Do yield curves normally slope up? The term structure of interest rates, 1862-1982

John H. Wood

The downward-sloping yield curves of recent years have been called *perverse*, but an examination of the history of American interest rates reveals that, at least since the Civil War, falling yield curves have been nearly as common as those with upward slopes. This article summarizes yield curve patterns since 1862 and suggests that (1) the traditional expectations theory remains a viable explanation of observed yield curves and (2) yield curves since the abandonment of the gold standard in 1971 have much in common with those of the greenback era of 1862-78 but are distinct from those of the gold standard years of 1879-1970. The slopes of yield curves appear to depend upon expectations of future yields as determined by expectations of inflation, which, in turn, depend upon the prevailing monetary standard.

U.S. yield curves in the 20th century

Yield curves for high-grade corporate bonds from 1900 to 1982 are shown in the two panels of Figure 1.[1] Each curve shows the term structure of yields in a particular year, i.e., the relationship between bond yields and terms to maturity at a point in time. Panel A shows yield curves for the period prior to 1930. Yield curves for 1930 through 1982 are shown in Panel B. Curves since 1966 have been identified by year of occurrence.

A striking feature of the yield curves in Figure 1 is their tendency to be positively sloped when yields are "low" and to be negatively sloped when yields are "high." Suppose, for example, that between 1900 and 1970 one-year bond yields above 4.40 percent were considered high and yields below 3.25 percent were thought to be low. The upper portion of Table 1 shows that if "high" and "low" are distinguished in this manner all yield curves had negative slopes when short-term yields were high and all yield curves had positive slopes when short-term yields were low.

This observation applies throughout the 1900-1970 period, but breaks down after 1970. In order to understand yield patterns since 1970, it is first necessary to examine a popular and persuasive explanation of the shapes of observed yield curves.

An explanation: the traditional expectations theory with regressive expectations[2]

Any theory of equilibrium relations among bond yields must specify (1) the criteria by which investors select bonds *given their expectations of future yields* and (2) how those expectations are formed. With regard to (1), the traditional expectations theory of the term structure of interest rates asserts that bond-market equilibrium requires equal expected returns on

John H. Wood is a Professor of Finance at Northwestern University and is currently on leave at the Federal Reserve Bank of Dallas. This paper was written while the author was a consultant for the Federal Reserve Bank of Chicago and is part of a larger study being conducted with Scott Ulman.

[1]Data are David Durand's "basic yields on high-grade corporate bonds," first published in 1942, updated by Durand and Winn to 1959, and updated since 1959 by Scudder, Stevens and Clark. Selected data are available for 1900-1970 in the U.S. Department of Commerce, *Historical Statistics of the United States*, Vol. 2, p. 1004, and more recently in the annual *Statistical Abstract of the United States*. Ruth Heisler of Scudder, Stevens and Clark has kindly supplied data for 1982. A detailed account of the method by which the yield curves in Figure 1 were constructed is given in Durand [1942].

[2]The "traditional" and other expectations theories, most notably the "modern" expectations theory, are compared in Cox, Ingersoll, and Ross [1981]. An early statement of the traditional expectations theory with regressive expectations was that of Lutz [1937].

bonds of all maturities.[3] For the simple case of pure discount (zero-coupon) bonds, this implies long-term yields that are averages of current and expected short-term yields (see Box).

To convert the expectations theory into an operational explanation of the term structure, a mechanism for determining expected short-term yields must be specified. Only two of the simplest and most common types of expectations—extrapolative and regressive—are considered here.

[3]This statement may be illustrated as follows for 1- and 2-period bonds and a 1-period holding period. The 1-period rate-of-return on a 2-period zero-coupon bond worth $1 at maturity is

$$\frac{{}_1P_1^e - P_2}{P_2} = \frac{\frac{\$1}{(1+{}_1R_1^e)} - \frac{\$1}{(1+R_2)^2}}{\frac{\$1}{(1+R_2)^2}} = \frac{(1+R_2)^2}{(1+{}_1R_1^e)} - 1,$$

where P_2 is the current price of the 2-period bond and ${}_1P_1^e$ is the price currently expected to prevail next period on a 1-period bond. If the expectations theory holds, (see equation (1) in Box) this rate-of-return equals R_1—i.e., the expected 1-period returns on 1- and 2-period bonds are equal. As indicated in the Box, these results hold precisely only under conditions of certainty.

Figure 1
Panel A: **yield curves for high-grade corporate bonds, 1900-1929**

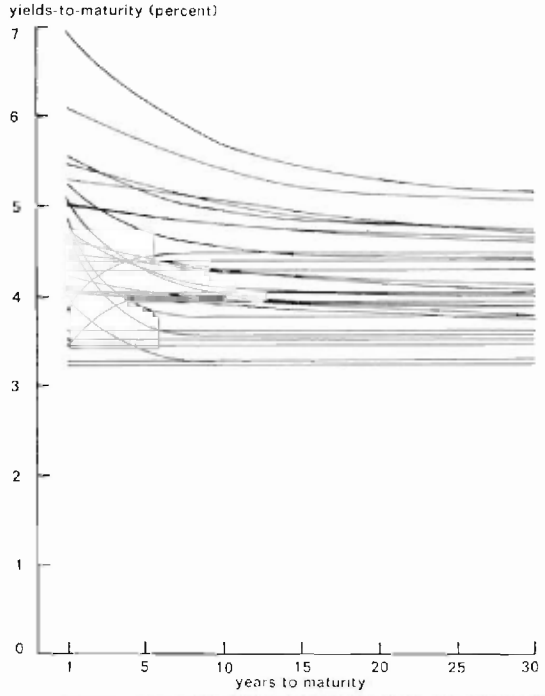
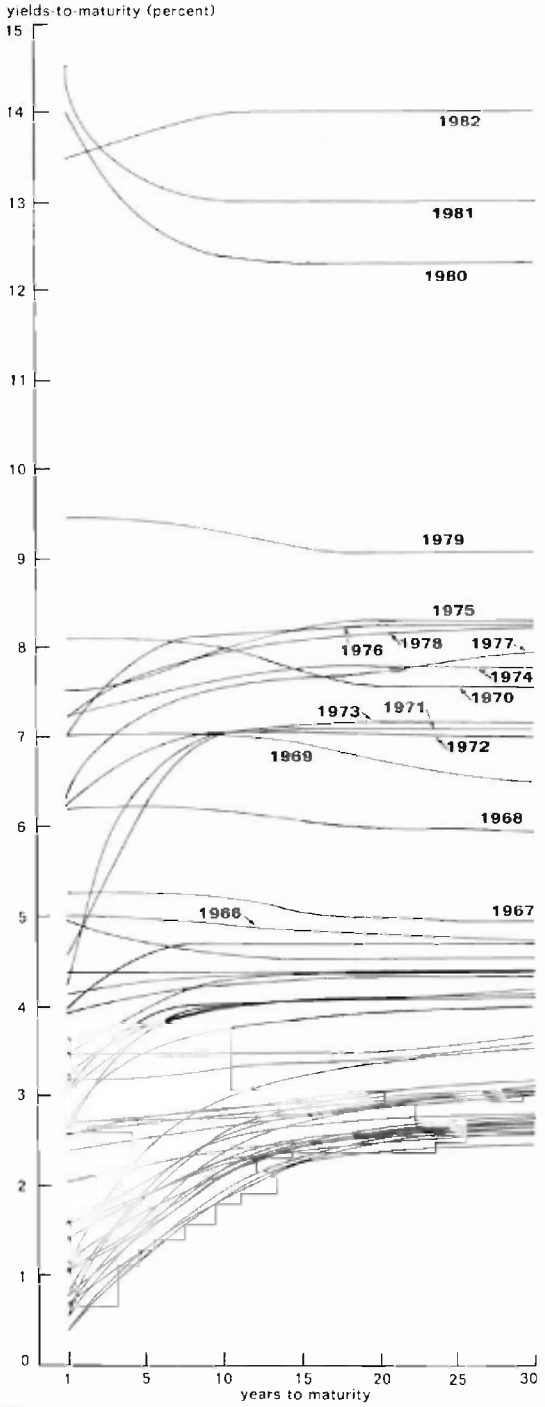


Figure 1
Panel B: **yield curves for high-grade corporate bonds, 1930-1982**



SOURCE: Durand (1942, 1958); Durand and Winn (1947); and Scudder, Stevens and Clark.

The traditional expectations theory of the term structure

The equilibrium term structure is

$$(1) \quad (1+R_n)^n = (1+R_1)(1+{}_1R_1^e)(1+{}_2R_1^e) \ldots (1+{}_{n-1}R_1^e),$$

where R_1 and R_n are the yields-to-maturity currently prevailing on bonds maturing after one and n periods, respectively, and

${}_1R_1^e, {}_2R_1^e, \ldots, {}_{n-1}R_1^e$ are the one-period yields currently expected by investors to prevail one, two, . . . , and (n-1) periods in the future.

A convenient linear approximation of the equilibrium term structure describes long-term yields as arithmetic averages, instead of geometric averages as in equation (1), of current and expected short-term yields:

$$(2) \quad R_n = \frac{R_1 + {}_1R_1^e + {}_2R_1^e + \ldots + {}_{n-1}R_1^e}{n}$$

This approximation deteriorates as short and long yields diverge. For example, let R_2^a be the approximate two-period yield given by equation (2). Then comparing R_2^a with R_2 from equation (1).

$R_2^a = R_2 = .10$ if $R_1 = {}_1R_1^e = .10$;

$R_2^a = .10$ and $R_2 = .0997$ if $R_1 = .075$ and ${}_1R_1^e = .125$; and $R_2^a = .10$ and $R_2 = .0989$ if $R = .05_1$ and ${}_1R_1^e = .15$.

Equation (1) is itself an approximation of observed yield curves even if all the usual assumptions of the traditional expectations theory are satisfied. One reason is that equation (1) neglects uncertainty and is therefore valid only under conditions of perfect foresight. (This point has been made in different ways by Nelson [1972, pp. 21-28] and Cox, Ingersoll, and Ross [1981].) Second, equation (1) strictly applies only to zero-coupon bonds—whereas most yield curves, including those in Chart 1, are for coupon bonds. Garbade [1982, pp. 293-99] and others have shown that the effect of coupons is to moderate the slopes of yield curves implied by equation (1).

Although it would be difficult to assess the empirical importance of these deficiencies, it is shown in the text that the traditional expectations theory with regressive expectations is at least roughly consistent with observed yield curves.

Extrapolative expectations mean that investors expect short-term yields to continue to move in the same direction as recent yield movements. If yields have been rising, they are expected to continue to rise in the future. If yields have been falling, they are expected to fall further.

Regressive expectations imply just the opposite of extrapolative expectations. If yields have been rising, they are expected to reverse course, or regress, towards what are considered "normal" levels. If yields are below "normal," they are expected to rise.

Now, suppose that yields have fallen to low levels such that the current short-term yield is $R_1 = .02$ and, because investors extrapolate recent events into the future, the short-term yield expected to prevail in the next period is ${}_1R_1^e = .01$. Using the approximation provided by equation (2) in the Box, this means a two-period yield of $R_2 = (.02 + .01)/2 = .015$, and the yield curve has a negative slope.

Considering another example, suppose yields have risen to high levels such that $R_1 = .20$. If expectations are formed extrapolatively, so that, perhaps, ${}_1R_1^e = .21$, we have $R_2 = .205$ and the yield curve is rising. Thus, the traditional expectations theory with extrapolative expectations suggests that yield curves will tend to have positive slopes when yields are high and negative slopes when yields are low. This is inconsistent with the data in Figure 1 and Table 1, at least for 1900-1970.

On the other hand, suppose short-term yields are expected to regress toward some "normal" value denoted by R_1^*. Assume $R_1^* = .06$ and that the change in each later period is expected to be one-half the difference between the normal yield and the short-term yield prevailing in the preceding period. Given $R_1 = .02$ and $R_1^* = .06$, these assumptions imply that

$${}_1R_1^e = R_1 + s(R_1^* - R_1) = .02 + .5(.06 - .02) = .04,$$

where s = .5 is the expected speed of adjustment. The resulting yield curve has a positive slope because $R_2 = (.02 + .04)/2 = .03$. Following the same procedure and letting $R_1 = .20$, we obtain

$$_1R_1^e = .13 \text{ and}$$

$R_2 = .165$, so that the yield curve has a negative slope when $R_1 = .20$. These examples support the view that the traditional expectations theory supplemented by regressive expectations is consistent with observed yield curves, at least during 1900-1970.[4]

An upward revision of expectations in the 1970s?

The upper portion of Table 1 suggests that yield curves between 1900 and 1970 were consistent with the traditional expectations theory with regressive expectations, if the normal one-year, high-grade corporate bond yield was thought by investors to be between 3.25 and 4.40 percent. But notice the high and rising yield curves for 1971-1978 and 1982 in Figure 1. Either (1) the explanation that is so effective for 1900-1970 has failed in recent years because investors no longer behave according to the tenets of the traditional expectations theory and/or they no longer form expectations regressively, or (2) they have revised their estimates of the normal rate.

Table 1

Frequencies of rising, flat, and falling yield curves, 1900-1982

One-year corporate bond yield (percent per annum)	Slope of yield curve		
	Positive	Flat	Negative
		1900 - 1970	
Above 4.40	0	0	20
3.25 - 4.40	10	10	5
Below 3.25	26	0	0
		1971 - 1982	
Above 8.00	1	0	3
Below 8.00	8	0	0

SOURCES: Durand, Durand and Winn, and Scudder, Stevens and Clark.

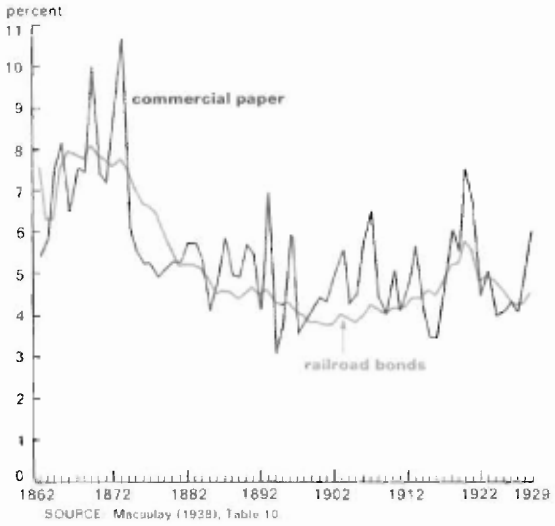
The extrapolative expectations version of the traditional expectations theory appears broadly consistent with the generally rising yields and positively sloped yield curves of 1971-78. But it does not look as promising in light of the yield curves of 1979-81, which had negative slopes during a period of rapidly rising yields. A variety of other explanations of the events of 1971-82 might be worth pursuing, but the analysis of this paper will remain with the explanation emphasized thus far—the traditional expectations theory with regressive expectations. That is, we will examine the extent to which alternative (2) in the preceding paragraph is capable of explaining yield curves since 1971. But this approach requires an additional hypothesis, one that supplies a rule by which investors revise their estimates of the normal rate. However, such a rule, whatever it is, cannot be subjected to any kind of test on the basis of data considered so far because the only unambiguous 20th century revision or revisions have occurred since about 1970. For other possible revisions we must go to the 19th century.

The 19th and 20th centuries compared

No complete yield curves such as those in Figure 1 are available for the 19th century. However, the slopes of yield curves may be inferred

[4]Both extrapolative and regressive expectations may be rational in an economy in which yields fluctuate cyclically about "normal" levels, with short-term expectations being formed extrapolatively and long-term expectations being formed regressively. Possible examples of the interaction of extrapolative and regressive expectations are the humpbacked yield curves that are common when yields are high. These humps tend to occur at maturities of 3 to 6 months and thus do not appear in the yield curves of Figure 1, in which the shortest maturity is one year.

Figure 2
Long and short rates, 1862-1929



SOURCE: Macaulay (1938), Table 10

from data on the prime commercial paper rate (the short-term yield) and Frederick Macaulay's railroad bond yield index (the long-term yield).[5] Annual averages of commercial paper and railroad bond yields for 1862-1929 are shown in Figure 2. This figure tells, in a different way, essentially the same stories as Figure 1: first, that yield curves tended to be positively sloped when yields were low and negatively sloped when yields were high and, second, that there was apparently a revision of the notions of "high" and "low".[6] However, instead of an upward revision, as in the early 1970s, Figure 2 suggests a downward adjustment of the normal rate in the late 1870s. Notice, for example, that the seven short-term yields between 5.58 percent and 7.55 percent during 1866-1875 were all associated with rising yield curves, while after those years all short-term yields above 5.40 percent were associated with falling yield curves.

No precise dating of the normal rate's revision, which may have occurred over several years, is immediately obvious from the data. (This is also true of the shift in the 1970s, or perhaps the late 1960s.) But suppose, for simplicity of exposition, that most of the adjustment took place early in 1879. Using this date to divide 1862-1929 into two periods, Table 2 suggests that the normal rate may have been in the vicinity of 7.50 percent during 1862-1878 and between 4 and 5.50 percent during the 1879-1929 period.

What events triggered these upward and downward revisions in investors' expectations of normal rates? A look at the history of U.S. monetary standards since 1862 may provide an answer.

Table 2

Frequencies of rising and falling yield curves, 1862-1929

Commercial paper yield (percent per annum)	Slope of yield curve	
	Positive	Negative
	1862 - 1878	
Above 7.57	0	5
Below 7.56	12	0
	1879 - 1929	
Above 5.40	0	16
4.21 - 5.40	4	17
Below 4.21	14	0

SOURCE: Macaulay, Table 10.

The monetary standard and the yield curve

The American monetary standard has undergone the following changes since early in the

[5] See Macaulay (1938, Table 10) for data on the unadjusted index of railroad bond yields. "Choice" and "prime" commercial paper rates, reported on a discount basis, have been converted to bond equivalent yields. Macaulay tried to construct yield curves for railroad bonds like those later reported by Durand, but he found the correlation between yield and maturity too small. However, the use of Macaulay's data in Table 2 is consistent with the use of Durand's yield curves in Table 1 because Macaulay found that longer-term bonds tended to have higher yields when short-term rates (such as the commercial paper rate) were low and that shorter-term bonds tended to have higher yields when short-term rates were high (p. 80).

[6] During 1900-1929, when Figures 1 and 2 overlap, the yield curves implied by the latter figure have the same sign as those in the former on three-quarters of the occasions on which Durand's yield curves are not flat. Furthermore, the slopes implied by Figure 2 tend to be smaller in absolute value when Durand's curves are flat than when they have non-zero slopes.

Civil War. The gold standard was abandoned when banks suspended specie payments on December 30, 1861.[7] In February 1862, Congress authorized the first of several issues of legal tender currency (the famous greenbacks). After a period of monetary expansion accompanied by depreciation of the dollar, followed by prolonged monetary controversy, a bill for the resumption of the gold standard at the prewar exchange rate was passed in January 1875. Resumption was achieved on the target date of January 1, 1879, although success was not assured until late in 1878.[8]

The monetary standard remained unchanged until banks were legally prohibited from paying out gold in March 1933. The *international* gold standard was resumed in January 1934,[9] although the gold value of the dollar was reduced to 59 percent of that prevailing between 1879 and 1933. Finally, in August 1971, the United States suspended the international convertibility of the dollar and embarked on a paper standard identical in all important respects to the greenback era of 1862-1878.

The following line of reasoning suggests that the monetary standard should be expected to be an important, perhaps the dominant, influence on the normal rate. First, define the normal rate on securities of a particular risk class as the yield expected by investors to apply to those securities in long-run equilibrium. (References from this point are to normal rates instead of to a single normal rate.) Second, the available evidence strongly suggests that interest rates are to a considerable extent determined by inflationary expectations, which in turn depend on actual inflation.[10] Finally, inflation has for centuries been highly correlated, and generally believed to be highly correlated, with the choice of monetary standard.[11]

These arguments are supported by the data in Charts 1 and 2 and Tables 1 and 2, which are consistent with a downward revision in the 1870s and an upward revision in the 1970s of investor estimates of normal rates. The rising 1982 yield curve suggests that the latter revision may not yet be complete. It is not clear from the data whether another revision occurred in the 1930s because the steeply rising yield curves of that decade (and of the 1940s and 1950s) were, in view of the record-low yields prevailing at the time, consistent with normal rates based on experience of both gold and paper standards.[12]

The values in Table 2 are not directly comparable with those in Table 1, because the yields in the two tables apply to different securities. Nevertheless, these tables and the figures upon which they are based combine to tell a single story—that American yield curves since 1862 are at least roughly consistent with the traditional expectations theory supplemented by regressive expectations *where the normal rate is a function of the monetary standard.* That is the hypothesized rule for revising the normal rate that earlier was declared to be required for a complete explanation of observed yield curves.

Concluding comment: Inflation and the monetary standard as parts of the same political decision.

The data presented above suggest that changes in inflationary expectations are asso-

[7]The official standard was bimetallic, but silver had long ceased to circulate because it had been undervalued by the official gold-silver exchange rate.

[8]For example, see Dewey (1936) and Friedman and Schwartz (1963) for histories of American monetary standards.

[9]The domestic circulation of gold was ended by the Gold Reserve Act.

[10]Most observers, including Fisher (1930) and Fama (1975), would agree with this statement. See Wood (1981) for a review of empirical work on the connections between interest rates and inflation.

[11]See Attwood (1819), Lester (1939), Dewey (1936), Friedman and Schwartz (1963), Barro (1980), and Bordo (1981) for discussions of evidence and attitudes regarding inflation under gold and paper standards.

[12]In annual averages, American commercial paper yields have not, except during 1935-46, been less than 1 percent and have not, except during 1931-58, been less than 3 percent. They were continuously less than 1 percent during 1935-46 and continuously less than 3 percent during 1931-55. These statements are based on data available since 1819 in Homer (1977).

ciated with, and perhaps influenced by, changes in the monetary standard. But it is important to stress that the monetary standard is not imposed upon an economic system from outside. A shift from a fixed-rate to a flexible-rate system, for example, may be viewed as merely one of several reflections of a decision by one or more countries to abandon long-run price stability as a goal. This means that the data contain no implications for monetary policy. The monetary authority is not free to attempt to influence inflationary expectations by manipulating the monetary standard. Both are chosen and imposed upon the central bank by the political process.

References

Thomas Attwood, *A Second Letter to the Earl of Liverpool on the Bank Reports as Occasioning the National Dangers and Distresses*, R. Wrightson, Birmingham, 1819.

Robert J. Barro, "U.S. Inflation and the Choice of Monetary Standards," NBER Conference on Inflation, Washington, October 1980.

Michael D. Bordo, "The Classical Gold Standard: Some Lessons for Today," Federal Reserve Bank of St. Louis *Review*, May 1981, 2-17.

John C. Cox, Jonathon E. Ingersoll, and Stephen A. Ross, "A Reexamination of Traditional Hypotheses About the Term Structure of Interest Rates," *Journal of Finance*, September 1981, 769-99.

Davis R. Dewey, *Financial History of the United States*, 12th ed., Longmans, Green, and Co., New York, 1936.

David Durand, "A Quarterly Series of Corporate Bond Yields, 1952-1957, and Some Attendant Reservations," *Journal of Finance*, September 1958, 348-56.

———, *Basic Yields of Corporate Bonds, 1900-1942*, National Bureau of Economic Research, Technical Paper 3, 1942.

David Durand and Willis J. Winn, *Basic Yields of Bonds, 1927-1947: Their Measurement and Pattern*, National Bureau of Economic Research, Technical Paper 6, 1947.

Eugene F. Fama, "Short-Term Interest Rates as Predictions of Inflation," *American Economic Review*, June 1975, 269-82.

Irving Fisher, "Appreciation and Interest," *Publications of the American Economic Association*, Vol. II, August 1896.

———, *The Theory of Interest*, Macmillan, New York, 1930.

Milton Friedman and Anna J. Schwartz, *A Monetary History of the United States, 1867-1960*, Princeton University Press, Princeton, N.J., 1963.

Kenneth Garbade, *Securities Markets*, McGraw-Hill, New York, 1982.

Sidney Homer, *A History of Interest Rates*, 2nd ed., Rutgers University Press, New Brunswick, N.J., 1977.

Richard A. Lester, *Monetary Experiments*, Princeton University Press, Princeton, N.J., 1939.

F. A. Lutz "The Structure of Interest Rates," *Quarterly Journal of Economics*, November 1940, 36-63.

Frederick R. Macaulay, *Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields and Stock Price in the United States Since 1856*, National Bureau of Economic Research, New York, 1938.

Charles R. Nelson, *The Term Structure of Interest Rates*, Basic Books, New York, 1972.

John H. Wood, "Interest Rates and Inflation," Federal Reserve Bank of Chicago *Economic Perspectives*, May/June 1981, 3-12.