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EXPLANATIONS OF THE TERM STRUCTURE OF INTEREST RATES

IT IS THE THESIS of this investigation that the term structure of interest rates can be explained better by a combination of the expectations and liquidity preference hypotheses than by either hypothesis alone. Alternatively, these two hypotheses can be viewed as complementary explanations of the same phenomenon—the term structure of interest rates. The evidence to be examined in support of this view falls into two classes. One is the findings of previous investigators; the works of Macaulay, Culbertson, Meiselman, Walker, and Hickman contain evidence relevant for evaluating the substantive merits of this thesis. The other class consists of evidence gathered as part of the present investigation.

A. What Is the Expectations Hypothesis

The expectations hypothesis has been enunciated by Fisher, Keynes, Hicks, Lutz, and others.[1] It has had widespread appeal for theoretical economists primarily as a result of its consistency with the way similar phenomena in other markets, particularly futures markets, are explained. In contrast, this hypothesis has been widely rejected by empirically minded economists and practical men of affairs. It was rejected by economists because investigators have been unable to produce evidence of a relationship between the term structure of interest rates and expectations of future short-term rates. (Others

[1] See Friedrich A. Lutz, "The Structure of Interest Rates," in the American Economic Association, *Readings in the Theory of Income Distribution*, Philadelphia, 1946, p. 499; and Joseph W. Conard, *An Introduction to the Theory of Interest*, University of California Press, 1959, Part III.

have found it difficult to accept the view that long- and short-term securities are perfect substitutes for one another in the market.) Meiselman contends that previous investigators have not devised operational implications of the expectations hypothesis. Moreover, he contends, they have examined propositions which were mistakenly attributed to the expectations hypothesis, and when these propositions were found to be false, they rejected the expectations hypothesis.[2]

Briefly, the expectations hypothesis asserts that a long-term rate constitutes an average (a weighted average in the case of coupon-bearing securities) of expected future short-term rates. It says that forward rates (or marginal rates of interest) constitute unbiased estimates of future spot rates.[3] It is based on the assumption that short- and long-term securities, default risks aside, can be usefully viewed as identical in all respects except maturity. It implies that the expected value of the returns derived from holding long- and short-term securities for identical time periods are the same.

The word *future* should be emphasized in discussing the expectations hypothesis, since it concerns the effects of expectations about future short-term rates upon the current term structure of interest rates. To illustrate with a simplified example: assume that two-year securities yield 3 per cent and one-year securities 2 per cent. The forward rate on one-year money one year hence, or the marginal cost of extending a one-year term to maturity for an additional year, is 4 per cent; this is arithmetic, not the expectations hypothesis. The expectations hypothesis, as interpreted by Lutz and Meiselman, but not by Hicks, states that the forward rates are unbiased estimates of future short-term rates. For the preceding example, it implies that the market expects the rate on one-year securities one year hence to be 4 per cent. Four per cent is not only the forward rate—it is the expected one-year rate one year hence; i.e., it is what the market thinks the one-year rate will be one year hence.

[2] David Meiselman, *The Term Structure of Interest Rates*, Englewood Cliffs, New Jersey, 1962, pp. 10 and 12.

[3] A spot rate is a rate on funds for immediate delivery; it is today's rate for money to be delivered today for a specified period of time. In contrast, a forward rate is today's rate for money to be delivered in the future for a specified period of time. This time period could be anything, a day, a year, or a decade.

Conversely, assume a 2 per cent rate on two-year maturities and a 3 per cent rate on one-year maturities. Then the yield on one-year securities one year hence which will equalize the net yield from holding two one-year securities successively with that of holding one two-year security is 1 per cent. This must follow if one accepts the view that securities are alike in all respects except term to maturity.[4]

B. Existing Evidence

1. MACAULAY

Macaulay was among the first to produce empirical evidence that related long-term rates to expectations of future short-term rates. Before the founding of the Federal Reserve System, there existed a pronounced and well-known seasonal in the call money rate. The widespread knowledge of the existence of this seasonal implied that time money rates, which are loans from one to six months that are otherwise similar to call money loans, should turn up before the seasonal rise in call money rates. Macaulay found that time money rates did in fact anticipate the seasonal rise in call money rates and concluded that this constituted ". . . evidence of definite and relatively successful forecasting."[5] Macaulay was unable to uncover additional evidence of successful forecasting. He warned against concluding that forecasting was not attempted. Macaulay's contention was that evidence of successful forecasting is rare because successful forecasting is also rare.[6]

2. HICKMAN

W. Braddock Hickman, in a preliminary, unpublished, but nevertheless widely cited and read, NBER manuscript prepared in 1942, reports the results of his tests of the expectations hypothesis.[7] Like Macaulay, he sought evidence of successful forecasting; unlike Macaulay, he failed to find it. He compared observed or actual yield curves with those predicted one year or more ahead by the

[4] These calculations ignore compounding of interest and intermediate payments in the form of coupons.

[5] Frederick R. Macaulay, *Movements of Interest Rates*, p. 36. The reappearance of a seasonal in the money market in recent years has made it possible to reproduce Macaulay's experiment with a new body of data.

[6] *Ibid.*, p. 33.

[7] W. Braddock Hickman, "The Term Structure of Interest Rates: An Exploratory Analysis," National Bureau of Economic Research, 1942, mimeographed.

term structure of interest rates, as interpreted by the Lutz-Meiselman variant of the expectations hypothesis. For such a comparison, expected yield curves must be determined at one point and actual yield curves at a later point of time. If the expectations hypothesis is valid, Hickman reasoned, then expected yield curves will be correlated with observed yield curves.

Hickman found that simply assuming that this year's yield curve will be the same as next year's gave what he regarded as better predictions of subsequently observed yield curves than the expectations hypothesis. This was one of the early uses of an inertia hypothesis as a benchmark for evaluating the predictive content of a substantive hypothesis. Hickman did not employ correlation analysis. If he did, as shall be shown, his conclusion that inertia is the better predictor would be more difficult if not impossible to sustain. In addition, he subjected the expectations hypothesis to two additional tests. (These tests, and the data employed are described in Appendix A.) All of his tests are based on the view that the validity of the expectations hypothesis hinges upon accurate forecasts. Meiselman does not regard this finding as relevant. "Anticipations may not be realized yet still determine the structure of rates in the manner asserted by the theory." [8]

3. CULBERTSON

Culbertson's empirical research is similar to Hickman's; both ran tests based on the assumption that forward rates are accurate predictions of future spot rates. Culbertson examined the yields of short- and long-term governments for identical periods of time. He argued that if the expectations hypothesis is valid, then yields to investors ought to be the same whether short- or long-term securities are held. (His calculations take into account both income streams and capital gains and losses.) He found marked differences in returns for the same holding periods. Since he found it difficult

[8] Meiselman, *Term Structure of Interest Rates*, p. 12. Hickman also had some doubts about the relevance of his test or any other test. The difficulties in conceiving of a means for testing the expectations hypothesis led Conard to contend erroneously, as Meiselman's work demonstrates, that only by assuming the market predicts accurately is it possible ". . . to build a theory whose predictions can be meaningfully tested." See Conard, *Theory of Interest*, p. 290.

to believe that speculators would operate in the government securities markets and predict as badly as his results suggested, he rejected the expectations hypothesis.[9]

4. WALKER

Walker's test of the expectations hypothesis also was based on the assumption that the market could predict accurately. However, it was more like Macaulay's work in this respect than that of Hickman and Culbertson. Both he and Macaulay revealed the consistency between the implications of accurate expectations and the expectations hypothesis; both observed instances in which the expectations of the market could be presumed to be accurate; and both found the behavior of the market was consistent with the expectations hypothesis.[10]

Walker's work deals with governmental interest rate policy during World War II. Around the beginning of that war, the Federal Reserve System and the Treasury embarked upon a policy of stabilizing, through open market operations and the maturity composition of new issues, the existing levels of rates on government securities. At that time, the yield curve was sharply rising; the bill rate was three-eighths of 1 per cent, one-year securities yielded 1 per cent, and long-term securities 2.5 per cent. If the expectations hypothesis is correct, the prestabilization term structure implied that future short-term rates were expected to be higher than existing short-term rates. In contrast, the stabilization policy implied that future short-term rates would be the same as current short-term rates. When the financial community became convinced that the monetary authorities could and would make this policy effective, it also became convinced that existing long-term rates were inconsistent with revised expectations of future short-term rates:

9 ". . . the explanation of broad movements in the term structure of rates must be sought principally in factors other than behavior governed by interest rate expectations." See John M. Culbertson, "The Term Structure of Interest Rates," *Quarterly Journal of Economics*, November 1957, p. 502.

Meiselman, *Term Structure of Interest Rates*, p. 12, regards this and Hickman's work as tests of nonexistent implications of the expectations hypothesis.

10 Charls E. Walker, "Federal Reserve Policy and the Structure of Interest Rates on Government Securities," *Quarterly Journal of Economics*, February 1954, p. 19.

long-term rates were too high. Hence, there was a tremendous shift out of short- and into long-term securities by the holders of governmental obligations. Such a shift is implied by the expectations hypothesis, given the prewar term structure and its wartime stabilization.[11] This shift in large part converted the stabilized yield on bills to a nominal rate similar to some other wartime prices.

Walker's results, unlike Macaulay's findings, cannot be interpreted as providing unambiguous support for the expectations hypothesis because they are also consistent with an implication of the liquidity preference hypothesis. Liquidity preference as a theory of the term structure of interest rates implies that the longer the term to maturity of a security, the higher its yield. Yield differentials between long- and short-term securities constitute equalizing differences that reflect differences in risks of capital losses. The establishment of a ceiling on long-term bond yields implies a floor or support price for their capital values. A price support program for long-term bonds implies that much of the risk of capital loss is eliminated. Therefore, long maturities become relatively more attractive investment media.

Although Walker's results do not discriminate between expectations and liquidity preference, they do discriminate between expectations and liquidity preference on the one hand and market segmentation on the other. If the holdings of governments by the major institutions of the financial community changed as much as Walker reports they did, this constitutes evidence against the market segmentation hypothesis; if the market segmentation hypothesis is correct, Walker should not have observed a shift in the maturity distribution of governments by the major institutions of the financial community.[12]

[11] If a rising yield curve exists, long-term securities yield more than short-term because the market anticipates offsetting losses on capital account attributable to holding long-term securities. The elimination of these anticipated capital losses implies that the yield of long-term securities is truly greater than that of short-term securities.

Conversely a declining yield curve implies that future short-term rates will be lower. Hence the holders of long-term securities trade a lower income on current account for anticipated capital gains. The stabilization of such a yield curve means that these anticipated capital gains cannot be realized, hence, that the yield of short-term securities is truly greater than that of long-term securities.

[12] This interpretation of Walker's findings as well as the contention that his results are consistent with liquidity preference does not appear in the original

The expectations hypothesis has been rejected for its unrealistic assumptions, particularly the assumption that short- and long-term securities of equivalent default risk can be treated as perfect substitutes. Many practitioners in financial markets, committing the fallacy of composition, reason that no one regards bills and long-term bonds as alternatives because they observe that many institutions specialize in a particular maturity spectrum. As long as some ranges of maturities are considered as alternatives by individual participants in this market, and in the aggregate these ranges cover the entire maturity spectrum, the market will act as though bills and bonds are alternatives. Yet every participant in this market may deal in a highly circumscribed maturity spectrum.

Mrs. Robinson has contended that the purchasers of a consol must know the course of future interest rates for ". . . every day from today till Kingdom Come." [13] Hickman and Luckett have enunciated, less colorfully, essentially the same argument.[14]

Presumably the size of the bonus a promising high school or college baseball player receives in exchange for his affiliation with a major league club is a function of his expected performance as a ball player. This interpretation, which is widely accepted, implies that the market predicts the performance of a ball player over his entire career. In order to properly calculate the size of these bonuses, the market must predict batting averages, fielding performance, and, in the case of pitchers, pitching effectiveness. Emotional stability, which appears to be irrelevant for determining future short-term rates, must also be predicted for ball players, since many become emotionally unstable in the face of severe competition and hence lose some of their economic value.[15]

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paper. Walker regarded his evidence as supporting the Lutz variant of expectations. For another statement of what the market segmentation hypothesis is, see Conard, *Theory of Interest,* p. 304.

[13] See Joan Robinson, "The Rate of Interest," *Econometrica,* April 1951, p. 102.

[14] Dudley G. Luckett, "Professor Lutz and the Structure of Interest Rates," *Quarterly Journal of Economics,* February 1959, p. 131. Hawtrey also seems to be a member of the school that rejects the expectations hypothesis because of difficulties in predicting short-term rates. He argues that short- and long-term rates are determined in completely segregated and independent markets. See Ralph G. Hawtrey, "A Rejoinder," *The Manchester School,* October 1939, p. 156.

[15] The objection to the expectations hypothesis for the lack of "realism" in its assumptions has led to an attempt to find an alternative, more realistic set

5. MEISELMAN

Meiselman is the first investigator to employ an operational test of the expectations hypothesis that does not depend upon accurate foresight for its validity. If a relationship exists between expectations and the term structure of interest rates, then its existence can be detected despite inaccurate predictions. The understanding by economists of how expectations are formed and revised in the light of new information has improved enormously in recent years. Meiselman, by utilizing this knowledge, was able to make the expectations hypothesis operational even when the market could not anticipate future rates of interest correctly. He showed that expectations, whether or not they are correct, nevertheless affect the term structure of rates. His results constitute striking evidence that the expectations hypothesis has empirical validity.[16]

The expectations hypothesis implies that the term structure of interest rates constitutes at one moment of time a set of predictions of short-term rates at various moments of time in the future. For every instant of time, there exists a term structure or yield curve and a set of implicit forward rates. These forward rates are, if the hypothesis is correct, expected short-term rates. If two term structures separated temporally are compared, the earlier contains predictions of future short-term rates and the later the data, i.e., the realized or actual short-term rates necessary for an evaluation of the accuracy of these predictions. Recent work on expectations suggests that if a realized or actual short-term rate is above its predicted level, then the predictions for other rates, yet to be realized, will be revised upward. Conversely, if the actual rate is below the predicted, then other predicted rates will be revised downward during the time interval between observations.

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of assumptions. See Burton G. Malkiel, "Expectations, Bond Prices, and the Term Structure of Interest Rates," *Quarterly Journal of Economics*, May 1962, No. 2, p. 197. The author claims his model is ". . . in closer conformity with the practices of bond investors who had always considered the Lutz theory chimerical." (See p. 218.) Conformity here should not be interpreted as predicting better; there is no test of the predictive powers of the models in the Malkiel paper. Conformity refers to the conformation of the assumptions of Malkiel's model with descriptions of how bond investors behave.

[16] Meiselman, *Term Structure of Interest Rates*, Chapter 2.

To illustrate: Assume at T_0, say January 1, 1960, the following relationships between yield and term to maturity are revealed by the market:

Yields as a Function of Term to Maturity at T_0

1-year governments yield	1.0 per cent
2	2.0
3	3.0
4	4.0

The expectations hypothesis, given this data at T_0, implies that the market expects future one-year rates to be higher than the current one-year rate. Since the one-year rate is 1 per cent and the two-year rate 2 per cent, the forward rate on one-year money one year hence must be 3 per cent for the returns on these alternatives to be equal. Analogously, if the current two-year rate is 2 per cent and the three-year rate 3 per cent, then the forward rate on one-year money two years later must be high enough to compensate for the difference between 2 and 3 per cent for two years. Therefore, a one-year rate of 5 per cent is implied for two years hence.

Market Predictions at T_0 of Expected One-Year Rates

Expected one-year rate for	T_1, the year beginning	1/1/61, is	3.0 per cent
	T_2	1/1/62,	5.0
	T_3	1/1/63,	7.0

Assume at T_1, a year later, that the following relationships between yield and term to maturity are revealed by the market:

Yields as a Function of Term to Maturity at T_1

1-year governments yield	2.0 per cent
2	3.3
3	4.0

Clearly the one-year rate observed in the market at T_1 (2 per cent) is less than it was expected to be a year ago (3 per cent). The difference between the anticipated one-year rate one year hence at T_0 and the realized one-year rate at T_1 (both rates are for an identical moment of time but are measured one year apart) is defined as the error. If recently acquired knowledge on the formation of expectations is correct, then forecasts of expected one-year rates for T_2 and

T_3, i.e., for January 1, 1962, and 1963, will have been revised downward during the year 1960, or between T_0 and T_1.

One can infer from the term structure of interest rates at T_0 and T_1 how much these estimates of future short-term rates have been revised.

Market Predictions at T_0 and T_1

Expected One-Year Rate for One Year, Beginning on	T_0	T_1	*Change in Forecast, or Magnitude of Forecast Revision (per cent)*
January 1, 1962 (T_2)	5.0	4.6	–0.4
January 1, 1963 (T_3)	7.0	5.4	–1.6

At T_1 the expected one-year rates beginning at T_2 and T_3 are 4.6 and 5.4 per cent respectively. The difference between 5.0 and 4.6 per cent measures the change in the forecast one-year rate for T_2; the difference between 7.0 and 5.4 measures the change in the forecast one-year rate for T_3. Hence, if the expectations hypothesis is correct, then errors and forecast changes should be positively correlated.[17] Meiselman found that his error terms (i.e., the difference between predicted and actual one-year rates) and his forecast revisions were in fact positively correlated.

The distinction between anticipated and unanticipated interest rate changes is crucial for an understanding of how Meiselman tested the expectations hypothesis. If forward rates a year apart are as depicted by Chart 1, then the expectations hypothesis would imply that there has been no change in the rates forecast. Yet the rates for one-, two-, and three-year maturities must have changed during this year; yield curves were not constant. Nevertheless the expected one-year rates for particular moments of time were unchanged. The observations that are correlated, i.e., the error term and the forecast revision, refer to interest rates for particular dates.[18]

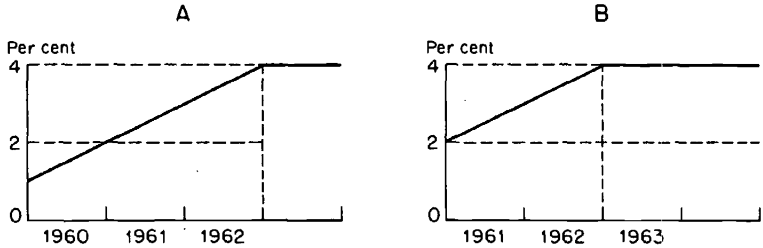
[17] Meiselman defines the error as the spot minus the forward; the revision of the forecast is defined as the later forecast less the earlier.

[18] An implication of this distinction is the proposition that stock prices can vary over time with no change in expectations of future earnings, if the market expects earnings to fluctuate. Hence, insofar as investors anticipate cyclical changes in the profitability of enterprises, anticipated cyclical variations in stock prices should exist.

Meiselman correlated errors with contemporaneous revisions in forecasts. For the example used, there are two forecast revisions, – 0.4 and – 1.6, that are correlated with the error, – 1.0. The future spot rates whose estimates were revised will be observed in the market as spot, and not forward, rates one and two years after the spot rate in the error term can be observed. For the data Meiselman employed, the future spot rates whose estimates were revised will be observed in the market as spot rates one through eight years after the spot rate in his error term can be observed. In both the example and Meiselman's work, forward rates pertaining to subsequently observable one-year spot rates for particular moments of calendar time were observed a year apart. The difference between observations which pertain to the same spot rate are forecast revisions. Since Meiselman observed his forward and spot one-year rates yearly, he observed eight forward rate revisions and one error term every year (with, of course, the exception of the earliest year that his data encompasses). Meiselman produced eight regressions relating forward rate revisions to errors observed simultaneously. He found significant relationships for all eight, with correlation coefficients ranging from a low of .59 to a high of .95. All eight regression lines went through the origin, in the sense that the constant terms of the regressions were insignificantly different from zero.

CHART 1

Marginal Rates of Interest with Stable Expectations



This led to the inference that forward rates are unbiased estimates of future spot rates, which implies, when trends in interest rates are ignored, that yield curves are on the average flat. Short- and long-term rates will tend to be equal. If forward rates are biased upward, then yield curves, again ignoring trends, are on the average positively sloped. Hence, short-term rates will average less than long-term rates, and both, on the average, will rise with term to maturity. Such differentials between different terms to maturity, usually referred to as liquidity premiums, reflect the greater liquidity of short maturities.[19] Meiselman argues that the absence of a constant term in his regressions implies the absence of liquidity premiums. If the constant term is zero, a forward rate that is equal to the subsequently observed actual spot rate, i.e., a zero error term, implies no forecast revision. If forecasts are not revised when the error term is zero, then Meiselman infers that liquidity premiums are absent. To show that this inference is incorrect, consider the following formal statement of the hypothesis Meiselman tests:

$$_{t+m}E_t - {}_{t+m}E_{t-1} = \beta({}_tR_t - {}_tE_{t-1}) \tag{1}$$

Let E represent expected rates, R spot rates, F forward rates, and L liquidity premiums. The pre-subscript represents a year of calendar time. The post-subscript measures the moment a rate is either inferred from the term structure or observed as an actual spot rate. The forward and spot rates Meiselman considered were for one year only. Hence, $_{t+m}E_t$ is the expected one-year spot rate for the year $t+m$ that is inferred from the term structure of interest rates at moment t. The expected one-year spot rate for the year $t+m$ that is inferred from the term structure of interest rates at moment $t-1$ is $_{t+m}E_{t-1}$. The difference between the post-subscripts t and $t-1$ is, for Meiselman's study, one year.

One cannot observe expected rates directly; the term structure of interest rates reveals only forward rates. Whether or not $E=F$, or $E+L=F$ must be established by empirical evidence. Suppose liquidity premiums exist and they increase monotonically at a decreasing rate as a function of term to maturity. Then the longer the time interval between the moment a one-year forward rate is in-

[19] The Hicksian view of the term structure of interest rates implies that forward rates are biased and high estimates of future short-term rates. He viewed the "normal" yield curve as being positively sloped. See John R. Hicks, *Value and Capital*, London 1946, pp. 135–140. Lutz explicitly rejected the view that liquidity premiums exist because he could observe short-term rates above corresponding long-term rates and he regarded this as a contradiction of the liquidity preference hypothesis. See Lutz, in *Theory of Income Distribution*, p. 528.

ferred from a term structure and the moment it becomes a spot rate, the greater the liquidity premium. Similarly, year-to-year changes in forward rates for specific calendar years will increase as they get closer in time to becoming spot rates. The largest increase will occur during the year a forward rate becomes a spot rate.[20]

If the forward rate, F, is equal to the expected rate, E, plus a liquidity premium, L, then substituting in (1) yields

$$({}_{t+m}F_t - {}_{t+m}L_t) - ({}_{t+m}F_{t-1} - {}_{t+m}L_{t-1}) = \beta[{}_tR_t - ({}_tF_{t-1} - {}_tL_{t-1})].$$

Let $- {}_{t+m}L_t + {}_{t+m}L_{t-1} = \Delta L$. Then the restatement of Meiselman's hypothesis becomes

$${}_{t+m}F_t - {}_{t+m}F_{t-1} = \beta({}_tR_t - {}_tF_{t-1}) + \beta_tL_{t-1} - \Delta L.$$

Letting $a = \beta_tL_{t-1} - \Delta L$, results in

$${}_{t+m}F_t - {}_{t+m}F_{t-1} = \beta({}_tR_t - {}_tF_{t-1}) + a. \qquad (2)$$

This is the regression equation Meiselman computed. He found that the observed constant was insignificantly different from zero. Hence, he inferred that a or $\beta_tL_{t-1} - \Delta L$ is also insignificantly different from zero.

A zero constant term is equally consistent with either $\beta_tL_{t-1} = \Delta L = 0$ or $\beta_tL_{t-1} = \Delta L > 0$. Hence, this piece of evidence is inappropriate for establishing the validity of the proposition that forward rates are unbiased estimates of expected spot rates; it is consistent with the existence of liquidity premiums. The proposition that forward rates are unbiased estimates of future spot rates remains untested.

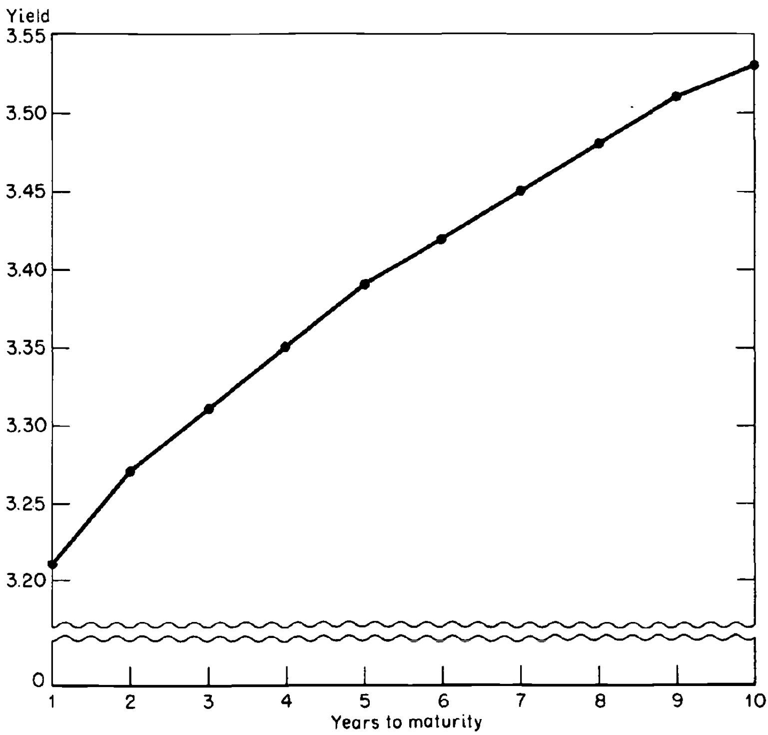
Meiselman's own work, the work of Hickman, the time series of short- and long-term governments for the past forty years (to be presented in Chapter 3), and some new evidence presented here, all support the view that the term structure of interest rates, as interpreted by the expectations hypothesis, embodies biased and high estimates of future short-term rates. Meiselman used Durand's yield curves for high-grade corporates from 1900 through 1954 for his tests. For each of these years, Durand estimated a yield curve. If an

[20] For the purpose of determining whether or not forward rates are biased or unbiased estimates of spot rates, the liquidity content of spot rates is irrelevant. It is only the difference, if any, between the liquidity content of forward and spot rates that matters.

average is computed of the yields for each term to maturity, i.e., an average of all fifty-five one-year maturities, two-year maturities, etc., the composite yield curve which results, reflects average conditions for all fifty-five years. This curve is in fact positively sloped (see Chart 2). Since interest rates, if anything, were trending down

CHART 2

Average Yield as a Function of Term to Maturity, Durand Data, 1900–1954



SOURCE: 1900–42, Durand, *Corporate Bonds;* 1943–47, Durand and Winn, *Basic Yields of Bonds;* 1948–51, *The Economic Almanac, 1956* (National Industrial Conference Board).

during these fifty-five years, forward rates must have been arithmetically high estimates of spot rates.

If liquidity premiums exist, the frequency of high estimates ought to be greater than that of low estimates and the average of the differences between estimated and actual rates ought to be positive.

Hence, Meiselman's error terms ought to have a significantly higher frequency of minus than plus signs and their average ought to be negative. Tests of these implications with the Wilcoxon two-sample and signed-rank tests lead to their acceptance.[21]

The foregoing demonstrates that forward one-year rates were on the average greater than actual one-year rates. It suggests that they were also greater than expected one-year rates and that they systematically overstate what the market expects one-year rates to be. This conclusion is based on an analysis of the inputs for Meiselman's independent variable. What about the dependent variable, i.e., the forward-rate changes that are regarded by Meiselman as prediction changes? Since forward rate changes are the difference between observations, separated by a year, of forward rates that pertain to a specific spot rate observable in the future, the first forward rate must be inferred from data further out on a yield curve than the second. Hence, if liquidity preference is operative (if it produces positively sloped yield curves), then the first forward rate ought to be, on the average, greater than the second. Meiselman observed prediction changes separated by one through eight years from the moment of time relevant for the measurement of the error term. The first forward rate is, on the average, larger than the second for all eight regressions. It is hard to rationalize this observation as a chance event; the probability of drawing eight successive negative numbers from a population in which negative and positive numbers are equally represented is less than 1 per cent. On the whole, this evidence is consistent with a positively sloped yield curve that flattens out as term to maturity increases; it is what one would expect to be derived from data summarized by Chart 2.

Meiselman's changes in forward rates and error terms constitute a measure of the marginal costs, more precisely the rate of change of yield with respect to term to maturity, of reducing term to maturity by a year. The pecuniary values at the margin, as revealed by the market, of liquidity changes attributable to changes in term

[21] See W. Allen Wallis and Harry V. Roberts, *Statistics: A New Approach*, Glencoe, 1956, pp. 596–598. Significance levels of 6 and 2 per cent were produced using one tail of the normal distribution. Of the fifty-four forward one-year rates, thirty-five were high and nineteen were low.

to maturity of one year are computed. They behave, roughly speaking, as one would expect; the longer it takes for a forward rate to become a spot rate, the greater the premium of forward over spot. With but two exceptions out of a possible nine cases, liquidity premiums decrease monotonically as term to maturity increases (see Table 1).

TABLE 1

MEISELMAN'S ERROR TERM AND FORECAST REVISIONS[a]

	Years Until Second Observation Becomes a One-Year Spot Rate	Per Cent
Mean error term[b]	0	-.143
Mean forward rate revision[c]	1	-.101
	2	-.078
	3	-.065
	4	-.077
	5	-.054
	6	-.040
	7	-.049
	8	-.022

[a]These data were obtained through personal communication with Meiselman.

[b]Mean of differences between one-year forward and spot rates.

[c]Mean change in one-year forward rates as term to maturity decreases by one year.

Hickman's data are consistent with Meiselman's findings. Predicted yield curves for the years 1936 through 1942, with a year between the time predicted and actual yield curves are observed, were all high. Even more interesting, and this is consistent with Meiselman's data, Hickman's results show that the longer the interval between predicted and observed or actual yield curves, the greater the bias in the estimates.[22] This empirical finding is an implication of a positively sloped yield curve when trends in rates are absent.

The data (to be presented in Chapter III) on yields of governments for the nine most recent business cycles, a period of roughly forty years, clearly indicate that the average yields of

[22] There are twenty-eight predictions, all too high. See Table A-1 which reproduces Hickman's data.

short-term governments are less than long-term governments. All nine cycles, without exception, conform to this generalization. These data constitute additional evidence that the term structure of rates, as interpreted by the expectations hypothesis, yields biased estimates of future short-term rates. If forward rates are not expected rates, but expected rates plus a liquidity premium, one should expect these time series to show that yields of short-term governments are usually less than long-term governments. Since Meiselman and Hickman worked with Durand's data, which reflect the yields of high-grade corporates, these data on the relative yields of short- and long-term governments for these nine cycles constitute independent evidence of the existence of bias in the predictions of the expectations hypothesis.

Unfortunately, this evidence is not unexceptionable. The fifty-five yearly observations of Durand, which Meiselman used, have a downward trend. In 1900, Durand's basic thirty-year rate was 3.30 per cent; in 1954, it was 3.00 per cent. If declining short-term rates are unanticipated, the predicted rates of the expectations hypothesis will exceed actual rates. From 1935 through 1942, the downward trend is still greater; the thirty-year basic rate fell from 3.50 to 2.65. Hence, if the long-term downward trend in rates has been unanticipated by the market, the relationship between the yields of short- and long-term governments may be a consequence of forecasting errors.[23]

Meiselman, like Walker, produced evidence relevant for evaluating the validity of the market segmentation hypothesis; unlike Walker, Meiselman points out the relevance of his work for this hypothesis. ". . . the systematic behavior of the yield curve would appear to contradict the widely held view that the market for debt claims is 'segmented' or 'compartmentalized' by maturity and that rates applicable to specific maturity segments can best be analyzed by rather traditional partial equilibrium supply and demand analysis where transactors act on the basis of preference for specific

[23] Hickman found that a simple projection of the previous year's yield curve produced numerically closer predictions than the expectations hypothesis, which is consistent with the foregoing interpretation. His finding is also, of course, consistent with an upward bias in the predictions of the expectations hypothesis.

maturities. . . ." [24] The correlation between forward rate revisions and error terms demonstrates that changes in the yields of one- and two-year securities are related to changes in yields of maturities up to nine and ten years. Consequently, at least for this maturity range, the market is not segmented enough to invalidate this test of the expectations hypothesis.

C. New Evidence

Confining tests of the expectations hypothesis to circumstances for which expectations can be presumed to be accurate has produced only fragmentary evidence. Expectations can be presumed to be accurate only under very special circumstances. Hence, forward rates can equal expected spot rates and yet differ from realized spot rates. But even this limited approach has not been fully exploited. Clearly, in a world in which spot rates are positive, and this would surely encompass the two most recent decades, one could assume that the market never expects negative spot rates. Therefore, if negative forward rates were observed, this would constitute evidence against the expectations hypothesis. Conversely, if negative forward rates were not observed, this would be evidence for the hypothesis.

The behavior of the term structure of bill yields during September 1960 contradicts the expectations hypothesis. In that month the forward rate on one-week money, inferred from the term structure of bill yields with maturities on December 8th and 15th, was often negative.[25]

For nine of the twenty-one trading days in September 1960, negative forward rates for one-week money could be observed. To restate the foregoing, on these nine dates in September 1960 (and this same phenomenon could be observed in September 1959) there existed some bills whose asked prices were higher than the asked prices for bills with one week less to maturity. Since it is unreasonable to argue that the market expected the spot rate for one-week

[24] Meiselman, *Term Structure of Interest Rates*, p. 34.

[25] The asked prices reported on the quote sheets of C. J. Devine were the source of price data. Salomon Bros. and Hutzler quote sheets contained data that led to the same conclusion.

bills on September 8th, or any other week since the end of World War II, to be negative, it follows that forward rates are not expected spot rates.

Critics have rejected the expectations hypothesis because the predictions of future short-term rates implied by the theory differed from subsequently observed actual rates. Meiselman argues that these critics have rejected the hypothesis for the wrong reasons. His position, that expectations need not be correct to determine the term structure of interest rates, is, of course, valid. Yet, given free entry and competition in securities markets, should not one expect to find a relationship between expectations as inferred from the term structure of interest rates and subsequently observed actual rates? It is of course unreasonable to expect expectations or predictions of future short-term rates to be absolutely accurate. New information coming to the market after a prediction is made will lead to prediction revisions and less than perfect forecasts. Yet new information should not lead to biases in the estimates; a mean bias should not be present. Hence, the average difference between predicted and actual rates ought to be insignificantly different from zero. The absence or presence of a mean bias in the relationship constitutes a test of whether or not forward rates are expected rates. Similarly, for very short intervals between the inference of predictions and the observation of actual short-term rates, there should be some observable advantage for the expectations hypothesis over some form of inertia hypothesis as a predictor of future short-rates. If not, why should the market waste its time and energy, which are scarce resources, in trying to predict future short-term rates? [26]

To control for trends in rates, and to measure forward and actual rates uninfluenced by capital gain considerations, the forward and actual yields of Treasury bills were examined from the beginning of 1959 through March 1962. All of the forward rates implicit in the

[26] Meiselman went too far in dismissing the work of Hickman and Culbertson. The expectations hypothesis, as he and Lutz interpreted it, does imply that there ought to be equality in the yields of short- and long-term rates in the absence of trends. If there is not, either the people operating in this market are doing an unbelievably bad job or this constitutes evidence against the Meiselman version of the expectations hypothesis.

TABLE 2

DISTRIBUTION OF ERRORS IN PREDICTING TREASURY BILL RATES[a]

	14-Day Rates	28-Day Rates	42-Day Rates	56-Day Rates	63-Day Rates	91-Day Rates
No. of observations	124	143	146	137	113	125
Frequency of high predictions	93	132	135	120	91	119
Average size of errors (per cent)	.199	.567	.599	.444	.455	.669
Average actual rates (per cent)	2.34	2.39	2.54	2.67	2.79	2.91

[a]Bills with precisely 182 and 91 days to maturity were used to compute the forward 91-day rate. Ninety-one days after this computation, the spot 91-day rate was observed and compared with the forward rate. Similarly, bills with 126, 112, 84, 63, 56, 42, 28, and 14 days to maturity were used to compute forward rates and to measure spot rates.

Bid and asked prices, obtained from government bond dealers, were averaged to obtain the prices used. The daily quote sheets of Salomon Bros. & Hutzler, C. J. Devine & Co., were the sources of bid and asked prices. These daily price reports quote bid and asked prices of bills for specified days to maturity from the time payment is received.

Forward 91-day rates were computed by subtracting the current 91-day rate from twice the current 182-day rate. This method of computing forward rates increases the difficulties of detecting an upward bias in the estimates of the expectations hypothesis. It understates forward relative to spot rates. Indeed, if the estimates of the expectations hypothesis were unbiased, this computing procedure would show a downward bias. Bill yields are bankers discount yields, and equal discount yields for different maturities are not comparable. For example, a 4 per cent discount yield on a 90-day bill implies a yield on a 360-day basis of 4.04 per cent. In contrast, a 4 per cent discount yield on a 180-day bill implies a yield of 4.08 on a 360-day basis. In general, the longer the term to maturity of a bill, the more its discount yield understates its bond equivalent yield. Hence, the procedure followed produces lower estimates of forward rates than would be produced by a correct computation.

term structure of interest rates during that time for two-, four-, six-, eight-, nine-, and thirteen-week bill rates were computed and compared with actual yields. The time period under investigation began and ended with the 91-day bill rate at the same level, approximately 2.75 per cent, although it rose sharply to 4.50 per cent and fell to 2.25 before it came back to its original level. The results of this investigation are tabulated in Table 2.

These results, along with the evidence already cited, strongly support the belief that forward rates are biased and high estimates of future short-term rates. Hence they are not the predictions of the market. In addition, these findings support the common belief that there exists a preference for short-term over long-term securities in the market. This preference produces a yield differential that constitutes an equalizing difference. The greater pecuniary yield of long-term securities represents compensation for the nonpecuniary advantages associated with holding short-term securities.

These findings also suggest that the futures market for money may be unlike other futures markets. Generally, one finds that forward prices are below corresponding spot prices when spot prices are rising and above them when spot prices are falling. For the futures market for money, however, forward rates in the Treasury bill market are typically above spot rates even when the latter are rising. During an upswing, the extent to which this occurs narrows, and some reversals, i.e., spot rates in excess of forward rates, occur. However, these reversals are suprisingly infrequent.

On theoretical grounds, one should expect liquidity premiums to vary with the level of interest rates. Treasury bills, like other securities, can be viewed as providing two streams of income: one is a pecuniary yield measured by interest rates; the other is a nonpecuniary yield as a money substitute. The average difference in 28- and 56-day bill yields can be viewed as an equalizing difference that reflects the greater value of the former as a money substitute. Economists customarily think of a rise in interest rates as implying an increase in the cost of holding money. By parity of reasoning, an increase in interest rates should also imply an increase in the cost of holding money substitutes. Since 28-day bills are better money substitutes than 56-day bills, a rise in interest rates implies that the opportunity costs of holding the former should rise relative to that of holding the latter. For this condition to be satisfied, yields of 56-day bills must rise relative to those of 28-day bills. Such a rise implies an increase in liquidity premiums, i.e., an increase in the spread between forward and actual 28-day rates. This reasoning is consistent with the results obtained for the range of bill maturities studied; the opportunity costs of holding any specified maturity, instead of a longer and hence less liquid maturity, increases as interest rates rise. Conversely, these opportunity costs decrease when rates fall. Within the range of bill maturities observed, and contrary to what is true for the yield curve as a whole, yield curves are steepest when rates are high and flattest when rates are low.

If the spread between 28- and 56-day bills increases with a rise in rates, and if liquidity premiums increase, then the premium of forward over spot money should also increase. This implies that what Meiselman and Hickman erroneously regarded as error terms, the difference between forward and subsequently observed spot rates, should be a positive function of the current level of spot rates. To determine whether or not this inference is correct, the difference between forward and subsequently observed 28-day spot rates was regressed on current 28-day spot rates. This is equivalent to regressing liquidity premiums plus or minus a forecasting error on current 28-day rates. These results are consistent with the hypothesis that liquidity premiums rise with the level of spot rates. The premium of forward over spot 28-day rates increases by one basis point for every increase of about five basis points in the spot rate.

The foregoing conclusion was derived from 137 monthly observations during the three business cycles from October 1949 through February 1961. They are supported by the results obtained from a regression using 138 weekly observations of 91- and 182-day bills from January 1959 through February 1961. For the latter test, the regression coefficient was about twice the former. A rise of about two and a half basis points in the 91-day bill rate is associated with a rise of about one basis point in the premium of forward over spot 91-day rates.[27]

[27] For the 91-day bills, the weekly observations cover a period when there were 182- and 91-day bills outstanding simultaneously. The regression coefficient was .43 with a standard error of .05.

For the 28-day bills, observations were obtained once a month. Typically, more than one observation could have been used in any month. The observation chosen was the one closest to the middle of the month. The regression coefficient was .22 with a standard error of .03.

The effects of bankers discount were eliminated from these data.

The association of a rise in liquidity premiums with a rise in the level of rates can also be shown by regressing the difference between forward and subsequently observed spot rates upon their sum.

The validity of these tests depends upon the absence of positive correlation between forecasting errors and spot rates. Unfortunately it is difficult to disentangle forecasting errors from liquidity premiums.

Since both interest rates and business conditions vary with the cycle, the finding that liquidity premiums rise with interest rates raises the question, are liquidity premiums a function of the level of interest rates or of the stage of the business cycle? In order to investigate this question, forward and actual 28-day bill rates were computed monthly from the term structure of 56- and 28-day bills for the three latest complete business cycles. During these three cycles, there was an upward trend in interest rates. Therefore, if liquidity premiums vary with the level of rates, it should be possible to observe that they rise secularly. The regression of the difference between predicted and actual 28-day rates on time for these three cycles does indicate an upward trend. Hence, liquidity premiums are positively related to the level of interest rates.[28]

The existence of liquidity premiums implies that the expectations hypothesis yields biased and high estimates of future short-term rates. It does not reveal in any direct way whether or not the market has any power to correctly anticipate subsequently observed spot rates. If liquidity premiums are held constant, if expected and not forward rates are observed, does a significant relationship exist between these expected rates and subsequently observed spot rates?

Forward rates for specific periods of calendar time and subsequently observed spot rates for the same periods were subjected to correlation analysis. This corrects, in a very crude way, for bias in the estimates of future spot rates attributable to liquidity premiums. Forward rates, which can be regarded as market predictions when adjusted for liquidity premiums, were inferred from the term structure of 182- and 91-day bill rates. (These rates were computed using an average of bid and asked prices adjusted for bankers discount.)

The results of this test indicate that the expectations hypothesis definitely does have predictive content. For 138 predictions of 91-day bill rates from the beginning of 1959 through the first quarter of 1962, the expectations hypothesis explained 58 per cent of the observed variation. The question remains whether an inertia hypothe-

28 Of 137 predictions of the Lutz variant of the expectations hypothesis, 121 were high, five low, and eleven were correct. The effects of bankers discount were eliminated from these data.

sis could do equally well or better. Perhaps the observed correlation could be attributable to serial correlation in the data.

To determine whether or not the results obtained should be imputed to correct expectations, two variants of an "inertia hypothesis" were considered. One "predicted" 91-day bill rates 91 days hence by assuming no change. The other extrapolated into the future the difference between current 91-day rates and those 91 days ago.

The correlations for both variants of the inertia hypothesis tested were the same; each explained 48 per cent of the observed variation. The expectations hypothesis explained approximately 20 per cent more of the observed variation. During most of the period of observation, from about the middle of 1959 through the middle of 1960, there was a sharp rise and fall in rates. For the remainder of the period, interest rates were roughly stable. If the two hypotheses are compared for the period when rates were highly unstable (this reduces the number of observations to fifty), then expectations explain 48 per cent of the observed variations, whereas the variants of inertia each explain 30 per cent. The comparative advantage of the theory was stronger, as one would expect, when interest rates were unstable.

Is the observed difference between these correlation coefficients significant? Could it have occured as a result of chance? To answer this question, forward and current spot rates were correlated with subsequently observed spot rates and the partial correlation coefficients were computed. The addition of current spot rates increased the fraction of the observed variation explained from 58 to 59 per cent. The partial regression coefficient for expectations was significant and positive (the partial regression coefficient was .86, with a standard error of .14). In contrast, the partial regression coefficient for inertia was negative and also significant (the regression coefficient was $-.31$, with a standard error of .18).

These results indicate clearly that the expectations hypothesis does have predictive content that cannot be attributed to inertia. However, the negative coefficient for inertia requires explanation. The hypothesis presented here views the forward rate as a function of expected spot rates plus a liquidity premium. But liquidity premiums are a function of the level of spot rates: when current spot rates are high, the premium over spot that is reflected in the forward rate is also high, and vice versa. Hence, the larger the spot rate, the larger the number that ought to be deducted from forward rates to obtain the expected rates of the market. Therefore, the negative coefficient which is observed is consistent with the view that liquidity premiums exist and vary directly with the level of interest rates, more specifically with spot rates.

To restate this argument more formally, using symbols already defined:

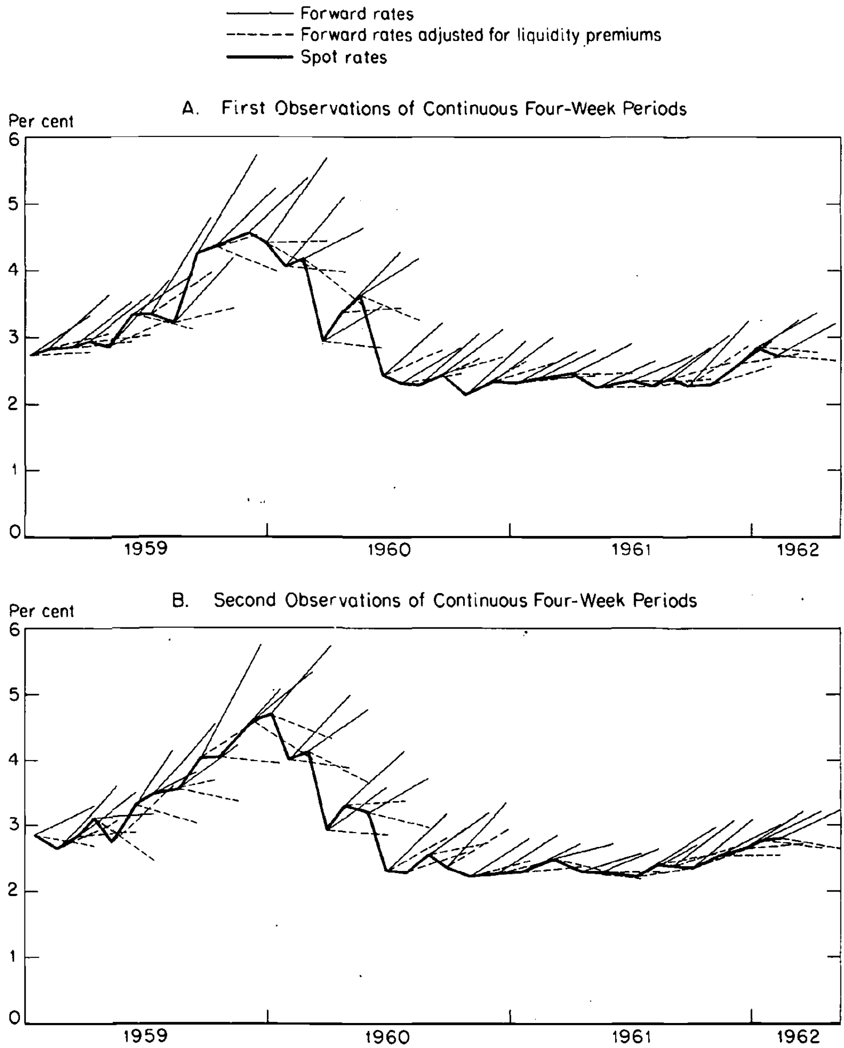
1. ${}_{t+1}F_t = {}_{t+1}E_t + {}_tLP_t.$
2. ${}_tLP_t = f({}_tR_t).$
3. ${}_{t+1}F_t - f({}_tR_t) = {}_{t+1}E_t.$
4. ${}_{t+1}E_t = {}_{t+1}R_{t+1} + U.$
5. ${}_{t+1}F_t - f({}_tR_t) = {}_{t+1}R_{t+1} + U.$

The data used to evaluate the predictive content of the expectations hypothesis are reproduced in Chart 3. The thick line depicts actual 91-day rates. The thin lines indicate forward rates adjusted and unadjusted for liquidity premiums. The point of origin of the thin lines at the thick line represents the moment a forward rate is inferred; the terminal point of the thin line measures the magnitude of the forward rate at the moment when the actual 91-day rate corresponding to this forward rate can be observed. Liquidity premiums were measured using the regression equation obtained by regressing the difference between forward and realized 91-day rates on current spot rates. These results suggest that within the range of maturities encompassed by Treasury bills, expectations do influence the term structure of interest rates, and the market forecasts future spot rates with some degree of accuracy. However, to obtain the expectations of the market, liquidity premiums must be deducted from forward rates.[29]

[29] The fact that forward rates are usually higher than actual spot rates may have led Hickman to abandon the search for a relationship between them. An inertia hypothesis could produce numerically closer predictions to spot rates than the expectations hypothesis, yet the latter could produce stronger correlations. It is the strength of the correlations, if one accepts the view that liquidity premiums exist, that is relevant for evaluating these alternatives. Insofar as liquidity premiums are a constant or linear function of forward rates, they do

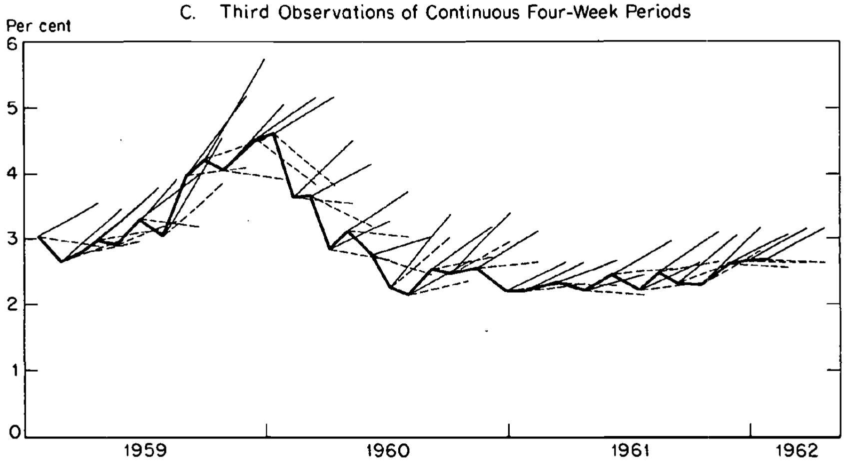
CHART 3

Market Expectations of Future 91-Day Bill Rates

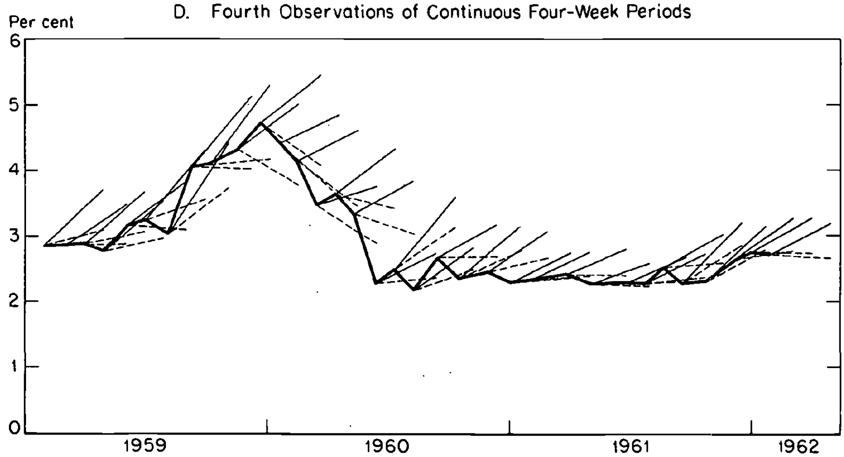


——— Forward rates
- - - - - - Forward rates adjusted for liquidity premiums
——— Spot rates

C. Third Observations of Continuous Four-Week Periods



D. Fourth Observations of Continuous Four-Week Periods



Thus far, this analysis does not reveal how stable the liquidity preference function is. Is the relationship between spot rates and liquidity premiums stable enough to permit one to estimate liquidity premiums for one business cycle and use these estimates to uncover successfully the expectations of the market, as distinguished from forward rates, for a second cycle? To answer this question, the regression of the difference between forward and subsequently observed 28-day spot rates upon current 28-day spot rates, for the two cycles from October 1949 through April 1958, was used to estimate liquidity premiums for the following cycle. Then inertia and expectations were compared as a means of forecasting subsequently observed spot rates. Expectations was definitely the better predictor. The standard error of estimate was .50 for inertia against .38 for expectations. The partial regression coefficient for inertia was –.07; for expectations, it was .75. The standard error of the regression coefficient was .19 for inertia and .16 for expectations. Multiple correlation analysis, using forward rates adjusted for liquidity premiums, yields results almost identical with those obtained with unadjusted forward rates.[30]

These results suggested that the data Meiselman employed, which were compiled by Durand, should be reexamined to see if forward rates do predict subsequently observed spot rates. Hence forward and current spot rates were considered as independent variables and subsequently observed spot rates as the dependent variable in a multiple regression equation. This involves using the same data Meiselman used to compute what he regards as an error term. No evidence of successful forecasting was detected; inertia appeared to be the better independent variable.

To utilize more recent data that are qualitatively more com-

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not influence the correlation of forward with spot rates. For the two sets of seven pairs of observations in Hickman's study, representing one-year forecasts, the correlation coefficient for expectations was .725; for inertia, .721. When both variables were included in a multiple correlation, neither had a significant partial correlation coefficient. Hence no basis is provided by correlation analysis for arguing that one or the other variable explained the observed variation. If one plots forward rates and the variant of inertia Hickman employed, there is almost a constant difference between them.

[30] For the three cycles, 1949 to 1961, the simple correlation coefficients indicated that expectations explained 88 per cent of the observed variation whereas inertia, i.e., extrapolating no change, explained 82 per cent.

parable to the data Meiselman utilized, the experiment performed with forward and spot three-month Treasury bills was repeated using monthly forward and spot one-year governments for 1958 through 1961. One- and two-year rates were read off the fixed maturity yield curve published monthly in the Treasury Bulletin.[31] Again forward and current spot rates were treated as independent variables and subsequently observed spot rates as the dependent variable. The result is consistent with that using three- and six-month bills and reinforces the view that the market has some power to forecast successfully. However, taken by itself it does not constitute quite as convincing evidence of the existence of successful forecasting. This is what one would expect; it is harder to forecast a year into the future than it is to forecast for three months.

If the rationalization of the statistical findings using three- and six-month bills is correct, then forward rates should have a positive coefficient and current one-year rates a negative one. One should also expect to find that the partial correlation coefficient for expectations would be smaller in the case of one- and two-year Treasury securities than it was for three- and six-month bills.

These anticipations are in general borne out. The sign of the regression coefficient for one-year spot rates is negative. For three- and six-month bills, this regression coefficient is 75 per cent greater than its standard error; for one- and two-year governments, it is a third larger than its standard error. For three- and six-month bills, the regression coefficient for forward rates is positive and six times its standard error; in the case of one- and two-year governments, it is positive but only nine-tenths its standard error.

Possibly the most convincing evidence that the market can forecast, with modest accuracy, one-year spot rates one year into the future was obtained through the following experiment. Liquidity premiums embodied in one-year forward rates for the 1958–61 cycle were estimated from an equation derived from the difference between forward and subsequently observed spot rates regressed on current one-year rates for the 1954–58 cycle. The expected rates of the market for the 1958–61 cycle were then obtained by subtracting

31 I am indebted to H. Irving Forman of the National Bureau staff for these measurements. They are reproduced, along with the related forward and spot rates, in Appendix Table B-1.

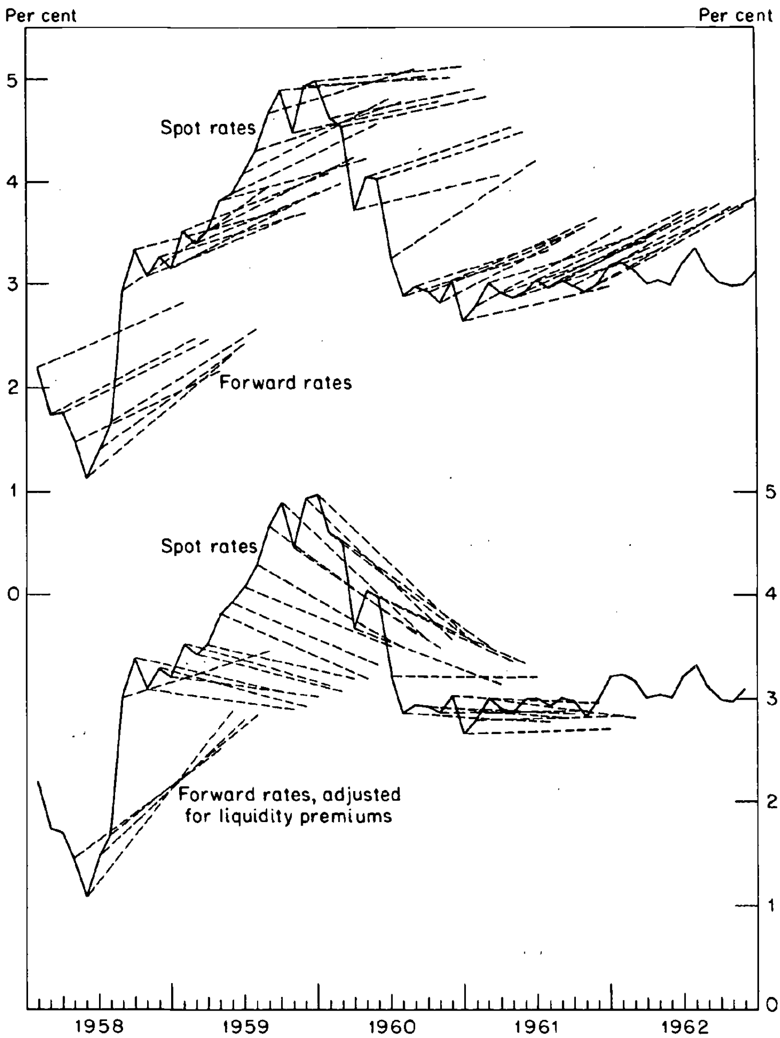
the estimated liquidity premiums from forward rates. The mean square errors in the implicit forecasts of the market, i.e., the difference between forward rates less liquidity premiums and subsequently observed spot rates were compared with those generated by assuming next year's one-year spot rates will be identical with current rates. Although neither independent variable appeared in some absolute sense to yield very good forecasts, it is clear that expectations was significantly better as an independent variable than inertia. For thirty-five monthly observations, the mean square error was 2.09 for inertia, .91 for expectations. The elimination of liquidity premiums contributed importantly to this reduction in error. Without such adjustment, the mean square error of the forward rates was 1.91, only slightly less than that for inertia. These results show that if one is predicting one-year rates one year hence, and the current one-year rate is known, adding the two-year rate to one's knowledge constitutes a valuable piece of information.

Time series of forward and spot one-year rates during the period 1958 to 1961 are reproduced as Chart 4. These data, as well as the data for forward and spot three-month bills, suggest that the market can detect spot rates that are abnormally high or low. All of the forward rates are biased estimates. However, if one examines the slopes of the lines connecting current spot rates with forward rates for one year into the future, these lines appear flattest when current spot rates are highest. Hence, if the market can abstract from liquidity premiums (which produce the bias) then it appears that the market can forecast. That is, when rates are high, the market expects them to fall, and conversely, as the adjusted forward rates in the lower part of the chart suggest. This is consistent with the view that the market has some notion of what constitutes a normal rate of interest.

What causes the observed difference between the results using Durand's data on corporates and the recent data on one- and two-year governments? The evidence provides the basis for highly speculative answers at best. Durand's data encompass fifty-five years and are yearly observations; the data on governments encompass five years and are monthly observations. Possibly the market cannot distinguish between cyclically and secularly high and low rates

CHART 4

Forward and Spot One-Year Rates on Government Securities



SOURCE: Derived from Treasury yield curves, using one- and two-year rates. The rates in the upper section of the chart are from Table B-1; those in the lower section, from Tables B-2 and B-3.

of interest. If the market could anticipate cyclical changes better than secular changes, there would be an observed difference in forecasting accuracy over one cycle as compared with many cycles. When spot rates are high cyclically, their subsequent change is quite different from that when they are high secularly. If the forecasts of the market are the same in either case, studies of the accuracy of forecasts will lead to different results depending upon the time period under investigation.

Another avenue for explaining secular and cyclical differences is the study of the stability of liquidity premiums over time. Before the 1930's, judging by Durand's data, liquidity premiums were much smaller or possibly nonexistent. There seems to have been a structural change in the economy in this respect since the early 1930's. Possibly this can be attributed to the abolition of interest on demand deposits, or perhaps to a change in attitude toward risk that led to changes in liquidity premiums. In any case, instability of liquidity premiums could account for the observed difference in the secular and cyclical correlations of forward and one-year spot rates.

Still another avenue for explaining these findings is data limitations. Durand did not use a criterion such as least squares for his curve fitting. He fitted only yield curves that do not have maximums or minimums. When his yield curves were not flat throughout, they either increased or decreased monotonically with term to maturity and then flattened out. By definition, Durand could not observe a yield curve with any other shape. He offers no explanation for this self-imposed constraint.

In the postwar period, when short-term rates have been above long-term rates, yield curves have been hump shaped. These curves at first rise with term to maturity, reach a maximum, and then fall and finally flatten out. It is difficult to believe that this was not also true during some of the fifty-five years encompassed by Durand's data. If one examines both the data and the curves fitted, it is clear that humped yield curves could just as correctly have been fitted some of the time. Since this was not done, one- and two-year rates derived from Durand's curves are probably high estimates of true one- and two-year rates, and are high relative to longer maturities.

If one examines the yield curves Durand fitted to data in the 1920's, yield curves for governments and corporates have opposite slopes for three of these years. Indeed, the data on governments presented above show short-term governments yielding, on average, less than long-term governments in the 1920's. Durand's findings on corporates indicate just the opposite.

Another difficulty, ignored by both Hickman and Meiselman, is the fact that Durand's yield curves are drawn for coupon bonds. Hence, the Hicksian formula for internal rates of return or yield to maturity, which implicitly assumes the absence of coupons, is inappropriate for computing forward rates. To compute forward rates correctly, both coupons and yields to maturity, or internal rates of return, must be known.

If one accepts the view that yield curves were, on average, positively sloped during the fifty-five years Durand observed, then coupon rates for bonds with one or two years to maturity must have, on average, exceeded internal rates of return. If coupons exceed internal rates of return, then it can be shown that the Hicksian formula underestimates forward rates. However, the measurement errors which can be attributed to ignoring coupons seem to be small compared to those attributable to uncertainties regarding the shape of Durand's yield curves. Using coupons of 6 per cent, errors in computing forward rates seem to be on the order of two or three basis points.

The figures on bill rates collected provide new data to repeat Meiselman's experiments. The results of tests of the expectations hypothesis using Treasury bills are tabulated in Table 3. Treasury bills with terms to maturity of less than six months are the source of price data.

Since these correlations are all unambiguously significant, they provide additional support for Meiselman's view that a relationship between expectations and the term structure of interest rates exists. His major conclusion—that there is validity in the expectations hypothesis—is sound, despite his failure to isolate unanticipated changes in interest rates and to recognize that forward rates were not expected rates. What about the data Meiselman used? How are the liquidity premiums related to the level of rates for Durand's

TABLE 3

CORRELATION OF FORECAST REVISIONS WITH ERRORS AS DEFINED BY MEISELMAN, 1958-61[a]

Type of Error	Correlation Coefficient	Regression Coefficient
1. Error in forecast of two-week rates with changes in expected two-week rates two weeks hence	.37	.40
2. Error in forecast of two-week rates with changes in expected two-week rates eleven weeks hence	.36	.26
3. Error in forecast of four-week rates with changes in expected four-week rates twelve weeks hence	.21	.27
4. Error in forecast of six-week rates with changes in expected six-week rates eighteen weeks hence	.59	.62
5. Error in forecast of eight-week rates with changes in expected eight-week rates sixteen weeks hence	.85	.59

Source

Line 1: Correlation of changes in predicted two-week bill rates with forecasting errors implied by the expectations hypothesis, i.e., with the difference between predicted and actual two-week rates. The error terms were obtained by comparing predictions implied by four- and two-week bill rates with actual two-week bill rates two weeks later. The prediction changes were obtained from the difference between the predicted two-week rate four weeks hence and then, two weeks later, two weeks into the future. The first prediction was obtained through the use of six- and four-week bills; the second was measured through the use of four- and two-week bills.

Line 2: Correlation of changes in predicted two-week bill rates as inferred from eleven- and nine-week bills and, two weeks later, from nine- and seven-week bills with the difference between predicted and actual two-week rates. The independent variables for this and the test described in Line 1 are identical.

Line 3: Correlation of changes in predicted four-week bill rates with the prediction errors implied by the expectations hypothesis. The independent variable is the difference between predictions implied by eight- and four-week bill rates and, four weeks later, actual four-week bill rates. The dependent variable--the prediction change--is the difference between the predicted four-week rate implied by the sixteen- and twelve-week bill rates and, four weeks later, the predicted four-week rate implied by the twelve- and eight-week bill rates.

Line 4: Correlation of changes in predicted six-week bill rates with prediction errors. The independent variable is the difference between predictions implied by twelve- and six-week bill rates and, six weeks later, actual six-week bill rates. The dependent variable, the prediction change, is the difference between the predicted six-week rate implied

NOTES TO TABLE 3 (concluded)

by the twenty-four- and eighteen-week rates and, six weeks later, the predicted six-week rate implied by the eighteen- and twelve-week bill rates.

Line 5: Correlation of changes in predicted eight-week bill rates with prediction errors. The independent variable is the difference between predictions implied by sixteen- and eight-week bill rates and, eight weeks later, actual eight-week bill rates. The dependent variable, the prediction change, is the difference between the predicted eight-week rate implied by the twenty-four- and sixteen-week rates and, eight weeks later, the predicted eight-week rate implied by the sixteen- and eight-week rates. This may be illustrated by the following sample calculation. On November 28, 1961, the sixteen-week rate was 2.61, and the eight-week rate 2.51. The expectations hypothesis implies that the eight-week rate eight weeks hence, on January 23, 1962, is expected to be 2.71. This is twice the sixteen-week rate less the eight-week rate. The actual eight-week rate on January 23, 1962, eight weeks after November 28, was 2.61. Hence the error is -.10. The first prediction in the data from which Line 5 was derived was inferred from the twenty-four- and sixteen-week rates on November 28, 1961. These were 2.72 and 2.61 respectively. Hence the predicted rate for March 20, 1962, which is three times the twenty-four-week rate less twice the sixteen-week rate, is 2.94. Eight weeks later, on January 23, 1962, the sixteen-week rate was 2.72, and the eight-week rate 2.61. Hence the predicted eight-week rate for March 20, 1962, was 2.83, and the prediction change -.11.

[a]The existence of liquidity premiums implies that the errors as defined by Meiselman are typically larger than the true errors the market committed. The true errors are the differences between forward rates minus liquidity premiums and spot rates; the true forecast revisions are the observed revisions net of liquidity differences.

data? The regression of the difference between forward and subsequently observed spot one-year rates against current one-year rates reveals little variation in the "error" with the level of spot rates. The regression coefficient is .09 with the standard error of .06, and only about 4 per cent of the variation is explained. In contrast, for the same regression using forward and spot one-year governments for the 1958–61 cycle, the regression coefficient is one, with a standard error of .10, and 70 per cent of the variation is explained. Clearly the different between forward and spot rates for the government data appears to be much more sensitive to variations in spot rates than it is for Durand's data.

The reappearance of a seasonal in the money market in recent years implies that it is possible to repeat Macaulay's experiment with a new body of data. If the expectations hypothesis is correct, seasonal adjustment factors ought to vary systematically with term to maturity. More specifically, just as the time money rates "anticipated" seasonal changes in call money rates, changes in, say, sixty-day seasonal adjustment factors ought to "anticipate" changes in thirty-day factors. Hence it should be possible to construct a set of seasonal adjustment factors for sixty-day rates if the factors for thirty-day rates are known; knowledge of seasonal adjustment factors for thirty-day bills implies knowledge of these factors for bills of longer maturity.

To test this hypothesis, weekly moving seasonal adjustment factors were computed for twenty-seven- and fifty-five-day bills for 1959, 1960, and 1961, using bid prices unadjusted for bankers discount. If the expectations hypothesis is correct, a set of seasonal adjustment factors for fifty-five-day bills constructed out of twenty-seven-day factors ought to be more strongly correlated with actual fifty-five-day factors than just twenty-seven-day factors alone. For every week, a simple average of twenty-seven-day factors for that week and for four weeks in the future was computed. This should be, according to the expectations hypothesis, a fifty-five-day seasonal. The correlation of this set of theoretical seasonal adjustments with actual fifty-five-day adjustment factors was stronger than the correlation between twenty-seven- and fifty-five-day factors. Converse results ought to hold for a fifty-five-day seasonal adjustment constructed out of twenty-seven-day factors, if the adjustment factors are obtained by averaging the current twenty-seven-day seasonal with that of four weeks in the past. This seasonal, when correlated with the fifty-five-day seasonal directly computed, ought to exhibit less correlation than exists for the relationship between twenty-seven- and fifty-five-day factors. Hence the rank ordering of cor-

TABLE 4

COEFFICIENTS OF CORRELATION BETWEEN WEEKLY SEASONAL FACTORS IN TREASURY BILL RATES, 1959-61

Type of Seasonal Program	Average of 27-Day Seasonals (Current and 4 Weeks Hence) with 55-Day Seasonal	27-Day Seasonal with 55-Day Seasonal	Average of 27-Day Seasonals (Current and 4-Weeks Past) with 55-Day Seasonal
Multiplicative	.844	.811	.520
Additive	.804	.750	.486

relations alone, quite apart from the question of whether or not there is a significant difference between the correlations, constitutes evidence that the market anticipates seasonal movements in rates. These findings are summarized in Table 4.

The Durand data and the data collected for this study provide a means for discriminating between expectations and liquidity preference on the one hand and market segmentation on the other. The market segmentation hypothesis implies that differences in maturity account for differences in substitutability between securities. If maturity differences are held constant, then the substitutability or the cross elasticity of demand ought also to be constant. In contrast, the expectations hypothesis implies that a seven-year security is more like an eight-year security than a one-year security is like a two-year security. The expectations hypothesis implies that the common element in two securities separated by a year in maturity increases monotonically as term to maturity increases.

Similarly, if one accepts the view that liquidity preference varies with the level of rates, then the premium increases as the level of rates increases. Hence, if securities separated by a year in term to maturity are examined, one should expect the common element to increase as term to maturity increases. Because both liquidity preference and expectations have common implications, this test does not discriminate between them. It does, however, produce evidence that must be regarded as discriminating between expectations and liquidity preference on the one hand and market segmentation on the other.

The foregoing tests were performed with two independent sets of data: the Durand data that Meiselman used and yields to maturity, for the latest cycle, read off the yield curve in the *Treasury Bulletin* by a draftsman. The test employed was a simple rank test. The expectations and liquidity preference hypotheses imply that the correlations between securities separated by a year in term to maturity ought to decrease monotonically as term to maturity increases. Hence the theory forecasts a set of ranks that can be compared with the observed ranks to see if they are positively correlated.

Consistent results were obtained using these independent sets of data. The ranks predicted by the expectations and liquidity preference hypotheses and the actual ranks were highly correlated. Each set of data consisted of nine pairs of ranks. Using the Olds rank correlation test, and interpreting the implications of the liquidity preference and expectations as implying a one-tail test, both significance levels were under 2 per cent.[32]

The foregoing analysis of the implications of liquidity preference and expectations for the correlation between the yields of securities separated by a constant time span as term to maturity increases also implies that yield curves ought to flatten out with maturity. Given that the weights assigned to marginal rates of interest, in the determination of average or internal rates of return, decrease with maturity, then yield curves must flatten out with maturity. This assumes that the variance in forward rates is independent of term to maturity.

The evidence presented supports the Hicksian theory of the term structure of interest rates; it supports the view that both expectations and liquidity preference determine the term structure of interest rates. These results show that forward rates should be interpreted as expected rates plus a liquidity premium. If forward rates are so interpreted, then the expectations of the market seem to forecast subsequently observed short-maturity spot rates; the relationship between expected and subsequently observed spot rates cannot be rationalized as the workings of chance.

With respect to the market segmentation hypothesis, the evidence is less clear. These findings show that this hypothesis is not of the same magnitude as liquidity preference and expectations in the determination of the term structure of rates. The fact that forward rates embody short-term forecasts of spot rates that have a perceptible degree of accuracy implies that liquidity premiums are stable. Hence the scope for the impact of market segmentation upon the term structure of rates must be limited. The Meiselman findings on the relationship between what he termed forecast revisions and errors support this view, as do the tests presented here.

[32] The test employed is described in W. Allen Wallis, "Rough-and-Ready Statistical Tests," *Industrial Quality Control,* March, 1952.

A proponent of market segmentation may argue that these tests, in particular, the test based on holding absolute maturity differences constant while varying relative maturity differences, are based on incorrect interpretations of market segmentation. Economic literature does not contain a statement of the market segmentation hypothesis that is as rigorous as those available either for liquidity preference or expectations. Therefore, the possibility of misinterpretation cannot be easily dismissed. The Walker findings which deal with the root of the market segmentation hypothesis are particularly relevant. He showed that institutions have sharply changed the maturity composition of their holdings in response to market forces. This seems to strike at the very foundation of the market segmentation thesis. The only contrary evidence uncovered—this is also subject to the same uncertainties about its relevance—is the existence of negative forward rates in the bill market. Such occurrences seem to be rare, and therefore relatively insignificant, but should not be dismissed entirely. There is always the possibility that more of such evidence exists or that the effects of market segmentation are relatively subtle and the tests employed too crude to detect its existence.[33]

[33] There were negative forward rates in the bill market in the 1930's. At that time rates were relatively low and taxes on bank deposits in Illinois were high enough to make it profitable to take a negative yield rather than be subject to taxation on deposits.