NBER WORKING PAPER SERIES

MONETARY POLICY AND LONG-TERM INTEREST RATES: AN EFFICIENT MARKETS APPROACH

Frederic S. Mishkin

Working Paper No. 517

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

July 1980

I wish to thank the following individuals for their helpful comments: an anonymous referee, Andrew Abel, John Bilson, Eugene Fama, Clive Granger, David Galenson, Robert Lucas, Thomas Mayer, A. R. Nobay, Steven Sheffrin, Gary Skoog and the participants in the Money Workshop at the University of Chicago and in seminars given at the University of California, Davis and San Diego. Research support from the National Science Foundation is gratefully acknowledged. The research reported here is part of the NBER's research program in Economic Fluctuations. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #517
July, 1980

Monetary Policy and Long-Term Interest Rates: An Efficient Markets Approach

ABSTRACT

The impact of a money stock increase on nominal long-term interest rates has been a hotly debated issue in the monetary economics literature. The most commonly held view - also a feature of most structural macro models - has an increase in the money stock leading, at least in the short-run, to a decline in long interest rates. Monetarists dispute this view because they believe that it ignores the dynamic effects of a money stock increase.

This paper is an application of effecient markets theory to analyze empirically the relationship of money supply growth and long-term interest rates. This approach has the advantage over earlier research on this subject in that it imposes a theoretical structure on this relationship that allows easier interpretation of the empirical results as well as more powerful statistical tests. In the interest of ascertaining the robustness of the results, many different empirical tests are carried out in this paper, and they uniformly do not support the proposition that increases in the money supply are correlated with declines in long rates.

Frederic S. Mishkin
Department of Economics
University of Chicago
1126 East 59th Street
Chicago, Illinois 60637

(312) 753-4518

I. INTRODUCTION

The impact of a money stock increase on nominal, long interest rates is an important issue .[1] The most commonly held view -- also a feature of most structural macro models -- has an increase in the money stock leading, at least in the short and medium runs, to a decline in long interest rates. In these macro models, the long rate decline not only stimulates investment directly, but also has a further expansionary impact on investment and consumer expenditure through its effect on the valuation of capital.[2] This decline in long rates is thus a critical element in the transmission mechanism of monetary policy. In addition, the view that increases in the money stock lead to an immediate decline in long rates has important implications for how the Federal Reserve System should conduct monetary policy when a decline in interest rates is desired. Government officials often warn the Fed that it should not keep the rate of money growth too low because this will encourage an objectionable increase in interest rates.

Milton Friedman (1968, 1969) has criticized the view above on the grounds that it ignores the dynamic effects of a money stock increase. Friedman concedes that a so-called "liquidity effect" -- where an excess supply of money will create increased demand for securities, a rise in their price, and a resulting fall in interest rates -- does work in the direction of a decline in interest rates when the money stock is increased. However, two other effects can counter this liquidity effect. The money stock increase will, over time, have an expansionary effect on both real income and the price level. This "income and price level effect" will, through the usual arguments in the money demand function, then tend to reverse the decline in interest rates. More importantly for short-run effects on interest rates, increases in the money stock could also influence anticipations of inflation.[3]

interpretation of the empirical results is difficult because the theoretical framework behind these results is obscure. Also, the absence of structure when changes in interest rates are regressed on changes in the money stock leads to a large number of parameters being estimated, and this results in statistical tests with low power.

Efficient markets theory suggests an alternative approach for analyzing the relationship of money stock increases to long interest rate movements. This paper develops an efficient markets model of long interest rate determination, and then estimates this model using postwar quarterly data. This approach has the advantage that it imposes a theoretical structure on the problem that allows easier interpretation of the empirical results as well as more powerful statistical tests of the proposition that increases in the money stock are correlated with declines in long rates. In addition, a Keynesian, liquidity preference view of interest rate determination can be embedded in the efficient markets model and tested. Finally, as a side issue, quite attractive tests of bond market efficiency result from the approach used here.

The model of market equilibrium then implies:

(3) $E_m(\tilde{BRET}_t \mid \phi_{t-1}) = r_{t-1} + \delta$

where

r_{t-1} = the return on a one-period bond (which of course equals the expected one-period return) — this is just the short-term interest rate.

δ = the constant liquidity premium.

$E_m(\ldots \mid \phi_{t-1})$ = the expectation assessed by the market.

Market efficiency then implies that

$$E_m(\tilde{p}_{b,t} \mid \phi_{t-1}) = E(\tilde{p}_{b,t} \mid \phi_{t-1})$$

and hence

(4) $E(\tilde{BRET}_t \mid \phi_{t-1}) - E_m(\tilde{BRET}_t \mid \phi_{t-1}) = E(\tilde{BRET}_t - r_{t-1} - \delta \mid \phi_{t-1}) = 0$

Equation (4) above states that $\tilde{BRET}_t - r_{t-1}$ should be uncorrelated with any past available information or linear combinations of this information. An equivalent characterization of the efficient markets model which satisfies equation (4) is thus:[5]

(5) $\tilde{BRET}_t - r_{t-1} = \delta + (X_t - X_t^e)\,\beta + \varepsilon_t$

where an e superscript denotes expected values conditional on all past available information (i.e. an optimal forecast defined as $X_t^e = E(X_t \mid \phi_{t-1})$], and

X_t = a variable (or vector of variables) relevant to the pricing of long bonds

β = a coefficient (or vector of coefficients)

ε_t = serially uncorrelated error process (because $E(\varepsilon_t \mid \phi_{t-1}) = 0$).

correlation with changes in long rates (as might be expected from "Keynesian" macro-econometric models), this implies that the coefficient on unanticipated money growth should be significantly positive in equation(6): i.e., $\beta_m > 0$.[9]

An important caveat is in order. The efficient markets model does not guarantee that equation (5) is a reduced form where $X_t - X_t^e$ is exogenous so that the estimates of β are consistent.[10] It only implies that $BRET_t - r_{t-1}$ is correlated with only unanticipated movements in variables. Another way of stating this point is to acknowledge that the efficient markets model does not indicate whether a significant β coefficient implies causation from its unanticipated variable to bond prices and hence long interest rates. As far as market efficiency is concerned, causation could just as well run in the other direction, or it could be nonexistent as in the case where new information is simultaneously affecting both bond returns and the right-hand-side variable. Thus, we must be careful in interpreting empirical results on the β 's not to ascribe causation to the results without further identitying information.

The above caveat must be kept in mind especially when we analyze the estimated β_m coefficient. If the money supply process is seen as exogenous -- a view that has received some support in the literature,[11] the interpretation of the estimated β_m is straightforward. The finding of a significant positive β_m would then provide evidence supporting the "Keynesian" position that increased money growth will, at least in the short-run, lead to declines in long-term interest rates; and a failure to find this result would cast doubt on this view. However, if the money supply process is not exogenous, which is the position taken by many critics of monetarist analysis, then the estimated β_m coefficient may suffer from simultaneous equation bias and give a misleading impression as to the effect of an increase in the money supply on long-term interest rates. Because the analysis in this paper provides no information on the exogeneity of the money supply process, This equation is really an efficient markets analog to the typical money demand relationship found in the literature, as its similarity to equation (8) indicates. In addition, equation (9) captures elements of interest rate models of the Feldstein and Eckstein (1970) variety.[13]

The magnitude and sign of the β coefficients in equations (6) and (9) depend on the time-series processes of the money supply, real income and the price level, even when the sign and magnitude of these coefficients are assumed to reflect an underlying structural theory such as liquidity preference. If the time-series processes of real income and the price level are such that an unanticipated rise in these variables is not followed by a more than compensating decline in these variables, then a liquidity preference view implies that the coefficients of unanticipated income growth and inflation should be negative in equation (9): i.e., $\beta_y < 0, \beta_\pi < 0$. In this case, an unanticipated increase in income growth would have a negative impact on bond returns, because, cateris paribus, the rise in income would lead to higher interest rates, currently and in the future. The negative effect of an unanticipated increase in inflation on bond returns follows from the resulting reduction in real money balances which also leads to rising interest rates. The unanticipated inflation effect should be further strengthened if, as in the Cagan (1956) adaptive expectations model, expected inflation rises when actual inflation is above its expected value. In this case, an unanticipated rise in inflation promotes a rise in nominal interest rates either through a Fisherian (1930) relationship or because expected inflation is a separate argument in the money demand function as in Friedman (1956).

Note also that the more persistent is the time series process of inflation and income growth -- that is, the more an unanticipated increase in these variables leads to further increases, the more powerful are the unanticipated income and inflation effects on interest rates indicated by the theoretical structure discussed

III. EMPIRICAL RESULTS

THE DATA

The empirical results below use postwar quarterly data over the 1954-1976 sample period. The data sources and definitions of the variables used in these estimates are as follows:

$BRET_t$ = quarterly return from holding a long term government bond from the beginning to the end of the quarter.

$M1G_t$ = growth rate of M1 (quarterly rate) = the first differenced series of the log of the average level of M1 in the last month of the quarter.

$M2G_t$ = growth rate of M2 (quarterly rate) = the first differenced series of the log of the average level of M2 in the last month of the quarter.

IPG_t = growth rate of industrial production (quarterly rate) = the first differenced series of the log of Industrial Production in the last month of the quarter.

π_t = the CPI inflation rate (quarterly rate) - the first differenced series of the log of CPI in the last month of the quarter.

UN_t = unemployment rate in the last month of the quarter--in percent.

RTB_t = the 90 day treasury bill rate, the last trading day in the quarter--in fractions.

r_{t-1} = the beginning of quarter 90 day bill rate at a quarterly rate, equals $RTB_{t-1}/4$.

Unless otherwise noted, all these variables have been constructed from seasonally adjusted data except for the BRET and RTB variables. The bond return series was obtained from the Center for Research in Security Prices (CRSP) at the University of Chicago and is described in Fisher and Lorie (1977) and Mishkin (1978). The IPG, π, and UN variables were constructed from data in the Department Commerce's Business Statistics and Survey of Current Business. The M1 and M2 data were obtained from the Board of Governors of the Federal Reserve, Banking and Monetary Statistics and the Federal Reserve Bulletin, while the RTB data were supplied by the Board of Governors of the

γ_i = a vector of coefficients

and the subscript i refers to either MG, IPG, or π .

A critical issue in the research strategy used here is the methodology for choosing the specification of the time-series models of (10). It is difficult on theoretical grounds to exclude any particular piece of information available at time t-1 as a useful predictor of an $X_{i,t}$ variable. For example, economic theory cannot provide much guidance as to which variables to exclude in a money growth equation. Even though there is no strong theoretical reason for expecting a particular variable to enter the Z-vector, it might be useful predictor of money growth because the personalities involved in policy making could be such that they react to this variable for their own inscrutable reasons. Thus the theoretical model that a researcher uses to explain this money growth specification might be relatively unimportant in deciding on the validity of his particular specification versus another researcher's.

The discussion above suggests that an atheoretical statistical procedure might be superior to economic theory for deciding on the specification of the time-series models in (10). Furthermore, because theory is less of a useful guide in evaluating the time-series models needed here than is true in other empirical work, it is more important to check for the robustness of results by using several model specifications in estimating the efficient markets model. In keeping with this line of thinking, two procedures for specifying the time-series models of (10) are used in the text, with several additional specifications used in the results discussed in the Appendix.

The simplest equations which can be used to descibe money growth, industrial production growth and inflation are univariate time-series models of the auto-

TABLE 1

UNIVARIATE TIME-SERIES MODELS

Equation No.	1.1	1.2	1.3	1.4
	Dependent Variable			
Coefficient of	M1G	M2G	IPG	π
Constant term	.0038 (.0013)	.0049 (.0017)	.0093 (.0283)	.0012 (.0066)
M1G(-1)	.3777 (.1078)			
M1G(-2)	.2205 (.1152) F(4,87) = 9.11			
M1G(-3)	.0550 (.1151)			
M1G(-4)	-.0341 (.1076)			
M2G(-1)		.6598 (.1080)		
M2G(-2)		-.0542 (.1280) F(4,87) = 18.26		
M2G(-3)		.1736 (.1286)		
M2G(-4)		-.0758 (.1094)		
IPG(-1)			.4254 (.1003)	
IPG(-2)			-.2346 (.1091) F(4,87) = 5.95	
IPG(-3)			.1507 (.1091)	
IPG(-4)			-.2516 (.1003)	
$\pi(-1)$				.4008 (.1044)
$\pi(-2)$				.5520 (.1112) F(4,87) = 58.96
$\pi(-3)$				.1063 (.1119)
$\pi(-4)$				-.1837) (.1033)
R^2	.2952	.4563	.2148	.7305
Std. Error	.0062	.0066	.0237	.0039
Durbin-Watson	1.97	1.96	2.00	2.03

__Note:__ Asymptotic F-statistics test the joint null hypothesis that the coefficients in brackets are equal to zero. Asymptotic standard errors of coefficients are in parentheses.

TABLE 2

MULTIVARIATE TIME-SERIES MODELS

Equation No.	2.1		2.2		2.3		2.3	
	Dependent Variable							
Coefficient of	M1G		M2G		IPG		π	
Constant term	-.0004 (.0017)		.0026 (.0016)		-.0148 (.0125)		.0053 (.0019)	
M1G(-1)	.0906 (.1655)				.6904 (.3938)			
M1G(-2)	.5233 (.1680)	F(4,79) = 3.10			.6883 (.4089)	F(4,75) = 6.53		
M1G(-3)	-.2765 (.1785)				1.0207 (.4200)			
M1G(-4)	-.1757 (.1791)				.2745 (.4337)			
M2G(-1)	.3590 (.1618)		.5050 (.1119)					
M2G(-2)	-.3972 (.1754)	F(4,79) = 3.98	.0985 (.1266)	F(4,83) = 15.37				
M2G(-3)	.3510 (.1757)		.1517 (.1167)					
M2G(-4)	.1396 (.1645)		-.0806 (.1036)					
IPG(-1)					-.0947 (.1622)			
IPG(-2)					-.6171 (.1727)	F(4, 75) = 3.71		
IPG(-3)					-.0902 (.1709)			
IPG(-4)					-.2807 (.1224)			
π(-1)					-.5539 (.6501)		.2245 (.1079)	
π(-2)					-.5186 (.6229)	F(4,75) = 7.61	.5527 (.1053)	F(4, 83) = 79.32
π(-3)					-.8774 (.6533)		.2833 (.1090)	
π(-4)					-.7464 (.6533)		-.0636 (.1116)	
UN(-1)					-.0904 (.0096)		-.0036 (.0009)	
UN(-2)					-.0018 (.0120)	F(4,75) = 3.00	.0012 (.0016)	F(4,83) = 6.51
UN(-3)					.0173 (.0114)		.0018 (.0015)	
UN(-4)					-.0001 (.0091)		-.0004 (.0095)	
RTB(-1)	-.2647 (.1067)		-.4966 (.1000)					
RTB(-2)	.2086 (.1305)	F(4,79) = 2.85	.4853 (.1373)	F(4,83) = 9.19				
RTB(-3)	.1250 (.1396)		.0332 (.1472)					
RTB(-4)	-.0277 (.1121)		.0519 (.1132)					
R^2	.5427		.6232		.5159		.7949	
Std. Error	.0053		.0056		.0200		.0035	
Durbin-Watson	1.97		1.96		2.03		1.96	

Note: Asymptotic F-statistics test the joint null hypothesis that the coefficients in brackets are equal to zero in the regression model. Asymptotic standard errors of coefficients are in parantheses.

γ = m x k matrix of coefficients

U = n x k matrix of white noise error terms

The optimal linear forecast of X is then

$$X^e = Z\gamma \tag{13}$$

and substituting this into (8) we have:

$$BRET - r_1 = \delta + (X - Z\gamma)\beta + \varepsilon \tag{14}$$

The system in (12) and (14) can be stacked into one regression system with n(k+1) observations, and it can be estimated by non-linear least squares methods imposing the non-linear constraints that the γ in (12) and (14) are equal. In order to obtain more efficient parameter estimates as well as consistent test statistics, corrections must be made for heteroscedasticity both within and across equations in this system.[25]

This procedure is superior to the alternative two-step procedure.[26] More efficient parameter estimates of β and γ will result because both (12) and (14) make use of information from each other in the estimation process. In addition, it generates a very simple test of market efficiency which is similar to recent tests of "rationality" in the literature that proceed along the lines of Modigliani and Shiller (1973).[27] If the market is efficient, it should behave as if its linear forecasts using the information in Z are no different except by chance, from the optimal linear forecasts using Z. If this were not the case, then a linear combination of the variables in Z could have been used to improve the market forecasts. Thus a test for whether the γ in (12) and (14) are equal is analogous to the usual procedure for testing market efficiency where the one-period return on a security is correlated with past information or linear combinations of past information.[28] The test for market efficiency is then a simple

TABLE 3

NON-LINEAR ESTIMATES OF THE EFFICIENT MARKETS MODEL USING SEASONALLY ADJUSTED DATA

Model #	Coefficients of (M1G-M1G^e)	(M2G-M2G^e)	(IPG-IPG^e)	($\pi - \pi^e$)	Likelihood Ratio Test of Non-linear Constraints	p-value
			Panel A. Using Univariate Models in (12)			
3.1	.0482 (.5961)				$\chi^2(4) = 6.45$	.1680
3.2	.0501 (.5517)		-.4242** (.1260)	-1.8482* (.8028)	$\chi^2(12) = 14.0$	.3007
3.3		.9174 (.5459)			$\chi^2(4) = 3.20$	.5249
3.4		.7174 (.5063)	-.4077** (.1243)	-1.7691* (.7880)	$\chi^2(12) = 12.43$	.4118
			Panel B. Using Multivariate Models in (12)			
3.5	-.2621 (.7429)				$\chi^2(12) = 18.10$	.1127
3.6	.4108 (.7164)		-.5039** (.1568)	-1.7529 (.9552)	$\chi^2(24) = 33.81$	.0881
3.7		.9199 (.6738)			$\chi^2(8) = 10.67$	.2211
3.8		1.0950 (.6283)	-.4987** (.1492)	-1.8206 (.9353)	$\chi^2(24) = 32.60$	.1128

Note: * = significantly different from zero at the 5 percent level.

** = significantly different from zero at the 1 percent level.

Asymptotic standard errors of coefficients in parentheses.

not altered as a result of using multivariate versus univariate time-series models in estimation. Again neither of the unanticipated M1G coefficients are significantly different from zero at 5%, and they continue to be small, with the largest of the coefficients indicating that a one percent surprise increase in M1 leads to only a 4.1 basis point decline in the long bond rate. Furthermore, one of the unanticipated M1G coefficients is now negative.

How different are the results found here from those that might be inferred from "Keynesian", structural macro-econometric models? Using a simulation technique discussed in Mishkin (1979) we can examine the respones of a macro model to a one percent surprise increase in M1. Equation 1.1 was used to trace out the effect on M1 growth from a 1% innovation. The resulting M1 numbers were then used in a simulation experiment with the MPS (MIT-Penn-SSRC) Quarterly Econometric Model (1977) in order to derive the response of this model to the 1% M1 innovation occuring in the 1967-1 quarter. The MPS model indicates that this 1% M1 innovation would lead to an immediate decline of 18.1 basis points in the long rate. Not only is this long rate decline several times larger than the maximum 4.1 basis point decline implied by the empirical evidence in Table 3, but also it is significantly larger at the 5% level for three of the four estimates in Table 3 (and is almost significantly larger for the remaining estimate.) Clearly, the coefficients on unanticipated M1 growth are quite low relative to what might be expected from a structural macroeconometric model.

Although the coefficients on unanticipated M2 growth in Table 3 are more positive than the unanticipated M1G coefficients,[33] they also do not lend strong support to the view that unanticipated money growth should be negatively correlated with the change in long rates. They are not significantly different from zero at the 5% level (although in 3.3 the unanticipated M2G coefficient is significantly

TABLE 4

NON-LINEAR ESTIMATES OF THE EFFICIENT MARKETS MODEL USING SEASONALLY UNADJUSTED DATA

Model #	Coefficients of				Likelihood Ratio Test of Non-linear Constraints	p-value
	$(M1G-M1G^e)$	$(M2G-M2G^e)$	$(IPG-IPG^e)$	$(\pi - \pi^e)$		
	Panel A. Using Univariate Models in (12)					
4.1	-.7339* (.3631)				$\chi^2(4) = 5.08$	.2792
4.2	-.5879 (.3553)		-.2028* (.0857)	-2.5145** (.6912)	$\chi^2(12) = 20.83$	.0529
4.3		.0001 (.3610)			$\chi^2(4) = 3.27$	.5137
4.4		.1406 (.3330)	-.2420** (.0838)	-2.4438** (.7111)	$\chi^2(12) = 19.53$	.0765
	Panel B. Using Multivariate Models in (12)					
4.5	-1.2781** (.4504)				$\chi^2(12) = 12.10$	.4377
4.6	-.8078 (.4339)		-.4105** (.1371)	-2.4472** (.8089)	$\chi^2(24) = 28.48$	.2403
4.7		-.1404 (.4821)			$\chi^2(8) = 7.23$	.5120
4.8		.1534 (.4391)	-.4741** (.1396)	-2.6226** (.8237)	$\chi^2(24) = 27.11$	.2994

Note: * = significantly different from zero at the 5 percent level.

** = significantly different from zero at the 1 percent level.

Asymptotic standard errors of coefficients in parentheses.

IV
Concluding Remarks

A wide range of empirical tests exploring the relationship of money growth and long interest rates have been conducted in this paper and in the Appendix. A guiding principle in this research has been the use of many different empirical tests of the model in order to provide information on the robustness of the results. The pursuit of this goal has led to model estimation where there have been variations along the following dimensions: 1) the choice of the monetary aggregate, 2) the choice of the relevant variables to include in the X-vector, 3) the use of seasonally adjusted versus seasonally unadjusted data, 4) the specification of the time-series models used to describe expectations formation, 5) the sample period and, 6) the econometric estimation technique. Even though some of these model estimates should be more reliable than others for the reasons discussed earlier, the large number of estimates will provide information on the sensitivity and reliability of the results reported here.

The results uniformly support the following conclusion. There is little empirical support here for the view that increases in the money stock are negatively correlated with changes in long interest rates.[34] However there are two aspects of the research methodology used here which raise questions about the general validity of this conclusion.

As has been discussed in the text, the β coefficients in the efficient markets models are not invariant to changes in the time-series processes of the money growth, income growth and inflation variables. Thus, if the time-series processes of MG, IPG and π variables were different in other periods, the conclusions derived from the estimates in this paper only provide information on the relationship of money growth and long rates for the postwar sample period. However, realize that on the commonly held view that an increase in the money stock will lead, at least in the short-run, to a decline in long interest rates. Not only does this suggest that the Federal Reserve cannot lower long interest rates by increasing the rate of money growth, but it also requires some modification of the monetary transmission mechanism embodied in structural macro-econometric models. However, this criticism of these models in no way denies the possible, potent effects of money supply increases on aggregate demand.[35]

As was mentioned in Section II of the paper, if unanticipated money growth is not exogeneous, then the β_m coefficient estimates are inconsistent and can lead to misleading inference. Particularly disturbing in this regard is the case where the Federal Reserve smooths interest rates so that an unanticipated increase in long rates causes a Federal Reserve reaction of an increase in unanticipated money growth. The resulting negative correlation of ε_t and $MG_t - MG_t^e$ would then tend to bias the β_m coefficient downward. Thus, even though the estimated β_m is close to zero or even negative, it is possible that an exogenous unanticipated increase in money growth over a quarter engineered by the Fed does lead to a higher quarterly return on long bonds because of an increase in the bond price. Therefore, the view in structural macroeconometric models that an exogenous increase in money growth leads to a decline in long rates cannot be ruled out despite the empirical results of this paper.

Note however the nature of money growth endogeneity that is required for the above statement to be the case. If money growth is endogenous in the sense that the Federal Reserve modifies money growth within a quarter only in response to past public information available at the start of the quarter, this does not result in $MG_t - MG_t^e$ being correlated with ε_t. Hence the existence of Granger (1969) "causality" running from interest rates to money growth does not imply that the

APPENDIX

Estimates of the Efficient Markets Models Using the Two-Step Procedure

Table A-1 contains estimates of the efficient markets models using the two-step procedure and seasonally adjusted data over the 1954-76 period. The coefficient estimates using this procedure are not appreciably different from the Table 3 estimates generated by the non-linear procedure of the text. The unanticipated IPG and π coefficients in Table A-1 have the same sign, are of a similar magnitude and have similar t-statistics to those in Table 3. The coefficients of unanticipated money growth also do not differ substantially from those in the text. However, they are slightly more favorable to the view that increased money growth is associated with a short- run decline in long interest rates; they are somewhat larger than in Table 3 and in one case the unanticipated M2G coefficient is positive and significantly different from zero. Market efficiency tests of whether only unanticipated changes are related to bond returns using the Barro (1977) procedure also reveal no violations of market efficiency in the models of Table A-1. (However, the significance levels of these market efficiency tests are quite different from those in Table 3, as might be ex-expected from the discussion in the text.)

The two-step procedure has been used to gain further information on the robustness of this paper's empirical results. Also used in estimating the efficients markets models were residuals from eighth order autoregressive time-series models, as well as residuals from multivariate models which excluded the four lagged values of a variable only if it was not significant at the ten percent level (rather than the five percent level as in the text). The results were quite close to those in Table A-1 and there was no strong evidence supporting a negative relationship between money growth and changes in long rates.

Because the Federal Reserve seems to have paid more attention to monetary aggregates in the 1970's than it did previously, it is possible that the results reported here do not hold up if the 1970's are excluded from the sample period. The two-step procedure was thus also used to estimate the efficient markets models for the 1954-69 period. The unanticipated IPG and π coefficients continue to be negative although the significance levels of the t-statistics are not as high as in Table A-1. The unanticipated money growth coefficients are never significantly different from zero and are more often negative when this sample period is used. Similar conclusions about the relationship of money growth and long interest rates thus result from estimates using this shorter sample period.

cent paper, Shiller (1979) has found evidence which can be interpreted as implying that the liquidity premium is correlated with the spread between long rates and short rates. To test this proposition for the 1954-76 sample period, $BRET_t - r_{t-1}$ has been regressed on this spread, again using weighted least squares to correct for heteroscedasticity. The evidence supporting Shiller's proposition is even weaker in this sample period than was true in the regression results reported in Mishkin (1978): the coefficient on the spread variable was not significantly different from zero at even the ten percent significance level (t = 1.01).

[7]For example, using the model of market equilibrium described in the text, over the 1954-76 period the variation in $E_m(\tilde{BRET}_t | \phi_{t-1})$ is less than two percent of the variation in the actual return stemming from other sources.

[8]A more precise wording of this point would state that, in the case discussed here, tests of hypotheses concerning the equilibrium return would have very low statistical power. This is essentially the same point made by Nelson and Schwert (1977) in their comment on Fama (1975). Note also that more discriminating tests provide evidence that liquidity premiums are not constant over time. See for example, Fama (1976b).

[9]A similar caveat applies to the empirical work of Barro (1977).

[10]This issue of the consistency of the β estimates is discussed more formally in Abel and Mishkin(1979).

[11]Sims (1972) contains a discussion of the differing views in the literature on the exogeneity of the money supply process and finds evidence which he interprets as supporting the view that causality runs from money growth to income rather than the other way around. As Jacobs, Leamer and Ward's (1979) and Zellner's (1979) criticisms of these causality tests indicate, however, these tests do not resolve the issue of the exogeneity of the money supply process.

[12]See Goldfeld (1973) and Laidler (1977).

[13]Note that if inflation was added as an argument in the money demand model of equation (7), we would still arrive at an efficient markets equation like (9).

[14]See Working (1960) for example.

[15]Note that because lagged dependent variables appear in the time-series models of Tables 1 and 2, all the test statistics are only valid asymptotically. The asymptotic F-statistics for the Chow tests of the equations in Table 1 are as follows: for 1.1, F(5,82) = 3.50; for 1.2, F(5,82) = 2.49; for 1.3, F(5,82) = 2.81; and for 1.4, F (5,82) = 1.59. The critical F (5,82) at the five percent level is 2.33.

[24]The technique used here is quite similar in concept to that proposed by Sargent (1979), although it is somewhat easier to execute and notationally is simpler. The empirical results found here are indeed consistent with Sargent's results.

[25]The following iterative procedure was used to correct for heteroscedasticity in these estimates. In the first stage estimation of the non-linear system, if Goldfeld-Quandt tests indicated that heteroscedasticity existed within an equation, the variables in this equation were weighted using a time trend procedure outlined by Glesjer (1969). (The IPG equation did have a somewhat unusual pattern of residuals which could not be corrected for heteroscedasticity with a single time trend. Here two separate time trend regressions were used for the 1954-76 period in order to calculate the weighting factors.) Furthermore, the variables in each equation of the system were appropriately weighted so that each equation individually had the same sum of squared residuals. After the first stage estimation, the sum of squared residuals for the two halves of each of the k+1 equations were calculated and were then used to weight the variables in each equation so that the sum of squared residuals were the same in all cases. Then the non-linear system was estimated all over again. This resulted in a similar sum of squared residuals in all equations of the (12) and (14) system so that no further iterations were performed. Some experimentation did indicate that no appreciable differences in the results occured if some modification of this iterative procedure was used which left the sum of squared residuals reasonably equal for all the equations.

[26]See Abel and Mishkin (1979) for a more detailed discussion of the econometric issues in using the joint non-linear procedure.

[27]See Pesando (1975), Sargent (1976), Carlson (1977), Mullineaux (1978) and Friedman (1978).

[28]For examples, see Fama (1970), Mishkin (1978) and Rozeff (1974).

[29]Abel and Mishkin (1979) show that this likelihood ratio test is asymptotically equivalent to the usual procedure for testing market efficiency if the k time-series models include the same set of variables in the Z-vector.

[30]See Goldfeld and Quandt (1972).

[31]For example, see the survey in Fama (1970), and see Mishkin (1978) for more recent tests of bond market efficiency using the same bond returns data used in this paper.

REFERENCES

Abel, A. and Mishkin, F. S., 1979, On the Econometric Testing of Rationality and Market Efficiency, Report 7933, Center for Mathematical Studies in Business and Economics, University of Chicago, (August).

Barro, R. J., 1977, Unanticipated Money Growth and Unemployment in the United States, American Economic Review 67, 101-115.

__________, 1978, Unanticipated Money, Output, and the Price Level in the United States, Journal of Political Economy 86, 549-580.

Brainard, W. C. and Cooper, R. N., 1976, Empirical Monetary, Macroeconomics: What Have We Learned in the Last 25 years:, American Economic Review 65, 167-175.

Cagan, P., 1956, The Monetary Dynamics of Hyperinflation, in: Milton Friedman, ed., Studies in the Quantity Theory of Money (University of Chicago Press)

__________, 1972, The Channels of Monetary Effects on Interest Rates (National Bureau of Economic Research)

Carlson, J. A., 1977, A Study of Price Forecasts, Annals of Economic and Social Measurement 6, 27-56.

Chow, G. C., 1960, Tests of Equality Between Sets of Coefficients in Two Linear Regressions, Econometrica 28, 591-605.

Durbin, J., 1970, Testing for Serial Correlation in Least Squares Regression When Some of the Regressions are Lagged Dependent Variables, Econometrica 38, 410-421.

Fair, R., 1978, The Senstivity of Fiscal-Policy Effects to Assumptions about the Behavior of the Federal Reserve, Econometrica 46

Fama, E. F., 1970, Efficient Capital Markets: A Review of Theory and Empirical Work, Journal of Finance 25, 383-417.

_____, 1975, Short-Term Interest Rates as Predictors on Inflation, American Economic Review 65, 269-282.

______, 1976, Foundations of Finance (Basic Books)(a)

______, 1976, Forward Rates as Predictors of Future Spot Rates, Journal of Financial Economics 3, 361-377. (b)

REFERENCES (Con'd)

Goldfeld, S. M. and Quandt, R. E., 1972, Non-Linear Methods in Econometrics (North-Holland)

Granger, C. W. J., 1969, Investigating Causal Relations by Econometric Models and Cross-Spectral Methods, Econometrica 37, 424-438.

Jacobs, R. L., Leaner, E. E., and Ward, M. P., 1979, Difficulties in Testing for Causation, Economic Inquiry 17, 401-413.

Laidler, D., 1977, The Demand for Money: Theories and Evidence (Dun-Donnelly) 119-152.

Mishkin, F. S., 1978:3, Efficient-Markets Theory: Implications for Monetary Policy, Brookings Paper on Economic Activity, 707-752.

_______, 1979, Simulation Methodology in Macroeconomics: An Innovation Technique, Journal of Political Economy 87, 816-836.

MIT-Penn-SSRC, 1977, Quarterly Econometric Model (unpublished)

Modigliani, F., 1974, The Channels of Monetary Policy in the FMP Econometric Model of the U.S. in: G. Renton, ed., Modelling the Economy (Heineman Educational Books)

Modigliani, F. and Shiller, R. J., 1973, Inflation, Rational Expectations, and the Term Structure of Interest Rates, Economica 40, 12-43.

Mullineaux, O. J., 1978, On Testing for Rationality: Another Look at the Livingston Price Expectations Data, Journal of Political Economy 86, 329-336.

Muth, J. F., 1961, Rational Expectations and the Theory of Price Movements, Econometrica 29, 315-335.

Nelson, C. R. and Schwert, G. W., 1977, Short-Term Interest Rates as Predictors of Inflation: On Testing the Hypothesis that the Real Rate is Constant, American Economic Review 67, 478-486.

SOME RECENT NBER WORKING PAPERS

Number	Author	Title	Date
465	Mervyn A. King	How Effective Have Fiscal Policies Been in Changing the Distribution of Income and Wealth	4/80
466	Anne O. Krueger	Trade Policy as an Input to Development	4/80
467	Don Fullerton	On the Possibility on an Inverse Relationship Between Tax Rates and Government Revenues	4/80
468	Mervyn A. King	An Index of Inequality: With Applications to Horizontal Equity and Social Mobility	4/80
469	William H. Branson	Trends in U.S. International Trade and Investment Since World War II	4/80
470	Edward J. Kane	Accelerating Inflation and the Distribution of Household Savings Incentives	4/80
471	Burton G. Malkiel and John G. Cragg	Expectations and the Valuation of Shares	4/80
472	Rudiger Dornbusch	Monetary Stabilization, Intervention and Real Appreciation	4/80
473	Rudiger Dornbusch	Exchange Rate Rules and Macroeconomic Stability	4/80
474	John F. O. Bilson	The 'Speculative Efficiency' Hypothesis	4/80
475	Anne O. Krueger	Interactions Between Inflation and Trade-Regime Objectives in Stabilization Programs	5/80
476	Jacob A. Frenkel and Michael L. Mussa	Efficiency of Foreign Exchange Markets and Measures of Turbulence	5/80
477	Martin Feldstein	Social Security Benefits and the Accumulation of Preretirement Wealth	5/80
478	Alan L. Gustman and Thomas L. Steinmeier	Labor Markets and Evaluation of Vocational Training Programs in the Public High Schools - Toward a Framework for Analysis	5/80

Number	Author	Title	Date
495	Alan J. Auerbach and Harvey S. Rosen	Will the Real Excess Burden Please Stand Up? (Or, Seven Measures in Search of a Concept)	6/80
496	Jerry Green	Taxation and the Ex-Dividend Day Behavior of Common Stock Prices	7/80
497	Daniel Feenberg and Harvey S. Rosen	Alternative Tax Treatment of the Family: Simulation Methodology and Results	7/80
498	John Boschen and Herschel Grossman	Monetary Information and Macroeconomic Fluctuations	7/80
499	Joseph E. Stiglitz	On the Almost Neutrality of Inflation: Notes on Taxation and the Welfare Costs of Inflation	7/80
500	Robert Philip Flood and Nancy Peregrim Marion	The Transmission of Disturbances under Alternative Exchange-Rate Regimes with Optimal Indexing	7/80
501	Louka Katseli-Papaefstratiou and Nancy Peregrim Marion	Adjustment to Variations in Imported Input Prices: The Role of Economics Structure	7/80
502	Ben S. Bernanke	Irreversibility, Uncertainty, and Cyclical Investment	7/80
503	Dennis W. Carlton	Modeling Price Rigidity or Predicting the Quality of the Good that Clears the Market	7/80
504	Charles E. McLure, Jr.	Taxes, Saving, and Welfare: Theory and Evidence	7/80
505	Robert E. Hall and Frederic S. Mishkin	The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households	7/80
506	Frederic S. Mishkin	Does Anticipated Monetary Policy Matter? An Econometric Investigation	7/80
507	Frederic S. Mishkin	Are Market Forecasts Rational?	7/80
508	Martin Feldstein and James Poterba	State and Local Taxes and the Rate of Return on Non-Financial Corporate Capital	7/80