A Different Look at Cointegration Relationship between Quarterly Inflation Rates and Growth via Seasonal Integration Tests

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Abstract

Detecting the direction of inflation-growth relationship has been a controversial issue in terms of the theoretical framework, notedly since the rise of Mundell-Tobin effect which is based upon the assumption of substitutability between money and capital. In this study, it has been aimed to investigate the cointegrating relationship and its direction between inflation and economic growth covering the period 1998Q1:2014Q4 for Turkey as grounded on the testing sequence that is illustrated by Ilmakunnas (1990) in order to handle unit root testing in a seasonal context by testing the appropriate order of differencing and concerns with the case where SI(2,1) (seasonally integrated of order (2,1)) is the maximum order of seasonal integration. It has been also utilized from ADF unit root test and DHF, HEGY & OCSB seasonal unit root tests in seasonal integration analysis. In the study, five cointegration regressions have been considered in the level, seasonally averaged, quarterly differenced, first differenced and twice differenced forms and two series have been found to have the same degree of seasonal integration as SI(1,1). Applying various residual tests have revealed the presence of a cointegrating relationship between two variables. In addition, the inflation-growth relationship in Turkey has been concluded to perform in an opposite direction.

1 Introduction

Inflation is one of the most important facts in our daily life referring to a sustained increase in consumer prices which can be measured through consumer price index (CPI), producer price index (PPI) or gross domestic product (GDP) deflator. Along with economic growth, they take place among the most crucial macroeconomic indicators giving information about the economic structure of a country and analysing the inflation-growth relationship has been a fundamental issue in empirical economic research especially starting from the rise of Mundell-Tobin effect which has been grounded on the assumption of substitutability between money and capital. Besides, the high inflation rates that have been experienced after World War II also gave rise to economists to put more weight on this issue.

The pioneering study by Phillips (1958) can be regarded as the most crucial approach which claimed a positive relationship between inflation and economic growth via Phillips curve analysis and this analysis reveals a negative correlation between inflation and unemployment rate. Thus, high inflation rates and decreased unemployment rates due to high employment relationship will contribute to economic growth in a positive direction. However, later studies have shown that this relationship will be able to be valid in the case of short run and expected inflation (Cetintas, 2003). According to the Mundell-Tobin framework, an increase in the rate of inflation will result in a positive influence on capital accumulation in the long run by creating a shift towards capital in the household portfolios through an increase in the cost of holding money and therefore will also lead to a higher economic growth. Consequently, as expressed by the Tobin (1965), one more time it can be mentioned about a positive relationship between inflation and economic growth (De Gregorio, 1996). The devaluation of the Turkish lira in the year 1970 and the continuous increases in oil prices in the same years increased the cost of imported capital goods and formed the starting point and the basis of the high inflation process. Depending upon increasing inflationary pressures and also due to hampered capital accumulation and technical progress, Turkey faced with a very serious balance of payments crisis in 1978. These developments resulted in a decreasing growth & rapidly increasing inflation and therefore, 1970s can be specified as the years in which inflation is imported from outside (Cetintas, 2003). On the other hand, along with many macroeconomists, Friedman (1977) has suggested that greater inflation uncertainty followed by an increase in inflation may create negative output growth effects coming out through inflation uncertainty that will lessen economic efficiency. When evaluated from this point of view, the sign of the relationship between inflation and economic growth has been frequently a controversial issue with respect to both theoretical framework and application results.

In the literature, although many studies investigating the relationship between inflation and economic growth are separated as linear or nonlinear; no clear picture has been put forward in the empirical studies presented on the relationship between these variables.

Mallik and Chowdhury (2001) have tried to reveal the relationship between inflation and GDP growth for four South Asian countries using Johnsen-Juselius co-integration test and error correction models covering the periods 1974-1997 for Bangladesh; 1961-1997 for India; 1957-1997 for Pakistan and 1966-1997 for Sri Lanka. As a result, findings have shown the presence of a long-run positive relationship between GDP growth rate and inflation.

Wilson (2006) has made a research on the association between inflation, inflation uncertainty and output growth using Japanese CPI and real GDP data for post-war period covering 1957Q4-2002Q3 and carried out a bivariate exponential generalized autoregressive conditional heteroskedasticity in mean (EGARCH-M) model as related to output growth and inflation in the analysis. As a result, the Engle–Granger and Johansen cointegration tests have pointed to the absence of cointegration between the logarithms of the CPI and real GDP in Japan.

Erbaykal and Okuyan (2008) have examined the existence of long-term relationship between the inflation and economic growth covering the period 1987Q1-2006Q2 by using Bound Test developed by Pesaran, Shin & Smith and found a cointegration relationship between two series. However, ARDL models have revealed a negative statistically significant short-run relationship, but no statistically significant long-run relationship between economic growth and inflation series.

In their study, Adrián Risso and Sánchez Carrera (2009) have made an investigation on the long-run relationships and threshold effects between inflation and economic growth for the Mexican Economy using annual data for the period 1970-2007 and found a significant and negative long-run relationship between these variables using Johansen's cointegration approach.

Karacor, Saylan and Ucler (2009) have analysed the relationship between quarterly inflation and economic growth series in Turkey over the period 1990-2005 using Johansen cointegration test. Max eigenvalue and trace statistics have shown that inflation and economic growth are cointegrated at the long-run. Also, inflation has been found to influence economic growth in a negative direction.

Kasidi and Mwakanemela (2013) have examined the relationship between inflation and growth variables through the data covering the period 1990-2011 for Tanzania. They have investigated the impact of inflation on economic growth by modifying the model proposed by Khan and Senhadji (2001) and using reduced form regression equation and found a negative effect of inflation on economic growth. In addition, Johansen cointegration results have revealed the absence of co-integration between inflation and economic growth in Tanzania.

Behera (2014) have tried to reveal the links between inflation and economic growth for seven south Asian countries using panel data analysis covering annual data for the period of 1980-2013 and found a negative association between variables in question. In addition, panel cointegration test proposed by Pedroni (1999) has pointed to the presence of a long-run relationship between inflation and GDP growth.

Epaphra (2016) covers a nonlinear relationship between inflation and economic growth in Tanzania by trying to determine the presence of threshold effects between these series by making use of annual data for the period 1967-2015 based on a quadratic and threshold endogenous models. Johansen cointegration test results have revealed a stable long-run relationship between economic growth, inflation rate, the squared term of inflation rate, total investment-to-GDP ratio, trade-to-GDP ratio, population growth rate and economic reform variables. Also, a negative relationship has been observed between inflation and growth series that are also statistically significant in Tanzania.

Behera and Mishra (2016) have examined the relationship between inflation and economic growth for BRICS countries covering the period 1980-2012 and utilized from Autoregressive Distributed Lag Model (ARDL) bound testing approach to reveal cointegration relationship. According to the Trace and eigen value statistics findings given in Johansen test results, it has been reported that only China and South Africa have experienced a long run (cointegrating) positive relationship between inflation and economic growth at 5% significance level and there has been found no long-run relationship between given variables for the rest of the BRICS countries. On the other hand, ARDL test results have not detected any long-run relationship for BRICS countries.

In her study, Topcu (2017) has aimed to investigate the cointegration and causality relationship between inflation and economic growth over the period 2006Q1-2017Q2 for Turkish economy through Granger causality test. According to the Johansen (1988) cointegration test results, no long-run relationship has been detected between two variables and it has been found a uni-directional causality from economic growth to inflation.

In this study, it has been aimed to investigate the cointegrating relationship between quarterly inflation and economic growth variables covering the period 1998Q1:2014Q4 for Turkey as based on the seasonal integration tests proposed by Ilmakunnas (1990).

The rest of the paper has been structured as follows: Section 2 introduces the theoretical framework regarding seasonal unit roots and seasonal integration testing sequence for quarterly data proposed by Ilmakunnas (1990). Section 3 presents data set used throughout the research and application results. Finally, Section 4 provides a brief summary of general conclusions of the study as combined with discussions.

2 Theoretical Framewok for Testing Seasonal Integration

It has been utilized from Augmented Dickey Fuller (ADF) unit root test and some seasonal unit root tests which are DHF test proposed by Dickey, Hasza & Fuller (1984), HEGY test proposed by Hylleberg, Engle, Granger & Yoo (1990) and OCSB test proposed by Osborn, Chui, Smith & Birchenhall (1988) test in seasonal integration analysis. However, in order to save space, these tests will not be discussed here.

The nonstationary stochastic process y_t, observed at S equally spaced time intervals per year, is said to be seasonally integrated of order d, denoted $y_t \sim SI(d)$, if $\Delta_S^d y_t$ is a stationary, invertible ARMA process. Here Δ_S denotes the seasonal differencing filter. Applying seasonal differencing to a deterministic seasonal process prompts the existence of first order annual differencing operator Δ_S in the MA operator and this will lead to non-invertibility of MA operator. Therefore, a deterministic seasonal process and a seasonally integrated process are not identical processes (Ghysels and Osborn, 2001).

Another definition for a seasonally integrated series is a simplified version of the definition given by Engle, Granger and Hallman (1989) for a seasonally integrated series as: A nonstationary series is said to be seasonally integrated of order (d,D), denoted $SI_s(d,D)$, If it can be transformed to a stationary series by applying s-differences D times and then differencing the resulting series d times using first differences.

In a simple manner, a seasonal difference is the difference between an observation and its value for the corresponding season one year before. If the series is measured s times per annum (for quarterly data, $s=4$ and for monthly data $s=12$) and it displays a seasonal pattern, then the differencing to remove seasonality should be s rather than one. So, the type of operator to be applied here is $x_t - x_{t-s}$ (representing seasonal difference) instead of $x_t - x_{t-1}$. Here, the transaction to get these variables is called seasonal differencing or s-differencing. Generally, it is very rare to use s-differencing more than once in order to remove seasonality. Taking seasonal differences transforms a linear trend with an additive seasonal effect to a constant (that is, to a variable with no trend or seasonal pattern). If this transaction is applied to a quadratic trend (where the trend is nonlinear) with additive seasonality, it brings about a series still including a trend component but with no seasonal pattern. So, in order to make such a series is stationary, first differencing of the s-differences may be required (Charemza and Deadman, 1992).

Ilmakunnas (1990) has tried to illustrate a testing sequence in order to test the appropriate order of differencing in quarterly data. Introducing this testing sequence requires two alternative definitions of seasonal integration. According to the first definition which is the one defined by Osborn et al. (1988), a time series is said to be integrated of order (d,D), denoted $I(d,D)$ if the series becomes stationary subsequent to first-differencing d times and seasonally differencing D times. In other saying; if $(1-L)^d(1-L^S)^D x_t = \Delta^d \Delta_S^D x_t$ becomes stationary, x_t is said to be $I(d,D)$. In the paper proposed by Ilmakunnas (1990), since the focus is on the quarterly time series $s=4$, it is concerned with the case where $I(1,1)$ is the maximum order of integration. The second alternative definition for seasonal integration comes from Engle, Granger and Hallman (1989) that has already been mentioned above. To this definition; if $(1-L)^d S(L)^D x_t = \Delta^d S(L)^D x_t$ is stationary, x_t is said to be seasonally integrated of orders d and D expressed as $SI(d,D)$ where $S(L)$ is a seasonal filter used in transforming the variables to moving sums. In the case of quarterly data, seasonal filter is stated as $S(L) = 1 + L + L^2 + L^3$ and it takes place in the decomposition of $\Delta_4 = (1-L)S(L) = (1-L)(1+L)(1+iL)(1-iL)$. Since $\Delta\Delta_4$ is decomposed as $(1-L)^2 S(L)$ or $(1-L)[(1-L)S(L)] = (1-L)(1-L^4)$, $SI(2,1)$ and $I(1,1)$ are the same. In the same manner, $SI(1,0)$ is the same as $I(1,0)$ and also $SI(1,1)$ and $I(0,1)$ are the same.

To illustrate the testing sequence for quarterly data, starting point is taken as the maximum order of seasonal integration, i.e. the case $SI(2,1)$. This testing sequence has been shown in Figure 1. The representation in Figure 1 pursues the view proposed by Dickey and Pantula (1987). According to their view, if it is mentioned about multiple unit roots, the best thing is to start the testing sequence from the maximum number of unit roots in hand and in this case the nominal test size is preserved. Therefore, it can be expressed that determining the suitable integration order is based on the starting point of the testing sequence (Ilmakunnas, 1990). Ilmakunnas (1990) mentions about how to handle unit root testing in a seasonal context considering the initial test of the $SI(2,1)$ null hypothesis. In the study, it is expressed that $SI(2,1)$ is tested against $SI(2,0)$, $SI(1,1)$ and $SI(1,0)$ alternatives using the HEGY test regression applied to ΔX_t rather than to X_t (for seasonal integration tests associated with different hypotheses in details, see Ilmakunnas, 1990).

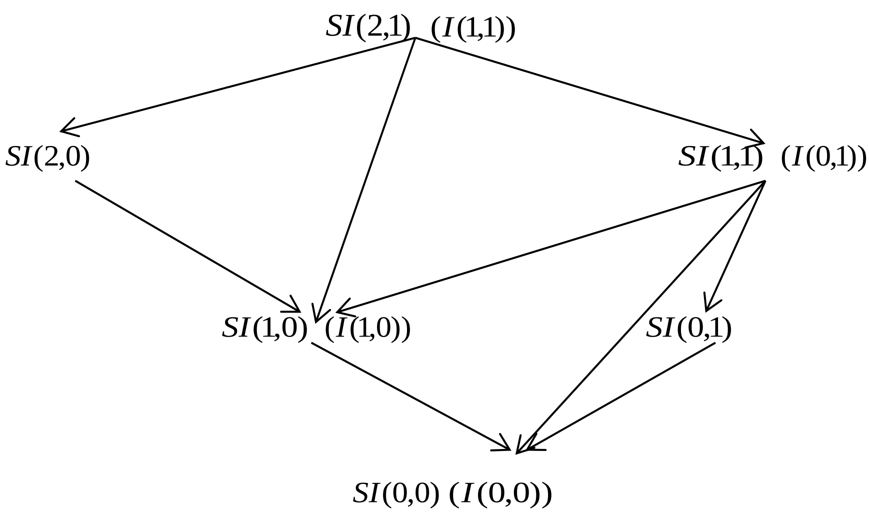

Figure 1. *The Testing Sequence for Determining the Appropriate Seasonal Integration Order in Quarterly Data (**Source**: Ilmakunnas, 1990).*

In case we reject the null hypothesis in favour of either $SI(1,1)$ or $SI(1,0)$ alternatives, we have to check the presence of zero frequency unit root against $SI(0,1)$ or $SI(0,0)$ processes, respectively continuing for testing against lower orders of integration (Ghysels and Osborn, 2001).

3 Data Set and Application

Inflation is one of the most important facts in our daily life referring to a sustained increase in consumer prices and it can be measured through CPI, PPI or GDP deflator. However, it is generally measured as a change in the harmonized index of consumer prices (HICP) that has been harmonized across all European Union member states. Holmes (2014) has presented the definition of HICP as "The HICP is the measure of inflation which the governing council uses to define and assess price stability in the Euro area as a whole in quantitative terms." (p.16). With respect to providing a joint measure of inflation by making international comparisons easier, in this study it has been utilized from HICP in order to measure inflation.

In the application part, first seasonal integration tests will be applied in a unified approach for inflation rates and growth variables and after determining the seasonal integration orders of these variables, the cointegration relationship between them will be investigated. Inflation data have been derived through $INF = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}}.100$ and real gdp growth rates have been obtained by $GR = \frac{GDP_t - GDP_{t-1}}{GDP_{t-1}}.100$ transformation where INF denotes inflation rate, CPI_t denotes consumer price index at time *t* and CPI_{t-1} denotes consumer price index at time *t*-1, GR denotes real gdp growth rate and GDP denotes real GDP. For deriving inflation data, we have utilized from quarterly HICP data (with Index 2010=100) as CPI for Turkey and HICP data have been obtained from Organization for Economic Co-operation and Development. On the other hand, GDP data have been collected from Central Bank of the Republic of Turkey (CBRT). In Figure 2, plots of inflation and growth variables have been presented in the same graph in terms of giving a clue about their cointegrating relations. Since it is seen that they are moving together in the graph, they are highly possible to be cointegrated.

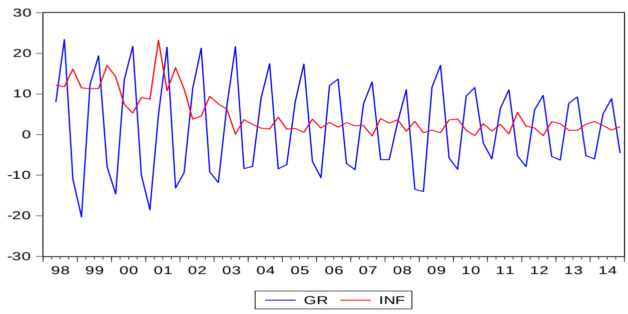

Figure 2. *Graphs of Quarterly Growth Rates and Inflation Rates Together against Time over 1998Q1-2014Q4 Period*

In this application, seasonal integration tests will be applied for quarterly data on the real gdp growth rates and inflation over 1998Q1:2014Q4 period by taking the study of Ilmakunnas (1990) as basis. When looked at the graphs in Figure 2, it is apparent to see the seasonal behaviors of both INF and GR variables. In ADF and HEGY test applications, constant term and seasonal dummies have been included in the regressions to be applied and seasonal means have not been removed in DHF and OCSB tests. As seen in Figure 2, a decrease (increase) in gdp growth is generally matched by a corresponding increase (decrease) in inflation. Depending on the clear seasonal patterns of these two series, we can recourse to seasonal differencing procedure in order to capture such patterns. Because two series have quarterly frequency, seasonally differenced variables have been obtained by using $(1-L^4)$ operator. Therefore our transformed series that will be called D4INF and D4GR respectively for inflation and growth can be expressed as $D4INF = INF_t - INF_{t-4}$ and $D4GR = GR_t - GR_{t-4}$. As a result of these transformations, D4INF and D4GR variables which are seasonally integrated of order SI $(1,1)$ (or integrated of order $I(0,1)$) have been graphed together in Figure 3:

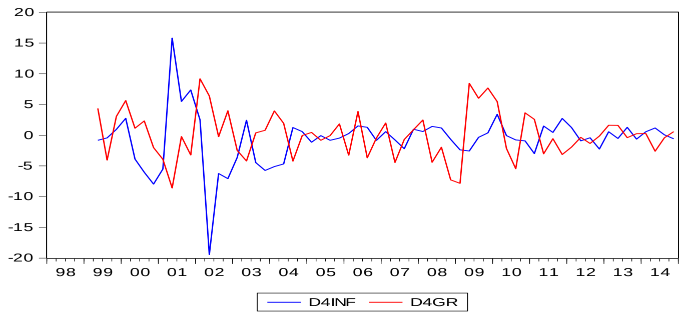

Figure 3. *Graph of Seasonally Differenced Growth Rates and Inflation Rates Together*

Figure 3 also shows that these seasonally differenced two series are moving together, but at an opposite direction. Thus, it supports the idea that they seem to be cointegrated.

Test	Test Statistic for Variable			
	GR	**Lag Length (p)**	**INF**	**Lag Length (p)**
ADF	-3.689032	4	-1.553273 (*)(**)(***)	4
ADF for Δ Series	-5.028365	7	-7.782215	3
ADF for Δ_4 Series	-6.711397	3	-2.826763 (*)(**)	4
ADF for $S(L)$ Series	-3.751048	1	-1.981335 (*)(**)(***)	5
DHF	-4.801168	1	-3.146821 (*)(**)(***)	5
DHF for Δ Series	-2.539052 (*)(**)(***)	5	-5.068007	9
HEGY π_1	-3.689032	$p=1$	-2.412879 (*)(**)(***)	$p=3$
π_2	-2.104948(*)(**)(***)		-2.797232(*)(**)	
π_3	-3.082795(*)(**)(***)		-6.117571	
π_4	-0.287342(*)(**)(***)		-2.678279(*)	
$\pi_3 \cap \pi_4$	4.804014(*)(**)(***)		22.65265	
HEGY (with $\pi_1 = 0$)		$p=5$		$p=1$
π_2	-1.916769 (*)(**)(***)		-5.872822	
π_3	-1.491104 (*)(**)(***)		-7.031611	
π_4	-0.561135 (*)(**)(***)		-5.095386	
$\pi_3 \cap \pi_4$	1.273491 (*)(**)(***)		37.99593	
HEGY (with $\pi_2 = \pi_3 = \pi_4 = 0$) π_1	*see ADF for $S(L)$ Series*			
HEGY for Δ Series (with $\pi_1 = 0$)		$p=8$		$p=4$
π_2	-1.081247 (*)(**)(***)		-2.582364 (*)(**)(***)	
π_3	-1.126513 (*)(**)(***)		-5.468436	
π_4	0.980675 (*)(**)(***)		2.412156 (*)(**)(***)	
$\pi_3 \cap \pi_4$	1.148816 (*)(**)(***)		20.04481	
HEGY for Δ Series (with $\pi_2 = \pi_3 = \pi_4 = 0$) π_1	*see ADF for Δ_4 Series*			
HEGY for Δ Series π_1	-5.028365	$p=4$	-7.782215	$p=0$
π_2	-1.916769(*)(**)(***)		-5.872822	
π_3	-1.447264(*)(**)(***)		-8.504117	
π_4	0.639263(*)(**)(***)		0.814304 (*)(**)(***)	
$\pi_3 \cap \pi_4$	1.273491(*)(**)(***)		37.99593	
OCSB β_1	-5.553677	$p=3$	-3.604473	$p=0$
β_2	-1.798949 (*)(**)		-10.06257	
OCSB (with $\beta_1 = 0$) β_2	*see DHF for Δ Series*			
OCSB(with $\beta_2 = 0$) β_1	*see ADF for Δ_4 Series*			

Note: * denotes insignificant values at 1% significance level.
** denotes insignificant values at 5% significance level.
*** denotes insignificant values at 10% significance level.

Table 1. *Seasonal Integration Test Results for Inflation and Growth Series*

Table 1 presents the results of different seasonal integration tests in order to decide about integration orders of both INF and GR variables. In this application, the selection of lags (p) has been made in a way not to have autocorrelation and heteroscedasticity problems apart from the examination of correlogram of residuals. First, it is necessary to choose appropriate integration orders for inflation and growth by utilizing from the given information in Table 1. In Table 1, the column GR presents the estimates of growth variable and the column for INF gives the estimates for inflation variable under the different regression models. The null and alternative hypotheses corresponding to different models have been mentioned in Ilmakunnas (1990). Therefore, we have three (null) hypotheses that will be used as the starting point of testing sequence: starting point may be either SI(2,1), SI(1,1) or SI(1,0). As a conclusion of a thorough evaluation on Table 1, the results of these three cases are given in Table 2 along with the accepted hypotheses shown in bold type.

Table 2 presents the accepted hypotheses of growth and inflation variables under the different forms of ADF, DHF, HEGY and OCSB tests. The second "GR" column gives the accepted hypotheses for this variable under the given tests and third column "INF" presents the accepted hypotheses for this variable under the given tests. In addition, the mostly accepted hypotheses for two variables when they are considered together are shown in bold type in Table 2 so that if the starting point is SI(2,1), mostly SI(2,1) has been accepted for two variables and if the starting point is SI(1,1), mostly SI(1,1) has been accepted.

Case 1: If the starting point is SI(2,1),	GR(growth)	INF (inflation)
ADF for Δ_4	SI(1,1)	**SI(2,1)** may be accepted for 1% and 5% levels (and SI(1,1) may be accepted for 10% level).
DHF for Δ	**SI(2,1)**	SI(1,0)
HEGY for Δ: while $\pi_1 = 0$, π_2, π_3, π_4 tested $\pi_1, \pi_2, \pi_3, \pi_4$ tested while $\pi_2 = \pi_3 = \pi_4 = 0$, π_1 tested	**SI(2,1)** **SI(2,1)** SI(1,1)	**SI(2,1)** can be accepted because of the presence of unit roots at π_2 and π_4. SI(1,0) may be accepted since there is no biannual and annual unit roots. (See *ADF for* Δ_4)
**The results of the case "while* $\pi_2 = \pi_3 = \pi_4 = 0$, π_1 *tested" in HEGY test for* Δ *are the same as ADF for* Δ_4 *results. The results for two series are not certain if the starting point is SI(2,1). However in most cases the hypothesis SI(2,1) cannot be rejected for growth series and inflation series may be accepted as either SI(2,1) or SI(1,0).*		
Case 2: If the starting point is SI(1,1),	GR(growth)	INF (inflation)
ADF for $S(L)$	SI(0,1)	**SI(1,1)**
DHF:	SI(0,0)	**SI(1,1)**
HEGY: while $\pi_1 = 0$, π_2, π_3, π_4 tested $\pi_1, \pi_2, \pi_3, \pi_4$ tested while $\pi_2 = \pi_3 = \pi_4 = 0$, π_1 tested	**SI(1,1)** **SI(1,1)** SI(0,1)	SI(1,0) For %1 level, **SI(1,1)** may be accepted. **SI(1,1)**
OCSB: $\beta_1 \neq 0$, β_2 tested	**SI(1,1)**	SI(0,0)
**The results of the case "while* $\pi_2 = \pi_3 = \pi_4 = 0$, π_1 *tested" in HEGY test are the same as ADF for* $S(L)$ *results. As it is seen obviously, the result of two variables may be in the form of SI(1,1) dominates.*		
Case 3: If SI(1,0) is tested,	GR(growth)	INF (inflation)
ADF:	SI(0,0)	SI(1,0)
HEGY: while $\pi_2, \pi_3, \pi_4 \neq 0$, π_1 tested	SI(0,0)	SI(1,0)
OCSB: $\beta_2 \neq 0$, β_1 tested	SI(0,0)	SI(0,0)

Note. [1] Bold expressions have been used to highlight mostly accepted hypotheses under the starting point in interest.

[2] For 1998Q1-2014Q4 period (that is, 68 observations), in most cases, N=100 (observations) has been taken as basis in critical values tables.

[3] ADF critical values have been considered as -3.51 for 1%, -2.89 for 5% and -2.58 for 10% significance level for the model with constant and no trend (N=100) (Critical values have been cited from Fuller (1976).

[4] DHF critical values have been cited from the table (percentiles, the studentized statistic for the seasonal means model) in Dickey et al.(1984). For quarterly data, d has been considered as 4 and for DHF test, n=md (total number of observations) has been taken as 80 (seasonal means have not been removed). Percentiles of the studentized statistic for the seasonal means model are given as: -4.78 for 1%, -4.11 for 5% and -3.78 for 10%.

[5] Critical values have been obtained from Osborn et al. (1988) for OCSB test (with no seasonal mean subtraction).

[6] Critical values for HEGY test have been taken from Hylleberg et al. (1990) for the model with intercept and seasonal dummies.

Table 2. *Accepted Hypotheses in Seasonal Integration Tests for INF and GR Series*

As Ilmakunnas (1990) expressed, the conclusion on the appropriate order of integration depends on the starting point of testing sequence. If starting from the most general model (case 1 in Table 2), the result is that in most cases the growth variable is stationary after both first differencing and quarterly differencing (in most cases, the null of SI(2,1) is accepted against the other alternative hypotheses) and according to this starting point, it may be concluded that inflation series may be either SI(2,1) or SI(1,0) (given in "INF" column). If the starting point is case 2 in Table 2 (or quarterly differencing (that is, SI(1,1)), we cannot obtain accurate results for variables: While INF series may be accepted as SI(1,1) in most cases, GR series may be SI(0,1), SI(1,1) or SI(0,0).

When looked at the DHF test result in Case 2 where the null hypothesis is SI(1,1) and the alternative is SI(0,0), GR variable can be said to reach full stationarity with SI(0,0) seasonal integration order. The other tests apart from DHF in Case 2 imply that seasonal frequency unit roots clearly can be accepted (or cannot be rejected) for GR variable. However, the evidence is not certain for INF series (it may also be SI(1,0) or SI(0,0) other than SI(1,1) – in other words, it may not include seasonal unit roots).

It is worth mentioning about some equivalences between the seasonal integration tests. In case the main hypothesis to be tested is the presence of seasonal frequency unit roots, i.e. $\pi_2 = \pi_3 = \pi_4 = 0$ in the HEGY test, the test regression does not differ from ADF test for seasonally averaged ($S(L)$) data. In a similar manner, in the case of $\pi_2 = \pi_3 = \pi_4 = 0$ in the HEGY test for first differenced data, the test regression is the same as the ADF test for seasonally differenced data. This is also the same as the OCSB test with $\beta_2 = 0$. At last, the OCSB test with $\beta_1 = 0$ is the same as the DHF test for first-differenced data (Ilmakunnas, 1990).

Form of the variables in the regression (Dependent Variable=GR)					
Estimated Coefficients	**Levels**	**Seasonally Averaged** $S(L)$ ($S(L)=1+L+L^2+L^3$)	**Seasonally Differenced** (Δ_4)	**Differenced** (Δ)	**Twice Differenced** (Δ^2)
INF	-0.083274 (Constant+ Dummies Model) "Significant"	-0.049137 (Constant Model) "Significant"	-0.258978 (Model with No Deterministic Component)	-0.394322 (Constant+ Dummies Model)	-0.409318 (Constant+ Dummies Model)
Test of the Residuals Test Statistics					
DW	1.999220*	0.492387*	1.662716*		
DF	-8.059352*	-2.996607*	-6.732354*		
ADF(p)	-3.648481(4)*	-3.838019(1)*	-6.713961(3)*		
	%5Critical Values: -1.945823(for DF) -1.946161(for ADF(p))	%5Critical Values: -1.946072 (DF) -1.946161(ADF(p))	%5Critical Values: -1.946161(DF) -1.946447(ADF(p))		
HEGY Test Results					
π_1				-6.486017*	-7.636372*
π_2				-2.762810*	-2.464176*
π_3				-2.558021*	**-0.253216**
π_4				**1.536945**	**0.923592**
π_3 & π_4 (Model with No Deterministic Component)				4.772130* ($p=0$)	**0.466443** ($p=4$)

Note. *[1] * denotes significant values at 5% level.*
[2] Critical values for HEGY test have been obtained from Hylleberg et al. (1990).
[3] Critical values for DW statistic have been taken from Engle and Yoo (1987) for N=2 variables.

Table 3. *Cointegration Results for Growth Equation*

One of the most important problems in applying integration tests is the appropriate choice of the value of lag length p to be used: too low a value gives rise to invalid statistics due to autocorrelation left in the residuals; on the other hand, the implication of an extremely high lag length is a reduction in power (Osborn et al., 1988). In this application, in selecting the appropriate lag lengths, LM test statistics for residual autocorrelation have been calculated and examined up to order four for all test regressions. Lag lengths have been increased one by one until detecting no significant autocorrelations at the 5% level. All applications in this section have been carried out in R.3.1.3. version and Eviews 7.

Now we will have a different look at cointegration relationship between INF and GR series for growth equation in which dependent variable is economic growth (GR) and independent variable is inflation (INF). Table 3 shows the cointegration results for growth equation. Since there are two variables in our model, at most one cointegrating relation can be found. In Table 3, "p" shows the necessary lag numbers that will be included in the regressions applied.

When the growth equation is taken into consideration, it can be said that the resulted statistics can be used to give a clue about whether the variables are cointegrated or not at seasonal frequencies. For the first three models in Table 3 which are given in level form, seasonally averaged form and seasonally differenced form, respectively; all tests of the residuals (DW, DF, ADF) strongly suggest that the variables are cointegrated (where the null hypothesis is H_0 : no cointegration and the alternative one is H_1 :cointegration exists) (in other saying, the evidence against no-cointegration is said to be very strong).

When we look at the first differenced (Δ) and twice differenced variables (Δ^2), it is seen that the evidence of cointegration is strong when differenced variables are considered with significant π_i estimates at seasonal frequencies. However in the twice differenced form, since π_3 and π_4 estimates regarding annual unit root are not significant, we cannot strictly say that twice differenced variables are cointegrated at seasonal frequencies even though only π_2 is significant.

Level form regression results show the existence of one cointegrating relation with significant residual test statistics which are Durbin-Watson (DW), DF and ADF test statistics. The seasonally averaged form results (S(L)) also support this result with significant ADF, DW statistics obtained for the residuals of given regressions.

Empirical results reveal that all forms of the variables except twice-differenced (Δ^2) form show the sign of cointegration. Therefore, this analysis in which GR is dependent variable and INF is independent variable has revealed that the variables in question are SI(1,1). Since seasonally averaged ($S(L)$) variables have been found to be cointegrated of order 1 at zero (non-seasonal) frequency and first differenced variables (Δ) have been found to be cointegrated at seasonal frequencies. Thus, it can be said that in growth-inflation model, it would be suitable to incorporate the variables in Δ_4 form into the regression.

4 Conclusion

At the core of this analysis, how different seasonal integration tests can be carried out in a unified approach lies. In the study, various seasonal integration tests have been carried out in order to detect the appropriate order of seasonal integration. Seasonal integration results imply that growth and inflation variables may be either SI(2,1) or SI(1,1) in the dominant sense. Therefore we have taken five cointegration regressions in the level, seasonally averaged (S(L)), quarterly differenced (Δ_4), first differenced (Δ) and twice differenced (Δ^2) forms. In the level form, GR series has been regressed on INF series. In the level, differenced and twice differenced forms; a constant and three seasonal dummies have been included and in the seasonally averaged form, a constant has been added. As a result of the application, two series have been found to have the same degree of seasonal integration as SI(1,1). Thus, based on the information that inflation and growth series have the same integration order (both are SI(1,1)) and by applying various tests (DW, DF, ADF, HEGY) to the residuals obtained from the regression equations formed by using difference operators and raw data, whether there is a long-term relationship between the series or not has been examined through the cointegration analysis and the analysis has revealed that both series in their level forms are cointegrated. When the results of regression analyses are considered in terms of economic interpretation, the inflation-growth relationship in Turkey has been understood to be in an opposite direction. This has been confirmed by the negative sign of the coefficient of INF variable in any case. According to the results of regression analyses applied, increases in inflation will reduce economic growth over 1998Q1-2014Q4 period.

To summarize, this application addresses the cointegrating relationship between inflation and growth from a different view adopting the approach proposed by Ilmakunnas (1990) by taking the concept of seasonality into consideration. As a result, the presence of a cointegrating relationship has been determined between two variables and this means a real long-term relationship. In addition, there should be further reductions in inflation in order to increase the average growth rate declining gradually in recent years.

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Information Notes

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