UNANTICIPATED MONEY, OUTPUT AND PRICES IN GREECE*

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In this paper, we estimate and test a small neoclassical macromodel for Greece. The model incorporates the 'natural rate' hypothesis in that only unanticipated inflation can affect real output, and is 'monetarist' in nature, as the demand for output is derived from the demand for money function. The restrictions implied by the model cannot be rejected by either single equation or simultaneous equation tests. Thus, we find little evidence against the proposition that no monetary policy rule can affect real output once it becomes anticipated, and that the elasticity of prices with respect to money is unity.

1. Introduction

The theoretical work of Lucas (1972), Sargent and Wallace (1975) and Barro (1976), suggests that in an economy in which agents have rational expectations, anticipated changes in the money supply have no effect on real output, but are simply translated into price level changes. Unanticipated changes in the money supply have real effects because agents cannot distinguish between current, relative and absolute demand shifts.

Sargent (1973) first attempted a direct test of the aforementioned suggestions. He proceeded to distinguish between unanticipated inflation and actual inflation as a cause of macroeconomic fluctuations in the United States. In that paper he successfully tackled most of the econometric problems that arise in such testing, including the questions of identification and appropriate methods of estimation. His results were mixed, but in his own words, 'not too unfavourable' to the neutrality proposition. Results similar in nature were presented in Sargent (1976).

The second round of testing was pioneered by Barro (1977, 1978). He made the logical jump from the notion of unanticipated inflation to the

notion of unanticipated money growth. He proceeded to empirically identify the determinants of money growth, treated the residuals from his estimated models as unanticipated money, and directly tested whether these residuals out-perform actual money growth in explaining the fluctuations of real variables (unemployment and output). His results were far more favourable to the neutrality proposition than the Sargent results.

In this paper we formulate and test a small structural classical model for Greece. The endogenous variables are output and prices. Our model consists of a Lucas-aggregate supply function and an output demand function derived from the quantity theory of money. Thus, it incorporates the natural rate hypothesis in that only unanticipated inflation can affect output, and in addition it is 'monetarist' in nature, as the demand for nominal income depends on the money supply. The money supply is assumed exogenous and determined in a separate sub-system.

Two types of tests of the model and its implications are presented. Single equation tests and simultaneous equation tests. In the context of the reduced form equation for output we test for the statistical significance of the coefficients of unanticipated money growth and actual money growth, respectively. As the measures of unanticipated money growth are so crucial for such testing, we have first carefully developed and estimated a forecasting model for the money supply. The reduced form tests suggest that one cannot reject the hypothesis that actual money growth does not affect output, and that unanticipated money growth does. In the context of the reduced form price equation, one cannot reject the hypothesis of a unitary elasticity of the price level with respect to money. In addition, a test for gradual price adjustment, by including a lagged dependent variable, suggests that gradual price adjustment can be rejected, as the coefficient of lagged prices is not significantly different from zero. In summary, our reduced form tests suggest that the strong classical and monetarist predictions of the model are not at variance with the properties of the Greek time series.

A stronger test of the model is performed in the context of simultaneous equations. We estimated the two equations with and without the cross equation restrictions implied by the structural model. The computed likelihood ratio test is below its critical value at the 95% level. This strengthens the results of single equation testing, as it does not suggest a rejection of the structural model.

A word of caution about the above tests is probably required. All the tests are conditioned on the largely untested assumption that the money supply is exogenous (presumably controlled by the monetary authorities). If that is not so, there exists the possibility of 'reverse causation', i.e., the association between output and unanticipated money could be due to unanticipated changes in output causing a higher money stock through the demand for money function. Contemporaneous causality is not something that can easily

be determined by statistical tests, and, thus, this possibility cannot be excluded on the basis of our tests. Our tests are conditional on the maintained hypothesis that the money stock is exogenous.[1]

The paper is organised as follows: in section 2 we present and solve the theoretical model; section 3 contains a discussion of the proximate determinants of the money stock in Greece; in section 4 we present our empirical forecasting model of money growth; estimates and tests of the model for output and prices are presented in section 5; and section 6 contains conclusions.

2. The model

The model consists of two behavioural equations. An output supply function and a demand for money function which can be used to derive output demand.

Output supply is given by

$$y_t = a_0 + a_1(p_t - Ep_t/I_{t-1}) + a_2 z_t + a_3 y_{t-1} + u_t, \tag{1}$$

and demand for money is given by

$$(m-p)_t = b_0 + b_1 y_t + b_2(m-p)_{t-1} + v_t. \tag{2}$$

E is the mathematical expectation operator and I denotes the information set upon which expectations depend. y is the log of GDP, p is the log of the price level, z is a set of variables driving the 'normal' level of output, m is the log of nominal money balances, and u_t, v_t are random disturbances with zero means and a diagonal variance–covariance matrix,

$$\begin{pmatrix} u_t \\ v_t \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_u^2 & 0 \\ 0 & \sigma_v^2 \end{pmatrix} \right]. \tag{3}$$

(1) is a variant of the Lucas (1973) aggregate supply function. Suppliers react positively to unanticipated inflation because they cannot observe current inflation but only prices in their own markets. Thus, they attribute part of unanticipated current inflation to a favourable relative price shift, and they produce more. The exact derivation of (1) can be found in Lucas (1973) or Barro (1976).[2]

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[1] See Buiter (1980). The same applies, of course, for the tests of Barro (1977, 1978), Wogin (1980), Attfield, Demery and Duck (1981a,b).

[2] (1) could of course be rationalized in terms of one period non-indexed wage contracts [Fischer (1977)].

(2) is a transactions demand for money function. Demand for real balances depends on output.

Lagged dependent variables have been included in both equations, in order to capture state dependence. (1) and (2) are seen as optimal dynamic decision rules of rational agents, as both can be rationalised in terms of equilibrium theory.[3]

If expectations about p_t are formed as postulated by the rational expectations hypothesis, the system of (1) and (2) implies that no monetary policy rule can affect the behaviour of real output. It is only unanticipated money growth and not actual money growth that affects output.

Our purpose in this paper is to assess the extent to which the restrictions imposed by a model of this nature can or cannot be rejected by the time series for Greece.

Solving the model for the two endogenous variables, y_t and p_t, and imposing the rational expectations hypothesis for Ep_t/I_{t-1}, we get the following reduced forms:

$$y_t = \phi_0 + \phi_1(m_t - Em_t/I_{t-1}) + \phi_2(z_t - Ez_t/I_{t-1}) + \phi_3 z_t$$

$$+ \phi_4 y_{t-1} + \varepsilon_{1t}, \tag{4}$$

$$p_t = \pi_0 + \pi_1 m_t + \pi_2(m_t - Em_t/I_{t-1}) + \pi_3 z_t + \pi_4(z_t - Ez_t/I_{t-1})$$

$$+ \pi_5(m-p)_{t-1} + \pi_6 y_{t-1} + \varepsilon_{2t}, \tag{5}$$

where

$$
\left.
\begin{aligned}
\phi_0 &= a_0, \\
\phi_1 &= a_1/(1 + a_1 b_1), \\
\phi_2 &= -b_1 a_2/(1 + a_1 b_1), \\
\phi_3 &= a_2, \\
\phi_4 &= a_3,
\end{aligned}
\right\} \tag{4'}
$$

[3]See, for example, Sargent (1979) for the derivation of equilibrium dynamic decision rules when agents face adjustment costs.

$$\left.\begin{array}{l} \pi_0 = -b_0 - b_1 a_0, \\[1.2em] \pi_1 = 1, \\[1.2em] \pi_2 = -a_2 b_1/(1 + a_1 b_1), \\[1.2em] \pi_3 = -a_2 b_1, \\[1.2em] \pi_4 = b_1^2 a_1 a_2/(1 + a_1 b_1), \\[1.2em] \pi_5 = -b_2, \\[1.2em] \pi_6 = -b_1 a_3, \end{array}\right\} \tag{5'}$$

$$\left.\begin{array}{l} \varepsilon_{1t} = (1 - a_1 b_1)u_t - a_1 v_t, \\[1.2em] \varepsilon_{2t} = -b_1 u_t - v_t, \end{array}\right\} \tag{6}$$

where

$$\begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} (1 - a_1 b_1)^2 \sigma_u^2 + a_1^2 \sigma_v^2 & \\ -b_1(1 - a_1 b_1)\sigma_u^2 + a_1 \sigma_v^2 & b_1^2 \sigma_u^2 + \sigma_v^2 \end{pmatrix} \right].$$

We see that output and prices depend, among other things, on unanticipated money and unanticipated movements in the 'normal' components of output. These two variables are unobservables. We devote the next two sections to building up a forecasting model for the money supply, in order to derive measures of unanticipated money.

3. On the proximate determinants of the money stock

To impose some discipline in our search for a forecasting money supply model, we shall start with a theoretical discussion of the determinants of the money supply in Greece. The formal model is due to Papadakis (1979) and is in the same tradition as the models described in Friedman and Schwartz (1963; app. B). In our econometric specification search we only considered variables directly or indirectly suggested by this theoretical model, bearing in mind the institutional framework of the Greek economy.

The variable chosen as our money stock variable is $M1$, i.e., currency plus demand deposits. Two main factors led us to this decision: firstly, $M1$ has a very close relationship to the monetary base, and the latter is as close as any monetary aggregate comes to be considered a controllable policy instrument.

Secondly, savings and time deposits in Greece are the most important outlet of private savings. As such, they are more of an asset than of a medium of exchange.

The model of the proximate determinants of $M1$ starts with

$$M1 = m_1 B \tag{7}$$

where

$$M1 = C + D, \qquad B = C + R. \tag{8}$$

$M1$ is the narrow definition of the money supply, B is the monetary base, C is currency in circulation, D is demand deposits and R is reserves held by commercial banks, m_1 is the money multiplier defined as

$$m_1 = (C + D)/(C + R). \tag{9}$$

Dividing numerator and denominator in (9) by D, and making a simple rearrangement, we get

$$m_1 = (1 + c)/(c + r(1 + t)), \tag{10}$$

where $c = C/D$ is the currency–demand deposit ratio, $r = R/(T + D)$ is the reserve ratio of commercial banks (T is savings and time deposits), and $t = T/D$ is the structure of deposits ratio.[4] c is primarily determined by payments patterns. r might increase with minimum reserve requirements, and uncertainty over net deposit flows, and decrease with the ratio of lending rates to the discount rate of the central bank. t increases with interest rates payable on time and savings deposits, as currency and demand deposits pay no interest.

The effects of changes in these ratios on the money multiplier, and, therefore, ceteris paribus, on $M1$, are all negative. This can be seen by the partial derivatives

$$\frac{\partial m_1}{\partial c} = \frac{r(1+t)-1}{[c+r(1+t)]^2} < 0 \quad \text{if} \quad R < D \quad \text{which holds for our sample,}$$

$$\frac{\partial m_1}{\partial t} = \frac{-r(1+c)}{[c+r(1+t)]^2} < 0,$$

$$\frac{\partial m_1}{\partial r} = \frac{-(1+t)(1+c)}{[c+r(1+t)]^2} < 0.$$

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[4]Note that: $(R/(T+D))(1 + T/D) = R/(T+D) + RT/D(T+D) = R(T+D)/D(T+D) = R/D$.

We next turn to the determinants of the monetary base. From the balance sheet of the central bank, the monetary base can be decomposed into a foreign component F, the net foreign exchange position, a public sector component G, net lending to the public sector, a private sector component I, net lending to the private sector, and finally A, which is a sum of unspecified items. We can therefore define the monetary base as

$$B = F + G + I + A.$$

In our econometric search for a money growth equation we considered: foreign exchange reserves as a measure of F, the public sector deficit (G), the ratio of investment to profits (I), the interest rate on savings deposits (t) and the ratio of lending rate for working capital to the Central Bank discount rate (r).

4. Forecasting money growth

After a fairly thorough specification search over most of the variables suggested by the theoretical discussion above, we choose the following equation as the most satisfactory empirical model of money growth:

$$\Delta m_t = -0.16 - 0.54 \Delta m_{t-1} + 0.07 \Delta f_t + 0.18 (f - m)_{t-1}$$
$$\quad (0.08) \ (0.17) \qquad (0.03) \qquad (0.02)$$

$$+ 0.05 d_t + 0.08 (r^s / r^d)_t, \tag{11}$$
$$\quad (0.01) \quad (0.03)$$

Sample 1960–1977: $R^2 = 0.88$, $RSS = 0.0039$, $s = 0.018$,
χ^2 test for random residual correlogram up to the 4th order: 6.05,
$\chi^2_{0.95}(4) = 9.49$.

Δ is the first-difference operator, $\Delta x_t = (x_t - x_{t-1})$, m_t is the natural logarithm of $M1$, f_t the log of foreign exchange reserves, d_t the log of the deficit of general government, r^s is the interest rate charged by banks for working capital, and r^d the rediscount rate of the central bank. Numbers in parentheses are standard errors of individual coefficients, R^2 the coefficient of determination, RSS residual sum of squares, and s the standard error of estimate.

Eq. (11) identifies as the major determinants of monetary growth in Greece, foreign exchange reserves, the borrowing requirement of the public sector, and the implicit cost of lending by commercial banks, proxied by the ratio of their main lending rate to the Central Bank rediscount rate.

The change in foreign exchange reserves affects monetary growth positively, with an elasticity of 0.07.

Interestingly enough, the ratio of reserves to the money supply of the previous year seems to affect monetary growth positively. This could be a policy response, reflecting the overriding concern of the Greek monetary authorities with the current account. When reserves are relatively abundant, the authorities feel freer to attempt monetary expansion and vice versa.

The deficit of General Government affects monetary growth positively with an elasticity of 0.05. Statistically, it is one of the most important variables in the equation with a t-statistic of 6.04.

Finally, money growth is positively affected by the ratio of the short-term lending rate to the rediscount rate of the Central Bank. Interest rates and their differentials in Greece are fixed by the monetary authorities. In addition, commercial banks operate under quotas for different types of lending, and, also, various types of reserve requirements. The less regulated and most profitable part of their operations is lending for working capital. It seems that the implicit cost of such lending affects money growth through its effects on the reserve ratio of commercial banks.[5]

Regarding the statistical features of eq. (11), apart from the fit which seems impressive, we are interested in the properties of the residuals and the stability of parameters after the change in exchange rate regime in 1975.

The hypothesis of lack of residual autocorrelation cannot be rejected. The Pierce (1971) diagnostic for a random residual correlogram of fourth-order is 6.05 and $\chi^2_{0.95}(4)=9.49$. A Lagrange Multiplier (LM) diagnostic for first-order serial correlation is 3.75, $\chi^2_{0.95}(1)=3.84$. Our diagnostic for Autoregressive Conditional Heteroscedasticity [see Engle (1979)] is 0.16, $\chi^2_{0.95}(1)=3.84$. Thus, the hypothesis of lack of ARCH cannot be rejected either.

As far as the stability of parameters in the post-1975 years is concerned, we re-estimated (7) for 1960–1974, using the 1975–1977 observations for post-sample parameter stability tests. The Chow test is 0.93, $F_{0.95}(3,9)=3.86$. The χ^2 test [see Hendry (1979)] that compares within-sample and post-sample residual variances is 3.74, where $\chi^2_{0.95}(3)=7.82$. Thus on the basis of these tests, we cannot reject the hypothesis of no parameter shift in the post-1975 period. This is not surprising. What happened in 1975 was that Greece abandoned fixed exchange rates for a crawling peg system. The drachma did not become a floating currency. In both the fixed exchange rate regime and the crawling peg regime the exchange rate is fixed by the monetary authorities. The difference is one of the degree of flexibility of the exchange rate.[6]

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[5]For an excellent description of the nature of the Greek financial system, see Halikias (1978).

[6]In principle, the assumption of a controllable money stock seems, in the absence of sterilization, incompatible with the fact that Greece has had a managed exchange rate. However, international capital movements in Greece are not free and even imports have been controlled through a complex licencing scheme. Thus, the short-run control of the money stock is not necessarily incompatible with managed exchange rates. In any case, we performed a (admittedly

In conclusion, (11) identifies lagged money growth, foreign exchange reserves, the Public Sector deficit and a measure of the structure of interest rates as the major determinants of money growth. It has the desirable statistical properties of no apparent residual autocorrelation and heteroscedasticity, and seems to be stable over the two exchange rate regimes. However, it is not a forecasting equation, as it contains current variables in Δf_t, d_t and $(r^s/r^d)_t$. In order to derive measures of unanticipated money growth we need a genuine forecasting model.

To get a forecasting model we must forecast current variables in (11). It turns out that we cannot do better than using univariate time series models for the change in reserves and the ratio of interest rates. The rate of growth of the public sector deficit is being forecast by the rate of growth of nominal income in the previous period and the log of the share of the deficit in GDP in the previous year.

Our forecasting equations are:

$$\Delta f_t = 0.50 \Delta f_{t-1},$$
$$(0.21)$$

(12)

Sample 1960–1977: $RSS = 0.5966$, $s = 0.187$,
Autocorrelation diagnostics: Pierce $\chi^2(4) = 3.27$, $LM(2) = 1.74$,   Durbin's $h^2 = 0.07$;

$$\Delta d_t = -4.00 + 6.29 \Delta(y+p)_{t-1} - 1.00(d-y-p)_{t-1},$$
$$(0.80) \quad (1.66) \qquad\qquad (0.21)$$

(13)

Sample 1960–1977: $RSS = 1.7734$, $s = 0.344$,
Autocorrelation diagnostics: Pierce $\chi^2(4) = 0.98$, $LM(2) = 1.69$ Durbin's $h^2 = 1.08$;

$$(r^s/r^d)_t = 1.00(r^s/r^d)_{t-1},$$
$$(0.03)$$

(14)

Sample 1960–1977: $RSS = 0.5256$, $s = 0.176$,
Autocorrelation diagnostics: Pierce $\chi^2(4) = 2.31$, $LM(2) = 1.44$,   Durbin's $h^2 = 0.75$.

y is the log of GDP at 1975 prices and p is the log of the GDP deflator 1975 = 100. (12), (13) and (14) have been derived sequentially from fairly general (2

weak) test for the exogeneity of the money stock. We estimated by instrumental variables a money growth equation containing only the lagged variables in (11) and the rate of growth of output. We used all current variables in (11) and the lagged rate of growth of output as instruments for current output growth. The coefficient on output was −1.73, standard error 1.35. Thus, one cannot reject the hypothesis that this coefficient is zero [see Nickell (1981)].

year lags) dynamic equations, which included many of the variables in our data set.

Little can be offered in comments on the first-order autoregression for Δf_t and the random walk for $(r^s/r^d)_t$. In both cases the autoregressive coefficients are statistically significant.

The change in the public sector deficit seems to depend on last year's change of nominal income and the proportion of nominal income taken up by the deficit in the previous year. This is just an empirical equation that seems to reflect the fact that the proportional growth of the deficit has been greater than the growth of nominal income in the period under examination.

All three equations have the desirable property of very little evidence against the hypothesis of non-autocorrelated residuals. The reported autocorrelation diagnostics are substantially below their critical values, $\chi^2_{0.95}(4) = 9.49$, $\chi^2_{0.95}(2) = 5.99$, $\chi^2_{0.95}(1) = 3.84$. This is very important as the rational expectations hypothesis requires that the errors in prediction are serially uncorrelated.

To derive one year ahead forecasts of money growth, and measures of unanticipated money, we estimated the four equation system of (11), (12), (13) and (14) by FIML. Current (endogenous) variables in the money growth equation were replaced by their forecasting schemes.

Table 1 presents the results of FIML estimation. Apart from the parameter

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The forecasting model of monetary growth; method of estimation: FIML, sample 1960–1977: log of likelihood function 61.15.[a]

$$\Delta m_t = -0.18 - 0.59 \Delta m_{t-1} + 0.15 \widehat{\Delta f_t} + 0.16(f-m)_{t-1} + 0.05 \hat{d_t} + 0.08 \widehat{(r^s/r^d)}_t,$$ (11')
$$\quad (0.05)\ (0.13) \qquad (0.05) \qquad (0.02) \qquad\qquad (0.01)\quad (0.02)$$

$$\Delta f_t = 0.49 \Delta f_{t-1},$$ (12')
$$\quad (0.19)$$

$$d_t = d_{t-1} - 4.46 + 7.30 \Delta(y+p)_{t-1} - 1.09(d-y-p)_{t-1},$$ (13')
$$\quad\qquad (0.66)\ (1.38) \qquad\qquad (0.17)$$

$$(r^s/r^d)_t = 1.00(r^s/r^d)_{t-1},$$ (14')
$$\quad\qquad (0.03)$$

Variance–covariance matrix of untransformed residuals

$$\begin{bmatrix} 0.0009 & & & \\ 0.0029 & 0.0331 & & \\ 0.0068 & 0.0269 & 0.1033 & \\ 0.0028 & -0.0017 & 0.0017 & 0.0292 \end{bmatrix}$$

[a]A $\wedge$ denotes the deterministic part of the relevant equation; asymptotic standard errors are given in parentheses.

for Δf_t in the money growth equation, differences from OLS estimation are negligible.

In what follows we shall use the residuals from (11') as our measures of unanticipated money growth, in estimating and testing the model presented in section 1.

Ideally, one would like to perform these tests in a simultaneous equations framework, i.e., by estimating the forecasting model for the money supply and the model for output and prices at the same time, and testing the implicit cross equation restrictions [see Leiderman (1980)]. However, in view of the lack of enough observations, such tests cannot be performed.

5. Estimation and testing

In this section we report estimates and tests of the model of output and prices. After a fairly extensive search we concluded that a time trend and the log of world trade adequately capture the movement of 'normal' output. In addition, one cannot reject the hypothesis that the coefficient of lagged output in the output supply function is zero. Our OLS estimates of the reduced forms (4) and (5) are

$$y_t = 9.99 + 0.37(m_t - Em_t/I_{t-1}) - 0.15(z_t - Ez_t/I_{t-1})$$
$$(0.30)\ (0.15) \qquad\qquad (0.11)$$

$$+ 0.61z_t + 0.02t, \tag{15}$$
$$(0.09)\quad (0.007)$$

Sample 1960–1977: $R^2 = 0.998$, $RSS = 0.0043$, $s = 0.018$ $DW = 2.17$,
Pierce $\chi^2(2) = 1.89$;

$$p_t = -0.84 + 1.03m_t - 0.76(m_t - Em_t/I_{t-1}) + 0.09z_t$$
$$(1.87)\ (0.15)\quad (0.21)\qquad\qquad (0.25)$$

$$-0.02(z_t - Ez_t/I_{t-1}) - 0.99(m-p)_{t-1} - 0.007t, \tag{16}$$
$$(0.17)\qquad\qquad (0.10)\qquad\qquad (0.03)$$

Sample 1960–1977: $R^2 = 0.997$, $RSS = 0.0066$, $s = 0.025$, $DW = 2.17$,
Pierce $\chi^2(2) = 1.40$.

z_t ·is world trade, $(z_t - Ez_t/I_{t-1})$ is the residual from a first-order autoregression of world trade, and t is a time trend.[7]

[7]The autoregression of world trade is

$$z_t = 1.02\ z_{t-1}, \qquad R^2 = 0.985, \qquad \text{Durbin's } h^2 = 0.054.$$
$$(0.003)$$

This is almost, but not quite, a random walk. The addition of further lags in z did not significantly improve the fit of the above equation.

(15) was tested against a regression of y on: two lags of output and prices, current world trade, and unanticipated world trade and money. The relevant F test for the 4 zero restrictions (15) implied for this equation is 1.30, where $F_{0.95}(4,9)=3.63$. Thus, (15) cannot be rejected against a fairly general specification. (15) was also estimated, with current money growth among the regressors. The F test for its exclusion is 0.16, where $F_{0.95}(1,12)=4.75$. Thus, on the basis of this test, one cannot reject the hypothesis that actual money growth does not affect output.[8]

Tests against more general forms were also performed for (16). The most important one was to test whether lagged prices could enter with coefficients significantly different from zero. This would constitute evidence against the hypothesis of continuous market clearing. We re-estimated (16) with the addition of a lagged dependent variable. The F test on its exclusion is 2.26, where $F_{0.95}(1,10)=4.96$. Thus, continuous market clearing cannot be rejected by this test.[9]

To simultaneously test all the restrictions implied by (1) and (2) and the hypothesis of rational expectations, we estimated by FIML a two equation model for output and prices with and without these restrictions. The unrestricted model has 14 parameters, 7 for each equation: a constant, a time trend and the coefficients of the exogenous variables,

$$m_t, \quad (m-p)_{t-1}, \quad (m_t-Em_t/I_{t-1}), \quad (z_t-Ez_t/I_{t-1}), \quad z_t.$$

The restricted model is given by (4) and (5) and the relevant overidentifying restrictions, (4') and (5'). Table 2 presents the estimates for the restricted

Table 2

The structural model; sample 1960–1977: log of likelihood function $= 88.59$.[a]

$y_t = 10.10 + 0.34(\widehat{p_t - Ep_t/I_{t-1}}) + 0.58z_t + 0.02t$
     (0.24) (0.14)   (0.07)   (0.005)

$p_t = m_t - 0.21\hat{y}_t - 0.76(m-p)_{t-1}$
       (0.03)   (0.04)

Variance–covariance matrix of untransformed residuals

$$\begin{bmatrix} 0.00026 & \\ -0.00012 & 0.00075 \end{bmatrix}$$

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[a]A $\bigwedge$ denotes the deterministic part of the relevant equation; asymptotic standard errors are given in parentheses.

[8](15) was also estimated with the addition of a lagged (m_t-Em_t/I_{t-1}). The sample was 1961–1977. The coefficient on the lagged monetary surprise was -0.06, standard error 0.13. Thus, the t-statistic of 0.45 suggests that we cannot reject the hypothesis that the above coefficient is zero.

[9]Note that a t-statistic for the difference of the coefficient of m_t from unity yields 0.2. Thus, one cannot reject the hypothesis that the coefficient of m_t is unity.

model. The log of the likelihood of the unrestricted model is 95.86, and that of the restricted one, 88.59. A likelihood ratio test is asymptotically distributed as $\chi^2(k)$ where k is the number of restrictions, and is computed as $-2(L_R - L_U)$, where L_R and L_U are the log likelihoods of the restricted and the unrestricted models respectively. In our case, the likelihood ratio test is 14.54, and the critical value $\chi^2_{0.95}(8) = 15.51$. Thus, the overidentifying restrictions implied by the model cannot be rejected by this test.[10]

In conclusion, neither the single equations nor the simultaneous equations tests provide strong evidence against a neoclassical explanation of output and price level fluctuations, and its policy implications for the economy of Greece.

6. Conclusions

In this paper we have set-up, estimated and tested a small neoclassical macro-model for Greece.

The model embodies the 'natural rate' hypothesis, in the sense that there exist no systematic output–inflation trade-offs. In addition, it has a strong 'monetarist' bias, as it ignores the IS-LM analysis of the determination of aggregate demand, and focuses on the quantity theory of money.

Our tests suggest that neither the exclusion restrictions, nor the nonlinear, cross-equation restrictions implied by the model can be rejected.

Thus, on the basis of the evidence presented in this paper, support is provided for the policy prescriptions of Simons (1936), Friedman (1960) and Sargent and Wallace (1975). Since no monetary policy rule can affect the behaviour of real output once it becomes anticipated, it would be better if the authorities followed a policy of stable monetary growth, since that would reduce the fluctuations in prices and output. The model also suggests that anti-inflationary policy works through a reduction in the rate of growth of the money supply.

Data appendix

$m =$ log of the yearly average of $M1$, total money supply, from Bank of Greece, *Monthly Statistical Bulletin*, various issues.

$f =$ log of the yearly average of net assets of gold and foreign exchange, from Bank of Greece, *Monthly Statistical Bulletin*, various issues.

$d =$ log of the public sector deficit, calculated as 'gross capital formation of producers of government services' minus 'current receipts' plus 'current

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[10]Due to software limitations (we used TSP 3.5 for FIML estimation), we did not impose the covariance restrictions implied by (6). Thus, strictly speaking, our test is one of the cross-equation restrictions implied by the structural model for the reduced form parameters.

disbursements' of general government, from OECD (1980), *National Accounts of OECD countries.*

r^s = annual average of the interest rate on credits for working capital, from Bank of Greece, *Monthly Statistical Bulletin.*

r^d = annual average of the rediscount rate of the Central Bank, from Bank of Greece, *Monthly Statistical Bulletin.*

y = log of gross domestic product at factor cost, 1975 prices, from OECD (1980).

p = log of the GDP deflator, 1975 = 100, from OECD (1980).

z = log of the index of imports of industrialised countries, from United Nations, *Monthly Bulletin of Statistics*, various issues.

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