Business Cycle Asymmetry: Deepness and Steepness in Turkey

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The purpose of this study is to examine "steepness" and "deepness" asymmetry in The Turkish business cycle. The study explains the concept and the kind of business cycle asymmetry and examines the kind of the asymmetry by using quarterly real GDP, industrial production, and manufacturing production in Turkey for the period of 1987:I-2014:I. The presence of seasonal component was determined by Kruskal-Wallis test and decomposed with X12-ARIMA method. Then skewness test that consists of steepness and deepness tests of Sichel (1993) was applied to cycle components. The significance level of the skewness statistics was investigated by using Newey-West (1987) method. According to Newey-West results, the presence of deepness asymmetry was accepted for real GDP, industrial production and manufacturing production in all the kernels options. The presence of steepness asymmetry was also accepted for all the variables.

Keywords: Business Cycle Asymmetry, Steepness and Deepness Asymmetry, Skewness Test, Kruskal-Wallis Test, Newey-West Standard Error
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1. Introduction

Business cycle asymmetry is the fact that the economy behaves differently over the contraction and expansion phases of the business cycle. Theoretically, there are many economic reasons why cycle asymmetries might occur in various macroeconomic variables. Aggregate demand and supply shocks which occur at each stage of the cycle might be different in terms of the size and length of their effects on the economy. In other words, the propagation mechanism might be different over the cycle. Alternatively, the economy might react differently to positive and negative shocks as suggested in Cover (1992), Kandil (1996), Karras and Stokes (1999), Tanrıover and Yamak (2012). The studies of Mitchell (1927) and Keynes (1936) note that although contractions are shorter than expansions, they are more sudden and violent, hence, asymmetric.

Business cycle asymmetry has been increasingly interested in theoretical and empirical macroeconomics since the early works of Keynes (1936) and Burns and Mitchell (1946). Although the theoretical view that macroeconomic variables behave asymmetrically over time has a long history, there was no motivation to investigate business cycle asymmetry until the studies of Neftçi (1984) and DeLong and Summers (1986). The analysis of asymmetric behaviors of the main macroeconomic variables has been heavily developed in the empirical macroeconomic literature over the past 20 years. In order to measure the degree of the asymmetric behaviors of the macroeconomic variables, Neftci (1984) developed his method which is based on the statistical theory of finite-state Markov processes. According to Neftci's approach, a series is symmetric if the transition probability of positive first difference is the same as the transition probability of negative first difference. DeLong and Summers (1986) applied a statistical test which is based on the one-dimensional skewness statistic for GNP, industrial production, and unemployment rate of the six OECD countries[3]. According to the test, business cycle is symmetric if the coefficient of skewness of the output growth rate, which is defined as the ratio of the third moment to the cube of the standard deviation, is zero and the mean of growth rate equals its median. DeLong and Summers (1986) found no evidence for the presence of the asymmetric behavior in the GNP and industrial production. They concluded that "asymmetry is probably not a phenomenon of first-order importance in understanding business cycles".

Recently, Sichel (1993) expanded DeLong and Summers's (1986) methodology by improving the estimation of the standard deviation of the third moment of the stationary component of the real variables. Sichel (1993) described two types of business cycle asymmetry that are deepness and steepness. *Deepness asymmetry* that is also called as transversal asymmetry implies that troughs are deeper than peaks. *Steepness asymmetry* that is referred as longitudinal asymmetry, on the other hand, exists when contractions are steeper and shorter-lived than expansions. Deepness asymmetry pertains to relative *levels* of cycle component while steepness asymmetry pertains to relative *slopes* of cycle component.

The number of papers on the subject of business cycle asymmetry has tremendously increased after the studies of Neftci (1984), DeLong and Summers (1986) and Sichel (1989; 1993)[4]. The existence of business cycle asymmetry is important because of a number of reasons. The most important reason is related to the asymmetric behaviors in the consumer and investor expectations. Consumers and investors can respond differently to changes in their incomes and expenditures,

[3] U.S., Japan, Canada, West Germany, U.K., and France.

[4] Some of papers on the subject of business cycle asymmetry are McQueen and Thorley (1993), and Ramsey and Rothman (1996), Acemoglu and Scott (1997), Razzak (2001), Kontolemis (2001), Bodman (2001), Knuppel (2004), Sinclair (2009), Yamak and Tanriover (2012) and Morley and Piger (2012).

respectively. For example a consumer whose income decreases does not reduce consumer expenditure suddenly because of standard of living, but a consumer whose income increases raises consumer expenditure immediately. Similarly, for the firms, exit and entry to an industry do not produce the same costs.
For these reasons, policy makers usually recommend to use expansionary aggregate demand or supply policies immediately when real output decreases, but to use contractionary demand and supply policies slowly when real output increases. The purpose of this study is to determine whether the behaviors of some main macroeconomic variables of Turkish economy are asymmetric. Another purpose is to confirm what kind of asymmetric movements in business cycle if the asymmetric movements exist.

2. Empirical Methodology and Data

In this paper, skewness test which depends on deepness and steepness statistics of Sichel (1993) was employed to test for the presence of business cycle asymmetry. For real macroeconomic variables which have secular growth, skewness test is applied to the detrended or the cyclical components of the variables. For this reason the time series under consideration must be removed from its seasonal component and trend.

2.1.Seasonal Adjustment

Seasonal adjustment is a statistical method for removing the seasonal component of the time series. This method allows us to determine long-term movements in macroeconomic variables by removing the short term seasonal fluctuations. In traditional time series analysis, sub-annual time series has trend, cyclical, seasonal, and irregular component.
Considering a time series y_t:

$$y_t = \tau_t + c_t + s_t + \xi_t \quad (1)$$

where τ_t is the nonstationary trend component, c_t is the stationary cyclical component, s_t is the seasonal component, and ξ_t is the irregular component. After determining all components of the series under consideration, skewness test is applied only to the stationary cyclical component of the series, c_t.

Seasonal component of any time series can be observed and measured by drawing the graph of the series. But, it will be difficult and subjective to prove the presence of a significant seasonal component of the series. Alternatively, Kruskal-Wallis one-way analysis of variance test can be easily and clearly used to detect the possible seasonal components of the series. Kruskal-Wallis test is a nonparametric method for testing equality of population medians among groups. The test does assume an identically-shaped and scaled distribution for each group of the study period in between day of the week, week of the month and month of the year. Kruskal-Wallis test essentially determines whether the sums of the means are different from each other. The null and alternative hypotheses of Kruskal-Wallis test are as follows:

$$H_0 : S_{quarter}^{first} = S_{quarter}^{second} = S_{quarter}^{third} = S_{quarter}^{fourth} = 0 \qquad (2)$$

$$H_1 : S_{quarter}^{first} \neq S_{quarter}^{second} \neq S_{quarter}^{third} \neq S_{quarter}^{fourth} \neq 0$$

These hypotheses can be tested by computing the following H-statistic:

$$H = \frac{12}{N(N+1)} \sum \frac{R_i^2}{n_i} - 3(n+1) \qquad (3)$$

where N is the total number of rankings, R_i is the sum of the ranking in $i.$ season, and n_i is the number of ranking in $i.$ season. Kruskal-Wallis test statistic, H follows a chi-square distribution with $G-1$ degrees of freedom (Sheskin:199, p.218). If null hypothesis of

Kruskal-Wallis test is rejected, the series includes stable seasonal component. Once the stable and significant seasonal component is found in the series, then that component must be removed from the series. There are various methods in the literature to remove the seasonal component from the time series. In this study, X12-ARIMA method which is called RegARIMA seasonal adjustment method was applied to the series. This method can also detect and correct for different types of outlier and estimate a calendar component.

2.2. Detrending

As known, trend is a long term change in the mean of the series. Detrending is a statistical and mathematical method for removing trend from the time series. High-frequency data are decomposed into trend, cyclical, and irregular component.

Considering a time series y_t:

$$y_t = \tau_t + c_t + \xi_t \qquad (4)$$

where τ_t is the nonstationary trend component, c_t is the stationary cyclical component, and ξ_t is the irregular component which is $NID(0, \sigma_\xi^2)$. Skewness test is applied only to stationary cyclical component of the time series, c_t.

The time series can be contain a stochastic trend (Nelson and Plosser, 1982) or deterministic trend with possible structural breaks (Perron, 1989). For this reason, it is necessary to detrend series containing a stochastic or deterministic trend. Many alternative methods are available for detrending the series. The methods can be classified as simple linear detrending, first-differencing, the Hodrick-Prescott (1980) filter and Beveridge-Nelson (1981) decomposition. Among them, Hodrick-Prescott (HP) filter has various features and advantages. In particular, the HP filter will not induce spurious asymmetry in the derived cyclical components because of its linear structure. For this reason, in this study HP filter was employed to measure τ_t.

$$\min \sum_{t=1}^{T} \left\{ (y_t - \tau_t)^2 + \lambda \left[(1-L)^2 \tau \right]^2 \right\} \qquad (5)$$

where L is the log operator, T is the sample size, and λ is smoothing parameter reflecting the ratio of the variance of c_t to the variance of τ_t. The extreme values as $\lambda = 0$ and $\lambda = \infty$ leads to the HP trend equaling the original series and a linear trend, respectively. The value of λ is 100 for annual data, 1600 for quarterly data, and 14400 for monthly data.

2.3. Deepness and Steepness Tests

Skewness test can be used to test whether the distribution of the stationary cyclical component, c_t is asymmetric. According to Sichel (1993), if the stationary cyclical component has negative skewness about nonstationary trend, then the asymmetric behavior in terms of deepness exists in the series. Deepness statistic is computed by using the coefficient of skewness for the stationary cyclical component as follows.

$$D(c) = \frac{T^{-1} \sum_{t=1}^{T} (c_t - \bar{c})^3}{\sigma(c)^3} \qquad (6)$$

where $\bar{c}$ is the mean of c_t, $\sigma(c)$ is the standard deviation of c_t, and T is the sample size. In order to test the significance of $D(c)$, the variable z_t^D corresponding to t. observation is constructed as below:

$$z_t^D = \frac{(c_t - \bar{c})^3}{\sigma(c)^3} \qquad (7)$$

Then, z_t^D is regressed on a constant:

$$z_t^D = \beta_0 + u_t \qquad (8)$$

where β_0 is the constant term and u_t is the error term. The significance of the estimated constant denotes the significance of $D(c)$.

The other kind of asymmetry is steepness. If the first difference of the stationary cyclical component exhibits negative skewness, then steepness asymmetry occurs in the series. In presence of steepness asymmetry, contractions are steeper and shorter-lived than expansions. Steepness statistic is computed as below:

$$ST(\Delta c) = \frac{T^{-1}\sum_{t=1}^{T}(\Delta c_t - \overline{\Delta c})^3}{\sigma(\Delta c)^3} \quad (9)$$

where $\overline{\Delta c}$ is the mean of Δc_t, $\sigma(\Delta c)$ is the standard deviation of Δc_t, and T is the sample size. z_t^{ST} is constructed to test the significances of $ST(\Delta c)$ and regressed on a constant as equations (10) and (11):

$$z_t^{ST} = \frac{(\Delta c_t - \overline{\Delta c})^3}{\sigma(\Delta c)^3} \quad (10)$$

$$z_t^{ST} = \alpha_0 + e_t \quad (11)$$

where α_0 is the constant term and e_t is the error term. The significance of the estimated constant in equation (11) is identical to the significance of $ST(\Delta c)$.

The standard error of Newey-West approach is computed to test the significance of the constants in equations (8) and (11) because OLS standard error will be invalid in presence of serial correlation. Newey-West standard error is consistent even in the presence of heteroscedasticity and autocorrelation which are in the unknown forms. For this reason, in this paper Newey-West standard error has been employed to test the significance of the constants in equations (8) and (11).

The purpose of this paper is to examine the presence of business cycle asymmetry in Turkey for the period 1987:I-2014:I by using skewness test containing deepness and steepness tests developed by Sichel (1993). The data used in this study are quarterly and come from real GDP, industrial production and manufacturing production. In addition, all data are in the natural logarithmic form. In order to perform the skewness test, the variables were first decomposed from their seasonal components by applying X12-ARIMA method and then removed from trend by using Hodrick-Prescott (1980) filter.

3. Empirical Results

In this study, the presence of seasonal component in the variables which are real GDP, industrial production and manufacturing production was separately determined by using Kruskal-Wallis one-way analysis of variance test.

Table 1

Kruskal-Wallis One-Way Analysis of Variance

Variables	H-Statistic	df	χ^2	Probability
GDP	100.246	4	9.49	0.000
IP	90.033	2	5.99	0.000
MP	101.644	5	11.07	0.000

Note: GDP, IP and MP represent real gross domestic product, industrial production, and manufacturing production, respectively; df denotes degree of freedom; χ^2 is chi-square statistic.

As seen in Table 1, the calculated value of H-statistic is greater than the critical value for each of three variables. According to H-statistics, there is strong seasonality in real GDP, industrial production and manufacturing production. In this study, X12-ARIMA method was applied to seasonally adjust the time series. Then seasonal adjusted variables were removed from trend by using Hodrick-Prescott (HP) filter. Although HP filter engages the stationarity of the variables, it was also investigated whether the cycle component (c_t) series had unit root. We applied Augmented Dickey-Fuller (ADF) unit root test (1979) to determine whether the cycle component was stationary in its level.

Table 2
ADF Unit Root Test Results for Cycle Component

Variable	With Constant-Without Trend	p	With Constant-Trend	p	Without Constant-Trend	p
$c_{1,t}$	-4.506***	1	-4.484***	1	-4.528***	1
$c_{2,t}$	-4.692***	1	-4.669***	1	-4.715***	1
$c_{3,t}$	-5.015***	1	-4.991***	1	-5.039***	1

Note: $c_{1,t}$, $c_{2,t}$, and $c_{3,t}$ show the stationary cycle components of real GDP, industrial production, and manufacturing production respectively; p denotes optimal lag length determined by Schwarz Information Criterion (SIC) ; *** denotes significance level of 1%. Maximum lag length equals 12.

Table 2 presents the results of ADF unit root test. The calculated t-statistics rejected the presence of the unit root in the cycle components obtained from real GDP, industrial production, and manufacturing production. Thus, skewness test containing deepness and steepness tests of Sichel (1993) can be employed for all of the cycle components.

Equations (8) and (11) were employed to test the presence of deepness and steepness asymmetries under four different kernel options and appropriate bandwidth. The kernels composed of autocovariance are Parzen, Bartlett, and Tukey kernels which are quadratic, declining, and trigonometric respectively. In addition to the kernels, measure of equal weight was also used in this paper. The appropriate bandwidth was determined by degree of the autocorrelation and selected as one third of the sample size. Thus appropriate bandwidth was selected as 36 because sample size was 109. Tables 3 and 4 show the results of the deepness and steepness tests for each of the kernels, respectively.

Table 3

Newey-West Estimating Results for Deepness Asymmetry

Variables	Kernels	Coefficient	Newey-West Standard Error	t-statistic
	Parzen	-0.102	0.005	-20.699***
	Bartlett	-0.102	0.005	-20.600***
$c_{1,t}$	Tukey	-0.102	0.003	-39.788***
	Equal Weight	-0.102	0.007	-14.938***
	Parzen	-0.136	0.009	-14.204***
	Bartlett	-0.136	0.009	-14.711***
$c_{2,t}$	Tukey	-0.136	0.007	-17.573***
	Equal Weight	-0.136	0.010	-13.464***
	Parzen	-0.093	0.005	-20.035***
	Bartlett	-0.093	0.005	-19.346***
$c_{3,t}$	Tukey	-0.093	0.003	-29.462***
	Equal Weight	-0.093	0.006	-20.199***

Note: $c_{1,t}$, $c_{2,t}$, and $c_{3,t}$ show the stationary cycle components of real GDP, industrial production, and manufacturing production, respectively. *** denotes %1 significance level.

Table 4

Newey-West Estimating Results for Steepness Asymmetry

Variables	Kernels	Coefficient	Newey-West	t-statistic

			Standard Error	
$c_{1,t}$	Parzen	-0.143	0.003	-49.949***
	Bartlett	-0.143	0.003	-51.109***
	Tukey	-0.143	0.0009	-150.889***
	Equal Weight	-0.143	0.003	-46.691***
$c_{2,t}$	Parzen	-0.130	0.006	-20.034***
	Bartlett	-0.130	0.005	-23.376***
	Tukey	-0.130	0.005	-27.157***
	Equal Weight	-0.130	0.003	-46.569***
$c_{3,t}$	Parzen	-0.132	0.004	-31.811***
	Bartlett	-0.132	0.003	-40.486***
	Tukey	-0.132	0.002	-57.869***
	Equal Weight	-0.132	0.0006	-205.707***

Note: $c_{1,t}$, $c_{2,t}$, and $c_{3,t}$ show the stationary cycle components of real GDP, industrial production, and manufacturing production, respectively. *** denotes %1 significance level.

According to the results of Newey-West approach, the presence of deepness and steepness asymmetries were separately accepted for real GDP, industrial production, and manufacturing production in all the kernels options. Table 3 indicates that there is strong deepness asymmetry in real GDP, industrial production and manufacturing production. In addition, as seen in Table 4, the presence of steepness asymmetry was not rejected for all of three variables at the %1 level.

4. Conclusions

In this study, the presence of business cycle asymmetry was investigated for the case of Turkey. Data used in this study come from real GDP, industrial production and manufacturing production, and cover the period of 1987-2014. Business cycle asymmetry was defined and analyzed as deepness and steepness. Skewness test consisting of steepness and deepness tests developed by Sichel (1993) was applied to cycle components of all three variables.

The empirical findings of the analysis demonstrate the presence of strong business cycle asymmetry in all the kernels options. Inferences on deepness asymmetry are consistent with those of Mitchell (1927) and Keynes(1936). According to Mitchell (1927) and Keynes (1936), in the business cycles, contractions are shorter than expansions and they are also more sudden and violent than expansions. In other words, business cycles are naturally asymmetric. This view is consistent with the evidence of Turkey. Moreover, real GDP, industrial production and manufacturing production have strong steepness asymmetry in Turkish business cycles. So, contractions in those real variables are steeper and shorter-lived than expansions.

Sichel (1993) describes two types of business cycle asymmetry: deepness and steepness. *Deepness asymmetry* called as transversal asymmetry implies that troughs are deeper than peaks. *Steepness asymmetry* called as longitudinal asymmetry, on the other hand, occurs when contractions are steeper and shorter-lived than expansions. In this type of asymmetry, contractions are steeper and expansions are more gradual. Thus deepness asymmetry pertains to relative *levels* of cycle component while steepness asymmetry pertains to relative *slopes* of cycle component. Shortly, characteristics of the Turkish business cycle can be summarized as follows:

Fluctuations in real GDP, industrial production and manufacturing production are asymmetric.

The asymmetric movements are appropriate to deepness and steepness asymmetry.

Troughs in the real variables are deeper than peaks.

Contractions are more sudden and violent than expansions.

The effects of contractions on economy are transitory.

Contractions are steeper and shorter-lived than expansions.
This final result can answer the questions that how the economic fluctuations in Turkey follow an asymmetric movement and how policy makers develop a macroeconomic policy to this kind of business cycle. Accordingly, Turkish policy makers should not interfere with the economic imbalance during the contraction periods because these periods seem to be short-lived. On the other hand, it is possible to say that policy makers should apply contractionary macroeconomic policies because of the long-term effects of the economic imbalances resulting from expansions.

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