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HEGY SEASONAL UNIT ROOT TEST: AN APPLICATION ON BALANCE OF PAYMENTS IN TURKISH ECONOMY

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ABSTRACT:
Many data series are often subject to seasonal movements and display regular patterns of ups and downs that recur every year in the same month or quarter. Some factors like climate, festivals, production cycle characteristics, calendar effects (such as Christmas effect in December), timing decisions (the timing of school vacations, ending of university sessions) etc. underlie such repetitive seasonal variations that might differ in magnitude from year to year even they are observed regularly (Hansda, 2012). In order to test these variations, what form of seasonality (deterministic or stochastic) exists in data worked should be determined. That is, modelling seasonality is of great importance. In this paper, it has been aimed to detect the presence of seasonal unit roots on capital and financial accounts of balance of payments by using quarterly data for the periods of 1984Q1–2014Q2 and for this aim HEGY (1990) seasonal unit root testing procedure has been utilized. The results obtained have been thought to be beneficial in determining an optimal policy on foreign economic relations
Key words: *Deterministic-Stochastic Seasonality, Seasonal Unit Roots, HEGY Test, Capital and Financial Accounts*

ÖZET:
Çoğu seri genellikle mevsimsel hareketlere tabidir ve aynı ayda ya da aynı çeyrekte her yıl tekrar eden düzenli iniş ve çıkış örüntüleri sergiler. İklim, festivaller, üretim döngüsü özellikleri, takvim etkileri (Aralık'taki yılbaşı etkisi gibi), zamanlama kararları (okul tatillerinin zamanlaması, üniversite akademik dönemlerinin sona ermesi) gibi bazı faktörler, düzenli olarak gözlenseler bile yıldan yıla büyüklükleri farklılık gösterebilen bu gibi yinelemeli mevsimsel varyasyonların temelini oluşturur (Hansda, 2012). Bu varyasyonları test etmek için çalışılan verilerde ne tür bir mevsimselliğin (deterministik ya da stokastik) bulunduğu belirlenmelidir. Yani, mevsimselliğin modellenmesi büyük bir öneme sahiptir. Bu çalışmada 1984Q1–2014Q2 dönemleri için ödemeler dengesinin çeyreklik frekanstaki sermaye ve finans hesapları serisindeki mevsimsel birim köklerin varlığının saptanması amaçlanmıştır ve bu amaçla HEGY (1990) mevsimsel birim kök test yönteminden yararlanılmıştır. Elde edilen sonuçların dış ekonomik ilişkiler üzerinde optimal bir politikanın belirlenmesinde yararlı olacağı düşünülmektedir.
Anahtar Kelimeler: *Deterministik-Stokastik Mevsimsellik, Mevsimsel Birim Kök, HEGY Testi, Sermaye ve Finans Hesapları.*

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1. Introduction:

The concept of stationarity is very crucial in order to analyse time series. For this reason, whether the series are stationary or not has to be tested. In case a series in question has a unit root (indicating to the nonstationarity of that series), the first action to be performed is to make that series stationary. The most convenient transaction to accomplish this is to take difference of series in interest by taking the number of available unit roots in series into consideration. In other saying, whatever the integration order of the series is, the process of taking difference should be performed as this order.

In analysing seasonal time series, determining whether the series includes a seasonal unit root or not has a great significance. In the case of seasonal time series, the presence of unit root can be investigated at both zero (long-run) and seasonal frequencies. As well-known most macroeconomic time series are subject to seasonality and very strong seasonal movements may obscure the trend and conjunctural properties of some series. If this is the case, seasonal adjustment procedure will enable to observe the patterns of series in a more apparent way. However, most methods used to remove the seasonal effect do not always present good results and in addition conducted studies have set forth that seasonal adjustments in question may produce spurious seasonal fluctuations. (Ayvaz Kızılgöl, 2011, pp.13-14). According to the Ghysels and Perron (1993), if seasonally adjusted data are used to apply unit root tests this will result in the biased ADF and Phillips-Perron statistics toward non-rejection of the unit root null. Therefore, in an asymptotical manner it is preferred to study with seasonally unadjusted data for more powerful unit root tests (Maddala and Kim, 1998, pp.364-365).

In case seasonal time series include unit roots, such roots repeat themselves due to the seasonal frequencies. Then, contrary to the traditional unit root tests, in the case of seasonal unit roots taking differences as the number of repeating unit roots in series will both leave the series as non-stationary and will be able to convert the series into very complex models. In this instance, it becomes important to get the knowledge of whether a unit root in a series in interest is seasonal or not (Türe and Akdi, 2005, p.3).

When series created as linked with facilities like peak of sales in Christmas, special days (Mother's Day, Father's Day etc.) or Bairams (especially, increasing sales before religious bairams) undergo some important changes in such periods mentioned, these changes affect the whole variance of the series and ignorance of seasonality creates an increase in variance of the series. Therefore, when seasonality in studied data is not taken into consideration, imprecise results could be obtained (Kutlar, 2000, p.49). On the other hand, inferences about the business cycles could also be interpreted in a complicate way in the presence of seasonal pattern. For instance assume that whether there is an expansion or recession in the economy, industrial production drops significantly in the first quarter of the year. So it is important for analysts to make inference about whether a first quarter dip is caused by seasonal factors that will disappear next quarter or whether the decline is an indicator for a change in the business cycle from boom to bust (Jaditz, 1994, p.17).

In order to make an inference about seasonal pattern of the series, it is necessary for us to make a division between stochastic and deterministic seasonality. The basic separation of these two depends on the long run effects when the series are subject to shocks. In deterministic seasonal models, shocks die out in the long run (temporary effect). However, in the stochastic seasonal models, since the level of the series also depends on past values, shocks will have a permanent effect on that series. (Charemza and Deadman, 1992, p.140). To discriminate between two types of seasonality, a test has been proposed by Hylleberg, Engle, Granger and Yoo (1990)**,** called the HEGY test. In the following section, theoretical structure of the HEGY test will be introduced and then an application will be done based on it.

2. Literature Review

There are many studies regarding seasonality. Hylleberg, Engle, Granger & Yoo (HEGY) (1990) have developed tests for roots in linear time series corresponding to seasonal frequencies and studied with different models including different combinations of constant, trend and seasonal dummies. They have mainly aimed to develop a testing procedure that will identify what class of seasonal process (purely deterministic, stationary or integrated) is responsible for the seasonality in a univariate process and that is the most popular one for testing unit roots at each seasonal frequency as well as at the long run frequency separately. This procedure has been applied to quarterly data at first and afterwards it has been extended to the data with different frequencies. There exist many other tests for testing seasonal unit roots such as Dickey-Hasza-Fuller (DHF) test proposed by Dickey, Hasza and Fuller (1984), OCSB test by Osborn, Chui, Smith and Birchenhall (1988) etc. Franses (1990) and Beaulieu and Miron (1993) have concerned with testing seasonal unit roots in monthly data. The study proposed by Leong (1997) focuses on the nature of the seasonality and testing for seasonal unit roots using HEGY testing procedure for various quarterly Australian macroeconomic data which display the relatively large amount of seasonal fluctuations. As a result, Leong (1997) has found that although the presence of seasonal unit roots is observed in total exports and total imports data, other analysed macroeconomic variables are seen to display deterministic fluctuations apart from stochastic seasonality. Alexander and Jordá (1997) have analysed the presence of seasonal unit roots at different frequencies in trade variables for Germany, France, the U.K. and Italy with both quarterly and monthly data based on the HEGY procedure. The evidence has shown that the presence of unit roots at most seasonal frequencies appears more often in monthly data than in quarterly data and Italy has been shown as the only country which exhibits seasonal unit roots in all its three variables. Rubia (2001) presents the extension of HEGY testing procedure to analyse the weekly seasonality of the daily electricity demand series taken from the Spanish, Argentine and Australian Electricity Markets. Çağlayan (2003) has analysed the presence of seasonal unit root for the monthly series associated with the life-long permanent income hypothesis over the period 1988:01-2000:04. The conclusion of the research has shown that consumption expenditures and disposable income series include seasonal unit roots for both zero and one-fourth frequencies and stock market returns series includes for one-fourth frequency. Ayvaz (2006) investigates the nature of the seasonal patterns of quarterly Gross National Product (GNP), consumption, export and import series in Turkish Economy based on the HEGY procedure for the period 1989:Q1-2004:Q4. According to the findings, it has been concluded that consumption series features stochastic seasonality, GNP and export series have seasonal unit roots at biannual and annual frequencies and imports series has a non-seasonal unit root. In their study, Gürel and Tiryakioğlu (2012) have analysed the seasonal patterns of the seasonally unadjusted quarterly Turkish Industrial Production Index and the sub-sectors of the mining industry, the manufacturing industry and electricity, gas and water sectors at constant 1997 prices over the period 1977:1–2008:4 by using the HEGY approach. The main findings have shown that all these four series contain seasonal unit roots at long-run (zero) frequency and the electricity and total industry production series are not stationary at each seasonal frequency. According to the evidence, the presence of both deterministic and non-stationary stochastic seasonality has been detected in the Turkish manufacturing industry series. The aim of the paper proposed by Meng and He (2012) is to propose a HEGY-type test in order to test seasonal unit roots in data with other frequencies not studied until that time such as hourly and daily data. Meng and He (2012) have tried to detect the presence of seasonal unit roots in hourly wind power production data in Sweden in warm season and cold season separately for 2008-2009 years. For these separate two series, they conclude that there are no seasonal unit roots in both series; however, zero frequency unit root exists in both.

3. Economic Theory

The Balance of Payments (BOP) reflects the overall statement of a country's economic transactions with the rest of the world over a year in terms of goods, services and assets. All transactions except these like the ones between domestic residents are excluded. The compilation of BOP is realized through the double-entry accounting system: each transaction that results in a payment to foreigners is reflected as a debit (negative sign) entry, and each transaction that results in a receipt of a payment from foreigners is reflected as a credit (positive sign) entry in the BOP accounts.

BOP consists of four components: the current account, the capital and financial account, net errors and omissions, and changes in official reserves. The current account includes exports and imports, receipts from and spending abroad on services, receipts of property incomes from abroad and remittances of property incomes abroad, and, finally, receipts and payments of international transfers. So, this account is said to measure the transfer of real sources (goods, services, income and transfers). The second component which is the capital and financial account, measures the trade in existing financial or real assets among countries. The capital account balance is equivalent to the amount of capital flows minus capital outflows, plus the net capital account transactions. If necessary to explain the capital account seperately, it can be said that it includes short, medium or long-term flows. Long-term flows consist of direct investment, portfolio investment (purchases and sales of bonds and equities) and other long-term capital. It is important to know that the sums of the current and capital accounts is an indicator for the economy's financing requirement (in other saying, overall balance or net external position). The third component, the net errors and omissions, is an amount that must be added to make the total balance of payments in balance and is caused by the inappropriate recording of international economic transactions. Because of that, this component is also called "the statistical discrepancy". On the other hand, the fourth component, changes in official reserves, shows the asset held by central banks to finance international payment imbalances and the official reserves balance shows the net increase in a country's official reserve assets (Elitok, 2008, pp.45,46 ; Rajcoomar and Bell, 1996, pp.27,30). In other saying, it could be said that changes in the international reserves reflect the movement in overall balance.

Since BOP is one of the basic indicators of a country's status in international trade arena with net capital outflow, as understood each component of BOP has also a separate significance. In our analysis, we have focused on the capital and financial accounts series. Therefore, it would be appropriate to explain the role of this series. Even if the underlying current account is in equilibrium, the capital and financial account may be a separate motive for external instability:

1. The NEAP (the economy's net external asset position) may be developing properly, and yet the country may be sustaining, *vulnerable external balance sheet structures,* which could be suddenly unwound.
2. Even temporary fluctuations in the current account may create disruptions in the presence of market imperfections leading to *financing constraints*. Therefore, another possible source of external instability is incapability to finance an excessive current account deficit on account of cyclical fluctuations (overheating) or temporary shocks**.** The fundamental factors that will be thought to take this case into account are the level of reserves and access to international capital markets (International Monetary Fund, 2011, pp.32-33).

4. Methodology:

For seasonally unadjusted time series, the concept of integration takes the possibility of seasonal unit roots into consideration. A seasonal economic time series, "X" is said to be integrated of order (d, D), that is X ~ I(d, D) if the series is stationary after first period differencing d times (unit root) and seasonal differencing D times (seasonal unit root) (see Osborn *et al.*, 1988). As a seasonal integration test, Dickey, Hasza and Fuller (1984) developed a test called DHF which looks like a generalization of ADF test. It tests the hypothesis of $\rho_s = 1$ against the alternative one which is $\rho_s < 1$ in the $y_t = \rho_s y_{t-s} + \varepsilon_t$ model. However, the most major disadvantage of this test is that it doesn't allow for unit roots at some but not all of the seasonal frequencies (Hylleberg *et al.*, 1990, p.221). Since many time series display substantial seasonality, the presence of unit roots corresponding to other frequencies (like seasonal ones) rather than zero is highly possible. The analysis of seasonal unit roots is fundamentally conducted with the most popular approach developed by Hylleberg, Engle, Granger and Yoo (1990) called HEGY by working with different models that include trends, constants and seasonal dummies in order to determine the type of seasonality. HEGY (1990) introduced a factorization of the seasonal differencing polynomial $\Delta_4 = (1-L)^4$ for quarterly data using lag operator L, where $L^j y_t = y_{t-j}$ and developed a testing procedure for seasonal unit roots that could be estimated by ordinary least squares in following way (Charemza & Deadman, 1992; p.141):

$$\Delta_4 y_t = \sum_{i=1}^{4} \alpha_i D_{i,t} + \sum_{i=1}^{4} b_i Y_{i,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \tag{4.1}$$

where k is the number of lagged terms included to ensure that residuals are white noise, the $D_{i,t}$ are seasonal dummy variables and the $Y_{i,t}$ variables are constructed from the series on y_t as:

$$Y_{1,t} = (1+L)(1+L^2).y_t = y_t + y_{t-1} + y_{t-2} + y_{t-3} \tag{4.2}$$

$$Y_{2,t} = -(1-L)(1+L^2).y_t = -y_t + y_{t-1} - y_{t-2} + y_{t-3} \tag{4.3}$$

$$Y_{3,t} = -(1-L)(1+L).y_t = -y_t + y_{t-2} \tag{4.4}$$

$$Y_{4,t} = -(L)(1-L)(1+L).y_t = Y_{3,t-1} = -y_{t-1} + y_{t-3} \tag{4.5}$$

The HEGY regression in the most general and a more clear form could be written as follows:

$$\Delta_4 y_t = \alpha + \beta t + \sum_{i=1}^{3} \alpha_i D_{i,t} + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \tag{4.6}$$

We mostly apply seasonal differencing to remove nonstationarity in seasonal data, so that we should use $\Delta_4 y_t = y_t - y_{t-4}$ in quarterly data.

In equation (4.6), the choice of lag parameter k could be done using a variety of lag selection criteria. According to Engle *et al.* (1993), the power and size of the unit root tests depend on the 'right' augmentation that will be used.

Ghysels *et al.* (1994) point out that DHF testing procedure seems unable to separate unit root at zero frequency or at one of seasonal frequencies of data generating processes with nonstationarity induced by the $(1 - L^4)$ factor and therefore HEGY is a more advantageous procedure. However, when looked at the results of their Monte Carlo studies, it is seen that there exist some problems with available seasonal unit root tests regarding near-cancellation problem of a unit root in the AR polynomial with an MA root. That is, in seasonal time series models, this problem is said to be very common and leads to adverse size distortions. Even if there are no size distortions, Monte Carlo study results indicate the weak power properties of DHF and HEGY tests especially in the case of absence of seasonal dummies.

Deterministic seasonality is defined as the part of the seasonal cycle that is known when the “process is started”. Usually, this concept is restricted to time-constant seasonal means or time-constant growth rates that differ across quarters/months. In these cases, deterministic seasonality can be expressed by means of seasonal dummy variables that are 1 in specific quarters and 0 otherwise in that way: $y_t = \sum_{s=1}^{S} \delta_{st} m_s + z_t$. Here $\delta = 1$, if *t* falls to season s, and $\delta = 0$ otherwise. m_s is the mean for season s and S is the number of seasons and z_t is a weakly stationary zero-mean process (Ghysels and Osborn, 2001, p.6). On the other hand, stochastic seasonality in its simple form where seasonal differences are stationary could be expressed as $y_t = y_{t-s} + \varepsilon_t$ or $\Delta_s y_t = \varepsilon_t$ where ε_t is a series of identically distributed independent random variables (here, series is measured s times per annum) (Charemza & Deadman, 1992, p. 140).

If the null hypothesis of stochastic seasonality is true rather than deterministic seasonality, in this case all the $\alpha_i s$ will be equal to each other and all the $b_i s$ will be equal to zero. In the case of different $\alpha_i s$ and at least one of the $b_i s$ that is nonzero, there exists a combination of both deterministic and stochastic seasonality. The interpretation of each negative b_i is different from each other. Let's say, only b_1 is negative, in this case there is no non-seasonal stochastic stationary component (no component corresponding to an I(0) process). If only b_2 is negative, then there exists no bi-annual cycle. On the other hand, b_3 and b_4 are related to the annual cycle and testing them jointly is possible. Critical values of these tests are provided in the Hylleberg *et al.* (1990) paper.

The factorization of the expression $\Delta_4 = (1-L)^4$ could say somethings relating to roots $(1-L)^4 = (1-L)(1+L)(1+L^2) = (1-L)(1+L)(1-i \cdot L)(1+i \cdot L)$ where i is an imaginary part of a complex number such that $i^2 = -1$. When looked at this factorization, it is seen that a quarterly stochastic seasonal unit root process has four roots of modulus one. One root $(1-L)$ described as being at 'zero frequency' removes the trend. The other three roots which remove the seasonal structure imply stochastic cycles of biannual and annual periodicity (Charemza & Deadman, 1992, p.141-142). In this case, the unit roots are 1, -1, i, and -i which correspond to zero frequency, $\frac{1}{2}$ cycle per quarter or 2 cycles per year, and $\frac{1}{4}$ cycle per quarter or one cycle per year. The last root, -i, is identical to i with quarterly data and therefore it is also interpreted as the annual cycle (Hylleberg *et al.* 1990, p. 221).

Now we can test the following hypotheses:

1) $H_0 : \pi_1 = 0$ **2)** $H_0 : \pi_2 = 0$ **3)** $H_0 : \pi_3 = \pi_4 = 0$

$H_1 : \pi_1 < 0$	$H_1 : \pi_2 < 0$	$H_1 : \pi_3 \neq \pi_4 \neq 0$
(t statistic)	(t statistic)	(F statistic)

Here, $H_A : \pi_1 = 0 \rightarrow$ the presence of nonseasonal unit root.

$H_B : \pi_2 = 0 \rightarrow$ the presence of biannual unit root

$H_C : \pi_3 = \pi_4 = 0 \rightarrow$ the presence of annual unit root

As seen, the first two hypotheses H_A and H_B are tested by using one-sided *t* tests against the hypothesis that $\pi_i < 0$. The other hypothesis which is H_C is tested with an F test. For a series to include no seasonal unit roots, both $\pi_2 = 0$ and the joint F test which is $\pi_3 = \pi_4 = 0$ should be rejected. On the other hand, each of the *t* test of $\pi_1 = \pi_2 = 0$ and the joint F test of $\pi_3 = \pi_4 = 0$ should be rejected in order to have a stationary series.

As an alternative testing strategy for the joint $\pi_3 = \pi_4 = 0$ hypothesis, at first a two-sided test of $\pi_4 = 0$ is computed, and then in case this null hypothesis cannot be rejected, it is continued with a one-sided test of $\pi_3 = 0$ against the one-sided alternative $\pi_3 < 0$. If our attention is restricted to alternatives where it is assumed that $\pi_4 = 0$, a one-sided *t* test for π_3 would be convenient with rejection for $\pi_3 < 0$. Possibly if the first-step assumption is not guaranteed this could lack power (Hylleberg, et al. 1990, p.224).

It should also be noted that in order to be able to carry out the HEGY (1990) testing procedure, at least fifty observations are required (Ayvaz Kızılgöl, 2011, p.15).

There are five auxiliary regressions to be run in order to decide about the choice of a proper HEGY regression. These are:

1) regression with no deterministic component (no intercept, no seasonal dummy, no trend):

$$\Delta_4 y_t = \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \tag{4.7}$$

2) regression with only intercept (no seasonal dummy, no trend):

$$\Delta_4 y_t = \alpha + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \tag{4.8}$$

3) regression with intercept and seasonal dummy (no trend):

$$\Delta_4 y_t = \alpha + \sum_{i=1}^{3} \alpha_i D_{i,t} + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \tag{4.9}$$

4) regression with intercept and trend (no seasonal dummy):

$$\Delta_4 y_t = \alpha + \beta t + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \tag{4.10}$$

5) regression with intercept, seasonal dummy and trend:

$$\Delta_4 y_t = \alpha + \beta t + \sum_{i=1}^{3} \alpha_i D_{i,t} + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \sum_{i=1}^{k} c_i \Delta_4 y_{t-i} + \varepsilon_t \quad (4.11)$$

Because HEGY test is easily affected by the inclusion of deterministic components, model selection amongst five models given above is based on the significance of the deterministic components (Habibullah, 1998, p.119).

5. Application:

The purpose of this paper is to apply HEGY testing procedure on quarterly Capital Accounts and Financial Accounts (Total Balance Including Change in Reserve Assets for Turkey) series for the periods of 1984Q1 – 2014Q2 and try to find out whether there exist seasonal unit roots for given frequencies or not. For this reason, series has been taken as not seasonally adjusted and data have been extracted from Organization for Economic Cooperation and Development in units of US Dollars.

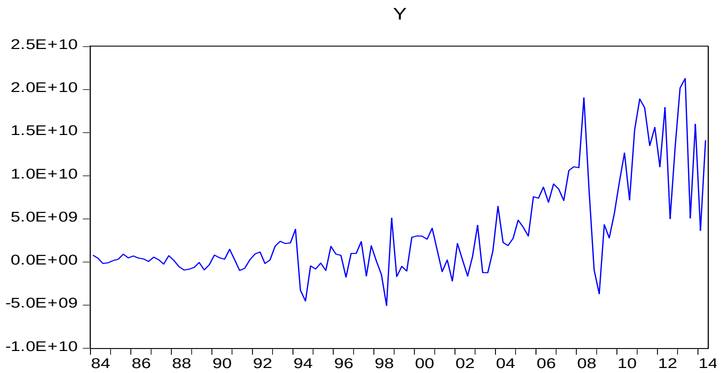

Figure 1: Capital Accounts and Financial Accounts (Total Balance Including Change in Reserve Assets for Turkey)

Table 1: Lag Order Selection Criteria for Five Auxiliary HEGY Regressions

MODELS	CRITERIA	LAGS SELECTED
No Deterministic Component	FPE	8
	AIC	8
	SC	**5**
	HQ	7
Only Intercept	FPE	8
	AIC	8
	SC	**5**
	HQ	8
Intercept and Seasonal	FPE	8

Dummies	AIC	8
	SC	**5**
	HQ	8
Intercept and Trend	FPE	8
	AIC	8
	SC	**5**
	HQ	8
Intercept, Seasonal Dummies and Trend	FPE	8
	AIC	8
	SC	**5**
	HQ	8

*FPE: Final Prediction Error
AIC: Akaike Information Criterion
SC: Schwarz Information Criterion
HQ: Hannan-Quinn Information Criterion

Table. 2 t-Statistic Values of HEGY Regression Parameters for Five Models (for k=5)

Deterministic Component	**Lag Parameter, k**	π_1	π_2	π_3	π_4
–	**5**	-0.332741*	1.054096*	-3.296855	-0.883067*
Intercept	**5**	-0.928357*	1.062938*	-3.286381	-0.840323*
Intercept + Dummies	**5**	-0.919437*	0.511210*	-4.046807	-1.005236*
Intercept + Trend	**5**	-2.549538*	1.101525*	-2.491327	-0.657781*
Intercept + Dummies + Trend	**5**	-2.507327*	0.543032*	-4.094279	-0.777497*

*****indicates statistically insignificant coefficients at 5% significance level

Table. 3 Critical Table Values - HEGY (1990), T=136, %5 Significance Level

Models with deterministic components	$t\pi_1$	$t\pi_2$	$t\pi_3$	$t\pi_4$
–	-1.93	-1.94	-1.92	-1.68
Intercept	-2.89	-1.91	-1.88	-1.68
Intercept + Dummies	-2.94	-2.90	-3.44	-1.96
Intercept + Trend	-3.46	-1.96	-1.90	-1.64
Intercept + Dummies + Trend	-3.52	-2.93	-3.44	-1.94

*****Note: Critical values in table 3 and table 4 have been taken from Hylleberg *et al.* (1990), pp.226-227.

For testing procedure, as shown in table 2, five auxiliary regressions from equation (4.7) to (4.11) with given deterministic components have been run. $t\pi_1$, $t\pi_2$, $t\pi_3$ and t π_4 statistics that are shown in table 2 have been compared with HEGY (1990) critical values at 5% significance level as expressed in table 3. In table 2, the estimates of five auxiliary regression models including various combinations of deterministic components as associated with seasonal unit root analysis have been presented for capital accounts and financial accounts series. Before running the auxiliary regressions, lag length criteria for these five models have been determined amongst various information criteria given in table 1 and the most proper lag length k has been chosen as five taking SC criterion as the basis for all these five models. The critical values to be compared with *t* statistic values above are given in Hylleberg *et al.* (1990).

In order to analyse if unit root exists at zero frequency, π_1 column of the series must be examined in table 2. When calculated *t* values for π_1 are compared to critical values given in table 3, all *t*-values have been found to be insignificant for 5% significance level. Therefore, the null hypothesis could not be rejected at zero (long-run) frequency and it can be inferred that nonseasonal unit root exists (at zero frequency) for all deterministic models.

On the other hand, in order to analyse if unit root exists at ½ (biannual) frequency, π_2 column must be examined in table 2. By looking at *t*-statistic values for π_2, we could say that they are all statistically insignificant for 5% significance level. As a result, nonrejection of the null hypothesis saying that seasonal unit root exists at ½ frequency implies the presence of biannual unit root (at ½ frequency that is six-month frequency) for 5% significance level and for all deterministic models.

After testing the first two hypotheses regarding 0 and ½ frequency, it is time to test the joint hypothesis of $\pi_3 = \pi_4 = 0$ to detect the presence of annual unit root at both ¼ and ¾ frequencies. Therefore, it is necessary to report F statistic values for five models. They are given as follows:

Table. 4 F-Statistic Values and Critical Values at both ¼ and ¾ Frequencies (for k=5)

Models with deterministic components	**F-statistic values** ($\pi_3 = \pi_4 = 0$)	**Critical values at 5% significance Level (T=136)**
–	5.697520	3.14
Intercept	5.632214	3.00
Intercept + Dummies	8.540979	6.63
Intercept + Trend	5.715603	3.04
Intercept + Dummies + Trend	8.563054	6.62

*indicates statistically insignificant coefficients at 5% significance level

In order to test $H_C : \pi_3 = \pi_4 = 0$ joint hypothesis, we need to look at the table 4. As seen in table 4, all F-statistic values are significant for 5% significance level when compared to given critical values. Thus, according to this result the null hypothesis of $\pi_3 = \pi_4 = 0$ is rejected concluding about the nonexistence of annual unit root at ¼ (¾) frequencies.

Theoretically, π_3 values are used to examine the presence of seasonal unit root at ¼ frequency. As an alternative strategy for testing $\pi_3 = \pi_4 = 0$ joint hypothesis, these values can be utilized. However, such an evaluation depends on examining π_4 column at first. Since in case $\pi_4 = 0$ hypothesis is accepted, it is possible to test $\pi_3 = 0$ hypothesis. When looked at the table 2 for testing $\pi_4 = 0$ hypothesis, it is concluded that *t-statistic values* for $\pi_4 = 0$ are insignificant. Thus, $\pi_4 = 0$ hypothesis is accepted and in this instance we can continue for testing $\pi_3 = 0$. Then when looked at π_3 values in table 2 as a result of comparison with critical values in table 3, it is obvious for *t* values to be significant and thus we have to reject the null hypothesis and conclude about the nonexistence of annual unit root at ¼ (¾) frequencies that gives the same result with testing the $\pi_3 = \pi_4 = 0$ joint hypothesis directly.

Now we recourse to other criteria except Schwarz information criterion and try to apply HEGY procedure by choosing the most frequently repeated order "8" as seen in table 1 for all five models. Application results have been presented as follows:

Table. 5 t-Statistic Values of HEGY Regression Parameters for Five Models (for k=8)

Deterministic Component	**Lag Parameter, k**	π_1	π_2	π_3	π_4
–	**8**	0.576304*	0.711918*	-2.496508	-0.127825*
Intercept	**8**	-0.080821*	0.710686*	-2.483929	-0.115891*
Intercept + Dummies	**8**	-0.124514*	0.183788*	-3.349960*	-0.092946*
Intercept + Trend	**8**	-1.799091*	0.692600*	-2.491327	-0.072704*
Intercept + Dummies + Trend	**8**	-1.835393*	0.177576*	-3.379871*	-0.012402*

*****indicates statistically insignificant coefficients at 5% significance level

In order to detect the presence of zero-frequency unit root, we have to look at the column of π_1. When *t* values for π_1 are compared to critical values given in table 3, the results show the insignificance of *t* values for 5% significance level implying that the null hypothesis could not be rejected at zero (long-run) frequency and nonseasonal unit root exists for all deterministic models.

For analysing if unit root exists at ½ (biannual) frequency, the column of π_2 has to be examined in table 5. When looked at *t*-statistic values for π_2, we conclude that they are all statistically insignificant for 5% significance level. As a result, we cannot reject the null hypothesis saying that seasonal unit root exists at ½ frequency and thus conclude about the presence of semi-annual unit root (at ½ frequency, that is six-month frequency) at 5% significance level for all deterministic models.

When it comes to test $H_C : \pi_3 = \pi_4 = 0$ joint hypothesis that implies the presence of annual unit root regarding the lag parameter k as 8, we need to evaluate F statistic values reported as follows:

Table. 6 F-Statistic Values and Critical Values at both ¼ and ¾ Frequencies (for k=8)

Models with deterministic components	**F-statistic values** ($\pi_3 = \pi_4 = 0$)	**Critical values at 5% significance Level (T=136)**
–	3.125616*	3.14
Intercept	3.092679	3.00
Intercept + Dummies	5.617547*	6.63
Intercept + Trend	3.106573	3.04
Intercept + Dummies + Trend	5.712241*	6.62

*indicates statistically insignificant coefficients at 5% significance level

In the case of lag order 8, it is encountered with a different conclusion compared to lag order 5. When lag order is taken as 5 in table 4, no annual unit roots have been found at ¼ (¾) frequencies at 5% significance level for all five models. However, in case lag order is taken as 8, it can be observed that for three models which are the ones with no deterministic component, intercept & dummies and intercept, trend & dummies the presence of annual unit root at ¼ (¾) frequencies cannot be rejected. On the other hand, no unit roots have been found at these frequencies only for the models with the intercept and intercept & trend.

6. Conclusions:

As well known, capital and financial accounts constitute a major part of balance of payments with current account. They could tell something about the strategies or current situation of an economy. For instance, if a country has a weak international performance on these accounts, it may have an undeveloped capital market. In today's world, countries should have liberalization policies on these accounts that will vanish all obstacles on international capital flows. Therefore, if there is an opportunity to find out that at which frequencies these accounts show seasonal pattern, it has been believed that this information will be useful for a country in determining the right policy in international arena. So that the purpose of this study is to apply HEGY seasonal unit root test on capital and financial accounts of balance of payments by using quarterly data. In this paper, five auxiliary models with the combinations of various deterministic components have been used in detecting at which frequencies seasonal unit roots exist. For each model, the most proper lag length has been chosen as five taking Schwarz information criterion as basis as seen in table 1 and three basic hypotheses have been tested in order to investigate about the presence of nonseasonal, biannual and/or annual unit roots. Critical values have been taken from Hylleberg *et al.*(1990). As a result, it has been found that the series in question has nonseasonal (at zero frequency) and biannual unit roots (at ½ frequency) for all deterministic models at 5% significance level over the period 1984Q1 – 2014Q2. However, it does not have annual unit root at ¼ (¾) frequencies for the given period. In this study, the HEGY testing procedure has been also applied for lag order 8. The results for nonseasonal and biannual unit roots are the same as the ones for lag order 5. However, for detection of annual unit roots the results differentiate from the ones for lag order 5. While no annual unit roots have been found in the case of lag order 5, for lag order 8 the presence of annual unit roots could not be rejected only for the models with no deterministic component, intercept+dummies and intercept+dummies+trend. Briefly it can be said that nonseasonal and semi-annual unit roots exist for both lag orders. The only difference has appeared in the case of annual unit roots. The presence of annual unit roots has been detected only for three models for lag order 8.

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