COWLES FOUNDATION FOR RESEARCH IN ECONOMICS

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COWLES FOUNDATION DISCUSSION PAPER NO. 528

INFORMATION AGGREGATION AND POLICY

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July 19, 1979

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by

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Applications of the rational expectations hypothesis to monetary theory have focused on the informational aspects of price signals. By portraying laissez-faire competitive economies as utilizing and processing information so as to exhaust all possibilities of gainful trade, these models suggest an extremely limited role for active demand management policy. I have shown, however (Weiss, 1980), that this is not an implication of the rational expectations hypothesis. In that paper, it was shown that if agents have access to different exogenous sources of information, then active policy can alter the informational content of price signals to the benefit of economic efficiency. The present analysis investigates this proposition in a model where traders have symmetric, although noisy, exogenous information and can also observe an equilibrium price on an economy-wide speculative market. Because private information is not perfect, each agent uses this price to infer needed information.

A model of the market for new capital goods is developed. Capital goods are desired by investors for their prospective return[1] and are supplied

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*Financial support from NSF Grant SOC 78-07291 is gratefully acknowledged. Some of this work was undertaken as a visitor to the Institute for International Economic Studies, Stockholm, Sweden. I have benefitted from conversations with Kenneth Arrow, William Brainard, Christophe Chamley, Doug Purvis, Stephen Ross and James Tobin.

by profit maximizing firms. A central concern is the informational content of the market clearing money price of capital. Such information is utilized by each agent to infer the intertemporal terms of trade which influence the division of available output between consumption and investment. In addition, the information may also be used to infer the equilibrium value of money if this is not directly observable.[2]

The model links monetary theory with the idea, addressed by Grossman (1976), that prices aggregate information. In that paper, a non-monetary model of a market was developed in which the price system conveyed all relevant information so as to yield an efficient allocation. However, this feature was also shown to break down if prices are influenced by several random factors.

The main result of this paper is that information lags of the type invoked by Lucas (1972, 1975) to explain real effects associated with monetary phenomena preclude equilibrium prices from "fully reflecting" all available information. In particular, it is shown that if agents confuse relative price changes with overall price level changes, then agents' forecasts of the yield to capital assets will not reflect all currently knowable information. A single price cannot communicate both the price level and information about the prospective yield to capital.

As in my earlier paper, the analysis shows that the problem of ascertaining the price level is, for the specified structure of information, equivalent to discovering the beliefs of others of the expected return to capital assets. One result, which may have implications for a number of models, is that the error of prediction of average opinion made by a representative agent is, in each period, functionally related to the error made by a representative agent in predicting the "true" (full information) expected return. The model employs a Lucas-type supply function to conclude that measured unemployment will be high in periods when the representative investor, employing all available information as suggested by normative economic theory, underestimates the profitability of capital assets. The theory is empirically tested by making the additional assumption that *ex post* excess returns on equity capital markets are a good proxy for the unobservable *ex ante* aggregate prediction errors.

Policy, by affecting the equilibrium values of current period and expected future money prices, can alter the structure of available information. An implication of the model is that a correctly formulated monetary policy will not only reduce cyclical fluctuations in output, but make capital markets more efficient as transmitters of structural information. A passive policy--such as Friedman's k% rule--will be optimal if and only if it would yield an equilibrium price path unaffected by sources of uncertainty other than the return to capital assets in the current period. If, however, equilibrium nominal prices have some independent exogenous movement (such as random component in money demand perhaps arising from changes in perceived risk) then active policy is necessary for both stable output and informational efficiency.

The paper is organized as follows: Section I outlines the basic non-monetary model and discusses the necessary and sufficient conditions for prices to aggregate all available information. This work is similar to that of Grossman. The second section analyzes "noisy" rational expectations and addresses the issue of average opinion of average opinion. In the third section, this concept is shown to have relevance for monetary theory. The fourth section contains the empirical test of the theory. Section five discusses the implications of the theory for the conduct of policy. The sixth section is the conclusion.

I. The Model

As in the models of Muth (1961) and Grossman (1976) the following five assumptions will be employed throughout the paper:

I. All exogenous random variables are distributed joint normally.

II. Certainty equivalents exist for all behavioral (structural) equations.

III. The structural equations are linear in the certainty equivalents.

IV. Equilibrium prices are linear functions of the underlying state variables.

V. A "representative trader" exists, i.e., all agents have identical behavioral equations and each individual's information may be thought of as independent draws from the same distribution.

In each period t there are n structural variables $\varepsilon_t = \langle \varepsilon_{1t} \ldots \varepsilon_{nt} \rangle$ which have direct influence upon tastes and technologies. These are distributed $N(0, I_n)$. Each agent j observes the true structural variables with an individual specific noise term $\alpha^j \sim N(0, xI_n)$. The noise is independent across factors and individuals and over time. There are many agents so that the mean error term across individuals is in each period identically 0. The term $(\varepsilon_t + \alpha_t^j)$ will be called the observation of trader j. These assumptions are meant to capture the idea that each agent has "a piece of information" and that private information is imperfect.

One particular structural model, similar to that of Grossman, assumes that capital supply depends only upon current price (in units of consumption), q_t :

$$(1) \qquad K^s = \beta q_t \ .$$

The demand for capital by the j^{th} agent depends upon his expectation of the gross return to capital ε_{1t} ,[3] and its current price:

$$(2) \qquad K^{D^j} = \frac{\alpha}{N}(E(\varepsilon_{1t}|\cdot) - q_t) \ .$$

The expectation by trader j is conditioned both upon his observation of the current equilibrium price q_t ,[4] and his private observation $\varepsilon_t + \alpha_t^j$.

Equilibrium in the market for capital goods implies that $K^s = \sum_j K^{D^j}$, or

$$(3) \qquad q_t = \frac{\alpha}{\alpha+\beta}\varepsilon_{1t}^* \ ,$$

where ε_{1t}^* is average across the N agents of the expected value of ε_{1t} , conditional upon available information.

If agents utilized only their private information, then the optimal prediction of ε_{1t} given that the agent observes $\varepsilon_{1t} + \alpha_{1t}^j$ is equal to $\delta(\varepsilon_{1t} + \alpha_{1t}^j)$ where $\delta = 1/(1+x)$ is the coefficient of linear regression of the observation on the gross return. In this case, the average expectation across agents, ε_{1t}^* , is equal to $\varepsilon_{1t}/(1+x)$, since the sample mean of α_{1t} is assumed zero. Thus the equilibrium would be given by

$$(4) \qquad q_t = \frac{\alpha}{\alpha+\beta}\frac{\varepsilon_{1t}}{(1+x)} \ .$$

On the other extreme, it could be imagined that prior to trade all agents exchange their observations directly. By the assumption that there are a large number of traders, this would be equivalent to assuming that all agents deserved the structural parameters ε directly. The resulting equilibrium, termed a full communication equilibrium, would be such that

$$(5) \qquad q_t = \frac{\alpha}{\alpha+\beta}\varepsilon_{1t} \ .$$

Although a full communication equilibrium need not be efficient,[5] it is an appealing benchmark to compare alternative information structures.

A natural question is to ask if the observation of an equilibrium price can substitute for direct exchange of information. In the present example the answer is yes. The following proposition is implicit in the work of Grossman (1976):

Proposition I: If, and only if, the equilibrium price is a function only of average expectations (of the yield to capital) will a rational expectations equilibrium be equivalent to a full communication equilibrium.

Proof: Assume there exists an equilibrium of the form

$$(6) \qquad q_t = Z\cdot\varepsilon_t \ , \quad Z \in R^n \ , \quad Z \neq 0 \ .$$

That is--the equilibrium is a linear function of the underlying state variables. Given a particular equilibrium mapping Z , each agent attempts to infer a particular combination of the structural variables.

Let π be the vector of coefficients of the linear combination of random variables of interest to each trader, which by assumption is identical across agents. The hypothesis of the proposition states that

$$q_t = Z \cdot \varepsilon_t = \pi \cdot \varepsilon_t^* \tag{7}$$

where $\pi \cdot \varepsilon_t^*$ is the average prediction across agents of the equilibrium yield to capital assets.

It will be shown that Z must equal π, so that all agents can infer the value of $\pi \cdot \varepsilon_t$ merely by observing the equilibrium price q. This means that not only is the average prediction correct $(\pi \cdot \varepsilon_t^* = \pi \cdot \varepsilon_t)$, but each trader, individually, can infer the exact value of $\pi \cdot \varepsilon_t$ by observing the equilibrium price.

In equilibrium, each agent makes use of all relevant information. He knows that statistical relationships between his own observation, $\varepsilon_t + \alpha_t^j$, the equilibrium price $Z \cdot \varepsilon_t$ and the yield to capital $\pi \cdot \varepsilon_t$. These are distributed joint normally, with a variance covariance matrix

$$\begin{array}{ccccc}
\pi \cdot \pi & \pi \cdot Z & \pi_1 & \cdots & \pi_n \\
\pi \cdot Z & Z \cdot Z & Z_1 & \cdots & Z_n \\
\pi_1 & Z_1 & 1+x & 0 & 0 \\
\vdots & \vdots & \cdot & \ddots & \\
n & Z_n & 0 & & 1+x
\end{array}$$

The expected value of $\pi \cdot \varepsilon_t$, conditional upon knowledge available is thus

$$E^j(\pi \cdot \varepsilon_t | \cdot) = \beta_1 (Z \cdot \varepsilon_t) + \beta(\varepsilon_t + \alpha_t^j) \tag{8}$$

where the scalar β_1 and the n vector β are given by (De Groot, p. 55)

$$(\beta_1 \quad \beta) = (\pi \cdot Z \quad \pi) \begin{pmatrix} Z\,Z & Z_1 & & Z_n \\ Z_1 & & (1+x)\,I_n & \\ Z_n & & & \end{pmatrix}^{-1} . \tag{9}$$

The average expectation of a trader is found by averaging the value of equation (8) across agents

$$Z \cdot \varepsilon_t = \beta_1 (Z \cdot \varepsilon_t) + \beta \cdot \varepsilon_t \tag{10}$$

which holds for each possible ε_t so that

$$Z = \beta_1 Z + \beta . \tag{11}$$

Equation (9) may be rewritten as two equations in the unknown scalar β_1 and n vector β :

$$\beta_1 (Z \cdot Z) + \beta \cdot Z = \pi \cdot Z \tag{12}$$

$$\beta_1 Z + \beta (1+x) I_n = \pi . \tag{13}$$

Multiplying both sides of (11) by Z and substituting into (12) shows that $Z \cdot Z = \pi \cdot Z$. Subtracting Z from both sides of (13) and substituting $\beta = (1 - \beta_1) Z$ (from (11)) shows $x(1 - \beta_1) Z = \pi - Z$. Post multiplying both sides of this expression by Z yields $x(1 - \beta_1)(Z \cdot Z) = 0$. Since $Z \neq 0$ (by assumption) $\beta_1 = 1$ and from (11) $\beta = 0$. Thus, from (13) $\pi = Z$ which proves that $E^j(\pi \cdot \varepsilon_t | \cdot) = q_t = \pi \cdot \varepsilon_t$. The equilibrium price is a sufficient statistic for each trader to infer the desired combination of random variables. No trader who observes the equilibrium price would desire to know the observations of others. Furthermore, he will ignore his own private data.[6]

Three points about this equilibrium should be noted. First, it does not require that the requisite information be contained in a single structural parameter. The relevant information need only be a linear combination of the structural random variables. Secondly, no extraneous information (sunspots, etc.) can be incorporated into the equilibrium price function. Thirdly, each agent will know not only the exact relevant information, he will know that others believe exactly as he does.

II. "Noisy" Rational Expectations and Average Opinion of Average Opinion

In this section, the structure of available information is analyzed when the equilibrium price of capital depends both upon the expectation of yield held by a representative investor and other random components. To illustrate this possibility, let it be supposed that the supply of new capital goods is modified to incorporate a random factor

$$(14) \qquad K^s = \beta q_t + \varepsilon_{2t} .$$

Assuming demand is expressed by (2) the equilibrium price is given by

$$(15) \qquad q_t = \frac{\alpha}{\alpha+\beta}\varepsilon^*_{1t} - \frac{\alpha}{\alpha+\beta}\varepsilon_{2t} .$$

The equilibrium price reflects average opinion of $(\alpha/\alpha+\beta)\varepsilon_{1t}$ and other random factors. From the viewpoint of traders who need to infer information, these other factors detract from the function of prices in conveying information; they contribute "noise" to agents' expectations.

More generally, the structure of information may be analyzed by postulating that there exists an equilibrium in which all traders attempt to infer the linear combination of structural random variables $\pi\cdot\varepsilon_t$. As before, let $\pi\cdot\varepsilon^*_t$ denote the average across agents of the expected value of the quantity. Assuming private noise has mean 0 , this will depend only upon the state variables. Let $Z\cdot\varepsilon_t = \pi\cdot\varepsilon^*_t$. The observed equilibrium price will depend both upon this factor and other random factors, denoted by $\theta\cdot\varepsilon_t$:

$$(16) \qquad q_t = Z\cdot\varepsilon_t + \theta\cdot\varepsilon_t .$$

The expectation of $\pi\cdot\varepsilon_t$, conditional upon knowledge available is given by

(17) $$E^j(\pi\cdot\varepsilon_t|\cdot) = \beta_1(Z+\theta)\cdot\varepsilon_t + \beta(\varepsilon_t+\alpha_t^j)$$

where the scalar β_1 and the n vector β are given by

(18) $$(\beta_1 \quad \beta) = ((Z+\theta)\cdot\pi \quad \pi)\begin{pmatrix}(Z+\theta)\cdot(Z+\theta) & Z+\theta \\ (Z+\theta)' & (1+x)I_n\end{pmatrix}^{-1}$$

Averaging equation (17) across agents gives average opinion of $\pi\cdot\varepsilon_t$:

(19) $$Z\cdot\varepsilon_t = \pi\cdot\varepsilon_t^* = \beta_1(Z+\theta)\cdot\varepsilon_t + \beta\cdot\varepsilon_t$$

which holds as an identity so that

(20) $$Z = \beta_1(Z+\theta) + \beta \ .$$

The system of equations (18) and (20) may be expressed in terms of equilibrium scalar β_1 :

(21) $$\beta = \frac{1-\beta_1}{1+(1-\beta_1)x}\pi - \frac{\beta_1}{1+(1-\beta_1)x}\theta$$

(22) $$Z = \frac{1-\beta_1}{1+(1-\beta_1)x}\pi + \frac{\beta_1}{1+(1-\beta_1)x}\theta$$

(23) $$Z+\theta = \frac{1}{1+(1-\beta_1)x}\pi + \frac{1+x}{1+(1-\beta_1)x}\theta \ .$$

The observed price $(Z+\theta)\cdot\varepsilon_t$ is a combination of the true return to capital which each agent would like to know $(\pi \cdot \varepsilon_t)$ and other random factors $(\theta \cdot \varepsilon_t)$. The equilibrium specifies the division of information between private and public sources. However, so long as private information is utilized $(\beta \neq 0)$ there is, with probability one, a difference between average opinion $(Z \cdot \varepsilon_t)$ and what average opinion would be under full information $(\pi \cdot \varepsilon_t)$ since (subtracting π from both sides of equation (22)):

(24) $$(\pi - Z) \cdot \varepsilon_t = x\beta \cdot \varepsilon_t \ .$$

By equation (21) β must be non-zero whenever the true return π is not a scalar multiple of the "other" random factors θ. The average expectation is contaminated by the "noise" term in the observed price. However, the average error $(Z-\pi) \cdot \varepsilon_t$ is orthogonal to the observed price, $(Z-\pi) \cdot (Z+\theta) = 0$. One cannot infer the direction or size of the aggregate error from observing the equilibrium price.

What will a representative trader believe about the expectations of others in such an equilibrium? In the present analysis, this concept does not have any direct bearing upon resource allocation, but is capable of analytic representation. This will prove to be a key element for understanding Lucas-type information lags in monetary economies, developed in the next section.

<u>Proposition II</u>: The error of a representative agent of the prediction of others' beliefs is, in each period, $1/(1+x)$ times the error of the prediction of a representative agent of the true return to capital. This means that whenever average opinion underestimates the true return to capital assets $(Z \cdot \varepsilon_t < \pi \cdot \varepsilon_t)$, the representative trader will underpredict the expectations of others $(Z \cdot \varepsilon_t^* < Z \cdot \varepsilon_t)$, and conversely.

Proof: Let it first be imagined that each trader j is asked for his expectation of the difference between the true return and the expectations of a representative trader, i.e., he is asked for his expectation of $(\pi-Z)\cdot\varepsilon_t$. Analogous to equations (18) and (20) there exists a scalar γ_1 and an n vector γ determined by

$$(25) \qquad (\gamma_1 \quad \gamma) = ((Z+\theta)\cdot(\pi-Z) \quad \pi-Z)\begin{pmatrix} (Z+\theta)\cdot(Z+\theta) & Z+\theta \\ (Z+\theta)' & (1+x)I_n \end{pmatrix}^{-1}$$

such that

$$(26) \qquad E^j((\pi-Z)\cdot\varepsilon_t | q_t, \varepsilon_t+\alpha_t^j) = \gamma_1 q_t + \gamma(\varepsilon_t+\alpha_t^j) \ .$$

The solution to (25) is $\gamma_1 = 0$ and $\gamma = [x/(1+x)]\beta$. The equilibrium price, q_t, will not be useful for each trader to infer the average prediction error. The coefficients on private information will be a scalar multiple (less than one) of the coefficients used to predict the true rate of return. Aggregating across agents

$$(27) \qquad (\pi-Z)\cdot\varepsilon_t^* = \frac{x}{1+x}\beta\cdot\varepsilon_t \ .$$

The true prediction error, given in equation (24) is

$$(28) \qquad (\pi-Z)\cdot\varepsilon_t = x\beta\cdot\varepsilon_t \ .$$

Thus,

$$(29) \qquad (\pi-Z)\cdot\varepsilon_t^* = \frac{1}{1+x}(\pi-Z)\cdot\varepsilon_t \ .$$

Expectations of the average error are regressed towards their mean value of zero. From this, the average opinion of average opinion, $Z \cdot \varepsilon_t^*$, may be found easily

$$(30) \qquad Z \cdot \varepsilon_t^* = \pi \cdot \varepsilon_t^* - \frac{1}{1+x}(\pi - Z) \cdot \varepsilon_t$$

$$= Z \cdot \varepsilon_t - \frac{1}{1+x}(\pi - Z) \cdot \varepsilon_t$$

so that

$$(31) \qquad Z \cdot \varepsilon_t - Z \cdot \varepsilon_t^* = \frac{1}{1+x}(\pi - Z) \cdot \varepsilon_t .$$

Q.E.D.

III. Implications for Monetary Theory

The preceding analysis has shown that if the observed price does not perfectly aggregate and convey structural information, then average opinion of average opinion will not generally be correct. In this section, a particular monetary model of an economy is developed in which this latter error has implications for resource allocation. As in several earlier works, the model makes use of the idea that monetary phenomena may have real effects if agents confuse relative price changes with movements in the value of money.

Suppose that instead of observing the relative price of capital in units of consumption, q_t, agents observe the money price of capital $V_t = q_t + P_t$, where P_t is the price of consumption goods in units of money. Agents cannot observe the price level directly in the current period. Let is also be assumed that the demand for capital depends only upon expected return (as in equation (2)) and that there is a stable supply of capital as a function of relative price (as in equation (1)). Thus the equilibrium real price of capital will depend only upon the expectation of return held by a representative agent: $q_t = \pi \cdot \varepsilon_t^* = Z \cdot \varepsilon_t$.[7] It is also assumed that equilibrium in the money market implies that the price level may be expressed as a linear function of the state variables $P_t = P \cdot \varepsilon_t$. The function must be such that the representative agent is content, given his information and preferences, to hold the exogenous fixed supply of nominal per capita balances, but is otherwise arbitrary. The theory is consistent with a number of possible specifications of money demand.

The nominal price of capital will be used by each trader to infer both the yield to capital assets and also the price level. Each trader understands that the real price of capital is a function only of average opinion, so that the problem of inferring the price level conditional upon observing the nominal price of capital is equivalent to ascertaining average opinion.

For each agent j :

$$(32) \qquad E^j(P\cdot\varepsilon_t | Z\cdot\varepsilon_t + P\cdot\varepsilon_t,\ \varepsilon_t + \alpha_t^j) = V_t - E^j(Z\cdot\varepsilon_t | Z\cdot\varepsilon_t + P\cdot\varepsilon_t,\ \varepsilon_t + \alpha_t^j) \ .$$

Let $P\cdot\varepsilon_t^*$ be the average across agents of the expected price level conditional on all available information. Averaging (32) across agents:

$$(33) \qquad P\cdot\varepsilon_t^* = V_t - Z\cdot\varepsilon_t^* \ ,$$

or

$$(34) \qquad P\cdot\varepsilon_t - P\cdot\varepsilon_t^* = Z\cdot\varepsilon_t^* - Z\cdot\varepsilon_t \ ,$$

by Proposition II:

$$(35) \qquad Z\cdot\varepsilon_t^* - Z\cdot\varepsilon_t = -\frac{1}{1+x}(\pi - Z)\cdot\varepsilon_t \ .$$

Thus the error made by the representative agent in inferring the equilibrium price level is, in each period, $-1/(1+x)$ times the error made by the representative agent in predicting the return to capital assets.

Lucas (1972) has formulated a model in which the observed unemployment rate is a function of unanticipated movements in the general price level:

$$(36) \qquad Un_t = -\alpha(P_t - P_t^*) \ .$$

If this view of the labor market is correct, the present model leads to the concluson that the observed unemployment rate will be high in periods when the average investor, using all available information rationally, underestimates the true return to capital:

$$(37) \qquad Un_t = \frac{\alpha}{1+x}(\pi - Z)\cdot\varepsilon_t \ .$$

Note that the above theory does not actually require that product and labor markets clear at the stated equilibrium prices. A number of theories of the labor market are consistent with equation (36). Prices are equilibrium in an informational sense only. They specify the degree to which agents make use of public versus private information. In disequilibrium models, however, it is more difficult to maintain the assumption that agents do not employ quantity signals, in addition to price signals, to infer needed information.

IV. Testing the Theory

The theory presented links unemployment to the error made by a representative agent in predicting the true return to capital assets. To make this idea testable, it is necessary to make additional assumptions linking *ex ante* beliefs with *ex post* returns. It will be assumed that the expected return to the market portfolio (as represented by the S+P 500 index) held by a representative agent is a constant risk premium plus the risk free rate (taken to be the yield of 3 month treasury bills). Thus the realized return to investing in a unit of aggregate equity less the risk free rate will be this constant risk premia plus the difference between the *ex ante* expected yield and what this quantity would have been under full communication. In other words, periods when the market does well are taken to follow periods of overly pessimistic forecasts. Of course, random terms realized at the end of the period and not potentially knowable at the beginning imply that the use of *ex post* excess returns as a proxy for prediction errors introduces an errors-in-variable problem. This introduces a bias against acceptance of the theory linking unemployment with prediction errors.

Another problem is to link errors in different periods. The theory presented is timeless--each period is independent of all others, thus implying the absence of serial correlation in measured unemployment. Several authors (Hall (1975), Sargent (1977), Blinder (1977), Phelps and Taylor (1977), and Lucas (1975)) have suggested factors which may give rise to persistent effects of information lags. Without developing a complete theory of cycles the empirical analysis will incorporate the assumption that the persistence effects are adequately captured by a two period lag on quarterly unemployment. Estimating this equation for the period 1948:3 to 1978:1 yields

$$\text{(38)} \qquad Un_t = .51 + \underset{(15.04)}{1.28}\, Un_{t-1} - \underset{(-4.76)}{.40}\, Un_{t-2} + \mu_t$$

$$R^2 = .86 \;, \quad DW(0) = 2.07$$

where Un_t = unemployment rate for males 20+.

The theory predicts that measured unemployment is high in periods when the ex post excess return to the market portfolio is also high. Regressing current unemployment on past unemployment and future realized excess returns for the period 1948:3 to 1978:1 yields

$$\text{(39)} \qquad Un_t = .48 + \underset{(13.96)}{1.21}\, Un_{t-1} - \underset{(-4.23)}{.36}\, Un_{t-2} + \underset{(.76)}{.0014}\, XR_t + \underset{(3.13)}{.0056}\, XR_{t+1}$$

$$- \underset{(-.9)}{.0017}\, XR_{t+2} + \underset{(2.2)}{.0038}\, XR_{t-3} + \mu_t$$

$$R^2 = .87 \;, \quad DW = 2.02 \;.$$

where $XR_t = (((S+P)_{t+1}/(S+P)_t)^4 - 1) \times 100 + \text{dividend yield}_t - t\ 6.11_t$.

The null hypothesis that each of the coefficients on future *ex post* excess returns in uncorrelated with current period unemployment may be rejected ($F^4_{112} = 4.125$ is greater than the 99% confidence interval of 3.96).

Alternatively, the *ex post* excess return from holding the market portfolio for one year is shown to be positively correlated with current unemployment

$$\text{(40)} \qquad Un_t = .49 + \underset{(13.77)}{1.19}\, Un_{t-1} - \underset{(-3.94)}{.33}\, Un_{t-2}$$

$$+ \underset{(3.12)}{.009}((XR_t + XR_{t+1} + XR_{t+2} + XR_{t+3})/4) + \mu_t$$

$$R^2 = .866 \, , \quad DW = 2.01$$

A one tenth of one percent rise in observed unemployment, given past unemployment is associated with an 11% rise in the value of the market portfolio above the safe return in the forthcoming four quarters.

V. The Role of Policy

The empirical results are consistent with the presence of independent, exogenous, random movements in the price level not mechanically related to the return to capital assets in the current period which induce a relationship between measured unemployment and ex post returns. One possible source of this disturbance, which has received much theoretical and empirical attention, is random components in money supply. A reasonable implication of this is that money supply should not have gratuitous random elements. If, however, monetary disturbances eminate from the demand side, then money growth feedback rules may be used to offset these random price level movements not related to the current yield to capital. In this way capital markets can aggregate and convey information efficiently.

The set of feasible policies depends upon the information available to the policy authority. In all of what follows it is assumed that the authority has access only to the same current period information as a representative trader. Nevertheless, the prospect of future injections of money contingent upon today's events will alter the current period demand for real cash balances by altering the return to money holdings.

As an example of how policy can improve information for each trader consider the following model of money demand: Let the demand for nominal cash balances by the j^{th} agent be given by

$$M_t^{d^j} = P_t^{*j} - m_1(r_t^{*j} + (P_{t+1} - P_t)^{*j}) + (\varepsilon_{2t} - \alpha_{2t}^j) \tag{41}$$

where P_t^{*j} and r_t^{*j} are the expectations of agent j of the current period price level and real return to capital, respectively. The term $(\varepsilon_{2t} + \alpha_{2t}^j)$ represents exogenous random movements in the demand for money by agent j. It may be identified with an increase in "liquidity preference." It is tempting to associate this shock with changes in perceived risk, although the model cannot really support this interpretation, since it is covariance stationary. What is important is that mean value of the shock across agents, ε_{2t}, is not directly observable in the current period. Let the demand and supply for capital goods be as described in (1) and (2).

If the policy authority maintains a constant nominal supply policy, then the equilibrium price path will obviously depend upon the current value ε_{2t} and information will not be efficiently dissiminated. However, a particular money growth feedback role of the form

$$(42) \qquad M_t^s = M_{t-1}^s + \pi_1 \cdot \varepsilon_{1,t-1} + \pi_2 \cdot \varepsilon_{2,t-1}$$

can be employed to offset the effects of ε_{2t} upon P_t and assure efficiency. Particularly, it will be shown that by suitable choice of π_1 and π_2 there exists an equilibrium price path $P_t = M_t$, unaffected by current period events. In this way the current nominal price of capital will aggregate information about the prospective return efficiently. Thus $r_t^{*j} = r_t = [\alpha/(\alpha+\beta)] \cdot \varepsilon_{1t}$; all agents will know the current return exactly. Only private information will be used to infer the current value of ε_{2t} so that $\varepsilon_{2t}^{*j} = [1/(1+x)] \cdot (\varepsilon_{2t} + \alpha_{2t}^j)$. For this structure of information:

$$(43) \qquad M_t^{d^j} = M_t(1+m_1) - m_1 \frac{\alpha}{\alpha+\beta}\varepsilon_{1t} + (\varepsilon_{2t} + \alpha_{2t}^j)$$

$$- m_1(M_t + \pi_1 \cdot \varepsilon_{1t} + \pi_2(\varepsilon_{2t} + \alpha_{2t}^j)/(1+x)) \; .$$

Aggregating equation (31) across agents and setting this equal to money supply implies that

(44) $$0 = -m_1 \frac{\alpha}{\alpha+\beta}\varepsilon_{1t} - m_1 \cdot \pi_1 \cdot \varepsilon_{1t} + \varepsilon_{2t} - m_1 \cdot \pi_2 \frac{1}{1+x}\varepsilon_{2t}$$

which holds as an identity if and only if

(45) $$\pi_1 = -\frac{\alpha}{\alpha+\beta}$$

(46) $$\pi_2 = \frac{1+x}{m_1} .$$

For this feedback rule, capital markets will be efficient.[8]

This policy requires that the authority observe ε_{2t} directly in period $t+1$. If the authoirty can observe only P_t in period $t+1$, then the theoretically curious possibility arises that no optimal policy exists. This stems from the fact that so long as the authority can observe the influence of ε_{2t} , it can work to mitigate its effects upon P_t to the benefit of informational efficiency. However, this effect can never be completely eliminated. For if it were, there would be no way of knowing the appropriate response. However, active policy can achieve an allocation arbitrarily close to that which would prevail under full communications.

VI. Conclusion

One of the main innovations of Keynesian economics is the explicit treatment of expectations. Through their effects on marginal efficiency of capital and liquidity preference schedules, expectations of future events are shown to exert an important influence on current period output. Keynes did not develop a general theory of expectation formulation. He assumed expectations to be a "fundamental exogenous determinant," perversely influenced by social and political factors. Keynes viewed active demand management policy as necessary to both influence these expectations and offset their harmful repercussion. Hicks, too, in his important 1935 paper, wrote:

> If I am right, the whole problem of applying monetary theory is largely one of deducing changes in anticipations from changes in the objective data which call them forth. Obviously, this is not an easy task, and above all, it is not one which can be performed in a mechanical fashion. It needs judgment and knowledge of business psychology much more than sustained logical reasoning.

Recent theories, employing alternative hypothesis of expectation formation, have raised doubts about the theoretical justification for active policy.

The present analysis shows that the rational expectations hypothesis by itself, does not deny the possibility that average opinion is objectively wrong at an instant of time. Furthermore, policy can be utilized to improve the process of expectation formation, not only about current and future money prices, but about society's intertemporal opportunities. This possibility may arise even though the controlling authority has no informational advantage over private agents. Active policy would appear useful whenever random shocks to money demand (LM shifts) are confused with changes in the prospective yield to capital (IS shifts).

FOOTNOTES

[1]In the competitive economics investors typically acquire shares in corporations which, in turn, acquire physical capital. It is assumed that the corporate form is a veil, and that the market for physical capital goods is a proxy for the market in corporate shares.

[2]Barro (1978) developed a model in which the nominal interest rate conveyed economy wide information about the equilibrium value of money.

[3]Measured in deviations from mean.

[4]It is assumed that agents cannot observe aggregate quantities, if even though in the context of the model this might be useful.

[5]Hirshleifer (1971) has shown that such information might preclude efficient risk sharing agreements.

[6]Grossman raises the question of how does the information get into the price. No answer is given, nor will one be offered here.

[7]Capital goods suppliers are assumed to know the price level, so that supply depends only on relative price.

[8]The value of π_1, necessary for informational efficiency is arbitrary, given the specified value π_2. This is because agents will always be able to decompose movements in the nominal price of capital into its component parts as long as both are functionally dependent upon a single random variable.

REFERENCES

Barro, R. J. "An Equilibrium Model of the Business Cycle with an Economy Wide Capital Market," Unpublished, University of Rochester, 1978.

Blinder, Alan. "Inventory Behavior, Real Wages and the Short-Run Keynesian Paradigm," Unpublished, Princeton University, 1977.

De Groot, M. H. Optimal Statistical Decisions. New York: McGraw Hill, 1970.

Grossman, S. "On the Efficiency of Competitive Stock Markets Where Traders Have Diverse Information," The Journal of Finance, XXXI (May 1976): 573-85.

Hall, R. E. "The Rigidity of Wages and the Persistence of Unemployment," Brookings Papers on Economic Activity, No. 2 (1975): 301-35.

Hirshleifer, J. "The Private and Social Value of Information and the Reward to Inventive Activity," American Economic Review, LXI, No. 4 (September 1971): 541-75.

Lucas, R. E., Jr. "Expectations and the Neutrality of Money," Journal of Economic Theory, 4, No. 2 (April 1972): 103-24.

________. "An Equilibrium Model of the Business Cycle," Journal of Political Economy, 83, No. 4 (December 1975): 1113-44.

Phelps, E. S. and J. B. Taylor. "Stabilizing Powers of Monetary Policy under Rational Expectations," Journal of Political Economy, 85, No. 1 (February 1977): 163-90.

Sargent, T. J. "The Persistence of Aggregate Employment and the Neutrality of Money," Unpublished, University of Minnesota, January 1977.

Weiss, L. "The Role for Active Monetary Policy in a Rational Expectations Model," Journal of Political Economy, forthcoming.