MACROECONOMIC POLICY AND AGGREGATE FLUCTUATIONS IN A SEMI-INDUSTRIALIZED OPEN ECONOMY

Greece 1951–1980*

George S. ALOGOSKOUFIS
University of London, London W1P 1PA, UK

Received March 1984, final version received January 1985

In this paper we model the effects of macroeconomic policy in a semi-industrialized open economy. Greece is our case, but the model could apply to other similar economies with tightly controlled financial markets and comprehensive foreign exchange restrictions, where both the exchange rate and interest rates are administered prices. The model consists of three equations which determine output, the price level and the trade balance. It is largely non-Keynesian, but, through the real exchange rate, it allows for anticipated monetary policy to affect real output. The model is estimated by FIML and its various restrictions cannot be rejected. A policy simulation suggests that even Friedman’s x% money growth rule would ensure greater macroeconomic stability in the 1970s than the monetary policy that was actually followed.

1. Introduction

For a number of years after World War II, the industrialized countries and the developing world experienced ever rising living standards matched with unprecedented stability of growth rates and, by historical standards, very low inflation.

This experience was almost entirely attributed to macroeconomic policies that were shaped following the Keynesian revolution of the 1930s. Keynesian macroeconomics rests on the belief that aggregate fluctuations are primarily caused by fluctuations in aggregate demand, while supply adjusts more or less passively. This is in sharp contrast to classical macroeconomics, that in turn rests on Say’s law, which states that supply creates its own demand.

The two major worldwide recessions of the 1970s, accompanied by rises in inflation, have done a lot to dispel the belief that aggregate demand policies are a panacea. In fact the seventies have witnessed something of a neoclassical resurgence that focussed on the work of Friedman (1968) and Lucas (1972a). The new school that has emerged stresses the view that business cycles should be analysed as an equilibrium phenomenon and dismisses the

*The comments of an anonymous referee and participants in a seminar at KEPE (Centre for Planning and Economic Research, Athens, Greece) are gratefully acknowledged. ESRC and KEPE provided financial assistance.
disequilibrium view that has been forwarded as the microfoundations of Keynesian macroeconomics. The new school even argues that aggregate demand policies are irrelevant as long as they are anticipated. These neoclassical views have been strengthened considerably by empirical tests that failed to provide sufficient evidence against them.¹

In this paper we set out to model the effects of macroeconomic policy in a newly industrialized economy. Greece is our case, but the model could apply to similar economies. It is a non-Keynesian equilibrium model, but it does not imply that macroeconomic policies are irrelevant.

In previous work, Alogoskoufis (1982), we failed to reject for Greece a neoclassical model based on the Lucas supply function. Our broad alternative hypothesis was that anticipated changes in the price level affect output, and this was rejected. In the model that is presented below we explore particular channels through which anticipated changes in the price level could affect real output. The most important such channel is the real exchange rate. In addition we investigate the effects of government expenditure.

Our tests are carried out in the context of a small macromodel that determines output, the price level and the trade balance. The model consists of three structural equations. An aggregate supply function, a demand for money function and a trade deficit equation. The money stock, government purchases, the interest rate and the exchange rate are treated as exogenous policy variables that can be manipulated by the authorities with a view to ultimately affecting the three policy goals.

It has to be stressed that the model is not meant to apply to the main industrial nations with their well developed capital markets. It is tailored to some of the characteristics of a small, open, semi-industrialized economy like Greece's, with tightly controlled financial markets and comprehensive foreign exchange restrictions, where both the exchange rate and interest rates are administered prices. It is only in such an economy that we can treat the money stock, the interest rate and the exchange rate as largely exogenous policy variables. In fact, in order to legitimately treat the money stock as exogenous, we assume that the government is able to sterilize balance of payments deficits by changing its borrowing accordingly. This does not seem to be at variance with what the Greek authorities have been doing.

We assume that there are two types of suppliers in the economy. Private competitive firms and the government. Firms maximize profits subject to a production function that depends on labour, foreign inputs and public goods.

¹For the equilibrium approach to business cycles see Lucas (1977, 1980) and Barro (1979). Sargent and Wallace (1975) demonstrate the ineffectiveness of aggregate demand policies in an equilibrium macromodel. Finally, empirical evidence is presented by Lucas (1973), Sargent (1973), Barro (1977, 1978). The Lucas paper presents cross-country evidence, whereas the others present evidence for the U.S.A. Evidence for other industrialised countries is presented by Wogin (1980) for Canada, and Attfield, Demery and Duck (1981) for the U.K.
whereas the government's supply decision is viewed as exogenous. The aggregate supply function is shown to depend on real wages, the real exchange rate, government supply and time, the latter included to account for capital accumulation and technical progress that are not modelled explicitly.

This aggregate supply function is the most important behavioural equation of the model. It is perhaps useful to discuss its most important characteristics from the beginning. First, the dependence on real wages. Since the Greek labour market was characterised by yearly non-indexed labour contracts, we assume, following Gray (1976) and Fischer (1977), that contract wages take account of anticipated inflation but remain fixed during the year. Thus, unanticipated inflation reduces real wages and, with firms determining employment, it brings about an increase in output. The second point relates to the role of the real exchange rate. This enters the aggregate supply function as the relative price of imported inputs, and it is expected to have a negative sign. With a real devaluation firms lower their utilization of imported inputs as the latter become more expensive, and through the production function output falls. Imported inputs, even excluding oil, are of major importance for newly industrialized economies. One also has to note that the sign predicted by the model for the real exchange rate is opposite to the sign predicted by Keynesian aggregate demand models. The third point we wish to raise with respect to the aggregate supply function is that government expenditure enters directly and with a positive influence, as both government production and the supply of public goods to private firms enhance output.

The second behavioural equation of the model is a demand for money function. This is assumed to be a linearly homogeneous function of nominal income, with velocity a function of the interest rate and other factors. The specification of the demand for money function, and its role, give the model a rather strong monetarist flavour [see Friedman (1956)]. With our assumption that the money stock is exogenous, the demand for money function gives us an equation for aggregate demand. Notice that there is no IS curve, and that the interest rate is exogenous as well. This specification reflects the absence of a developed financial market.

The first two equations simultaneously determine output and the price level. Our final equation, a trade deficit function, depends on domestic income and the exchange rate. It rests on a combination of the absorption and elasticities approaches. There is no direct feedback from the trade deficit to output and the price level. The three-equation model is thus block recursive.

The main policy implications of the model are discussed after its exact structure has been presented. The most important conclusion is that anticipated increases in both government expenditure and the money stock cause an increase in output. Thus, both monetary and fiscal policies are effective.
As for the effects on the price level, the money stock has a positive effect, but government expenditure that is not accompanied by a money stock increase reduces the price level. This happens because as government expenditure increases output, the demand for real balances goes up. With a constant money stock and an exogenous interest rate, the price level must fall for the money market to clear. Even with indirect taxes going up, the price level will fall, the reduction in pre-tax prices more than compensating the increase in indirect taxes. This is a monetarist model, there is no effect of indirect taxes on the price level, and the latter is solely determined by the condition that the money market clears.

We estimate the model using yearly time series for Greece. Our estimates suggest that the various restrictions of the model cannot be rejected. The predictions of the model about the signs of the various parameters and the various other overidentifying restrictions are tested using Full Information Maximum Likelihood (FIML) estimation and Likelihood Ratio tests. In addition the model performs quite well in a dynamic simulation and changes in the base period do not affect the results.

We finally present a policy simulation to see how Friedman's well known x% rule for monetary growth would fare in the 1970's. The results were strikingly favourable to this policy rule.

The rest of the paper is organized as follows. Section 2 presents the details of the model and the policy implications. Section 3 presents estimates, tests and the simulation results. The final section contains conclusions.

2. The model

The model presented in this paper is a small, market clearing aggregate model. It reflects some of the major conventions of macroeconomics, but at the same time it takes into account some of the important characteristics of the economy it is meant to describe. These characteristics are the existence of non-indexed yearly labour contracts, the fact that government agencies directly 'produce' part of measured GDP, the fact that imported raw materials and semi-finished goods are very significant inputs in the production process of private firms, and finally the characteristics of foreign exchange and financial markets which make both the exchange rate and interest rates administered prices. The model consists of an aggregate supply function, an aggregate demand function and a trade deficit equation.

2.1. Aggregate supply

We assume there are two kinds of suppliers in the economy. Competitive private firms and the government. Private firms are assumed to maximise profits whereas the government supply decision is viewed as exogenous.
Let us first examine the behaviour of private firms. We denote their output by \( \bar{Y}_t \). They are assumed to maximise profits \( \Pi_t \), where

\[
\Pi_t = \bar{Y}_t - \frac{W_t}{P_t} L_t - \frac{E_t}{P_t} P^*_t - Y^*_t, \quad \text{and}
\]

\( W_t \) stands for wages, \( P_t \) for the price of output, \( L_t \) for employment, \( E_t \) for the exchange rate, \( P^*_t \) for the price of foreign inputs and \( Y^*_t \) for the quantity of foreign inputs.

Profits are maximised subject to a Cobb–Douglas production function

\[
\bar{Y}_t = A(t)(L_t)^\alpha(Y^*_t)^\beta(Y^*_t)^\gamma, \quad \alpha, \beta, \gamma > 0, \quad \alpha + \beta + \gamma < 1,
\]

where \( t \) is a time trend for capital accumulation and technical progress which are not modelled explicitly. \( Y^* \) is productive government expenditure which comes free to the firms. We assume it is a constant fraction of government expenditure

\[
Y^*_t = \psi G_t, \quad \psi < 1,
\]

where \( G_t \) is total government expenditure.\(^2\)

With the assumptions stated above we get the following demand functions for inputs:

\[
L_t^d = (A(t)(Y^*_t)^\gamma)^{1/\delta}(W_t/\alpha P_t)^{-(1 - \beta)\delta/(\beta + \gamma)}(E_t P^*_t/\beta P_t)^{-\beta/\delta},
\]

\( Y_t^d = (A(t)(Y^*_t)^\gamma)^{1/\delta}(W_t/\alpha P_t)^{-(1 - \alpha)\delta/(\beta + \gamma)}(E_t P^*_t/\beta P_t)^{-\alpha/\delta}, \)

where \( \delta = 1 - \alpha - \beta. \)

Substituting (3), (4) and (5) in (2) we get

\[
\bar{Y}_t = A(t)^{1/\delta}(\psi G_t)^{\gamma/\delta}(W_t/\alpha P_t)^{-(1 - \alpha)\delta/(\beta + \gamma)}(E_t P^*_t/\beta P_t)^{-\beta/\delta}.
\]

Apart from output produced by private firms, there exists direct government production. We again assume it is a constant fraction of government expenditure.

\[
G^r_t = \omega G_t, \quad \omega < 1,
\]

where \( G^r \) is direct government production.\(^3\)

\(^2\) \( Y^*_t \) comes free to firms but will be deflated by the same deflator as private production \( \bar{Y}_t \). For a model in which public goods enter the production function this way, see Barro and Grossman (1976).

\(^3\) \( G^r \) will again be deflated by the same deflator as private production, i.e., by \( P \). In this model, the only relative price that will be allowed to vary will be that between domestic and foreign goods. We shall assume that Hicks' aggregation theorem holds for private and public goods [see Hicks (1939)].
Total supply in the economy (Gross Domestic Product) is equal to the sum of private and government production.\(^4\)

\[ \bar{Y}_t = \bar{Y}_t + G_t. \]  

Since we assume that firms are competitive, they are price takers. We assume that they take the price of output and the price of foreign inputs as given. However, following Gray (1976) and Fischer (1977), we shall assume that the wage rate is determined by a prior negotiation between firms and workers, and that it is fixed for one period (a year in our case). The nominal wage will be assumed to be set at the beginning of each year, with the objective of keeping real wages on their trend level. Thus, the contract will take account of expected inflation and normal productivity growth. Wages are not indexed and, ex post, firms determine employment. Thus,

\[ W_t = P^*_t \alpha(t), \]  

where \( P^*_t \) is the antilog of the log of the price level that agents expect to prevail during the year, given their information at the beginning of the year; and \( \alpha(t) \) is the trend level of real wages.\(^5\)

Substituting (9) into (6), and after a logarithmic transformation, we get

\[ \log y_t = a_0 + a_1(p_t - \bar{p}_t) - a_2(e_t + p^*_t - p_t) + a_3 t + a_4 g_t, \quad a_1, a_2, a_3, a_4 > 0. \]

(10)

Lower case letters denote the natural logarithms of the variables defined so far. The logarithm of aggregate supply (8) is approximately given by

\[ \bar{y}_t \approx \bar{\pi}_0 + \pi_1 \bar{y}_t + (1 - \pi_1) \bar{g}_t \]

\[ = \pi_0 + \pi_1 \bar{y}_t + (1 - \pi_1) \bar{g}_t, \quad \pi_0 = \bar{\pi}_0 + (1 - \pi_1) \log \omega. \]  

(11)

From (10) and (11), aggregate supply is given by

\[ \bar{y}_t = a_0 + a_1(p_t - \bar{p}_t) - a_2(e_t + p^*_t - p_t) + a_3 t + a_4 g_t, \quad \text{where} \]

\[ a_0 = \pi_1 a_0 + \pi_0, \]

\[ a_i = \pi_1 a'_i, \quad i = 1, 2, 3, \]

\[ a_4 = \pi_1 a'_4 + (1 - \pi_1). \]

\(^4\)For the recognition of this distinction in the context of the aggregate labour market, see Andrews and Nickell (1982).

\(^5\)This assumption is not unreasonable in the case of Greece. Wage negotiations are centralised, and labour contracts last for a year. Very little overlapping exists, and no indexation, until 1981.
Eq. (12) can be viewed as 'normal' aggregate supply. It depends positively on 'surprises' in the price level (or inflation) because such surprises cause a reduction in the ex post real wages and firms produce more. It is negatively related to the real exchange rate because as the real exchange rate goes up, foreign inputs become more expensive and firms reduce output. Aggregate supply increases over time because of technological progress and capital accumulation which are not modelled explicitly. Finally 'normal' aggregate supply increases with government expenditure as the free supply of government inputs to private firms increases and direct government production increases.\(^6\)

However, aggregate supply is not always at its 'normal' level. We shall assume that suppliers make random errors in the implementation of their plans, and also that, because of adjustment costs, actual supply adjusts only slowly to its 'normal' level after a change in the determinants of the latter.

Thus, our short-run aggregate supply function depends on lagged values of output as well. It is given by

\[
y_t = \theta_0 + \theta_1 (p_t - p^*_t) - \theta_2 (e_t + p^*_t - p_t) + \theta_3 t + \theta_4 g_t + \sum_{i=1}^{n} \theta_{4+i} y_{t-i} + u_{1t},
\]

(13)

where

\[
\theta_j = \left[1 - \sum_{i=1}^{n} \theta_{4+i}\right] a_p, \quad j = 0, 1, 2, 3, 4,
\]

and \(n\) is the order of the lag polynomial.\(^7\)

According to (13), short-run aggregate supply depends on the factors affecting 'normal' supply, and a distributed lag of aggregate supply, entered to capture state dependence in the short run. \(u_{1t}\) is an independent random error in the implementation of the dynamic plan (13), where \(u_{1t} \sim N(0, \sigma_{u_t}^2)\).

2.2. Aggregate demand

The analysis of aggregate demand policies in Keynesian economics rests on the IS–LM framework suggested by Hicks (1937). One fundamental

\(^6\)For a similar definition see Lucas (1973). Note that \(\sigma_i (p_t - p^*_t)\) is a temporary component because the expected real wage will return to its trend level at the next negotiation. Thus, this term should not be considered as part of 'normal' supply. However, we shall keep this terminology, in order to distinguish (12) from the short-run dynamic supply function.

\(^7\)See Sargent (1979) for a rationalisation of such functions as the optimal dynamic decision rules of rational, forward-looking agents. In this paper we do not derive the lags from a particular problem of intertemporal maximisation. We allow them to be determined by the data, noting that the existence of lagged dependent variables in no way results in a refutation of equilibrium macroeconomics. On this last point, see Lucas and Sargent (1979) and McCallum (1979).
distinction of this framework from classical macroeconomics is the assumption emphasised by Keynes (1936), that the decision to invest is independent from the decision to save. The gist of neoclassical economics is that this distinction is not really important and that wealth effects in the consumption function will ensure that aggregate demand cannot cause serious deviations from full employment [see, for example, Pigou (1943)]. Thus, neoclassical economists feel justified in ignoring the IS curve and concentrating on the demand for money function.

Following the restatement of the quantity theory of money by Friedman (1956) we shall assume that the ‘normal’ demand for money function is given by

\[ \left( \frac{M}{P} \right)_t = K(z_t, r_t) \cdot Y_t \]  

(14)

where \( M \) is the nominal money stock, \( P \) the price level, \( Y \) output and \( r \) a vector of returns of alternative assets; \( z \) is intended to capture other factors that affect the quantity of money demanded like payments habits, financial innovations, etc.

Eq. (14) implies two important restrictions for the demand for money function. The one is homogeneity of degree zero with respect to the price level and the other is homogeneity of degree one with respect to income. The first restriction arises from Friedman’s view of money as a ‘consumers’ and producers’ good’, the demand for which should be independent of the price level. The second restriction is also quite important to Friedman’s theory, as it is the common element between his ‘restatement’ and the old equation of exchange [Fisher (1911)]. Neither of these restrictions is necessary for the validity of other portfolio theories of the demand for money [e.g., Tobin (1958)] and a test of these restrictions would constitute a test of Friedman’s theory.

Assuming that (14) is a log-linear function we can write it as

\[ (m - P)_t = b_0 + y_t - b_2 r_t + b_3 z_t, \quad b_1, b_2, b_3 > 0. \]  

(15)

Again lower case letters stand for natural logarithms. \( r \) however is the rate of interest itself, not its logarithm.

We shall again assume that the short-run demand for money adjusts only slowly after a change in the factors that affect the steady state demand for money. Thus, we shall allow for lagged dependent variables

\[ (m - P)_t = \eta_0 + \left( 1 - \sum_{i=1}^{l} \eta_3 + i \right) y_t - \eta_2 r_t + \eta_3 z_t + \sum_{i=1}^{l} \eta_3 + i (m - P)_{t-i} + u_{2t}, \]  

(16)
where \( n_j = (1 - \sum_{i=1}^{l} \eta_{j+i}) b_j, j=0,2,3 \) and \( l \) is the order of the lag polynomial; \( u_{2t} \) is an independent random error in the implementation of this dynamic plan, and \( u_{2t} \sim N(0, \sigma^2_{u_2}) \).

If we assume that both the money stock and the interest rate are policy variables exogenous to money holders, then we can solve (16) for \( p_t \),

\[
\begin{align*}
p_t &= -\eta_0 + m_t - \left(1 - \sum_{i=1}^{l} \eta_{3+i}\right) \eta_1 + \eta_2 r_t - \eta_3 z_t \\
&\quad - \sum_{i=1}^{l} \eta_{3+i}(m-p)_{t-i} - u_{2t}.
\end{align*}
\]

Eq. (17) is our price equation.

2.3. The trade balance

In this model we shall not consider the determination of imports and exports separately. We shall concentrate on the determination of the trade deficit, i.e., the difference of imports and exports. This is quite common practice in the macroeconomic approach to balance of payments adjustment.\(^8\)

We shall assume that the normal trade deficit is a function of the real exchange rate, and domestic output.\(^9\)

\[
TD_t = \frac{E_t P^*_t}{P_t},
\]

where \( TD \) stands for the trade deficit.

In log-linear form (18) can be written as\(^10\)

\[
\begin{align*}
\tilde{td}_t &= c_0 + c_1 y_t - c_2 (e_t + P^*_t - P_t),
\end{align*}
\]

where \( c_1, c_2 > 0 \).

As before, we shall assume that the trade deficit adjusts only slowly. Thus, our short-run trade deficit equation is

\[
\begin{align*}
td_t &= \xi_0 + \xi_1 y_t - \xi_2 (e_t + P^*_t - P_t) + \sum_{i=1}^{k} \xi_{2+i} td_{t-i} + u_{3t},
\end{align*}
\]

\(^8\)For a discussion of the evolution of the macroeconomic approach to problems of the balance of payment, see Grubel (1981). A more formal treatment is in Dornbusch (1980).

\(^9\)Our approach to the problem of the external deficit is a combination of the income (or absorption) and elasticities approaches. This combination determines the trade balance, in contrast to the monetary approach which is concerned with the basic balance, which is a different sub-total of the balance of payments accounts [see Kreinin and Officer (1978)].

\(^10\)Note that a log-linear function for the trade deficit can only be estimated for countries in which the trade deficit has always been positive. This has been the case with Greece over the period we shall be concerned with (1951–1980). However, a different functional form has to be specified for countries which have had both surpluses and deficits.
where \( \xi_j = (1 - \sum_{i=1}^{k} \xi_{2+i}) c_j, j = 0, 1, 2 \) and \( k \) is the order of the lag polynomial; \( u_{3t} \) is a random error in implementation of this dynamic plan, and \( u_{3t} \sim N(0, \sigma^2_{3j}) \).

The model is now completely described. Eq. (13) is our aggregate supply equation, (16) our aggregate demand equation and (20) our trade deficit equation. The endogenous variables are output \( (y) \), the price level \( (p) \) and the trade deficit \( (td) \). The model is block recursive as output and prices can be determined simultaneously from eqs. (13) and (16) [or (13) and (17)] and eq. (20) determines the trade deficit. To put it another way, output and the price level affect the trade deficit, but the trade deficit does not affect them. This block recursiveness of the system can be exploited in estimation, since it implies that estimating (13) and (16) jointly, and (20) simply by OLS is in fact equivalent to FIML. The next section is devoted to solving the model.

2.4. Solution of the model

It is perhaps useful to present the whole model at this stage.

Aggregate supply

\[
y_t = \theta_0 + \theta_1 (p_t - p_t^e) - \theta_2 (e_t + p_t^e - p_t) + \theta_3 t + \theta_4 g_t + \sum_{i=1}^{n} \theta_{4+i} y_{t-i} + u_{1t}, \tag{13}
\]

Demand for money

\[
(m - p)_t = \eta_0 + \left( 1 - \sum_{i=1}^{l} \eta_{3+i} \right) y_t - \eta_2 r_t + \eta_3 z_t + \sum_{i=1}^{l} \eta_{3+i} (m - p)_{t-i} + u_{2t}, \tag{16}
\]

trade deficit

\[
td_t = \xi_0 + \xi_1 y_t - \xi_2 (e_t + p_t^e - p_t) + \sum_{i=1}^{k} \xi_{2+i} td_{t-i} + u_{3t}, \tag{20}
\]

where

\[
\theta_j = \left( 1 - \sum_{i=1}^{n} \theta_{4+i} \right) a_j, \quad j = 0, 1, 2, 3, 4,
\]

\[
\eta_j = \left( 1 - \sum_{i=1}^{l} \eta_{3+i} \right) b_j, \quad j = 0, 2, 3,
\]

\[
\xi_j = \left( 1 - \sum_{i=1}^{k} \xi_{2+i} \right) c_j, \quad j = 0, 1, 2.
\]
As we have already noted, the model is block recursive and we can solve it in blocks. The block of eq. (13) and (16) can be solved to derive the reduced form equations for output and the price level. The solution seems a little complicated as (13) includes $p^*_t$ which is the rational expectation of the endogenous variable $p_t$. However, by using the method of undetermined coefficients [see Lucas (1972a)] we can derive the reduced form in a fairly straightforward way.

Before we derive the reduced forms one more point should be noted. $g_t$ is in real terms. It is however deflated by the GDP deflator, which is an endogenous variable. Thus, for purposes of estimation we shall treat only nominal government expenditure as exogenous. We shall denote it by $g^a_t$ where $g_t = g^a_t - p_t$. For purposes of evaluation of the effects of policy we can have government expenditure fixed either in nominal terms or in real terms.

The reduced forms of the first block of the model are given below. Eq. (21) is the reduced form price equation and (22) the reduced form output equation;

$$p_t = \phi_{10} + \phi_{11}\lambda(L)y_{t-1} + \phi_{12}\mu(L)(m-p)_{t-1} + \phi_{13}m_t$$
$$+ \phi_{14}r_t + \phi_{15}g^a_t + \phi_{16}(e_t + p^*_t) + \phi_{17}\tau + \phi_{18}z_t$$
$$+ \phi_{19}(m_t - m_i^t) + \phi_{110}(r_t - r^*_t) + \phi_{111}(g^a_t - g^a_i^t)$$
$$+ \phi_{112}[(e_t + p^*_t) - (e_t + p^*_i^t)^*] + \phi_{113}(z_t - z_i^t) + v_{1t}, \quad (21)$$

$$y_t = \phi_{20} + \phi_{21}\lambda(L)y_{t-1} + \phi_{22}\mu(L)(m-p)_{t-1} + \phi_{23}m_t$$
$$+ \phi_{24}r_t + \phi_{25}g^a_t + \phi_{26}(e_t + p^*_t) + \phi_{27}\tau + \phi_{28}z_t$$
$$+ \phi_{29}(m_t - m_i^t) + \phi_{210}(r_t - r^*_t) + \phi_{211}(g^a_t - g^a_i^t)$$
$$+ \phi_{212}[(e_t + p^*_t) - (e_t + p^*_i^t)^*] + \phi_{213}(z_t - z_i^t) + v_{2t}, \quad (22)$$

where $x_i^* = \text{Ex}_1|x_i^*|_{t-1}$ for any variable $x$ and where

$$\sum_{i=1}^n \theta_4 + \eta_{y_{t-i}} = \lambda(L)y_{t-1}, \quad \sum_{i=1}^n \eta_{(m-p)_{t-i}} = \mu(L)(m-p)_{t-1}.$$ 

The new errors $v_{1t}$ and $v_{2t}$ follow a bivariate normal distribution,

$$\begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix} \sim N \left[ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \phi_{114}\sigma^2_{u_1} + \phi_{115}\sigma^2_{u_2} \\ \phi_{114}\phi_{214}\sigma^2_{u_1} + \phi_{115}\phi_{215}\sigma^2_{u_2} + \phi_{214}\sigma^2_{u_2} + \phi_{215}\sigma^2_{u_2} \end{pmatrix} \right]. \quad (23)$$
The reduced form parameters are defined in table 1. The structural equations imply a number of restrictions for the reduced form parameters, and testing these restrictions will constitute the major test of the model. By substituting (21) and (22) in the trade deficit equation we get the

| Table 1 |
| Reduced form parameters of the price and output equations.* |

| \( \phi_{10} = -\frac{\theta_0 - \eta_0/\mu}{\Omega_1} \) | \( \phi_{20} = \theta_0 - \frac{(\theta_2 - \theta_4)(\theta_0 + \eta_0/\mu)}{\Omega_1} \) |
| \( \phi_{11} = -\frac{1}{\Omega_1} \) | \( \phi_{21} = \frac{1}{\mu \Omega_1} \) |
| \( \phi_{12} = -\frac{1}{\mu \Omega_1} \) | \( \phi_{22} = -\frac{\theta_2 - \theta_4}{\mu \Omega_1} \) |
| \( \phi_{13} = \frac{1}{\mu \Omega_1} \) | \( \phi_{23} = \frac{\theta_2 - \theta_4}{\mu \Omega_1} \) |
| \( \phi_{14} = \frac{\eta_2}{\mu \Omega_1} \) | \( \phi_{24} = \frac{\eta_2(\theta_2 - \theta_4)}{\mu \Omega_1} \) |
| \( \phi_{15} = -\frac{\theta_4}{\Omega_1} \) | \( \phi_{25} = \frac{\theta_4}{\mu \Omega_1} \) |
| \( \phi_{16} = \frac{\theta_2}{\Omega_1} \) | \( \phi_{26} = \frac{\theta_2}{\mu \Omega_1} \) |
| \( \phi_{17} = -\frac{\theta_3}{\Omega_1} \) | \( \phi_{27} = \frac{\theta_3}{\mu \Omega_1} \) |
| \( \phi_{18} = -\frac{\eta_3}{\mu \Omega_1} \) | \( \phi_{28} = -\frac{\eta_3(\theta_2 - \theta_4)}{\mu \Omega_1} \) |
| \( \phi_{19} = -\frac{\theta_1}{\mu \Omega_1 \Omega_2} \) | \( \phi_{29} = \frac{\theta_1}{\mu^3 \Omega_1 \Omega_2} \) |
| \( \phi_{110} = -\frac{\theta_1 \eta_2}{\mu \Omega_1 \Omega_2} \) | \( \phi_{210} = -\frac{\theta_1 \eta_2}{\mu^2 \Omega_1 \Omega_2} \) |
| \( \phi_{111} = \frac{\theta_1 \theta_4}{\Omega_1 \Omega_2} \) | \( \phi_{211} = -\frac{\theta_1 \theta_4}{\mu \Omega_1 \Omega_2} \) |
| \( \phi_{112} = -\frac{\theta_1 \theta_2}{\Omega_1 \Omega_2} \) | \( \phi_{212} = \frac{\theta_1 \theta_2}{\mu \Omega_1 \Omega_2} \) |
| \( \phi_{113} = \frac{\theta_1 \eta_2}{\mu \Omega_1 \Omega_2} \) | \( \phi_{213} = -\frac{\theta_1 \eta_2}{\mu^2 \Omega_1 \Omega_2} \) |
| \( \phi_{114} = -\frac{\theta_1}{\Omega_2} \) | \( \phi_{214} = \frac{(1 - \theta_1)(\theta_2 - \theta_4 + \theta_1) + 1/\mu}{\Omega_2} \) |
| \( \phi_{115} = -\frac{\theta_1}{\mu \Omega_2} \) | \( \phi_{215} = -\frac{\theta_1(\theta_2 - \theta_4 + \theta_1)}{\mu \Omega_2} \) |

*\( \Omega_1 = \theta_2 + 1/\mu - \theta_4 \), \( \Omega_2 = \theta_2 + 1/\mu - \theta_4 + \theta_1 \), \( 1 - \mu = \sum_{i=0}^{\eta_3+1} \).
reduced form for the trade deficit. This reads
\[
\begin{align*}
\text{td}_t &= \phi_{30} + \phi_{31}\lambda(L)y_{t-1} + \phi_{32}\mu(L)(m - p)_{t-1} + \phi_{33}m_t + \phi_{34}r_t \\
&\quad + \phi_{35}\eta_t^a + \phi_{36}(e_t + p_t^s) + \phi_{37}t + \phi_{38}z_t + \phi_{39}(m_t - m_t^s) \\
&\quad + \phi_{310}(r_t - r_t^s) + \phi_{311}(g_t^m - g_t^ms) + \phi_{312}[(e_t + p_t^s) - (e_t + p_t^s)^s] \\
&\quad + \phi_{313}(z_t - z_t^s) + \sum_{i=1}^{k} \xi_{2,i} + \text{td}_{t-i} + v_{3t}.
\end{align*}
\]

(24)

The reduced form parameters for the trade deficit equation, which is the second block of our block-recursive model, are defined in table 2.

Table 2
Reduced form parameters of the trade deficit equation.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\phi_{30})</td>
<td>(\xi_0 + \xi_1 \theta_0 - \frac{(\theta_0 + \eta_0/\mu)(\xi_2 + \xi_1(\theta_2 - \theta_4))}{\Omega_1})</td>
</tr>
<tr>
<td>(\phi_{31})</td>
<td>(\xi_1 - \xi_2 \mu)</td>
</tr>
<tr>
<td>(\phi_{32})</td>
<td>(- \frac{\xi_1(\theta_2 - \theta_4) + \xi_2}{\mu \Omega_1})</td>
</tr>
<tr>
<td>(\phi_{33})</td>
<td>(\xi_1(\theta_2 - \theta_4) + \xi_2)</td>
</tr>
<tr>
<td>(\phi_{34})</td>
<td>(\xi_1 \eta_2(\theta_2 - \theta_4) + \xi_2 \eta_2)</td>
</tr>
<tr>
<td>(\phi_{35})</td>
<td>(\frac{\theta_4(\xi_1 - \mu \xi_2)}{\mu_1})</td>
</tr>
<tr>
<td>(\phi_{36})</td>
<td>(- \xi_2 + \frac{\theta_2(\xi_1 - \mu \xi_2)}{\mu_1})</td>
</tr>
<tr>
<td>(\phi_{37})</td>
<td>(\frac{\theta_4(\xi_1 - \mu \xi_2)}{\mu_1})</td>
</tr>
<tr>
<td>(\phi_{38})</td>
<td>(\eta_3(\xi_1(\theta_2 - \theta_4) + \xi_2))</td>
</tr>
<tr>
<td>(\phi_{39})</td>
<td>(\frac{\theta_1(\xi_1 - \mu \xi_2)}{\mu^2 \Omega_1 \Omega_2})</td>
</tr>
<tr>
<td>(\phi_{310})</td>
<td>(\frac{\theta_1 \xi_2}{\mu \Omega_1 \Omega_2})</td>
</tr>
<tr>
<td>(\phi_{311})</td>
<td>(- \frac{\theta_1 \theta_2(\xi_1 - \mu \xi_2)}{\mu_1 \Omega_1 \Omega_2})</td>
</tr>
<tr>
<td>(\phi_{312})</td>
<td>(\frac{\theta_1 \theta_2(\xi_1 - \mu \xi_2)}{\mu_1 \Omega_1 \Omega_2})</td>
</tr>
<tr>
<td>(\phi_{313})</td>
<td>(- \frac{\theta_1 \theta_2(\xi_1 - \mu \xi_2)}{\mu^2 \Omega_1 \Omega_2})</td>
</tr>
<tr>
<td>(v_{3t})</td>
<td>(\xi_1 v_{2t} + \xi_2 v_{1t} + u_{3t})</td>
</tr>
</tbody>
</table>

*aSee footnote table 1.

The reduced form equations can be utilised in evaluating the policy implications of our model, and this is the task to which we now turn.

2.5. Policy implications

We shall evaluate the policy implications of the model using two alterna-
tive assumptions. The first is that government expenditure is fixed in real terms and the second is that government expenditure is fixed in nominal terms, i.e., that the government sets cash limits. The effects of monetary, fiscal and exchange rate policies differ under these two regimes.

Under the assumption that government expenditure is fixed in real terms, the reduced form parameters in tables 1 and 2 change in a specific way. In all places in which \( \theta_2 - \theta_4 \) appears, we get \( \theta_4 = 0 \). This also means that \( \Omega_1 \) and \( \Omega_2 \) are redefined as \( \Omega_1 = \theta_2 + 1/\mu \), \( \Omega_2 = \theta_1 + \theta_2 + 1/\mu \). Thus, \( \Omega_1 \) and \( \Omega_2 \) become unambiguously positive.

Let us first consider monetary policy. Anticipated changes in the money stock affect output with an elasticity of \( \phi_{23} = \theta_2/\mu \Omega_1 > 0 \). This occurs because changes in the money stock bring about increases in the price level through the demand for money function. As the price level increases, foreign inputs become less expensive, and therefore production increases as well. This effect is the model's account for output-inflation trade-offs. The same type of effect occurs if the interest rate on savings deposits increases. The price level goes up because the demand for real money balances goes down, and this increase in the price level brings about an increase in output. We have already noted that increases in the money stock and the interest rate cause increases in the price level. The elasticity of the price level with respect to the money stock is \( \phi_{13} = 1/\mu \Omega_1 > 0 \). Note that if the elasticity of output with respect to the real exchange rate is zero, i.e., if \( \theta_2 = 0 \), then \( \mu \Omega_1 = \mu(\theta_2 + 1/\mu) = 1 \), which implies that the elasticity of the price level with respect to the money stock would be unity.

Fiscal policy, which in this model we assume is equivalent with changes in government expenditure, has different effects. An increase in real government expenditure increases output directly, since direct government production and the inputs supplied freely to private firms increase. Through the demand for money function, the price level decreases. The relevant elasticities are \( \theta_4/\mu \Omega_1 \) for output, and \( -\theta_4/\Omega_1 \) for prices. Note that this discussion assumes that the money stock remains constant. If the higher government expenditure is financed by money, then we have a further expansion in output, but an increase in the price level as well.

The effects on the trade balance are unambiguous for an expansionary monetary policy, but ambiguous for an expansionary fiscal policy. An expansionary monetary policy increases both output and the price level. Thus, the trade balance deteriorates on both accounts. However, an expansionary fiscal policy increases output but reduces the price level. Thus, the output effect points to a deterioration of the trade balance, but the price effect points to an improvement. To assess the total effect we need to estimate the relevant parameters.

Finally, changes in the exchange rate affect output directly through the changes they bring about to the relative price of foreign inputs. A depreci-
ation, i.e., an increase in $e$, causes a reduction in output and the latter, through the demand for money function, causes an increase in the price level. The effects on the trade balance are unambiguously beneficial as the increase in the domestic price level turns out to be smaller than the increase in the domestic currency price of foreign goods. Thus, both the fall in the relative price of domestic goods and the drop in domestic output work in the direction of reducing the trade deficit.

Unanticipated changes in all these policy variables have absolutely smaller price effects. They only affect output through the further positive effect of unanticipated changes in the price level.

Under the assumption that government expenditure is fixed in nominal terms, many more ambiguities arise. $\Omega_1$ and $\Omega_2$ must again be positive, as it is unlikely that $|\theta_2-\theta_4| > 1/\mu > 1$. Assuming $\Omega_1, \Omega_2 > 0$, the output effects of all policies apart from monetary policy are in the same direction as before. However, monetary policy will have the same effect on output only if $\theta_2-\theta_4 > 0$ (look at $\phi_{23}$ and $\phi_{24}$). If $\theta_2-\theta_4 < 0$, then monetary policy will have perverse effects on output, as increases in the price level cause a contraction in output. This contraction takes place because with a higher price level, real government expenditure decreases, and this offsets the expansionary effect of the fall in the relative price of foreign inputs. The question of course is ultimately an empirical one, and it cannot be resolved until the estimates of $\theta_2$ and $\theta_4$ are obtained.

At this point we can move on to the empirical section of the paper.11

3. Estimation and testing

3.1. Preliminaries

The model was estimated using annual time series for Greece, 1951–1980. However, before we proceed to present our estimates we need to clear up three issues.

First, the question of the degree of the lag polynomials in our structural equations. Some pre-testing suggested that only one lagged dependent variable was significant in the output and trade deficit equations, and two lagged dependent variables were significant in the demand for money equation.

Second is the question of $z_1$, the unspecified determinant of the desired ratio of money to income. We used a dummy variable that moves like a trend until 1957 and is constant since then. This is intended to capture the fact that during the fifties, confidence in the monetary and banking system

11For fairly detailed but predominantly non-formal studies of the effects of monetary and fiscal policy in Greece see Papadakis (1979) and Provopoulos (1981). For an excellent description of the Greek financial system see Halikias (1978).
was building up only gradually after a series of blows in the previous decade, like a hyperinflation, a civil war, repudiation of the public debt, etc. For those reasons fiat money was only partly a unit of account and a medium of exchange, and gold coins were a parallel currency. Confidence in the banking system kept building up during the fifties, and it is believed that by 1957, after a successful series of measures by the authorities, the credibility of the system was fully restored.\footnote{On these developments see Halikias (1978) and Papadakis (1979).} It has to be stressed at this point that the estimates of the model look quite similar irrespective of whether we use this dummy variable or not. The main difference is in the estimates of the interest elasticity of the demand for money, and the coefficients of lagged balances, which are blown up without the dummy. However, the results of our tests are qualitatively similar, even when we do not use this dummy.

The third issue to be cleared up is the question of how we measure the unanticipated component of the exogenous variables $m_t$, $r_t$, $g_t$ and $e_t + p^*_t$. We adopted the solution proposed and implemented by Barro (1977). We specified and tested forecasting equations for these variables that are meant to approximate the rational expectations of agents one year in advance. The main property of these forecasting schemes should be that they do not suffer from residual autocorrelation, as this is one of the main differences between the rational expectations hypothesis and arbitrary adaptive expectations mechanisms.\footnote{See Shiller (1978).} In deriving these forecasting equations we used a number of hunches from economic theory, but these only proved successful in the case of the forecasts of monetary growth.

Our estimated forecasting schemes are presented in table 3. We shall only discuss them briefly.

The most interesting equation is the equation for the rate of growth of the money supply. It identifies the past rate of growth of nominal income, the ratio of foreign exchange reserves to the money supply, and the ratio of the government's budget deficit to the money supply as the major determinants of monetary growth. Accommodation of the growth in nominal income has not been full. However about half (0.44) of the growth of nominal income has been accommodated. The positive coefficient on $(f - m)_{t-1}$ is consistent with the view that the authorities are more inclined to attempt monetary expansion when reserves are relatively abundant. Finally, the coefficient on $d_{t-1}$, which is not an elasticity, suggests that about 13% of the government deficit has been financed by methods that lead to monetary expansion.\footnote{Apart from the studies by Barro (1977, 1978), Wogin (1980), and Attfield, Demery and Duck (1981), cross-country evidence on the determinants of monetary growth has been presented by Dornbusch and Fischer (1981). In contrast to the other papers they found that accommodation of the rate of growth of nominal income is the major determinant of monetary growth. Our own results, suggest that both accommodation and the budget deficit significantly affect monetary growth.}
Table 3

<table>
<thead>
<tr>
<th>Equation Description</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Money stock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta m_t = 0.099 + 0.445 \Delta (y+p)<em>{t-1} + 0.033 (f-m)</em>{t-1} + 0.134 d_{t-1}$</td>
<td>0.028</td>
<td>0.137</td>
<td>0.016</td>
<td>0.065</td>
</tr>
<tr>
<td>$s = 0.040$, Durbin-Watson statistic = 1.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nominal government expenditure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta g_t^e = 0.066 + 0.528 g_{t-1}^e$</td>
<td>0.025</td>
<td>0.157</td>
<td></td>
<td>0.061</td>
</tr>
<tr>
<td>$s = 0.061$, Durbin's h statistic = 1.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Opportunity cost of money</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r_t = 1.315 r_{t-1} - 0.376 r_{t-2} + 0.067 p_{t-1}$</td>
<td>0.211</td>
<td>0.195</td>
<td>0.042</td>
<td>0.010</td>
</tr>
<tr>
<td>$s = 0.010$, Durbin's h statistic = 1.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Foreign prices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta (e + p^<em>) = -0.020 + 0.103 \Delta (e + p^</em>)_{t-1} + 0.005 t$</td>
<td>0.073</td>
<td>0.062</td>
<td>0.003</td>
<td>0.158</td>
</tr>
<tr>
<td>$s = 0.158$, Durbin's h statistic = 0.015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Standard errors of individual coefficients are in parentheses, $s$ is the standard error of estimate, $f-m$ is the log of the ratio of foreign exchange reserves to the money stock, and $d$ is the ratio of the budget deficit to the money stock. $\Delta$ is the first-difference operator, $dx_t = x_t - x_{t-1}$ for any variable $x$.

Lack of first-order residual autocorrelation cannot be rejected by the Durbin–Watson statistic. Finally, it could be claimed that the coefficients of this equation might have changed after 1975, when the Greek monetary authorities abandoned the fixed drachma/dollar exchange rate in favour of a crawling-peg system. To test for stability we split the sample at 1974 and calculated a Chow test. The statistic was 0.12, with a critical value of $F_{0.95}(6, 20) = 2.60$. Thus, the hypothesis of no parameter shift cannot be rejected.

The other three equations are simple forecasting schemes where lagged dependent variables dominate. None of them seems to suffer from residual autocorrelation. The addition of further plausible explanatory variables does not seem to improve their fit, as we found out in a number of experiments.

The residuals from the equations in table 3 serve as our measures of unanticipated changes in the relevant variables, and in what follows they are treated as exogenous variables for purposes of estimation.

Having cleared up these three issues, we can now present our estimates of the model.

3.2. Estimation and testing of the structural model

The Full Information Maximum Likelihood estimates of our structural
model are presented in table 4. The estimates presented in table 4 are based on the additional restriction that the long-run income elasticity of the trade deficit is equal to one. This was suggested in preliminary Two-Stage Least Squares estimation, and the Likelihood Ratio test for this restriction is 1.36, with a critical value of \( \chi^2_{0.95}(1) = 3.84 \). Thus, the restriction cannot be rejected.\(^\text{15}\)

Table 4

<table>
<thead>
<tr>
<th>Aggregate supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y_t = (1 - 0.392) + 4.315 + 0.387(p_t - p_t') - 0.182(e_t + p_t^* - p_t) + 0.028 \cdot t + 0.403g_t + 0.392y_{t-1} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Price equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_t = m_t - (1 - 0.530 - 0.289) \cdot 2.015 + y_t - 8.2142 \cdot r_t + 0.133z_t - 0.530(m - p)<em>{t-1} - 0.289(m - p)</em>{t-2} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade deficit equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( td_t = (1 - 0.567) \cdot 0.194 + y_t - 0.906(e_t + p_t^* - p_t) + 0.567td_{t-1} )</td>
</tr>
</tbody>
</table>

Variance-covariance matrix of untransformed residuals

\[
\begin{bmatrix}
0.000046 & 0.000085 & R^2(y_t) = 0.998, h(y_t) = 0.202 \\
0.000303 & 0.000854 & R^2(p_t) = 0.997, h(p_t) = 0.374 \\
0.000074 & -0.001586 & 0.018682 & R^2(td_t) = 0.957, h(td_t) = 1.48 \\
& & & \text{Log of likelihood function} = 156.713
\end{bmatrix}
\]

\^R^2 is calculated as (1 - RSS/DPSS) where RSS is the sum of squared residuals and DPSS is sample size times variance of dependent variable. Estimation was carried out using the TSP 3.5 package. \( h \) is Durbin’s \( h \) statistic for first-order serial correlation and is asymptotically normally distributed. Asymptotic standard errors of individual coefficients are in parentheses below them.

As can be seen from table 4, all the structural parameters are statistically significant at the 5% significance level, apart from \( a_1 \), the elasticity of ‘normal’ aggregate supply with respect to unanticipated changes in the price level. One cannot reject the hypothesis that \( a_1 = 0 \) at the 5% significance level, as \( a_1 \) has an asymptotic \( t \)-ratio of 1.24 and the critical value is 1.96.\(^\text{16}\)

\(^15\)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 values of the log of the likelihood function of the restricted and the unrestricted models respectively [see Silvey (1970)].

\(^16\)However, \( a_1 \) is statistically significant at the 25% significance level (critical value 0.68), and for purposes of analysis of policy we shall stick to the estimates of table 4. Note also that the estimate of \( a_1 \) is not very different from a similar estimate in Alogoskoufis (1982), which was based on a model that implied structural neutrality and also on a different sample period (1960-1977). That estimate was 0.34, s.e. 0.14.
Note that $a_1$ has the predicted sign, and this is true for all the estimates of the structural parameters. However, before we discuss the rest of the estimates, let us assess the restrictions that the structural model implies for the reduced form parameters.

In doing that we assumed that $a_1 = 0$ and ignored the influence of unanticipated changes in the exogenous variables. This is not unreasonable since the hypothesis that $a_1 = 0$ cannot be rejected, and in addition it saves valuable degrees of freedom when the model is estimated unrestricted. Even in this case, we cannot estimate the unrestricted version of the model simultaneously, as this would require the estimation of 33 parameters, and we only have 30 observations. However, due to the block-recursive nature of the model we can test it in blocks. We can first test the output–price-level block, and then, conditional on that, we can test the trade balance equation.

To test the output–price-level block, we first estimated by FIML an unrestricted two-equation model, according to which output and the price level depend on all the exogenous variables. Then we re-estimated the two-equation model imposing the restrictions implied by our structural model. The structural model involves 11 restrictions. The computed likelihood ratio test is 13.796, and the critical value at the 5% level of significance is $\chi^2_{0.95}(11) = 19.675$. Thus, the restrictions of the structural model cannot be rejected by this test.

We also tested separately the two homogeneity restrictions of the demand for money function. The likelihood ratio test for homogeneity of degree one with respect to the price level, i.e., that the money stock has a unit elasticity in (17), yields a statistic of 2.27, the critical value being $\chi^2_{0.95}(1) = 3.84$. The likelihood ratio test for a unitary income elasticity of the ‘normal’ demand for money is 0.04, with the same critical value. Thus, neither of the homogeneity restrictions can be rejected, even if we test them separately.

To test for the restrictions of the second block, i.e., the trade deficit equation, we re-estimated the three-equation model with the trade deficit equation unrestricted. The LR test for the seven restrictions that the restricted model implies for the trade deficit equation is 4.54, the critical value being $\chi^2_{0.95}(7) = 14.07$. Again the restrictions cannot be rejected.

In summary, the barrage of tests to which the model in table 4 is subjected fail to reject it. Neither the homogeneity, nor the exclusion, nor the non-linear, cross-equations restrictions that the model implies for the reduced form parameters can be rejected. Thus, this equilibrium model appears to be a fairly adequate description of the time series for Greece. Note, before we leave this discussion that no evidence of autocorrelation is suggested by Durbin’s $h$ diagnostics. We can now turn to a discussion of the parameter estimates. The elasticity of normal output supply with respect to unanticipated inflation is estimated at 0.39, while the short-run elasticity of output supply is 0.24 (see table 5 for a listing of the short-run elasticities and semi-elasticities, $\theta, \eta, \xi$). The elasticity of normal aggregate supply with respect to
The real exchange rate is 0.18, and the short-run elasticity is 0.11. The elasticity of normal aggregate supply with respect to government expenditure is 0.40, and the short-run elasticity is 0.25. Government expenditure according to the model has a significant effect on aggregate supply.\footnote{For models which justify the output effects of government purchases in terms of intertemporal substitution, see Hall (1980) and Barro (1981). The rationalisation given in the present model is quite different. It is also different from the rationalisation of Keynes (1936).}

Turning to the demand for money, we have already referred to the unit income elasticity of normal money demand. The short-run elasticity is estimated at 0.18. The semi-elasticity of the normal demand for money with respect to the interest rate implies an elasticity of $-0.49$ at the mean. The implied short-run interest rate elasticity is $-0.09$.

Finally, the estimated elasticities of the trade deficit equation confirm that the Marshall–Lerner condition is satisfied, and that the trade deficit has a positive income elasticity. The estimated price and income elasticities of the normal trade deficit are $-0.91$ and $1.00$ respectively, and the short-run elasticities are $-0.39$ and $0.43$.

In order to assess the effects of macroeconomic policy, we need to calculate the implied reduced form parameters of the model. These are presented in table 6, under the two alternative assumptions about government expenditure. Column A presents the reduced form parameters under the assumption that government expenditure is fixed in real terms, and B under the assumption that it is fixed in nominal terms. Only the effects of anticipated monetary policy on output differ qualitatively under the two regimes. This is because according to the model, monetary policy affects output through its effects on the price level. When government expenditure is fixed in real terms, an increase in the price level through monetary policy brings about an increase in output because imported inputs become relatively cheaper. However, when government expenditure is fixed in nominal terms, an increase in the price level through the money supply is in fact a

---

**Table 5**  
Estimated short-run elasticities and semi-elasticities.*

<table>
<thead>
<tr>
<th>$\theta_0$</th>
<th>$\eta_0$</th>
<th>$\xi_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.62</td>
<td>0.36</td>
<td>0.08</td>
</tr>
<tr>
<td>0.24</td>
<td>0.18</td>
<td>0.43</td>
</tr>
<tr>
<td>0.11</td>
<td>1.49</td>
<td>0.39</td>
</tr>
<tr>
<td>0.02</td>
<td>0.02</td>
<td>0.57</td>
</tr>
<tr>
<td>0.25</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>0.39</td>
<td>0.29</td>
<td></td>
</tr>
</tbody>
</table>

* $\eta_1 = 1 - \eta_4 - \eta_3$, $\xi_1 = 1 - \xi_3$. 
Table 6
Estimated reduced form parameters.*

<table>
<thead>
<tr>
<th>Endogenous variables</th>
<th>( y_t )</th>
<th>( p_t )</th>
<th>( td_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous and predetermined</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Constant</td>
<td>2.532</td>
<td>2.739</td>
<td>-0.797</td>
</tr>
<tr>
<td>( y_{t-1} )</td>
<td>0.374</td>
<td>0.400</td>
<td>-0.067</td>
</tr>
<tr>
<td>( (m-p)_{t-1} )</td>
<td>-0.056</td>
<td>0.076</td>
<td>-0.508</td>
</tr>
<tr>
<td>( (m-P)_{t-2} )</td>
<td>-0.031</td>
<td>0.042</td>
<td>-0.278</td>
</tr>
<tr>
<td>( t_{d,t-1} )</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>( m_t )</td>
<td>0.105</td>
<td>-0.144</td>
<td>0.958</td>
</tr>
<tr>
<td>( r_t )</td>
<td>0.157</td>
<td>-0.214</td>
<td>1.427</td>
</tr>
<tr>
<td>( e_t + p_t^* )</td>
<td>-0.105</td>
<td>-0.113</td>
<td>0.019</td>
</tr>
<tr>
<td>( t )</td>
<td>0.019</td>
<td>0.021</td>
<td>-0.003</td>
</tr>
<tr>
<td>( z_t )</td>
<td>-0.002</td>
<td>0.003</td>
<td>-0.019</td>
</tr>
<tr>
<td>( m_t - m^*_t )</td>
<td>0.211</td>
<td>0.241</td>
<td>-0.038</td>
</tr>
<tr>
<td>( r_t - r^*_t )</td>
<td>0.315</td>
<td>0.360</td>
<td>-0.057</td>
</tr>
<tr>
<td>( g_t - g^{n}_t ) (or ( g^{n}_t - g^{n*}_t ))</td>
<td>-0.010</td>
<td>-0.011</td>
<td>0.002</td>
</tr>
<tr>
<td>([e + p^<em>]_t - (e + p^</em>^*)_t ]</td>
<td>0.004</td>
<td>0.004</td>
<td>-0.001</td>
</tr>
</tbody>
</table>

*A refers to the reduced form parameters under the assumption that government expenditure is fixed in real terms, and B under the assumption that government expenditure is fixed in nominal terms.

combination of an expansionary monetary policy and a contractionary fiscal policy. This is because government expenditure falls in real terms. This fiscal effect dominates the expansionary effect of the cheaper imported inputs.

It is perhaps interesting to provide an assessment of the macroeconomic policy that was followed in Greece during the seventies. This may be compared to various alternative scenarios. We chose to examine the effects of Friedman's well-known and controversial \( x\% \) money growth rule. This requires a dynamic policy simulation of the model. Given that our short-term equations were not derived from an explicit dynamic programming problem, the limitations emphasized by Lucas (1976) have to be borne in mind when evaluating the results. Nevertheless, we feel that such an exercise is necessary if one is to reach any conclusions about the actual monetary policy that was followed in Greece, and also about stable monetary growth rules.

Before we perform our policy experiment we have to check the dynamic properties of the model. We ran two dynamic historical simulations with 1951 and 1971 as base years respectively. The root-mean-square percent errors for these simulations are reported in table 7. The base year makes very little difference for the results, which indicate that, apart from the trade deficit equation, the model tracks down the historical experience very closely.
Table 7
RMS percent errors for dynamic historical simulations.

<table>
<thead>
<tr>
<th>Base year</th>
<th>GDP</th>
<th>GDP deflator</th>
<th>Trade deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>2.6%</td>
<td>2.9%</td>
<td>14.0%</td>
</tr>
<tr>
<td>1971</td>
<td>2.7%</td>
<td>2.9%</td>
<td>14.3%</td>
</tr>
</tbody>
</table>

In addition, all major turning points in the evolution of real output and the price level were captured.

To perform our policy experiment we fixed the growth rate of $M_1$ at 18.24% per annum, which was the average rate from 1971 to 1980. This number was chosen to be consistent with the financing of actual government deficits in the seventies. All other policies were left unchanged.

The results are shown graphically in fig. 1. It is clear that this simple monetary growth rule has a strong stabilizing influence. The coefficient of variation of output growth is reduced from 56.2% for the historical simulation, to 30.9%, while the average growth rate increases from 4.8% to 5.5%. The coefficient of variation of inflation is reduced from 38.8% to 4.7%, a dramatic reduction indeed. Given that most of the costs of inflation are related to its unpredictability this is quite important. Finally, even the average percentage of the trade deficit to GDP is reduced from 8.3% for the historical simulation, to 7.7%.

4. Conclusions

In this paper we have presented a small aggregate model for Greece. It is a market clearing, monetarist model, that takes account of some of the special characteristics of a semi-industrialised economy. The model’s main characteristic is an aggregate supply function that highlights the role of the real exchange rate and direct government production. The demand side is derived from an aggregate demand for money function.

The substantial number of restrictions that the model implies for the Greek time series cannot be rejected by a number of tests based on maximum likelihood estimation. The model has a number of interesting policy implications which were analysed in section 2.5. The quantitative effects of macroeconomic policy and the various tradeoffs can easily be established from table 6. Finally, although

Note, however, that the tests of Alogoskoufis (1982) failed to reject a model based on the Lucas aggregate supply function. In that paper the alternative to the ‘natural rate’ hypothesis was the broad hypothesis that anticipated changes in prices affect output. On the basis of the results of our present tests it seems that the tests based on the methodology of Lucas (1972b), Sargent (1973) and Barro (1977, 1978) may specify too weak an alternative for the ‘natural rate’ hypothesis, although this was not suggested in the tests of Leiderman (1979).
Fig. 1

Trade Deficit % of GDP

GDP Growth

Inflation

- historical simulation
- x % rule
the model does not imply that anticipated monetary policy is ineffective, a policy simulation suggests that Friedman’s x% money growth rule would have been far more stabilizing in the 1970s, than the actual monetary policy that was followed in Greece.

Appendix 1: Deriving the reduced forms

Let us denote \( \sum_{i=1}^{\lambda} \theta_{4} + i = (1 - \lambda) \), \( \sum_{i=1}^{\lambda} i \eta_{3} + i = (1 - \mu) \). Let us also denote \( \sum_{i=1}^{\lambda} \theta_{4} + i \gamma_{i-1} = \lambda(L) \gamma_{i-1} \), \( \sum_{i=1}^{\lambda} \eta_{3} + i (m - p)_{i-1} = \mu(L)(m - p)_{i-1} \), where \( L \) is the lag operator.

Eq. (13) can be written as

\[
y_{t} = \theta_{0} + \theta_{1}(p_{t} - p_{T}^*) - \theta_{2}(e_{t} + p_{t}^*) - p_{t} + \theta_{3}t + \theta_{4}(g_{t}^n - p_{t}) + \lambda(L)\gamma_{i-1} + u_{1t}.
\] (A.1)

Solving (16) for \( y_{t} \) and using the above conventions we get

\[
y_{t} = \frac{1}{\mu}(m - p)_{t} - \frac{\eta_{0}}{\mu} r_{t} - \frac{\eta_{3}}{\mu} z_{t} - \frac{\mu(L)}{\mu} (m - p)_{i-1} - \frac{1}{\mu} u_{1t}. \] (A.2)

Equating the right-hand side of (A.1) and (A.2) and solving for \( p_{t} \) we get

\[
p_{t} = \frac{1}{(\theta_{2} + (1/\mu) - \theta_{4})} \left[ \left( \theta_{0} - \frac{\eta_{0}}{\mu} \right) - \theta_{1}(p_{t} - p_{T}^*) - \lambda(L)\gamma_{i-1} - \frac{\mu(L)}{\mu} (m - p)_{i-1} - \frac{1}{\mu} u_{1t} \right].
\] (A.3)

(A.3) is not a reduced form since it includes \( (p_{t} - p_{T}^*) \) which is the deviation of the current price level from the rational expectation of \( p_{t} \), conditional on information available at the end of the previous period. To derive the reduced form we can use the method of undetermined coefficients. Let us assume that the reduced form equation for \( p_{t} \) has the form

\[
p_{t} = \phi_{10} + \phi_{11}\lambda(L)\gamma_{i-1} + \phi_{12}\mu(L)(m - p)_{i-1} + \phi_{13}m_{t} + \phi_{14}r_{t}
\]

\[
+ \phi_{15}g_{t}^{n} + \phi_{16}(e_{t} + p_{t}^*) + \phi_{17}t + \phi_{18}z_{t} + \phi_{19}(m_{t} - m_{T}^*)
\]

\[
+ \phi_{110}(r_{t} - r_{T}^*) + \phi_{111}(g_{t}^{n} - g_{T}^{n}) + \phi_{112}[(e_{t} + p_{t}^*) - (e_{t} + p_{T}^*)]^e
\]

\[
+ \phi_{113}(z_{t} - z_{T}^*). \] (A.4)
Using (A.4), \( p_t - p^*_t \) is equal to
\[
(p_t - p^*_t) = (\phi_{13} + \phi_{19})(m_t - m^*_t) + (\phi_{14} + \phi_{110})(r_t - r^*_t)
\]
\[
+ (\phi_{15} + \phi_{111})(g_t^n - g^{n^e}_t) + (\phi_{16} + \phi_{112})[(e_t + p^*_t) - (e_t + p^*_t)]
\]
\[
+ (\phi_{18} + \phi_{113})(z_t - z^*_t).
\]
(A.5)

Substituting (A.5) in (A.3) and comparing coefficients between the resulting equation and (A.4) we can determine the \( \phi \)'s as in the main text. The parameters of the output equation can be derived by substituting the reduced form for \( p_t \) in either the aggregate supply or the demand for money equation.

Appendix 2: Data definitions and sources


\( m_t \) = Log of yearly average of the money supply (\( M1 \)). For the early part of the sample (1950–1957), the yearly average was computed as a weighted average of the money stock at the beginning and at the end of each year. The weights were computed by running a regression for 1958–1980 and they were 0.75 for the beginning of the period and 0.25 for the end. Source: Bank of Greece, Monthly Statistical Bulletin, various issues.

\( f_t \) = Log of yearly averages of net foreign exchange reserves of the Bank of Greece. For 1950–1957 the yearly average was computed in the same way as \( m_t \). The weights in this case were 0.65 for the beginning of the year and 0.35 for the end. Source: Bank of Greece, Monthly Statistical Bulletin, various issues.

\( r_t \) = Opportunity cost of \( M1 \). This was computed as the difference of the yearly average of the interest rate on savings deposits, and the interest rate on demand deposits. The latter was weighted by the percentage of demand deposits in \( M1 \) at the end of the previous year. Source: Bank of Greece (1980) and Monthly Statistical Bulletin, Dec. 1981.

$td_t$ = Log of trade deficit, deflated by the GDP deflator. The trade deficit is calculated as imports minus exports on a national accounts basis. *Source*: OECD (1982).

**References**


Durbin, J., 1970, Testing for serial correlation in least-squares regression when some of the regressors are lagged dependent variables, Econometrica 38, 410–421.


Hicks, J.R., 1937, Mr. Keynes and the classics: A suggested interpretation, Econometrica 5, 147–159.

Hicks, J.R., 1939, Value and capital (Oxford University Press, London).

