse response functions for each model are estimated. Measure of persistence is obtained for the level of real GNP from impulse response functions. As it was mentioned in (Cochrane 1988), ARIMA model approach may incorrectly imply large random walk component and non-parametric persistence estimates can give more precise results. Regarding this warning, in the second approach, non-parametric estimate for the persistence is used and the results of these two estimates are compared.

The organization of this study is such that in the Section 2, approaches for estimating persistence will be discussed. Brief description of the data, results of two approaches and the comparison are given in section 3. In the last section, section IV, conclusion will be presented.

2. Approaches to Estimating Persistence

Before giving details about the estimating procedures, it is notable to give an answer to the question of "Why the properties of the fluctuations are so important?"

If the fluctuations are dominated by temporary deviations from the natural rate, that is to say trend, then a shock to an economy will not affect the forecasts for the long horizon since it is known that transitory fluctuations have trend-reverting property. This means that any deviation from trend will be compensated by opposite effect so that for the long run the level of GNP will follow that particular trend. In this case, real GNP is said to follow trend-stationary process and handling of a trend stationary series statistically requires simple detrending and then applying classical regression techniques. On the other hand, if the fluctuations are dominated by permanent deviations then the effect of the shock to the economy will be persistent, and the forecasts for the long horizon must be revised. In this case real GNP is said to follow unit root process. In this case, for econometric applications series requires special treatment.

Persistence can be thought as the measure of the effect of one unit shock to an economy on the far future forecasts of GNP. If the effect is zero, then this means that the shock has transitory effect and the level of real GNP will revert to its trend in a short period. If the effect is one then this implies that the process is random walk and the shock has permanent effect, which required the revision of the forecasts for the long horizon. Other than these two extremes, the effect can be between 0 and 1 that implies the shock has an effect but not lasts for a long horizon.

From the definitions given for the persistence, it can be recognized why the determination of the properties of the fluctuations are so important both for the econometricians, economists and policy makers.

Two approaches for measuring the persistence of the fluctuations in the literature are gives as follows;

2.1. ARMA Approach

In this approach, change in real GNP is assumed to be represented by a stationary ARMA (p, q) process:

$$\Phi(L)\,\Delta\,Y_t = \Theta(L)\,\varepsilon_t \tag{2.1}$$

where

$$\Phi(L) = \phi_1 L + \phi_2 L^2 + \cdots + \phi_p L^p \quad and \quad \Theta(L) = \theta_1 L + \theta_2 L^2 + \cdots + \theta_q L^q$$

Moving average representation of the differenced real GNP, ΔY_t (known as impulse response function) is given by:

$$\Delta Y_t = \left[\Phi(L)\right]^{-1}\Theta(L)\,\varepsilon_t = A(L).\varepsilon_t \tag{2.2}$$

where $$\mathrm{A}(L) = \sum_{i=*}^{\infty} \varphi_i L^i$$

Moving average representation for the level of real GNP, Y_t, can be obtained by inverting the difference operator,

$$\begin{aligned} (1-L)\,Y_t &= A(L).\varepsilon_t \\ Y_t &= (1-L)^{-1}.A(L).\varepsilon_t = B(L).\varepsilon_t \end{aligned} \tag{2.3}$$

where $B_i = \sum_{j=0}^{i} A_j$, and the value of B_i for large i gives the measure of persistence since it measures the response of Y_{t+i} to an innovation at time t. A_i is given by the following formula,

$A_k = z'.T^k R$ where

$$T = \begin{bmatrix} \phi_1 & & \\ \vdots & I_{m-1} & \\ \phi_{m-1} & & \\ \phi_m & 0 \quad \cdots \quad 0 & \end{bmatrix} \quad and \quad R = \begin{bmatrix} 1 \\ \theta_1 \\ \vdots \\ \theta_{m-1} \end{bmatrix} \quad z = \begin{bmatrix} 1 & 0 & \cdots & 0 \end{bmatrix}$$

$$m = \max(p, q+1)\ \theta_i = 0\ for\ i > q, \phi_i = 0\ for\ i > p$$

The persistence estimate can be obtained by replacing the AR and MA coefficients by their sample estimates, $\hat{\phi}_i$ *and* $\hat{\theta}_i$.

2.2. Nonparametric Approach

The idea of this approach is to measure the size of a random walk component in GNP by the use of variances of the long differences. This idea comes from the fact that if the process, y_t, is purely random walk then the variance of its k-differences grows linearly with k, i.e. $var(y_t - y_{t-k}) = k.\sigma_\varepsilon^2$. On the other hand, if y_t is trend stationary, then $var(y_t - y_{t-k})$ approaches to a constant (two times the unconditional variance of y_t, $2.\sigma_y^2$). By using this idea, Cochrane proposed nonparametric measure of persistence. This measure can be written either as the ratio of variances or as a function of autocorrelations:

$$\frac{1}{k+1}\frac{Var(Y_{t+k+1} - Y_t)}{Var(Y_{t+1} - Y_t)} \equiv 1 + 2\sum_{j=1}^{k}(1 - \frac{j}{(k+1)}).\rho_j \qquad (2.4)$$

where ρ_j is the j th autocorrelation of ΔY_t.

If this ratio is zero then the series is trend stationary, which implies the fluctuations are transitory. If the ratio is one, this means that the series is random walk and the fluctuations are permanent. Other then these two cases, if the ratio settles down to a particular constant between zero and one, then this implies that the fluctuations are partly permanent and partly transitory. Hence, nonparametric persistence measure can be considered as the size of random walk component in the series.

The persistence measure,V, can be estimated either by replacing the population autocorrelation ρ_j in equation (2.4) by its sample counterpart, $\hat{\rho}_j$ or by estimating

the variances in equation (2.4). In this study, second way of estimation is used, so that the persistence estimator is:

$$\hat{V}^k \equiv 1 + 2.\sum_{j=1}^{k} (1 - \frac{j}{k+1}).\hat{\rho}_j \qquad (2.5)$$

The choice of k, the number of autocorrelations to include, is important. Including too few autocorrelation may omit the trend reverting behaviour of the process in higher autocorrelations. However, including too many autocorrelations may tend to find excessive trend reversion since as k approaches to sample size, the estimator approaches to zero. Hence, there is a trade-off between bias and efficiency in selecting k. From previous Monte Carlo studies conducted by Cochrane and Campbell and Mankiw, they suggest that k=30 was large enough to identify the random walk from stationary components. Also, one can recognise that, it is also possible to compute nonparametrically an approximate estimate of A(1),

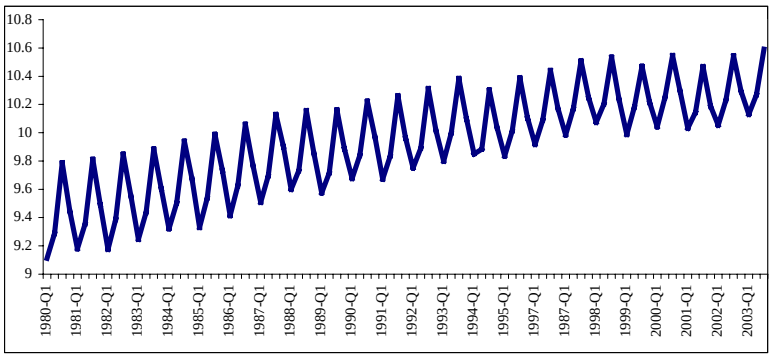
$$\hat{A}^k \equiv \sqrt{\hat{V}^k / (1 - \hat{\rho}_1^2)} \qquad (2.6)$$

As it can be seen from the above equation, the square root of nonparametric persistence measure is a lower bound for the ARMA approach persistence measure. The more highly predictable is the difference series, i.e. higher $\hat{R}^2 = (1 - \hat{\rho}_1^2)$, the greater is the difference between the two approaches.

3. Empirical Results

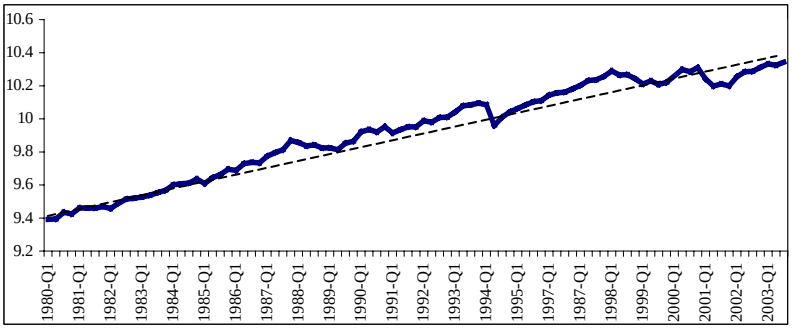
In this study, seasonally adjusted, quarterly real GNP data from 1980:Q1 to 2003:Q3 are used. Figure 1 displays the logarithm of the real GNP data and as it is expected data display highly seasonal pattern. Seasonal peaks occur at the third quarter of the year in real GNP.

Fig. 1. Logarithm of Real GNP (1987=100)
(Q1, 1980 – Q3, 2003)



Since the aim is to investigate the properties of the fluctuations from its long-term trend, seasonally adjusted data is used. Seasonal adjustment is carried out with TRAMO-SEATS. Figure 2 presents the seasonally adjusted log of real GNP data, which will be referred as GNP from now on. It can be observed from the plot that GNP exhibits two types of fluctuations. One of them is the upward trend and the other oscillations around this upward trend.

Fig. 2. Seasonally Adjusted Logarithm of Real GNP (1987=100)
(Q1, 1980 – Q3, 2003)



It seems that GNP is not stationary either due to linear trend or unit root. In order to conclude whether real GNP is trend stationary or unit root process, more elaborate investigation required. Instead of using tests for unit root process, such as Dickey Fuller test, Augmented Dickey Fuller test, persistency of fluctuations will be investigated. Two approaches for the measure of persistence are used in this study, ARIMA based and nonparametric approaches.

3.1. ARMA Approach Results

The ARMA processes for the differenced series are estimated and the impulse response functions for the level of the real GNP,(B_i), are calculated as mentioned in Section 2. ARMA models up to 3 AR and 3 MA orders are considered. As a result, there are 15 equations to consider. Since the goal is not selecting particular ARMA process that describes the real GNP data but to see the persistence of the fluctuations, the behaviour of the fluctuations for 15 models will be investigated separately. ARMA model estimations are carried out in Eviews, in which non-linear least square is used as an estimation technique. Table 1 shows the estimation results for 15 models.

Table 1
Parameter Estimates of the ARMA Model

	ϕ_1	ϕ_2	ϕ_3	θ_1	θ_2	θ_3
ARMA(0,1)				-0.07		
ARMA(0,2)				-0.07	0.22	
ARMA(0,3)				-0.08	0.22	-0.01
ARMA(1,0)	-0.08					
ARMA(1,1)	-0.71			0.72		
ARMA(1,2)	0.01			-0.08	0.22	
ARMA(1,3)	-0.63			0.65	0.22	0.28
ARMA(2,0)	-0.07	0.05				
ARMA(2,1)	-0.75	-0.11		0.70		
ARMA(2,2)**	-0.38	-0.76		0.31	0.97	
ARMA(2,3)**	-0.58	-0.67		0.57	0.92	0.21
ARMA(3,0)	-0.06	0.05	0.03			
ARMA(3,1)	-0.63	0.02	0.16	0.59		
ARMA(3,2)**	-0.34	-0.62	0.08	0.29	0.88	
ARMA(3,3)**	-1.08	-0.86	-0.36	1.06	1.06	0.65

** Highest AIC and SIC value together with jointly significant coefficients.

From the estimation results it can be argued that higher order ARMA models have higher capability in capturing the properties of GNP growth. Since, ARMA(2,2), ARMA(2,3), ARMA(3,2) and ARMA(3,3) have the highest Akaike and Schwartz information criteria together with jointly significant coefficients. As it was mentioned before, the aim is not selecting a particular model for real GNP, I will continue analysis by considering all the estimated models. However, interpretation of the persistency will mainly be based on those four significant models. Table 2 gives the calculated impulse responses of logarithm of real GNP for different time horizon, k.

Table 2
Estimated Impulse Responses for the Logarithm of the Real GNP

	k								
	1	**2**	**4**	**8**	**16**	**20**	**25**	**30**	**40**
ARMA(0,1)	0.932	0.932	0.932	0.932	0.932	0.932	0.932	0.932	0.932
ARMA(0,2)	0.930	1.150	1.150	1.150	1.150	1.150	1.150	1.150	1.150
ARMA(0,3)	0.924	1.144	1.136	1.136	1.136	1.136	1.136	1.136	1.136
ARMA(1,0)	0.925	0.930	0.930	0.930	0.930	0.930	0.930	0.930	0.930
ARMA(1,1)	1.018	1.005	1.008	1.010	1.011	1.011	1.011	1.011	1.011
ARMA(1,2)	0.930	1.152	1.154	1.154	1.133	1.133	1.133	1.133	1.133
ARMA(1,3)	1.025	1.231	1.287	1.318	1.290	1.290	1.290	1.290	1.290
ARMA(2,0)	0.931	0.987	0.983	0.982	1.021	1.021	1.021	1.021	1.021
ARMA(2,1)	0.944	0.881	0.901	0.912	0.913	0.913	0.913	0.913	0.913
ARMA(2,2)**	0.925	1.158	0.961	1.007	1.074	1.073	1.055	1.055	1.055
ARMA(2,3)**	0.982	1.243	1.095	1.276	1.277	1.277	1.277	1.277	1.277
ARMA(3,0)	0.938	0.993	1.020	1.098	1.098	1.098	1.098	1.098	1.098
ARMA(3,1)	0.958	1.003	1.045	1.100	1.097	1.097	1.097	1.097	1.097
ARMA(3,2)**	0.949	1.226	1.060	1.114	1.160	1.546	1.566	1.566	1.566
ARMA(3,3)**	0.981	1.199	1.012	1.179	1.148	1.148	1.148	1.148	1.148

** Denotes those models that have the highest AIC and SIC values and jointly significant coefficients.

Supposing that the real GNP increases 1 percent, how much should the forecasts of the real GNP for k quarters change? According to the table above, a shock to an economy has persistence effect since the impulse responses do not die out as k increases. For all of the above models, the impulse responses settle down to a fixed value that is different than zero as k increases. In addition to the persistence of the fluctuations, generally, the impulse responses are above 1 percent. This means that 1 percent change in real GNP, causes the level of GNP to change more than 1 percent for the far future. However, as Cochrane argued, one must be aware the

small sample properties of ARIMA estimation. Hence, nonparametric estimation of the persistence can give deeper insight about the persistence of the fluctuations.

3.2. Nonparametric Approach Results

Equation (2.4) suggest that one can estimate the persistence measure by replacing population autocorrelations with sample autocorrelations. So, in order to calculate the nonparametric persistence measure, one should estimate the sample autocorrelations for real GNP first. Then by using equation (5), $\hat{V}^k$, can be estimated. In table 3, the nonparametric persistence estimate for real GNP is given.

Table 3
Nonparametric Estimates of Persistence of Real GNP

Window Size *(k)*	**Estimate of V** $\hat{V}^k$	**Estimate of A(1)** $\hat{A}^k(1)$
5	0.708	0.844
10	0.484	0.697
20	0.363	0.604
30	0.349	0.593
40	0.380	0.618
50	0.399	0.633

The nonparametric persistence estimates are below unity at 0.484,for k=10, but for increasing k, it does not converge to zero. It settles down around 0.38 even for k=50 which is an indication of persistence fluctuations. As it is expected, nonparametric estimate of the persistence found to be smaller, but still different than zero which implies the persistency of the flactuations. In ARMA approach it is found that the persistence is above 1 whereas in nonparametric approach, it is found to be around 0.38. So this difference in the size of the random walk component may arise due to the fact that low order ARMA models systematically overestimate the random walk component of GNP, even though they adequately represent the series by all the usual diagnostic tests (Cochrane 1988).

However, although these two approaches give different results for the size of random walk component in the Turkish real GNP data, we can say that the fluctuations are not transitory completely as it was presumed by conventional macroeconomists.

6. Conclusion

One of the main stylized facts about the macroeconomic variables is that economic output exhibits two types of fluctuations. One of them is the upward trend, indicating long-term changes and the other short-term oscillations, representing temporary changes. Threating short-term oscillations around the long run trend as temporary implies the effect of one unit shock to an economy on the far future forecasts of GNP is negligible. However, this stylized fact has been examined by many researchers due to the fact that this issue is important not only just for the statistical purposes but also important for more precise evaluations of the economic developments. In this study, the validity of this presumption was questioned for Turkish economic output using two common approaches in measuring the persistence of the flactuations, ARIMA and non parametric approaches.

In ARIMA approach, standard ARIMA processes were estimated for logarithm of Turkish real GNP using quarterly seasonally adjusted time series and the impulse response functions were used as the measure of persistence. However, results obtained from this approach should be interpreted with caution since, it is known that small samples and low-order ARMA estimates may incorrectly imply large random walk components. Hence to be more precise, nonparametric approach that was proposed by Cochrane was also used. Since the nonparametric persistence measure is given by the ratio of the variance of the shocks to the random walk component. If the ratio is zero then fluctuations are said to be transitory, if the ratio is one, the fluctuations are said to be permanent. In between these two cases, if the ratio settles down to a particular constant between zero and one, then this implies that the fluctuations are partly permanent and partly transitory.

From the application of the ARMA approach revealed that the fluctuations are highly persistent since for most of the models the persistence measure settles down to a number that is above 1. This implies that one should change the forecast of the GNP by more than 1 unit when one unit shock hits the economy, that is to say the effect of one unit shock to the economy has an impact that is greater than one in the economic output. Although, in ARMA approach it has been found highly persistence structure, non parametric approach result was more modarate about the persistence measure. For Turkish quarterly real GNP data, nonparametric approach finds the persistence estimate to settle down to 0.380, which is between zero and one. This characterises the series that returns toward a “trend” in the far future, but

does not get all the way there. As a result, although these two approaches give different results for the size of random walk component in the Turkish real GNP data, we can conclude that the fluctuations are not transitory completely as it was presumed by conventional macroeconomists.

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