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Determinants of interest rate expectations

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DETERMINANTS OF INTEREST RATE EXPECTATIONS

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I. INTRODUCTION

In reviewing the literature dealing with alternative explanations of the term structure of interest rates, the ultimate purpose of this 30-year debate is not always clear. The exchange often resembles an argument over whose theory is the "best" with little emphasis on why it really matters.[1]

Consideration of the role of interest rates in economic analysis elicits two critical questions. First, do the levels of interest rates exert an important influence on the level of economic activity; and second, what determines the levels of interest rates as well as the relationships among them? The term structure literature directs itself to the second question. Two reasons may be cited for trying to explain the relationships among interest rates on debt instruments of differing maturities. One is to provide the best possible explanation of the term structure simply for the sake of providing an explanation. The other is to attempt to determine what factors, if any, affecting the term structure are under the control of the Federal Reserve System or the Treasury. In other words, can monetary policy and/or debt management[2] influence the term structure of interest rates? The second purpose is often treated as an afterthought.

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[1]This criticism should not be viewed as applying only to the term structure literature.

[2]We define debt management as any activity undertaken by the Treasury or the Federal Reserve which affects the maturity composition of the public debt.

The present study seeks to make the determination of the impact of policy on the term structure its central goal. We proceed from the basic premises that investors behave so as to maximize their returns and that their behavior is guided by what they expect interest rates to be in the future. It is, therefore, this profit-maximizing behavior based on expectations which determines the term structure of interest rates. The critical task, then, is to explain why expectations are what they are, with particular emphasis on the influence of monetary policy and debt management. The expectational horizon adopted for most of the investigation is one year, though some information is also provided for horizons of six months and two years.

The study is presented in the following fashion. Chapter II provides a brief discussion of alternate theories of the term structure together with the results of some empirical investigations. Chapter III is directed to a summarization of two recent studies dealing with the determination of expectations. Chapter IV presents our theoretical and analytical framework together with our empirical results. The final chapter is devoted, as is customary, to summary and conclusions.

II. THE EXPECTATIONS HYPOTHESIS: A THEORY OF THE TERM STRUCTURE OF INTEREST RATES

While there is considerable disagreement over the relative significance of expectations in determining the term structure of interest rates, it is virtually impossible to find an explanation of the term structure that does not make reference to the role of expectations.[1] Since the major purpose of this study is to explain why expectations are what they are, it is desirable that we first demonstrate that knowing what factors affect expectations is important to interest rate policy. For this reason we shall present the pure expectations hypothesis of the term structure of interest rates. We shall also look briefly at some modifications and justifications of this hypothesis.

The purpose of undertaking this examination of past work in the area of the term structure is not to provide an exhaustive review of the literature. It is merely to establish that there is ample theoretical and empirical support for considering expectations, an important determinant of the term structure.

The pure expectations hypothesis, usually associated with the name of Friedrick Lutz,[2] involves four basic assumptions,[3] two which are behavioral and two which are institutional.

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[1]Even John M. Culbertson, perhaps the most ardent critic of expectational explanations of the term structure, has noted that expectations regarding the immediate future clearly affected the timing of rate adjustments (8, p. 131).

[2]Much of this chapter draws on the work of Malkiel (33).

[3]Lutz should not be viewed as the creator of this theory, since, as Malkiel argues (33, p. 17), elements of the theory may be found as far back as the works of J. B. Say. It was Lutz's (28) 1940 articulation of the theory which established the association with his name. Luckett (27) makes a similar observation.

Behavioral Assumptions

1. All investors perceive, with perfect certainty, a consistent set of expectations regarding short-term interest rates far into the future.

2. All investors conduct their activities in the market solely to maximize profit.

Institutional Assumptions

3. Securities are identical in every respect except term to maturity and are riskless with respect to principal and interest.

4. The cost to the investor of shifting from one maturity to another is zero, thus insuring unrestricted arbitrage.

The critical implication of these assumptions is that all investors will seek to equalize holding-period yields[4] on different maturities of debt. The desire to equalize holding-period yield implies that, in the market, the rate of return on long-term securities will be equal to the geometric mean of future expected short-term rates. Before formalizing the theory algebraically, a numerical example using simple interest should serve to clarify this relationship and thus the theory in general.

Suppose an investor wishes to maximize his return on funds available for a period of 2 years. He is faced with two alternatives. He may purchase a two-year security or he may purchase two successive one-

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[4]Holding-period yield refers to the coupon rate plus or minus any rate of capital appreciation or depreciation caused by a change in the price of the security during the period the security is held. Equality of holding-period yield implies that arbitrage will guarantee an identical return regardless of the maturity of the security held.

year securities.[5] If the current or spot-rate of return on a one-year security is 3% and the investor expects the rate of return on a similar security one year hence to be 5%, then to be consistent with the theory the spot-rate on a two-year security must be approximately 4%. If this is the case then the investor should be indifferent between the two alternatives.

Let us now suppose that the rate on the two-year security is not equal to 4%. This will provide us with an example of how the market adjusts to equate holding-period yields. If the yield on the two-year security is above 4% this investor, as well as other investors with a two-year investment horizon, will prefer the two-year security to two successive one-year securities. This activity will increase the demand and thus the price of the two-year security, at the same time decreasing the demand and price of one-year securities. Since security prices and yields move in opposite directions,[6] the yield on two-year securities will fall while the yield on one-year securities will rise. The process continues until holding-period yields are equated.

The equality of yields just described may be expressed in general as:

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[5]There is, of course, a third alternative. Our investor might purchase a security maturing beyond the two-year horizon and sell it at the end of two years. In this case the theory suggests that the market would equate the return on this security for the period with the returns from the two other options. The equilibrating process is essentially the same as that described between the returns for the other options.

[6]For a proof of this relationship see Malkiel (33, p. 54).

$$(2.1) \qquad \bar{P}(1 + {}_tR_n)^n = \bar{P}(1 + {}_tR_1)(1 + {}_{t+1}r^e_{1_t})(1 + {}_{t+2}r^e_{1_t})\ldots(1 + {}_{t+n-1}r^e_{1_t})$$

where the capital R's represent spot-rates and the small r^e's represent expected rates. The prescript indicates the time at which the rate is to apply. The first subscript designates the number of periods to maturity for that security. The second subscript appearing on expected rates indicates the time when the expectation is formed. Hence, ${}_{t+4}r^e_{1_t}$ designates the expectation at time t of the yield which will exist for a one-period security in period t+4. $\bar{P}$ represents the size of the investment.[7]

Dividing Equation 2.1 by $\bar{P}$ and taking the n^{th} root of both sides we have

$$(2.2) \qquad (1 + {}_tR_n) = \left[(1 + {}_tR_1)(1 + {}_{t+1}r^e_{1_t})(1 + {}_{t+2}r^e_{1_t})\ldots(1 + {}_{t+n-1}r^e_{1_t})\right]^{\frac{1}{n}}$$

or, that one plus the n year spot-rate is equal to the geometric mean of one plus each of the expected one-period rates.[8]

An additional implication of the Expectation Hypothesis is that the current term structure forecasts a set of forward rates. These implicit rates derive from the relation:

$$(2.3) \qquad (1 + {}_{t+n-1}r_{1_t}) = \frac{(1 + {}_tR_n)^n}{(1 + {}_tR_{n-1})^{n-1}} \qquad \text{or}$$

---

[7]This notation will be used throughout this study.

[8]Note that ${}_tR_1 \equiv {}_tr^e_{1_t}$. Also Equations 2.1 and 2.2 implicitly assume that all coupon payments are made at maturity. This is equivalent to assuming all coupon payments made during the life of the security can be reinvested at R_n. For an interesting criticism of this simplifying assumption, see A. Buse (5).

(2.4) $$_{t+n-1}r_{1_t} = \frac{(1 + {}_tR_n)^n}{(1 + {}_tR_{n-1})^{n-1}} - 1$$ where

$_{t+n-1}r_{1_t}$ is the forward rate on a one-period security which will apply at time t+n-1.

While this statement is essentially a mathematical tautology, the expections hypothesis gives it economic meaning by asserting that the forward rates implicit in the term structure are unbiased estimates of future expected rates (33, p. 22). In other words:

(2.5) $$_{t+n-1}r_{1_t} = {}_{t+n-1}r^e_{1_t} \quad .$$

The Hicksian variation of the expectation hypothesis takes issue with this last assertion (19, pp. 144-47). Hicks argues that forward rates are upward-biased estimates of expected rates; biased upward by a liquidity premium. The rationale for the existence of the liquidity premium derives from abandoning the assumption of perfect certainty and introducing the assumption that investors are risk avertors. Within an atmosphere of uncertainty about the level of future rates, Hicks asserts that any person entering into a long-term contract is placing himself in a risky position (19, p. 146). There are, however, certain borrowers with long-range capital needs who prefer long-term securities to insure the acquisition of this capital. In order to encourage lenders and speculators to enter into long contracts, borrowers must pay a risk or liquidity premium. The result of this premium is to biase forward rates upward so that they exceed expected rates. Algebraically $r = r^e + P$ where r is the forward rate, r^e is the expected rate and P is the liquidity premium. Thus, long rates "normally" lie above short rates, producing an upward-sloping yield curve.[9] A downward-sloping yield curve would result only when short rates are expected to fall. The pure expectations hypothesis does not suggest any "normal" shape for the yield curve.

Before turning to a review of empirical tests of expectations hypotheses, we shall look at one additional major theoretical contribution; the work of Burton Malkiel (31, 32, 33). Malkiel's contribution differs from the Hicks-Lutz theory in two important respects. First, investor behavior is assumed to be guided by expectations regarding security prices rather than rates; and second, these expectations are formed about all securities one period into the future rather than about one period securities for an infinite time horizon (33, p. 50).[10] The critical similarity between the two approaches is

[9]The yield curve is constructed by plotting spot-rates against the range of terms to maturity.

[10]The essentials of Malkiel's theory (33, pp. 50-81) may be presented by drawing on three theorems dealing with the mathematics of security price movements and the assumption that investors envision interest rates moving within some "normal range" historically established. The three theorems stated here without proof are:

1. Security prices move inversely to security yields.
2. For a given change in yield, changes in security prices are greater the longer the term to maturity of the security.
3. The percentage changes in security prices increase at a decreasing rate as term to maturity increases.

We shall describe here how Makiel is able to explain an upward-sloping yield curve. We begin by supposing that the yield curve is constrained to a horizontal position below the middle of the "normal range" of rates. If the market is then freed, investors will feel that they have more to fear than hope in terms of security price fluctuations during the next period. (Remember, we are assuming a one-period horizon.) Within the "normal range," interest rates can rise more than they can fall; thus, by theorem 1, prices can fall more than they can rise. Further, by theorem 2, the price of long-term securities can fall more than the price of short-term (footnote continued on next page)

the assumption that the market equalizes holding-period yield over the investors' horizon. Indeed, Luckett has shown that this assumption is sufficient to demonstrate the two theories are mathematically equivalent, though they derive from very different behavioral assumptions (25, p. 323). Malkiel's theory, then, implies that the current term structure forecasts all rates which will apply one period hence. An algebraic expression for this implicit set of rates is

$$(2.6) \qquad {}_{t+1}r_{n_t} = \left[\frac{(1 + {}_tR_{n+1})^{n+1}}{(1 + {}_tR_1)} \right]^{\frac{1}{n}} - 1 \, .$$

(footnote continued from previous page) securities. Thus, in an attempt to minimize capital loss, investors will move out of longs and into shorts. This action will push down the price of longs and raise their yield while having the opposite effect on the price and yield of shorts. Hence, we have an upward-sloping yield curve. Theorem 3 guarantees that the yield curve tends to flatten out as term to maturity increases. This corresponds to empirical observation. Note that the yield curve obtains, without any explicit assumptions, about investors' expectations. The only expectation they held was that interest rates would continue to fluctuate within their normal range. They sought to equalize, over a short period, the expected value of potential price fluctuations for securities of different terms to maturity. Consequently, investors in effect estimated the expected value of the price of each security at the end of the horizon period (33, p. 74). A downward-sloping curve results when we begin our argument with rates near the upper end of the "normal range." The argument is completely analogous to the one just presented. In such a circumstance, potential fluctuation gives the investor more to hope than to fear. If no fluctuation is expected over the next period, a horizontal yield curve obtains.

Introducing expectations proper in terms of the relative probabilities that rates will rise or fall may effect the relative steepness of the yield curve, but will not alter the overall direction of the slope. The theory will readily accommodate additional assumptions regarding such things as tax and call features (33, p. 72). It is also adaptable to the Hicksian liquidity premium concept, a factor which will prove very useful in the empirical work of this study.

The Hedging Hypothesis

In order to fully appreciate much of the empirical work dealing with the term structure, it is necessary to note an alternative to the expectations hypothesis. John Culbertson's (8) institutional or hedging hypothesis argues that the market is segmented; that there are distinct groups of borrowers and lenders in each end of the markets; and that short-term and long-term securities are not perfect substitutes. Since investors do not, therefore, move freely from one end of the market to the other, the major determinant of the term structure is not expectations but rather the relative supply of securities in each end of the market. The predominant objective of most recent empirical work has been to support or discredit one of these theories.

Because it is unlikely that either theory contains the entire explanation of the term structure, it is critical to understand the policy implications of each. Clearly, the institutional hypothesis implies that Federal Reserve open-market operations and Treasury debt management exert significant influence on the term structure. On the other hand, the pure expectations hypothesis suggests that if expectations are perfectly inelastic with respect to economic policy, the only possible channel through which policy might effect the term structure is through the one-period interest rate, R_1. Each empirical test of the determinants of the term structure then, at least implicitly, is a test of whether economic policy can alter the term structure significantly.

Empirical Evidence

We now turn to a brief discussion of these empirical tests. We shall confine ourselves to the presentation of conclusions, with minimal reference to analytical technique. Two qualifications should be noted at the outset. First, one can never prove an hypothesis statistically. He can only lend support to it by failing to reject it. Second, one cannot test "the" expectations hypothesis directly. He can only test his or someone else's formulation of the hypothesis (2, p. 62).

Early formulations of the expectations hypothesis argued that if the theory were valid, the forward rate implied by the term structure, *ex ante*, ought to forecast future spot-rates accurately, *ex post*. Culbertson (8) and Hickman (18) find this not to be the case and thus reject the hypothesis. Walker (53) and Macaulay (30), on the other hand, find what they consider to be adequate evidence of accurate forecasting; hence, they do not reject the hypothesis (22, pp. 7-10). Meiselman, however, correctly observes that the expectations hypothesis does not require that expectations be realized, only that anticipations determine the current rate structure (34, p. 12).

Recognizing the validity of Meiselman's point, Kessel (22) and Wendel (55) argue that though forecasts may not be accurate, the expected value of forecasting errors over time ought to be zero. Their findings, however, contradict this hypothesis. The work of both men reveal a positive mean forecasting error. This positive residual they conclude is evidence of a liquidity premium, thus supporting the Hicksian version of the expectations hypothesis.

The error-learning model of David Meiselman (34) has been hailed by many as the strongest operational support for the expectations hypothesis. Because this model has generated an impressive volume of literature, we shall look at it in some detail. Meiselman's contribution does not concern the level of rates, but rather is concerned with changes in rates (34, p. 18). Specifically, the model seeks to show how expectations are revised given additional information; that information being the error made in forecasting the current one-period rate. Establishing this relationship provides an operational tie between unanticipated changes, the spot-rate and changes in expectations (34, pp. 30-31).

The regression model which Meiselman fits with Durand's (11, 12, 13) data is:

$$(2.7) \qquad {}_{t+n}r_{1_t} - {}_{t+n}r_{1_{t-1}} = a + b\,(R_{1_t} - {}_{t}r_{1_{t-1}}) \,,$$

where the dependent variable is the revision in expectations and the independent variable is the forecasting error. The results of testing the model for values of n ranging from 1 to 8 may be summarized as follows:[11]

1. The correlation coefficients are relatively large, ranging from 0.95 for n = 1 to 0.59 for n = 8.

2. The estimates of the b coefficients are positive and significantly different than zero. They decline from 0.70 for n = 1 to 0.21 for n = 8. This decline in the size of the coefficients suggests that recent errors in forecasting exert a lessening impact as the horizon of the forecast increases.

[11]For a detailed presentation of the results, see Meiselman (34, pp. 21-30).

3. None of the estimates of the constant term, a, are significantly different from zero. Meiselman has observed that this result casts doubt on the existence of any liquidity premium. Both Kessel (22) and Wood (56) have demonstrated that this observation is not valid.[12]

The comments, criticisms and commendations dealing with Meiselman's work have been numerous and diverse. Grant (17), for example, fits Meiselman's model to British data, deriving his yield curves by interpolation rather than free-hand as Durand has done. Grant's results duplicate Meiselman's except that Grant's correlation coefficients are much smaller. Fisher (14) using the same British data as Grant but constructing his yield curves with a multiple regression technique, duplicates Meiselman's results in terms of the forecasting error coefficients and the correlation coefficients, but finds negative intercepts significantly different from zero.

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[12] If we alter Meiselman's model to include the Hicksian specification of forward rates, (i.e., that forward rates equal expected rates plus a liquidity premium) we have:

$$({}_{t+n}r^{e}_{1_t} + {}_{t+n}P_{1_t}) - ({}_{t+n}r^{e}_{1_{t-1}} + {}_{t+n}P_{1_{t-1}}) = a + b\left[R_{1_t} - ({}_{t}r^{e}_{1_{t-1}} + {}_{t}P_{1_{t-1}})\right]$$

where the P's represent the liquidity premiums contained in the forward rates. Suppose now that no error is made in forecasting so that $R_{1_t} = {}_{t}r^{e}_{1_{t-1}}$. This implies that there will be no revision of expectations; hence, ${}_{t-n}r^{e}_{1_t} = {}_{t+n}r^{e}_{1_{t-1}}$.

Therefore, $a = {}_{t+n}P_{1_t} - {}_{t+n}P_{1_{t-1}} + b\,{}_{t}P_{1_{t-1}}$. Clearly, a = 0 is a necessary condition to conclude that all liquidity premiums are zero, but it is certainly not a sufficient condition.

Bierwag and Grove (2) develop an adaptive error-learning model which allows for non-uniform expectations. They fit this model with Durand's data (11, 12, 13) as well as Grant's data. The correlation coefficients for the Durand data indicate an excellent fit but are rather disappointing for the Grant data. The authors thus conclude that the formulation of expectations in the United States and Britain differ.[13]

Both James Van Horne (51) and Neil Wallace (54), in fitting an error-learning model to Treasury data taken from smooth free-hand yield curves, generally duplicate Meiselman's results. However, they find a positive, significant intercept which implies the existence of a liquidity premium. Wallace argues that if such a premium exists in order to induce investors into one end of the market or the other, then the explanatory values of the model should be improved by adding some measure of the supply of debt of differing maturity. The result of adding such variables was disappointing.

In evaluating Meiselman-type models, one should keep in mind two important criticisms. First, Luckett has shown that Meiselman's model cannot distinguish between the Lutz expectations hypothesis with its infinite horizon and the Malkiel theory which is based on a one-period horizon (25). A further and far-more devasting criticism comes from Buse (4, 6, 7) who argues that smooth yield curves are sufficient to give Meiselman-type results. Further, these results may merely reflect the empirical fact that short and long rates move together, with shorts more variable. This empirical fact, however, is not inconsistent with the expectations hypothesis.

[13]Buse (6) argues that this is not the case, but that the diverse results obtain from the fact that Grant's data do not provide smooth yield curves.

Several additional studies using differing analytical techniques and data reach conclusions which lend support to an expectational explanation of the term structure. John Wood, in an unpublished paper,[14] concludes that the relationship among interest rates was better explained by expectations than by security supplies (33, p. 229). Similarly, Jacob B. Michaelson concludes "expectations about future short-term rates exert an important influence on the term structures" (35, p. 463).

In 1967, Kane and Malkiel (21) conducted a survey of investors. The results of this survey provide important support for Malkiel's expectations hypothesis. The evidence indicates that investors are willing to make short-term forecasts about long-term rates. While expectations do not appear to be uniform, they do effect the appraisal of the market. There is also evidence of the existence of liquidity premium as well as some security supply effects. Three studies which concentrate particularly on supply effects are the works of Scott (42), Okun (38) and de Leeuw (10). Scott, using the average maturity of marketable government debt as an independent variable, finds that indices of liquidity contribute significantly to explaining the variation between short and long rates. Okun and de Leeuw on the other hand, basing their explanations of rate differentials on the proportion of public debt in particular maturity classes, find very weak supply effects.

The conclusions of Wood (56) are particularly relevant for our study. He concludes that expectations are elastic and that the yield curve can be affected if expectations respond to changes in the current

[14] Wood, John. An econometric model of the term structure of interest rates. Unpublished paper presented to the Econometric Society. 1962. Cited in Malkiel (33, p. 229).

rate. Since we are concerned with the determinants of expectations and their implications for economic policy, it is critical that expectations are not completely inelastic.

The recent work of Modigliani and Sutch (36, 37) and Taylor (45) shed additional light on the responsiveness of expectations to economic phenomenon, particularly past spot-rates. Modigliani and Sutch, in testing their preferred habitat model,[15] define and measure the expected change in the long rate as a 16-quarter distributed lag of short rates. Expectations, however, never appear explicitly as a dependent variable in their model. Taylor, fitting a similar model to the pegging period[16] during and following World War II, achieves a fit comparable to that of Modigliani and Sutch,[17] though his lag structure

[15] The preferred habitat theory is essentially a hybrid, drawing on both the expectations theory and Culbertson's hedging hypothesis. The three distinguishing assumptions from which the theory derives are (a) future rates are uncertain, (b) borrowers and lenders have a distinct preference regarding the maturities they issue or hold (they have a preferred habitat) and (c) these transactors are risk-averse and are generally unwilling to accept the uncertainty of cost or income associated with moving to a non-preferred habitat unless some inducement (e.g., a liquidity premium) exists to compensate them for accepting the risk (36, p. 569). The model also allows for the existence of speculators. Thus, in such a world as the model describes the differential between short and long rates is determined by both expectations and the relative supply of securities of different maturities. It is this hypothesis which Modigliani and Sutch test.

[16] From March 1942 to March 1951, the Federal Reserve Open-Market Committee agreed to buy any and all government securities at par, thus effectively placing a ceiling on interest rates.

[17] Both studies exhibit correlation coefficients in a range from 0.88 to 0.95.

is considerably different. Both studies find that the expectational model accounts for most of the variation in the term structure with little fluctuation remaining to be explained by security supplies. Taylor, however, finds evidence which indicates that supply effects may be found in the lag structure, thus implying that changes in the supply of debt may affect the term structure through expectations (45, p. 166).

> "The implication of recent empirical finding, although far from being one-sided, have shifted opinion --- toward either the pure expectations theory or this theory modified to include the existence of liquidity premium on long-term debt." (44, p. 15).

In summarizing the current state of knowledge regarding the term structure, Telser clearly indicates the direction which further study must take.

> "The most challenging task for future research on the term structure of rates is the extension of the expectations model so as to incorporate the effects of other variables that might affect expectations in addition to the forecast error. In concrete terms, one ought to explain more of the changes in forward roles." (46, p. 560).

We seek to provide this explanation.

III. ENDOGENOUS EXPECTATIONS

We turn now to an examination of an empirical investigation which has specifically attempted to explain expectations. Luckett (24), in a study which is a forerunner to the present investigation, tests the Keynesian hypothesis of the existence of some "normal" rate of interest, at the same time explaining changes in expectations on the basis of monetary policy; namely, free reserves. Since this study relates directly to our current research, we shall look at it in some detail.

Luckett's model is based on the theoretical work of Burton Malkiel (31) in that the expectations which are explained are for all rates one year into the future.[1] The basic model derives from the postulate that expectations about next year's rates are a linear function of spot-rates. That is,

(3.1) $\quad {}_{t+1}r^{e}_{n_t} = a + b\,{}_{t}R_{n}$ where a and b are constants. $a > 0$ and $0 < b < 1$ if investors indeed expect rates to return to some norm.

In order to obtain data to test the model, it was assumed that expectations are approximated by the forward rate implied by the term structure, ala Malkiel.[2] To avoid consideration of any constant liquidity premium the dependent variable used in the final model was the expected change in the yield on an n period security over the one-year horizon defined as:

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[1]This is as opposed to Meiselman's error-learning model which deals with the expectation of short rates up to eight years into the future.

[2]That is, $${}_{t+1}r^{e}_{n_t} = {}_{t+1}r_{n_t} = \left[\frac{(1 + {}_{t}R_{n+1})^{n+1}}{(1 + {}_{t}R_{n})^{n}}\right]^{\frac{1}{n}} - 1 .$$

(3.2) $E(\Delta r_n) = {}_{t+1}r^e_{n_t} - {}_tR_n = {}_{t+1}r_{n_t} - {}_tR_n$.

To avoid having ${}_tR_n$ on both sides of the equation, it was assumed that the spot-rate was a function of monetary policy. The level of free reserves was used as a measure of that policy. Expressed linearly:

(3.3) $R_n = c + d\,F$

where F is the level of free reserves and c and d are constants. It was assumed that $c > o$ and $d < 0$.

Combining the three equations above, we have:

(3.4) $E(\Delta r_n) = \alpha + \beta\,F$

where $\alpha = (a + bc - d)$ and $\beta = (b - 1)d$.[3]

A time trend was also added to allow for possible changes in the "normal" rate or in the relationship between spot-rates or in the relationship between spot-rates and free reserves. The final model which was tested was

(3.5) $E(\Delta r_n) = \alpha + \beta\,F + \gamma\,T$

where T is the trend and γ is a constant. The model was fitted with monthly yield data obtained from Kessel (22) for the periods January, 1954 through November, 1962 for n = 1 - 5 and September, 1957 through November, 1962 for n = 1 - 9. The results appear in Table 3.1.

Three important conclusions may be drawn from these results. First, all the β coefficients are positive and significantly different from zero; thus supporting the Keynesian hypothesis. Second, the correlation coefficients are relatively high, considering that the dependent variable is in the nature of a first difference. And finally, the size of the

[3] If the Keynesian hypothesis is valid, it was hypothesized that $\beta > 0$.

Table 3.1. Effect of free reserves on expected change in interest rates[a]

n	Constant	Coefficient of[b] F	T	R^2
		Panel A: 1/'54 through 11/'62		
1	.511	.00039	-.001	.42
	(14.0)	(8.7)	(1.7)	
2	.317	.00041	-.0006	.65
	(13.3)	(14.0)	(1.5)	
3	.238	.00037	-.0007	.75
	(14.2)	(17.9)	(2.6)	
4	.199	.00033	-.0008	.80
	(14.8)	(20.1)	(3.9)	
5	.176	.00030	-.001	.81
	(15.3)	(21.0)	(5.3)	
		Panel B: 9/'57 through 11/'62		
1	.566	.00041	-.0035	.32
	(10.4)	(5.2)	(2.1)	
2	.371	.00048	-.0030	.65
	(11.6)	(10.3)	(3.0)	
3	.249	.00041	-.0020	.77
	(12.0)	(13.7)	(3.1)	
4	.180	.00037	-.0015	.81
	(10.9)	(15.3)	(2.9)	
5	.151	.00032	-.0016	.82
	(10.9)	(16.0)	(3.7)	
6	.129	.00029	-.0015	.82
	(10.3)	(15.9)	(3.9)	
7	.116	.00026	-.0015	.84
	(10.9)	(17.2)	(4.6)	
8	.110	.00024	-.0017	.84
	(11.7)	(17.6)	(5.8)	
9	.112	.00023	-.0020	.74
	(9.3)	(13.1)	(5.5)	

[a]Source: Luckett (24, p. 188).

[b]The dependent variable is expressed as a percent, free reserves in millions of dollars. The figures in parentheses are the "t" statistic.

R^2's is directly related to the maturity of the security. This tends to suggest some undefined independent variables.[4] Is, for example, the assumption regarding constant liquidity premiums valid? This is one of the questions we seek to answer.

We should also note a study by Helmut Wendel (55) which is similar in some respects. Like Luckett, he attempts to explain expectations and also to test the Keynesian normality hypothesis. The dependent variable which he uses is merely a more complicated transformation of the variable used by Luckett. The independent variable used to test the normality hypothesis is the percentage deviation of the current spot-rate from a distributed lag of past rates. His work lends support to this hypothesis, as does Luckett's. In addition, Wendel adds several measures of economic activity to his model in an attempt to better explain expectations. However, even with these added variables, the Durbin-Watson statistic remains too low to place much confidence in their significance.

The primary goal of Wendel's study is not to arrive at policy implications. Indeed, the only policy variable he includes in his model is treated in an appendix and with little success. His major purpose is to explain the formation of expectations in order "to evaluate whether expectations formulated in such a manner would explain changes in yield

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[4]We suspected that had a Durbin-Watson statistic been computed for this model, it would have been quite low, implying incomplete specification of the model. Fitting this model to Morgan Guaranty Trust Company data, we obtained results strikingly similar to Luckett's; however, we found the Durbin-Watson statistic to be in the range 0.58 to 0.87 confirming our suspicions.

spreads" (55, p. i). Within this context his study does lend further support to the expectations hypothesis. His work has also provided some suggestions which are further pursued in our study. In particular we are interested in determining the significance of the impact on expectations of a lagged index of industrial production, a variable used by Wendel, relative to the impact of policy variables.

IV. DETERMINANTS OF EXPECTATIONS

In this chapter we shall present the findings of this study regarding determinants of interest rate expectations with particular emphasis on the impact of economic policy variables. The chapter is divided into three sections. In the first section we describe the variables and data used in developing and testing our model. In the second section we present the technique and results of testing the model within the context of a one-year horizon. The final section is devoted to testing the same model using a six-month and a two-year horizon to ascertain whether the impact of policy on expectations is markedly different for different investment horizons. Unless directly applicable to the current discussion of the final model, the presentation of alternative tests and analytical techniques is deferred to the appendix.

Variables and Data

Since we are concerned with explaining why expectations are what they are, we have selected as the dependent variable the level of expected interest rates. As a measure of these expected rates, we have used the forward rates implied by the current term structure.[1] In particular, we have chosen the forward rates implied by Malkiel's formulation since we are concerned with expectations about rates on all maturities one period in the future.[2] Our dependent variable is conse-

[1]This is, of course, consistent with both the expectational theories of Lutz (28) and Malkiel (31).

[2]The length of this period is of course arbitrary. We will examine horizons of six months and two years in the final section of this chapter.

quently derived from the algebraic statement presented in chapter II and repeated here:

$$(4.1)\qquad {}_{t+i}r_{n_t} = \left[\frac{(1 + {}_tR_{n+i})^{n+i}}{(1 + {}_tR_i)}\right]^{\frac{1}{n}} - 1 .^{3}$$

Data for the above computations were generously made available by Edward C. Fecht of Morgan Guaranty Trust Company. The yields used were on marketable government securities for the period January, 1954 to January, 1968.[4]

While the pure expectations hypothesis implies forward rates are unbiased estimates of expected rates; i.e., $r_n = r_n^e$, we have noted in chapter II the possibility of the existence of a liquidity premium P_n such that $r_n = r_n^e + P_n$. In the two previously-mentioned studies of expectational determinants, it was assumed that any liquidity premiums

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[3]In this expression we have replaced the "1" used in chapter II to designate a one-period horizon with "i" to emphasize the fact that the horizon may vary in length. For example, with a one-year horizon $i = 1$, but for a six-month horizon $i = \frac{1}{2}$.

[4]Each month the Morgan Guaranty staff compute a set of monthly averages of daily rates on securities of differing maturities. These averages are plotted on a graph where yield is measured on the vertical axis and term to maturity on the horizontal axis. Through this series of points, a smooth free-hand yield curve is drawn. It is from this yield curve that the rates used in this study were taken. The construction of such a yield curve is necessary since the expectations hypothesis requires knowledge of adjacent yields while in reality issues of every maturity do not exist. While it may be argued that this is a questionable means of obtaining data, there are two redeeming features of the method. First, the same person constructed the curves throughout the period; and second, a different person took the yields used from the curves.

which might exist were constant over time.[5] Our model provides a test for the existence of such a liquidity premium without making this assumption.

The first independent variable we define is thus a measure of the liquidity of a security where liquidity is defined as "the ability to realize value in an accepted means of exchange" (52, p. 527).[6] The principal determinants of the liquidity of a security are the fluctuation in its price and the length of time required to convert it to money. Since we are here concerned with government securities which are traded in a highly-organized market, the time factor is relatively unimportant. We thus adopt a measure of liquidity developed by Van Horne and Bowers (52) which is based on the fluctuation in security price. "The liquidity of a Treasury security can be thought to represent the lower confidence limit with respect to the dispersion of market price around the mean price" (52, p. 528). Since security

[5]Luckett (24) incorporated this assumption into his model by using the quasi-first difference as a dependent variable. Wendel (55) following Kessel's (22) reasoning that the mean forecasting error ought to be zero over time, argues that the average forward rate should correctly forecast the change in the spot rate. This implies that at the point in time when a forecast is formulated, that forecast should equal the existing spot rate plus the correctly-received change in spot rates plus any forecast error. If, over time, the mean forecast rate exceeds the mean spot rate plus the mean change in spot rates, then this excess represents a constant liquidity premium. Wendel finds this to be the case and thus estimates that liquidity premium which he proceeds to subtract from r_n to obtain r_n^e (55, p. 22).

[6]See also Keynes (23), Tobin (47), Luckett (26) and Pierce (39).

price data are not as readily available as are rate data, the Van Horne-Bowers liquidity measure draws on the inverse relationship between rates and prices. The measure is essentially the present value of the stream of returns from a security discounted by the rate of return adjusted for fluctuation. Specifically, the liquidity measure for an n period security is defined as:

$$(4.2) \qquad L_n = \sum_{t=1}^{n} \frac{\bar{R}_n \cdot 100}{(1 + \bar{R}_n + 3\sigma_{R_n})^t} + \frac{100}{(1 + R_n + 3\sigma_{R_n})^n}$$

where $\bar{R}_n$ is the mean yield over the past 12 months and σ_{R_n} is the standard deviation about this mean. Thus, the greater the fluctuation in rate, the smaller the liquidity measure L_n and hence, the less liquid the security. If there exists a liquidity premium in forward rates we would expect the coefficient of L_n to be negative. In other words, an inverse relationship between forward rates and the liquidity of a security is consistent with the hypothesis that forward rates contain a liquidity premium which is inversely related to the liquidity of that security.

Having made allowance for the possibility of a liquidity element in forward rates, we turn now to a presentation of those independent variables used to explain the expectational element of forward rates. As noted by Wendel (55), there are two broad classes of factors which we might suppose influence expectations; those variables which measure the level of economic activity and those variables which represent economic policy. We do not, however, agree with Wendel's assertion that because these two classes of variables are correlated, "It is immaterial in this context whether one views the short-term rate as being determined predominantly by monetary policy, so that only policy has to be predicted, or whether one regards the vigor of domestic economic activity as the direct independent variable" (55, p. 19). Even though a model containing both types of variables is sure to contain multicollinearity, as long as the correlation between the variables is less than perfect and as long as one has reason to think that each variable makes a distinct contribution to expectations in its own right, it is both important and justifiable to consider their effects within the same model.

The variables which we have chosen to represent economic activity and economic policy are: Q, the first difference of a distributed lag index of industrial production; DR, the discount rate; $R_{n_{t-1/12}}$, last month's spot rate on an n period security;[7] $\dot{M}$, the time rate of change of the M_2 money stock;[8] and D_j, the level of marketable debt outside the Federal Reserve in the j^{th} debt class.[9] It is clear some of these variables are correlated and this fact should be kept in mind in evaluating our results.

The data for Q, the lagged index of industrial production, were obtained from the U. S. Department of Commerce publications (48, 49, 50) and represent the total index for all production, including utilities.

[7]t-1/12 refers to last month and is consistent with t-1 which has been used to designate a point in time one year earlier.

[8]The M_2 money stock is defined as currency in circulation plus demand deposits plus time deposits.

[9]These variables were selected because of their significance and because of the consistency of their performance in several different models.

The lag covers the past six months. The lag structure used, beginning with the most recent month, was 0.300, 0.225, 0.175, 0.125, 0.100 and 0.075.[10]

Values for $\dot{M}$ were also obtained from U. S. Department of Commerce data (48, 49, 50), while the discount rate data were obtained from the Federal Reserve Bulletin (3). Data for $R_{n_{t-1/12}}$ was, of course, taken from the Morgan Guaranty yields.

Information regarding the maturity composition and ownership of the public debt was generously made available by Stephen Taylor of the Flow of Funds Section of the Federal Reserve System. By using the level of debt in a particular maturity class outside the Federal Reserve, we have a measure of any activity which influences the maturity composition of the debt. The activities of both the Federal Reserve and the Treasury are reflected in this variable. The Flow of Funds Section has divided the debt into four maturity classes--short, intermediate-short, intermediate-long and long. It was this maturity breakdown that was used in this study. The short class includes debt maturing within one year. The intermediate-short class contains securities of two- to four-year maturity. Debt maturing in six to eight years is classified as intermediate-long. Securities maturing beyond twelve years are considered long term. In order to facilitate smooth transition between classes as debt matures, the Federal Reserve has developed a weighting scheme to

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[10] Wendel used a similar variable in his final model as sole measure of economic activity and policy. His lag structure, covering the past five months, was 1.000, 0.500, 0.250, 0.125 and 0.063 which place a much heavier weight on the recent past than our structure.

allocate issues of securities whose maturity places them between the classes we have described. This scheme places a fraction of such issues in each of the adjacent classes. As the maturing process moves an issue closer to a particular class the larger the fraction of the issue allocated to that class. Our analysis deals with expected rates one period hence for securities maturing in from one to nine and in nineteen years. This gives us at least one maturity corresponding to each debt class, thus enabling us to test the effect of debt supply on expectations. Clearly the one- and nineteen-year maturities correspond to the short- and long-debt classes, respectively. Similarly, it is logical to suppose that the supply of intermediate long debt would effect expectations regarding six to nine-year maturities, while expectations about two- to four-year maturities would be most influenced by intermediate-short debt. Only the five-year security fails to correspond, a priori, to a particular debt class. In preliminary analysis, the forward rate for a five-year maturity was regressed on the two intermediate classes separately. Comparing the two regressions revealed that the coefficient corresponding to the intermediate-short class was over twice as large as the intermediate-long coefficient.[11] It was thus concluded that if any significant debt supply effects were to be found on expectations about five-year maturities, they would come from changes in the intermediate-short class.

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[11]The R^2's and Durbin-Watson statistics were too low to make any tests of significance meaningful, but this does not invalidate coefficient comparison.

The Model

Using the variables we have just defined, the model with which we propose to explain expectations may be written as follows:

(4.3) $$r_n = a + b\,L_n + c\,Q + d\,DR + c\,R_{n_{t-1/12}} + f\,\dot{M} + g\,D_j \text{ where}$$

a, b, c, d, e, f and g are constants, n = 1, 2, ..., 9, 19 and j represents the short (S), intermediate short (IS), intermediate long (IL) and long (L) debt classes.

The usual method for testing the above model would be to fit ten separate equations, one for each maturity with which we are concerned. This procedure, however, assumes these equations are independent, which they clearly are not. It further assumes that there is something to be gained from viewing the impact of the independent variables on each maturity expectation separately. Thus, for example, while it seems reasonable to suppose that the impact of a change in the discount rate might have a significantly-different impact on expectations about short-term rates than on expectations about long-term rates, it is not clear that there is any information to be gained from comparing this impact on immediately-adjacent expectations.

In an attempt to provide statistically-more efficient[12] coefficient estimates with stronger and more useful economic meaning, we have chosen to fit a single equation using Generalized Least Squares. We hasten to add that withour single equation we have allowed for differing effects on particular blocks of expecations by using a dummy variable type technique. For example, we are able to compare the impact of the discount

[12] An efficient estimator is defined as having minimum variance in large samples (1, p. 94-95).

rate on expectations about short rates (i.e., 1-5 year maturities) with the impact on expectations about long rates (i.e., 6-9 and 19-year maturities) and statistically test the significance of the difference. In order to clarify further we set forth the entire model in matrix notation. We will then explain the technique used to segment the independent variables in order to achieve this comparison of effects on the dependent variable.

Let r_n^*, L_n^*, Q^*, DR^*, R_n^*, $\dot{M}^*$ and D_j^* represent k x 1 vectors where k denotes the number of sample observations.[13] The final model may thus be written:

[13]Note we have dropped the t-1/12 subscript from R_n to simplify notation.

(4.4)

$$
\begin{bmatrix} r_1^* \\ r_2^* \\ r_3^* \\ r_4^* \\ r_5^* \\ r_6^* \\ r_7^* \\ r_8^* \\ r_9^* \\ r_{19}^* \end{bmatrix}
=
\begin{bmatrix}
I & 0 & L_1 & 0 & 0 & Q^* & 0 & DR^* & 0 & R_1^* & 0_1 & \dot{M}^* & 0 & D_S & 0 & 0 & 0 \\
0 & I & 0 & L_2 & 0 & Q^* & 0 & DR^* & 0 & R_2^* & 0 & 0 & \dot{M}^* & 0 & D_{IS} & 0 & 0 \\
0 & I & 0 & L_3 & 0 & Q^* & 0 & DR^* & 0 & R_3^* & 0 & 0 & \dot{M}^* & 0 & D_{IS} & 0 & 0 \\
0 & I & 0 & L_4 & 0 & Q^* & 0 & DR^* & 0 & R_4^* & 0 & 0 & \dot{M}^* & 0 & D_{IS} & 0 & 0 \\
0 & I & 0 & L_5 & 0 & Q^* & 0 & DR^* & 0 & R_5^* & 0 & 0 & \dot{M}^* & 0 & D_{IS} & 0 & 0 \\
0 & I & 0 & L_6 & 0 & 0 & Q^* & 0 & DR^* & 0 & R_6^* & 0 & \dot{M}^* & 0 & 0 & D_{IL} & 0 \\
0 & I & 0 & L_7 & 0 & 0 & Q^* & 0 & DR^* & 0 & R_7^* & 0 & \dot{M}^* & 0 & 0 & D_{IL} & 0 \\
0 & I & 0 & L_8 & 0 & 0 & Q^* & 0 & DR^* & 0 & R_8^* & 0 & \dot{M}^* & 0 & 0 & D_{IL} & 0 \\
0 & I & 0 & L_9 & 0 & 0 & Q^* & 0 & DR^* & 0 & R_9^* & 0 & \dot{M}^* & 0 & 0 & D_{IL} & 0 \\
0 & I & 0 & 0 & L_{19} & 0 & Q^* & 0 & DR^* & 0 & R_{19}^* & 0 & \dot{M}^* & 0 & 0 & 0 & D_L
\end{bmatrix}
\begin{bmatrix} a_1 \\ a_{2-19} \\ b_1 \\ b_{2-9} \\ b_{19} \\ c_{1-5} \\ c_{6-19} \\ d_{1-5} \\ d_{6-19} \\ e_{1-5} \\ e_{6-19} \\ f_1 \\ f_{2-19} \\ g_S \\ g_{IS} \\ g_{IL} \\ g_L \end{bmatrix}
$$

where I and 0 designate k x 1 vectors of 1's and 0's, respectively. Note that the subscripts on the coefficients correspond to the maturities to which the effect applies. For example, a_{2-19} refers to the intercept corresponding to expectations about maturities from 2-9 and 19 years.

The form of this model was determined in the following manner. We first fit the model as ten separate equations. We then plotted the estimated coefficients together with their standard deviations for each of the six independent variables and the intercept. Where the coefficients were not markedly different and there was substantial overlap of their standard deviations, we concluded it was not reasonable to expect significantly different effects from these variables on these different maturities. Hence, we lumped sample values together to provide a single estimated coefficient for the block of maturities.

Fitting this single equation model using Generalized Least Squares for the period January, 1954 to December, 1968, assuming a one-year horizon, we obtain:[14]

(4.5)

$$r_n = \underset{(3.95)}{0.141X_1} + \underset{(4.17)}{0.170(10^{-1})X_{2-19}} - \underset{(3.72)}{0.136(10^{-2})L_1} - \underset{(2.86)}{0.120(10^{-3})L_{2-9}}$$

$$- \underset{(1.94)}{0.843(10^{-4})L_{19}} + \underset{(9.70)}{0.105(10^{-2})Q_{1-5}} + \underset{(5.32)}{0.592(10^{-3})Q_{6-19}}$$

$$+ \underset{(11.76)}{0.296DR_{1-5}} + \underset{(5.80)}{0.140DR_{6-19}} + \underset{(18.53)}{0.439R_{1-5}} + \underset{(28.54)}{0.740R_{6-19}}$$

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[14]Note that X_1 and X_{2-19} are dummy variables. $X_1 = 1$ when $n = 1$ and zero otherwise, $X_{2-19} = 1$ when $n = 2, 3, \ldots, 9, 19$ and zero otherwise. All rates used in this study are expressed in decimal form in hundredths rather than as a percentage. The rate of change of the M_2 money stock is also expressed in decimal form in hundredths. Debt is expressed in millions of dollars. (Footnote continued on next page)

$$- \underset{(0.35)}{0.155(10^{-1})}\dot{M}_1 + \underset{(3.76)}{0.536(10^{-1})}\dot{M}_{2-19} + \underset{(4.42)}{0.973(10^{-7})}D_S$$

$$+ \underset{(10.52)}{0.187(10^{-6})}D_{IS} + \underset{(1.27)}{0.218(10^{-7})}D_{IL} - \underset{(1.53)}{0.129(10^{-6})}D_L$$

$\bar{R}^2 = 0.993$, Durbin-Watson = 1.725

If the only goal of our analysis was to explain expectations for the sake of an explanation, an adjusted R^2 of 0.993 indicates our model has at least achieved this. At first glance, even the Durbin-Watson (D-W) statistic of 1.725 would seem large enough to indicate no autocorrelation present in the residuals. We should, however, keep in mind that we are dealing with a sample of 1790 observation[15] so the D-W is probably[16] still in the indeterminant range. Nevertheless, it is doubtful that another G.L.S. transformation would add much reliability to our significance tests. A more important qualification is the probable existence of some correlation among the blocks of re-

(footnote continued from preceding page) The liquidity measure is the discounted present value of a $100.00 security, while the first difference of the distributed lag index of industrial production is expressed as a decimal in tenths. The subscripts on the variable designate the maturities to which these coefficients apply. In the case of the debt class variables S corresponds to n = 1, IS to n = 2-5, IL to n = 6-19 and L to 19. The absolute value of the t statistic appears in parentheses below the coefficients. For t ≥ 1.96 the coefficients are significantly different from zero at the 0.05 level. All significance tests in the study are conducted at the 0.05 level.

[15] While we started with 1800 observations, 10 were lost in the Generalized Least Squares (G.L.S.) transformation.

[16] It is impossible to say exactly because no D-W table exists for a sample as large as 1800 observations.

siduals which correspond to the various maturities. Two transformation techniques exist for dealing with this problem, one developed by Fuller (16) and another credited to Zellner (57). Both transformations should give similar results, but when each was applied to our G.L.S. model, the results were so diverse as to prevent our using either.[17] We decided to accept the results of the G.L.S. model because its coefficients were the most consistent, in terms of size, sign and significance, with the various other models we have tested, including Zellner and Fuller's transformations. One should, however, keep in mind the possibility of residual correlation in evaluating our results.

Our preliminary analysis indicated the desirability of looking for significantly different effects from independent variables on expectation regarding particular segments of the yield curve rather than on individual maturities. One of the advantages of the single equation model is that it provides a simple method of testing for these differences statistically (20, p. 132). For example, the model contains two intercepts--one applicable when n = 1 and the other applicable for all other n. Both intercepts are significantly different from zero and significantly different from each other.[18]

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[17]The only explanation we can offer for the inconsistency of the two transformations is that presumably our data violates some assumptions of the techniques, but it is not clear how or why.

[18]This model was also fit with one intercept corresponding to the period before the balance of payments became a serious policy issue and another corresponding to the period during which it was a serious issue. Interestingly, these two intercepts also proved to be significantly different. This provides some indication that overall policy during the period may have affected expectations.

The coefficients of the three liquidity measures provide support of the existence of a Hicksian liquidity premium. They are significantly different from each other; they have the hypothesized negative sign; and they decline as term to maturity increases. Two of the three, the one-year maturity coefficient and the two- to nine-year maturity group coefficients were significantly different from zero, while the non-significance of the third coefficient indicates investors do not believe long-term securities contain a significant liquidity element. While these results are consistent with the findings of most of the other models we tested, we did find some evidence[19] to support the Preferred Habitat Theory (36, 37) of liquidity premium. The P.H.T. is that the premiums exist because of relative supply and demand in particular "habitats" (maturity sectors) rather than because there is any "constitutional weakness"[20] in the market.

We have used as an indicator of the level of economic activity the first difference of the lagged index of industrial production previously described. We have sought to distinguish between its impact on expectations about short rates (n = 1, ..., 5) vs. long rates (n = 6, ..., 9, 19). Both coefficients carry a positive sign and are significant. The influence on expectations about shorts is significantly greater than on expectations about longs. This may be interpreted as indicating that investors expect the current trend in economic

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[19]See Appendix.

[20]That is, borrowers prefer to borrow long; lenders prefer to lend short.

activity to continue, but place less reliance on its continuing for a long period.

The model contains two variables which are relatively "pure" measures of economic policy, the discount rate and the level of debt in particular maturity classes. The effect of these variables is our major concern.

As in the case of industrial production we have distinguished between the impact of the discount rate on expectations about short vs. long rates and found that impact to be significantly different. In both cases the influence is both significantly different from zero and positive, suggesting that a rise in the discount rate leads investors to believe interest rates will rise. The larger coefficient on DR_{1-5} is consistent with the generally-held belief that the discount rate exerts a greater impact on short than on long-term rates.

The effect of the debt variable is broken up in terms of the four maturity classes. If one hypothesizes that an increase in the supply of debt in a particular class, ceteris paribus, causes a decline in security prices and thus leads to expectations of rising rates, one would expect the sign of debt coefficients to be positive. The resulting estimated coefficients for the three shorter maturity classes lend support to this hypothesis.

The level of debt in short- and intermediate-short classes was found to exert a significant influence on expectations about one year and two- to five-year maturities, respectively. The influence of the intermediate-short debt is significantly larger than that of short debt.

Even so, this influence can hardly be considered great in absolute terms. According to our model, it would take an increase of approximately five billion dollars in intermediate-short debt to raise expectations about two to five-year rates by one basis point and nearly twice as much short debt for a similar effect on expectations about one-year rates. Neither the intermediate-long nor the long debt variables exhibit any significant impact on expectations. And, in fact, the coefficient for the long class is negative. This may simply be an indication that the Treasury has pursued a procyclical debt policy, issuing long-term debt only when interest rates are low and/or falling. This "wrong" sign is not a particularly critical result since this negative coefficient is not significantly different from the positive coefficient for the intermediate-long class.

The rate of change in the M_2 money stock ($\dot{M}$) may be viewed as something of a hybrid variable, since it may be strongly influenced by both monetary policy and the level of economic activity. It was included in the model because it is a frequently-mentioned economic indicator. It's contribution to explaining expectations is, however, questionable. While the coefficient on $\dot{M}_{2-19}$ is positively significant, it is not significantly different from the coefficient for $\dot{M}_1$ which is negative and nonsignificant. There is no obvious explanation for this phenomenon.

It remains for us to examine the justification for and the impact of including last month's spot rate in the model. By including this variable we immediately open ourselves to critics who would say we have provided a "boot strap" [21] explanation of expectations. We are attempting to explain expectations which in turn explain the term structure, but expectations depend on spot rates. Hence, are we not caught in a circle? Further, is the lagged spot-rate not the major source of multicollinearity in the model? We make no attempt to deny that these two questions require an affirmative answer. What we do deny is that this affirmation is adequate justification for excluding the spot-rate. Our goal has been to explain expectations for the explicit purpose of determining the impact of economic policy. We have attempted to do this within as realistic a context as possible. We have included in our model those variables which possess the greatest intuitive appeal for providing a realistic explanation of expectations. One of those variables is certainly the level of rates in the recent past. While we are concerned with the effect of policy, we have never claimed that policy is the sole determinant of expectations. The impact of policy can only be realistically evaluated if it is viewed within a framework which includes the other important factors influencing expectations. It does not seem reasonable, therefore, to exclude the spot-rates from our model.

In a sense the inclusion of the spot-rate "explains" nothing, yet few would deny that this rate is an important consideration as investors view the horizon. And, as Joan Robinson has said, "If the rate of interest is hanging by its boot straps, so is the price of Picasso's paintings" (41, p. 19). While we have included in the appendix a model run without the lagged spot-rate for the unconvinced, we choose to place much more reliance on the policy implications of model presented here.

[21] See for example Robertson (40).

The impact of last month's spot-rate has been evaluated in terms of its effect on expectations regarding short-term vs. long-term maturities. These effects were found to be positively significant and significantly different from each other. The greater influence of the spot-rate on expectations about long-term rates indicates that investors rely more heavily on extrapolation when forming forecasts about long-term rates, even if this forecast is only for one year. This is consistent with Kane and Malkiel's (21) finding investors more willing to make forecasts about long-term rates than short-term rates.

For purposes of comparing relative impact we have computed mean elasticities for the independent components of our model.[22] These elasticities appear in Table 4.1.

While the lagged spot-rate exerts the most important effect, as might be expected, the relative impact of the policy variables is quite encouraging. We might also call attention to the extreme importance of the liquidity element for the one-year maturity.

Varying Horizon Lengths

One question which permeates the term structure literature concerns horizon length.[23] In its most general form the question involves making a choice between the infinite horizon of the Hicks-Lutz formulation and Malkiel's one-period horizon. Having chosen, largely on the basis of in-

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[22]Mean elasticity is defined as:

$$\frac{\text{(Mean of independent variable)}}{\text{(Mean of dependent variable)}}\text{(Coefficient)}.$$

[23]Taylor has presented an interesting theoretical framework which integrates expectations and a specific time horizon into the decision-making process. This framework implies that the market behavior of investor and thus the term structure is critically influenced by both expectations and horizon (45, pp. 30-56).

Table 4.1. Mean elasticities of expected rates with respect to independent variables

Variable	Elasticity
L_1	-3.372
L_{29}	-0.291
L_{19}	-0.200
Q_{1-5}	0.012
Q_{6-19}	0.007
DR_{1-5}	0.246
DR_{6-19}	0.117
R_{1-5}	0.407
R_{6-19}	0.727
$\dot{M}_1$	-0.002
M_{2-19}	0.006
D_S	0.161
D_{IS}	0.193
D_{IL}	0.014
D_L	0.009

tuitive appeal, the one-period approach, the remaining question which faces us is how long is one period? All of the analysis to date has been within the context of a one-year horizon. While the work of Kane and Malkiel (21) provides some basis for this choice, it is by no means clear that one year is the "correct" or "true" horizon applicable to most investors.

The study we have undertaken was not designed to provide an answer to the question of what is the "correct" horizon. However, in an attempt to determine what influence the length of the forecast period has on policy effects, we have estimated the same single equation G.L.S. model for a six-month and a two-year expectational horizon. The coefficients for these two horizons, together with the coefficients from the one-year horizon, appear in Table 4.2. An examination of policy influence within the context of three arbitrarily-selected horizons can scarcely be regarded as providing anything more than tentative implication regarding the effect of horizon length. The comments which follow should be evaluated with this in mind.

If six months is the most relevant horizon for investors, then the coefficients of the model seem to suggest that policy variables in general exert a lesser influence than if the horizon were longer. The coefficients for the lagged spot-rate are considerably larger for the short horizon. This is consistent with a hypothesis that in forecasting rates for short periods, investors rely heavily on extrapolation from the recent past.

Table 4.2. Coefficients for varying expectational horizons[a]

Variable[c]	6-Month Horizon Coefficient	1-Year Horizon Coefficient	2-Year Horizon[b] Coefficient
X_1	0.130^*	0.141^*	0.212^*
X_{2-19}	$0.169(10^{-1})^*$	$0.170(10^{-1})^*$	$0.190(10^{-1})^*$
L_1	$-0.127(10^{-2})^*$	$-0.136(10^{-2})^*$	$-0.206(10^{-2})^*$
L_{2-9}	$-0.147(10^{-3})^*$	$-0.120(10^{-3})^*$	$-0.124(10^{-3})^*$
L_{19}	$-0.121(10^{-3})^*$	$-0.843(10^{-4})$	
Q_{1-5}	$0.119(10^{-2})^*$	$0.105(10^{-2})^*$	$0.111(10^{-2})^*$
Q_{6-19}	$0.572(10^{-3})^*$	$0.592(10^{-3})^*$	$0.523(10^{-3})^*$
DR_{1-5}	0.164^*	0.296^*	0.225^*
DR_{6-19}	$0.571(10^{-1})^*$	0.140^*	$0.651(10^{-1})^*$
D_S	$0.391(10^{-7})^*$	$0.973(10^{-7})^*$	$0.131(10^{-6})^*$
D_{IS}	$0.991(10^{-7})^*$	$0.187(10^{-6})^*$	$0.214(10^{-6})^*$
D_{IL}	$0.238(10^{-7})$	$0.218(10^{-7})$	$0.353(10^{-7})$
D_L	$-0.882(10^{-7})$	$-0.129(10^{-6})$	
$\dot{M}_1$	$-0.938(10^{-2})$	$0.155(10^{-1})$	$0.193(10^{-1})$
$\dot{M}_{2-19}$	$0.654(10^{-1})^*$	$0.536(10^{-1})^*$	0.112^*
R_{1-5}	0.670^*	0.439^*	0.436^*
R_{6-19}	0.870^*	0.740^*	0.752^*
	$\bar{R}^2 = 0.997$	$\bar{R}^2 = 0.993$	$\bar{R}^2 = 0.994$
	D.W.= 1.809	D.W.= 1.725	D.W.= 1.728

[a,*] Indicates significance at the 0.05 level.

[b] The two-year horizon does not contain data for nine and nineteen-year maturities due to data limitations.

[c] The form of the variables is as described in footnote 14, pages 33-34.

The discount rate appears to be most potent as a policy tool if the "true" horizon is one year. For the two-year horizon, it ceases to exert a significant influence on expectations about long-term rates. Instead, the positive coefficient for the rate of change in the M_2 money stock, as it applies to long-term securities, doubles in size. This development is of particular interest because it is consistent with Friedmanian monetary theory.[24]

Coefficients for the debt variables tend to suggest that the longer the horizon the greater the influence of debt on expectations. This may indicate that the effects of debt management are viewed by investors as being more permanent and far-reaching than monetary policy.

Finally, a comparison of the liquidity coefficients for differing horizon yields several interesting observations. For example, the liquidity component in one-year forward rates becomes increasingly important as the horizon lengthens, whereas the liquidity of other maturities exerts its greatest influence for a six-month horizon. Indeed, even the nineteen-year security shows a significant liquidity element for the short horizon. These results are consistent with the fact that the prices of short-term securities fluctuate less than the prices of longer-term securities. Hence, over a long period, short-term maturities would be expected to be more liquid. Similarly, over a short horizon, when there is less time for price fluctuation, even very long maturities possess a liquid-

[24] Stated very simply, Friedman argues that an increase in the rate of change of the money supply causes high interest rates in the future and vice versa. More explicitly, an increase in the rate of change of the money stock causes investors to adjust their asset portfolios. Initially this adjustment may take place in the financial markets forcing prices up and rates of return down. Portfolio adjustment spreads to the real sector with a lag of substantial (footnote continued next page)

ity component. The results of comparing coefficients for differing horizons lead us to conclude that some rather different policy and liquidity implications arise, depending on the length of the forecast period for which the investigation is conducted. As noted earlier, these results are tentative. To obtain more conclusive information regarding the influences of horizon, one would need to evaluate numerous alternative forecast periods. One method of obtaining this information might be to begin by evaluating a very short horizon, say one month, and then successively adding one month to the length of the horizon. Such an approach would provide greater continuity to the evaluation of policy effects over an increasing horizon.

In the final analysis the determination of the "true" horizon is an empirical question which must be answered through further research before positive policy pronouncements can be made.

(footnote continued from preceding page) duration, stimulating economic activity and increasing the demand for loanable funds. This increase in demand, in turn, pushes interest rates up (15, pp. 59-64). Thus a significant positive relationship between expectations two years hence and the rate of change in the money stock is consistent with this theory.

V. SUMMARY AND CONCLUSIONS

This study was begun and conducted on the premise that there is adequate empirical evidence to support the contention that expectations are an important determinant of the term structure of interest rate. Acceptance of this premise makes it of paramount importance to determine how expectations are formed if we wish to broaden our understanding of the term structure. Following the lead of Luckett (24) and Wendel (55), we have attempted to explain why expectations are what they are. The central goal of the investigation has been to examine the influence of monetary policy and debt management on expectation. The approach has been to seek policy effects within the context of a completely-specified model. That is, the influence of policy has been sought within a framework which contains, in addition to policy indicators, additional variables which exert a major influence on expectations. This method should provide more meaningful implications than an approach which examines policy effects in isolation from the influence of other expectational determinants.

Using the level of forward rates implied by the current term structure as proxies for expectations, we were also able to provide a test for the existence of a liquidity premium within forward rates. The method we have used to make allowance for this liquidity premium does not require the assumption made in previous studies that this premium is constant over time. The evidence which the analysis provides supports the hypothesis that forward rates contain a liquidity premium and are thus an upward biased estimate of expected rates. The results are, however, somewhat inconclusive regarding the distribution of the premium with respect to maturity. The basic model presented in the text lends support to the Hicksian theory, while some alternative models tested suggest that a Preferred Habitat explanation may be applicable. Clearly, additional investigation is needed.

In summarizing the findings of this study regarding the influence of economic policy on interest rate expectations, four observations are in order. The first and most general conclusion is that in every model tested in this study, regardless of the horizon used, monetary policy and debt management variables made a significant contribution to the determination of expectations.

The second observation concerns the relative impact of policy variables within the context of a one-year horizon. A comparison of mean elasticities revealed the discount rate to be the most potent policy tool. Indeed, its relative influence also appears to exceed that of the lagged index of industrial production. The least potent and least dependable measure of policy seems to be the rate of change of the M_2 money stock. Not only do the mean elasticities indicate that its influence is relatively weak, but it is not clear that its contribution is statistically significant.

The most interesting concluding comments deal with the differential effects of policy on expectations about differing maturities. There seems to be a clear indication that both the discount rate and the level of debt exert a significantly-greater influence on expectations about short-term rates than on expectations about long rates. In fact, the long and intermediate-long debt classes do not appear to exert any significant influence on expectation about long rates. While the absolute impact of a change in the supply of short or intermediate-short debt is not large, the results we have obtained suggest that debt management, if undertaken with enough vigor, can have a marked effect on expectations and hence, on the term structure. Similar implications derive from the apparent differential effect of a change in the discount rate.

The final observation which we wish to make deals with varying horizons. It would appear that the influence of policy depends to a considerable extent on just what constitutes the "true" horizon. If this "true" horizon is six months, indications are that the influence of policy is considerably less than if the horizon is longer. If the "true" horizon proves to be two years, our analysis has revealed an interesting implication regarding the validity of Friedmanian Monetary Theory. In point of fact, of course, different investors have different horizons. The issue then may not be so much what is the "true" horizon as what is the "dominant" horizon. Alternatively, obtaining the "true" horizon may necessitate constructing some sort of weighted average of the horizons of different investors.

While the results of this study provide singificant evidence in support of the monetary authorities' ability to affect the term structure by influencing expectations, considerable additional research needs to be done before precise policy pronouncements can be made. In particular, we need additional information regarding the "true" or "dominant" horizon. Finally, it should be remembered that the results we have presented here possess validity only insofar as the model we have developed is a reasonably-realistic specification of the major determinants of expectations.

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APPENDIX

Alternative Variables Tested

As noted in Chapter IV, the variables used in the final model were selected because of the consistency of the results which their coefficients provided in a variety of empirical models. Given below is a list of alternative variables which were tested and rejected because of inconsistencies or lack of statistical significance.

Liquidity

1. Liquidity index based on the dispersion of rates over the past twenty-four months.

Indicators of economic activity

1. First difference of the index of industrial production.
2. Five-month distributed index of industrial production using Wendel's (55) weights.
3. Percentage change in consumer prices over the past years.

Indicators of monetary policy

1. Level of free reserves.
2. Reserve requirement.
3. M_1 Money stock (i.e., currency plus demand deposits).
4. First difference of the M_1 money stock.
5. First difference of the M_2 money stock (i.e., M_1 plus time deposits).

Indicators of debt management

1. First difference of the quantity of debt in the j^{th} class.
2. First difference of the quantity of debt in the j^{th} class

held by the Federal Reserve.

3. Percentage of the total marketable debt in the j^{th} class.

4. Percentage of debt in the j^{th} class held by the Federal Reserve.

Alternative Models Tested

We have included in this section two additional one-year horizon models as a representation of the numerous alternative approaches tested. The first is a single equation G.L.S. model which excludes last month's spot-rate. The results from fitting this model appear below. Again the t values appear in parentheses below the coefficients.[1]

(A.1)

$$
\begin{aligned}
r_n = {} & \underset{(0.01)}{0.424(10^{-3})}X_1 + \underset{(6.30)}{0.412(10^{-1})}X_2 + \underset{(0.20)}{0.128(10^{-3})}\,L_1 \\
& - \underset{(3.77)}{0.258(10^{-3})}L_{2-9} - \underset{(1.98)}{0.147(10^{-3})}L_{19} \\
& + \underset{(6.99)}{0.943(10^{-3})}Q_{1-5} + \underset{(5.56)}{0.758(10^{-3})}Q_{6-19} + \underset{(20.59)}{0.506}DR_{1-5} \\
& + \underset{(30.02)}{0.602}DR_{6-19} \\
& + \underset{(3.87)}{0.136(10^{-6})}D_S + \underset{(6.53)}{0.178(10^{-6})}D_{IS} + \underset{(4.43)}{0.128(10^{-6})}D_{IL} \\
& - \underset{(1.87)}{0.281(10^{-6})}D_L - \underset{(1.19)}{0.552(10^{-1})}\dot{M}_1 + \underset{(0.37)}{0.572(10^{-2})}\dot{M}_{2-19}
\end{aligned}
$$

$\bar{R}^2 = 0.962$ D-W = 1.454

---

[1]The form of the variables is as described in footnote 14, pages 33-34.

The coefficients for this model differ from the model presented in the text in several respects. First, one of the intercepts is no longer significant. Second, the one-year maturity liquidity coefficient shifts from negative significant to positive nonsignificance. Third, the influence of the discount rate shows a marked increase, particularly in its impact on long-term maturities. Finally, the intermediate-long debt class now provides a positive and significant contribution to expectations. Certain other differences may be noted as well. For example, the Durbin-Watson statistic is low enough to suggest that a good deal of autocorrelation exists in the residual. Clearly the inclusion of the lagged spot-rate eliminates much of this autocorrelation. This is another argument in favor of its inclusion. We reiterate our conclusion of Chapter IV. A model which seeks to explain expectations but excludes spot-rates is incompletely specified and thus less believable than the model used in the text. Even so, the model we have just presented does not contradict the basic conclusion that the level of the two short-term debt classes and the discount rate have a significant effect on expectations.

The second model we present here involves the fitting of ten separate equations, one for each maturity. We have regressed r_n on the same variables as in the single equation model with the exception that we have excluded $\dot{M}$. One other difference is that the data used covers the period May, 1952 to December, 1968 instead of January, 1954 to December, 1968.[2] The estimated coefficients for these ten equations

[2]The 1952-53 data was not used in the single equation model because of computer program constraints.

appear in Table A.1.

Again, the results of this model do not contradict the general conclusions of the single equation model presented in the text. Policy variables continue to exert a significant influence on expectation.

There are, however, three noteworthy differences between this model and the single equation model of the text. First, the liquidity coefficients in this model lend support to the Preferred Habitat rather than the Hicksian Theory. The nonsignificance of the liquidity coefficients for maturities of two to five years might be interpreted as indicating that the quantity of debt in these maturity classes exceeds the quantity demanded by investors with two to five-year habitats. The fact that the intermediate-short debt class contains the largest proportion of marketable debt is consistent with this conclusion.

Another interesting result of this model is that the impact of the discount rate is not significant for expectations about longer-term maturities. This is, of course, not inconsistent with our earlier results which seemed to indicate that a change in the discount rate exerts a greater effect on expectations about short rates than on expectations about long rates.

The final point which we wish to make regarding this model is to call attention to the nonsignificance of the short debt class and the significance of the intermediate-long class. Since in several alternative single equation models the intermediate debt has bordered on significance at the 0.05 level, the results presented here are not surprising. The nonsignificance of the short class has also appeared before. We are thus lead to conclude that the effect of these two classes

Table A.1. Ten-equation model

Variables[c]	Coefficients[a]: Intercept	L_n	Q	DR	D_j[b]	$R_{n_{t-1/12}}$	$\bar{R}^2$	D-W
r_1	$0.712(10^{-1})^*$	$-0.160(10^{-2})^*$	$0.113(10^{-2})^*$	0.347^*	$0.351(10^{-7})$	0.516^*	0.886	1.636
r_2	$0.210(10^{-1})^*$	$-0.411(10^{-3})$	$0.103(10^{-2})^*$	0.338^*	$0.190(10^{-6})^*$	0.447^*	0.905	1.636
r_3	$0.161(10^{-1})^*$	$-0.302(10^{-3})$	$0.843(10^{-3})^*$	0.278^*	$0.167(10^{-6})^*$	0.511^*	0.911	1.672
r_4	$0.131(10^{-1})^*$	$-0.227(10^{-3})$	$0.787(10^{-3})^*$	0.249^*	$0.140(10^{-6})^*$	0.552^*	0.917	1.679
r_5	$0.106(10^{-1})^*$	$-0.163(10^{-3})$	$0.733(10^{-3})^*$	0.202^*	$0.114(10^{-6})^*$	0.612^*	0.924	1.673
r_6	$0.179(10^{-1})^*$	$-0.257(10^{-3})^*$	$0.481(10^{-3})^*$	$0.915(10^{-1})$	$0.600(10^{-7})^*$	0.797^*	0.944	1.708
r_7	$0.153(10^{-1})^*$	$-0.204(10^{-2})^*$	$0.426(10^{-3})^*$	$0.553(10^{-1})$	$0.571(10^{-7})^*$	0.840^*	0.951	1.728
r_8	$0.123(10^{-1})^*$	$-0.153(10^{-3})^*$	$0.371(10^{-3})^*$	$0.258(10^{-1})$	$0.517(10^{-7})^*$	0.879^*	0.956	1.743
r_9	$0.106(10^{-1})^*$	$-0.126(10^{-3})^*$	$0.325(10^{-3})^*$	$0.782(10^{-2})$	$0.454(10^{-7})^*$	0.904^*	0.960	1.767
r_{19}	$0.411(10^{-2})^*$	$-0.142(10^{-4})$	$0.258(10^{-3})^*$	$-0.213(10^{-1})$	$-0.650(10^{-7})$	0.967^*	0.977	1.808

[a,*] Indicates significance at the o.05 level.

[b] The level of debt in the short class is used in the first equation, the level in the intermediate short class in equations two through five, the level of intermediate-long in equations six through nine, and the level of long for n = 19.

[c] The form of the variables is as described in footnote 14, pages 33-34.

is questionable. We add, however, that multiple equation models which assume that the equations are unrelated, when in fact they are not, provide less reliable results than the single equation approach.