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THE INFORMATION IN THE TERM STRUCTURE: SOME FURTHER RESULTS

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The Information in the Term Structure: Some Further Results

ABSTRACT

This paper provides some refinements and updating of Fama's (1984) evidence on the information in the term structure about future spot interest rate movements. First, it uses econometric techniques that properly correct standard errors for overlapping data and for conditional heteroscedasticity. Second, it makes use of a new data set that has some potential advantages over Fama's and which has more recent data. Overall, the results are in broad agreement with those of Fama. The term structure does help predict spot interest rate movements several months into the future. Indeed, updating Fama's results indicates that the forecast power of forward rates is generally higher during the October 1982 to June 1986 period than it was during the sample periods Fama examined.

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I. Introduction

In a recent important paper, Fama (1984) resurrects the view that the term structure of interest rates contains information about the future movements of spot interest rates. Using ordinary least squares estimation, Fama finds evidence that the forward rate-spot rate differential helps predict changes in the spot rate, while the difference between adjacent maturity forward rates helps predict the future one-month changes in the spot rate.

This paper provides some refinements of Fama's regression evidence. First, it uses econometric techniques that properly correct standard errors for overlapping data and for conditional heteroscedasticity. Second, it uses an econometric procedure which can exploit additional information in the term structure. Finally, it makes use of a new data set that has some potential advantages over Fama's and which has more recent data.[1]

II. The Methodology and Data

In examining the information in the term structure about future movements in spot interest rates, Fama runs the following ordinary least squares (OLS) regressions:

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[1] All the results in this paper have been produced using an IBM PC with the GAUSS programming language. The data and all the computer programs used to produce this paper will be made available free of charge to any researcher who will send me a standard formatted 360 KB diskette with a self-addressed mailer.

(1) $$R_{t+\tau} - R_{t+1} = \alpha_1 + \beta_1(F\tau_t - R_{t+1}) + \eta^{\tau}_{t+\tau-1}$$

(2) $$R_{t+\tau} - R_{t+\tau-1} = \alpha_2 + \beta_2(F\tau_t - F(\tau-1)_t) + \eta^{\tau}_{t+\tau-1}$$

where,

$R_{t+\tau}$ = the one-month spot rate observed at time $t+\tau-1$,

$F\tau_t$ = the forward rate for month $t+\tau$ observed at time t.

The error term in these regressions will be serially correlated when $\tau > 2$ because the error term, which can be thought of as a forecast error, is realized only after $\tau - 1$ periods. Thus $\eta^{\tau}_{t+\tau-1}$ is likely to be correlated with $\eta^{\tau}_{t+1}, \eta^{\tau}_{t+2}, \ldots, \eta^{\tau}_{t+\tau-2}$, and therefore $\eta^{\tau}_{t+\tau-1}$ will follow a MA(τ-2) process. Because of the resulting serial correlation, the OLS standard errors of the coefficients -- which is what Fama (1984) reports -- will not be correct.

A solution to this problem is provided by Hansen and Hodrick (1980) who develop the following consistent estimate of the variance-covariance matrix of the parameter estimates.

(3) $$V_\tau = (X_\tau' X_\tau)^{-1} X_\tau' \Omega_\tau X_\tau (X_\tau' X_\tau)^{-1}$$

where,

V_τ = the variance-covariance matrix for the parameter estimates of the equation τ,

X_τ = the matrix of explanatory variables for equation τ, which is Txk.

(T = the number of observations, k = the number of explanatory variables).

Ω_τ = the variance-covariance matrix of the residuals $E(\eta_\tau\eta_\tau')$,

and the (i,j)th element of the estimated Ω_τ is defined as

$$(4) \qquad \omega_\tau(i,j) = \sum_{s=p+1}^{T} \hat{\eta}_s^\tau \hat{\eta}_{s-p}^\tau \qquad \text{for } p \leq q$$

$$= 0 \qquad \text{otherwise}$$

where $p = |i - j|$ and q = the order of the MA process, $\tau - 2$.

Because researchers have found that interest rate volatility has changed markedly in the postwar sample period that Fama examined, the error terms in equations (1) and (2) are likely to be conditionally heteroscedastic.[2] To obtain correct standard errors when there is conditional heteroscedasticity, the Hansen-Hodrick variance-covariance matrix needs to be modified using the method described by White (1980). This involves redefining $\omega_\tau(i,j)$ to be,

$$(5) \qquad \omega_\tau(i,j) = \hat{\eta}_i^\tau \hat{\eta}_j^\tau \qquad \text{for } p \leq q$$

$$= 0 \qquad \text{otherwise}$$

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[2]There is some evidence for conditional heteroscedasticity in the regression equations here, but it is not always very strong. In Fama's February 1959 to July 1982 sample period when $\tau = 2$, for example, White's (1980) test for conditional heteroscedasticity yields a test statistic (distributed as $\chi^2(1)$) of 3.65. This statistic indicates a rejection of conditional homoscedasticity at the 10% level but not at the 5% level. On the other hand, Engle's (1982) test for autoregressive conditional heteroscedasticity, in which squared residuals are regressed on one lag of the squared residuals, provides strong evidence for conditional heteroscedasticity: in the February 1959 to July 1982 sample period when $\tau = 2$, the lagrange multiplier statistic (distributed as $\chi^2(1)$) equals 21.95 which is highly significant. To check on the robustness of the results, I also have calculated the standard errors for the coefficients of regressions (1) and (2) under the assumption of conditional homoscedasticity. Although the calculated standard errors do sometimes differ appreciably from those found in the text (sometimes larger and sometimes smaller), the conclusions from these results are the same as the conclusions discussed in the text.

A problem with the Hansen-Hodrick estimate of the variance-covariance matrix and the variant allowing for conditional heteroscedasticity is that it need not be positive-definite in finite samples. In practice this means that standard errors of coefficients and test statistics may turn out to be negative. Newey and West (1985) have proposed a solution to this problem which involves down-weighting the off-diagonal elements of the Ω_τ matrix to produce a consistent estimate of the variance-covariance matrix which is guaranteed to be positive-definite. The Newey-West estimate of the variance-covariance matrix allowing for conditional heteroscedasticity calculates the $\omega_\tau(i,j)$ elements of Ω_τ as follows:

$$(6) \qquad \omega_\tau(i,j) = [1 - p/(q+1)]\hat{\eta}_i^\tau \hat{\eta}_j^\tau \qquad \text{for } p \leq q$$

$$= 0 \qquad \text{otherwise}$$

Additional information is available in the term structure that is not being used in ordinary least squares estimation because contemporaneous errors in forecasting changes in the spot rate may be highly correlated for different τ's. Therefore, seemingly unrelated regression (SUR) estimates of the system of equations with different τ's may produce substantial gains in efficiency. Indeed in other research on the information in the term structure, Mishkin (1987) finds that taking into account the cross-equation correlation of the error terms resulted in the estimated standard errors of coefficients falling by over 50%.

The SUR standard error estimates will again be incorrect because of the serial correlation of the error terms. The Hansen-Hodrick, Newey-West estimate of the variance-covariance matrix allowing for conditional heteroscedasticity can be generalized to apply to a seemingly unrelated regression system of g equations as follows. The SUR method assumes that the variance-covariance matrix of the residuals is $\Sigma \otimes I_T$, where,

Σ = variance-covariance matrix of the contemporaneous residuals from the g equations,

I_T = TxT identity matrix.

Using the Choleski decomposition $\Sigma^{-1} = P'P$, we get the GLS (i.e., the SUR) estimates by premultiplying the system by $P \otimes I_T$ and then proceed with OLS estimation. Allowing for conditional heteroscedasticity, the Hansen-Hodrick variance-covariance matrix of the parameter estimates of the transformed system is then,

$$V = (\tilde{X}'\tilde{X})^{-1}\tilde{X}'\tilde{\eta}\tilde{\eta}'\tilde{X}(\tilde{X}'\tilde{X})^{-1} \tag{7}$$

where,

V = variance-covariance matrix of estimated coefficients

$$X = \begin{bmatrix} X_1 & 0 & . & . & . & 0 \\ 0 & X_2 & 0 & . & . & 0 \\ . & & & & & \\ . & & & & & \\ 0 & . & . & . & 0 & X_g \end{bmatrix}$$

$\tilde{X} = (P \otimes I_T)X$,

$\tilde{\eta} = (P \otimes I_T)\eta$.

Writing the variance-covariance matrix out results in

$$V = (X'(P' \otimes I_T)(P \otimes I_T)X)^{-1}X'(P' \otimes I_T)(P \otimes I_T)\eta\eta' (P' \otimes I_T)(P \otimes I_T)X(X'(P' \otimes I_T)(P \otimes I_T)X)^{-1} \tag{8}$$

Making use of the fact that $P'P = \Sigma^{-1}$ and $\eta\eta' = \Omega$, the Newey-West modification of $\eta\eta'$ matrix, the equation above can be rewritten as,

$$(9) \qquad V = (X'(\Sigma^{-1}\otimes I_T)X)^{-1}X'(\Sigma^{-1}\otimes I_T)\Omega(\Sigma^{-1}\otimes I_T)X(X'(\Sigma^{-1}\otimes I_T)X)^{-1}$$

with the (i,j)th element of the $\Omega_{m,n}$ block of Ω defined as follows,

$$\begin{aligned} \omega_{m,n}(i,j) &= [1 - p/(q_m+1)]\hat{\eta}_i^m\hat{\eta}_j^n && \text{for } i \geq j \text{ and } p \leq q_m \\ &= [1 - p/(q_n+1)]\hat{\eta}_i^m\hat{\eta}_j^n && \text{for } i < j \text{ and } p \geq q_n \\ &= 0 && \text{otherwise} \end{aligned}$$

where $p = |i - j|$ and q_m = the order of the MA process for the error term of equation $\underline{m}$ and q_n = the order of the MA process for the error term of equation $\underline{n}$.

As in Fama (1984), the end-of-month Treasury bill rate data was obtained from the Center for Research in Security Prices (CRSP) at the University of Chicago and the one-month bill was defined to have a maturity of 30.4 days, the two-month bill 60.8 days, on up to the six month bill with a maturity of 182.5 days. For each defined maturity the interest rate was interpolated from the bills that were closest to the defined maturity. In effect, this means that the slope of the term structure is assumed to be constant between these two bills. Fama (1984) instead chooses a bill that has a maturity closest to six months and then keeps on taking the interest rate from this same bill every month as its maturity shortens in order to get interest rates on one to six-month bills. In effect, Fama is assuming that the slope of the term structure is zero around the desired maturity of the bill. The procedure used here which assumes the slope around the desired maturity is constant rather than zero is less restrictive, which is an advantage when you are examining the ability to predict future spot rate movements as in this paper. However, Fama's procedure makes use of actual transaction price data, which is an advantage when you are focusing on predicting future premiums as in his paper.

III. The Results

Table 1, which corresponds to Fama's (1984) Table 4, shows the estimated β's, their standard errors and the R^2's for regression equation (1), which regresses the change in the spot rate on the forward-spot differential. The first six rows contain the results for the sample periods in Fama (1984), and the coefficient estimates are typically quite close to those found there. The standard errors of the coefficients, however, are sometimes quite different from those found in Fama (1984).[3] For example, in Fama's full sample period, February 1959 to July 1982, the standard errors of the coefficients for $\tau = 2$ to 6 were .07, .10, .12, .10, and .10; the corresponding standard errors in the first row of Table 1 are .11, .18, .24, .15, and .11, which are larger and in one case is twice as large.[4] In general, however, the conclusion from the results

[3]This stems from the estimation technique and not from the modification of Fama's data set. Ordinary least squares estimates with the modified data set used here produced standard error estimates that were very close to those reported in Fama (1984).

Table 1

Regressions of the Change in

The Spot Rate, $R_{t+\tau} - R_{t+1}$, on the Forward

Rate Minus the Current Spot Rate, $F\tau_t - R_{t+1}$.

$$R_{t+\tau} - R_{t+1} = \hat{\alpha} + \hat{\beta}\ (F\tau_t - R_{t+1}) + \hat{\eta}_{t+\tau-1}$$

	Dependent Variable									
	$R_{t+2}-R_{t+1}$		$R_{t+3}-R_{t+1}$		$R_{t+4}-R_{t+1}$		$R_{t+5}-R_{t+1}$		$R_{t+6}-R_{t+1}$	
Sample Period	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2
2/59 - 7/82	.41** (.11)	.11	.27 (.18)	.03	.25 (.24)	.01	.21 (.15)	.01	.16 (.11)	.01
2/59 - 1/64	.44** (.12)	.22	.34** (.10)	.16	.28 (.16)	.06	.05 (.11)	.00	.06 (.14)	.01
2/64 - 1/69	.52** (.13)	.39	.40** (.14)	.19	.22 (.12)	.04	.32** (.09)	.18	.26** (.08)	.14
2/69 - 1/74	.32** (.07)	.12	.17 (.16)	.01	.61** (.18)	.13	.07 (.17)	.00	.15 (.11)	.02
2/74 - 1/79	.69** (.17)	.10	.10 (.25)	.00	.31 (.29)	.02	.20 (.22)	.02	-.12 (.18)	.01
2/79 - 7/82	.61** (.21)	.15	.43 (.32)	.04	.29 (.37)	.01	.43 (.33)	.03	.50 (.37)	.03
1/59 - 6/86	.40** (.09)	.11	.30* (.15)	.04	.29 (.19)	.02	.20 (.11)	.02	.16 (.10)	.01
1/59 - 9/79	.44** (.06)	.14	.25** (.08)	.04	.34** (.10)	.05	.12 (.09)	.01	.05 (.09)	.00
10/79 - 9/82	.71** (.23)	.20	.59 (.33)	.08	.47 (.35)	.03	.58 (.31)	.06	.64* (.30)	.07
10/82 - 6/86	.51** (.12)	.26	.64** (.15)	.23	.61** (.21)	.17	.13 (.17)	.02	-.03 (.17)	.00

Notes for all tables

Standard errors of coefficients in parentheses.
* = significant at the 5% level.
** = significant at the 1% level.

is similar to Fama's. In all cases, the forward rate-spot differential for one month ahead, $F2_t - R_{t+1}$, has significant predictive power for the change in the spot rate one month ahead, $R_{t+2} - R_{t+1}$. The forward-spot differential also has significant explanatory power for changes in spot rates further out in the future, although the number of significant β-coefficients (five) is less than in Fama's Table 4 (nine).

The last four rows of Table 1 contain results for a longer sample period than Fama's, January 1959 to June 1986, and for three subperiods January 1959 to September 1979, October 1979 to September 1982, and October 1982 to June 1986. These subperiods are examined because the Federal Reserve altered its techniques of monetary control in October 1979 and October 1982 and because previous research [Huizinga and Mishkin (1986) and Roley (1986)] have documented shifts in the stochastic process of interest rates in October 1979 and October 1982. The results in these sample periods indicate that forward rates do have predictive power for spot rates several months in the future. The β-coefficient estimates for one, two and three months in the future ($\tau = 2$ to 4) are statistically significant at the 1% level in both the pre-October 1979 and post-October 1982 sample periods. However, since the β-coefficient estimates for $\tau = 2$ to 4 are higher in the October 1979 to September 1982 period than in the pre-October 1979 period, the failure to find statistical significance when $\tau = 3$ and 4 in the October 1979 to September 1982 period is probably

[4]However, it is not always the case that the estimated standard errors here are larger than those found in Fama (1984). For example, the standard errors in the February 1979 to July 1982 sample are smaller in Table 1 than in Fama's Table 4.

due to the shortness of the sample period, which is only three years long. Indeed, the β-coefficient estimates are generally higher in both the post-October 1979 periods than in the pre-October 1979 period, as are the R^2's of the regressions. These results provide some support to the conclusion in Hardouvelis (1986) that the term structure has more predictive power for spot rates after October 1979 than before.

Table 2 provides Wald tests for whether the coefficients remain unchanged in Fama's five subperiods and the three subperiods with breaks in October 1979 and October 1982. The tests do not indicate that the coefficients change over Fama's five subperiods; the marginal significance levels of the test statistics are quite high, indicating that the probability of obtaining the value of the test statistic or higher under the null hypothesis that the coefficient estimates are equal in the five periods is high. The tests for whether the coefficients change in October 1979 and October 1982 do provide some evidence that the α and β coefficients shift when $\tau = 2$ or 3. However, tests for changes in the β-coefficients alone do not provide significant rejections of the equality of the β-coefficients in the three subperiods. Overall, there is little support for instability of the information in the term structure about future spot rate movements. However, it should be recalled that the Wald tests reported here may not have very great statistical power, and in addition, there is some evidence that for one and two months in the future, the information in the term structure did change with the shift in the Federal Reserve's operating procedures in October 1979 and October 1982.

The results on the marginal predictive power of forward rates on the one-month changes in future spot rates is obtained from the equation (2)

Table 2

Tests for Shifts in Parameters
of Table 1 Regressions

	Dependent Variable				
	$R_{t+2}-R_{t+1}$	$R_{t+3}-R_{t+1}$	$R_{t+4}-R_{t+1}$	$R_{t+5}-R_{t+1}$	$R_{t+6}-R_{t+1}$
Test of Equality of $\hat{\beta}$ coefficients in 2/59-1/64, 2/64-1/69, 2/69-1/74, 2/74-1/79, 2/79-7/82 Sample Periods					
$\chi^2(4)$ =	6.15	2.19	3.25	4.58	5.06
Marginal significance level	.1876	.7001	.5162	.3330	.2815
Test of Equality of $\hat{\alpha}$ and $\hat{\beta}$ coefficients in 2/59-1/64, 2/64-1/69, 2/69-1/74, 2/74-1/79, 2/79-7/82 Sample Periods					
$\chi^2(8)$ =	10.67	3.45	4.67	5.82	6.30
Marginal significance level	.2209	.9033	.7923	.6774	.6134
Test of Equality of $\hat{\beta}$ coefficients in 1/59-9/79, 10/79-9/82, 10/82-6/86 Sample Periods					
$\chi^2(2)$ =	1.51	5.92	1.35	2.12	3.94
Marginal significance level	.4696	.0518	.5085	.3466	.1395
Test of Equality of $\hat{\alpha}$ and $\hat{\beta}$ coefficients in 1/59-9/79, 10/79-9/82, 10/82-6/86 Sample Periods					
$\chi^2(4)$ =	16.47**	9.51*	6.23	6.70	7.63
Marginal significance level	.0024	.0496	.1826	.1523	.1061

regression of the future one-month changes in the spot rate, $R_{t+\tau} - R_{t+\tau-1}$, on the forward rate spread, $F\tau_t - F(\tau-1)_t$. Table 3 (which corresponds to Fama's (1984) Table 5) provides the β-coefficients, their standard errors and the R^2's for these regressions. Although the results are similar to those of Fama (1984), they are slightly less favorable to the view that the term structure has marginal predictive power for changes in the spot rate that are more than one month in the future. For two months ahead or more ($\tau \geq 3$), only four β-coefficients are significant and positive in the Fama sample periods and one coefficient is even significantly negative; in contrast, Fama found six significant positive coefficients and no significant negative coefficients. The results for the post-October 1982 sample period, however, provide additional evidence that the term structure has marginal predictive power for changes in the spot rate more than one month in the future. The results in the last row of Table 3 indicate that forward rate spreads provide significant predictive power for the change in the spot rate up to three months in the future ($\tau \leq 4$), a result also found in Hardouvelis (1986).

Table 4 which provides tests for shifts in the coefficients of the Table 3 regressions suggests that there is more coefficient instability for the marginal prediction equations of Table 3 than there were for the regressions in Table 1. In the first row of the table, there are two significant rejections of the equality of the β-coefficients in the Fama subperiods; while the last two rows of the table indicate that for τ = 2, 3 and 4 there are significant shifts in the coefficients in October 1979 and October 1982.

Table 3

Regressions of the Change in

The Spot Rate, $R_{t+\tau} - R_{t+\tau-1}$, on the Forward

Rate Spread, $F\tau_t - F(\tau-1)_t$

$$R_{t+\tau} - R_{t+\tau-1} = \hat{\alpha} + \hat{\beta}\,(F\tau_t - F(\tau-1)_t) + \hat{\eta}_{t+\tau-1}$$

	Dependent Variable									
	$R_{t+2}-R_{t+1}$		$R_{t+3}-R_{t+2}$		$R_{t+4}-R_{t+3}$		$R_{t+5}-R_{t+4}$		$R_{t+6}-R_{t+5}$	
Sample Period	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2	$\hat{\beta}$	R^2
2/59 - 7/82	.41** (.11)	.11	-.03 (.12)	.00	-.02 (.11)	.00	.04 (.08)	.00	.00 (.06)	.00
2/59 - 1/64	.44** (.12)	.22	.45** (.10)	.21	.25* (.11)	.07	.11 (.09)	.03	.19** (.06)	.09
2/64 - 1/69	.52** (.13)	.39	.34** (.12)	.21	.18 (.14)	.04	.21 (.11)	.14	.12 (.07)	.07
2/69 - 1/74	.32** (.07)	.12	.21 (.12)	.06	.16 (.09)	.04	-.08 (.06)	.01	-.08 (.06)	.04
2/74 - 1/79	.69** (.17)	.10	-.00 (.23)	.00	-.55 (.49)	.10	-.02 (.16)	.00	-.09 (.08)	.02
2/79 - 7/82	.61** (.21)	.15	-.59* (.28)	.07	-.36 (.29)	.02	.03 (.23)	.00	.26 (.37)	.01
1/59 - 6/86	.40** (.09)	.11	.03 (.11)	.00	.07 (.10)	.00	.05 (.07)	.00	.02 (.06)	.00
1/59 - 9/79	.44** (.06)	.14	.25** (.08)	.06	.06 (.11)	.00	.02 (.06)	.00	-.03 (.05)	.00
10/79 - 9/82	.71** (.23)	.20	-.56* (.27)	.07	-.24 (.27)	.01	.09 (.22)	.00	.25 (.34)	.01
10/82 - 6/87	.51** (.12)	.26	.42* (.17)	.13	.60** (.16)	.28	.14 (.12)	.03	.06 (.13)	.00

Table 4

Tests for Shifts in Parameters of Table 3 Regressions

	Dependent Variable				
	$R_{t+2}-R_{t+1}$	$R_{t+3}-R_{t+2}$	$R_{t+4}-R_{t+3}$	$R_{t+5}-R_{t+4}$	$R_{t+6}-R_{t+5}$
Test of Equality of $\hat{\beta}$ coefficients in 2/59-1/64, 2/64-1/69, 2/69-1/74, 2/74-1/79, 2/79-7/82 Sample Periods					
$\chi^2(4)$ =	6.16	14.74**	6.02	6.68	14.11**
Marginal significance level	.1876	.0053	.1973	.1538	.0069
Test of Equality of $\hat{\alpha}$ and $\hat{\beta}$ coefficients in 2/59-1/64, 2/64-1/69, 2/69-1/74, 2/74-1/79, 2/79-7/82 Sample Periods					
$\chi^2(8)$ =	10.67	15.00	7.97	8.96	15.03
Marginal significance level	.2209	.0591	.4367	.3458	.0585
Test of Equality of $\hat{\beta}$ coefficients in 1/59-9/79, 10/79-9/82, 10/82-6/86 Sample Periods					
$\chi^2(2)$ =	1.51	9.99**	10.02**	.80	1.03
Marginal significance level	.4696	.0068	.0067	.6706	.5966
Test of Equality of $\hat{\alpha}$ and $\hat{\beta}$ coefficients in 1/59-9/79, 10/79-9/82, 10/82-6/86 Sample Periods					
$\chi^2(4)$ =	16.47**	10.23*	10.68*	4.02	2.89
Marginal significance level	.0024	.0368	.0304	.40	.5762

Tables 5 and 6 provide the seemingly unrelated regression (SUR) estimates of the β-coefficients for the regression equations (1) and (2). In contrast to results in Mishkin (1987) which finds large gains in efficiency from SUR estimation when examining the information in the term structure about future inflation, the estimated standard errors do not decline substantially when SUR estimation is used here.[5] An explanation for the lack of success of the seemingly unrelated regression technique to produce large gains in efficiency is that the error terms of the regression equations examined here are not that highly correlated across equations. The contemporaneous correlations of the error terms across equations in the Table 5 regressions ranges from .4 to .9, while the correlations are near zero for the Table 6 regressions. Not surprisingly, then, the Tables 5 and 6 results are very similar to those found in Tables 1 and 3.

IV. Conclusion

This paper provides some refinements and updating of Fama's (1984) evidence on the information in the term structure about future spot interest rate movements. Overall, the results are in broad agreement with those of Fama. The term structure does help predict spot interest rate movements several months into the future. Indeed, updating Fama's

[5]Indeed, in some cases the estimated standard errors are higher in Tables 5 and 6 than they are in Tables 1 and 3. Even though the SUR estimates are asymptotically more efficient than OLS estimates, in small samples estimated SUR standard errors can turn out to be larger than OLS standard errors.

Table 5

SUR Estimates of $\hat{\beta}$ From Regressions of the Change in The Spot Rate, $R_{t+\tau} - R_{t+1}$, on the Forward Rate Minus the Current Spot Rate, $F\tau_t - R_{t+1}$

$$R_{t+\tau} - R_{t+1} = \hat{\alpha} + \hat{\beta}\,(F\tau_t - R_{t+1}) + \hat{\eta}_{t+\tau-1}$$

	Dependent Variable				
Sample Period	$R_{t+2}-R_{t+1}$	$R_{t+3}-R_{t+1}$	$R_{t+4}-R_{t+1}$	$R_{t+5}-R_{t+1}$	$R_{t+6}-R_{t+1}$
2/59 - 7/82	.27** (.10)	.02 (.12)	.11 (.12)	.04 (.07)	.02 (.08)
2/59 - 1/64	.46** (.10)	.41** (.07)	.40** (.13)	.17* (.08)	.12 (.08)
2/64 - 1/69	.44** (.10)	.34** (.08)	.26* (.11)	.20* (.10)	.17 (.07)
2/69 - 1/74	.28** (.08)	.17 (.14)	.10 (.20)	-.03 (.07)	-.07 (.17)
2/74 - 1/79	.53** (.17)	-.13 (.30)	.14 (.16)	-.04 (.17)	-.13 (.10)
2/79 - 7/82	.36* (.17)	-.07 (.23)	.16 (.24)	.20 (.21)	.30 (.24)
1/59 - 6/86	.28** (.08)	.09 (.10)	.15 (.10)	.07 (.05)	.02 (.07)
1/59 - 9/79	.37** (.05)	.15 (.08)	.15 (.07)	.03 (.04)	-.04 (.06)
10/79 - 9/82	.48* (.19)	-.01 (.25)	.20 (.27)	.25 (.25)	.39* (.27)
10/82 - 6/86	.50** (.10)	.54** (.13)	-.40** (.14)	.16 (.11)	-.02 (.12)

Table 6

SUR Estimates of $\hat{\beta}$ From Regressions of the Change in The Spot Rate. $R_{t+\tau} - R_{t+\tau-1}$, on the Forward Rate Spread, $F\tau_t - F(\tau-1)_t$.

$$R_{t+\tau} - R_{t+\tau-1} = \hat{\alpha} + \hat{\beta}\ (F\tau_t - F(\tau-1)_t) + \hat{\eta}_{t+\tau-1}$$

	Dependent Variable				
Sample Period	$R_{t+2}-R_{t+1}$	$R_{t+3}-R_{t+2}$	$R_{t+4}-R_{t+3}$	$R_{t+5}-R_{t+4}$	$R_{t+6}-R_{t+5}$
2/59 - 7/82	.43** (.11)	-.05 (.12)	-.03 (.11)	.03 (.08)	.02 (.06)
2/59 - 1/64	.45** (.11)	.51** (.11)	.38** (.11)	.16 (.09)	.14 (.06)
2/64 - 1/69	.52** (.12)	.36** (.11)	.19 (.12)	.24** (.09)	.10 (.06)
2/69 - 1/74	.32** (.07)	.21 (.12)	.16 (.09)	-.09 (.07)	-.09 (.07)
2/74 - 1/79	.66** (.18)	.04 (.23)	-.50 (.41)	-.15 (.24)	-.08 (.09)
2/79 - 7/82	.70** (.23)	-.68* (.27)	-.58 (.30)	.00 (.25)	.45 (.34)
1/59 - 6/86	.41** (.09)	.02 (.11)	.07 (.10)	.05 (.07)	.03 (.05)
1/59 - 9/79	.43** (.05)	.27** (.07)	.12 (.10)	.01 (.07)	-.03 (.05)
10/79 - 9/82	.84** (.24)	-.61* (.26)	-.41 (.28)	.07 (.24)	.34 (.31)
10/82 - 6/86	.54** (.12)	.47** (.16)	.58** (.18)	.09 (.12)	.07 (.12)

results indicates that the forecast power of forward rates is generally higher during the October 1982 to June 1986 period than it was during the sample periods Fama examined.

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