FORECASTING PERFORMANCE OF LINEAR AND NON-LINEAR MODELS OF GREEK INFLATION

I. Papanastasiou

T. Karagiorgos

C. Vasiliadis

I. Introduction

Greece has experienced periods of high inflation rate during the past. These movements of Greek inflation are depicted in diagram 1, which shows upward and downward trends from 1970 to 1998. This indicates the efforts of the monetary authorities in controlling inflation. However, Greek inflation rate has always been above European average. Investigating movements of inflation, two general types of models have been used in the literature, that is linear and non-linear time series models. The latter has been drawn much attention due to the developing of computational capabilities. In the present paper we apply both type of models to Greek data of inflation and compare their forecasting performance. Specifically, we estimate a linear autoregressive moving average (ARIMA) model and smooth transition class of non linear models (STAR).

Erlat H. (2002) has examined the performance of different ARIMA models to various specifications of inflation in Turkey. Arango L. and Gonzalez A. (2002) applied STAR-type non-linear models to Colombian inflation rate. They found no evidence of non-linearity for the annual inflation in Colombia.

In the second section, the theoretical models are discussed. Data and empirical results are presented in the third section. The conclusions follow in the last section.

II. The Theoretical Models

ARIMA models have been used frequently in the applied time series for short run forecasting. The formulation and estimation of these models has drawn basically from the Box – Jenkins approach. A general ARIMA (p, o, q) model is:

$$Y_t = a_0 + \sum_{i=1}^{p} a_i Y_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \varepsilon_t \qquad [1]$$

where Y_t is a stationary variable, and ε_t is an identically independently normally distributed random variable (error) with zero mean and constant variance.

The most known model of the smooth transition non-linear class is the threshold autoregressive (TAR) model, proposed by Tong (1978), Tong and Lim (1980). This model assumes that the regime occurring at time t is determined by an observable variable Z_t. That is the regime is determined by the value Z_t relative to a threshold value denoted c. As a special case threshold variable Z_t is taken to be any past value of the series itself.

A general STAR (p) model is given by:

$$Y_t = a_o + \sum_{i=1}^{p} a_i Y_{t-i} + \left(a'_o + \sum_{i=1}^{p} a'_i Y_{t-i} \right) \Phi(Y_{t-d}) + \varepsilon_t \quad [2]$$

where Φ is a transition function bounded by zero and one. Teräsvirta (1994), Granger and Teräsvirta (1993) have suggested two specifications of the transition function, that is the logistic function and the exponential function.
The logistic transition function is:

$$\Phi(Y_{t-d}) = 1/(1+\exp[-\gamma(Y_{t-d}-c)]),\ \gamma > o \quad [3]$$

Substituting [3] into [2] yields the logistic STAR model (LSTAR)

The exponential transition function is:

$$\Phi(Y_{t-d}) = 1-\exp[-\gamma(Y_{t-d}-c)^2],\ \gamma > o \quad [4]$$

Replacing [4] into [2] yields the exponential STAR model (ESTAR). The parameter γ represents the speed of the transition process.

III. Data and Empirical Results

Our data set consists of quarterly values of the consumer price index (CPI) for Greece from 1970 first quarter to 1998 fourth quarter. These values have been obtained from the OECD (2000) database.

Initially, we examine whether Greek inflation is a stationary variable or it has unit roots.

Table 1: UNIT ROOT TESTS	
Test	5% Critical Value
ADF (8 lags) = 2.67	-2.89
PP (16 lags) = 212.34	-14.51
B. = 0.00522	0.01004
KPSS (16 lags) = 0.2231	0.463

Table 2: ADF AND STRUCTURAL BREAKS	
Test	5% Critical Value (sample size = 100)
Recursive = -3.275	-4.33
Rolling = -2.577	-5.01
Mean Shift: r = -3.448	-4.80
Mean Shift: F =14.96	18.62

The table 1 shows the results of the unit roots tests for the inflation.

Where ADF is the augmented Dickey – Fuller test, PP is the Phillips – Perron test (see Phillips and Perron (1988)), B is the Breitung test (see Breitung (2002)) and KPSS is the Kwiatkowski, Phillips, Schmidt and Shin (1992) test.

As we can see from Table I, all test except ADF test show that inflation is a stationary variable. Since ADF test has poor and size properties, we try to estimate this test assuming the presence of structural breaks in the inflation series. Using a recursive, rolling and sequential approach suggested by Banerjee et al. (1992), we allowed for an endogenously determined structural break. The ADF tests are provided in table 2.

Again the tests of table 2 indicate a rejection of the stationarity hypothesis. However, these tests have been criticized as testing the joint hypotheses of a null of unit root and no break in the series where the right approach is to allow for breaks under both the null and the alternative hypotheses. Thus, we use the approach suggested by Perron (1994), Perron (1997) and the modifications of Harvey, Leybourne and Newbold (2001) and Zivot – Andrews (1992). The tests allowing change only in the intercept are presented in table3.

From table 3 we can see that the conclusion from the tests crucially depends on the lag structure. Therefore all the unit – root test cannot unequivocally reject the hypothesis

Table 3: BREAKS AND ADF TESTS (Perron's approach)		
Test	Break Date	5% Critical Value
Perron (using 2 lags) = -6.17	1993:1	-4.80
Harvey et.al. = -6.04	1993:2	
Zivot – Andrews = -6.20	1993:2	
(using 4 lags)		
Perron = -4.03	1993:1	
Harvey et. Al. = -3.94	1993:2	
Zivot-Andrews = -4.05	1993:2	

TABLE 4: ESTIMATION OF ARIMA (4,0,2)			
Parameter	Estimate	T-statistic	P-value
α_0	2.92	3.75	0.000
α_1	-0.04	-0.67	0.505
α_2	-0.02	-0.37	0.715
α_3	0.003	0.06	0.950
α_4	0.86	17.9	0.000
I73	9.19	8.93	0.000
I74	-1.54	-1.50	0.137
I85	4.11	4.43	0.000
β_1	0.17	1.12	0.265
β_2	0.38	2.45	0.016

Normality = (0.067), ARCH(1) = (0.6983), Q(12) = (0.1836).

of non-stationarity. For that reason we finally calculate the ADF-GLS test, which has, been shown by Vogelsang (1999) to be robust against the presence of additive outliers.

ADF – GLS = -2.35, 5% critical value = - 1.94.

Thus, the ADF – GLS test indicates a rejection of the null hypothesis of non stationarity. Therefore we conclude that inflation is stationary.

Using the Box-Jenking approach we specified an ARIMA (4,0,2) to the series of inflation. The estimates are given in table 4.

Where p-values are in parentheses for normality, ARCH and Portmanteau (Q) tests.

The empirical estimates of the LSTAR (2) model with d=2, are given in table 5.

TABLE 5: ESTIMATION OF LSTAR			
Parameter	Estimate	T-statistic	P-value
α_0	-3.76	-2.05	0.040
α_1	1.43	3.42	0.001
α_2	-0.63	-1.62	0.105
I73	9.75	5.09	0.000
I74	-1.39	-0.72	0.470
I85	5.15	2.69	0.007
α'_0	7.99	3.42	0.001
α'_1	-1.87	-4.10	0.000
α'_2	0.93	2.56	0.010
γ	1.75	2.28	0.023
c	2.26	6.69	0.000

$R^2 = 0.546$ $\overline{R}^2 = 0.500$ DW = (0.880) HETERO. = (0.085).

TABLE 6: ESTIMATION OF ESTAR			
Parameter	Estimate	T-statistic	P-value
α_0	7.19	5.96	0.000
α_1	-1.48	-3.30	0.001
I73	11.15	4.99	0.000
I74	-1.38	-0.61	0.541
I85	5.58	-2.50	0.012
α'_0	-4.62	-3.00	0.003
α'_1	1.78	4.12	0.000
γ	0.14	2.46	0.014
c	2.36	3.55	0.00

$R^2 = 0.377$ $\overline{R}^2 = 0.327$ DW = (0.786) HETERO. = (0.074).

Where p-values are in parentheses for Durbin Watson (DW) and heteroscedasticity (HETERO) tests.

The empirical estimates of the ESTAR (1) model with d=1, are presented in table 6.

All models have been estimated by leaving out the last four observations in order to compare the out of sample performance.

Models fit within sample is shown in the diagrams below.

Comparing the out-of-sample forecasting performance of the models we calculated the mean square error for all quarters of 1998. The values of the mean square error for each model are presented in table 7.

TABLE 7: MEAN SQUARE ERRORS		
ARIMA	LSTAR	ESTAR
0.025	0.923	0.290

TABLE 8: ABSOLUTE PERCENTAGE ERRORS			
DATE	ARIMA	LSTAR	ESTAR
1998:1	-201.5	56.7	-933.4

From table 7 we conclude that the ARIMA model has overall the best fit for out of sample data. This may reflect that a linear model is suffice to capture the dynamics of the inflation rate. Looking for a short run forecasting, we estimate the absolute percentage error of the models for the first quarter of 1998. The values of these errors are given in table 8.

Therefore, from Table 8 we can see that both ARIMA and ESTAR provide larger forecasting errors compare to that of LSTAR model. Thus a non-linear model may be more appropriate for (very) short-run forecasting.

IV. Conclusions.

In this paper we apply linear and non-linear time series models to Greek inflation. Using quarterly data form 1970 to 1998, we investigate stationarity properties of the the inflation series. The unit-root tests showed that inflation can be considered as a stationary variable. Therefore, employing the Box-Jenkins approach we fit an ARIMA (4,0,2) model. From the non linear class of models we used LSTAR (2,2) and ESTAR (1,1) specification to describe our data at hand. Comparing the out-of-sample forecasting performance of the models we found the ARIMA to be superior. This fact may reflect the lack of nonlinearities in the dynamics of the Greek inflation rate.

BIBLIOGRAPHY

Arango,L.E., and A. Gonzalez (2002) "Some evidence of smooth transition non linearity in Colombian inflation" Republic Bank of Colombia (working paper).

Banerjee, A., Lunsdaine, R.L. and J.H. Stock (1992) "Recursive and sequential tests of the unit-root and trend-break hypotheses: Theory and international evidence" Journal of Business and Economic Statistics, 10, 271-287.

Breitung J. (2002) "Nonparametric Test for unit roots and cointegration" Journal of Econometrics, 108, 343-364.

Erlat H. (2002) "Long memory in Turkish inflation rates" (working paper).

Harvey, D.I., Leybourne, S.J., and P. Newbold (2001) "Innovation outlier unit root tests with an endogenously determined break in level" Oxford Bulletin of Economics and Statistics, 63, 559 – 575.

Kwiatkowski, D., Phillips, P., Schmidt P. and Y. Shin (1992) "Testing the null of stationarity against the alternative of a unit root" Journal of Econometrics, 54, 159 – 178.

Phillips, P.C.B and P. Perron (1988) "Testing for a unit root in time series regression" Biometrica, 335 – 346.

Perron, P. (1994) "Trend, unit root and structural change in macroeconomic time series, in B. Bhaskara Rao (ed). Cointegration for the Applied Economist, Macmillan Press, Basingstoke, U.K.

Zivot, E. and D.W.K. Andrews (1992) "Further evidence on Great Crash, the oil price shock and the unit root hypothesis" Journal of Business and Economic Statistics, 10, 251-270.