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Efficient-Markets Theory: Implications for Monetary Policy

EXPECTATIONS have come to the forefront in recent discussions of macroeconomic policy. The theory of rational expectations, initially developed by Muth, asserts that both firms and individuals, as rational agents, have expectations that will not differ significantly from optimal forecasts made using all available information. When rational expectations are imposed on macroeconomic models, some startling observations emerge. Lucas finds that changes in policy affect the parameters of many behavioral relations; thus the use of current econometric models to project effects of macro policy can be misleading.[1] Rational expectations, together with the "natural rate hypothesis" of Friedman and Phelps, lend support to the proposition that a deterministic monetary policy has no effect on the output of the economy. In these models only unanticipated

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1. Robert E. Lucas, Jr., "Econometric Policy Evaluation: A Critique," in Karl Brunner and Allan H. Meltzer, eds., *The Phillips Curve and Labor Markets*, Carnegie-Rochester Conference Series on Public Policy, vol. 1 (Amsterdam: North-Holland, 1976), pp. 19–46.

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monetary policy affects output, and there is some empirical support for this proposition.[2]

Several major objections have been raised against rational expectations theory. The cost of obtaining and analyzing information may be quite high for many agents in the economy, and their use of rules of thumb to form expectations in decisionmaking might well be appropriate, even though these expectations would not be quite "rational."[3] In addition, the implications of certain rational-expectations models—in particular, the so-called equilibrium models of the business cycle that include both the natural rate hypothesis and rational expectations—have been criticized as being highly unrealistic. It has been argued that these models cannot explain the persistence of unemployment, and they are therefore an inaccurate guide to the effects of policy.[4]

Although the existence of rational expectations in all markets in the economy can be questioned, it seems sensible that behavior in speculative-auction markets, such as those in which bonds and common stocks are traded, would reflect available information. As is discussed below, plausible and less stringent conditions are needed to demonstrate that, as a useful approximation for macroeconomic analysis, bond and stock markets are efficient—that is, prices in these markets fully reflect available information. When this concept is tested on bond and stock markets, as Fama's survey in support of the efficient-markets theory states, "contradictory evidence is sparse."[5]

Efficient-markets theory has major implications for the econometric evaluation of policy as well as for macro forecasting methodology.[6] In-

2. See Thomas J. Sargent and Neil Wallace, " 'Rational' Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule," *Journal of Political Economy,* vol. 83 (April 1975), pp. 241–54, and Robert J. Barro, "Unanticipated Money Growth and Unemployment in the United States," *American Economic Review,* vol. 67 (March 1977), pp. 101–15.

3. See William Poole, "Rational Expectations in the Macro Model," *BPEA, 2: 1976,* pp. 463–505, and Robert J. Shiller, "Rational Expectations and the Dynamic Structure of Macroeconomic Models: A Critical Review," *Journal of Monetary Economics,* vol. 4 (January 1978), pp. 1–44.

4. Franco Modigliani, "The Monetarist Controversy or, Should We Forsake Stabilization Policies?" *American Economic Review,* vol. 67 (March 1977), pp. 1–19.

5. Eugene F. Fama, "Efficient Capital Markets: A Review of Theory and Empirical Work," *Journal of Finance,* vol. 25 (May 1970), p. 417.

6. Poole discussed some of these implications in his "Rational Expectations in the Macro Model"; this paper extends some of Poole's analysis.

deed, some of the conclusions developed by rational-expectations theorists continue to hold up even if expectations are not assumed to be rational in all markets. Furthermore, efficient-markets theory implies that the macroeconometric models currently used for policy analysis and forecasting are deficient in a fundamental way.

In this article these issues are inspected empirically, both with statistical tests and simulation experiments. Before the empirical analysis is tackled, efficient-markets theory is examined in more detail,[7] as is the importance of its application to bond and stock markets.

Efficient-Markets Theory

The statement that prices fully reflect available information in an efficient market is so general that it is not empirically testable. To make this concept testable, efficient-markets theory uses "fair game" models of the following form. For a security the excess return, $\tilde{Z}_t$, is defined as

$$\tilde{Z}_t = \tilde{R}_t - R_t^*, \tag{1}$$

where

$\sim$ = random variable

$\tilde{R}_t$ = one-period (from $t - 1$ to t) nominal return from holding this security, including both capital gains and intermediate cash income

R_t^* = expected R_t for the security arising from market equilibrium.

Then

$$E(\tilde{Z}_t | \phi_{t-1}) = 0, \tag{2}$$

where

ϕ_{t-1} = available information at time $t - 1$.

Equations 1 and 2 assert that at today's price of this security the expected excess returns over the next period will be zero. When the equi-

7. A more extensive discussion of the theory can be found in Eugene F. Fama, *Foundations of Finance: Portfolio Decisions and Securities Prices* (Basic Books, 1976), and in Fama, "Efficient Capital Markets."

librium expected return (or "normal" return), R_t^*, is viewed as determined by factors like risk and the covariance of $\tilde{R}_t$ with the overall market return, the above proposition can be stated in a slightly different way.[8] Efficient-markets theory implies that no unexploited profit opportunities will exist in securities markets: at today's price, market participants cannot expect to earn a higher than normal return by investing in that security.

One important attribute of the theory embodied in 2 is that not all participants in the securities markets have to use information efficiently. Some market participants could even be irrational without invalidating market efficiency.

Equation 2 is analogous to an arbitrage condition. Arbitrageurs who are willing to speculate may perceive unexploited profit opportunities and purchase or sell securities until the price is driven to the point where 2 holds approximately.[9] Several costs involved in speculating could drive a wedge between the left- and right-hand sides of 2. Because the collection of information is not costless, arbitrageurs would have to be compensated for that cost and others incurred in their activities, as well as for the risk they bear. Transaction and storage costs would also affect 2. Yet securities have the key feature of homogeneity, for they are merely paper claims to income on real assets. Transactions and holding costs should thus be negligible, while compensation of arbitrageurs and the cost of information collection (especially for the data on interest rates analyzed here) should be quite small relative to the total value of securities traded. Therefore, the efficient-markets theory of 2 is a close approximation to reality and could be extremely useful in macroeconomic analysis.

8. An example can be found in the capital-asset-pricing model of Sharpe and Lintner discussed in Fama, "Efficient Capital Markets."

9. Depending on the arbitrage condition, 2 may not always hold exactly. Indeed, as Sanford J. Grossman and Joseph E. Stiglitz have pointed out, if 2 held exactly, efficient-markets theory would imply a paradox. See "Information and Competitive Price Systems," *American Economic Review*, vol. 66 (May 1976), pp. 246–53. If all information were fully reflected in a market according to 2, obtaining information would have zero return. Thus the market would not be able to reflect this information because it would be uncollected and hence unknown. The Grossman and Stiglitz argument does not, however, deny the usefulness of efficient-markets theory for macroeconomic analysis. Even though their argument implies that information collection must be compensated, the difference between the right- and left-hand sides of 2 would be negligible if the cost of collecting a piece of information were small, as it is for the data on interest rates discussed in this article.

MARTINGALE IMPLICATIONS

Whether there are significant correlations between past information and current changes in securities prices is the crucial issue in the empirical tests and analysis of this article. The martingale model, which is a special case of efficient-markets theory, leads to hypotheses about these correlations.

Equation 2 implies that, if the excess return, $R_t - R_t^*$, is regressed on any past available information, ϕ_{t-1}, the coefficients on this past information should be zero. A common assumption in tests of market efficiency is that the equilibrium return, R_t^*, is constant over time. This then implies that there is no correlation between the actual return, R_t, and past information, ϕ_{t-1}.

If ϕ_{t-1} is taken to be past returns on the security—that is, $\phi_{t-1} = R_{t-1}$ or R_{t-2}, and so on—no serial correlation of one-period returns should be found. This is the basic martingale result. On the other hand, if ϕ_{t-1} includes variables that describe other information that was publicly available in the past (or linear combinations of them), the general result is that returns are uncorrelated with these variables, even though they are generated outside the market for the security in question. In Fama's terminology, tests of the serial correlation of returns are "weak form" tests; tests of the more general proposition are "semi-strong form" tests.

An example might clarify the intuition behind these martingale results. Assume that the return for a security over the coming period is positively correlated with the volume of trading in that security at the beginning of the period. Then if the trading volume were high today, a return that is higher than normal for this security would be expected over the subsequent period. This implies a contradiction because an unexploited profit opportunity would now exist. Efficient-markets theory indicates that in this case the security would have been immediately bid up in price until the expected return was equal to the normal return, and the positive correlation between past trading volume and the return from this security would have disappeared.

One crucial point is central to an understanding of much of the empirical literature on efficient markets. Even if the equilibrium return, R_t^*, is not constant over time, so long as its variation is small relative to other sources of variations in returns, the correlation of R_t and ϕ_{t-1} will be near zero. This would be the case for long-term bonds and common stocks when large fluctuations in prices occur as new information is received by the market. Efficient-markets theory thus implies that, as a useful approximation, one-period returns in long-term bond and stock markets should be affected only by new information in the marketplace and should be uncorrelated with any past available information. Because changes in security prices and long-term bond yields are highly correlated with one-period returns,[10] changes in stock prices and long-term bond yields should also be uncorrelated with past information—that is, stock prices and long-term bond rates approximately follow random walks.

Efficient-markets theory does not imply that one-period returns in all securities must satisfy the martingale conditions, nor does it imply that short-term interest rates approximately follow a random walk.[11] Very short-term securities, such as 90-day treasury bills, clearly exhibit serial correlation of nominal returns.[12] With a holding period of three months, the one-period return for a treasury bill is the treasury bill rate at the beginning of the holding period. Since this information is clearly known, variation in one-period returns is due solely to changes in the expected return. If the expected return is serially correlated, a condition that is not ruled out in efficient markets, the one-period returns will be serially correlated as well. Furthermore, the treasury-bill rate will follow a random walk only if the expected one-period return does so also. This clearly does not have to be the case in an efficient market.

The discussion thus far implies that important restrictions should be imposed on any model that attempts to explain the behavior of long-term bond yields and common stock prices. As is discussed in the next section,

10. For example, using data described below, over the 1964–76 period the correlation of the quarterly change in long-term government bond yields with the quarterly returns is 0.97.

11. For example, Llad Phillips and John Pippenger indicate market efficiency implies that short-term interest rates are a random walk. This is not true, as the discussion above indicates. Phillips and Pippenger do, however, come to conclusions that are similar to mine. See Phillips and Pippenger, "Preferred Habitat vs. Efficient Market: A Test of Alternative Hypotheses," Federal Reserve Bank of St. Louis, *Review*, vol. 58 (May 1976), pp. 11–19.

12. Tests for serial correlation of treasury bill rates reject at very high significance levels the hypothesis that correlations with past bill rates are all zero. Using data on treasury bills at the end of the quarter over the 1964–76 period, the Box-Pierce $Q(12)$ statistic (which will be described later in the article) equals 112.0, while the critical Q at the 1-percent level is 26.2.

modern, structural macroeconometric models view monetary policy as affecting aggregate demand primarily through its effects on long-term bond and stock markets. Incorporating the implications of efficient-markets theory into these models is thus crucial to an understanding of monetary policy and the formulation of appropriate prescriptions for stabilization policy.

Efficient-Markets Theory and the Term Structure of Interest Rates

Monetary transmission mechanisms found in the literature, especially those of structural macroeconometric models, focus primarily on the effects of monetary policy that operate through long-term securities markets.[13]

Most traditional mechanisms in structural macro models emphasize the effects of monetary policy on long-term interest rates and on the cost of capital. Changes in the latter alter spending for both business and consumer investment. Variants of the cost-of-capital approach also stress the effects of the stock market on investment, either directly through changes in the cost of capital, or through the ratio of the value of capital to its replacement cost, the Tobin-Brainard q ratio. The stock market is also cited as a factor in consumer expenditures through its effects on wealth and the composition of the household balance sheet.

The effect of credit availability on residential housing is the one significant monetary transmission mechanism that does not operate primarily through long-term securities markets. Saving flows into and out of institutions issuing mortgages are viewed as important determinants of the residential housing cycle. Recent work, however, finds that the effects of credit availability are not as clear-cut as was previously thought, espe-

13. A more extensive survey of the literature on monetary transmission appears in Frederic S. Mishkin, "Efficient Markets Theory: Its Implications for Monetary Policy," report 7809 (University of Chicago, Center for Mathematical Studies in Business and Economics, February 1978). References to research on the monetary transmission mechanisms discussed here can be found in this working paper. Other recent surveys are W. C. Brainard and R. N. Cooper, "Empirical Monetary Macroeconomics: What Have We Learned in the Last 25 Years?" *American Economic Review*, vol. 65 (May 1975), pp. 167–75, and Franco Modigliani, "The Channels of Monetary Policy in the Federal Reserve-MIT-University of Pennsylvania Econometric Model of the United States," in G. A. Renton, ed., *Modelling the Economy* (Heinemann Educational Books for the Social Science Research Council, 1975), pp. 240–67.

cially for single-family housing. In any case, the literature on monetary transmission indicates that behavior in long-term bond and stock markets is critical to the properties of macroeconomic models. The implications of efficient-markets theory for behavior in these markets should thus be examined carefully.

The link between monetary policy and long-term bond rates and stock prices in structural macroeconometric models can be characterized as follows. An action by the Federal Reserve, such as a change in the discount rate or unborrowed reserves, leads to a change in short-term interest rates, usually through some kind of money-demand relationship. Changes in short-term rates are then linked to long-term rates through a term-structure equation in which the long-term rate responds to a long distributed lag on current and past short-term rates.[14] In models with a stock market sector (such as the MPS model), long-term rates then affect the value of stocks with a distributed lag.

The previous discussion of efficient-markets theory leads to doubts about the appropriateness of these term-structure equations. First, it is disturbing that these equations allow the prediction of changes in long-term rates and stock prices from publicly available information in the past (in particular, interest rates). Second, the use of these equations in the context of policy evaluation is suspicious because expectations about changes in policy have no role in these equations. I now turn to a more detailed discussion of the problems that arise in these equations.

THE TERM-STRUCTURE EQUATION

The typical equation linking short- and long-term rates is derived from the expectations hypothesis of the term structure. Let RL_t^n be the yield to maturity of an n-period discount bond at time t, and let r_t be the one-period short-term rate at time t. Assume that there is a positive but constant liquidity premium equal to k. Using the approximation that $\ln(1 + r_t) = r_t$, the expectations hypothesis can be characterized by

$$(3) \qquad RL_t^n = k + \left(\frac{1}{n}\right) E_t(r_t + r_{t+1} + \ldots + r_{t+n-1}),$$

14. This is modeled either with the long-term rate regressed directly on current and past short-term rates or with a Koyck-type lag mechanism in which the long-term rate is regressed on the current short-term rate and the long-term rate is lagged one period.

where E_t is the expectations operator conditioned on information available at time t. Equation 3 shows that the long-term rate is an average of expected future short-term rates and a liquidity premium. A distributed lag on current and past short-term rates is then used as a proxy for the expected future short-term rates, and this results in

$$RL_t = a + b_0 r_t + B(L) r_{t-1}, \tag{4}$$

where $B(L)$ is a polynomial in the lag L. Empirical results using 4 have been quite attractive; the fit is good and the t-statistics on the current and past short-term rates tend to be high.[15]

As Modigliani and Shiller have shown, even though an estimated equation like 4 uses a backward-looking, distributed lag on short-term rates, it still can be consistent with the forward-looking view embodied in the expectation hypothesis of the term structure.[16] A simple hypothetical example should convey this point.

Assume that the short-term rate follows the time-series process,

$$(1 - L) r_{t+1} = (1 - \lambda L) u_{t+1}, \tag{5}$$

or, equivalently,

$$r_{t+1} = (1 - \lambda) \sum_{i=0}^{\infty} \lambda^i r_{t-i} + u_{t+1},$$

where

L = the lag operator

u = a white-noise error process in which $E(u)$ is zero.

This can be written as

$$r_{t+1} = \frac{1 - \lambda}{1 - \lambda L} r_t + u_{t+1}. \tag{6}$$

Therefore

$$E_t(r_{t+1}) = \frac{1 - \lambda}{1 - \lambda L} r_t, \tag{7}$$

15. Franco Modigliani and Richard Sutch, "Innovations in Interest Rate Policy," *American Economic Review*, vol. 56 (May 1966), pp. 178–97, and "Debt Management and the Term Structure of Interest Rates: An Empirical Analysis of Recent Experience," *Journal of Political Economy*, vol. 75 (August 1967, pt. 2), pp. 569–89.

16. Franco Modigliani and Robert J. Shiller, "Inflation, Rational Expectations, and the Term Structure of Interest Rates," *Economica*, vol. 40 (February 1973), pp. 12–43.

and because $r_{t+2} = r_{t+1} + u_{t+2} - \lambda u_{t+1}$,

$$E_t(r_{t+2}) = E_t(r_{t+1}) = \frac{1-\lambda}{1-\lambda L} r_t. \tag{8}$$

More generally,

$$E_t(r_{t+i}) = E_t(r_{t+1}) = \frac{1-\lambda}{1-\lambda L} r_t \quad \text{for} \quad i = 1, 2, 3, 4, \ldots . \tag{9}$$

Substituting 9 into equation 3 yields

$$\begin{aligned} RL_t^n &= k + \frac{1}{n}\left[r_t + (n-1)\left(\frac{1-\lambda}{1-\lambda L} r_t\right)\right] \\ &= k + \frac{r_t}{n} + \frac{n-1}{n}\left(\frac{1-\lambda}{1-\lambda L} r_t\right), \end{aligned} \tag{10}$$

or, equivalently,

$$RL_t^n = k + \frac{r_t}{n} + \frac{n-1}{n}(1-\lambda)\sum_{i=0}^{\infty}\lambda^i r_{t-i}. \tag{11}$$

A compelling reason for the addition of an error term is that market participants have information on other variables besides current and past short-term rates. Thus, based on this information, their expectation of future u may not be zero. The long-term bond rate, RL_t^n, will reflect these expectations and will fluctuate around the values given by 11 as new information on these variables is received by the market. In addition, an error term, ϵ_t, should be added to 11 to allow for possible shifts in the liquidity premium.[17] Thus

$$RL_t^n = k + \frac{r_t}{n} + \frac{n-1}{n}(1-\lambda)\sum_{i=0}^{\infty}\lambda^i r_{t-i} + \epsilon_t. \tag{12}$$

Equation 12, which uses a distributed lag on current and past variables to reflect expectations, can be used in empirical work to provide valuable information. For example, estimates of equations like 12 strongly indicate that movements in long-term rates are heavily influenced by movements in short-term rates. However, even though these term-structure equations are useful as a summary of average historical experience dur-

17. This discussion does not imply that ϵ_t is serially uncorrelated. It is entirely conceivable that information on other variables relevant to expectations of future u is serially correlated. Thus ϵ_t might also be serially correlated.

ing the sample period, they can be viewed as structural equations only under extremely restrictive and highly implausible assumptions. In terms of the equation system above, λ would have to be an unvarying structural parameter because the distributed lag coefficients of r_t will be altered by any change in λ, which reflects the time-series process of the short-term rate. For example, with a larger λ, the shock to the short-term rate is less persistent over time and the distributed lag weight on the current short-term rate is smaller, while the lag weights on short-term rates further in the past would be correspondingly higher. If λ is close to zero, the time-series process becomes similar to a random walk, and the weight on the current short-term rate approaches one, while past short-term rates have little importance. In effect, λ can be unvarying only if market participants assigned to every surprise in short-term rates the same degree of persistence (or same rate of decay) in the future, regardless of any information they had about the source and significance of the disturbance.

Realistically, changes in expectations of policy rules would alter λ and hence the distributed lag weights of 12. For example, if Federal Reserve policy were expected to result in a permanent lowering of the short-term rate by 100 basis points, equation 3 would not predict a slow adjustment while 12 could do so.[18]

In policy evaluation or forecasting, the estimated distributed lag weights of term-structure equations are assumed to be constant regardless of what policy change is being evaluated or anticipated. Yet, as should be clear from the above example, the invariance of the weights is a dangerous assumption.

The example also can be used to clarify interpretations of the important work on the term structure by Modigliani and Shiller.[19] They indicate that, if expectations are "rational," an estimated term-structure equation should have coefficients that are consistent with the time-series behavior of variables such as short-term rates. This is equivalent, in the above example, to finding that the λ estimated in 12 is no different from the λ of 5. Their finding that this condition is met and that the term structure is rational does *not* imply, however, that such a term-structure equation is invariant to policy changes and can be used as a structural equation

18. The point raised here is similar to that made by Lucas in his consumption example described in "Econometric Policy Evaluation."

19. Modigliani and Shiller, "Inflation, Rational Expectations, and the Term Structure of Interest Rates."

in a macro model. This is easily seen from the discussion above in which, by assumption, the term-structure equation 12 is "rational," but the coefficients are not invariant.

The proposition that a typical term-structure equation such as 4 is not invariant can also be proved if the time-series process of the short-term rate is allowed to be more general than it is in the example. The advantage of this example is its simplicity and the ease with which it demonstrates that, although long-term rates can be reasonably characterized by a distributed lag on short-term rates, such a term-structure equation cannot be viewed as structural. Hence, it is not usable in any simulation context, whether it is oriented to choosing appropriate policy or it accurately describes the dynamics of the economy.

FORECASTING WITH THE TERM-STRUCTURE EQUATION

As Poole has mentioned in his recent *BPEA* article, the use of an equation like 4 to generate forecasts for the bond market is likely to be inconsistent with market efficiency.[20] For example, assuming that the error term is serially uncorrelated, the expected long-term rate derived from 4, one period in the future, would be

$$(13) \qquad E_t(RL^n_{t+1}) = a + b_0 E_t(r_{t+1}) + B(L)r_t.$$

Because RL_{t+1} and RL_t correspond to particular prices of the long-term bond, the relationship between the expected long-term rate, $E_t(RL_{t+1})$ and the current long-term rate, RL_t, implies a particular one-period expected return from holding a long-term bond. For example, if the long-term bond were a consol, the implied one-period return would be[21]

$$(14) \qquad RL^c_t \left[\frac{1}{E_t(RL^c_{t+1})} - \frac{1}{RL^c_t} \right] + RL^c_t = \frac{RL^c_t}{E_t(RL^c{}_{+1})} + RL^c_t - 1,$$

where

RL^c_t = the yield on the consol at time t.

Efficient-markets theory as described by equations 1 and 2 then holds that the implied expected return, given past information, equals what

20. Poole, "Rational Expectations."

21. Note that the approximation, $1/E_t(RL^n_{t+1}) = E_t\left(\frac{1}{RL^n_{t+1}}\right)$, is used both here and in the calculations below.

would be a normal return for a security with the risk characteristics of long-term bonds—that is, there should be no unexploited profit opportunities. Given reasonable measures of $E_t(r_{t+1})$, it is unlikely that this efficient-markets constraint would be satisfied because forecasts using an equation such as 4 do not use all available relevant information. In generating forecasts, the market will use information from distributed lags of past variables, and it will also be concerned with subjective information, such as whether or not the mood in Congress is to pursue expansionary fiscal policy. As was discussed above, the existence of error terms in equations such as 4 and 12 implies that past information besides short-term rates is important to expectations of future short-term rates. Thus when 4 is used to forecast RL^n_{t+1}, it does not exploit information embodied in RL_t, which in an efficient market reflects all available information. The resulting forecast of RL^n_{t+1} is less than optimal when compared with RL^*_t and will probably imply the existence of an unexploited profit opportunity.

To ascertain how serious a violation of market efficiency is implied by one-period forecasts with equations such as 4, a number of experiments have been conducted that are akin to simulation experiments. These are not intended to settle the issue of whether financial markets are efficient, but rather to illustrate the properties of term-structure equations like 4.[22] Using term-structure equations estimated over several sample periods, along with several measures of $E_t(r_{t+1})$, the implied, expected quarterly returns were calculated for the most recent five-year period for which data are available. In the interest of conserving space, only one experiment is discussed below. (Other experiments are discussed in note 32.) The results discussed in the text are by no means atypical, and, if anything, of the results I explored, these tend to be among the least unfavorable to term-structure equations of the form of 4.

Modigliani and Sutch[23] have estimated a term-structure equation in which the long-term government bond rate is a seventeen-quarter distributed lag on current and past 90-day treasury bill rates, with the coefficients of past bill rates lying on a fourth-order polynomial with an end-point constraint. In the example discussed here, this equation has been

22. In a similar way, simulation experiments with macroeconometric models only illustrate the properties of these models and do not settle the question of what the true structure of the economy is.

23. Modigliani and Sutch, "Innovations" and "Debt Management."

reestimated over the 1964–76 period,[24] using the same polynomial lag constraints as Modigliani and Sutch and a correction for first-order serial correlation. The government bond series uses yields from taxable government bonds callable in ten years or more, with bonds chosen so that tax-induced distortions from capital gains and estate privileges are minimized. Both the bond yields and the treasury bill rates are end-of-quarter figures.[25]

The reestimated term-structure equation using ordinary least squares is as follows, with the coefficient on $\hat{u}_{t-1}$ equal to the first-order serial correlation coefficient; standard errors are in parentheses as is the case throughout the article. All interest rate variables are expressed in fractions—that is, a 6 percent yield is 0.06.

$$\text{(15)} \qquad \begin{aligned} RGOV_t = & \underset{(-0.0052)}{-0.0041} + \underset{(0.0741)}{0.3756}\, RTB_t \\ & + \sum_{i=1}^{16} b_i\, RTB_{t-i} + 0.5212\, \hat{u}_{t-1} + \epsilon_t \\ & \sum_{i=1}^{16} b_i = \underset{(0.1059)}{0.9444}, \end{aligned}$$

$R^2 = 0.9450$; Durbin-Watson $= 2.12$; standard error $= 0.0033$;

where

$RGOV_t$ = long-term government bond yield, end of quarter
RTB_t = treasury bill rate at end of quarter.

At first glance, the term-structure equation looks quite satisfactory. The fit is good—the percentage of variance explained is high and the

24. The 1964–76 sample period has been used for all my empirical tests because the need for forward rates in some of the empirical work requires that the sample period begin no earlier than 1964. Whenever possible, I also conducted empirical tests on the longer sample period from 1954–76. (Some of the results from the longer sample period are reported in the notes.)

25. Lawrence Fisher supplied me with these bond data, which also include the returns from holding these bonds. The data are described in Lawrence Fisher and James H. Lorie, *A Half Century of Returns on Stocks and Bonds: Rates of Return on Investments in Common Stock and on U.S. Treasury Securities, 1926–1976* (University of Chicago, Graduate School of Business, 1977). The Board of Governors of the Federal Reserve System supplied me with the data on prime commercial paper and the 90-day treasury bill market yield for the last trading day of the quarter on a discount basis.

standard error is only 33 basis points. Furthermore, both the coefficients on the current treasury bill rates and the sum of the coefficients on past bill rates are significant well above the 1 percent level.

Equation 15 is used to forecast the one-period expectation of the government bond rate, making use of the serial correlation properties of the error terms. This is expressed as

$$E_t(RGOV_{t+1}) = -0.0041 + 0.3756\, E_t\,(RTB_{t+1}) + \sum_{i=1}^{16} b_i\, RTB_{t-i+1} + 0.5212\, \hat{u}_t. \quad (16)$$

Some measure of $E_t(RTB_{t+1})$ is necessary for these calculations, and two alternative measures are used here.

One possible description of expectations can be gleaned from the yield curve if the modified expectations hypothesis proposed by Kessel is used.[26] Thus

$$E_t(RTB_{t+1}) = F_{t+1} - LP, \quad (17)$$

where

F_{t+1} = forward rate for the bill rate at the end of the next quarter, derived from the yield curve at the end of the current quarter[27]

LP = liquidity premium.

Over the 1964–76 period, on average the forward rate was 59 basis points above the realized treasury bill rate, and this is used as an estimate of the liquidity premium, LP. The resulting measure for $E_t(RTB_{t+1})$, denoted by ERF_{t+1}, is

$$ERF_{t+1} = F_{t+1} - 0.0059. \quad (18)$$

For this expectations measure to be plausible, it must pass the criterion implied by efficient-markets theory, which states that deviations of expec-

26. Reuben A. Kessel, *The Cyclical Behavior of the Term Structure of Interest Rates,* Occasional Paper 91 (Columbia University Press for the National Bureau of Economic Research, 1965).

27. The forward rate is calculated by the formula

$$F_{t+1} = 4\left[1 - \frac{(360 - 1.8\, RTB6_t)}{(360 - 0.9\, RTB_t)}\right],$$

where $RTB6_t$ = 180-day treasury bill rate at the end of the quarter.

tations from realizations should be serially uncorrelated. If this were not the case, the expectations measure could clearly be made more accurate by using this information on serial correlation, and this measure could not represent expectations in an efficient market. Box and Pierce have suggested a so-called Q statistic to test for serial correlation.[28] They find that, for an unfiltered series,

$$Q(K) = T \sum_{k=1}^{K} \hat{r}_k^2,$$

where

T = number of observations

$\hat{r}_k$ = correlation between the series and its value k periods earlier.

This $Q(K)$ is distributed approximately as $X^2(K)$ under the hypothesis H_0 that

$$\hat{r}_1 = \hat{r}_2 = \ldots = \hat{r}_k = 0.$$

For $RTB_t - ERF_t$ over the 1964–76 period, $Q(12) = 8.7$ and $Q(24) = 22.0$, while the critical Q at 5 percent are 21.0 and 36.4, respectively. Thus the hypothesis that the first twelve or twenty-four autocorrelations are zero cannot be rejected, and the forward-rate measure for expectations meets the criterion implied by market efficiency.

An alternative measure of expectations can be obtained from the time-series process of the treasury bill rate. Using Box-Jenkins identification procedures, an autoregressive model was estimated over the 1964–76 period[29] as

$$\begin{aligned}(19)\qquad RTB_t = \underset{(0.0037)}{0.0096} &+ \underset{(0.1058)}{0.7859}\, RTB_{t-1} + \underset{(0.1348)}{0.2865}\, RTB_{t-3} \\ &- \underset{(-0.1022)}{0.2609}\, RTB_{t-5} + u_t.\end{aligned}$$

Durbin-Watson = 1.82.

28. G. E. P. Box and David A. Pierce, "Distribution of Residual Autocorrelations in Autoregressive-Integrated Moving Average Time Series Models," *Journal of the American Statistical Association*, vol. 65 (December 1970), pp. 1509–26. The Q-statistics below were derived using Charles R. Nelson's ESTIMATE program.

29. Significant heteroscedasticity was present in the regression, so it is estimated here with weighted least squares, using a procedure similar to that outlined below.

Taking expectations of both sides of 19 yields an autoregressive measure of $E_t(RTB_{t+1})$, which is

$$(20) \qquad ERAR_{t+1} = 0.0096 + 0.7859\ RTB_t + 0.2865\ RTB_{t-2} - 0.2609\ RTB_{t-4}.$$

The $Q(12)$ statistic for $RTB_t - ERAR_t$ is distributed as $X^2(9)$. For the 1964–76 period it is 6.7, while the critical Q at the 5 percent level is 16.9. Furthermore, $Q(24) = 10.7$, while the critical Q at 5 percent equals 32.7. Thus there is no evidence of serial correlation in the forecast errors.[30]

Based on 16 and either of the two measures of $E_t(RTB_{t+1})$, implied one-period quarterly returns from holding a long-term government bond have been calculated for the 1972–76 period. Because these government bonds are not consols, a formula more complicated than 14 generates these returns, using information on the maturity date of each bond.

The implied expected returns from 15, the term-structure equation (shown in table 1), illustrate how forecasts from this type of equation are inconsistent with market efficiency.[31] The implied expected returns fluctuate substantially and the violation of efficient markets is severe because it is quite implausible that normal returns for long-term bonds would equal the implied returns of table 1. Using either measure of expected *RTB*, the quarterly returns on government bonds were 20 percent or higher at an annual rate at the end of 1976, well above what can be considered a normal rate of return for this type of security. Expected losses in nominal terms appear for some quarters of 1973 and 1974, but nominal

30. The measure of autoregressive expectations suffers from the same problem that arises for term-structure equations such as 4: the coefficients in the equation are not invariant to a change in policy regime. The time-series process of the short-term rate thus might change over time, and $ERAR_t$ might at times be a poor measure of expectations. $ERAR_t$ also suffers from the disadvantage that it restricts itself to information on past short-term rates, while the market may use other information in generating its expectations. However, $ERAR_t$ is used in the above experiment because it also shows that implied expected returns from equation 15 are inconsistent with market efficiency according to a number of expectations measures.

31. Because of the way bond-pricing conventions reflect bond coupon payment, there are some subtle technical issues in calculating bond returns that have been allowed for in Fisher's data on bond returns and in the calculations found here. The Fisher series uses the average of bid and asked prices in calculating returns, and transactions costs are not included in his calculations of quarterly bond returns.

Table 1. Expected Return on Long-Term Government Bonds Implied by Term-Structure Equation 15, and Actual Return on Treasury Bills and Government Bonds, 1972:1 to 1976:4[a]

Annual rate in percent

	Expected return		Actual return	
Year and quarter	*Using forward rate, ERF_t*[b]	*Using auto-regressive, $ERAR_t$*[b]	*Ninety-day treasury bills*[c]	*Long-term government bonds*
1972:1	11.2	7.5	3.7	2.1
2	8.4	9.5	3.8	8.9
3	9.2	20.0	4.1	−3.4
4	8.5	20.6	4.6	15.0
1973:1	9.6	8.5	5.1	−5.2
2	−0.7	4.1	6.4	−2.4
3	−2.4	−1.9	7.5	3.8
4	−7.2	−1.4	7.0	5.0
1974:1	5.4	−4.5	7.5	−14.0
2	4.6	−3.2	8.3	−3.5
3	−1.8	15.2	7.3	−0.8
4	−2.4	22.3	6.1	45.6
1975:1	2.7	1.5	7.1	−3.4
2	17.4	28.0	5.5	16.2
3	7.5	10.8	5.9	−13.7
4	4.8	18.1	6.6	30.3
1976:1	14.9	21.4	5.0	16.6
2	12.4	11.4	5.0	−0.8
3	14.3	22.6	5.4	19.0
4	20.0	26.9	5.1	40.6

Sources: The first two columns are derived from text equations 16, 18, and 20. Data on 90- and 180-day treasury bill rates were furnished by the Board of Governors of the Federal Reserve System. The data on returns for long-term government bonds were provided by Lawrence Fisher and are described in Lawrence Fisher and James H. Lorie, *A Half Century of Returns on Stocks and Bonds: Rates of Return on Investments in Common Stocks and on U.S. Treasury Securities, 1926–1976* (University of Chicago, Graduate School of Business, 1977).

a. The bond series is returns on taxable government bonds callable in ten years or more, with bonds chosen so that tax-induced distortions from capital gains and estate privileges are minimized. The numbers are nominal returns for a holding period of one quarter, expressed as annual percentage rates.

b. ERF_t and $ERAR_t$ are calculated according to text equations 18 and 20, respectively.

c. The actual return is equal to the expected treasury bill rate at the beginning of the quarter.

returns could never be negative with the existence of money, a risk-free asset with a nonnegative return.[32]

In summary, a typical term-structure equation is theoretically an inadequate structural equation in a macro model. More direct empirical tests follow, which indicate that past information, such as that used in term-structure equations, is not particularly helpful in predicting changes in long-term rates or stock prices. This provides further evidence that the use of these term-structure equations should be abandoned.

Tests of Efficient-Markets Theory for Bond and Stock Markets

The tests of market efficiency conducted in this section use quarterly returns for the long-term government bonds discussed above and the quarterly, value-weighted stock returns of New York Stock Exchange stocks compiled by the University of Chicago, Center for Research in Security Prices.[33] These returns are expressed in fractions. Other information includes data on treasury bills and forward rates discussed above and on the Moody's Aaa corporate bond rate. Because misleading results can be obtained from tests with averaged data, all information on security

32. Using the same estimation procedures as in 15, implied quarterly returns for 1972–76 analogous to those in table 1 are as follows:

Equation	*Period of estimation*	*Serial correlation*	*Range (percent)*
1	1964–76	Uncorrected	−10.6 to 29.7
2	1954–76	Corrected	−3.6 to 23.9
3	1954–76	Uncorrected	−6.0 to 34.3
4	1964–71	Corrected	−51.4 to 178.9
5	1954–71	Corrected	−3.3 to 35.7

The sum of the coefficients on the treasury bill rates in these equations ranges from 0.99 to 1.31. All the term-structure equations discussed in this note are characterized by the same difficulties as equation 15.

In the 1964–76 sample period, a change of 11 basis points in the long-term government bond rate corresponds to a 4 percentage point movement in the quarterly bond return at an annual rate. Thus if the equilibrium return for these bonds is taken to be close to the return on 90-day bills, table 1 indicates that the long-term bond rate predicted by 15 never differed from the efficient-markets prediction for bond yields by more than 60 basis points.

33. Quarterly stock returns have been computed for these data from the value-weighted, monthly returns, with dividends reinvested.

prices is taken at a particular point in time.[34] The bond and stock returns are calculated from security prices at the beginning and the end of the quarter. All tests are carried out on the 1964–76 sample period. (Additional tests on longer sample periods, when this was possible, are discussed in the notes.)

Particular attention must be paid to possible heteroscedasticity in these tests. Heteroscedasticity does not lead to inconsistent parameter estimates, but it does lead to inconsistent test statistics. Because the test statistics are of primary interest in the empirical work below, corrections for heteroscedasticity are made if necessary.

Two types of efficient-market tests are conducted. Weak-form tests analyze whether one-period long-term bond or stock returns are serially uncorrelated—the implication of the martingale model of the first section. Both the $Q(K)$ statistic, which jointly tests whether the first K autocorrelations are zero, and test statistics on individual autocorrelations are used.

For semistrong form tests, the efficient-markets model can be characterized by the following linear equation:

$$R_t = R_t^* + \beta(X_t - X_t^e) + \epsilon_t, \tag{21}$$

where

e = expected values conditional on all past publicly available information
R_t = one-period return on a security for the period $t-1$ to t
R_t^* = equilibrium return
X_t = a variable (or vector of variables) relevant to the pricing of the security for the period $t-1$ to t
β = coefficient (or vector of coefficients)
ϵ_t = white-noise error process.

The returns in this equation deviate from the equilibrium return only when new information is received by the market—that is, when there is a surprise, $X_t - X_t^e \neq 0$. Market efficiency implies, therefore, that in a regression equation of the form

$$R_t = R_t^* + \beta(X_t - X_t^e) + \sum_{i=1}^{N} \gamma_i(X_{t-i} - X_{t-i}^e) + \epsilon_t, \tag{22}$$

34. For example, security prices averaged over a quarter will not follow a random walk even though the price series can be characterized as a random walk. See Holbrook Working, "Note on the Correlation of First Differences of Averages in a Random Chain," *Econometrica*, vol. 28 (October 1960), pp. 916–18.

$\gamma_i = 0$ for all i. This hypothesis can easily be tested with standard F tests. Regression tests on 22 have the advantage that they are on a comparable footing with typical characterizations of bond and stock market behavior in which current as well as lagged variables are used as explanatory variables.

Nevertheless, care must be taken in interpreting results from 22. If an inappropriate proxy is chosen for X_t^e so that $X_t - X_t^e$ is correlated with any past information, the hypothesis that $\gamma_i = 0$ might be rejected, even though the martingale model is valid. A hypothetical example will clarify this point. If X followed the time-series process,

$$X_t = X_{t-1} + b(X_{t-2} - X_{t-3}) + u_t, \tag{23}$$

then the surprise would be

$$X_t - X_t^e = X_t - X_{t-1} - b(X_{t-2} - X_{t-3}). \tag{24}$$

Substituting 24 into 21, the result is

$$R_t = R_t^* + \beta(X_t - X_{t-1}) - b\beta(X_{t-2} - X_{t-3}) + \epsilon_t. \tag{25}$$

If X_{t-1} were mistakenly chosen for X_t^e, the equation 22 regression would yield a significant coefficient on the supposed lagged surprise, $X_{t-2} - X_{t-3}$. To avoid this danger, tests of the random walk model should also be conducted by estimating the following regression:

$$R_t = R_t^* + \sum_{i=1}^{N} \gamma_i(X_{t-i} - X_{t-i}^e) + \epsilon_t. \tag{26}$$

In this case, whichever proxy is chosen for X_t^e, the random walk model asserts that $\gamma_i = 0$ for all i.

To conduct empirical tests of the efficient-markets model, the equilibrium return, R_t^*, must be specified. The usual assumption in market efficiency tests is that the equilibrium return is constant. As discussed above, even if this assumption is not strictly true, imposing it will not invalidate empirical tests of market efficiency as long as the variation in the equilibrium return, R_t^*, is small relative to other sources of variation in the actual return, R_t. This condition apparently holds for long-term bonds and common stocks where actual returns have tremendous variation, but the proposition should be put to an empirical test.[35]

35. For example, if 21 is used to characterize the equilibrium returns, in the long-term bond data used here the variation of R_t^* is less than 2 percent of the variation in $R_t - R_t^*$.

In a taxless world, R_t^* would be expected to equal the one-period short-term rate at the beginning of the period, r_{t-1}, plus a liquidity premium, k:

$$R_t^* = r_{t-1} + k. \tag{27}$$

In this case, a regression of the actual returns, R_t, on the short-term rate, r_{t-1}, should yield a coefficient on the short-term rate of 1.0 if the liquidity premium and that short-term rate are uncorrelated. Because capital gains and interest income receive different tax treatments and because of a possible correlation of the liquidity premium and short-term rate, the regression coefficient need not equal 1.0, but should be near this value. However, if the equilibrium return has small variation relative to other sources of variation in the actual return, the standard error of the short-term rate coefficient would be quite large, and this coefficient would not be significantly different from zero. In this situation, the usual assumption of a constant equilibrium return would not appreciably affect the empirical results in weak or semistrong tests of market efficiency.

The quarterly bond and stock returns are regressed against the treasury bill rate at the beginning of the quarter; the bill rate is adjusted to a quarterly rate so that the units of the returns data and bill rate data are consistent. The results, using weighted least squares to correct for heteroscedasticity, are as follows:[36]

$$\begin{aligned} BONDRET_t &= \underset{(-0.0182)}{-0.0110} + \underset{(1.4950)}{1.6427}\, RTBQ_{t-1} + u_t, \\ &\text{Durbin-Watson} = 2.04, \end{aligned} \tag{28}$$

$$\begin{aligned} STOCKRET_t &= \underset{(0.0457)}{0.0834} - \underset{(-3.5223)}{4.9924}\, RTBQ_{t-1} + u_t, \\ &\text{Durbin-Watson} = 2.04, \end{aligned} \tag{29}$$

where

$BONDRET_t$ = one-quarter return from holding a long-term government bond (from beginning of quarter to end of quarter)

$STOCKRET_t$ = one-quarter return from holding New York Stock Exchange stocks

36. The procedures used in constructing the weights are the same as those outlined below for regressions of bond and stock returns.

$RTBQ_{t-1}$ = treasury bill rate at beginning of quarter with a quarterly rate that equals $RTB_{t-1}/4$.

The bond return regression indicates that the equilibrium return is reasonably characterized by 27, and the hypothesis that the coefficient on the bill rate is 1.0 is not rejected at the 5 percent level ($t = 0.43$). Yet the standard error of this coefficient is so large that the hypothesis of a constant equilibrium return cannot be rejected either ($t = 1.10$). The stock return regression presents a peculiar result. Instead of expected positive correlation between stock returns and the bill rate for the beginning of the period, the regression displays a negative correlation for the 1964–76 sample period. Yet the hypothesis that the coefficient on the bill rate is 1.0 cannot be rejected at the 5 percent level (although $t = 1.70$ indicates it can be rejected at the 10 percent level). However, this result holds only because the coefficient is estimated with such imprecision; indeed, the constancy of the equilibrium return cannot be rejected either ($t = 1.42$). In a recent paper, Fama and Schwert obtain results similar to those found here using a different sample period. They find a negative correlation for stock returns and short-term rates for the beginning of the period, but they also find that this correlation is statistically significant.[37]

The statistical results found above are unclear about the relationship between short-term rates and the equilibrium return; and the constancy of the equilibrium return is not rejected. Semistrong-form empirical tests of market efficiency have thus been conducted in two ways. In one set of tests, the equilibrium return is assumed to be a function of the treasury bill rate at the beginning of the period. Thus the following regressions have been run for several lag lengths, N,

$$(30) \quad R_t = \alpha + \delta RTBQ_{t-1} + \beta(X_t - X_t^e) + \sum_{i=1}^{N} \gamma_i(X_{t-i} - X_{t-i}^e) + \epsilon_t$$

$$(31) \quad R_t = \alpha + \delta RTBQ_{t-1} + \sum_{i=1}^{N} \gamma_i(X_{t-i} - X_{t-i}^e) + \epsilon_t,$$

and test statistics have been calculated for the hypothesis that γ_i equals zero for all $i = 1, \ldots, N$.

In the other set of tests the equilibrium return was assumed to be con-

37. Eugene F. Fama and G. William Schwert, "Asset Returns and Inflation," *Journal of Financial Economics*, vol. 5 (November 1977), pp. 115–46.

stant. Here the test statistics for the hypothesis $\gamma_i = 0$ were calculated from the following regression equations:

$$R_t = \alpha + \beta(X_t - X_t^e) + \sum_{i=1}^{N} \gamma_i(X_{t-i} - X_{t-i}^e) + \epsilon_t \tag{32}$$

$$R_t = \alpha + \sum_{i=1}^{N} \gamma_i(X_{t-i} - X_{t-i}^e) + \epsilon_t. \tag{33}$$

The results from these two sets of regressions are not appreciably different, either in the magnitude of the relevant F-statistics or in the number of rejections of market efficiency. Only the results from the regressions that assume a constant equilibrium return (equations 32 and 33) are discussed in this article to conserve space, although the other results are available on request from the author. Equations 32 and 33 were chosen because the bond and stock market tests are directly comparable to each other, as well as to other time-series tests of market efficiency in the literature that commonly uses the assumption of a constant equilibrium return.[38]

BOND MARKET TESTS

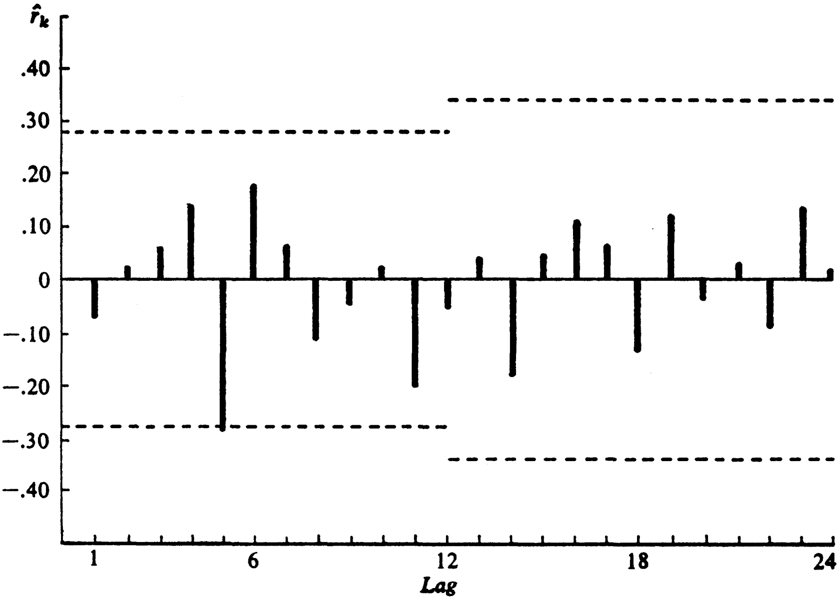
Heteroscedasticity is present in all the tests of bond markets in this section. For example, when carrying out tests of the serial correlation of bond returns, it becomes obvious that residuals from a regression of bond returns on the constant term exhibit rising variation over time. A Goldfeld-Quandt test rejects homoscedasticity at the 1 percent level.[39] In a procedure outlined by Glejser, the absolute values of these residuals are then regressed against a time trend, and the fitted values are used to weight the data.[40] The regression with weighted least squares results in more effi-

38. The one bond market rejection in the equation 32–33 tests is found in table 3—the only rejection in these tests of the bond market—and this disappears when the short-term rate is included in the regression as in the 30–31 tests.

39. Stephen M. Goldfeld and Richard E. Quandt, "Some Tests for Homoscedasticity," *Journal of the American Statistical Association*, vol. 60 (June 1965), pp. 539–47. Sixteen observations were excluded from the middle of the sample for this test. $F(17, 17) = 3.38$, while the critical F at 1 percent is 3.24. These Goldfeld-Quandt tests have also been performed for all other bond return regressions, and there is rejection of homoscedasticity at the 5 percent level or higher in all cases.

40. H. Glejser, "A New Test for Heteroskedasticity," *Journal of the American Statistical Association*, vol. 64 (March 1969), pp. 316–23.

Figure 1. Autocorrelations of Returns on Long-Term Government Bonds[a]



Source: The data were provided by Lawrence Fisher and are described in Lawrence Fisher and James H. Lorie, *A Half Century of Returns on Stocks and Bonds: Rates of Return on Investments in Common Stocks and on U.S. Treasury Securities, 1926–1976* (University of Chicago, Graduate School of Business, 1977).

a. The bond series is taxable government bonds callable in ten years or more, with bonds chosen so that tax-induced distortions from capital gains and estate privileges are minimized. The $\hat{r}_k$ is the correlation between the series and its value k periods earlier. The dotted lines denote approximately two standard deviations from zero.

cient parameter estimates (the mean of the bond return series, in this case) and the resulting homoscedastic residuals can be used to give the following consistent test statistics for serial correlation in the bond returns.

The martingale model does seem to be an accurate description of the bond return series. As figure 1 indicates, only one of the first twenty-four autocorrelations—that is, at lag 5—is more than two standard deviations away from zero, indicating statistical significance at the 5 percent level. At the 5 percent significance level, one in twenty autocorrelation coefficients would be expected to be significant. Thus it is necessary to test whether the autocorrelations are jointly significant. Here, the Q tests of the hypothesis that the first twelve or twenty-four autocorrelations are zero cannot be rejected at the 5 percent level: $Q(12) = 12.7$ and $Q(24) = 22.5$, while the critical Q at 5 percent are 21.0 and 36.4, respectively.

Semistrong form tests of market efficiency are performed using data on treasury bill rates. The expectations hypothesis of the term structure states that long-term bond rates are determined by current and expected future short-term interest rates. Movements in treasury bill rates should thus be relevant information that will affect bond returns. When conducting the regression tests of equations 22 and 26, the same two proxies for expected treasury bill rates are used that were discussed in the previous section.

When the ERF_t forward-rate measure for the expected bill rate is introduced, the efficient-markets model (with a constant expected return) leads to a regression of bond returns ($BONDRET_t$) on ($RTB_t - ERF_t$). (The ERF_t measure of the expected bill rate at the end of the quarter is derived from data at the end of the previous quarter.) Heteroscedasticity is present in the residuals, and the weighted least squares procedure is used in estimation. The regression results, time-corrected for heteroscedasticity, are

$$(34) \qquad \underset{}{BONDRET_t} = \underset{(0.0045)}{0.0131} - \underset{(-0.5475)}{3.2439}\,(RTB_t - ERF_t) + u_t.$$

Durbin-Watson = 2.16.

The coefficient on (RTB_t − ERF_t) is almost six times larger than its standard error, indicating that, as expected, movements in treasury bill rates are relevant information to the pricing of long-term bonds.

The coefficient on (RTB_t − ERF_t) also contains information on how the market views the time-series process of the bill rate. In the sample period a decrease in the bond return of 0.01 corresponds, on average, to an increase of 11 basis points in the long-term government bond rate, $RGOV$. Thus the equation above indicates that a surprise increase of 10 basis points in the bill rate in the 1964–76 period was matched by an increase of only 3.6 basis points in the long-term rate. The less than one-to-one movement of long- and short-term rates indicates that the market did not expect the short-term rate to follow a random walk. On the contrary, the market expected any surprise jump in the short rate to diminish over time, implying stationarity in the short-term rate series. If the short-term rate were expected to follow the nonstationary, random walk process, the expectations hypothesis of the term structure implies that a change in the short-term rate would be matched by an equal change in the long-term rate. The results in 34, together with the previous estimates of the time-series process of the bill rate and the fact that, historically, the bill rate

Table 2. Tests for Significant Effects on Long-Term Government Bond Returns from Lagged Surprises in Treasury Bill Rates, Using Forward Rate Expectations for Treasury Bills[a]

Number of lags, N	*F-statistic*[b]	*p value*[c]
$BONDRET_t = \alpha + \beta(RTB_t - ERF_t) + \sum_{i=1}^{N} \gamma_i(RTB_{t-i} - ERF_{t-i}) + u_t$		
1	0.01	0.933
4	0.25	0.911
8	0.93	0.504
12	0.87	0.585
16	1.10	0.392
20	1.10	0.399
$BONDRET_t = \alpha + \sum_{i=1}^{N} \gamma_i(RTB_{t-i} - ERF_{t-i}) + u_t$		
1	0.25	0.620
4	0.74	0.572
8	1.42	0.218
12	1.05	0.428
16	1.21	0.310
20	1.20	0.319

Sources: Same as table 1 for basic data.

a. The long-term government bond series, $BONDRET_t$, is described in table 1, note a. RTB_t is the 90-day treasury bill rate at the end of the quarter. ERF_t is the forward rate expectations measure of RTB_t and is calculated according to text equation 18.

b. Tests for $\gamma_i = 0$ for all $i = 1, 2, \ldots, N$.

c. Probability of getting that value of F or higher under H_0: $\gamma_i = 0$ for all $i = 1, 2, \ldots, N$.

has not fluctuated outside a fairly narrow range, strongly support rejection of the random walk characterization of the short-term interest rate. As discussed before, this in no way contradicts financial market efficiency.

The question of whether past information on bill rates helps significantly to explain bond returns is addressed in table 2. This table presents F tests for significant effects on bond returns from lagged surprises in bill rate movements, as measured by $RTB_{t-i} - ERF_{t-i}$. Included in the table are F tests using regressions (time-corrected for heteroscedasticity) like 32, which includes the current $RTB_t - ERF_t$, or like 33, which excludes it.[41] The p values are the probability of obtaining a value of F or higher, under the null hypothesis that the coefficients on lagged surprises are zero.

41. For the tests using equation 32, the weights in the generalized least squares procedure are the same as those used in 34. Tests with 33 use the weights calculated by taking the fitted value from the time-trend residuals regression, in which the residuals are derived from the bond return minus its mean.

A p value less than 0.05 would indicate rejection at the 5 percent level of the null hypothesis and, therefore, rejection of the efficient-markets model used here. The results in table 2 are clear-cut: in no case do lagged surprises in bill rates contribute significantly to explaining government bond returns. In fact, the p values of table 2 are quite high.

Using the autoregressive measure for expected bill rates, $ERAR_t$, the efficient-markets model is represented by a regression of bond returns on $(RTB_t - ERAR_t)$. A time-correction for heteroscedasticity is necessary, and the resulting weighted least squares estimates are

$$(35) \qquad BONDRET_t = \underset{(0.0040)}{0.0074} - \underset{(-0.7351)}{2.9276}\,(RTB_t - ERAR_t) + u_t.$$

Durbin-Watson = 2.02.

The forward rate measure of expectations seems to be slightly more accurate as a measure of market expectations than the autoregressive measure because the t-statistic on the $(RTB_t - ERAR_t)$ coefficient (about four in absolute value) is smaller than the t-statistic (about six) for the $(RTB_t - ERF_t)$ coefficient in equation 34. This is not surprising because the autoregressive measure relies solely on bill rate information in generating expectations, while the forward rate measure may reflect additional information used by the market. Table 3 contains F tests for significant effects from past innovations in bill rate movements, in this case measured by $RTB_{t-i} - ERAR_{t-i}$. Only one case occurs in which there is a significant rejection of the efficient-markets model at the 5 percent level (marked by b). This occurs with sixteen lagged innovations, with the current innovation included in the regression. However, when the current innovation is excluded, as shown in table 3, the sixteen lagged innovations no longer contribute significantly to the explanation of movements in bond returns. Thus there is little evidence here that supports the rejection of market efficiency.[42]

My results thus conflict with those of Robert J. Shiller, who finds evidence using long-term bond data that past information is useful in predicting bond returns.[43] Shiller runs regressions of bond returns minus the

42. Furthermore, as noted above, this one rejection of market efficiency disappears if the short-term rate at the beginning of the period is included in the regression model.

43. Robert J. Shiller, "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure," research paper 36 (Federal Reserve Bank of Philadelphia, July 1978).

Table 3. Tests for Significant Effects on Long-Term Government Bond Returns from Lagged Surprises in Treasury Bill Rates, Using Autoregressive Expectations for Treasury Bills[a]

Number of lags, N	*F-statistic*	*p value*
$BONDRET_t = \alpha + \beta(RTB_t - ERAR_t) + \sum_{i=1}^{N} \gamma_i(RTB_{t-i} - ERAR_{t-i}) + u_t$		
1	2.55	0.117
4	0.98	0.430
8	1.26	0.288
12	1.00	0.469
16	1.98[b]	0.047[b]
20	1.84	0.064
$BONDRET_t = \alpha + \sum_{i=1}^{N} \gamma_i(RTB_{t-i} - ERAR_{t-i}) + u_t$		
1	0.70	0.406
4	0.43	0.788
8	1.01	0.440
12	0.75	0.693
16	1.23	0.297
20	1.15	0.353

Sources: Same as table 1 for basic data.

a. $ERAR_t$ is the autoregressive expectations measure of RTB_t and is calculated according to text equation 20. The other symbols are defined in table 2.

b. Significant at the 5 percent level.

short-term rate at the beginning of the period on the long-term bond rate at the beginning of the period and on the spread between the long- and the short-term rate at the beginning of the period. He finds that this past information is significant in these regressions, some of which use data similar to those used here. I reran these regressions over the 1964–76 period and corrected for heteroscedasticity, which is highly significant. The results were

$$BONDRET_t - RTBQ_{t-1} = \underset{(-0.0186)}{-0.0292} + \underset{(0.3339)}{0.4751}\, RGOV_{t-1} + u_t,$$

Durbin-Watson = 2.05,

$$BONDRET_t - RTBQ_{t-1} = \underset{(-0.0061)}{-0.0117} + \underset{(0.6080)}{1.1718}\,(RGOV_{t-1} - RTB_{t-1}) + u_t.$$

Durbin-Watson = 2.26.

The *t*-statistics on $RGOV_{t-1}$ and $(RGOV_{t-1} - RTB_{t-1})$ are 1.42 and 1.93, respectively, and are not statistically significant at the 5 percent level, although in the latter case statistical significance is almost achieved. Thus the evidence here is not as strong as Shiller's for rejecting the view that past information is uncorrelated with the return on bonds.[44]

In any case, a significant coefficient on $RGOV_{t-1}$ or $(RGOV_{t-1} - RTB_{t-1})$ in the above regressions does not necessarily imply a rejection of market efficiency. An equally plausible alternative is that when $RGOV$ is high or high relative to RTB, the liquidity premium is especially large. Thus when this occurs, the expected bond return might be higher because the equilibrium return has risen to reflect the larger liquidity premium.

Similar tests were run on constructed bond return data for the corporate bond market, although the data were not nearly as satisfactory as the government bond return data used here. Nevertheless, these tests, which are described in an appendix available from the author, tell the same story as is told here. The corporate bond data give no indication that market efficiency is violated.

In summary, the bond market results support the efficient-markets model. And furthermore, the evidence here does not support the existence of a distributed lag relationship between bond returns and past interest rate movements, which casts further doubt on the typical term-structure equations found in macro models.

STOCK MARKET TESTS

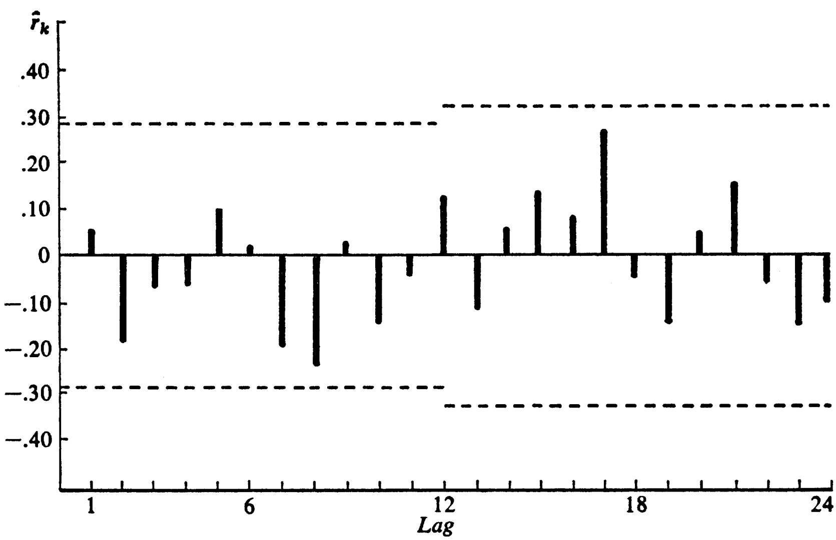
In the 1964–76 sample used here, stock returns do exhibit heteroscedasticity,[45] although it seems to be of a different nature from that found for bond returns. Goldfeld-Quandt tests do not indicate a rising variance for the period 1964:1 to 1973:3, yet beginning with the oil embargo in 1973:4, variance increases significantly.[46] Heteroscedasticity corrections,

44. The difference between these results and Shiller's when he used a similar sample period is largely due to his failure to correct for heteroscedasticity. If there is no correction, the data used here produce results closer to Shiller's.

45. Heteroscedasticity, significant at the 5 percent level or higher, is evident in the stock return regressions. For example, a Goldfeld-Quandt test, excluding sixteen observations, indicates rejection of the hypothesis that the variance of stock returns is homoscedastic: $F(17, 17) = 3.73$, while the critical F at 1 percent is 3.24.

46. F tests similar to Goldfeld-Quandt tests can be used to examine whether the residual variances are the same for both periods, and this null hypothesis is rejected at the 1 percent level for the stock return regressions here. For example, the hypothe-

Figure 2. Autocorrelations of Stock Returns[a]



Source: The data were supplied by the University of Chicago, Center for Research in Security Prices.
a. The stock series is quarterly, value-weighted returns of New York Stock Exchange stocks, with dividends reinvested. The quarterly series is computed from monthly returns. The $\hat{r}_k$ is the correlation of the series with its value k periods earlier. The dotted lines denote approximately two standard deviations from zero.

using weighted least squares, are used here for all tests on stock returns, as they were for the tests on bond returns. The weights for the two periods, 1964:1 to 1973:3 and 1973:4 to 1976:4, are derived by a procedure proposed by Feldstein that uses residual variances for the two periods to calculate the weights.[47]

The weak-form tests do not reject stock market efficiency; this finding is consistent with the results of other similar tests in the literature on efficient markets. None of the stock return autocorrelations shown in figure 2 is significantly different from zero at the 5 percent level. And the *Q*-

---

sis that the variance of stock returns in the two periods is the same can be rejected at 1 percent: $F(12, 19) = 3.69$ while the critical F at 1 percent = 3.30. However, a Goldfeld-Quandt test (excluding eight observations) for heteroscedasticity of stock return variance over the 1954:1 to 1973:3 period does not reject homoscedasticity—$F(14, 14) = 2.44$, critical F at 5 percent = 2.48—while it does for bond-return variance—$F(14, 14) = 4.85$, critical F at 1 percent = 3.70.

47. Martin S. Feldstein, *Economic Analysis for Health Service Efficiency: Econometric Studies of the British National Health Service* (Amsterdam: North-Holland, 1967), pp. 52–54.

statistics for stock returns, corrected for heteroscedasticity, do not reject the hypothesis that the first twelve or twenty-four autocorrelations are zero: $Q(12) = 11.4$ and $Q(24) = 27.0$, while the critical Q at the 5 percent level are 21.0 and 36.4, respectively.

Long-term bond rates and, in particular, corporate bond rates, often are considered an important determinant of common stock prices because these bonds are an attractive alternative investment. (This is the view of the stock market sector of the MPS model.) An alternative and equally plausible view is that information important to the determination of corporate bond rates is also important to stock prices. The semistrong-form tests use the Moody's Aaa corporate bond rate because it captures information relevant to stock prices. Because bond returns are serially uncorrelated, this should also be approximately true of the change in corporate bond rates. The lagged Aaa rate (plus a possible constant, captured by the constant term of the regression model) is therefore used as a proxy for the expected Aaa rate.[48] The resulting estimate of the efficient-markets model, using weighted least squares, is

$$(36)\quad \underset{}{STOCKRET_t} = \underset{(0.0091)}{0.0325} - \underset{(-2.9949)}{15.7986}\,(RCB_t - RCB_{t-1}) + u_t,$$

$$\text{Durbin-Watson} = 2.17,$$

where

$STOCKRET_t$ = quarterly return on stocks

RCB_t = corporate Aaa bond rate on the last trading day of the quarter.

Corporate bond rates do seem to embody important information for the stock market, as is shown by the t-statistic on the $(RCB_t - RCB_{t-1})$ coefficient exceeding five in absolute value.

Table 4 contains the F tests (corrected for heteroscedasticity) for significant effects on stock returns from past changes in the corporate bond rate. In only one case is there a significant rejection at the 5 percent level of the efficient-markets model (marked by b), and the rejection is not significant for this number of lags in the other test in the table. The p values

48. Changes in the Aaa corporate bond rate display no significant serial correlation. The Q-statistics, time-corrected for heteroscedasticity, are $Q(12) = 9.12$ and $Q(24) = 15.8$, with the critical Q at the 5 percent level equal to 21.0 and 36.4, respectively.

Table 4. Tests for Significant Effects on Stock Returns from Past Changes in the Corporate Bond Rate[a]

Number of lags, N	*F-statistic*	*p value*
$STOCKRET_t = \alpha + \beta(RCB_t - RCB_{t-1}) + \sum_{i=1}^{N} \gamma_i(RCB_{t-i} - RCB_{t-i-1}) + u_t$		
1	3.72	0.060
4	2.55	0.052
8	2.12	0.055
12	1.75	0.095
16	1.78	0.078
20	2.09[b]	0.033[b]
$STOCKRET_t = \alpha + \sum_{i=1}^{N} \gamma_i(RCB_{t-i} - RCB_{t-i-1}) + u_t$		
1	2.48	0.122
4	1.42	0.243
8	1.11	0.373
12	0.85	0.597
16	0.68	0.797
20	1.23	0.294

Sources: The data are from Standard and Poor's, *The Outlook*, various issues, and the University of Chicago, the Center for Research in Security Prices.

a. $STOCKRET_t$ is the quarterly, value-weighted returns of New York Stock Exchange stocks, with dividends reinvested. The quarterly series is computed from monthly returns. RCB_t is Moody's Aaa corporate bond rate on the last trading day of the quarter. The *F*-statistic and *p* value are defined in table 2, notes b and c, respectively.

b. Significant at the 5 percent level.

are lower in this table than those in bond return tests, and the results are a little less clear-cut.[49] Nevertheless, the efficient-markets model appears to be reasonably consistent with the data, and the evidence is quite weak in support of past corporate bond rates having an effect on stock returns.[50]

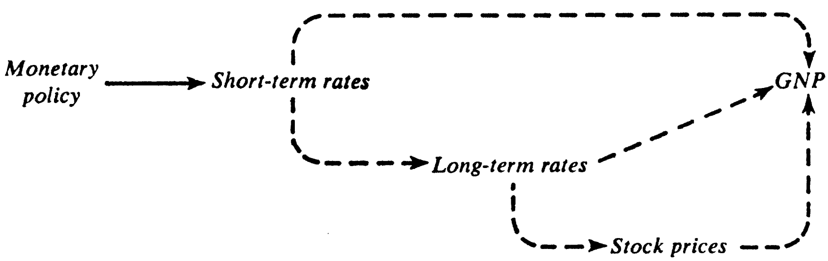
49. The time-trend procedure used in the bond market tests to correct for heteroscedasticity was also tried in the stock market tests. The results were similar to those of table 4. Only two rejections occurred at the 5 percent level: for one and four lags, using the regression equation including the current change in *RCB* as an explanatory variable. Using the Feldstein heteroscedasticity correction, these tests were also carried out on the 1954–76 sample period with similar results. There was only one rejection at the 5 percent level: for one lag, using the regression equation that includes the current change in *RCB* as an explanatory variable.

50. Michael S. Rozeff, "Money and Stock Prices: Market Efficiency and the Lag in Effect of Monetary Policy," *Journal of Financial Economics*, vol. 1 (September 1974), pp. 245–302, has conducted tests on stock market returns similar to mine, using the supply of money as relevant information to stock returns. He also found evidence consistent with efficient-markets theory.

The empirical tests of this section also do not support the view implicit in standard term-structure equations that past changes in interest rates affect current bond and stock returns with long distributed lags. The results of these empirical tests that support bond and stock market efficiency are not surprising, considering the wealth of literature in defense of financial market efficiency. The characterizations of bond and stock markets in macroeconomic models thus appear to be potentially deceptive. What implications does this have for stabilization policy and macro forecasting methodology?

Implications for Monetary Policy

The speed with which the economy responds to changes in monetary policy is obviously of great importance to policymakers. Simulation results from structural macroeconometric models tend to display long lags between a change in monetary policy (represented as either a change in the money stock or in short-term interest rates) and its effect on aggregate demand. Yet these lags are found to be much shorter in reduced-form models of the St. Louis variety.[51] A schematic diagram showing how monetary policy affects aggregate demand in structural macroeconometric models helps illustrate why, in these models, long lags occur between monetary policy and aggregate demand. (For the sake of simplicity, feedback effects are not shown.)



The solid line indicates immediate effects; dashed lines, distributed lag effects.

51. I have serious doubts about the reduced-form approach. Research is needed on the differences in results between reduced-forms and structural models. Carl F. Christ, "Judging the Performance of Econometric Models of the U.S. Economy," *International Economic Review*, vol. 16 (February 1975), pp. 54–74, discusses the response of many macroeconometric models to monetary policy changes.

A slow response to monetary policy occurs in these models because there are distributed lag effects from interest rates and stock prices on aggregate demand, and because there are long lags between long-term and short-term rates, as well as between stock prices and long-term rates. These lags between short- and long-term rates and between stock prices and long rates violate market efficiency. A macro model that corrects for this and is consistent with efficient-markets theory would have the following schematic representation:

$$
\begin{tikzcd}
\textit{Monetary policy} \arrow[r] & \textit{Short-term rates} \arrow[r, dashed] \arrow[d] & \textit{GNP} \\
& \textit{Long-term rates} \arrow[d] \arrow[ur, dashed] & \\
& \textit{Stock prices} \arrow[uur, dashed] &
\end{tikzcd}
$$

Here any effect of monetary policy would be immediately incorporated into long-term rates and stock prices. Because the effects of these rates and prices on aggregate demand are important channels through which monetary policy influences the economy, the effects of monetary policy should occur much faster. Thus the discrepancy between reduced-form and structural macro models over the speed of monetary policy effects may be illusory.

Simulation experiments with the 1977 version of the MPS model are used here to provide a more quantitative perspective on the importance of financial market efficiency for macro models.[52] To show how misleading macro models with the usual term-structure relation can be, the following policy question is posed: if the Federal Reserve made the surprise announcement that it would permanently lower the treasury bill rate by 50 basis points, and the public expected this policy to be carried out, what would be the effect on the economy? In these experiments, a simulation starting in 1972:1 with a treasury bill rate exogenously set at 50 basis points below its historical path is compared to a control simulation in which all exogenous variables (including the treasury bill rate) are at historical values. This comparison shows the response of the economy to the expansionary monetary stimulus of a permanent decline in the treasury bill rate.

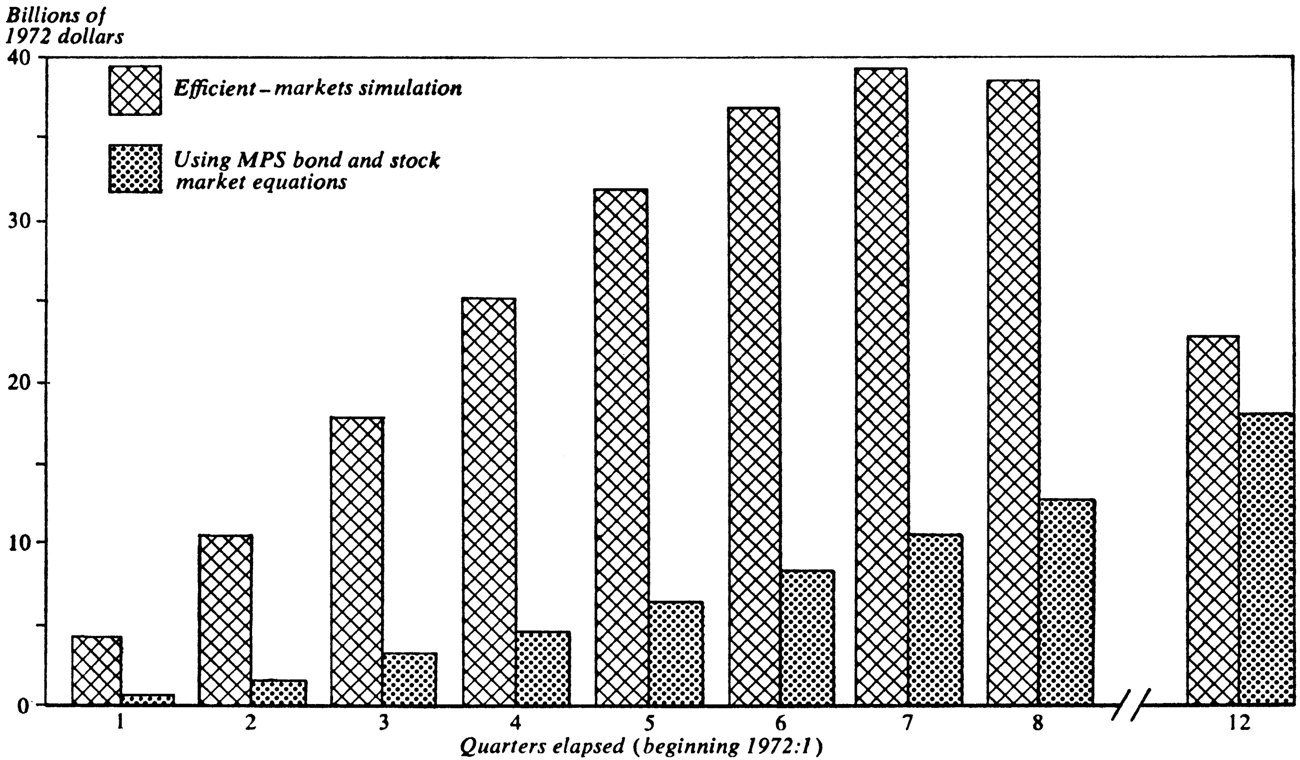
52. "MPS Quarterly Econometric Model" (MIT-Penn-SSRC, May 1977, preliminary).

Figure 3 illustrates the real GNP response to the bill rate decline for the MPS model (a) when bond and stock markets are characterized by the existing term-structure equations in the MPS model, which have long distributed lags, and (b) when bond and stock market equations are consistent with market efficiency and have no distributed lags. The (a) results are generated with straightforward simulations of the MPS model, while the (b) results of the efficient-markets model require the following procedure. According to the expectations hypothesis of the term structure, which is described in equation 3, the permanent decline in the bill rate of 50 basis points would, on average, immediately lead to a decline of 50 basis points in long-term rates. Thus in the (b) simulations the corporate bond rate is also exogenously set at 50 basis points below its historical path, and the equation for an efficient stock market, 36, is used to translate this change in the bond rate to a change in the value of common stocks.

When bond and stock market equations are consistent with market efficiency, care must be taken in interpreting the simulation results. Because the rest of the MPS model was estimated over periods in which the treasury bill rate did not change permanently (as is indicated by the rejection of the random walk characterization of the bill rate), the assumed policy is quite different from policy changes of the past. The rest of the MPS model may not, therefore, be invariant to this policy change, which casts doubt on these simulation results. In particular, in this case the equations generating inflation expectations in the MPS model would probably undergo parameter changes. Thus the purpose of these simulations is not to evaluate this particular monetary policy from a stabilization viewpoint. Such an effort would not only involve the above problems, but would also have to address the question of whether the Federal Reserve's policy announcement would be believed, especially considering the past correlation between actual policy and the Federal Reserve's pronouncements.

The simulation results shown in figure 3 indicate that the response of aggregate demand to this monetary policy is indeed much faster when financial market efficiency is imposed on the MPS model. In the efficient-markets simulation, within a year the GNP response is about two-thirds of the peak response (which occurs in the seventh quarter), and it is larger than the response at the end of three years; in contrast, for the MPS

Figure 3. Simulated Response of Real GNP over Twelve Quarters to a Permanent Decline of Fifty Basis Points in the Treasury Bill Rate, Efficient-Markets Formulation versus MPS Model Formulation for Bond and Stock Market Equations



Source: Simulations using MPS quarterly econometric model. In the efficient-markets formulation the decline in the bill rate, according to text equation 3, leads to an immediate equal decline in the corporate bond rate. The bond rate is thus set at 50 basis points below its historical path, and text equation 36 is used to translate this change in the bond rate into a change in the value of common stocks.

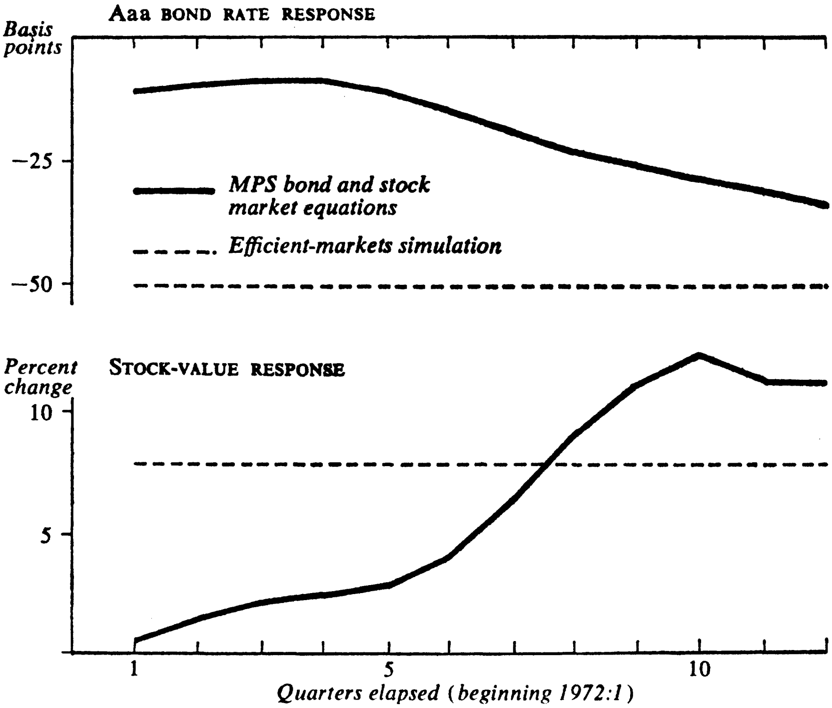
bond and stock market equations, by the end of the first year the GNP response is about one-quarter of the response reached after three years.

The results in figure 3 should be made more understandable by figure 4, which indicates how long-term bond rates and the value of stocks respond to the decline in the bill rate under the two regimes. In the efficient-markets simulation, there is an immediate and permanent decline of 50 basis points in the Aaa corporate bond rate and a 7.9 percent increase in the value of stocks. The MPS bond and stock market equations, on the other hand, lead after several quarters to a gradual decline of the Aaa rate, and the value of stocks also builds up slowly, in contrast to the immediate response implied by market efficiency.

These simulations do not imply that monetary policy will generally have a larger impact if market efficiency is imposed on the macro model. The magnitude of the effect is dependent on the nature of the policy action. It is easy to imagine policy changes that will lead to a smaller effect when market efficiency is imposed on the model. As a contrasting example, suppose that the Federal Reserve announces it will lower the bill rate by 50 basis points for one year only, and that this policy is both expected and carried out. If the discount bond has a ten-year maturity, market efficiency implies that this would lead to an immediate decline of only 5 basis points in the long-term rate. As can be seen from figure 4, this immediate decline in the long-term rate (as well as the subsequent decline) will be *smaller* than that implied by the MPS term-structure equations. Similarly, the GNP response is clearly smaller in this case when financial market efficiency is imposed on the MPS model. Nonetheless, as in the experiments just discussed, the speed of response to this policy will be *faster* when market efficiency is imposed on the bond and stock market sectors of the MPS model than when the MPS model is unmodified. The basic point conveyed by either example is that, from consideration of financial market efficiency alone, macro models should have very different dynamic characterizations than they do now.

There is another way of looking at why, when use is made of a macroeconometric model inconsistent with efficiency in the financial market, problems arise with a simulation experiment evaluating policy changes like those above. The policy changes under consideration impose a time-series process on the bill rate that is inconsistent with the historical time-series process. An unmodified macroeconometric model will produce misleading results because the resulting change in the time-series processes

Figure 4. Simulated Response of Aaa Corporate Bond Rate and Value of Stocks to a Permanent Decline of Fifty Basis Points in the Treasury Bill Rate, Efficient-Markets Formulation versus MPS Model Formulation for Bond and Stock Market Equations



Source: Same as figure 3.

of the model variables will cause the parameters of the model to shift. One method for preventing this difficulty is to conduct simulation experiments so that the time-series processes of the variables in the model do not change.[53]

The faster speed with which the economy responds to short-term rates in a macro model consistent with efficient-markets theory also has implications for crowding out effects of fiscal policy through the following mechanisms. Expansionary fiscal policy leads to higher short-term rates with unaccommodating monetary policy, usually through a money-demand relationship, and this then has a contractionary effect that slowly

53. Frederic S. Mishkin, "Simulation Methodology in Macroeconomics: An Innovation Technique," *Journal of Political Economy*, forthcoming.

over time counters some of the expansionary fiscal stimulus. For the reasons discussed above, it is not clear whether the contractionary effect from crowding out will be *greater* when financial market efficiency is imposed on the macro model. However, if such a model is consistent with efficiency in the financial market, it will display a much faster crowding out mechanism. Expansionary fiscal policy will immediately have an effect on long-term rates and stock prices in these markets, unlike its effect in current macroeconometric models. Ray Fair has also conducted simulation experiments that impose market efficiency on bond and stock markets. Although the macro model and technique he uses are quite different from that used here, he does conclude that the crowding out mechanism may be a far more important factor in fiscal policy effects than has previously been thought to be the case.[54]

Robert Lucas has warned that the behavioral relationships in macroeconometric models will not be invariant to changes in policy.[55] Expectations will change as policy changes and this will alter behavioral relationships. Efficient-markets theory states that term-structure relationships with long distributed lag effects from short-term rates to long-term security prices are not invariant, either to changes in policy or to changes in information relevant to market prices. Rather, new information is immediately incorporated into bond and stock prices, together with expectations of future events and policies.

Lucas' argument indicates that policy evaluation with econometric models, especially optimal control methods, will be deceptive. Efforts to apply discretionary policy are thus useless and may even be counterproductive. Efficient-markets theory indicates that Lucas' critique is quite valid for the use of monetary policy. Market efficiency insures that bond and stock prices respond only to surprises in short-term interest rates. Because expectations about short-term rates incorporate all information on monetary policy as well as expectations of future policy, to the extent that

54. Ray C. Fair, "An Analysis of a Macroeconometric Model with Rational Expectations in the Bond and Stock Markets," *American Economic Review*, forthcoming, uses an iterative method suggested by Poole, "Rational Expectations." The advantage of using a procedure such as that of Fair and Poole is that it can analyze a much wider range of policy changes than the approach used above. It has the disadvantage, however, that the results for bond and stock markets are completely dependent on the structure of the macro model used in the simulations, and this structure may vary with the policy change chosen.

55. Lucas, "Econometric Policy Evaluation."

monetary policy operates through long-term security markets, only unanticipated monetary policy will have additional effects on aggregate demand.

The problem that this creates for the policymaker can be seen more clearly using a hypothetical example. If the Federal Open Market Committee decides that the unemployment rate is too high and that monetary stimulation of the economy is needed, the money supply would be increased at what is considered to be a highly expansionary rate, say, 15 percent a year. If the securities market expected the Federal Reserve to react this way and expected 15 percent money growth, this information would have been anticipated and incorporated into security prices; there would be no further change in long-term rates or stock prices and no new expansionary effect on the economy. The expectation that this would be the Federal Reserve's policy would have already had its expansionary effect. In fact, if the market expected a more expansionary Federal Reserve policy, say, a 20 percent growth in money supply, the policy would now cause a decline in bond and stock prices, and this would tend to depress the economy. The effects of Federal Reserve policy thus depend on expectations in financial markets, and determining these expectations is not a simple task. Furthermore, efforts to assess market expectations would lead to additional alterations in these expectations, thus making it impossible for the Federal Reserve to solve this problem.

These conclusions do not depend on rational expectations pervading the economy. All that is required is that financial markets be efficient, which is certainly highly plausible. The proposition that only unanticipated monetary policy will have additional effects on aggregate demand does not have to depend on a model incorporating the natural rate hypothesis. The same result is obtained with efficient-markets theory together with a standard *IS-LM* analysis in which the interest rate relevant to the *IS* curve is a long-term rate.

Efficiency in the financial market does not imply that the form of the stabilization rule governing monetary policy is irrelevant to the performance of the economy. For example, if a policy rule existed which stated that the money supply would increase when unemployment rose, then even though the rule was known in advance, an unanticipated rise in unemployment would lead to an unexpected increase in the supply of money. Under certain assumptions, such as rigid or sticky prices, a rule that money growth increases with the unemployment rate might possibly result in smaller business cycle fluctuations.[56] Indeed, financial market efficiency could make monetary policy rules even more effective as a stabilization device. If a policy rule were known, an efficient market would not wait until the publication of the minutes of the Federal Open Market Committee to react to policy. Financial markets could respond in a stabilizing way to new information indicating the future course of monetary policy even before the actual policy was carried out. Thus financial market efficiency does not deny that the difficult task of designing appropriate monetary policy rules for stabilization purposes is still a relevant one for macroeconomists.[57]

Implications for Econometric Model Forecasting

Forecasting with current macroeconometric models requires predictions of monetary policy instruments, which are exogenous to the model. Depending on the model, these instruments, ranging from unborrowed reserves and the discount rate to short-term rates or the actual money supply, are plugged into a sometimes quite complicated financial sector to produce forecasts of interest rates and stock prices. It is costly to build an extensive financial sector and guess future Federal Reserve behavior, and forecasts from such a procedure may be inconsistent with market efficiency for bonds and stocks.

Efficient-markets theory provides an alternative procedure for forecasting long-term bond rates and stock prices. Current forecasting practice ignores some of the information inherent in today's bond and stock prices, and implicitly assumes that professional macroeconomists can

56. See Stanley Fischer, "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule," *Journal of Political Economy*, vol. 85 (February 1977), pp. 191–205; and Edmund S. Phelps and John B. Taylor, "Stabilizing Powers of Monetary Policy under Rational Expectations," *Journal of Political Economy*, vol. 85 (February 1977), pp. 163–90. Both these articles show that, even in models with rational expectations, the presence of long-term contracts allows monetary rules to have a stabilizing effect on the economy.

57. Efficient-markets theory, together with the traditional *IS-LM* analysis, does not imply that anticipated fiscal policy has no effect on the economy. It does imply, however, that what is important to changes in long-term security prices is unanticipated rather than anticipated fiscal policy. Under certain conditions, a fiscal policy rule is irrelevant to the economy, although these conditions have been shown to be quite restrictive by Shiller in "Rational Expectations and the Dynamic Structure of Macroeconomic Models."

forecast these prices better than Wall Street experts. Economists, with the exception of John Maynard Keynes (and even he had his ups and downs), have never had the reputation of being superior speculators in financial markets. What is suggested here is that macro forecasters let the market do the work for them and use the information in current market prices to generate forecasts. An outline of such a procedure is developed below. This procedure is simple and inexpensive to implement, and there is reason to believe that it will produce more accurate forecasts than current techniques.

The expectations hypothesis of the term structure provides equation 3, an approximation for an n-period discount bond:

$$RL_t^n = k + \left(\frac{1}{n}\right) E_t(r_t + r_{t+1} + \ldots + r_{t+n-1}), \tag{3}$$

where k = liquidity premium.

Advancing the time subscript by one and then first differencing yields

$$RL_{t+1}^n - RL_t^n = \left(\frac{1}{n}\right) [E_{t+1}(r_{t+1} + r_{t+2} + \ldots + r_{t+n})] - E_t(r_t + r_{t+1} + \ldots + r_{t+n-1}), \tag{37}$$

which can be rewritten as

$$RL_{t+1}^n - RL_t^n = \left(\frac{1}{n}\right) \eta_{t+1} + \left(\frac{1}{n}\right) [E_{t+1}r_{t+n} - r_t], \tag{38}$$

where

$$\eta_{t+1} = (r_{t+1} - E_t r_{t+1}) + (E_{t+1}r_{t+2} - E_t r_{t+2}) + \ldots + (E_{t+1}r_{t+n-1} - E_t r_{t+n-1}).$$

Through suitable algebraic manipulation it is easy to show that 38 is consistent with the efficient-markets model of 21. This result should come as no surprise because market efficiency must be consistent with the expectations hypothesis of the term structure as long as expectations are formed optimally.

Efficient-markets forecasts have the property that

$$E_t(E_{t+1}X_{t+i} - E_t X_{t+i}) = 0$$

for all i, implying that $E_t\eta_{t+1} = 0$.

Therefore,

$$(39)\qquad E_t RL^n_{t+1} = RL_t + \left(\frac{1}{n}\right)(E_t r_{t+n} - r_t).$$

For reasonably flat yield curves and large n, $(1/n)(E_t r_{t+n} - r_t)$ will be close to zero, which results in the approximation

$$(40)\qquad E_t RL^n_{t+1} \approx RL^n_t.$$

This approximation, although quite crude, has been used previously in the literature because it tells the simple story that the long-term bond rate approximately follows a random walk.[58] More accurate forecasts can be obtained by using other readily available market information to measure the second term on the right-hand side of 39. For example,

$$(41)\qquad E_t r_{t+n} = (n + 1)RL^{n+1}_t - nRL^n_t - k,$$

where

RL^{n+1}_t = yield to maturity of an $n + 1$ period discount bond at time t.

An improved forecast of RL^n_{t+1} is given by the following formula, which is derived by substituting 41 into 39.

$$(42)\qquad E_t RL^n_{t+1} = RL^n_t + \left[\frac{n+1}{n} RL^{n+1}_t - RL^n_t - \left(\frac{1}{n}\right)(r_t + k)\right].$$

Because long-term rates found in macro models come from coupon bonds with a fixed maturity, more complicated formulas than 42 would be needed for even more accurate forecasting. However, the analysis would proceed along lines similar to these.[59] Further refinements for forecasting

58. See, for example, Thomas Sargent, "A Classical Macroeconometric Model for the United States," *Journal of Political Economy*, vol. 84 (April 1976), pp. 207–37.

59. For example, the approximation for the consol rate due to Robert J. Shiller, "Rational Expectations and the Structure of Interest Rates" (Ph.D. dissertation, Massachusetts Institute of Technology, 1972), is

$$RL^c_t = (1 - \gamma)E_t(r_t + \gamma r_{t+1} + \gamma^2 r_{t+2} + \ldots),$$

where

γ = discount factor = $1/1 + r^*$,
r^* = a representative short-term rate.

This leads to the following equation for the efficient-markets forecast of the consol rate of the next period:

$$E_t RL^c_{t+1} = RL^c_t + \frac{1-\gamma}{\gamma}[RL^c_t - (r_t + k)].$$

could come from eliminating the assumption of a constant liquidity premium and deriving more accurate measures of how the liquidity premium moves over time.[60]

How accurate would an efficient-markets strategy like that above be in comparison to current forecasting techniques? Evidence on the performance of professional forecasters does not suggest that they can beat the market.

There is a large literature indicating that financial analysts do not do better than a buy-and-hold strategy in the stock market. Furthermore, empirical studies have compared forecasters' predictions of long-term rates with the most naive and crude approximation that an analyst recognizing market efficiency would use—equation 40, in which the long-term rate is predicted to be unchanged from today's rate. The conclusion of these studies is that the predictions of professional forecasters are no better than the no-change prediction implied by the naive efficient-markets strategy.[61] Forecasting long-term rates with more sophisticated efficient-markets strategies should therefore lead to more accurate forecasting. This type of forecasting procedure has the further advantage of avoiding the necessity for macroeconomists to assume responsibility for guessing future Federal Reserve actions or for building complicated financial sectors into econometric models. All this is bypassed, and the job of forecasting is made easier.[62]

60. See Eugene F. Fama, "Forward Rates as Predictors of Future Spot Rates," *Journal of Financial Economics*, vol. 3 (October 1976), pp. 361–77.

61. This conclusion is reached by Michael J. Prell, "How Well Do the Experts Forecast Interest Rates," Federal Reserve Bank of Kansas City, *Monthly Review* (September-October 1973), pp. 3–13, who uses data from various issues of *Goldsmith-Nagan Bond and Money Market Letter* (Washington, D.C.: Goldsmith-Nagan, Inc.), for the period covering September 1969 to December 1972. Donald R. Fraser, "On the Accuracy and Usefulness of Interest Rate Forecasts," *Business Economics*, vol. 12 (September 1977), pp. 38–44, also reaches the same conclusion for the 1974–76 period, using forecasts from the National Association of Business Economists and econometric forecasts made by Wharton Econometric Forecasting Associates and by Chase Econometrics, Incorporated.

62. Poole, "Rational Expectations," also suggests that forecasters should use information from futures markets, or implied forward rates in spot markets, to predict relevant macro variables such as treasury bill rates. Douglas W. Caves and Edgar L. Feige, "Efficient Markets, Stock Returns, the Money Supply and the Economy: Which Tail Wags the Dog?" (University of Wisconsin-Madison, n.d.), also argue for use of auction-market prices, in particular, bond and stock prices, to improve economic forecasting ability. Caves and Feige conduct tests on stock market returns that are consistent with the empirical results found here.

Concluding Remarks

This article shows that current procedures for evaluating policy and forecasting with macroeconometric models are inconsistent with market efficiency in bond and stock markets. If these procedures are consistent with market efficiency in financial markets, what does this mean for macro policymaking? On the one hand, information from efficient markets can be used with structural macroeconometric models both to improve the accuracy of macro forecasting and to make it both cheaper and easier. Furthermore, the economy should respond faster to monetary stimulus than most structural macroeconometric models indicate, thus decreasing the disagreements between the builders of structural models and reduced-form models. On the other hand, because expectations take on such an important role in financial markets, evaluation of the effects from a particular change in monetary policy becomes extremely difficult. Difficulties in policy evaluation make the use of discretionary monetary policy to fine-tune the economy precarious, indeed.

Where does this leave the professional monetary economist? Although there may be less effort needed to forecast the outcomes in financial markets, the estimated effect of the outcomes of these financial markets on the economy will be quite different, depending on macroeconomic theory. The MPS model, for example, shows a far different and stronger response of the economy to a change in long-term interest rates than do most other structural macroeconometric models. Thus the skills of macro forecasters in building models are still crucial to accurate forecasting. Although the goal of fine-tuning the economy through monetary policy should probably be abandoned as too difficult to attain, monetary policy rules must be designed that decrease unwanted fluctuations in the economy. The events that are most destabilizing to the economy must be identified, as well as the ways in which monetary policy rules can best correct for them. To do this a macro theory is needed to provide a better description of the real world, as well as a deeper understanding of the transmission mechanism of monetary policy. Incorporating efficient-markets theory into macroeconomics does not lessen the need for policy-oriented and basic research, but it does require some redirection of thinking.