DETERMINANTS OF MONEY DEMAND IN GREECE 1966 I - 1977 IV

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The paper examines the determinants of the money demand in Greece. Theoretically, we distinguish between the short-run and the long-run money demand equations and introduce an adjustment mechanism linking these two expressions. The arguments entering in the long -as well as in the short-run money demand equations are permanent income, the rate of interest and the rate of change of the general price level.

1. *Introduction*

As is well-known, in the last twenty years, the literature on the demand for money — both at the theoretical and the empirical level — has been extensive and growing. This proposition pertains to the advanced industrialized economies of the West, especially to the U.S. and the U.K. The related literature on this subject in Greece is very limited. To our knowledge there are only two recent studies on this subject by Brissimis and Leventakis (1981) and Prodromidis and Dimitriadou-Kotsikou (1980). The purpose of this paper is to help close this gap by investigating the money demand in Greece for the period 1966 I - 1977 IV. In section 2 we introduce a theoretical model by means of which we examine the most important determinants of measured money[1]. In section 3 we examine the data required for the analysis and their sources. The empirical analysis is given in the fourth section, whereas the main findings of the study are summarised in the last section of the paper.

2. *The Model*

The determinants of money demand are examined within the con-

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1. This part of the paper draws upon earlier work by K. Prodromidis and C. Dimitriadou-Kotsikou (1975, 1980).

text of a theoretical model combining short-run and long-run money demand equations by means of an adjustment mechanism. The distinction between short- and long-run money demand functions is suitable for an analysis explaining the cyclical vis-a-vis the long-run income velocity of money [cf. Friedman (1959)]. The adjustment mechanism is a basic ingredient of our analysis for it explains how measured money is adjusted to its desired — equilibrium — level. According to this mechanism, the public will seek to adjust the change in its actual money stock to the change in its desired stock as well as to the difference between actual and desired real cash balances. To facilitate our understanding in this regard an extra assumption, commonly used, is needed, namely that money is a consumer durable good yielding services to its owner [Friedman (1956), (1959)].

A. The Adjustment Mechanism

In symbols, the adjustment mechanism we propose is given by the expression[2]

$$m_t - m_{t-1} = \lambda_1(m_t^* - m_{t-1}^*) + \lambda_2(m_{t-1}^* - m_{t-1}) + u_t \qquad (2.1)$$

where m and m* denote respectively the actual and desired (permanent) total quantity of money in real terms, λ_1 and λ_2 are two adjustment coefficients such that $0 \leqslant \lambda_1, \lambda_2 \leqslant 1$, u is a random variable with certain properties, and t and $t-1$ are time indices. The presence of m_{t-1} in the RHS of (2.1) implies that it is autocorrelated with u_t. In this connection we make the assumption that u_t follows a first-order autoregressive scheme, i.e., $u_t = \rho u_{t-1} + e_t$ where $|\rho| < 1$ and e_t is a normally and independently distributed random variable with zero mean and constant variance[3].

Equation (2.1) suggests that the observable change in actual money stock, $m_t - m_{t-1}$, is explained by two factors: the change in desired real cash balances $m_t^* - m_{t-1}^*$ and the difference between actual and desired real cash balances at the time period $t-1$, $m_{t-1}^* - m_{t-1}$. The former change may itself be broken down into two parts, one attributable to variables changing slowly and steadily over time, the other to variables

2. All variables employed in the text are expressed in natural logarithms.
3. Specifically, $E\, e_t = 0$ and $\sigma_e^2 = \sigma_u^2 / (1 - \rho^2)$ for all t.Cf. Johnston (1972, pp. 244-45).

changing more irregularly. Among the variables included in the former group is real permanent income, y_{pt}, and among those in the latter group are the nominal rate of interest, r_t, and the rate of change of prices, $\dot{p}_t$, i.e., variables representing the opportunity cost of holding money. The numerical value of parameter λ_i, $i = 1, 2$, in (2.1) expresses the speed of adjustment of measured money to its desired level. If $\lambda_i = 1$ then the speed of adjustment is realized within a single time period, i.e., $m_t = m_t^*$. On the contrary, if $\lambda_i = 0$ then the adjustment never takes place because in that case the measured quantity of money remains invariant over time, i.e., $m_t = m_{t-1}$. In principle, the adjustment coefficients λ_1 and λ_2 are not equal to each other. If they were equal that would be pure coincidence. In that case our adjustment mechanism would reduce to the well-known partial (stock) adjustment mechanism $m_t - m_{t-1}^* = \lambda(m_t^* - m_{t-1})$, which has been used in numerous studies associated with the demand for money[4]. Furthermore, if we take into account the variables associated with λ_1 and λ_2, we may argue that the former is greater in value than the latter[5]. [Notice again that λ_2 is the coefficient of adjustment to unintended discrepancies at any point in time between actual and desired real cash balances]. In fact, in an empirical study utilizing US (annual) data there were estimated values for λ_1 between 0.76 and 0.89 and for λ_2 up to 0.15[6].

B. The Long-run Equation

As we mentioned in the beginning of this section the long-run and the short-run money demand equations are combined in the adjustment mechanism (2.1). The former expression is given by

$$m_t^* = \beta_0 + \alpha_1 y_{pt} + \alpha_2 r_t + \alpha_3 \dot{P}_t + v_t \qquad (2.2)$$

where the expected signs of the elasticities appearing in (2.2) are: $\alpha_1 > 0$, a_2 and $\alpha_3 < 0$; and v_t is a random variable satisfying the assumptions of the classical normal linear regression model. To obtain the first term

4. See, for instance, the studies by Feige (1967), Starleaf (1970), Price (1972), Goldfeld (1973, 1976), Hacche (1974), Lybeck (1975), Laumas and Mehra (1976), Laumas (1979), and Al-Khuri and Nsouli (1979).

5. Cf. Chow (1966), p 114.

6. Prodromidis and Dimitriadou (1975).

in the RHS of (2.1) we lag (2.2) one period and substract the latter from (2.2). The result is

$$m_t^* - m_{t-1}^* = \alpha_1(y_{pt} - y_{pt-1}) + a_2(r_t - r_{t-1}) + \alpha_3(\dot{P}_t - \dot{P}_{t-1}) + v_t - v_{t-1} \quad (2.3)$$

where $v_t - v_{t-1}$ is a normally distributed random variable with zero mean and constant variance equal to $2\sigma_v^2$.

C. The Short-run Equation

By inserting (2.3) and the lagged form of (2.2) in the adjustment mechanism (2.1), we obtain, after arranging the terms, the short-run demand for money function

$$m_t = \beta_1 + \alpha_1\lambda_1 y_{pt} + \alpha_1(\lambda_2 - \lambda_1)y_{pt-1} + \alpha_2\lambda_1 r_t + \alpha_2(\lambda_2 - \lambda_1)r_{-1}$$
$$+ \alpha_3\lambda_1\dot{P}_t + \alpha_3(\lambda_2 - \lambda_1)\dot{P}_{t-1} + (1 - \lambda_2)m_{t-1} + \varepsilon_t \quad (2.4)$$

where $\varepsilon_t = \lambda_1(v_t - v_{t-1}) + \lambda_2 v_{t-1} + u_t$[7].

In view of the terms entering in the RHS of equation (2.4), we observe that a direct estimation of this expression is not efficient, since it requires the estimation of seven parameters (excluding the constant) while our problem only calls for five. The overidentification problem at issue may be handled by estimating (2.4) via a non-linear regression program allowing for non-linear constraints on the coefficients. However, since such programs are not available to us, we have to resort to a simpler method of estimation. Furthermore, it is rather certain that the direct estimation of (2.4) would suffer from a high degree of intercorrelation among the explanatory variables involved. To overcome these problems we rewrite (2.4) as

$$m_t = \beta_1 + \lambda_1[\alpha_1(y_{pt} - y_{pt-1}) + \alpha_2(r_t - r_{t-1}) + \alpha_3(\dot{P}_t - \dot{P}_{t-1})] +$$
$$\lambda_2(\alpha_1 y_{pt-1} + \alpha_2 r_{t-1} + \alpha_3\dot{P}_{t-1}) + (1 - \lambda_2)m_{t-1} + \varepsilon_t \quad (2.5)$$

and set forth to estimate it subject to the estimated values $\hat{\alpha}_1$, $\hat{\alpha}_2$ and $\hat{\alpha}_3$ stemming from equation (2.2). Nevertheless, the overidentification

7. The mean and the variance of the disturbance term ε_t are $E\varepsilon_t = 0$ and $\sigma_\varepsilon^2 = (2\lambda_1^2 + \lambda_2^2)\,\sigma_v^2 + \sigma_e^2/(1 - \rho^2)$, respectively. Moreover $E(\varepsilon_t m_{t-1}) = E(u_t\, m_{t-1}) \neq 0$.

problem mentioned above continues to remain. This may be taken care of by transforming (2.5) into

$$m_t - m_{t-1} = \beta_1 + \lambda_1[\alpha_1(y_{pt} - y_{pt-1}) + \alpha_2(r_t - r_{t-1}) + \alpha_3(\dot{P}_t - \dot{P}_{t-1})]$$

$$+ \lambda_2(\alpha_1 y_{pt-1} + \alpha_2 r_{t-1} + \alpha_3 \dot{P}_{t-1} - m_{t-1}) + \varepsilon_t \qquad (2.6)$$

and fitting the resulting expression. The efficient estimates of the adjustment coefficients λ_1 and λ_2 emanating from (2.6) may then be compared to the respective estimates obtained from (2.5).

3. *The Data*

It is perhaps proper to state at the outset that the annual data available are not sufficient to help us construct the permanent variables series required by our analysis. Consequently, the empirical estimations are based on quarterly data[8]. Our sample consists of forty eight quarterly observations and covers the period 1966 I - 1977 IV. In addition, it makes use of the last quarter of 1965 for variables lagged one quarter. The computation of the permanent variables series relies on observations going back to 1958 II (1958 I for lagged variables), since the weights required for their computation correspond to thirty-two quarters. The procedure followed for the derivation of the weights at issue is explained in the Appendix at the end of the paper.

The data required for our analysis and their sources are as follows:

M = Measured quantity of money in the middle of the quarter, adjusted for seasonality, in millions of current drachmas. The two concepts of money used are : M_2 = currency in circulation plus sight deposits plus savings deposits of individuals and business firms at commercial banks and special credit institutions; $M_3 = M_2$ + time deposits of individuals and business firms at commercial banks and special credit institutions. *Source :* Bank of Greece, *Monthly Statistical Bulletin.*

Y = Measured GNP in millions of current drachmas. *Source:* Ministry of Coordination, *National Accounts.* The quarterly observations for variables Y and y (see below) were derived from

8. The data used in the empirical analysis are available upon request to the author.

annual data by means of the Boot, Feibes and Lisman (1967) method[9].

y = Measured GNP in millions of drachmas at 1970 prices. *Source:* Ministry Coordination, *National Accounts*.

Y_p = Permanent GNP in millions of current drachmas. See Appendix.

y_p = Permanent GNP in millions of drachmas at 1970 prices. See Appendix.

$\dot{P}_y$ and $\dot{P}_p$ are the ratios Y/y and Y_p/y_p, respectively.

P_y and P_p are the rates of change of P_y and P_p, respectively.

m and m* are the ratios M/P_y and M/P_p, respectively.

r = Weighted average of interest rates on time deposits and on savings deposits at commercial banks, the agricultural bank and the postal savings bank, adjusted for seasonality, in the middle of the quarter. *Source :* Bank of Greece, *Monthly Statistical Bulletin.*

4. Empirical Analysis

In this section we present the estimates of the long and short-run money demand functions introduced in section 2. In addition, we provide the tests performed for stability and homogeneity with respect to prices of the long-run money demand function. The method employed is regression analysis. All variables are in natural logarithms. Numbers in parentheses below each coefficient are t values. R^2 and SER denote the coefficient of multiple determination and the standard error of the regression equation, respectively. DW stands for the Durbin-Watson statistic, h is Durbin's statistic for testing serial correlation in regressions employing lagged dependent variables among their regressors, and ρ is the first-order autocorrelation coefficient obtained from the Cochrane-Orcutt (CORC) iterative process.

9. This method has been used as well in other countries, eg. Ireland; cf. Fase and den Butter (1979).

A. Estimation of the long-run demand for money function

In the first place, we test for the *homogeneity* of the long-run money demand equation with respect to prices. To this end we rewrite the double-log expression (2.2) in nominal terms, and set forth to estimate equation

$$M_i = \beta_0 + \alpha_1 y_p + \alpha_2 r + \alpha_3 \dot{P}_p + \alpha_4 P_p + v \tag{4.1}$$

where all variables are explained in section 3 (except v which is discussed in section 2) and index i, i = 2, 3, stands for the narrower and the wider money stock concepts of the preceding section. The time subscripts have been omitted for simplicity.

In addition to equation (4.1), we also estimate its Keynesian counterpart for the sake of comparison. The latter expression is written as

$$M_i = b_0 + a_1 y + a_2 r + a_3 \dot{P}_y + a_4 P_y + \nu \tag{4.2}$$

where all variables are explained in section 3 and ν should be interpreted in a manner analogous to v of (4.1). The statistical results are exhibited in the first four columns of Tables 1 and 2.

The estimates presented in these tables are based on the ordinary least squares (OLS) and the CORC iterative process, respectively. The use of the latter process was necessitated by the existing serious positive autocorrelation of disturbances, which is reflected in the very low values — around 0.5 — of the DW statistics associated with the M_2 and M_3 estimated versions of equations (4.1) and (4.2). These are given in Table 1. Moreover, the serial dependance of the disturbance terms was so pronounced, especially in the case of both M_2 and M_3 estimated versions of equation (4.2), that even the application of the CORC procedure did not help in reducing it. On the other hand, the autocorrelation problem at hand was substantially reduced when both versions of equation (4.1) were estimated by means of the CORC process. This can be seen by inspecting the corresponding DWs in Table 2.

All regression coefficients of both estimated versions, M_2 and M_3, of equations (4.1) and (4.2) have the correct signs and, with a few exceptions, are statistically significant at the one percent level (Tables 1 and 2). The exceptions relate to the constant term, the interest rate and the price level coefficients reported in Table 2 in connection with the M_2 and M_3 versions of equation (4.2). Upon inspection of the estimated values of the price variables P_p and P_y reported in the first four co-

TABLE 1

Estimates of the long-run money demand equation

Eq. No	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
depend. var. →	M_2	M_2	M_3	M_3	m_2	m_2^*	m_3^*	m_3
intercept →	—3.1903	—3.0681	—3.7993	—3.5747	—3.8874	—3.0429	—4.4725	—3.5423
	(—30.7468)	(—17.8341)	(—36.3102)	(—20.0031)	(—33.2168)	(—18.3142)	(—37.3636)	(—20.4712)
y_p	1.7576		1.9166		1.7848		1.9360	
	(87.8761)		(95.0238)		(93.1947)		(98.8338)	
$\dot{P}_p$	—0.0356		—0.0355		—0.1058		— 0.1065	
	(—5.1188)		(—5.0655)		(—12.7881)		(—12.5904)	
P_p	1.0282		1.0174					
	(60.9017)		(59.7616)					
r	—0.1215	—0.0814	—0.1398	—0.0749	—0.1885	—0.0934	—0.2086	—0.0902
	(—6.0923)	(—2.7180)	(—6.9512)	(—7.5709)	(—7.8972)	(—4.1115)	(—8.5450)	(—3.8151)
Y		1.6937		1.8411		1.6797		1.8232
		(47.8032)		(50.0240)		(61.9300)		(64.5428)
P_y		—0.0449		—0.0459		—0.0448		—0.0457
		(—7.6926)		(—7.5709)		(—7.7259)		(—7.5773)
P_y		0.9828		0.9781				
		(35.9146)		(34.4074)				
R^2	0.9996	0.9987	0.9996	0.9986	0.9977	0.9950	0.9980	0.9955
DW	0.48	0.46	0.48	0.49	0.64	0.47	0.63	0.48
SER	0.0128	0.0228	0.0129	0.0237	0.0155	0.0226	0.0158	0.0236

Note : All variables are in natural logarithms. Method of estimation: ordinary least squares. Sample period: 1966 I - 1977 IV (observations: 48). Numbers in parentheses are t values. The critical t values at the one and five percent levels are 2.41 and 1.69 respectively.

TABLE 2

Estimates of the long-run money demand equation

Eq. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
depend. var. →	M_2	M_2	M_3	M_3	m_2^*	m_2	m_3^*	m_3
intercept →	—3.1644 (—10.0391)	—0.1931 (—0.2127)	—3.8229 (—11.5844)	0.0553 (0.0577)	—3.7465 (—13.7903)	—0.4065 (—0.5240)	—4.2997 (—14.9942)	0.0972 (0.1077)
y_p	1.7685 (26.1778)		1.9400 (27.3838)		1.7226 (35.8665)		1.9217 (36.6486)	
$\dot{P}_p$	—0.0434 (—3.7255)		—0.0478 (—4.0721)		—0.1125 (—7.6347)		—0.1162 (—7.6671)	
P_p	1.0159 (25.6668)		0.9968 (24.3286)					
r	—0.0884 (—3.5407)	—0.0673 (—1.5023)	—0.0934 (—3.7524)	—0.0773 (—1.6661)	—0.1464 (—4.4534)	—0.0699 (—1.8166)	—0.1534 (—4.6027)	—0.0850 (—2.0695)
y		1.1230 (5.4569)		1.1044 (5.1113)		1.1544 (6.7940)		1.0839 (5.5118)
$\dot{P}_y$		—0.0159 (—2.2222)		—0.0145 (—1.9538)		—0.0166 (—2.3154)		—0.0147 (—1.9938)
P_y		0.9551 (12.3058)		0.9609 (11.8927)				
ρ	0.7890 (8.8041)	0.9607 (23.7249)	0.8024 (9.2194)	0.9629 (24.4762)	0.7187 (7.0865)	0.9533 (21.6512)	0.7381 (7.4994)	0.9612 (23.8794)
R^2	0.9998	0.9996	0.9988	0.9996	0.9987	0.9984	0.9989	0.9985
DW	1.40	0.77	1.32	0.67	1.50	0.76	1.47	0.68
SER	0.0082	0.0124	0.0081	0.0129	0.0113	0.0125	0.0114	0.0129

Note : All variables are in natural logarithms. Method of estimation: CORC. Sample period: 1966 I - 1977 IV (observations: 47). Numbers in parentheses are t values. The critical t values at the one- and five percent levels are 2.41 and 1.68, respectively. The lower and upper limits for the significance of DW at the one percent level are (1.20, 1.48) and (1.16, 1.53) for the cases of three and four explanatory variables respectively.

lumns of Tables 1 and 2, we observe that nominal money stock is homogeneous of the first degree to prices. This conclusion holds as stated in the case of variable P_p, whereas it is somewhat weaker in the case of variable P_y. In the former case the respective elasticity estimates are 1.0 and 1.02 (Table 2, columns 1 and 3), and in the latter they are both about 0.96 (Table 2, columns 3 and 4).

Having established that the nominal quantity of money M_i is homogeneous of the first degree to prices, we deflate it by the respective prices and get the quantities $m_i^* = M_i/P_p$ and $m_i = M_i/P_y$, $i = 2, 3$. Next, we fit to our data the corresponding real versions of both money stock equations (4.1) and (4.2) [i.e., we omit the price level variable from the estimation process][10]; the former of these two expressions is equation (2.2). The statistical results are cited in the last four columns of Tables 1 and 2. Not surprisingly, these results are similar in nature to those reported in the first four columns of these tables. They suggest that real money is elastic with respect to real income (permanent or measured) and inelastic with respect to the rate of interest and the rate of change of prices (permanent or measured). Apart from this qualitative similarity, however, the quantitative differences are quite pronounced: The permanent income elasticity estimates of real money exceed, to a large degree, the corresponding measured income elasticity estimates; the former are between 1.8 and 1.9 and the latter between 1.1 and 1.15. Similarly, the interest rate elasticities and the rate of price change elasticities associated with the real permanent money concepts (m_2^*, m_3^*) have been estimated as about –0.15 and –0.11 respectively. These estimates are about two and six times higher in absolute terms than the corresponding estimates associated with real measured money (m_2 or m_3). Accordingly, the latter estimates are not significantly different from zero at the one percent level, and the DW and SER statistics connected with the real measured money expressions are inferior to those related to the real permanent money equations. To put it another way, the results given in columns (5) and (7) of Table 2 seem to be superior to the estimates of columns (6) and (8) of the same table.

10. At this point a comment may be in order. One could argue that the estimation of the real versions of equations (4.1) and (4.2) is redundant because, in principle, they convey the same piece of information as the nominal expressions (4.1) and (4.2). In doing this, however, we reduce the number of explanatory variables by one and, hence, we reduce the possibility of serious intercorrelation among the explanatory variables especially when performing our stability test. (See below.).

The next step is to examine whether the long-run demand for money function remained *stable* in Greece throughout the observation period. This is important to the academician and the policy-maker given that the Greek economy was hit by the stagflation syndrome during the 1972 II - 1974 II subperiod[11]. To test for the intertemporal stability of the overall long-run expression implies testing for differences in intercepts and in slopes between subperiods. To this end we introduce among the regressors of equation (2.2) a dummy variable, D, taking a unit value for the quarters 1972 II - 1974 II and zero elsewhere, as well as product variables Dy_p, Dr, and $D\dot{P}_p$. This technique was preferred to the familiar Chow test because the latter differentiates between just two subperiods. The results are presented in Table 3. They indicate that the long-run demand function for real money did not remain constant throughout the sample period. This statement applies to both m_2^* and m_3^* concepts of real money. In fact, the estimated F statistics[12] exceed the critical values $F(4, 40; 0.05) = 2.61$ and $F(4, 40; 0.01) = 4.43$. (The coefficients of D, Dy_p and $D\dot{P}_p$ are significantly different from zero). The estimated equations in Table 3 are free of autocorrelation. Furthermore, the y_p, $\dot{P}_p$ and r elasticities of both real money concepts with respect to the subperiods 1966 I - 1972 I and 1974 III - 1977 IV are almost identical to their counterparts pertaining to the sample period 1966 I - 1977 IV. Cf. the corresponding elasticities in Tables 3 and 2, columns (5) and (7).

B. Estimation of the short-run demand for money function

In this part of the paper we are concerned with the estimation of the short-run money demand equation. We remind the reader that our objective is to estimate equations (2.5) and (2.6) subject to restrictions and compare, in turn, the resulting rates of adjustment. The restrictions

11. In addition to the international monetary and oil crises that afflicted the world economy during the period at issue, the Greek economy was also affected by its internal political situation and was struck by the long state of military alert and emergency due to the Turkish invasion of Cyprus. In the 1972 II - 1974 II subperiod, the average rates of change of real GNP and the GNP deflator were 0.6 and 5 percentage points respectively. The corresponding average rates of change of real GNP and the GNP deflator were 1.8 and 0.7 percent per quarter in the 1966 I - 1972 II subperiod, and 1.4 and 2.9 percent in the 1972 II 1977 IV subperiod.

12. The formula for deriving the F values cited in Table 3 is given in Kmenta (1971, pp. 370-71).

are the y_p, $\dot{P}_p$ and r elasticities of m_2^* and m_3^* presented in Tables 2 and 3, columns (5) and (7).

The statistical results are listed in Table 4. In particular, regres-

TABLE 3

Testing the stability of the long-run money demand function

Respective equation No. in Table 2	(5)	(7)		(5)	(7)
dependent var. →	m_2^*	m_3^*		m_2^*	m_3^*
intercept →	—3.5994	—4.1795	ρ	0.6430	0.6339
	(—17.8445)	(—22.9225)		(5.7579)	(5.6198)
y_p	1.7569	1.9070	R^2	0.9992	0.9994
	(51.2124)	(61.7064)			
$\dot{P}_p$	—0.1164	—0.1167	DW	1.59	1.65
	(—7.4046)	(—8.1831)			
r	—0.1111	—0.1316	SER	0.0093	0.0085
	(—2.4382)	(—3.1740)			
D	18.2041	20.9811	F	6.250	8.333
	(4.3779)	(5.4725)			
Dy_p	—3.8194	—4.3933			
	(—4.4134)	(—5.5063)			
$D\dot{P}_p$	0.2829	0.3193			
	(4.2258)	(5.1738)			
Dr	0.0409	0.0713			
	(0.7353)	(1.4012)			

Note : All variables are in natural logarithms. Method of estimation: CORC process. Sample period: 1966 I - 1977 IV (observations: 47). For critical t values and DW values see Note to Table 2. The critical F values are: $F(4, 40; 0.05) = 2.61$ and $F(4,40; 0.01) = 4.43$.

sions (1) and (3) are the m_2 and m_3 estimates of equation (2.5), whereas regressions (2) and (4) are the $\Delta m_2 = m_2 - m_{2t-1}$ and $\Delta m_3 = m_3 - m_{3t-1}$ estimates of equation (2.6). The restrictions $\hat{\alpha}_i$, $i = 1, 2, 3$ related to regressions (1), (2) and (3), (4) originate from the long-run estimated regressions (5) and (7) of Table 2. Similarly, regressions (1′) — (4′) should

TABLE 4

Estimates of the short-run money demand equation under restrictions $\hat{\alpha}_i$, i = 1, 2' 3

Eq. No. →	(1)	(2)	(3)	(4)	(1')	(2')	(3')	(4')
depend. var. →	m_2	m_2	m_3	Δm_3	m_2	Δm_2	m_3	Δm_3
intercept →	—0.9546 (—2.3742)	—0.9706 (—2.4661)	—0.9994 (—2.2791)	—1.0212 (—2.3729)	—0.8008 (—2.2615)	—0.8067 (—2.3247)	—08762 (—2.1729)	—0.8906 (—2.2532)
λ_1	0.8931 (8.2024)	0.9028 (8.8731)	0.8753 (8.4241)	0.8882 (9.1578)	0.9205 (7.9072)	0.9257 (8.5834)	0.9055 (8.2486)	0.9154 (8.9873)
λ_2	0.2573 (2.4191)	0.2597 (2.4749)	0.2353 (2.3229)	0.2382 (2.3814)	0.2240 (2.2955)	0.2247 (2.3320)	0.2118 (2.2115)	0.2137 (2.2605)
$1 - \lambda_2$	0.7412 (6.9877)	na	0.7629 (7.5513)	na	0.7752 (7.9556)	na	0.7868 (8.2350)	na
λ_2'	0.2588	na	0.2371	na	0.2248	na	0.2132	na
R^2	0.9988	0.6376	0.9989	0.6523	0.9998	0.6254	0.9990	0.6286
DW	1.33	1.35	1.27	1.29	1.21	1.22	1.22	1.23
h	3.16		3.54		3.71		3.60	
SER	0.0111	0.0109	0.0111	0.0110	0.0113	0.0111	0.0112	0.0111
$\hat{\alpha}_1$	1.7226	1.7226	1.9217	1.9217	1.7569	1.7569	1.9070	1.9070
$\hat{\alpha}_2$	—0.1464	—0.1464	—0.1534	—0.1534	—0.1111	—0.1111	—0.1316	—0.1316
$\hat{\alpha}_3$	—0.1125	—0.1125	—0.1162	—0.1162	—0.1164	—0.1164	—0.1167	—0.1167

na = non applicable

Note; All variables are natural logarithms. Method of estimation : OLS. Sample period : 1966 I-1977 IV (observations 48). Restrictions $\hat{\alpha}_i$, i = 1, 2, 3, in connection with columns (1)-(4) come from Table 2, columns (5) and (7); and restrictions $\hat{\alpha}_i$ in connection with columnes (1') - (4'): come from Table 3. Odd- and even numbered equations are associated with equations (2.5) and (2.6), respectively. Numbers in parentheses are t values. Critical t values at the one and five percent levels are about 2.4 and 1.68, respectively. The lower and upper limits for the significance of DW at the one percent level are (1.24, 1.42) for the case of two explanatory variables. The critical h values at the one and five percent levels are 2.326 and 1.645 respectively.

be interpreted accordingly. Their respective restrictions $\hat{\alpha}_i$, $i = 1, 2, 3$ emanate from the long-run estimates of Table 3, and correspond to subperiods 1966 I - 1972 I and 1974 III - 1977 IV.

On the whole, the above results appear to be satisfactory. All estimates of the regression coefficients (rates of adjustment) are positive but smaller than unity and are at least statisticaly significant at the five percent level. Specifically, the λ_1 estimated values are, as expected,

TABLE 5

Forecasting outside the sample period by means of equations (2.5) and (2.6)

Respective equation No. in Table 4		(1)	(3)	(1′)	(3′)
1978 I	actual	5.293	5.366	5.293	5.366
	forecast	5.235	5.402	5.233	5.401
1978 II	actual	5.307	5.377	5.307	5.377
	forecast	5.761	5.865	5.805	5.888
R.M.S.E.		0.324	0.345	0.355	0.362
		(1.382)	(1.413)	(1.4257)	(1.434)
Respective equation No in Table 4		**(2)**	**(4)**	**(2′)**	**(4′)**
1978 I	actual	0.032	—0.060	0.032	—0.060
	forecast	—0.026	—0.024	—0.028	—0.025
1978	actual	0.013	0.011	0.013	0.011
	forecast	0.473	0.507	0.515	0.528
R.M.S.E.		0.328	0.351	0.357	0.366
		(1.388)	(1.421)	(1.429)	(1.442)

Note: All values are in natural logarithms. Odd- and even numbered equations are associated with equations (2.5) and (2.6,) respectively. Figures in parentheses are antilogs.

greater in size than the λ_2 estimates. The former range between 0.875 and 0.926, and the latter between 0.21 and 0.26. The indirect estimates $\lambda_2' = 1 - \lambda_2$ (see odd-numbered columns in Table 4) are included in that range. At this point it is worth emphasizing that the discrepancy in the estimates of the adjustment coefficients coming from equations (2.5) and (2.6) is not important.

Finally, the forecasting ability of the odd numbered regressions appearing in Table 4 is quite satisfactory. (On the contrary, the forecasting ability of the even numbered expressions is not promising). This statement applies to their fitted values in relation to the first two quarters outside the sample. The reader may confirm this finding by comparing the predicted values of real money balances to their actual ones for quarters 1978 I and 1978 II. The figures pertaining to the odd numbered expressions are given in the upper part of table 5. In other words, the RMSEs of these forecasts range between 0.32 and 0.36. Taking in turn the antilog values of the RMSEs at issue we note that they correspond to approximately 1.4 billion real drachmas, i.e., to less than one percent of the values of either of the monetary concepts realized in the first two quarters outside the sample. In relative terms, the forecasts emanating from equations (1) and (3) of Table 5 are more promising than those connected with equations (1′) and (3′).

5. *Summary*

In this paper we examined the determinants of money demand in Greece. The paper consisted of a theoretical and an empirical part. In the theoretical part, we distinguished between the short-run and the long-run money demand equations and introduced an adjustment mechanism linking these two expressions. According to this mechanism, the observable change in money stock was explained by two terms: the difference between actual and desired real cash balances in time period t — 1, and the change in the desired real cash balances from time period t — 1 to time period t. The arguments entering in the long- as well as in the short-run money demand equations were: permanent income, the rate of interest and the rate of change of the general price level.

The empirical analysis was based on a sample of forty-eight quarterly observations covering the period 1966 I - 1977 IV, and utilized quarterly data going back to 1958 II for the formation of the necessary observations of the permanent variables. Thirty-two observations of a measured variable were needed to make one observation of a permanent variable.

In the empirical part of the paper we tested for the stability as well as for the homogeneity of the long-run money demand equation in relation to prices. The results suggest that the demand for nominal cash balances in Greece was homogeneous to the first degree to prices (permanent or measured). However, the long-run demand function for real permanent (desired) money stock was unstable during the 1972 II - 1974 II period. The long-run elasticity estimates of real permanent money with respect to real permanent income, the rate of interest and the rate of change of permanent prices were around 1.8 to 1.9, —0.15 and —0.11, respectively. Furthermore, the coefficients of the adjustment mechanism introduced in the paper were estimated to about 0.9 and 0.25, respectively. This finding suggests that, in the 1966 I - 1977 IV period, the relative change in the observable real money stock in Greece was explained mainly by the relative change in desired real cash balances, and in part by the relative change in the gap between the desired and measured real money stock of the preceding quarter. Finally, forecasts made for the first two quarters outside the sample period were satisfactory. The root mean square errors of the forescats were less than one percent.

APPENDIX

To compute the permanent income series, we adopted its well-known — empirical — approximation given by the infinite order linearly distributed lagged relationship

$$y_{pt} = a \sum_{\tau=0}^{\infty} (1 - a)^{\tau} y_{t-\tau} \tag{A.1}$$

where y_{pt}[13] and y_t stand for permanent and measured real GNP, respectively, and the coefficients of the successive y's decline geometrically as we go back in time. Variable y_{pt} in (A.1) originates from the adaptive expectations model $y_{pt} - y_{pt-1} = \alpha (y_t - y_{pt-1})$ by means of the just mentioned Koyck specification regarding the bahavior of the income coefficients. [For details see Goldberger (1964), pp. 274-76].

To get an estimate of parameter a in (A.1) we worked as follows: At first, we estimated the linear consumption function

$$\begin{array}{cccc} c_t = & 7.8913 & + \ 0.3795\ y_t & + \ 0.5426\ c_{t-1} \\ & (2.3639) & (4.0806) & (4.2758) \end{array} \tag{A.2}$$

$$R^2 = 0.996, \ DW = 1.86$$

13. Alternatively, y_{pt} may be computed via Wold' non-linear iterative least squares method. Unfortunately, however, such a program was not available to us.

by employing *annual* data covering the 1958-75 period. Variable c denotes private consumption in million drachmas at 1970 prices, and figures in parentheses below the coefficients are t values. The *annual* estimate of parameter a is obtained from (A.2) and is written as $a_A = 1 - .5426 = .4574$. Secondly, we transformed the annual coefficient a_A to the *quarterly* coefficient a_Q by means of formula $a_A = 1 - (1 - a_Q)^4$ [see Darby (1974), p. 233]. Finally, we obtained the quarterly weights needed in (A.1) from the formula $a_{Q,\tau} = (1 - a_Q)^{\tau} \cdot a_Q$, where $\tau = 0, 1, \ldots, 31$, and $\Sigma a_{Q\tau} = 1$. The numerical values of the thirty-two weights at issue are:

$a_0 = .143$, $a_1 = .123$, $a_2 = .105$, $a_3 = .091$, $a_4 = .078$, $a_5 = .066$, $a_6 = .057$, $a_7 = .049$, $a_8 = .042$, $a_9 = .036$, $a_{10} = .031$, $a_{11} = .026$, $a_{12} = .023$, $a_{13} = .019$, $a_{14} = .017$, $a_{15} = .014$, $a_{16} = .012$, $a_{17} = .011$, $a_{18} = .009$, $a_{19} =$ 008, $a_{20} = .007$, $a_{21} = .006$, $a_{22} = .005$, $a_{23} = a_{24} = 0.004$, $a_{25} = a_{26} = .003$, $a_{27} = \ldots = a_{29} = .002$, $a_{30} = a_{31} = .001$. [The above values were rounded up to the third decimal place][14].

The thirty-two quarterly weights mentioned above were also used for the construction of all other permanent variables required by the empirical analysis. For a similar view, see also Friedman (1959) and Friedman and Schwartz (1963).

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14. At the early stages of the research we had derived thirdty-seven weights. Nonetheless, we collapsed the last six of them into one due to their very small size size. Cf. also Friedman (1957) p. 146.