EXPECTATIONS AND ADJUSTMENTS IN THE MONETARY SECTOR*

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The growing interest in the application of distributed lag models has important implications for the area of monetary economics. Although distributed lag models have been most extensively used in connection with studies of consumption and investment expenditure behavior, they also appear to have very attractive features for specifications of financial behavior. The theoretical underpinnings of distributed lag models have in general been quite weak, and as Griliches [8] has pointed out in his recent survey on distributed lags, these models are often open to the charge of "theoretical ad-hockery." The two important exceptions to this generalization are distributed lag models which are rationalized by reference to an adaptive expectation mechanism or a partial adjustment mechanism. Since monetary theory places particular emphasis on the role of expectations in portfolio behavior and on speeds of adjustment to desired positions, it seems natural that empirical studies would come to focus greater attention on the manner in which expectations are formulated and the manner in which both expectations and adjustments to desired positions affect the monetary sector.

The purpose of this paper is, first, to provide a rough sketch of the theoretical underpinnings of the adaptive expectation and partial adjustment mechanisms as applied to the monetary sector. We then analyze the problem of empirically discriminating between adaptive expectation and partial adjustment processes and finally present some preliminary estimates of the structural parameters of a simplified monetary sector which incorporates both adaptive expectation and partial adjustment processes.

Simple Adaptive Expectations and Partial Adjustments

A number of econometric studies of the demand for money have specified demand functions which include the lagged value of cash balances as an argument of the demand for money.[1] In order to properly interpret such studies, it is necessary to know the explicit structure of

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[1] See Bronfenbrenner and Mayer [1], Chow [3], DeLeeuw [4], and Teigen [15].

the monetary sector so that one can interpret the coefficients of the reduced equations in terms of the stuuctural parameters of the model.

The difficulty in interpreting the coefficients from reduced equations results from the fact that a number of alternative structural specifications will give rise to similar reduced equations.[2] In order to illustrate this point we begin by considering a simple model of the monetary sector which incorporates both adaptive expectation and partial adjustment mechanisms.

The model specifies that the "desired" long-run stock of real cash balances depends upon "expected" real income such that

$$m_t^* = \beta y_t^e + u_t \tag{1}$$

where

m_t^* is the "desired" long-run stock of real cash balances
y_t^e is "expected" real income
u_t is a disturbance term

and lower case letters are used to denote logarithms throughout the paper.

Since both the desired long-term stock of real cash balances and expected real income are theoretical magnitudes which are not directly observable, it is necessary to relate these theoretical magnitudes to observed values. This can be accomplished by first specifying a partial adjustment process which relates current effective demand for real cash balances to the long-run desired stock such that

$$m_t^d = m_{t-1} + \gamma(m_t^* - m_{t-1}), \tag{2}$$

where m_t^d is the current effective demand for real cash balances and γ is simply the adjustment elasticity.

Expected real income can also be related to observable values by specifying an expectation generating equation such as,

$$y_t^e = y_{t-1}^e + \lambda_y(y_t - y_{t-1}^e) \tag{3}$$

which implies that income expectations are revised in proportion to the proportionate error associated with previous levels of expectations.[3] Since equation (3) is linear in logarithms, λ_y is simply the elasticity of income expectations. Equation (3) can be solved for expected income as a function of all past values of realized income

[2] Griliches [8], Waud [17], and Zellner [18] all contain excellent discussions of the difficulties involved in interpreting distributed lag formulations.

[3] See Nerlove [14].

$$(3') \qquad y_t^e = \lambda_y[y_t + (1-\lambda_y)y_{t-1} + (1-\lambda_y)^2 y_{t-2} + \cdots + (1-\lambda_y)^n y_{t-n} + \cdots]$$

and in this form, the expectation generating equation can be viewed as a distributed lag with geometrically declining weights. The specification of the monetary sector is completed by assuming that the supply of real cash balances depends upon the predetermined value of nominal cash balances and the price level, such that,

$$(4) \qquad m_t^s = z_t - p_t$$

where

m^s_t is the real supply of cash balances
z_t is the predetermined nominal money supply
p_t is the price level

and the equilibrium condition for the monetary sector is

$$(5) \qquad m_t^d = m_t^s = m_t$$

where m_t is the observed stock of real cash balances. Specifications similar to (4) and (5) are indeed implicit in those models which simply relate the observed stock of real cash balances to variables which are assumed to affect the demand for money. Combining equations (1)–(5) and applying the Koyck transformation results in the following reduced equation for the monetary sector[4]

$$(6) \qquad m_t = [(1-\lambda_y) + (1-\gamma)]m_{t-1} - [(1-\lambda_y)(1-\gamma)]m_{t-2} + \gamma\lambda_y\beta y_t + \gamma[u_t - (1-\lambda_y)u_{t-1}].$$

When only the adaptive expectation process is operative, that is when $\gamma = 1$ and $0 < \lambda_y < 1$, the reduced equation (6) becomes

$$(7) \qquad m_t = (1-\lambda_y)m_{t-1} + \lambda_y\beta y_t + u_t - (1-\lambda_y)u_{t-1}.$$

Alternatively, when only the partial adjustment process is operative, namely when $\lambda_y = 1$ and $0 < \gamma < 1$, the reduced equation becomes

$$(8) \qquad m_t = (1-\gamma)m_{t-1} + \gamma\beta y_t + \gamma u_t.$$

Since equations (7) and (8) contain the same observed variables, one cannot discriminate between the simple adaptive expectation process and the partial adjustment process, except insofar as the disturbance terms differ. When both processes are operative, the reduced equation (6) is relevant; however, one cannot, on the basis of knowledge

[4] See Koyck [9].

of the reduced equation coefficients, identify λ_y, γ and β separately. It is clear, however, that when both processes are operative, the reduced equation for the monetary sector must include two lagged values of cash balances. Thus the dynamic properties of the monetary sector depend critically on the initial specification of the structure.

The adaptive expectation and partial adjustment processes can be derived from a capital theoretic interpretation of the monetary asset. In this perspective, money is regarded as the financial analogue of a consumer durable good which is held primarily for the flow of services yielded by the durable. Friedman's extension of the permanent income hypothesis to the demand for money suggests that wealth, or, alternatively, the expected yield on wealth, is the most important determining variable affecting the demand for cash balances.[5] Expected income is assumed to be an appropriate proxy for the expected yield on wealth, and the expectation generating equation utilized above is analogous to Friedman's permanent income construct.[6] The implication which Friedman derives from his analysis is that money does not perform the role of shock absorber or buffer stock in the portfolio of individuals but rather, the short-run buffer stock function is relegated to "other balance sheet items such as personal debt, consumer credit and perhaps securities." This view is generally regarded in contradistinction to the traditional notion that the transactions motive for holding cash balances is dominant, and thus, that the demand for cash balances is determined by measured income or, more generally by one's forecast of measured income. Perhaps a more direct interpretation of the adaptive expectation model is to regard expected income as a forecast of measured income. Muth [12] has demonstrated that if the process generating measured income is such that the change in measured income is a first order moving average of random deviates, then the expectation generating function described by equation (3) provides an optimal forecast of measured income. In the case where the elasticity of income expectations is unity, the demand for money is simply a function of current measured income. Thus, the adaptive expectation mechanism can be interpreted as representing either an optimal forecast of measured income, or, alternatively, a function which generates a proxy for the expected long-term yield on wealth.

Given the adaptive expectation framework, one can also provide a rationalization for the particular partial adjustment process described by equation (2).[7] Assume that an individual, given his expected income,

[5] See Friedman [7].
[6] See Friedman [6].
[7] The following analysis is analogous to the development in Griliches [8] which considers a rationalization of a partial adjustment process in a capital accumulation framework. The original development is to be found in Eisner and Strotz [5] in connection with the theory of investment expenditures.

chooses a long-run desired level of cash balances (m_t^*). We now wish to consider the costs associated with a particular cash balance position (m_t). The costs can be broken down into two components: (1) the cost associated with being out of long-run equilibrium and (2) the direct costs of portfolio change The cost of being out of equilibrium is assumed to depend upon the gap between the individual's current cash position and his long-run desired position. If his current cash position exceeds his long-run desired position, the individual suffers the cost of foregone income. Alternatively, if his current position falls short of his long-run desired position, he suffers the costs of increased risk and inconvenience. We can represent this cost by

$$c_1 = \alpha(m_t - m_t^*)^2. \tag{9}$$

The second cost incurred represents the brokerage charges and other transaction costs associated with changes in the portfolio, and these costs are assumed to depend upon the change in the current cash position. Thus

$$c_2 = \delta(m_t - m_{t-1})^2. \tag{10}$$

The cost functions are assumed to be quadratic, and the total cost function can be written as

$$c = c_1 + c_2 = \alpha(m_t - m_t^*)^2 + \delta(m_t - m_{t-1})^2. \tag{11}$$

The problem, then, is to choose that cash position (m_t), which, given the long-run desired position (m_t^*) and the previous cash position (m_{t-1}), minimizes total cost. Differentiating (11) with respect to current cash position and setting the derivative equal to zero enables one to solve for the current cash position, such that

$$m_t = \frac{\alpha}{\alpha + \delta} m_t^* - \frac{\delta}{\alpha + \delta} m_{t-1}. \tag{12}$$

Defining $\gamma = \alpha/\alpha + \delta$ and rearranging terms, results in the following expression for the current cash position as a function of the long-run desired position and the previous cash position:

$$m_t = m_{t-1} + \gamma(m_t^* - m_{t-1}). \tag{13}$$

Equation (13) is simply the partial adjustment mechanism specified in the original model. The elasticity of adjustment will depend upon the marginal costs of being out of equilibrium relative to the marginal costs of portfolio change. In this connection it is interesting to note that if the major impact of innovation in financial intermediation is to reduce the costs of portfolio change by reducing the spread between borrowing and lending rates, we can expect more rapid adjustment of actual cash balances to desired positions. Alternatively, if the major impact of financial innovation is to provide close substitutes for money, thus reducing the costs associated with a disequilibrium position, the effect may be to reduce the speed of cash balance adjustments.

Multiple Expectations and Partial Adjustments

The simple model presented in the preceding section has two important drawbacks. The first of these is the omission of expected interest rates in the demand function for real cash balances and the second the empirical impossibility of discriminating between the simple adaptive expectation mechanism and the partial adjustment mechanism. Both inadequacies can be remedied by introducing the expected rate of interest into the demand function, in order to represent the substitution possibilities available to holders of cash balances. We thus replace equation (1) by

$$m_t^* = a + \beta_1 y_t^e + \beta_2 r_t^e + u_t \qquad (1')$$

where, r_t^e is the expected rate of interest which is generated by the adaptive expectation mechanism

$$r_t^e = r_{t-1}^e + \lambda_r(r_t - r_{t-1}^e), \qquad (14)$$

and λ_r is the elasticity of interest rate expectations. This expectation generating function is again subject to two interpretations. The expected interest rate can either be viewed as an optimal forecast of the short-term interest rate or alternatively can be interpreted as an average long-term rate expected in the future.

The foregoing formulation of the monetary sector is of considerable interest insofar as it takes explicit account of both interest rate and income expectation effects in addition to a dynamic specification of the process whereby actual cash balance positions are adjusted to desired levels. A special case of this model has been widely used in estimating the demand function for money. The special case is derived by constraining the elasticities of expectation and adjustment to be equal to unity and thus to define the demand function solely in terms of current interest rates and current income. Other studies which have directly employed Friedman's constructed permanent income series (derived from his consumption function study) can be regarded as implicitly constraining the elasticity of income expectations to equal 0.40 which is Friedman's estimate, and furthermore, constraining the interest expectations elasticity to equal unity.[8] The advantage of the present

[8] See for example Chow [3], Laidler [10], and Meltzer [11].

model is that it allows one to simultaneously derive estimates of the behavioral elasticities, the expectations elasticities and the adjustment elasticity without the imposition of prior constraints on the values of these parameters.

When equations (1′)–(5) are combined with the expectation generating equation for interest rates, one can, after repeated application of the Koyck transformation, derive the following reduced equation for the monetary sector

$$m_t = c_0 + c_1 m_{t-1} + c_2 m_{t-2} + c_3 m_{t-3} + c_4 y_t + c_5 y_{t-1} + c_6 r_t + c_7 r_{t-1} + v_t. \tag{15}$$

The coefficients of the reduced equation (15) are simply functions of the structural parameters of the model and the disturbance term of the reduced equation can be expressed in terms of the original disturbances as

$$v_t = u_t - \theta_1 u_{t-1} + \theta_2 u_{t-2} \tag{16}$$

where the θ's are also functions of the structural parameters. In terms of equation (15) which contains eight variables, the six structural parameters are overidentified. Therefore, estimation of (15) by constrained nonlinear least squares is required in order to obtain unique estimates of the structural parameters. It is possible, then, to estimate all of the structural parameters simultaneously, and thus to avoid the difficulty of lack of identification encountered in the simple adaptive expectation and partial adjustment model.

The nonlinear least squares estimates of the structural parameters would, however, be subject to two principal sources of bias; namely, simultaneous equation bias and bias due to the possible presence of autocorrelation in the disturbance term of the reduced equation. Since the monetary sector which we have specified represents only a segment of a simultaneous equation model in which real income, the rate of interest and the price level are all endogenously determined, one can avoid the problem of simultaneous equation bias by utilizing a two-stage estimation procedure.[9]

In order to deal with the problem of autocorrelated disturbances we postulate that the reduced form disturbance assumes the following form

$$v_t = \rho v_{t-1} + \epsilon_t \tag{17}$$

where ρ is the autoregressive coefficient and ϵ_t is a non-autocorrelated error term with zero mean. In terms of the original disturbances, we must assume that they follow a rather general third order auto-

[9] The instrumental variables employed are high-powered money, the discount rate, government expenditures and exports.

regressive process; namely,

$$u_t = (\rho + \theta_1)u_{t-1} - (\theta_2 + \rho\theta_1)u_{t-2} + \rho\theta_2 u_{t-3} + \epsilon_t. \tag{18}$$

When specification (17) is combined with the other equations of the model, the resulting reduced equation is

$$\begin{aligned} m_t = d_0 + d_1 m_{t-1} + d_2 m_{t-2} + d_3 m_{t-3} + d_4 m_{t-4} + d_5 y_t \\ + d_6 y_{t-1} + d_7 y_{t-2} + d_8 r_t + d_9 r_{t-1} + d_{10} r_{t-2} + \epsilon_t. \end{aligned} \tag{19}$$

The coefficients of (19) can be expressed in terms of the structural parameters of the model as follows:

$$\begin{aligned}
d_0 &= \gamma\lambda_y\lambda_r(1-\rho)a \\
d_1 &= (3 - \gamma - \lambda_y - \lambda_r + \rho) \\
d_2 &= -[(3 - \gamma - \lambda_y - \lambda_r)\rho + (1-\gamma)(1-\lambda_y) \\
&\quad + (1-\gamma)(1-\lambda_r) + (1-\lambda_y)(1-\lambda_r)] \\
d_3 &= \rho[(1-\lambda_y)(1-\lambda_r) + (1-\gamma)(1-\lambda_r) + (1-\gamma)(1-\lambda_y)] \\
&\quad + (1-\gamma)(1-\lambda_y)(1-\lambda_r) \\
d_4 &= -(1-\gamma)(1-\lambda_y)(1-\lambda_r)\rho \\
d_5 &= \gamma\beta_1\lambda_y \\
d_6 &= -\gamma\beta_1\lambda_y[\rho + (1-\lambda_r)] \\
d_7 &= \gamma\beta_1\lambda_y(1-\lambda_r)\rho \\
d_8 &= \gamma\beta_2\lambda_r \\
d_9 &= -\gamma\beta_2\lambda_r[\rho + (1-\lambda_y)] \\
d_{10} &= \gamma(1-\lambda_y)\beta_2\lambda_r\rho.
\end{aligned}$$

Since equation (19) contains ten variables, the seven structural parameters are overidentified. Estimation of equation (19) by a constrained nonlinear two-stage estimation procedure enables us to obtain unique estimates of all of the structural parameters simultaneously.[10] The results from the constrained two-stage estimation procedure are reported in Table 1 for money defined as currency plus demand deposits (M_1), and for money defined as currency plus demand deposits plus time deposits (M_2).[11]

The estimated income elasticity, β_1, for the narrow definition of money is about 1.3 and does significantly differ from unity, whereas

[10] See Zellner [18].

[11] The data utilized in this study are annual observations covering the period 1915–63. The income series is Kuznets' estimate of net national product and the price series is the implicit NNP price deflator. The interest rate is the commercial paper rate. The data were generously supplied by Anna Schwartz and Milton Friedman.

TABLE 1

CONSTRAINED TWO-STAGE LEAST SQUARES ESTIMATES OF THE PARAMETERS OF THE MULTIPLE ADAPTIVE EXPECTATION—PARTIAL ADJUSTMENT MODEL 1915–63

Quantity Estimated	M_1		M_2	
	Coefficient	Standard Error	Cofficient	Standard Error
β_1	1.282	(0.081)	1.073	(0.084)
β_2	−0.195	(0.036)	−0.136	(0.034)
λ_y	0.373	(0.087)	0.296	(0.065)
λ_r	0.745	(0.276)	0.854	(0.291)
γ	1.228	(0.375)	1.091	(0.399)
ρ	0.165	(0.535)	0.239	(0.489)
a	−0.367	(0.304)	1.000	(0.111)

the income elasticity for Friedman's broader definition of money does not differ significantly from unity.[12] As expected, the interest elasticities, β_2, are negative and significantly different from zero, thus rejecting Friedman's contention that once expected income is included in the demand function that interest rates no longer contribute to explaining variations in cash balances. This result can be given two interpretations. First, if the yield on wealth is the appropriate scale variable in the demand function for money, then expected income may be regarded as a poor proxy for the expected yield on wealth, and the interest rate effect can be interpreted as reflecting additional information on the expected wealth position. Alternatively, and I believe more convincingly, one could accept the interpretation that the transaction motive is appropriately captured by expected income, viewed as an optimal predictor of measured income, and that the independent effect of the interest rate simply reflects the relevant substitution possibilities confronting the holder of cash balances. This latter view appears to be supported by the finding that the interest elasticity for M_1 exceeds the interest elasticity for M_2. This result is not surprising since if the interest rate utilized is correlated with the yield on time deposits, the computed interest elasticity for the broader definition of money will reflect both own and cross elasticities and thus will be biased toward zero.

Of particular interest are the estimates of the expectation and adjustment elasticities. The estimates of the income expectation elasticities, λ_y, are 0.37 and 0.30 for M_1 and M_2, respectively. These results represent independent evidence to support Friedman's contention that the constructed permanent income weights derived from his study of the consumption function might be directly applicable to the demand for money since his computed estimate of the income expectations elasticity is 0.40.[13]

The interest rate expectation elasticities do not significantly differ

[12] The 0.05 level was adopted for all tests of significance.

[13] See Friedman [7].

from unity, suggesting that interest rate expectations are static, or, alternatively, that current interest rates appropriately reflect the substitution possibilities available to holders of cash balances.

Of considerable interest is the estimated elasticity of adjustment which does not significantly differ from unity for either definition of money.[14] The unitary elasticity suggests that cash balance portfolio adjustments to desired positions are completed within a single year. In terms of the cost minimization model of the partial adjustment process previously presented, the result suggests that the costs of being out of equilibrium with respect to cash balances far outweigh the costs of portfolio adjustment.

The estimates of the structural parameters suggest that some concept of expected income rather than current income ought to be used in specifying the demand for cash balances; however, they cast doubt on the usefulness of extending the expectation framework to interest rates, even though expected interest rates have received considerable theoretical attention.[15] The analysis also suggests an alternative to utilizing the "permanent" weights derived by Friedman, insofar as the "expectation" weights can be derived simultaneously with the other parameters of the model.

By separating expectation elasticities and adjustment elasticities it is now possible to identify the process which generates lagged values of cash balances in the reduced equation for the monetary sector. Previous studies of the demand for money have found significant coefficients for lagged money balances and have concluded on this basis that there exist substantial lags in the adjustment of actual cash balances to desired positions.[16] The foregoing results suggest an alternative interpretation; namely, that the coefficient of lagged cash balances reflects the effects of expected income rather than a partial adjustment to desired positions. This can be most easily seen by substituting the estimated values of the structural parameters into the expressions for the coefficients of the reduced form equation (19). Since λ_r and γ are approximately equal to unity, and the autoregressive parameter ρ does not significantly differ from zero, equation (19) reduces to

$$(20) \qquad m_t = (1-\lambda_y)m_{t-1} + \beta_1\lambda_y y_t + \beta_2 r_t - \beta_2(1-\lambda_y)r_{t-1}.$$

The coefficient of lagged cash balances now simply reflects the effects of the adaptive expectation process relating to income expectations. From the macro viewpoint, we must attach some significance to the

[14] Mundlak [13] has demonstrated that aggregation over time can give rise to biased estimates of the adjustment elasticity; however, his analysis suggests that estimates based on annual data are likely to be underestimates of the true adjustment elasticity.

[15] The author has also estimated a model which includes expected prices and population in the demand function for money; however, neither expected prices nor population appears to have a significant effect on the demand for cash balances.

[16] See Chow [3], Teigen [15], and DeLeeuw [4].

finding that the coefficient of lagged balances is nonzero, since Tucker [16] has demonstrated that the existence of nonzero coefficient for lagged cash balances can offset lagged responses in the expenditure sector, which would otherwise impair the speed with which monetary policy can affect the level of income and employment.

Summary

The application of distributed lag models to the monetary sector appears to be a highly useful tool for investigating the effects of expectations on financial behavior and for analyzing the dynamic adjustment properties of the financial sector. It has been shown that when the simple adaptive expectations model is extended to include more than one expectation variable and when a partial adjustment process is explicitly specified, it is possible to identify the separate contribution of each process. Moreover, since expectation elasticities can be estimated simultaneously with the other structural parameters of the model, it is no longer necessary to impose a priori weights for the expectation generating functions. More generally, the specifying and estimation procedures utilized in this study permitted a relaxation of a number of the restrictive assumptions usually employed in macro investigations of the monetary sector.

Future investigations of the monetary sector will hopefully analyze the consequences of a further relaxation of particular specifying assumptions. One would wish, for example, to modify the assumption that the nominal money supply is exogenously determined, in order to capture the effects of the endogenous responses of the banking system. Since the banking system's response may also depend on expected magnitudes, one could extend the analysis to include a more complete specification of expectation and adjustment processes on the supply side of the market.

This study allowed for different elasticities of expectation for income and the rate of interest; however, it did impose a particular form on the expectation generating equations and on the disturbances in the structural equations. Further investigation of alternative expectation functions and alternative disturbance specifications may yield additional payoffs. More generally, the further application of distributed lag models to the monetary sector is likely not only to improve our powers of prediction but should also enhance our understanding of the structural processes which generate the dynamic responses in the financial sector.

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