SENSITIVITY AND STABILITY OF THE U.K. DEMAND FOR MONEY FUNCTION : 1963 - 1974.

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I. INTRODUCTION

The initial aim of this paper is to investigate the sensitivity, in terms of the relative magnitudes of parameter estimates, of the U.K. demand for money function with respect to alternative specifications of functional form.

This approach highlights an important facet of empirical research which has been overlooked in previous studies in this field. The feature of these studies has been the endeavour to obtain the correct choice and combination of independent variables in the function; hence concentration has focused on the merits of long or short term interest rates, real or nominal definition of variables, the form of the lag structure, 1/ etc.

While not denying the importance of such research it must be emphasised that economic theory gives no a priori specification of the functional form of the demand for money. Researchers have thus been content to work with an arbitrarily chosen functional form, which in the interests of simplicity has either been the arithmetic or the logarithmic linear specification. Ramsey, in a series of papers (1969, 1970, 1974), has analysed the effect of specification errors committed by the use of an incorrect functional form, concluding that in general the distributional properties of estimators are affected, with consequent inconsistency and introduction of bias to the estimates. Kavanagh and Walters are indeed aware of the problem involved in the arbitrary adoption of a (possibly incorrect)

1/ This work is characterised by Kavanagh and Walters (1966), Fisher (1968), Laidler and Parkin (1970), and the Bank of England (1970, 1972, 1974). In a wider context see Laidler (1971), which also reviews the earlier work.

functional form since they write

> "many investigators of demand functions....prefer to fit logarithmic fractions directly. The advantages (inter alia) are that homoskedasticity is more likely to be true for the logarithmic series than for arithmetic data, and that regression coefficients can be immediately interpreted as elasticities. The real issue, however, is whether a log linear surface is a 'best fit' or at least a better fit than any other simple function." (1966) p.108.

The stance taken by the present paper is to accept a usual specification of the variables used in the demand function; namely real money balances as the dependent variable and real income, a representative interest rate and lagged real money balances as independent variables, and to investigate the sensitivity of this function to alternative specifications of functional form. It can readily be seen that if the demand for money is sensitive to the specification of functional form, in the sense that, for example, estimated elasticities vary significantly in magnitude, then the choice of functional form has an important bearing on the expected effectiveness of monetary policy. If, however, elasticities are insensitive to functional form, then the most convenient specification may be employed without seriously effecting policy conclusions. With these aims in mind a generalised functional form of the type used by Zarembka (1968) and White (1972) for the United States is derived and estimated in Section II.

The results obtained in Section III by this approach lead to the conclusion that the demand for broad money is subject to some form of instability over the period tested. (1963-1974, quarterly observations). This leads naturally to the introduction of the concepts of functional and structural stability of a relationship. These are defined in Section IV, in which the demand for money is tested as to its exhibition of these twin concepts of instability in response to an exogenous shock, namely the introduction of Competition and Credit Control in 1971. Section V brings together the conclusions of this study and also compares the general results with those of previous research.

II. DERIVATION AND ESTIMATION OF A GENERALISED FUNCTIONAL FORM

Let us assume that a statistical relationship exists at time t between the demand for real money balances, M_t , real income Y_t , the interest rate r_t , and the demand for real balances in the previous time period M_{t-1} , such that

(1) $$M_t = f(Y_t , r_t , M_{t-1}) + u_t , t = 1, 2, .. , T.$$

where u_t is an error term which may be brought in additively. Let us further assume that this relationship may be approximated by a model additive in its independent variables and linear in parameters, i.e.

(2) $$g(M_t) = \alpha_o + \alpha_1 h_1(Y_t) + \alpha_2 h_2(r_t) + \alpha_3 h_3 (M_{t-1}) + u_t.$$

where g(.) and $h_i(.)$, i = 1, 2, 3, are functions of their respective arguments and $\alpha = [\alpha_o, \alpha_1, \alpha_2, \alpha_3]$ is a vector of coefficients. To make equation (2) explicit, the power transformation of Box and Cox (1964),

(3) $$X^{(\lambda)} = \frac{X^\lambda - 1}{\lambda} \quad \text{for } \lambda \neq 0, X > 0$$

$$X^{(0)} = \ln X \quad \text{for } \lambda = 0, X > 0$$

is applied to g(.) and $h_i(.)$. Thus equation (2) may be written

(4) $$M_t^{(\lambda)} = \alpha_o + \alpha_1 Y_t^{(\lambda)} + \alpha_2 r_t^{(\lambda)} + \alpha_3 M_{t-1}^{(\lambda)} + u_t$$

This equation may be interpreted as the reduced form arising from a demand for desired money balances equation subject to a partial adjustment mechanism. If M_t^* is desired real money balances at time t,

$$(5) \qquad M_t^{*(\lambda)} = \beta_o + \beta_1 Y_t^{(\lambda)} + \beta_2 r_t^{(\lambda)} + \varepsilon_t .$$

$$(6) \qquad M_t^{(\lambda)} - M_{t-1}^{(\lambda)} = \gamma\left[M_t^{*(\lambda)} - M_{t-1}^{(\lambda)}\right], \quad 0 \leqslant \gamma \leqslant 1$$

Use of the Koyck transformation yields the reduced form

$$(7) \qquad M_t^{(\lambda)} = \gamma\beta_o + \gamma\beta_1 Y_t^{(\lambda)} + \gamma\beta_2 r_t^{(\lambda)} + (1-\gamma) M_{t-1}^{(\lambda)} + \gamma\varepsilon_t .$$

This is seen to be equivalent to equation (4) on making the substitutions

$$(8) \qquad \alpha_i = \gamma\beta_i \qquad i = 0, 1, 2.$$

$$\alpha_3 = 1 - \gamma$$

$$u_t = \gamma\varepsilon_t .$$

The two usual specifications of the demand function, the linear and log linear forms are obtained by setting λ equal to one and zero respectively in equation (4). We obtain, for $\lambda = 1$,

$$(9) \qquad M_t = \alpha_o^1 + \alpha_1 Y_t + \alpha_2 r_t + \alpha_3 M_{t-1} + u_t .$$

where $\alpha_o^1 = 1 + \alpha_o - \alpha_1 - \alpha_2 - \alpha_3$, and for $\lambda = 0$

(10) $\ln M_t = \alpha_o + \alpha_1 \ln Y_t + \alpha_2 \ln r_t + \alpha_3 \ln M_{t-1} + u_t.$

Furthermore, the long-run elasticities of real money balances with respect to real income, η_{yt} , and the interest rate, η_{rt}, are defined as

(11) $$\eta_{Yt} = \frac{\partial M_t}{\partial Y_t} \cdot \frac{Y_t}{M_t} = \beta_1 \left(\frac{Y_t}{M_t}\right)^{\lambda} = \frac{\alpha_1}{1 - \alpha_3} \cdot \left(\frac{Y_t}{M_t}\right)^{\lambda}$$

(12) $$\eta_{rt} = \frac{\partial M_t}{\partial r_t} \cdot \frac{r_t}{M_t} = \beta_2 \left(\frac{r_t}{M_t}\right)^{\lambda} = \frac{\alpha_2}{1 - \alpha_3} \cdot \left(\frac{r_t}{M_t}\right)^{\lambda}$$

Equation (4) may, in the terminology of Zarembka (1968), be called the Generalised Functional Form and since it has the property that the value of the transformation parameter λ defines a particular functional form, utilisation of the theory of likelihood enables us to assess the relative merits of alternative functional forms. Furthermore, the elasticities associated with a particular functional form are capable of varying over time since they are dependent on both the transformation parameter and the levels of the relevant variables. In general, the degree of variation present in an elasticity series, given the levels of the variables, decreases as λ tends towards zero, since when λ equals zero, $\eta_{Yt} = \beta_1$ and $\eta_{rt} = \beta_2$ for all t; the familiar constant elasticity property of log linear functions (viz. Cobb-Douglas production functions). Any underlying trend in the magnitude of the elasticities may also be ascertained. This variable elasticity property has been utilised in an assessment of the effect of money substitutes on monetary policy by Mills and Wood (1975). In any case, the value taken by the parameter λ conditions the coefficient vector α , which also enters into the determination of the elasticities. Comparison of α for alternative values of λ will also facilitate tests as to the sensitivity of the demand for money to alternative functional forms.

The generalised functional form may be estimated by forming the likelihood of equation (4) on the assumption that the error term u_t is normally distributed with constant variance for some 'true' functional form indexed by λ^*. The likelihood, $L(\lambda)$, is thus,

$$(13) \quad L(\lambda) = \frac{1}{(2\Pi)^{T/2}\sigma^T} \exp. \left[\frac{-\sum_{t=1} (M_t^{(\lambda)} - \alpha_o - \alpha_1 Y_t^{(\lambda)} - \alpha_2 r_t^{(\lambda)} - \alpha_3 M_{t-1}^{(\lambda)}}{2\sigma^2} \right] . J$$

where J is the Jacobian of the inverse transformation from the dependent variable $M_t^{(\lambda)}$ to the actually observed M_t.

$$(14) \quad J = \prod_{t=1}^{T} \left| \frac{dM_t^{(\lambda)}}{dM_t} \right| = \prod_{t=1}^{T} M_t^{\lambda-1}$$

The maximized log likelihood, or support in the terminology of Edwards (1972), of a given λ, is a more convenient concept to work with. This may be denoted by $S(\lambda)$ and is, except for an arbitrary additive constant

(15) $$S(\lambda) = -{}^{T}/_{2} \log \hat{\sigma}^{2} + \log J$$

where $\hat{\sigma}^2 = R(\lambda)/T$; $R(\lambda)$ being the residual sum of squares from the regression of equation (4) (the generalised functional form) for the given λ. Equation (15) may be rewritten

(16) $$S(\lambda) = -{}^{T}/_{2} \log |R(\lambda)| + (\lambda - 1) \sum_{t=1}^{T} \log M_t + \frac{T}{2} \log T$$

The relative merits of alternative functional forms may be assessed by comparing maximized log likelihoods. Edwards (1972) shows that the data supports the functional form indexed by the parameter λ_k in preference to the form indexed by λ_i if

(17) $$S(\lambda_k) > S(\lambda_i)$$

An estimate of the coefficient vector α , conditional on a given λ, may be obtained as the usual ordinary least squares estimate from the associated regression of equation (4).

By a simple extension of these results, a maximum likelihood estimate of the 'true' parameter of transformation λ^*, is that value, $\hat{\lambda}$ say, for which

(18) $$S(\hat{\lambda}) > S(\lambda) \text{ , for all } \lambda.$$

At this value $\hat{\lambda}$, the corresponding estimate of α may also be termed the maximum likelihood estimate of the coefficient vector.

Inferences on λ may be made with recourse to the Chi-square distribution. Box and Cox (op.cit) and Zarembka (op. cit) show that an approximate 100(1 - α) % confidence interval is obtained from

$$(19) \qquad S(\hat{\lambda}) - S(\lambda) < \frac{1}{2} X^2_\alpha (1)$$

Thus, for instance, a 95% confidence interval for $\hat{\lambda}$ is approximately given by

$$(20) \qquad S(\hat{\lambda}) - S(\lambda) < 1.92$$

i.e. the confidence interval includes those values of λ which are supported not more than 1.92 units less than the maximum likelihood estimate $\hat{\lambda}$.

The use of the likelihood function in the preceding analysis relies on the assumption that the error term of equation (4) is normally distributed with constant variance for the 'true' value λ^*. However, there is no certainty that this will actually hold at the maximum likelihood estimate $\hat{\lambda}$. In reality this estimate only increases the degree of approximation to which these assumptions hold for the error term. In these circumstances it is important to ascertain the robustness of the maximum likelihood estimate to the non attainment of normality and heteroskedasticity. Draper and Cox (1969) have shown that a consistent estimate is still obtained in the presence of non normality if the error distribution is reasonably symmetric. Their conclusion was that the effect of distributional form of the error was likely to be relatively unimportant in the fitting of reasonably complex models of the type considered in this paper. Zarembka (1974) has examined consistency under the non attainment of homoskedasticity, with the finding that the maximum likelihood estimate is biased in these circumstances. However, the extent of the bias, which may be termed the 'robustness' of the estimate, may be determined in any given problem.

The presence of bias was investigated in the results presented in Sections III and IV, and although a bias was introduced by the non attainment of homoskedasticity in a number of cases, this bias was found to be very small when present. It is therefore concluded that the maximum likelihood estimates thus presented are robust, and may be taken as approximately consistent estimates of λ^*. However, as Zarembka (1974) has found, this robustness of estimates depends on the particular problem, in general the robustness being proportional to the degree of precision in estimating $\hat{\lambda}$, and should therefore be investigated in each application of this technique.

III. SENSITIVITY OF THE DEMAND FUNCTION

The generalised functional form represented by equation (4) was estimated over the period 1963 II to 1974 I, a total of 44 quarterly observations. Four alternative real monetary aggregates were employed; M1, M3, company sector holdings of M3 (denoted MC), and personal sector holdings of M3 (denoted MP). Each monetary aggregate specification was estimated using three interest rates; the Treasury bill rate (TB), the Consol Yield (C), and the local authority rate (LA). Thus twelve alternative specifications were estimated and these are defined specifically as equations (4.1) to (4.12) in Table 1, where definitions of the variables and data sources are also given. These specifications were thought to be a representative sample of the alternative demand for money equations employed in previous research.

The estimation procedure for the j^{th} specification (j = 1, ...12) was as follows. The maximized log likelihood $S(\lambda_j)$ given by equation (16) was computed for alternative values of λ_j. The plot of these log likelihoods are shown for each specification in Figures 1 and 2. 1/ The value of λ_j for which $S(\lambda_j)$ was maximized was considered the maximum likelihood estimate $\hat{\lambda}_j$. Approximate 95% confidence intervals were constructed by inspection of the likelihood plots, using the inequality (20). Maximum likelihood estimates of the coefficient vector α were obtained by the associated regression of equation (4.j), each variable being transformed by $\hat{\lambda}_j$. These regression estimates, along with associated statistics are shown in Table 2. The corresponding elasticities and adjustment coefficients

1/ The plots are shown for $-.5 < \lambda_j < 4.0$, in which λ all range maxima occurred. The step size for the values of λ_j was intervals of 0.1.

obtained from this maximum likelihood estimate of the coefficient vector (see equations (8), (11) and (12)), are compared with the elasticities and adjustment coefficients obtained in an identical fashion from the functional forms indexed by integer values of λ_j and included in the confidence interval. This is shown in Table 3, and is intended to illustrate the sensitivity of the parameters over alternative, simple, functional forms which are equally well supported by the data.

Figures 1 and 2 show that each log likelihood plot is characterised by a pronounced skewness to the left, i.e. the log likelihood decreases rapidly for values of α_j less than -0.4, while the decrease is much more gradual for a wide range of positive α_j values. This skewness creates non-symmetrical confidence intervals for $\hat{\lambda}_j$, in sharp contrast to the symmetrical plots obtained by Zarembka (1968) in a similar study for the U.S. From the plots, it is seen that for all specifications except equations (4.2) and 4.3), (MI with short interest rates), $\hat{\lambda}_j$ is negative The logarithmic form (λ_j = 0) is included in all confidence intervals apart from (4.8), where it is just excluded. Equations (4.2) and (4.3) have positive maximum likelihood estimates, and include the linear form (λ_j = 1) in their confidence intervals. The overall similarity of the plots is striking, with only equations (4.2) and (4.3) varying somewhat from the overall characteristics.

For the MI equations (4.1 - 4.3), all important coefficients (i.e. excluding the constant) are significant and of the expected sign. For all three specifications the demand for money is inelastic with respect to both income and the interest rate. The estimates of the adjustment coefficient imply that about 50% of the desired adjustment to any exogenous change is accomplished after three quarters for the consol yield specification, while for the short rates there is about 30% adjustment completed in the same period. Although the h statistic rejects the hypothesis of zero auto correlation at the 5% level there is no evidence to suggest any apparent instability in the demand for narrowly defined money, MI. Furthermore, inspection of Table 3 reveals that the short rate specifications yield parameter estimates which are insensitive with respect to alternative functional forms, and although the logarithmic form is the only 'simple' functional form included in the confidence interval for the consol yield specification, comparison of parameter estimates gives the conclusion that these are reasonably insensitive as well.

Similar overall conclusions apply to the MP specifications, (4.10 to 4.12). For the consol yield specification all coefficients are significant and of the expected signs, with both elasticities being greater than unity. The income elasticities for the short rate specifications are also greater than unity, although in these cases the interest elasticity falls below unity and is very small for the treasury bill rate. Furthermore, the local authority rate coefficient is insignificant in equation (4.12). The logarithmic form is included in all three confidence intervals, and while there are differences in the magnitudes of the parameters for alternative functional forms, no qualitative conclusions are altered. Once again, although the h statistic rejects zero autocorrelation, no serious instability is encountered in the MP specificiations of the demand for money function.

For the M3 and MC specifications (4.4 to 4.9), the estimated coefficients present problems in their interpretation. Although all are significant and of the correct sign, apart from the short rate income coefficients of the M3 equations, the coefficient $\hat{\alpha}_{3j}$ on the lagged dependent variable is greater than unity for every specification. This implies that the partial adjustment coefficient is negative, in which case the parameters of the desired money balances equation (5) are of the opposite signs to those predicted by theory, and hence long run elasticities are also of the 'wrong' sign. Both the Bank of England (1974) and Artis and Lewis (1974) have obtained similar results for this period and have attributed it to the presence of an unstable dynamic adjustment process, in which no finite long run elasticities may be defined. Although this may well be the case, no consideration seems to have been given to the causes of this instability. While not advancing any concrete ideas on this point, it may well be the case that an analysis of the Bank of England's actual policy of adjusting interest rates (the 'leaning with the wind' policy), will provide an explanation for this anomolous result.

Whatever the underlying cause of this instability, it is undeniably present and the next section of this paper examines the form of the instability brought about by an exogenous change in the underlying structure of the demand for money.

IV. STABILITY OF THE DEMAND FUNCTION

The results presented in the previous section implicitly assume that the demand for money over the period 1963 to 1974 is adequately explained by a single relationship holding for the entire period. In the light of the results obtained for the M3 and MC specifications this assumption may be open to question. Indeed, evidence of a shift in the demand for money function can be found by considering the effect on banking behaviour of the Bank of England's consultative document Competition and Credit Control, hereafter referred to as CCC (Bank of England, 1971). This was issued in May of that year and quickly promoted a new approach to monetary policy, which was in operation by September. The conclusion of the Bank of England (1974) was that the introduction of CCC had increased the attractiveness of money, if defined sufficiently broadly to include wholesale time deposits and negotiable certificates of deposits. The monetary aggregates whose definitions include these deposits are M3 and its company sector component, MC. On the other hand MP, the public sector component, is assumed to include no certificates of deposits and furthermore time deposits form a less important constituent of MP than the other broad money aggregates. M1, by definition, excludes all time deposits.

This increased attractiveness has been put forward as the cause of an acceleration in the growth of broad money since 1971. For example, Stone (1974) attributes this acceleration to CCC increasing sterling deposit accounts through the new freedom of the clearing banks to bid for deposits through the Certificates of Deposit market and through the phenomenon of round tripping, i.e. the financing of deposits by the drawing down of overdraft facilities. Furthermore, CCC is thought to have encouraged the banking system to enter the sphere of medium term finance and this too has accelerated the growth of broad money.

The extent of the acceleration in the growth of broad money can be seen from Figure 3. This shows that M3 and MC have increased by 75% and 100% respectively over the period since 1971 IV, while MP has increased by 50% and M1 by only 20% over the same period.

In response to this increased attractiveness of money, if defined sufficiently broadly, it is feasible to entertain the hypothesis of a shift in the demand for money function brought about by the introduction of CCC, i.e. the demand for money is explained by two different functions, one in operation before the introduction of CCC and one in operation afterwards.

This hypothesis may be tested formally by setting up the following framework. In the fashion of Section II, assume that the demand for money in the entire period t = 1, 2, ... T is given by the function

$$M_t^{(\theta)} = \alpha_{o1} + \alpha_{11} Y_t^{(\theta)} + \alpha_{21} r_t^{(\theta)} + \alpha_{31} M_{t-1}^{(\theta)} + u_t \qquad (21)$$

or the sub period $t = 1, 2, \ldots s$ and by the function

$$(22) \qquad M_q^{(\Phi)} = \alpha_{o2} + \alpha_{12} Y_q^{(\Phi)} + \alpha_{22} r_q^{(\Phi)} + \alpha_{32} M_{q-1}^{(\Phi)} + u_q$$

for the sub period $q = s + 1, s + 2, \ldots T$, where Θ and Φ are the transformation parameters for the respective sub periods and $\alpha_i = \{\alpha_{oi}, \ldots , \alpha_{3i}\}$; $i = 1,2$ are the respective coefficient vectors.

As an alternative hypothesis, the transformation parameters may be assumed to be constant across sub periods. Thus if $\Theta = \Phi = \lambda$ say, this hypothesis can be represented by

$$(23) \qquad M_t^{(\lambda)} = \alpha_{o1} + \alpha_{11} Y_t^{(\lambda)} + \alpha_{21} r_t^{(\lambda)} + \alpha_{3-1} M_{t-i}^{(\lambda)} + u_t$$

for $t = 1,2, \ldots s$ and

$$(24) \qquad M_q^{(\lambda)} = \alpha_{o2} + \alpha_{12} Y_q^{(\lambda)} + \alpha_{22} r_q^{(\lambda)} + \alpha_{32} M_{q-1}^{(\lambda)} + u_q$$

for $q = s+1, s+2, \ldots T$.

If such a situation in fact holds the demand for money may be said to be 'functionally stable'. This hypothesis of functional stability may be tested in the following manner.

Let $S_1(\hat{\Theta})$ be the log likelihood of equation (21) at the maximum likelihood estimate $\hat{\Theta}$ and $S_2(\hat{\Phi})$ be the log likelihood of equation (22) at the maximum likelihood estimate $\hat{\Phi}$, where $S_1(\Theta)$ and $S_2(\phi)$ are defined in an analogous manner to equation (16) in Section II. Furthermore, let $S_{1+2}(\hat{\lambda})$ be the value of the sum of the log likelihoods $S_1(\Theta)$ and $S_2(\Phi)$ at the maximum likelihood estimate $\hat{\lambda}$ of this combined log likelihood, i.e.

$$(25) \qquad S_{1+2}(\hat{\lambda}) = S_1(\lambda) + S_2(\lambda), \quad \text{for } \lambda = \Theta = \Phi$$

which utilises the result that loglikelihoods may be summed over independent sets of data (see Edwards (1972) ch.2).

Then on the null hypothesis $H_o : \theta = \Phi = \lambda$, the test statistic

$$(26) \qquad A = S_1(\hat{\Theta}) + S_2(\hat{\Phi}) - S_{1+2}(\hat{\lambda})$$

is distributed as $\frac{1}{2}\chi^2$ with one degree of freedom. Thus if

$$(27) \qquad A > \frac{1}{2}\chi^2_{\alpha A}(1)$$

at some α_A level of significance the null hypothesis of functional stability is rejected and the alternative hypothesis of different transformation parameters, i.e. different functional forms existing for sub periods, is accepted.

However, even if the above null hypothesis is not rejected, another form of instability may still be present since the coefficient vectors α_1 and α_2 are assumed to be unequal. If indeed the coefficient vectors are equal, i.e. $\alpha_1 = \alpha_2 = \alpha$ say, the demand for money over the whole period may be represented by the single relationship

$$M_t^{(\lambda)} = \alpha_o + \alpha_1 Y_t^{(\lambda)} + \alpha_2 r_t^{(\lambda)} + \alpha_3 M_{t-1}^{(\lambda)} + u_t \tag{28}$$

for $t = 1,2, \ldots s, s+1, s+2, \ldots, T$ and this situation may be termed as exhibiting 'structural stability'.

The hypothesis of equal coefficient vectors across sub periods may be tested if the log likelihood of equation (28) at $\hat{\lambda}$, the maximum likelihood estimate of the combined sample defined in equation 25, is denoted $S(\hat{\lambda})$. Then, on the null hypothesis $H_o : \alpha_1 = \alpha_2 = \alpha$, the test statistic

$$B = S(\hat{\lambda}) - S_{1+2}(\hat{\lambda}) \tag{29}$$

is distributed as $\frac{1}{2}\chi^2$ with four degrees of freedom (since α has four elements). Thus, if

$$B > \frac{1}{2}\chi^2_{\alpha B}(4) \tag{30}$$

at some α_B level of significance the null hypothesis of structural stability is rejected and the alternative hypothesis of unequal coefficient vectors across sub periods is accepted.

A drawback of the χ^2 test is that it is only an asymptotic test. An exact test for structural stability is, however, available since the problem of testing for equality of coefficient vectors over two periods, given a single functional form, is essentially the problem considered by Chow (1960). Thus it can be shown that if $R_1(\hat{\lambda})$ is the residual sum of squares from the regression of equation (23), $R_2(\hat{\lambda})$ is the residual sum of squares of the regression of equation (24) and $R(\hat{\lambda})$ is the residual sum of squares of the regression of equation (28), for $\lambda = \hat{\lambda}$, then on the null hypothesis $H_o : \alpha_1 = \alpha_2 = \alpha$ the test statistic

$$(31) \qquad C = \frac{R(\hat{\lambda})/K}{\{R_1(\hat{\lambda}) + R_2(\hat{\lambda})\}/(T-2K)}$$

is distributed as F with (K, T-2K) degrees of freedom, where K is the number of elements in α. Thus if

$$(32) \qquad C > F_{\alpha c}(K, T-2K)$$

at some α_c level of significance the null hypothesis of structural stability is rejected.

Both the χ^2 and F tests are available, therefore, to test the hypothesis of structural stability.

In order to perform these tests on the demand for money function the observation period was therefore split into pre and post CCC periods, the sub periods being 1963III to 1971III and 1971IV to 1974I in accordance with the split made by the Bank of England (1974). In the above notation, therefore, $s = 33$ and equation (21) was estimated over the period $t = 1, \ldots 33$ and equation (22) over the period $q = 34..43$. The likelihood plots for equation (21) are shown in Figures 4 and 5. Although these plots have the same general features as those obtained for the whole period, they are much flatter around the maximum, leading to rather inprecise confidence intervals. This is to be expected, since as Draper and Cox (1969) showed, for given variation in the dependent variable M_t the precision of the estimate of the transformation parameter increases with the number of observations available. Nevertheless, from inspection of the support plots, it may be seen that the maximum likelihood estimates $\hat{\Theta}_j$ are in general close to those obtained for the whole period. This apparent stability is also seen in the maximum likelihood estimates of the short post CCC period. Since only ten observations are available for this period the likelihood plots are very flat and are not shown. However the estimates $\hat{\Phi}_j$ shown in Table 6 are, allowing for the lack of precision, reasonably close to the estimates of the longer periods.

This apparent stability is confirmed by the test statistic A, the values of which are given in Table 4. It is seen that the null hypothesis of equality of transformation parameters is accepted for all twelve specifications at the 95% significance level. Thus it may be concluded that the demand for money has been functionally stable in its response to the introduction of CCC.

Given the non rejection of this hypothesis, the question of structural stability may now be addressed. The values of the test statistic B in Table 4 show that the null hypothesis of equal coefficient vectors is rejected at the 95% significance leve by all twelve specifications. This is confirmed by the results of the exact Chow test. The values of the test statistic C in Table 4 also show that the null hypothesis is rejected at the 95% significance level by all twelve specifications. Thus it may be concluded that the demand for money has been structurally unstable in its response to the introduction of CCC.

At this point it is of interest to note that Artis and Lewis (1974) have put forward an alternative explanation for the instability shown in the broad money specification. Their contention is that in 1971 and 1972 (at least) there was an excess supply of money brought about by repeated expansions of the money stock forcing individual transactors money holdings to be in excess of their expectations and desires. They therefore conclude that the demand equations have been unable to explain the behaviour of the money stock simply because the observed variables have been off the demand curve. While this seems a plausible explanation (although see the comments of the Bank of England (1974, p.293)) it cannot be tested until future observations become available.

The coefficient estimates for the sub periods are shown in Tables 5 and 6. The problem of the unstable adjustment coefficient appears to be satisfactorily deal with, for although three negative adjustment coefficients remain for the post CCC period any conclusions drawn from the estimates presented for this period should be regarded as very tenuous, since only six degrees of freedom leads to little significance of coefficients.

For the M1 specifications, short interest rates lead to insignificant negative income coefficients for the pre CCC period. In general all elasticities are less than unityand there is some evidence, albeit tenuous, that adjustment has increased rapidly since the introduction of CCC since the adjustment coefficient α_3 is not significantly different from zero in this period.

For the broad money aggregates a consol yield specification leads to income elasticities greater than unity, whereas short rate specifications yield income elasticities less than unity. All interest elasticities are less than unity, but consol yield elasticities are larger in magnitude than those for short rates.

For all specifications, in a comparison of short interest rates, the local authority rate elasticity is higher than that of the treasury bill rate. All adjustment coefficients are significantly different from zero, with adjustment rates varying between about 5% and 60% adjustment being completed after three quarters.

Since the confidence intervals are less precise for the sub periods than for the overall period, a greater number of 'simple' alternative functional forms are included in these intervals. The elasticities and adjustment coefficients corresponding to these simple form for the pre CCC period are shown in Table 7. The overall conclusion that must be drawn from these results is that the parameters are relatively insensitive to alternative specifications of the demand for money function.

V. CONCLUSIONS.

The conclusions of this paper fall into three categories.

Firstly, the results presented lend support to the general conclusions reached by previous researchers and summarised by Laidler (1971). There has been a consistent positive relationship between money and income, and a negative relationship between money and the interest rate in all specifications in which a long interest rate, represented by the consol yield is included. The inclusion of short interest rates do not seem to offer such satisfactory conclusions, since there are a number of anomolous results, but in general the local authority rate performs somewhat better than the treasury bill rate. This accords well with earlier work, notably the Bank of England (1970). The importance of lags of adjustment has also been verified.

Secondly these results confirm a number of conclusions reached by the Bank of England (1972, 1974) using the same monetary aggregates over similar observation periods, namely that the long run real income elasticity of the demand for narrow money is less than that for broad money, however defined; short term interest rates have not been significant in explaining MP, whereas the Consol Yield performs much better, and finally, MC has been more interest elastic and adjusted faster to exogenous changes than MP.

Thirdly, the conclusions may be directed at the fundamental aim of the paper, that of determining the sensitivity and stability of the demand for money over the period 1963III to 1974I. Although the demand for money is functionally stable it seems structurally unstable in its response to the exogenous shock brought about by the introduction of Competition and Credit Control. This is particularly evident in the unstable adjustment process of the M3 and MC specifications. However, even after incorporating this factor into the model, the long run elasticities generated for the period are relatively insensitive to alternative 'true' functional forms. It is therefore the conclusion of this paper that the demand for money is a relatively stable function in the sense that it is able to provide a stable and efficient transmission mechanism for the working of monetary policy.

TABLE 1. SPECIFICATIONS OF EQUATION 4.

$$M1_t^{(\lambda_1)} = \alpha_{01} + \alpha_{11} Y(A)_t^{(\lambda_1)} + \alpha_{21} C_t^{(\lambda_1)} + \alpha_{31} M1_{t-1}^{(\lambda_1)} + u_{1t} \qquad (4.1)$$

$$M1_t^{(\lambda_2)} = \alpha_{02} + \alpha_{12} Y(A)_t^{(\lambda_2)} + \alpha_{22} TB_t^{(\lambda_2)} + \alpha_{32} M1_{t-1}^{(\lambda_2)} + u_{2t} \qquad (4.2)$$

$$M1_t^{(\lambda_3)} = \alpha_{03} + \alpha_{13} Y(A)_t^{(\lambda_3)} + \alpha_{23} LA_t^{(\lambda_3)} + \alpha_{33} M1_{t-1}^{(\lambda_3)} + u_{3t} \qquad (4.3)$$

$$M3_t^{(\lambda_4)} = \alpha_{04} + \alpha_{14} Y(A)_t^{(\lambda_4)} + \alpha_{24} C_t^{(\lambda_4)} + \alpha_{34} M3_{t-1}^{(\lambda_4)} + u_{4t} \qquad (4.4)$$

$$M3_t^{(\lambda_5)} = \alpha_{05} + \alpha_{15} Y(A)_t^{(\lambda_5)} + \alpha_{25} TB_t^{(\lambda_5)} + \alpha_{35} M3_{t-1}^{(\lambda_5)} + u_{5t} \qquad (4.5)$$

$$M3_t^{(\lambda_6)} = \alpha_{06} + \alpha_{16} Y(A)_t^{(\lambda_6)} + \alpha_{26} LA_t^{(\lambda_6)} + \alpha_{36} M3_{t-1}^{(\lambda_6)} + u_{6t} \qquad (4.6)$$

$$MC_t^{(\lambda_7)} = \alpha_{07} + \alpha_{17} Y(A)_t^{(\lambda_7)} + \alpha_{27} C_t^{(\lambda_7)} + \alpha_{37} MC_{t-1}^{(\lambda_7)} + u_{7t} \qquad (4.7)$$

$$MC_t^{(\lambda_8)} = \alpha_{08} + \alpha_{18} Y(A)_t^{(\lambda_8)} + \alpha_{28} TB_t^{(\lambda_8)} + \alpha_{38} MC_{t-1}^{(\lambda_8)} + u_{8t} \qquad (4.8)$$

$$MC_t^{(\lambda_9)} = \alpha_{09} + \alpha_{19} Y(A)_t^{(\lambda_9)} + \alpha_{29} LA_t^{(\lambda_9)} + \alpha_{39} MC_{t-1}^{(\lambda_9)} + u_{9t} \qquad (4.9)$$

$$MP_t^{(\lambda_{10})} = \alpha_{0,10} + \alpha_{1,10} Y(B)_t^{(\lambda_{10})} + \alpha_{2,10} C_t^{(\lambda_{10})} + \alpha_{3,10} MP_{t-1}^{(\lambda_{10})} + u_{10,t} \qquad (4.10)$$

$$MP_t^{(\lambda_{11})} = \alpha_{0,11} + \alpha_{1,11} Y(B)_t^{(\lambda_{11})} + \alpha_{2,11} TB_t^{(\lambda_{11})} + \alpha_{3,11} MP_{t-1}^{(\lambda_{11})} + u_{11,t} \qquad (4.11)$$

$$MP_t^{(\lambda_{12})} = \alpha_{0,12} + \alpha_{1,12} Y(B)_t^{(\lambda_{12})} + \alpha_{3,12} LA_t^{(\lambda_{12})} + \alpha_{3,12} MP_{t-1}^{(\lambda_{12})} + u_{12,t} \qquad (4.12)$$

t = 1963 III, ... 1974 I.

Definitions of Variables

$M1 = \frac{\text{nominal } M1}{P(A)}$; $M3 = \frac{\text{nominal } M3}{P(A)}$; $MC = \frac{\text{nominal } MC}{P(A)}$; $MP = \frac{\text{nominal } MP}{P(B)}$.

nominal M1) £millions, seasonally adjusted, end-quarter
nominal M3)

nominal MC holdings of M3 of industrial and commercial companies (as defined for the flow of funds accounts: £millions, seasonally adjusted, end-quarter.

nominal MP holdings of M3 of the personal sector (as defined by the flow of funds accounts): £millions, seasonally adjusted, end quarter.

Y(A)	Total Final Expenditure at 1970 prices : £millions, seasonally adjusted, quarterly.
Y(B)	Personal Disposable Income at 1970 prices : £millions seasonally adjusted, quarterly.
P(A)	Implicit Deflator of total final expenditure : 1970 ≡ 1
P(B)	Deflator of personal disposable income : 1970 ≡ 1
C	Yield on 2½% Consolidated Stock : quarterly averages of working days.
LA	Rate on 3 month deposits with local authorities : quarterly averages of working days.
TB	Yield on 91 day Treasury Bills: quarterly averages of working days.

TABLE 2. MAXIMUM LIKELIHOOD ESTIMATES (1963 III to 1974 I) EQUATION 4.

EQN	$\hat{\lambda}_j$	$\hat{\alpha}_{oj}$	$\hat{\alpha}_{ij}$	$\hat{\alpha}_{2j}$	$\hat{\alpha}_{3j}$	γ	$\bar{\eta}_{yj}$	$\bar{\eta}_{rj}$	h	R^2
(4.1)	-0.3	.066 (.16)	.310 (2.43)	-.004 (2.76)	.661 (5.98)	.339	.810	-.339	2.56	.633
(4.2)	0.8	$-7.06\text{x}10^2$ (2.52)	.070 (2.65)	$-8.57\text{x}10^2$ (5.29)	.777 (9.12)	.223	.436	-.277	3.32	.742
(4.3)	0.7	$-1.36\text{x}10^2$ (1.34)	.077 (2.76)	$12.30\text{x}10^2$ (5.33)	.740 (8.69)	.260	.394	-.227	2.80	.744
(4.4)	-0.4	-.761 (3.81)	.283 (3.10)	-.0008 (3.14)	1.027 (18.54)	*	*	*	.70	.982
(4.5)	-0.3	-.436 (5.28)	.057 (1.16)	-.001 (4.11)	1.081 (23.65)	*	*	*	.34	.990
(4.6)	-0.4	1.363 (6.36)	.057 (1.32)	-.0003 (5.46)	1.091 (26.67)	*	*	*	.14	.992
(4.7)	-0.3	-3.01 (6.05)	.933 (5.75)	-.009 (5.24)	1.012 (27.86)	*	*	*	.41	.981
(4.8)	-0.4	-.842 (3.99)	.306 (2.90)	-.0007 (3.43)	1.037 (23.83)	*	*	*	.68	.975
(4.9)	-0.4	-.923 (4.68)	.328 (3.34)	-.0009 (4.44)	1.048 (25.84)	*	*	*	.14	.979
(4.10)	-0.3	-.623 (4.42)	.243 (4.86)	-.0015 (3.18)	.955 (17.47)	.045	5.90	-1.16	3.59	.991
(4.11)	-0.3	-.228 (2.36)	.179 (2.83)	$-7.98\text{x}10^5$ (2.92)	.895 (11.18)	.105	1.86	-.003	3.85	.988
(4.12)	-0.2	-.384 (3.06)	.166 (2.67)	-.0007 (.81)	.926 (12.13)	.074	2.38	-.363	3.03	.988

NOTES : Figures in parentheses are t statistics; $t_{.95}(39) = 1.68$, $t_{.995}(39) = 2.70$
The partial adjustment coefficient, $\gamma = 1 - \hat{\alpha}_{3j}$.
Elasticities $\bar{\eta}$ are average elasticities over the period, defined as the average values of eq^{u}s (2.11) and (2.12).
If $h > 1.645$, then the null hypotheses of zero autocorrelation is rejected at the 5% significance level.
The asterisk (*) denotes an undetermined parameter. For discussion of this see text.

TABLE 3. CONDITIONAL PARAMETER ESTIMATES 1963 III to 1974 I.

EQN.	λ_j	$\bar{\eta}$	$\bar{\eta}$	γ_j	$\lvert S(\hat{\lambda}_j) - S(\lambda_j)\rvert$
(4.1)	-0.3	.810	-.339	.339	0
	0	.748	-.348	.322	0.59
(4.2)	0	.391	-.266	.233	0.74
	0.8	.436	-.277	.223	0
	1	.443	-.275	.221	0.03
	2	.440	-.248	.214	1.43
(4.3)	0	.363	-.228	.267	0.55
	0.7	.394	-.227	.260	0
	1	.399	-.223	.257	0.11
	2	.376	-.191	.250	1.88
(4.10)	-0.3	5.90	-1.16	.045	0
	0	7.26	-1.43	.035	0.82
(4.11)	-0.3	1.86	-0.003	.105	0
	0	1.92	-0.100	.101	0.48
(4.12)	-0.2	2.38	-0.363	.074	0
	0	2.50	-0.100	.070	0.41

NOTES : For equation (4.8) no integer value is included in the confidence interval for λ_8.
For equations (4.3), (4.4), (4.5), (4.6), (4.7), (4.9); $\lambda_j = 0$ is included in confidence interval for λ_j, j = 3,4,5,6,7,9.
However since $\gamma_j < 0$ in each case, no elasticities are presented.

TABLE 4. STABILITY TEST STATISTICS.

Specification	A	B	C	$\hat{\lambda}$
1	0	10.14	8.71	3.4
2	0.19	14.49	14.22	3.5
3	0.29	10.84	15.43	-0.3
4	0	14.22	15.35	-0.1
5	0.04	10.29	14.10	-0.2
6	0.05	7.18	13.20	-0.2
7	0.02	9.34	13.48	-0.2
8	0.02	15.34	16.72	-0.3
9	0.02	9.36	13.50	-0.2
10	0	13.08	16.06	-0.2
11	0.15	9.25	4.51	-0.2
12	0.04	8.68	12.80	0.8

95% Significance Levels

$$\frac{1}{2}\chi^2_{0.95}(1) = 1.92$$

$$\frac{1}{2}\chi^2_{0.95}(4) = 4.75$$

$$F\ (4,35) = 2.65$$

TABLE 5. MAXIMUM LIKELIHOOD ESTIMATES 1963 III TO 1971 III

EQN	$\hat{\theta}_j$	$\hat{\alpha}_{oj}$	$\hat{\alpha}^1_{1j}$	$\hat{\alpha}^1_{2j}$	$\hat{\alpha}^1_{3j}$	γ	$\bar{\eta}_{yj}$	$\bar{\eta}_{rj}$	h	R^2
(21.1)	-0.3	.448	.323	-.005	.525	.474	.608	-.380	1.68	.759
		(.73)	(2.28)	(3.31)	(3.82)					
(21.2)	3.7	-2.73×10^{17}	-.001	-1.01×10^{18}	.644	.356	-.013	-.200	9.14	.616
		(2.87)	(.07)	(2.87)	(3.84)					
(21.3)	3.8	-5.06×10^{17}	-.009	-1.92×10^{18}	.511	.489	-.079	-.135	3.95	.726
		(3.48)	(.65)	(3.48)	(3.39)					
(21.4)	-0.2	-.404	.313	-.007	.778	.222	1.46	-.379	1.38	.963
		(1.13)	(2.79)	(2.50)	(8.04)					
(21.5)	-0.2	.15	.074	-.001	.890	.110	.697	-.111	.40	.957
		(.56)	(.97)	(1.14)	(7.40)					
(21.6)	-0.2	.037	.091	-.002	.899	.101	.933	-.241	.72	.96-
		(.18)	(1.28)	(2.07)	(8.57)					
(21.7)	-0.2	-1.52)	.696	-.022	.627	.373	1.46	-.516	.22	.698
		(1.76)	(3.36)	(3.32)	(5.69)					
(21.8)	-0.2	.317	.140	-.004	.772	.228	.488	-.171	.49	.628
		(.54)	(1.55)	(1.86)	(6.23)					
(21.9)	-0.4	-.001	.236	-.0006	.761	.239	.631	-.259	.23	.657
	(.004)	(2.06)	(2.50)	(6.54)						
(21.10)	0.7	-4.58×10^2	.438	-2.35×10^2	.830	.170	2.11	-.331	.61	.978
		(3.08)	(4.50)	(3.23	(13.95)					
(21.11)	-0.2	.200	.219	.007	.737	.263	.883	.030	1.67	.971
		(1.01)	(2.89)	(.70)	8.36)					
(21.12)	-0.2	.033	.194	-.0005	.800	.200	1.03	-.028	1.54	.970
		(.17)	(2.62)	(.47)	(9.59)					

Figures in Parentheses are t statistics; $t_{.95}(29) = 1.70$, $t_{.995}(29) = 2.76$

TABLE 6. MAXIMUM LIKELIHOOD ESTIMATES 1971 IV TO 1974 I

EQN.	$\hat{\theta}_j$	$\hat{\alpha}^{11}_{oj}$	$\hat{\alpha}^{11}_{1j}$	$\hat{\alpha}^{11}_{2j}$	$\hat{\alpha}^{11}_{3j}$	γ	$\bar{\eta}_{rj}$	$\bar{\eta}_{rj}$	R^2
(21.1)	-0.3	1.06	.192	-.003	.464	.536	.307	-.189	.209
		(.56)	(.26)	(.75)	(.71)				
(21.2)	2.4	-6.02×10^{10}	.181	-1.46×10^{11}	.075	.925	.668	-.117	.689
		(3.21)	(1.73)	(3.26)	(.20)				
(21.3)	2.5	-1.17×10^{11}	.159	-3.00×10^{11}	-.032	1.032	.553	-.100	.707
		(3.35)	(1.71)	(3.42)	(.08)				
(21.4)	-0.2	-.730	.382	.0009	.791	.209	1.93	.047	.988
		(1.10)	(2.23)	(.15)	(6.86)				
(21.5)	-0.3	-.298	.356	.0004	.741	.259	1.49	.088	.986
		(.41)	(1.93)	(.41)	(4.35)				
(21.6)	-0.3	-1.55	.400	-.002	1.091	*	*	*	.991
		(2.06)	(2.69)	(1.52)	(5.56)				
(21.7)	-0.3	-2.51	.792	-.009	.996	.004	149.4	-62.05	.984
		(1.97)	(1.64)	(1.85)	(6.36)				
(21.8)	-0.3	-1.32	1.027	.005	.388	.612	1.27	.244	.992
		(1.40)	(3.22)	(3.69)	(3.54)				
(21.9)	-0.2	-1.93	1.045	.014	.396	.604	1.43	.219	.981
		(1.02)	(2.29)	(1.40)	(1.51)				
(21.10)	1.0	-6.58×10^{2}	.574	2.91×10^{3}	1.009	*	*	*	.991
		(.51)	(.35)	(.65)	(10.94)				
(21.11)	4.0	2.74×10^{18}	.460	1.10×10^{19}	.976	.024	5.83	.969	.992
		(1.24)	(1.22)	(1.24)	(7.16)				
(21.12)	-0.3	-.67	.089	-.006	1.125	*	*	*	.989
		(1.04)	(.67)	(.75)	(6.99)				

Figures in Parenthesis are t statistics $t_{.95}(b) = 1.94$ $t_{.995}(b) = 3.71$

TABLE 7. CONDITIONAL PARAMETER ESTIMATES 1963 III TO 1971 III

EQN.	Φ_j	η_{yj}	η_{rj}	γ_j	$\lvert S(\hat{\phi}_j)-S(\Phi_j)\rvert$
(21.1)	-0.3	.608	-.380	.475	0
	0	.565	-.333	.478	0.23
	1	.438	-.282	.477	1.06
	2	.337	-.244	.464	1.81
(21.2)	1	.036	-.169	.321	1.57
	2	.013	-.176	.335	0.78
	3	-.019	-.182	.346	0.24
	3.7	-.013	-.200	.356	0
(21.3)	2	-.024	-.142	.452	1.58
	3	-.060	-.138	.477	0.43
	3.8	-.079	-.135	.489	0
(21.4)	-0.2	1.46	-.379	.222	0
	0	1.44	-.342	.225	0.11
	1	1.37	-.307	.234	0.74
	2	1.30	-.278	.240	1.51
(21.5)	-0.2	.697	-.111	.110	0
	0	.708	-.123	.106	0.07
	1	.754	-.205	.089	0.50
	2	.810	-.280	.074	1.01
	3	.876	-.373	.062	1.61
(21.6)	-0.2	.933	-.241	.101	0
	0	.949	-.260	.098	0.01
	1	1.027	-.325	.085	0.13
	2	1.066	-.373	.078	0.46
	3	1.053	-.387	.076	1.02
(21.7)	-0.2	1.46	-.516	.373	0
	0	1.47	-.519	.376	0.08
	1	1.35	-.468	.391	0.52
	2	1.27	-.432	.403	.097
	3	1.20	-.411	.414	1.44

TABLE 7 (cont'd).

EQN	Φ_j	$\bar{\eta}_{yj}$	$\bar{\eta}_{rj}$	γ_j	$S(\hat{\Phi}_j)-S(\Phi_j)$
(21.8)	-0.2	.488	-.171	.228	0
	0	.491	-.186	.226	0.06
	1	.500	-.211	.215	0.43
	2	.510	-.236	.205	0.84
	3	.438	-.269	.194	1.29
(21.9)	-0.4	.631	-.259	.239	0
	0	.636	-.233	.236	0.03
	1	.626	-.252	.230	0.22
	2	.633	-.263	.225	0.56
	3	.643	-.268	.223	1.04
(21.10)	0	2.15	-.350	.165	0.08
	0.7	2.11	-.331	.170	0
	1	2.08	-.324	.172	0.01
	2	3.00	-.300	.179	0.20
	3	1.93	-.278	.185	0.60
(21.11)	-0.2	.883	.030	.263	0
	0	.881	.031	.261	0.04
	1	.890	.027	.248	0.48
	2	.902	.023	.235	0.92
	3	.910	.018	.223	1.51
(21.12)	-0.2	1.03	-.028	.200	0
	0	1.03	-.031	.196	0.02
	1	1.07	-.049	.178	0.16
	2	1.08	-.064	.166	0.37
	3	1.09	-.074	.158	0.69

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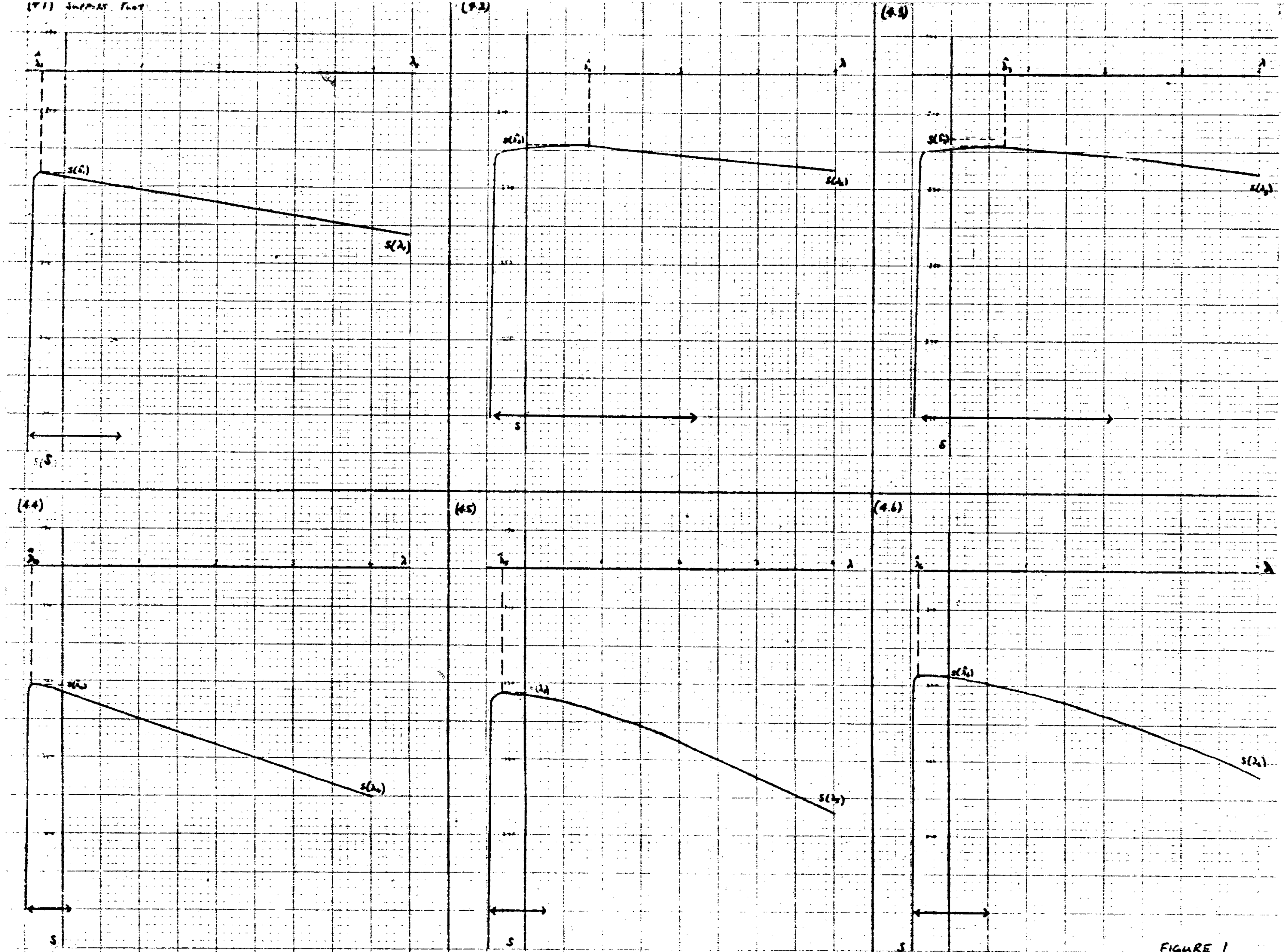


FIGURE 1

1963III - 1974I

SUPPORT PACTS
for EQNS (4.1) to (4.6)

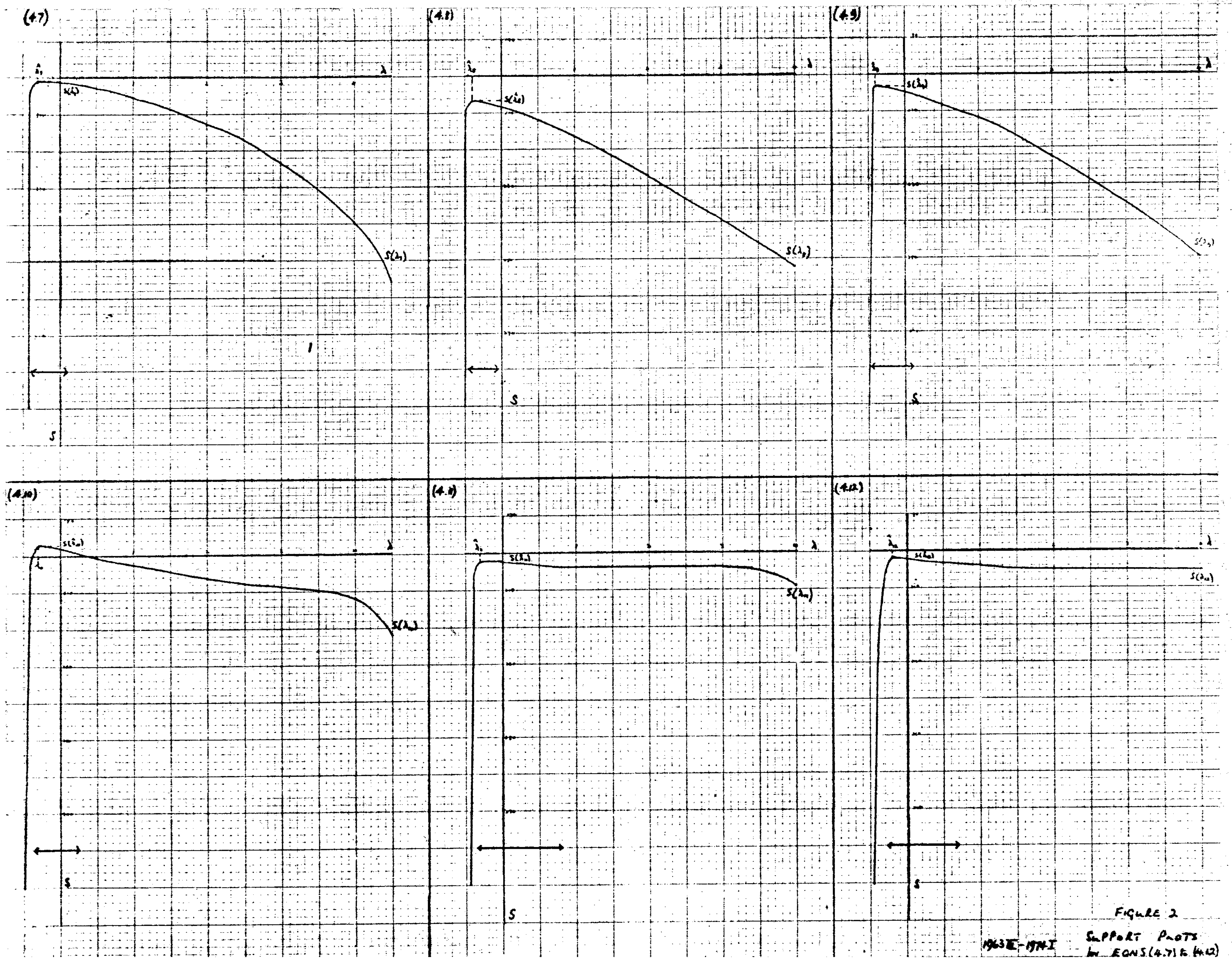
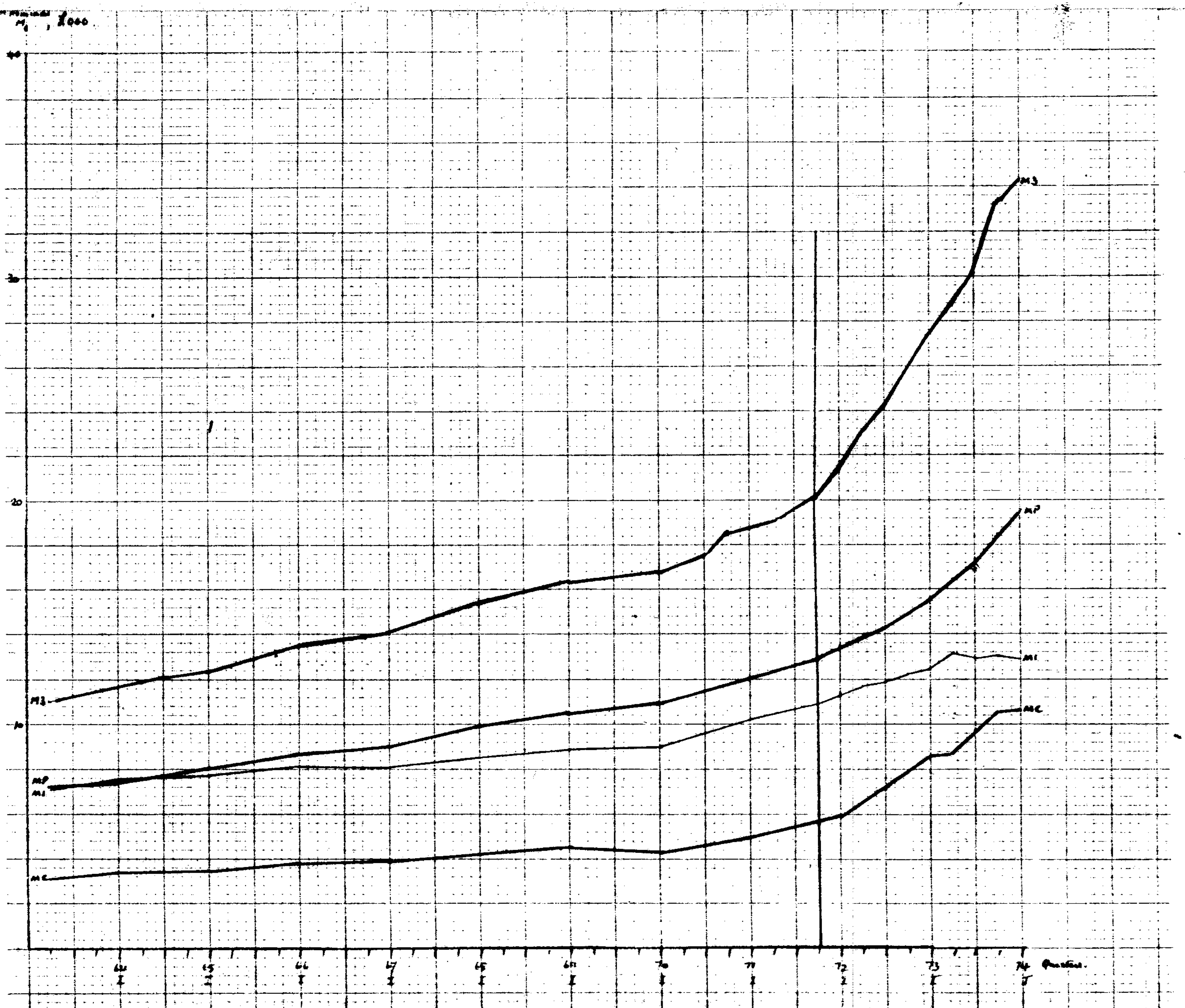


FIGURE 2

SUPPORT PLOTS
for EQNS (4.7) to (4.12)



NOMINAL MONEY SUPPLY : 1963 II TO 1974 I

FIGURE 3.

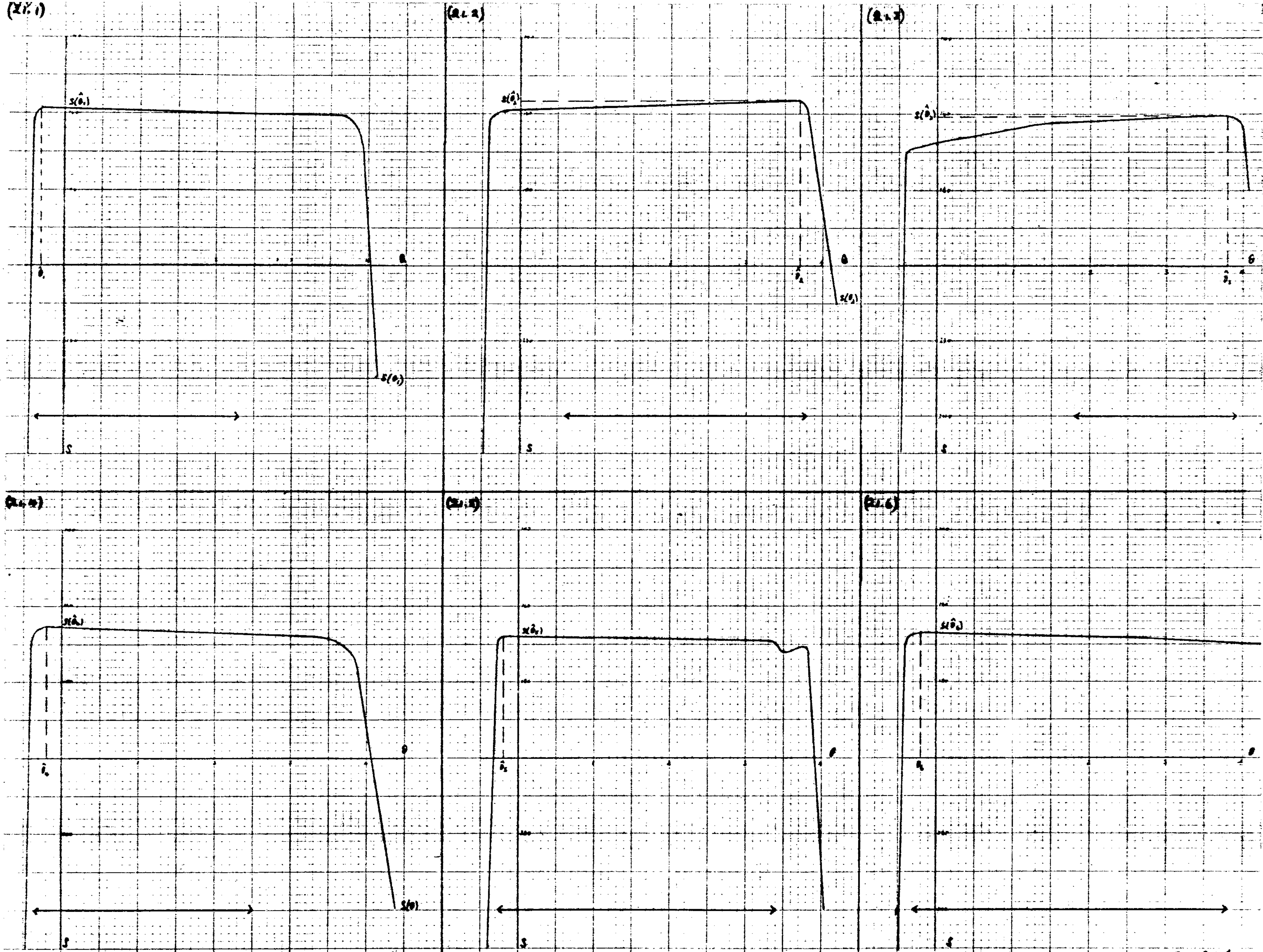


FIGURE 4
1963 III - 1971 III ; SUPPORT PLOTS
[illegible] EDN ([illegible])

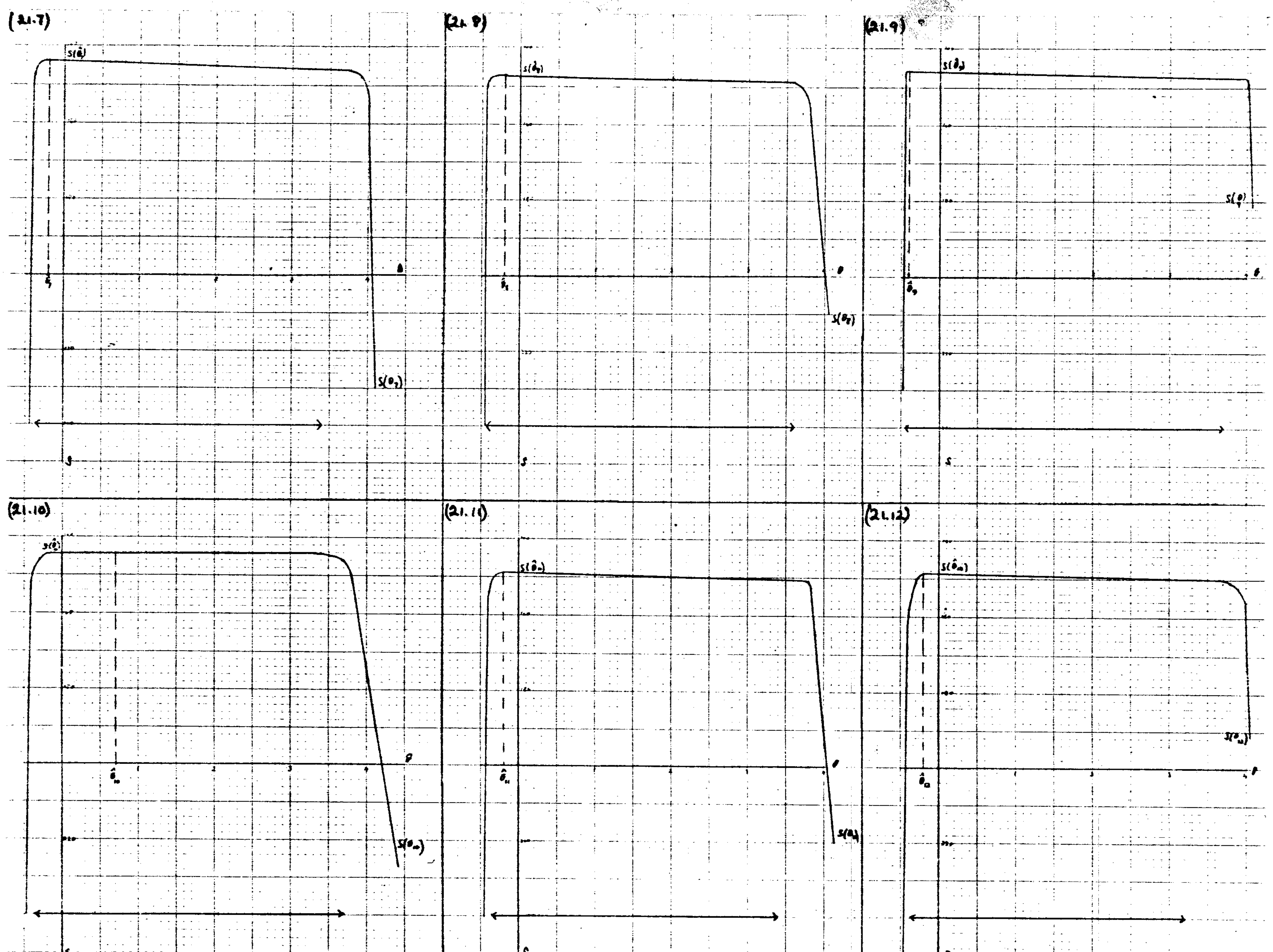


FIGURE 5