PANOECONOMICUS, 2009, 1, str. 39-53 UDC 339.727 (560)

DOI: 10.2298/PAN0901039T
ORIGINAL SCIENTIFIC PAPER

Seasonal Co-integration – An Extension of the Johansen and Schaumburg Approach with an Exclusion Test*

Ozlem Tasseven**

Summary: In this paper, the Johansen and Schaumburg method for seasonal co-integration has been tried to be applied for testing an *a priori* hypothesized co-integrating money demand variable space. We aim to provide a comprehensive discussion of the significance of the variables in the long-run context as stationary relationships for both zero and bi-annual frequencies. For this purpose, several restrictions have been used to impose for identification purposes of the relevant vectors. We also touch upon the possibility that most time series data have been subject to the stochastic seasonality as opposed to the general acceptance in empirical papers. Our results employing data from the Turkish economy show that it is not possible to estimate only a single theory-accepted money demand relationship in the long-run variable space for both zero and bi-annual frequences, but we are able to identify different vectors somewhat consistent with theoretical arguments for the annual frequency.

Key words: Seasonality, Co-integration

JEL: B23, C16, C32, C82, E41

Introduction

The analysis of unit roots and co-integration at zero frequency has recently been extended to the seasonal frequencies in the co-integration literature. Assuming that there is a deterministic seasonality when in fact a stochastic seasonality exists may lead to inappropriate inferences about both the short- and the long-

* Main parts of the paper were written while the author was at the Newcastle University for her Philosophy Doctorate researches. The author is grateful to her supervisor Hugh Metcalf of the Newcastle University and Aysit Tansel of the Middle East Technical University for helpful comments and suggestions. The author also would like to thank Levent Korap for his invaluable efforts for the final design of the paper.
** Okan University, Banking and Finance Department, Istanbul Turkey:
ozlem.tasseven@okan.edu.tr *Received:04 September 2008; Accepted: 23 December 2008.*

run dynamics of a system of variables (Lof and Lyhagen, 2002). Dealing with a money demand functional relationship, Soto and Tapia (2001) state that when the seasonal co-integrating vectors have been omitted from the estimation they are likely to be resulted in a substantial fraction of the observed instability in the long-run variable space. Thus permitting seasonal frequencies in a co-integration analysis has been of a special importance especially when the researchers choose their main issue of interest as carrying out an analysis of the money demand relationship. On this subject, Lee (1992) tries to develop a seasonal co-integration approach using reduced rank regression (RR) procedure, however, the method suggested for this purpose has a limitation of applying only to synchronous co-integration at annual frequency. Following the seasonal co-integration approach of Lee (1992), Franses and Kunst (1999) and Johansen and Schaumburg (1999) extend this approach by some modifications. Of the two papers, Johansen and Schaumburg (1999) succeed in developing a maximum likelihood inference for seasonal series and introduce a general asymptotic theory. For this purpose, they consider a polynomial (non-synchronous) co-integration approach in an error-correction modelling (ECM) framework with complex valued coefficient matrices and apply to an iterative procedure for estimating co-integration relations at annual frequency. Ahn and Reinsel (1994) initially develop the Gaussian reduced rank estimation that deals with the polynomial co-integration and Cubadda (2001) extends the reduced rank regression procedure by using an ECM that includes complex valued data.

In this paper, the methodology of Johansen and Schaumburg (1999) has been re-examined and then applied to a conventional money demand space also subject to some exclusion tests using data from the Turkish economy. In the recent empirical literature upon this issue, exclusion tests have not been frequently considered by the researchers.[1] Thus our applied research can be one of the recent contributions upon this issue for testing whether the significant knowledge of money demand relationship or some stationary linear combinations extracted from variables attributed to the long-run *a priori* hypothesized money demand variable space can be associated with the potential co-integrating relationship(s). In this sense, we try to discuss the significance of the variables in the long-run co-integration space for both zero and bi-annual frequencies. For this purpose, we use seasonal co-integration methods by also imposing some restrictions upon the relevant vectors examined so that the identification of the co-integrating relationships can be obtained.

We also touch upon the possibility that most time series data have been subject to the stochastic seasonality, but this issue in general has been ignored for that the seasonality of co-integrating relationships tends to be modelled

[1] Among many others, for example, see Hamori and Tokihisa (2001) and Herwartz and Reimers (2003). The author would like to thank an anonymous referee who calls attention on this ssue.

deterministically. A typical representation of the time series data that account for time varying trends and seasonal components assumes the presence of the stochastic trends at zero and seasonal frequencies. Moreover, the long-run relationships among the seasonal frequencies cannot unfortunately be considered in the papers constructed on such issues.

The paper is organized as follows. The next section gives a brief review of the papers that examine the concept of seasonal co-integration. Section 3 describes data used in the paper. In section 4 an empirical model has been tried to be carried out by way of employing the HEGY tests described below upon the Turkish economy. The last section summarizes results and concludes.

1. A Brief Review of the Papers on the Seasonal Co-integration

The presence of a co-integrating relationship between the variables of interest can be attributed to the validity of a parallel long-run movement in the non-stationary time series data, whereas co-integration at a particular seasonal frequency can be interpreted as some evidence for a parallel movement that lies in the corresponding seasonal component of the time series data with a varying seasonal pattern. The concept of co-integration has been extended to modelling seasonality in Hylleberg et al. (1990) (henceforth HEGY) and also the test for seasonal co-integration has been mainly revealed by Engle et al. (1993). When the empirical papers constructed on seasonal co-integration have been examined, it is observed that they tend to mostly follow the approach developed by Lee (1992) for multivariate system analyses and that the concept of co-integration for zero frequency is extended for seasonally integrated series.

If we briefly touch upon the main contribution of these papers; Lee (1992) presents a maximum likelihood estimator for seasonal co-integrating relations similar to the approach proposed by Johansen (1995) for zero frequency. In the original specification of seasonal error correction model presented in Lee (1992), a certain restriction at the complex frequency is suggested assuming the absence of *so-called* non-synchronous seasonal cycles. Kunst (1993) and Franses and Kunst (1999) state that by imposing this restriction the testing procedure for the number of co-integrating vectors at annual frequency becomes the same as the zero and bi-annual frequencies. However, Johansen and Schaumburg (1999) argue that this restriction is too strong and only partially correct as well as being not justified theoretically. All aspects of asymptotic inference are treated using complex Brownian motion which simplifies the calculations for the annual frequency for limit distribution. Furthermore in the more general seasonal error correction modelling (SECM) specification proposed by Johansen and Schaumburg (1999) quarterly observed variables containing different number of unit roots, which are likely to be a more common situation when the real world data are taken into account, have been considered. Franses and Kunst (1999) criticize the inclusion of the deterministic seasonal dummy variables into the SECM unrestrictedly. They argue that these constants should exist in the seasonal co-integration relations instead and infer that if co-integration at the seasonal frequency exists the inclusion of unrestricted seasonal intercepts would lead to divergent trends in the seasonal cycles. However, such a case has not been observed in the real data sets.

In order to accommodate possible deterministic seasonal effects, deterministic seasonal dummies have generally been used in the analyses. Using the Lee (1992) approach, Lee and Siklos (1995), Kunst (1993) and Ermini and Chang (1996) test stochastic seasonality with / without deterministic seasonal dummies. Solo and Tapia (2001) and Mcdougall (1994) include seasonal dummies without any restriction in the co-integration space using a seasonal co-integration modelling approach proposed by Engle et al. (1993). As Ermini and Chang (1996) clearly state, adding deterministic seasonal dummies over-parametrizes seasonality and thus no inference can be made in a certain way about whether or not the estimation of the SECM must include seasonal dummies. Since the estimated ranks and co-integrating vectors can differ across the methods applied in the analyses, it is difficult to compare the results of the studies on seasonal co-integration efficiently. On this issue, Lee and Siklos (1995, 1997), Kunst (1993), Shen and Huang (1999), Ermini and Chang (1996) and Herwartz and Reimers (2003) apply to the Lee (1992) approach as an original method for modelling seasonal co-integration in their analyses. Cuevas (2002) uses the seasonal vector error correction and structural time series models and compares the estimation results between the competing methods, while Mcdougall (1994), Hamori and Tokihisa (2001) and Solo and Tapia (2001) apply to the Engle et al. (1993) approach.

Papers in the literature using seasonal co-integration other than Engle et al. (1993) approach have not provided the statistical significance of the variables and thus have not supplied useful guidance for the inspection of monetary authorities. In these studies mainly the number of co-integrating vectors has been obtained at each frequency and all co-integrating vectors have been normalized according to the monetary aggregate used in the study assuming that vector represents a money demand relation. In this respect, our paper can be considered an empirical contribution to these issues.

2. Data

In this paper, we aim to test the Johansen and Schaumburg approach with an application carried out upon a conventional money demand space using data from the Turkish economy. For empirical purposes, the monetary variable we use ($RealM2_t$) is the M2 broad monetary aggregate inclusive of currency in circulation plus demand and time deposits in the banking system excluding the foreign currency based deposits. Under the assumption of no money illusion, we suppose that demand for money is a demand for real money balances. In our case, we use the GDP-deflator to deflate the broad money supply. The other variables used in our empirical analysis are the real GDP data (Gdp_t) as a scale income variable to represent the maximum amount of money balances that the economic agents can hold, the weighted nominal interest rate on 3 and 12 months deposits (Int_t) to represent the return on interest-bearing financial assets and the monthly inflation (Inf_t) to represent the expected rate of return on real assets under the assumption of substitution between commodities and domestic money. For the relevant interest rate data, a combination of compound interest rates is used as a share of deposits by maturity.

A significant presence of the rate of change of exchange rate in the demand function for real money balances may provide evidence of currency substitution especially in high inflation countries, which reduces domestic monetary control by also reducing the financing of deficit by means of seigniorage and the base of the inflation tax. Since the Turkish economy is a small open economy with a highly liberalized capital account, such a consideration for the alternative costs to hold money may be crucial for the economic agents. Indeed, the proportion of foreign exchange based accounts in the Turkish banking system grows from 16% in 1987 till 57% by the end of 2001, which reflects a great deal of dollarization and currency substitution for the Turkish economy.[2] So we have also included into our model specification a variable (Dep_t) representing exchange rate depreciation and currency substitution phenomenon settled in the economy.

More clearly to say, the variable Dep_t has been calculated as $\ln(nom_t)$-$\ln(nom_{t\text{-}1})$, where nom_t is defined as the nominal exchange rate of the Turkish lira against the US dollar and the phrase ln represents the natural logarithm operator. The Turkish lira / US dollar exchange rate has been used because the US dollar is the main alternative currency used in transactions and as a store of value. Likewise, the variable Inf_t is defined as the first difference of the natural logarithm of the price level represented by consumer price indices (cpi_t), which is calculated as $\ln(cpi_t)$ - $\ln(cpi_{t\text{-}1})$. Thus, we must express that these latter variables have been constructed by use of their past realizations.

[2] Giovannini and Turtelboom (1992), Yılmaz (2005) and Civcir (2005) touch on the difference between the terms dollarization and currency substitution in the sense that in high inflation countries foreign currency is first used as a store of value or unit of account representing dollarization and only at the later used as a medium of exchange. That is, currency substitution is the last stage of the dollarization process. But, for our estimation purposes in this paper, we can ignore such a theoretical distinction.

In this paper, for empirical purposes, the quarterly frequency data have been used and all the data in their seasonally unadjusted forms have been taken from the electronic data delivery system of the Central Bank of the Republic of Turkey covering the period from 1986Q1 to 2003Q1. The model considered to be tested can be written down in a linear functional relationship as follows:

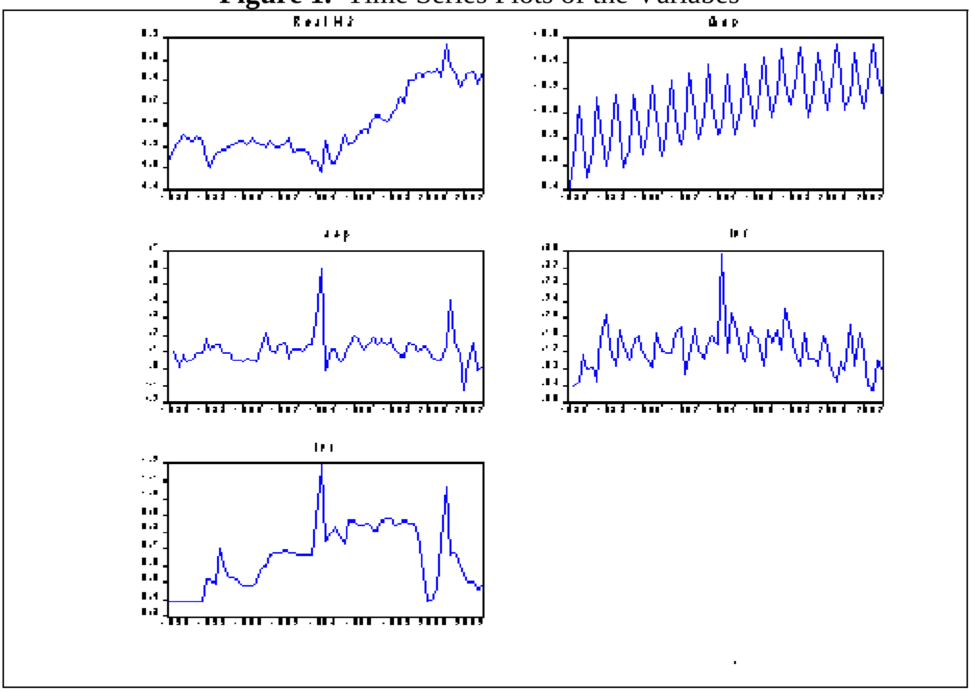
$$RealM2_t = \mathrm{f}(Gdp_t, Inf_t, Int_t, Dep_t) \tag{1}$$

or more clearly in a log-linearized form with expected signs:

$$RealM2_t = \alpha + \beta\, Gdp_t - \delta\, Inf_t - \phi\, Int_t - \gamma Dep_t + \varepsilon_t \tag{2}$$

where ε_t is assumed to represent a random disturbance term whitening the error structure. Fig. 1 below shows the time series graphs of the variables used in the analysis. As can easily be noticed, there seems to be a strong seasonal pattern in the Gdp_t series. We can also expect seasonality in the inflation data because of the strong dependence between the climate conditions and domestic prices. However, seasonality has not now been found as dominating as in the Gdp_t series.

Figure 1. Time Series Plots of the Variabes



3. HEGY Tests for Sasonality

In this study the seasonality in the Turkish economy has been extensively modelled while also allowing seasonal mean shifts in more than one year and the HEGY (1990) seasonal unit root procedure is tried to be enlarged by including dummy variables for the seasonal mean shifts. So the effects of more than one structural break in modelling seasonality have been tried to be taken into consideration under the assumption that the breaks considered are exogenous and occurred at known dates. By this way the distribution of the HEGY (1990) test for the seasonal unit roots can be revealed with respect to the mean shifts. Using a Monte Carlo simulation method the percentage points of the modified HEYG test distributions have been calculated for several sample sizes. We must state that the original HEGY (1990) seasonal unit root test procedure which does not account for the presence of possible structural breaks can be considered more powerful when the data do not in fact have seasonal mean shifts. Thus there must be clear evidence of structural breaks in the data in order to use modified HEGY test procedure.[3]

For informational purposes we must specify that once the order of integration of the variables using an endogenous variable vector X_t has been determined, an unrestricted vector autoregressive (VAR) model with 4+n lags, seasonal intercepts and modified linear term has been estimated as in Eq. 3:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots + A_n X_{t-4-n} + D_t + \mu f(t) \qquad (3)$$

In Eq. (3), for the maximum lag length is to be *a priori* considered as 8, the optimal lag of the underlying VAR model is determined as 5 in line with the widely used sequential modified LR statistics and the Akaike information criterions. In Tab. 1, the modified HEGY test results for testing seasonal unit roots have been presented for the possible shifts of the seasonal means in the crises years 1994 and 2001 witnessed by the Turkish economy:

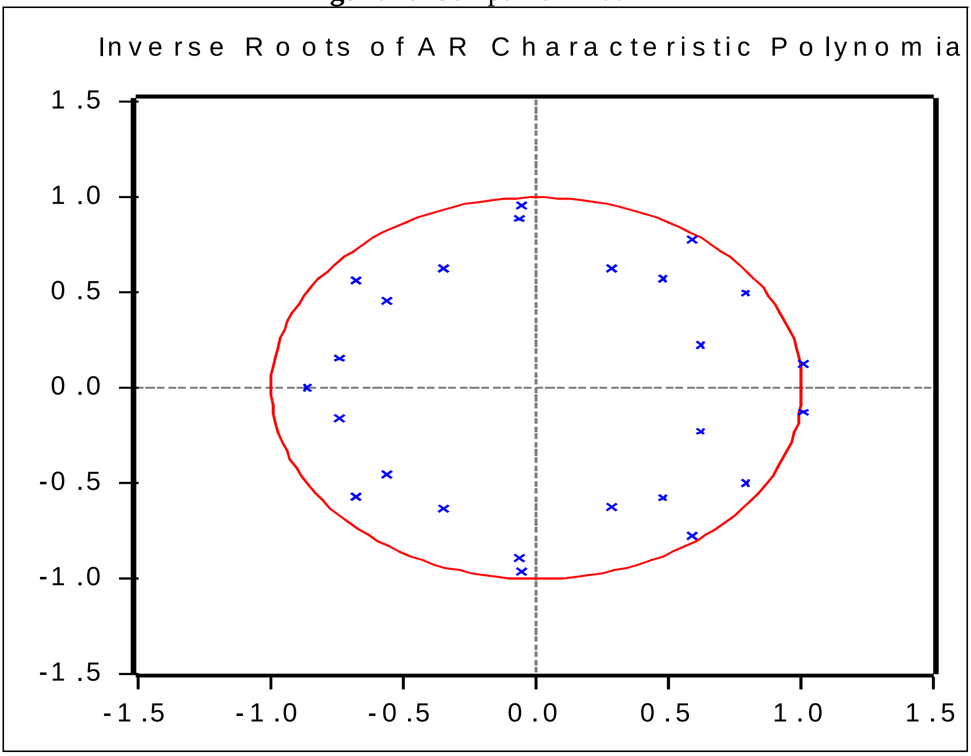
Table 1. Modified HEGY Test in the Presence of Mean Shifts in Two Years

Variables	Modified HEGY
Gdp_t	Unit roots at π_1, π_2, π_3 and π_4
$RealM2_t$	Unit roots at π_1, π_2, π_3 and π_4
Dep_t	Unit root at π_1
Inf_t	Unit roots at π_1, π_3 and π_4
Int_t	Unit root at π_1

[3] For more detailed investigation of this estimation procedure, see Battal (2007).

Modified HEGY test procedure for seasonal unit roots for the Gdp_t series shows that there are unit roots at zero and seasonal frequencies. Test results for the $RealM2_t$ variable reveal that there are unit roots at zero and seasonal unit roots at annual frequencies. It is also found that there is seasonal unit root at bi-annual frequency. Test results for the depreciation rate show that there are unit roots at zero frequency. It is found that there are unit roots at zero frequency and seasonal unit roots at annual frequency for the domestic inflation. For the interest rates on deposits we find unit roots only at zero frequency. We can easily observe in Fig. 2 of the companion matrix below that there exist unit roots at all frequencies:

Figure 2. Companion Matrix



To test the seasonal co-integration, the trace test results calculated for the zero and bi-annual frequencies using the Johansen and Schaumburg (1999) approach have also been presented in Tab. 2 below. In the trace test for zero frequency the null hypothesis of r against the alternative of p co-integrating relations has been tested. We must note that for the annual frequency the trace tests have been implemented separately for each rank condition by way of employing log-likelihood estimation findings. In the conventional co-integrating analysis, the asymptotic distributions of this test have always been given for testing against the full model, however in our paper we consider bi-annual and annual frequencies. For example in order to test the null hypothesis that the number of rank equals one at annual frequency L(5, 5, 1) – L(5, 5, 5) is calculated. It is not possible to calculate the log-likelihood ratio test statistics for rank zero at annual frequency as the log-likelihood does not exist which prevents researcher to calculate the log-likelihood ratio using relevant values of log-likelihoods. The trace test results show the presence of 4 potential co-integrating vectors at the zero frequency and three co-integrating vectors at the bi-annual frequency.

In the trace test for zero frequency, the null hypothesis of *r* co-integrating relations against the alternative of *p* co-integrating relations, for *r* = 0,1, ..., *p*-1 where *p* is the number of endogenous variables are constructed. The null hypothesis that there are at most *r* co-integrating vectors and thus *p*-*r* unit roots is tested. This restriction can be imposed for different values of *r* and then the log of the maximized likelihood function for the restricted model is compared to the log of the maximized likelihood function of the unrestricted model and a standard likelihood ratio test computed. Trace test statistics are interpreted for bi-annual and annual frequencies similarly:

Table 2. Trace Test Statistics

p-r	Frequency w=0		*w*=1/2		*w*=1/4		
	Trace	%10	Trace	%10	Trace	%10	5 %
5	116.34***	82.68	84.89***	64.74			
4	75.71***	58.96	53.55***	43.84	104.33***	95.6 1	100.45
3	48.71***	39.08	28.28***	26.70	50.01	60 .01	63.9
2	25.15***	22.95	12.66	13.31	23.89	32.48	35.47
1	11.61**	10.56	4.46***	2.71	6.16	13.07	15.12

Notes: Critical values for the trace test statistics for the annual and bi-annual frequencies include restricted seasonal intercepts and a restricted zero frequency trend. *** and ** denotes rejection at 10% and 5% significance levels, respectively. *r* shows the rank of the trace test statistics whereas (*p-r*) shows the number of stochastic trends and *p* is the number of variables, which is 5 in our analyses. The trace test statistics at zero frequency for (*p-r*)=1 imply that 5-*r*=1, so that *r*=4 is rejected at 5% level and it is accepted at 10% level using the critical values for the trace test statistics for the zero frequency supplied by Pedersen (1996) for model 3. The trace test statistics at bi-annual frequency for (*p-r*)=2 imply that 5-*r*=2, so that *r*=3 is accepted at 5% level using the critical values for the trace statistics for bi - annual frequency supplied by Pedersen (1996) for model 3. The trace test statistics at annual frequency for (*p-r*)=3 implies that 5-*r*=3, so that *r*=2 is accepted at 5 % level using the critical values for the trace statistics for annual frequency supplied by Johansen & Schaumburg (1999) for model 3.

Trace test statistics given in Tab. 2 indicate that unlike to our *a priori* expectations for a conventional money demand model, the Turkish data reveal 4 potential co-integrating vectors at the zero frequency considering 10% critical values and 3 co-integrating vectors at the bi-annual frequency according to the 5% critical values. Two co-integration relations at the annual frequency are found to exist within the range of 5% critical values. The hypothesis testing for a restricted zero-frequency intercept cannot be rejected by the data. This result is not surprising as there is no trending pattern in the inflation and depreciation rate and there is a slight trend in the Gdp_t series. The un-normalized and normalized seasonal co-integrating vectors at the zero frequency can be seen in Tab. 3 and Tab. 4 below, respectively:

Table 3. Un-normalized Co-integrating Vectors at the Zero Frequency

Variables	Coefficients			
Dep_t	0.6373	-0.1359	0.6842	0.2431
Int_t	0.3154	-0.6919	-0.5607	0.3247
Inf_t	-0.0629	0.2273	-0.2158	0.0447
$RealM2_t$	-0.0271	-0.4518	0.1397	-0.7269
Gdp_t	-0.0596	0.1955	-0.0279	0.4212
constant	0.6972	0.4569	-0.3882	-0.3573

At zero frequency as there as 4 co-integrating vectors, 1 common stochastic trend exists in the system. It is not uncommon to find more than one co-integrating relationship in a system with more than two variables using Johansen procedure. Some researchers in this situation revert back to a system with one co-integrating vector by choosing the vector corresponding to the largest eigenvalue or by choosing the most theoretically plausible co-integrating relationship. Since the Johansen approach only provides information on the uniqueness of the co-integration space, it will be necessary to impose some restrictions to obtain unique vectors lying within the co-integrating space and then test whether the columns of β are identified. In our paper, to achieve identification the variables have been normalized in a way that we assume a linear stationary relationship running from the real GDP to each of the variable for testing purposes. Normalized co-integration vectors have been given below:

Table 4. Normalized Co-integrating Vectors at Zero Frequency

Variables	Coefficients			
Dep_t	1	0	0	0
Int_t	0	1	0	0
Inf_t	0	0	1	0
$RealM2_t$	0	0	0	1
Gdp_t	-0.18	-0.04	-0.79	-0.70
constant	1.72	0.35	7.46	1.68

Four co-integrating vectors can be re-written as follows:

$$Dep_t = 0.18\ Gdp_t - 1.72 \tag{4}$$

$$Int_t = 0.04\ Gdp_t - 0.35 \tag{5}$$

$$Inf_t = 0.79\ Gdp_t - 7.46 \tag{6}$$

$$RealM2_t = 0.70\ Gdp_t - 1.68 \tag{7}$$

We find that there seems to exist a positive relationship between real income data and depreciation rate, real income and inflation and real income and real money balances. The relation between interest rate and real income takes a value about zero. According to the exclusion test results we have found that all the variables belong to the co-integration space at zero frequency. Tab. 5 shows the identified co-integration vectors at bi-annual frequency:

Table 5. Normalized Co-integrating Vectors at Bi-annual Frequency

Variables	Coefficients		
Dep_t	1	0	0
Int_t	0	1	0
Inf_t	0	0	1
$RealM2_t$	1.02	-1.65	-0.73
Gdp_t	0	0	-1
constant	-0.01	0.03	0.06

The normalizations applied for identification of the co-integrating vectors in this case can be written as follows:

$$Dep_t = -1.02\ RealM2_t + 0.01 \tag{8}$$

$$Int_t = 1.65\ RealM2_t - 0.03 \tag{9}$$

$$Inf_t = 0.73\ RealM2_t + Gdp_t - 0.06 \tag{10}$$

The monetary authorities should consider the growth rates of gross domestic product and the money supply measure when conducting monetary policy since the half-yearly movements of $RealM2_t$, Inf_t and Gdp_t are related to each other. There is a long run relationship between all these aggregates at the bi-annual frequency. According to the modified HEGY test procedure results $t\pi_2$ test statistics have not been rejected at the 2.5% significance level. $RealM2_t$ variable is seasonally integrated at bi-annual frequency at the 2.5% significance level. Therefore, the weak finding of seasonal co-integration at bi-annual frequency still makes sense. In order to decide about the significance of the variables in the long-run co-integration space at bi-annual frequency, exclusion tests for each variable have been undertaken. In analysing the annual frequency, the LR-test for the real beta hypothesis is accepted as the likelihood ratio test statistic yields a p-value that is of magnitude 0.10. Thus only the co-integrating vectors at the annual frequency for β_R have been normalized in Tab. 6 below:

Table 6. Normalized Cointegrating Vectors at the Annual Frequency

Variables		
Dep_t	0.27	-0.35
Int_t	1.03	0.23
Inf_t	1	-1.35
$RealM2_t$	0.31	1
Gdp_t	-0.07	2.82
constant	-0.21	0.05

The two co-integrating vectors can be re-written as follows:

$$RealM2_t = -0.35\ Dep_t + 0.23\ Int_t - 1.35\ Inf_t + 2.82\ Gdp_t + 0.05 \tag{12}$$

$$Inf_t = 0.27\ Dep_t + 1.03\ Int_t + 0.31\ RealM2_t - 0.07\ Gdp_t - 0.21 \tag{13}$$

We now normalize the first vector on the real money balances and are able to find a vector which has similar characteristics as for a money demand vector. Real income has a positive but larger than unity coeficient which probably leads to the decreasing velocity of money in long-run stationary equilibrium conditions. As alternative costs to hold money balances, depreciation rate and inflation have been found with a negative sign representing their opportunity cost characteristics. The exception to the theoretical considerations is the interest rate. For the second vector, we can infer that domestic inflation has a positive relationship with exchange rate depreciation which can be attributed to the imported inflation through exchange rate channel. Also there seems to be a long-run positive relationship between the interest rate and inflation which somewhat supports a *so-called* Fisher type relationship that requires real interest rates be stationary in the long-run. Thus the data used in annual frequency are most likely to produce a monetary relationship that can theoretically be explained for the Turkish economy.

Conclusion

In this paper, the Johansen and Schaumburg method for seasonal co-integration has been tried to be applied for testing an *a priori* hypothesized co-integrating money demand variable space. We aim to provide a comprehensive discussion of the significance of the variables in the long-run context as stationary relationships for both zero and bi-annual frequencies. For this purpose, several restrictions have been used to impose for identification purposes of the relevant vectors. We also touch upon the possibility that most time series data have been subject to the stochastic seasonality as opposed to the general acceptance in empirical papers. Our results employing data from the Turkish economy show that it is not possible to estimate only a single theory-accepted money demand relationship in the long-run variable space for zero and bi-annual frequences, but we are able to identify different vectors somewhat consistent with theoretical arguments for the annual frequency.

References

Ahn, and Greg C. Reinsel. 1994. "Estimation of Partially Non-stationary Vector Autoregressive Models with Seasonal Behaviour."*Journal of Econometrics,* 62: 317-350.

Alberto, and Bart Turtelboom. 1992. "Currency Substitution." NBER Working Paper 4232.

Altinkemer, Melike. 2004. "Importance of Base Money Even When Inflation Targeting." Central Bank of Republic of Turkey Research and Monetary Policy Department Working Paper 04/04.

Battal, Ozlem. 2007. "Money Demand and Currency Substitution for Turkey." PhD Diss. Newcastle University.

Chung-Hwa and Tai-Hsin Huang. 1999. "Money Demand and Seasonal Co-Integration." *International Economic Journal,* 13(3): 97-106.

Civcir, Irfan. 2003. "Broad Money Demand, Financial Liberalization and Currency Substitution in Turkey." *Journal of Economic Studies,* 30(5): 514–534.

Cubadda, Gianluca. 2001. "Complex Reduced Rank Models for Seasonally Co-integrated Time Series." *Oxford Bulletin of Economics and Statistics,* 63(4): 497-511.

Cuevas, A. Mario. 2002. "Money Demand in Venezuela: Multiple Cycle Extraction in a Co-integration Framework." World Bank Policy Research Working Paper 2844.

Engle, et al. 1993. "Seasonal Co-integration, the Japanese Consumption Function." *Journal of Econometrics,* 55: 275-98.

Gianluca and Pieter Omtzigt. 2003. "Small Sample Improvements in the Statistical Analysis of Seasonally Co-integrated Systems." University of Molise Economics and Statistics Discussion Papers 12/03.

Hahn S., Lee. 1992. "Maximum Likelihood Inference on Co-integration and Seasonal Co-integration." *Journal of Econometrics,* 54: 1-47.

Hahn, and Pierre L. Siklos. 1995. "A Note on the Critical Values for the Maximum Likelihood (Seasonal) Co-integration Tests." *Economics Letters,* 49: 136-45.

Helmut, and Eggert H.Reimers. 2003. "Seasonal Co-integration Analyses for German M3Money Demand." *Applied Financial Economics*, 13: 71-8.

Hylleberg et. al. 1990." Seasonal Integration and Co-integration." *Journal of Econometrics,* 44, pp. 215-38.

Johansen, Soren. 1995. *Likelihood-based Inference in Co-integrated Vector Auto-Regressive Models.* Oxford: Oxford University Press.

Kunst, Robert. 1993."Seasonal Co-integration, Common Seasonals and Forecasting Seasonal Series." *Empirical Economics,* 18: 761-76.

Luigi, and Dongkoo Chang. 1996." Testing the Joint Hypothesis of Rationality and Neutrality under Seasonal Co-integration." *Journal of Econometrics,* 74: 363-86.

Marten, and Johan Lyhagen. 2002. "Forecasting Performance of Seasonal Co-integration Models." *International Journal of Forecasting,* 18: 31-44.

Mcdougall, R. Stuart. 1994. "The Stability of Velocity: a Test for Seasonal Co-integration." *Applied Economics Letters,* 1: 152-57.

Miron, Jeffrey. 1996. "The Economics of Seasonal Cycles." The MIT Press, Cambridge.

Pedersen, D. Iben. 1996. "A Practical Implementation of the Seasonal Co-integration Theory." PhD Diss. Denmark.

Phillip, and Robert. M. Kunst. 1999. "On the Role of Seasonal Intercepts in Seasonal Co-integration." *Oxford Bulletin of Economics and Statistics, 6*1(3): 409-33.

Raimundo, and Matias Tapia. 2001. "Seasonal Co-integration and the Stability of the Demand for Money." Central Bank of Chile Working Papers 103.

Shigeyuki, and Akira Tokihisa. 2001. "Seasonal Co-integration and the Money Demand Function: Some Evidence from Japan." *Applied Economics Letters,* 8(5): 305-10.

Soren, and Ernst Schaumburg. 1999. "Likelihood Analyses of Seasonal Co-integration." *Journal of Econometrics,* 88: 301-39.

Yılmaz, Gokhan. 2005. "Financial Dollarization, (De)Dollarization and the Turkish Experience." TEA Discussion Paper 2005/6.