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TERM-STRUCTURE FORECASTS OF INTEREST RATES, INFLATION, AND REAL RETURNS

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The one-year expected inflation rate and the expected real return on one-year bonds move opposite one another. The result is that the term structure shows little power to forecast near-term changes in the one-year interest rate, even though it shows power to forecast its components. When the forecast horizon is extended, interest-rate predictions improve because they primarily reflect changes in expected inflation that are less strongly offset by changes in the expected real return. The information is the term structure about interest rates, inflation, and real returns is related to the business cycle.

1. Introduction

The term-structure literature has long been concerned with the extent to which current yields or forward rates forecast future short-term or 'spot' interest rates. For the most part, the evidence is negative [see, for example, Culbertson (1957), Shiller, Campbell, and Schoenholtz (1983), and Fama (1984)]. In a recent paper, Fama and Bliss (1987) confirm that forward-rate forecasts of near-term changes in interest rates are poor. They find, however, that forecast power improves with the forecast horizon. The one-year forward rates calculated from the prices of two- to five-year bonds explain, 8%, 24% and 48% of the variances of changes in the one-year spot rate two, three, and four years ahead.

The spot rate is the sum of an expected inflation rate and an expected real return. In principle, the behavior of term-structure forecasts of the one-year spot rate observed in Fama and Bliss (1987) can be explained in terms of

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forecasts of the one-year inflation rate, the real return on one-year bonds, or both. Investigating this possibility is the main task of this paper.

The main tests are regressions that forecast changes in the one-year spot rate, inflation rate, and real return with the spread of the yield on a five-year bond over the one-year spot rate. The regressions show that the one-year expected inflation rate and the expected real return on one-year bonds move opposite one another. For forecasts one and two years ahead, expected changes in inflation and the real return are close to offsetting. The result is that the yield spread shows no power to forecast the spot rate one and two years ahead, even though it shows strong power to forecast its components. When the forecast horizon is extended, the information in the spread about the real return decays relative to the information about inflation. Predictions of the spot rate improve because they primarily reflect expected changes in inflation that are less strongly offset by changes in the expected real return on one-year bonds.

Forecasts of interest rates, inflation, and real returns from the five-year yield spread have business-cycle patterns. The spread is countercyclical – low near business peaks and high near troughs. Positive slopes in regressions of changes in inflation or the spot rate on the spread then say that the spread forecasts declines in (typically high) inflation and interest rates after business peaks and increases in the (typically lower) values observed around troughs. Negative slopes in regressions of changes in the real return on the spread say that the spread forecasts increases in the real return on one-year bonds after business peaks and declines in the years after troughs.

The information in the five-year yield spread is not limited to future spot rates, inflation, and real returns. The spread also forecasts the term premiums in the returns on two- to five-year bonds (the one-year returns on the bonds less the one-year spot rate).

In short, the main finding of this paper is that yield spreads have information about the future values of a range of economic variables. Because the variables are less than perfectly correlated, however, yields spreads are noisy forecasts of any one of them.

2. Data and methods

Treasury bonds with maturities beyond a year are not issued on a regular basis. At any time, only irregularly spaced maturities are available. To estimate term structures for a set of fixed maturities, some method of interpolation must be used. Such a method is used to construct end-of-month prices from June 1952 to December 1988 for discount bonds with annual maturities from one to five years. (Details are available on request.)

Any method of estimating term structures for discount bonds from term structures for coupon bonds involves measurement error that tends to obscure the information in bond prices. Thus the forecast power of the measured term structures documented below probably understates the information in bond prices about term premiums and future spot rates, inflation, and real returns.

2.1. The variables

The one-year inflation rate, $I(t)$, is the change in the log of the U.S. Consumer Price Index (CPI) for the year ending at t. The one-year spot rate is

$$s(t) = -\ln p(1:t), \tag{1}$$

where $p(T:t)$ is the time t price of a discount bond with $1 face value and T years to maturity, and ln is a natural logarithm. The spot rate is a special case ($T = 1$) of the yield on a T-year bond,

$$r(T:t) = -\ln p(T:t)/T. \tag{2}$$

The one-year real return on a one-year bond is

$$R(t+1) = s(t) - I(t+1). \tag{3}$$

The term premiums in the one-year returns on two- to five-year bonds are

$$h(T:t+1) - s(t) = [\ln p(T-1:t+1) - \ln p(T:t)] - s(t), \tag{4}$$

$$T = 2,\ldots,5.$$

2.2. The regression framework

The price $p(T:t)$ of a T-year discount bond can be expressed as the present value of the $1 payoff on the bond discounted at the time t expected values (E_t) of the future one-year returns on the bond,

$$p(T:t) = \exp[-E_t h(T:t+1) - E_t h(T-1:t+2)$$
$$- \cdots - E_t s(t+T-1)]. \tag{5}$$

Eq. (5) is a tautology, implied by the definition of returns. It acquires content with the hypothesis that the expected returns in (5) are rational forecasts used by the market to set $p(T:t)$. Eq. (5) then says that the price contains rational forecasts of expected returns over the life of the bond. This hypothesis about the price is the basis of the tests.

With (5) and (2), the spread of the T-year yield over the spot rate is

$$r(T:t) - s(t) = \{[\mathrm{E}_t h(T:t+1) - s(t)] + \cdots + [\mathrm{E}_t s(t+T-1) - s(t)]\}/T. \tag{6}$$

Thus the T-year yield spread contains a forecast of the change in the one-year spot rate from t to $t+T-1$. Eq. (6) shows, however, that the yield spread also contains the expected term premium in the one-year return on a T-year bond. Variation in the expected term premium [or in other terms omitted from (6)] can obscure the information in the spread about the expected change in the spot rate.

Eq. (6) suggests that one way to measure the information in yields about expected term premiums is to regress $h(T:t+1) - s(t)$, the premium in the one-year return on a T-year bond, observed at $t+1$, on the T-year yield spread, $r(T:t) - s(t)$, observed at t. This approach is in the spirit of the tests in Fama (1984) and Fama and Bliss (1987). Since the yield spreads for different maturities are highly correlated, however, another approach is to use a common spread to track expected term premiums for all maturities.[1] An advantage of this approach is that the slopes from regressions of term premiums on a common spread can provide information about variation in expected premiums as a function of maturity. The tests use the five-year spread, $r(5:t) - s(t)$, to track expected term premiums in the one-year returns on two- to five-year bonds.

Eq. (6) also suggests that we can extract forecasts of spot rates from yields with regressions of the future $(T-1)$-year change, $s(t+T-1) - s(t)$, on the T-year spread, $r(T:t) - s(t)$. This approach is in the spirit of the tests used by Fama and Bliss (1987) and others. But again, the slopes from regressions of $s(t+T-1) - s(t)$ on a common spread can be informative – in particular, about how the magnitude of expected changes in the spot rate changes with the forecast horizon. The tests use the five-year spread, $r(5:t) - s(t)$, to forecast changes in the spot rate one to five years ahead.

The regression forecasts of changes in inflation and the real return on one-year bonds assume that the spot rate is driven by rational forecasts (E_t) of the one-year inflation rate and the real return on one-year bonds,

$$s(t) = \mathrm{E}_t I(t+1) + \mathrm{E}_t R(t+1). \tag{7}$$

Thus the market's forecast of the change in the spot rate from t to $t+T$ is

[1]The correlation between the two-year yield spread, $r(2:t) - s(t)$, and the five-year spread, $r(5:t) - s(t)$, is 0.93. The correlations of three- and four-year spreads with the five-year spread are 0.97 and 0.98. Table 2 (below) shows that the two- to five-year spreads also have nearly identical time-series properties.

driven by rational forecasts of the changes in inflation and the real return,

$$E_t s(t+T) - s(t) = [E_t I(t+T+1) - E_t I(t+1)] + [E_t R(t+T+1) - E_t R(t+1)]. \quad (8)$$

Consider the three regressions of the changes in the spot rate, the inflation rate, and the real return on the five-year yield spread,

$$s(t+T) - s(t) = a_0 + b_0[r(5:t) - s(t)] + e_0(t+T), \quad (9)$$

$$I(t+T+1) - I(t+1) = a_1 + b_1[r(5:t) - s(t)] + e_1(t+T+1), \quad (10)$$

$$R(t+T+1) - R(t+1) = a_2 + b_2[r(5:t) - s(t)] + e_2(t+T+1). \quad (11)$$

Since (3) says that the spot rate, $s(t)$, is the sum of the inflation rate, $I(t+1)$, and the real return, $R(t+1)$, the change in the spot rate from t to $t+T$ is the sum of the changes from $t+1$ to $t+T+1$ in the inflation rate and the real return,

$$s(t+T) - s(t) = [I(t+T+1) - I(t+1)] + [R(t+T+1) - R(t+1)]. \quad (12)$$

Eq. (12) implies that the regressions (10) and (11) split the forecast of the change in the spot rate from t to $t+T$, given by (9), between forecasts of the changes from $t+1$ to $t+T+1$ in the inflation rate and the real return on one-year bonds. Formally, the intercepts, slopes, and residuals in (10) and (11) sum to the intercept, slope, and residual in (9),

$$a_0 = a_1 + a_2, \quad b_0 = b_1 + b_2,$$

$$e_0(t+T) = e_1(t+T+1) + e_2(t+T+1). \quad (13)$$

Alternatively, since the two inflation rates in (10) and the two real returns in (11) are observed after the yield spread, the regressions estimate the changes from t to $t+T$ in the one-year expected inflation rate and the expected real return on one-year bonds.

The choice of the five-year yield spread as the common forecasting variable is arbitrary, but inconsequential. The yield spreads for different maturities are highly correlated, and other spreads produce similar results. Results and inferences are also much the same if spreads of forward rates over spot rates are used as forecasting variables.

2.3. A caveat

The regressions have an important limitation. Since b_1 and b_2 are constants, the split of the forecasted change in the spot rate between its components estimated by (10) and (11) is constant. It is unlikely that the actual period-by-period split is constant. Moreover, (6) shows that variation in expected term premiums can cloud the information about future spot rates in the yield spread. In short, a yield spread responds to information about term premiums and changes in the spot rate and its components. If these variables are not all perfectly correlated, the spread is a noisy forecast of any one of them. Thus the forecast power of the five-year spread, documented next, probably understates the information in the spread. We return to this issue later.

3. Regression estimates

3.1. Term premiums

Table 1 shows that the five-year yield spread captures variation in the expected term premiums in the one-year returns on two- to five-year bonds. The slopes in the regressions of the term premiums, observed at $t+1$, on the spread observed at t are all two or more standard errors from zero. The fact that the slopes for a common yield spread are larger for longer-term bonds suggests that the variation in expected term premiums increases with maturity.

The regressions confirm growing evidence that expected term premiums in bond returns vary through time [see, for example, Fama (1976, 1984, 1986), Shiller, Campbell, and Schoenholtz (1983), Keim and Stambaugh (1986), Fama and Bliss (1987), and Stambaugh (1988)]. For present purposes, table 1 suffices to show that, as suggested by (6), there is variation in expected term premiums that can obscure the information in the term structure about future spot rates, inflation and real returns.

3.2. Forecasting the spot rate and its components

Table 1 summarizes estimates of (9) to (11). As in Fama and Bliss (1987), the yield spread shows no power to forecast the one-year spot rate one year ahead. Forecast power improves with the forecast horizon. The slopes in the regressions of changes in the spot rate on the five-year spread grow from 0.18

for one-year changes to 2.22 for five-year changes. The slopes for one- and two-year changes are less than one standard error from zero. The slope for three-year changes is 1.58 standard errors from zero; the slopes for four- and five-year changes are more than 2.9 standard errors from zero. The regression R^2 grows from less than 0.03 for one- and two-year changes to 0.24 for five-year changes.

The first surprising result in table 1 is that the yield spread shows more consistent power to forecast changes in the one-year inflation rate than changes in the spot rate. The slopes in the regressions for one- to three-year changes in inflation are more than 2.6 standard errors from zero. R^2 rises from 0.23 for one-year changes to more than 0.3 for two- and three-year changes. Forecast power falls some for four- and five-year changes in inflation, but the regression slopes are still more than two standard errors from zero.[2]

The second novel result in table 1 is that the yield spread also shows power to forecast one- and two-year changes in the real return on one-year bonds. The regression slopes are more than 2.8 standard errors from zero. The forecast power of the spread decays quickly for longer-horizon changes in the real return – more quickly than for changes in inflation.

Most interesting, the yield spread forecasts changes in the inflation rate and the real return on one-year bonds of opposite sign. The offset is almost exact for forecasts of one-year changes; the positive slope, 1.30, for forecasts of changes in inflation is almost matched by the negative slope, -1.12, for changes in the real return. Thus, although the spread shows power to forecast one-year changes in the components of the spot rate, the sum of the slopes for the components is close to zero, and the spread shows no power to forecast the change in the spot rate one year ahead.

As the forecast horizon is extended, the information in the yield spread about cumulative changes in the expected real return on one-year bonds decays relative to the information about changes in the one-year expected inflation rate. Predictions of changes in the spot rate from the spread improve because they primarily reflect information about changes in expected inflation that is not strongly offset by information about changes in the expected real return.

The evidence that expected inflation and expected real returns on bonds move opposite one another is not new [see, for example, Fama and Gibbons (1982)]. It is, however, interesting that the yield spread forecasts the opposite

[2]Consistent with the inflation evidence presented here, Mishkin (1990) finds that the spread of the yield on a twelve-month Treasury bill over the yield on a six-month bill forecasts the change in the six-month inflation rate six to twelve months ahead. He finds, however, that the spread of the six-month bill yield over the three-month yield has no power to forecast the change in the three-month inflation rate three to six months ahead. He suggests that the information in short-term yields about changes in inflation is obscured by strong variation in the expected term premiums in short-term yields.

Table 1

Simple and multiple regressions of term premiums in one-year returns and changes in (a) the one-year spot rate, (b) the one-year inflation rate, and (c) the real return on one-year bonds on the five-year yield spread and the lagged levels of variables; 6/53–12/88.[a]

		Simple regressions						Multiple regressions					
		$r(5:t)-s(t)$			Lagged variable			$r(5:t)-s(t)$		Lagged variable			
T	Obs.	b_1	$t(b_1)$	R^2	b_2	$t(b_2)$	R^2	b_1	$t(b_1)$	b_2	$t(b_2)$	R^2	
		Term premiums: $h(T:t+1)-s(t)=a+b_1[r(5:t)-s(t)]+b_2s(t)+e(t+1)$											
2	427	0.68	2.00	0.08	0.13	1.09	0.05	0.88	2.94	0.19	1.79	0.17	
3	427	1.30	2.09	0.09	0.17	0.76	0.03	1.59	2.58	0.27	1.37	0.15	
4	427	1.96	2.20	0.10	0.23	0.71	0.02	2.36	2.60	0.37	1.35	0.17	
5	427	2.49	2.29	0.11	0.25	0.63	0.02	2.95	2.64	0.42	1.26	0.17	
		Changes in the spot rate: $s(t+T)-s(t)=a+b_1[r(5:t)-s(t)]+b_2s(t)+e(t+T)$											
1	403	0.18	0.54	0.00	−0.18	−1.79	0.10	−0.02	−0.08	−0.18	−1.75	0.10	
2	391	0.41	0.63	0.02	−0.32	−2.95	0.20	0.02	0.04	−0.32	−2.97	0.20	
3	379	1.02	1.58	0.08	−0.41	−3.05	0.25	0.44	0.56	−0.38	−1.89	0.26	
4	367	1.75	2.99	0.18	−0.47	−2.89	0.27	1.02	0.95	−0.37	−1.38	0.32	
5	355	2.22	4.44	0.24	−0.55	−2.64	0.31	1.23	1.37	−0.41	−1.33	0.36	

		Changes in inflation: $I(t+T+1) - I(t+1) = a + b_1[r(5:t) - s(t)] + b_2 I(t) + e_1(t+T+1)$										
1	403	1.30	2.93	0.23	−0.28	−3.22	0.21	0.97	2.19	−0.20	−2.44	0.32
2	391	2.44	2.64	0.34	−0.42	−2.69	0.19	2.03	1.98	−0.25	−1.75	0.39
3	379	2.77	2.82	0.32	−0.41	−2.04	0.15	2.40	1.99	−0.21	−1.00	0.36
4	367	2.27	2.89	0.21	−0.39	−1.68	0.14	1.81	1.84	−0.24	−0.95	0.25
5	355	1.70	2.14	0.11	−0.47	−2.72	0.21	0.91	1.46	−0.40	−2.35	0.24
		Changes in the real return: $R(t+T+1) - R(t+1) = a + b_1[r(5:t) - s(t)] + b_2 R(t) + e_1(t+T+1)$										
1	403	−1.12	−2.80	0.13	−0.32	−2.09	0.15	−0.64	−1.33	−0.23	−1.42	0.18
2	391	−2.03	−3.50	0.21	−0.54	−2.21	0.20	−1.34	−2.44	−0.35	−1.62	0.27
3	379	−1.76	−5.22	0.12	−0.62	−3.84	0.19	−0.87	−1.69	−0.51	−2.77	0.21
4	367	−0.52	−0.73	0.01	−0.70	−4.22	0.21	0.76	1.27	−0.79	−3.99	0.23
5	355	0.53	0.51	0.01	−0.90	−2.96	0.23	1.82	1.94	−1.11	−3.58	0.31

[a] $h(T:t+1)$ is the one-year return (t to $t+1$) on a T-year discount bond. $s(t)$ is the time t spot rate (the yield on a one-year bond.) $r(5:t)$ is the yield on a five-year bond. $I(t+1)$ is the one-year inflation rate (the change in the log of the CPI) from t to $t+1$. $R(t+1) = s(t) - I(t+1)$ is the real return on a one-year bond. R^2 is the coefficient of determination (adjusted for degrees of freedom). The term-premium regressions use the 427 monthly observations on one-year premiums from June 1953 to December 1988. Since one-year changes in the inflation rate and the real return on one-year bonds cover two years and the lagged variable uses up an additional year, the regressions for one-year changes include 403 monthly observations from June 1955 to December 1988. To ensure the complementarity of (13) between the regressions for changes in the spot rate, inflation rate, and real return, the regressions for one-year changes in the spot rate include the 403 monthly observations from June 1954 to December 1987. An additional year (twelve observations) is lost each time the forecast horizon T for changes in the spot rate, inflation rate, and real return is extended one year. The t-statistics $t(b_1)$ and $t(b_2)$ use standard errors adjusted for residual autocorrelation due to overlap of monthly observations and for heteroscedasticity with the method of Hansen (1982) and White (1980). The Hansen–White covariance matrices in the $R(t+T+1) - R(t+1)$ regression for $T = 5$ have singularity problems. In these regressions the t's use Hansen and Hodrick (1984) standard errors which only adjust for residual autocorrelation due to observation overlap. (In other regressions, Hansen–Hodrick and Hansen–White standard errors are similar.)

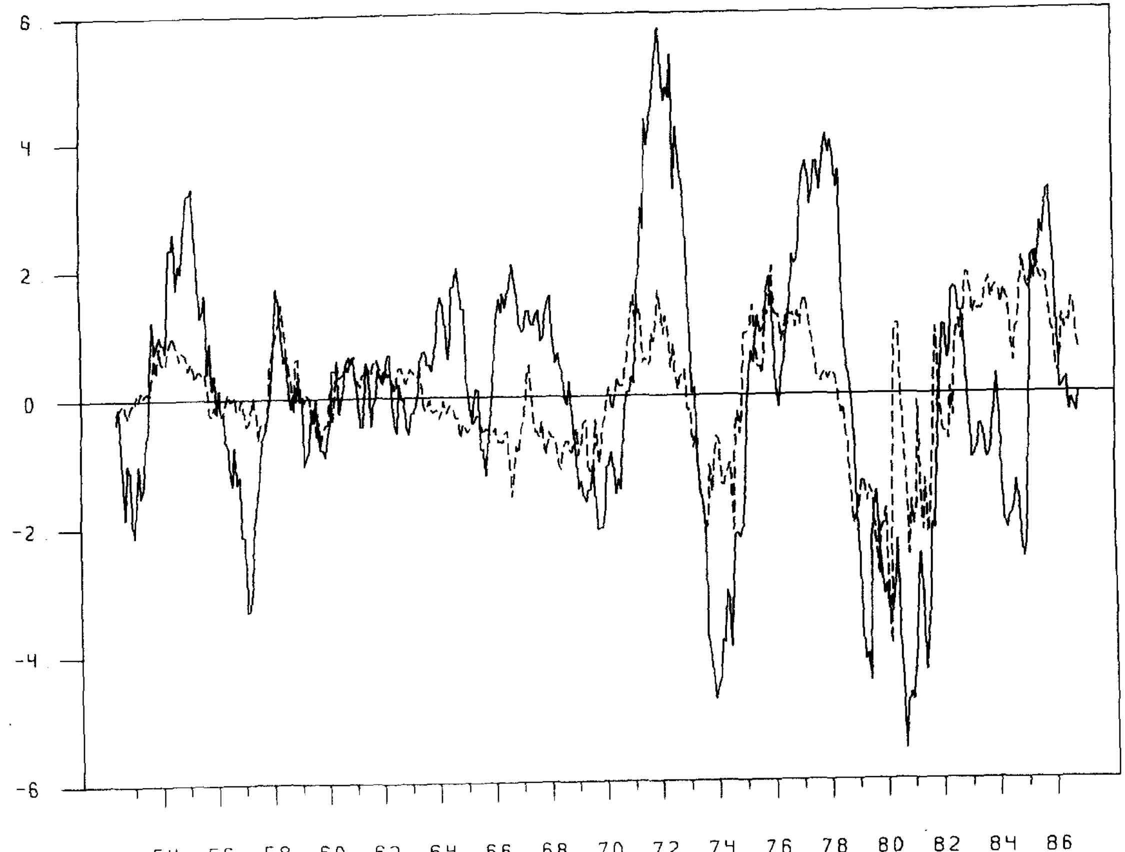

Fig. 1. Month-by-month values of the one-year change in the one-year inflation rate, and fitted values from regressions of the change on the five-year spread. The change, $I(t+2) - I(t+1)$, is plotted at t, the date of the spread $r(5:t) - s(t)$. The period for t is 6/52–12/86. $I(t+2) - I(t+1)$ = solid line; fitted values = short dashes.

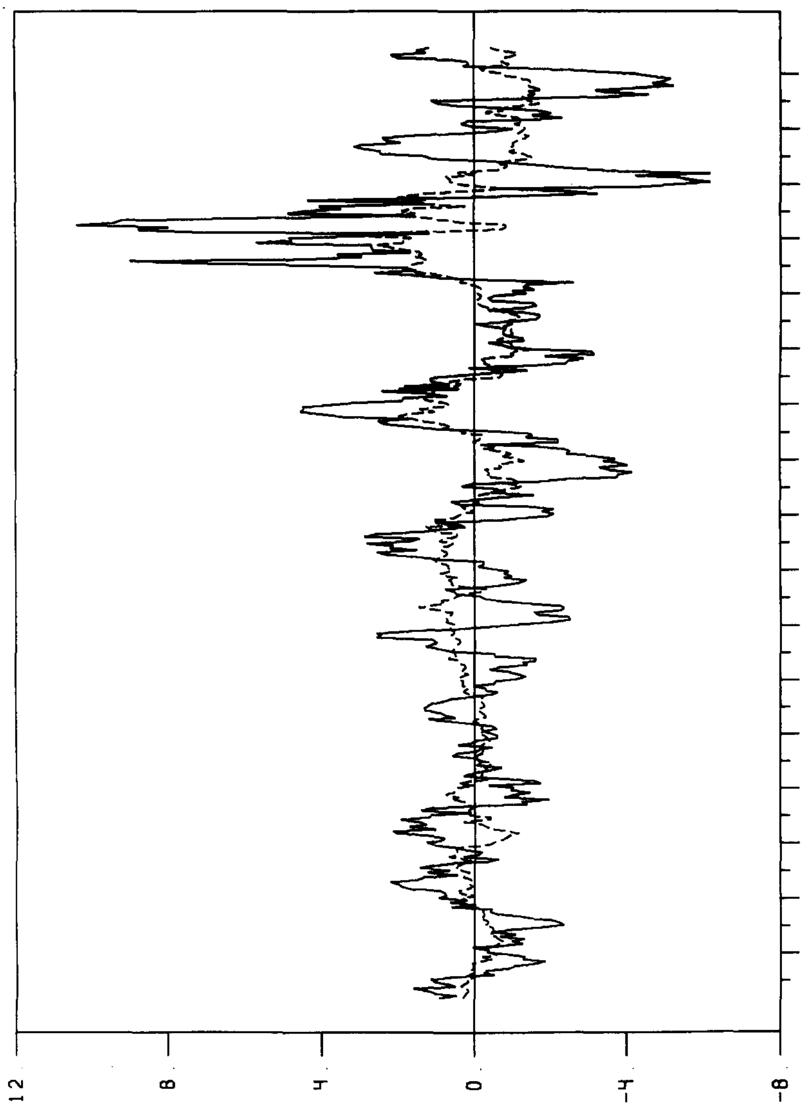

Fig. 2. Month-by-month values of the one-year change in the real return on one-year bonds and fitted values from regressions of the change on the five-year spread. The change, $R(t+2) - R(t+1)$, is plotted at t, the date of the spread $r(5:t) - s(t)$. The period for t is 6/52–12/86. $R(t+2) - R(t+1)$ = solid line; fitted values = short dashes.

paths of the variables. It is also interesting that the behavior of expected inflation and the expected real return explains why term-structure forecasts of spot rates are weak for short horizons but stronger for longer horizons.

3.3. Regression diagnostics

It is good form to check that tests on a long sample period produce similar results for subperiods. Although the sample period (1952–88) is long, the dependent variables in the regressions cover long (one- to six-year) horizons. Effective sample sizes are thus small, and subperiod tests lack power.

Another way to judge whether the regressions are a good summary of the behavior of the variables for the whole sample is from plots. Figs. 1 and 2 show the one-year changes in one-year inflation and the real return on one-year bonds and the fitted values from the regressions of the changes on the five-year spread. The plots illustrate the most novel result in table 1 – that the five-year spread forecasts both one-year changes in one-year inflation and the real return on one-year bonds. The general impression is that the regressions track changes in inflation and the real return throughout the sample period.

Figs. 1 and 2 also seem to suggest that changes in inflation above or below forecasted values tend to persist. Such autocorrelation might reflect shifts in regression parameters. However, since one-year changes in one-year inflation (or the real return on one-year bonds) cover two years, positive residual autocorrelation for lags less than two years is expected even when the yield spread perfectly tracks expected changes in inflation and the real return. The autocorrelation (table 2) of the residuals for one-year changes in inflation is, as expected, positive (0.18) at the one-year lag, but the autocorrelations for two- and three-year lags are negative (-0.23 and -0.17). Though small in magnitude, the autocorrelations (table 2) of the residuals for one-year changes in the real return on one-year bonds are negative at all annual lags but the fourth. If anything, then, the residuals from the regressions in figs. 1 and 2 show a hint of negative autocorrelation.

In short, the plots and residual autocorrelations do not suggest large shifts in regression coefficients during the 1952–88 period. This conclusion is, however, inherently weak, given the unavoidable problems in making subperiod inferences in tests for long forecast horizons.[3]

[3]For example, there are 427 observations in the term-premium regressions. If the observations did not overlap, and if the true residual autocorrelations were zero, the standard error of the estimated autocorrelations would be about $(1/427)^{0.5} = 0.05$. If the regressions were instead run on nonoverlapping annual observations on the term premiums, the sample size would be 36, and the standard error of the residual autocorrelations would be about $(1/36)^{0.5} = 0.17$. The analysis in Fama and French (1988, app.) implies that the effective sample size is much closer to 36 than 427. In the regressions for changes in the spot rate, the inflation rate, and the real return on one-year bonds, the effective sample size declines further as the forecast horizon (and the overlap of observations) increases. Cochrane (1988), Fama and French (1988), and Poterba and Summers (1988) discuss power problems in tests on long-horizon changes in economic variables.

Table 2

Summary statistics; 6/52–12/88.[a]

Variable	Obs.	Mean	Std.	Autocorrelation – Annual lag 1	2	3	4	5
				Term premiums				
$h(2:t+1)-s(t)$	427	0.14	1.82	0.14	−0.05	−0.03	−0.14	−0.20
$h(3:t+1)-s(t)$	427	0.22	3.27	0.10	−0.08	0.02	−0.13	−0.27
$h(4:t+1)-s(t)$	427	0.14	4.49	0.08	−0.08	0.05	−0.11	−0.33
$h(5:t+1)-s(t)$	427	−0.02	5.51	0.07	−0.10	0.05	−0.10	−0.33
				Yield spreads				
$r(2:t)-s(t)$	427	0.15	0.36	0.43	0.07	−0.20	−0.16	−0.00
$r(3:t)-s(t)$	427	0.28	0.55	0.44	0.02	−0.25	−0.21	−0.04
$r(4:t)-s(t)$	427	0.37	0.67	0.47	0.05	−0.25	−0.23	−0.08
$r(5:t)-s(t)$	427	0.43	0.75	0.46	0.06	−0.25	−0.24	−0.10
				Spot rate, inflation rate, and real return				
$s(t)$	427	5.90	3.20	0.86	0.74	0.66	0.58	0.51
$I(t+1)$	427	4.19	3.24	0.80	0.53	0.41	0.42	0.44
$R(t+1)$	427	1.71	2.82	0.67	0.35	0.17	0.08	−0.04
				AR1 models				
$s(t)$	415	0.84	0.10	−0.05	−0.10	0.06	−0.01	−0.08
$I(t+1)$	415	0.79	0.12	0.22	−0.30	−0.24	0.04	0.22
$R(t+1)$	415	0.67	0.10	0.12	−0.10	−0.08	0.03	−0.06
				Term-premium residuals: $h(T:t+1)-s(t)=a+b[r(5:t)-s(t)]+e(t+1)$				
$h(2:t+1)-s(t)$	427		1.75	−0.07	−0.13	0.02	−0.07	−0.15
$h(3:t+1)-s(t)$	427		3.12	−0.11	−0.17	0.08	−0.05	−0.23
$h(4:t+1)-s(t)$	427		4.25	−0.16	−0.18	0.14	−0.01	−0.28
$h(5:t+1)-s(t)$	427		5.19	−0.17	−0.20	0.14	0.01	−0.29
				Residuals: $s(t+1)-s(t)$, $I(t+2)-I(t+1)$ and $R(t+2)-R(t+1)$ on $r(5:t)-s(t)$				
$s(t+1)-s(t)$	415		1.72	−0.06	−0.14	0.01	−0.07	−0.16
$I(t+2)-I(t+1)$	415		1.79	0.18	−0.23	−0.17	0.15	0.21
$R(t+2)-R(t+1)$	415		2.17	−0.23	−0.17	−0.00	0.15	−0.09

[a] $h(T:t+1)$ is the one-year return (t to $t+1$) on a T-year discount bond. $s(t)$ is the time t spot rate (the yield on a one-year bond). $r(x:t)$ is the yield on an x-year bond. $I(t+1)$ is the one-year inflation rate (the change in the log of the CPI) from t to $t+1$. $R(t+1)=s(t)-I(t+1)$ is the real return on a one-year bond. The term premiums, inflation rate, and real return are the 427 monthly observations for June 1953 to December 1988. The yield spreads and the spot rate are the 427 monthly observations for June 1952 to December 1987.

The AR1 models for $s(t)$, $I(t+1)$, and $R(t+1)$ are estimated with OLS regressions of a variable on its value lagged twelve months. The statistics shown for the AR1 models are the AR1 slope and its standard error (in the 'mean' and 'std.' columns) and the autocorrelations of the residuals from the models. The standard errors of the AR1 slopes are adjusted for residual autocorrelation (eleven monthly lags) and for heteroscedasticity with the method of Hansen (1982) and White (1980). Statistics shown for other regressions are residual standard errors and autocorrelations.

The residual autocorrelations from the AR1 models for the spot rate and the real return are close to zero. The residual autocorrelations for the inflation model are larger, but not necessarily important, given the small effective sample sizes for monthly observations on overlapping one-year inflation rates. The AR1 slopes for the spot-rate and inflation models are around two standard errors below one. Only the slope for the real return model is much more than two standard errors below one. The slopes illustrate the well-known problems in distinguishing slowly mean-reverting processes from random walks. See, for example, Nelson and Plosser (1982).

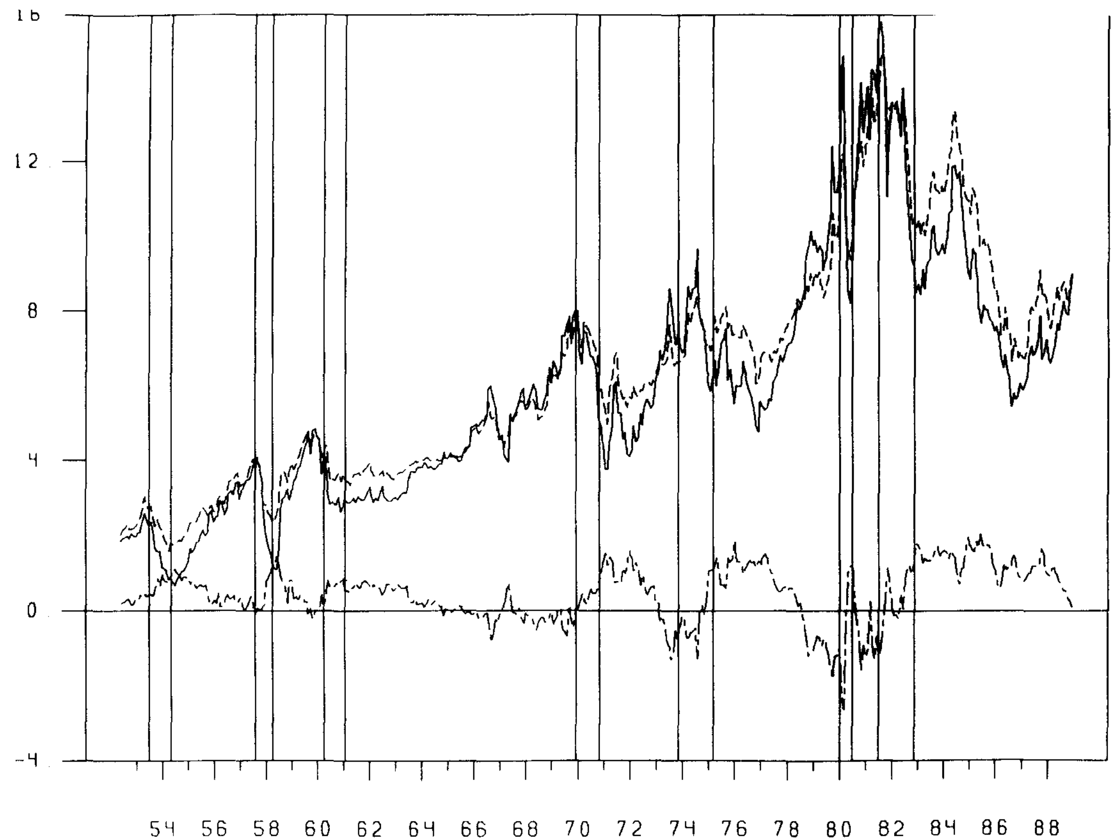

Fig. 3. Month-by-month values of the five-year yield, $r(5:t)$, the one-year spot rate, $s(t)$, and the five-year yield spread, $r(5:t)-s(t)$. The period for t is 6/52–12/88. $s(t)$ = solid line; $r(5:t)$ = short dashes; $r(5:t)-s(t)$ = long dashes. Grid lines are National Bureau of Economic Research business-cycle peaks and troughs. The dates are:

Peaks	7/53	8/57	4/60	12/69	11/73	1/80	7/81
Troughs	5/54	4/58	2/61	11/70	3/75	7/80	11/82

4. Forecast power and the business cycle

A stylized fact about the term structure is that interest rates are pro-cyclical [see, for example, Kessel (1965) and Fama (1986)]. Fig. 3 shows that in every business cycle of the 1952–88 period the one-year spot rate is lower at the business trough than at the preceding or following peak. (Business cycles are those identified by the National Bureau Economic Research, on the basis of variables other than interest rates.) Another stylized fact is that long rates rise less than short rates during business expansions and fall less during contractions. Thus spreads of long-term over short-term yields are countercyclical. Fig. 3 shows that in every business cycle of the 1952–88 period the five-year yield spread (the five-year yield less the one-year spot rate) is higher at the business trough than at the preceding or following peak.

The countercyclical pattern in the yield spread implies patterns in its forecasts of interest rates, inflation, and real returns. The positive slopes on the yield spread in the spot-rate and inflation-change regressions say that the spread forecasts decline in (typically high) interest and inflation rates in the years after business peaks and increases after troughs. The negative slopes in regressions of changes in the real return on the spread say that the spread forecasts that the real return on one-year bonds will rise in the years after business peaks and fall after troughs.

Since inflation is driven in part by money, shifts in monetary policy could change the path of inflation over the business cycle, which in turn could change the behavior of interest rates. The business-cycle patterns in inflation and interest rates, and the power of the yield spread to forecast inflation and the spot rate, would not necessarily survive a change in monetary regime. Fig. 1 suggests, however, that the power of the spread to forecast changes in inflation did survive the change in monetary policy during the 1979–82 period. [See Huizinga and Mishkin (1986).]

Finally, the positive slopes on the yield spread in the term-premium regressions say that expected term premiums in the one-year returns on two- to five-year bonds have the countercyclical pattern of the spread. Expected term premiums are low near business peaks and high near troughs. Fama and French (1989) find that a spread of long-term over short-term yields like that used here also tracks variation in the expected term premiums (excess returns) on corporate bonds and common stocks. They argue that the countercyclical variation of expected term premiums is consistent with the 'permanent-income' model of Modigliani and Brumberg (1955) and Friedman (1957).

5. Other tests

The yield spread is a jack-of-all-trades. It responds to information about term premiums and future spot rates, inflation rates, and real returns. As noted earlier, if the predictable components of these variables are not perfectly correlated, the spread is a noisy forecast of any one of them. It is thus interesting to check whether other forecasting variables uncover information lost in the noisy variation of the spread.

One possibility is to estimate multiple regressions that forecast with more than one yield spread. As noted earlier, however, the yield spreads for different maturities are highly correlated, so including more than one in a regression obscures the information in the slopes. The alternative chosen here is to forecast changes in the spot rate, inflation rate, and real return with the current yield spread and the most recent level of the variable.

The lagged level of a variable will forecast changes in the variable for a range of stochastic processes in which the level has a mean-reverting tendency. For example, if $z(t)$ is a first-order autoregression (AR1) with parameter $k < 1$ and mean u, the time t forecast of the T-period change in $z(t)$ is

$$\mathrm{E}_t z(t+T) - z(t) = u(1-k^T) + z(t)(k^T - 1).$$

[See, for example, Nelson (1973, p. 148).] Thus the lagged level of a stationary AR1 perfectly captures expected changes due to mean reversion. Without going into details, or meaning to put any emphasis on the results, table 2 suggests that AR1's explain, reasonably well, the times-series properties of the one-year spot rate, the inflation rate, and the real return on one-year bonds.

Table 1 shows that, used alone, the lagged levels of the spot rate, inflation rate, and real return forecast changes in the variables. All the slopes in the simple regressions on the lagged levels are negative and close to two or more standard errors from zero. These results suggest that the spot rate, inflation rate, and real return show tendencies toward mean reversion like that predicted by an AR1 with parameter less than one.

For present purposes, however, the important result in table 1 is that the lagged levels capture information about changes in the variables that is missed by the yield spread. In the multiple regressions for the change in the spot rate, the lagged spot rate seems to have forecast power for changes one to three years ahead – horizons where the yield spread shows no forecast power. Thus, there is predictability in one- to three-year changes in the spot rate, but (given market rationality) it is apparently buried in the noisy variation of the spread.

Although the yield spread shows power to forecast changes in inflation, the lagged inflation rate has marginal forecast power for some horizons. Thus the yield spread seems to miss some of the predictability of inflation. The lagged real return has marginal forecast power for changes in the real return, especially changes three to five years ahead. Even in simple regressions, the yield spread shows no power to forecast changes in the real return more than three years ahead. Thus the spread apparently misses some long-horizon mean reversion captured by the lagged level of the real return.

Finally, Kessel (1965) argues that expected term premiums should be positively related to the level of short-term interest rates. The lagged level of the spot rate is, in any case, a predetermined variable and thus a candidate to capture variation in expected term premiums that might be buried in the noisy information in the five-year yield spread. Table 1 shows that in simple regressions, the spot rate never has reliable power to forecast term premiums. When the yield spread is included in the regressions, there is a hint that the spot rate captures variation in expected term premiums missed by the spread.

6. Conclusions

The spread of the yield on a five-year bond over the one-year spot rate forecasts changes in the one-year inflation rate and the real return on one-year bonds. But the inflation rate and the real return move opposite one another, especially over shorter horizons. The result is that the yield spread shows little power to forecast one- to three-year changes in the one-year spot rate even though it shows strong power to forecast its components. The yield spread also tracks variation through time in the expected term premiums in the one-year returns on two- to five-year bonds.

In short, the simple tests presented here suffice to show that bond prices contain information about expected term premiums, future spot rates, and the components of the spot rate. The range of variables forecast by bond prices means, however, that more complicated tests will be needed to isolate the information in the term structure about of any one of them.

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