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I. Introduction and Summary

It has been observed that when the level of interest rates rises all rates increase, but short-term rates rise systematically more than long-term rates. Over time, therefore, short-term rates experience wider fluctuations than long-term rates. This behavior, however, does not provide any clue as to which interest rate leads the other over the cycle. Most research on term structure of interest rates has focused on the yield curve at a point in time;[1] little has been done to investigate the joint movement of short- and long-term interest rates through time. In this study, we compare the cyclical behavior of short-term and long-term interest rates in the United States during the period 1954-1967. The relationship between the 90-day Treasury bill rate and the 10-year U. S. Government bond rate is analyzed by the cross-spectral method.[2]

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[1]For summaries of such studies, see B. G. Malkiel, *The Term Structure of Interest Rates* (Princeton: Princeton University Press, 1966), Chapter 2; and L. G. Telser, "A Critique of Some Recent Empirical Research on the Exploration of the Term Structure of Interest Rates," *The Journal of Political Economy*, Vol. 75, No. 4, Part II (August 1967).

[2]Other recent studies which use spectral and cross-spectral analysis to analyze cyclical behavior of interest rates are D. Fand, "A Time Lines Analysis of the Bills-Only Theory of Interest Rates," *The Review of Economics and Statistics*, Vol. XLVIII (November 1966), pp. 361-371; C. W. J. Granger and H. J. B. Rees, "Spectral Analysis of the Term Structure of Interest Rates," *The Review of Economic Studies*, Vol. XXXV, No. 101 (January 1968), pp. 67-76; and J. T. Sargent, "Interest Rates in the Nineteen-fifties," *The Review of Economics and Statistics*, Vol. L, No. 2 (May 1968), pp. 164-172. These studies differ widely in their conclusions.

This study differs from previous research on the cyclical behavior of interest rates[3] in that the yield data employed for the cross-spectral analysis were obtained from regression-fitted yield curves (rather than hand-fitted curves). It is also different from previous studies in regard to the method of correction of the non-stationary nature of the rate series. Rather than the conventional method of using first differences, deviations from a fitted trend line were employed. In addition, two lag windows were used to insure as much significance as possible in the interpretation of the cyclical pattern of behavior.

Our results show that a short-run cycle of 18 to 24 months is significant in both series and that, over this range, the long rate leads the short rate. As the cycle length increases, the lead period (of the long rate over the short rate) becomes shorter. The observed cycle may be due to the pattern of the refinancing of the debt by the Treasury, or to changes in the demand for funds by other borrowers. The finding that the long rate leads the short rate is consistent with the expectations hypothesis of the term structure of interest rates. In its simplest form, that hypothesis asserts that the long rate is a geometric average of the current short rate and expected future short rates. To the degree that expectations are realized, therefore, the expectations hypothesis implies that the long rate should move in advance of the current short rate.[4]

II. The Data

The data used in this study were derived from monthly observations on U. S. Treasury securities. Since securities of a specified term to maturity are not always to be found at prespecified time intervals, it is customary

[3]See, for example, Fand, *op. cit.*, Granger and Rees, *op. cit.*, and E. Parzen, "Mathematical Consideration in the Estimation of Spectra," *Technometrica*, Vol. 3 (1961), pp. 167-190.

[4]Evidence on this point has also been sought in the seasonal movements of interest rates. See R. A. Kessel, *The Cyclical Behavior of the Term Structure of Interest Rates*, Occasional Paper 91 (New York: National Bureau of Economic Research, 1965), pp. 7, 39-41. The lead of long rates over short rates in the short cycles may be due to the fact that errors in forecasting long-term rates are more costly to investors than errors in forecasting short-term rate peaks and troughs. Long-term securities typically experience larger capital losses -- for a given percentage increase in interest rates -- than do short-term securities.

to obtain the desired yields from yield curves. A yield curve for a particular point in time is based on plotting yields versus term to maturity for a number of outstanding securities for which yield quotations are available. A curve is then fitted through these points in some manner. This curve permits the yield for any desired term to maturity to be estimated as the height of the yield curve for that maturity.

The yield curve is supposed to reflect the relation between yields on securities which differ only with respect to term to maturity. It is assumed that consideration of Treasury securities removes one of the largest potential sources of differences in yield aside from term to maturity -- i.e., differences in risk of default. Most term structure studies, therefore, have used the monthly yield curves appearing in the *Treasury Bulletin.*[5] These curves have been fitted by eye to observed market yields, before taxes, on various Treasury issues outstanding. Cohen, Kramer and Waugh (hereafter CKW) pointed out that a freehand yield curve, in addition to the inherent problem of the limited accuracy in reading it, suffers also from non-objectivity and non-reproducibility.[6] Different people fitting hand-drawn yield curves to the same data will get different results.[7]

CKW proposed the use of regression analysis to generate yield curves. Regression equations are both objective and reproducible. On the basis of various tests, they recommended the following model:

$$R(D) = d_o + d_1 D + d_2 (\ln D)^2, \tag{1}$$

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[5]U. S. Treasury Department, "Market Quotations on Treasury Securities," *Treasury Bulletin* (various issues, 1954-1968).

[6]J. C. Cohen, R. L. Kramer, and H. W. Waugh, "Regression Yield Curves for U. S. Government Securities," *Management Science*, Vol. 13 (December 1966), pp. B-168 - B-175.

[7]Given a set of observed yields, there is no certainty as to whether there is a single most "correct" yield curve for these points. One should not, therefore, infer from the above comment that the yield curves in the *Treasury Bulletin* are inferior in a conceptual sense. Rather, it is the practical difficulties in reading values from these curves, with the disadvantages this poses for reproducibility of research, that concern us here.

where D denotes days to maturity and R(D) denotes the fitted value of the absolute yield.[8] We used this yield curve model to obtain the data for our cross-spectral analysis.

The raw data for the yield curves for this study are essentially those on which the *Treasury Bulletin* yield curves are based.[9] From these data, a yield curve (based on closing bid prices) for the last day of each month was constructed. D was calculated for each issue using the following expression:

$$(2) \qquad D = 360(Y_m - Y_c) + 30(M_m - M_c) + (D_m - D_c),$$

where Y_m, M_m, and D_m are the year, month, and day, respectively, of the maturity date of this issue and Y_c, M_c, and D_c are the year, month, and day, respectively, of the date for which the yield curve is being constructed. The D values obtained from (2) and the yields of the associated issues were used to construct a yield curve based on (1).[10] Yield curves for U. S. Treasury securities were estimated for each of the 168 end-of-month dates for the period 1954-1967. The two yield series used in this study (for 90-day and 10-year U. S. Treasury securities) were calculated from these yield curves.

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[8] CKW evaluated over 250 multiple regression models and on the basis of various tests recommended the use of (1). It should be emphasized that the object in fitting a yield curve is not to show that term maturity causes yield. Rather, we seek to describe, in functional form, whatever pattern the yields exhibit with regard to term to maturity. Note also that all observations for a given yield curve are for one point in time. The yield curve for a different time involves different values of d_0, d_1, and d_2 in (1).

[9] The *Treasury Bulletin* yield curves include yields on three maturities of Treasury bills; no bill yields were used in forming the yield curves for this study.

[10] For the purpose of constructing yield curves, the error involved in calculating D by the assumption that each year contains 12 months of 30 days each is not believed to be significant. To illustrate the derivation of yield data, suppose we have estimates $\hat{d}_0$, $\hat{d}_1$, and $\hat{d}_2$ for the parameters of (1) for some given date. Suppose now that it is desired to calculate the rate for a four year and three month term to maturity from this yield curve. The value of D according to (2) is D = 360(4) + 30(3) = 1530 and the estimate of the desired rate would then be calculated as: $R(1530) = \hat{d}_0 + \hat{d}_1(1530) + \hat{d}_2(\ln 1530)^2$.

III. Cross-Spectral Analysis: Some Practical Considerations

Cross-spectral analysis is employed to measure the extent to which two series are inter-related and to determine the type of lead-lag structure involved.[11] The interpretation of the cross spectrum is based on two measures: coherence and phase angle. The coherence, Co(w), between two series, x(t) and y(t), is defined as:

$$Co(w) = \frac{C^2(w) + Q^2(w)}{fx(w) \quad fy(w)} ,$$

where C(w) is the co-spectrum, Q(w) is the quadrative spectrum and fx(w) and fy(w) are the spectra of x(t) and y(t), respectively. The coherence measures the square of the correlation coefficient between the corresponding frequency components of the two series. It is analogous to the R^2 statistic and is interpreted similarly.[12] The second measure is the phase angle, Ph(w), defined as:

$$Ph(w) = \text{arc tan} \frac{Q(w)}{C(w)} .$$

This measure indicates the lead-lag relation between the two series. If positive, x(t) leads y(t); if negative, y(t) leads x(t). The phase angle (expressed in radians) is meaningful only at frequencies which have large coherence values.

A major assumption underlying the spectral estimation method is that the time series being analyzed are stationary. The interest rate series for 1954-1967 are non-stationary due to the existence of trend. The simplest technique for handling this difficulty is to operate upon first differences

[11]The technique is described in detail by C. W. J. Granger and M. Hatanaka, *Spectral Analysis of Economic Time Series* (Princeton: Princeton University Press, 1964), and by Parzen, *op. cit.* For a non-mathematical treatment, see I. Adelman, "Long Cycles -- Fact or Artifact?" *The American Economic Review*, Vol. LV, No. 3 (June 1965), pp. 444-463, and M. Weiss, *Quantitative Analysis of Egg Price Quotations*, unpublished Ph. D. dissertation (Ithaca, N. Y.: Cornell University, January 1969).

[12]See Granger and Hatanaka, *op. cit.*, p. 77.

of the data. This method was used by Granger and Rees for analyzing quarterly data for the United Kingdom[13] and by Sargent for analyzing monthly data for the United States for 1951-1960.[14] An alternative method, which was the one employed for this study, is to use deviations from a regression of each rate series against time.[15]

In order to obtain statistically reliable results in the spectral analysis of economic time series, it is necessary to estimate the average power in a frequency band centered around the frequency in question, rather than the power associated with a precise frequency, ω.[16] In practice, the averaging function (commonly known as a "window") is accomplished by weighting the covariances (of x(t) and y(t)) before deriving the spectral estimates by Fourier transformation.[17] A problem arises because it is impossible to find a window that will center all the power in the desired frequency band. The "leakage" may be reduced by narrowing the frequency bands (that is, increasing the number of lags) but the finite length of the series imposes limits on this practice. In this study, we used Parzen's window because the leakage through this window is relatively small,[18] and the cross-spectral results are more significant.[19] The maximum number of lags used was 36.

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[13]Granger and Rees, *op. cit.*

[14]Sargent, *op. cit.*

[15]This is a linear trend of interest rates against time of the form $R = \bar{R} + bT$ where $\bar{R}$ is the average rate of interest for the series, T is the assigned value to the months such that $\Sigma T = 0$ and $b = \Sigma TR/\Sigma T^2$. In our time series, $\bar{R}$ turned out to be 3.07 and 3.86 for the 90 days and 10-year U.S. Treasury securities, respectively. The slope values (of the b coefficients) for these series were 0.020 and 0.014, respectively.

[16]See Adelman, *op. cit.*, pp. 451-453.

[17]See Parzen, *op. cit.*

[18]*Ibid.*

[19]See Granger and Hatanaka, *op. cit.*, pp. 220-222.

IV. Cross-Spectral Results

The results of our analysis are given in Table 1. The phase angle measure is somewhat difficult to interpret. Had the phase angle been a linear function of the frequency (or of the time period), such as

$$Ph(w) = a + bw,$$

more definite conclusions could have been drawn. For instance, if the relation were such that $a = 0$ and $b > 0$, one could conclude that there is a fixed time lag between the two series, the length of which is determined by the value of b. If the relation were such that $a = a_o > 0$ and $b = 1$ for all frequencies in the relevant range, one could conclude that there is a time lag of a/w at frequency w and the smaller the frequency (the longer the period), the larger is the lag.

Our results show no clear linear trend for the phase angle. However, over the range of periods in which we are interested, a definite pattern of relations is visible between the short-rate and long-rate series. As can be seen in Table 1, the coherence level in both "windows" is quite high.[20] For most frequencies less than .097 (corresponding to cycles with periods of 10.3 months or longer), the coherence level exceeds 0.7.

The coherence for the two rate series is, in general, low for seasonal frequencies, indicating that the seasonal component is relatively insignificant in both series. The highest estimated coherence levels are for periods between one and two years. For the lag window of 36 months, the highest coherence level is at an 18-month cycle but a cycle of 24 months also appears to be very significant. We may infer from the results that a cycle of 18 to 24 months is significant in both series.[21]

The phase angle coefficients are negative for all cycles with periods up to 24 months. The negative sign -- for frequencies with high coherence levels -- implies that, at these frequencies, the long rate leads the short

[20] There is no accepted theoretical method for determining what is a significantly high value of coherence. We decided -- somewhat arbitrarily -- that coherence values of 0.7 and above indicate that at the particular frequency in question the cross spectrum is significant.

[21] The lag window of 36 months is believed to be more reliable since it "averages" longer cycles.

rate. This result supports Sargent's conclusion that "the predominance of negative signs suggests that the longer rates generally lead the bill rate."[22]

Table 1

Coherence and Phase Angle for 90-Day Bills and 10-Year Bonds, 1954-1967

Period (months)	Lag Window = 24 months		Lag Window = 36 months	
	Coherence	Phase Angle	Coherence	Phase Angle
72.0	0.6332	0.0705	0.6453	0.2285
36.0	0.6783	0.0717	0.7298	0.1077
24.0	0.7249	-0.0150	0.8112	-0.1352
18.0	0.7692	-0.1591	0.8280	-0.2910
14.4	0.8120	-0.3014	0.7977	-0.3773
12.0	0.8011	-0.4002	0.8105	-0.4423
10.3	0.7717	-0.4640	0.8027	-0.5214
9.0	0.6724	-0.4921	0.6227	-0.5584
8.0	0.4557	-0.4050	0.2689	-0.3559

Another interesting conclusion may be drawn from the pattern of the phase angle coefficients. In general, lower frequencies (longer periods) are associated with lower absolute values of the phase angle coefficients.[23] This pattern, of less negative values for longer cycles, suggests that the lead of the long rate over the short rate becomes smaller as the cycle length increases. In fact, for cycles of 36 and 72 months, the phase angle is positive.

[22]Sargent, *op. cit.*, p. 167.

[23]It should be noted that lower absolute values of the phase angle coefficients indicate shorter lag (lead) between the series. In our case, in the range of high coherence values, the lead of the long rate over the short rate is in general one month. It ranges from 2 to 20 days for cycles of 12 to 24 months duration.

REFERENCES

1. Adelman, I., "Long Cycles -- Fact or Artifact?" *The American Economic Review,* Vol. LV, No. 3 (June 1965), pp. 444-463.

2. Cohen, J. C., R. L. Kramer, and H. W. Waugh, "Regression Yield Curves for U. S. Government Securities," *Management Science,* Vol. 13 (December 1966), pp. B-168 - B-175.

3. Fand, D., "A Time Lines Analysis of the Bills-Only Theory of Interest Rates," *The Review of Economics and Statistics,* Vol. XLVIII (November 1966), pp. 361-371.

4. Granger, C. W. J., "The Typical Spectral Shape of an Economic Variable," *Econometrica,* 34 (1966), pp. 150-161.

5. ________________, and M. Hatanaka, *Spectral Analysis of Economic Time Series* (Princeton: Princeton University Press, 1964).

6. ________________, and H. J. B. Rees, "Spectral Analysis of the Term Structure of Interest Rates," *The Review of Economic Studies,* Vol. XXXV, No. 101 (January 1968), pp. 67-76.

7. Kessel, R. A., *The Cyclical Behavior of the Term Structure of Interest Rates,* Occasional Paper 91 (New York: National Bureau of Economic Research, 1965).

8. Malkiel, B. G., *The Term Structure of Interest Rates* (Princeton: Princeton University Press, 1966).

9. Parzen, E., "Mathematical Considerations in the Estimation of Spectra," *Technometrica,* Vol. 3, 1961, pp. 167-190.

10. Sargent, J. T., "Interest Rates in the Nineteen-fifties," *The Review of Economics and Statistics,* Vol. L, No. 2 (May 1968), pp. 164-172.

11. U. S. Treasury Department, "Market Quotations on Treasury Securities," *Treasury Bulletin* (various issues, 1954-1968).

12. Telser, L. G., "A Critique of Some Recent Empirical Research on the Exploration of the Term Structure of Interest Rates," *The Journal of Political Economy,* Vol. 75 (No. 4, Part II)(August 1967).

13. Weiss, M., *Quantitative Analysis of Egg Price Quotations* (an unpublished Ph. D. dissertation, Cornell University, January 1969).