The Behavior of Interest Rates

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The evidence in Fama and Bliss (1987) that forward interest rates forecast future spot interest rates for horizons beyond a year repeats in the out-of-sample 1986–2004 period. But the inference that this forecast power is due to mean reversion of the spot rate toward a constant expected value no longer seems valid. Instead, the predictability of the spot rate captured by forward rates seems to be due to mean reversion toward a time-varying expected value that is subject to a sequence of apparently permanent shocks that are on balance positive to mid-1981 and on balance negative thereafter.

A forward interest rate is the rate one can lock in now for a commitment to buy a one-period bond in the future. This leads naturally to the hypothesis that forward rates forecast future spot (one period) interest rates. Early tests of this hypothesis largely use US Treasury bills, and the results are rather negative. Forward rates do not seem to predict spot rates, except perhaps a month or two ahead [Hamburger and Platt (1975), Shiller, Campbell, and Schoenholtz (1983), Fama (1984)]. Fama and Bliss (1987) find, however, that when the forecast horizon is extended, longer-term forward rates have strong power to forecast spot rates. They attribute this forecast power to slow mean reversion of the spot rate that only becomes evident over long horizons.

Figure 1 raises suspicion about this story. The figure shows the path of the updated one-year spot rate used by Fama and Bliss (1987), along with the spread of the five-year forward rate over the one-year spot rate, $f(5{:}t) - r(t)$. There is lots of variation in the spot rate, but its dominant feature during 1952–2004 is upward movement to mid-1981, followed by a long decline to the end-of-the-sample period. The spot rate is 1.8 in June 1952, it peaks at 15.8 in August 1981, and finishes at 2.7% at the end of 2004. This long swing in the spot rate may be the result of slow mean reversion, but the path of the five-year forward-spot spread suggests that such mean reversion does not explain why forward rates forecast longer-term changes in the spot rate. If the five-year forward-spot spread is driven by predictions of the long-term swing in the spot rate, $f(5{:}t) - r(t)$ should be more often positive before August 1981, when the spot rate rises, and more often negative thereafter, when the spot rate falls. There is no such pattern in the forward-spot spread. In fact, it is more often positive and on average

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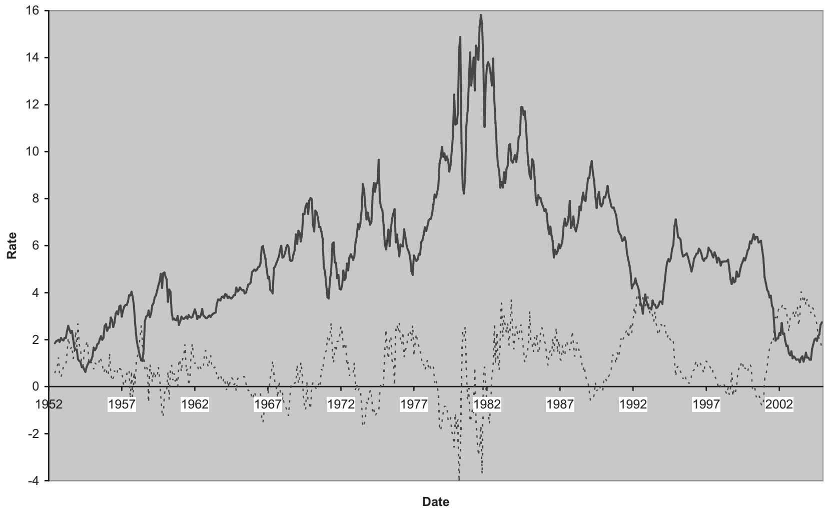

Figure 1
Spot rate, $r(t)$ (solid line) and five-year forward-spot spread, $f(5{:}t) - r(t)$ (dashed line).

about three times larger after August 1981 than before. In short, the long swing in the spot rate during 1952–2004 may be due to slow mean reversion, but Figure 1 and the more formal tests below suggest that any such slow mean reversion is not the source of the forecast power of forward rates.

One possibility is that the forecast power of forward rates in Fama and Bliss (1987) is sample specific. We shall see, however, that forward rates actually show more power to forecast spot rates in the post-1985 out-of-sample period.

What is the source of this forecast power if not mean reversion of the spot rate? The answer I suggest and test is that the long up and down swing in the spot rate during 1952–2004 is largely the result of permanent shocks to the long-term expected spot rate that are on balance positive to mid-1981 and negative thereafter. The power of forward rates to forecast spot rates then comes from a transitory component of the spot rate, which produces what I call local mean reversion, toward the spot rate's current long-term expected value.

The economic story to explain the long swing in the spot rate during 1952–2004 centers on the behavior of inflation. There was little prior experience with a fiduciary currency when the right to exchange currency for gold was discontinued in 1971, and it is reasonable that the high inflation and interest rates that followed were a surprise. It is also reasonable that the experience led market participants to rationally predict that a fiduciary currency (a currency that is not backed by a commodity like gold) implied permanently higher expected inflation. In other words, the preceding positive shocks to expected inflation were judged to be permanent. It turns out, however, that the Federal Reserve (and other central banks) won what was a long-odds game; they learned how to manage a fiduciary currency to bring about low inflation and interest rates. The result is a sequence of mostly negative permanent shocks to the spot rate. This story can explain why the spot rate appears to be slowly mean reverting in Figure 1, but the apparent mean reversion is missed by the forecasts of changes in the spot rate in forward-spot spreads.

The model I propose for the spot rate rings somewhat true to readers of the literature on dynamic multifactor term structure models, for example, Chen and Scott (1993), Duffee (2002), and Dai and Singleton (2002). The prime goal in these articles is to explain the evidence of Fama and Bliss (1987), Campbell and Shiller (1991), and others about how the term structure of yields and the term structure of one-period expected returns on bonds vary through time. In other words, modern dynamic term structure models basically attempt to capture all the stylized facts about the behavior of the term structure.

As in Litterman and Scheinkman (1991), the work on dynamic term structure models typically concludes that three factors, related to the level, slope, and "twist" of the term structure, drive yields and one-period returns. The first two of these factors are important in determining the time-series behavior of the spot rate. Thus, Duffee (2002: 438–439) concludes that

> Level shocks correspond to near-permanent changes in interest rates and only minimal changes in expected excess returns. Slope shocks correspond to business-cycle-length fluctuations in both interest rates and expected excess returns to bonds, while twist shocks correspond to short-lived 'flight to quality' variations in expected excess returns.

These statements about how level and slope shocks affect interest rates agree somewhat with the evidence presented here but not entirely. In my terms, the quote above says that the spot rate has a slow mean-reverting component (the result of near-permanent level shocks) and a more rapid (business-cycle-length) mean-reverting component (due to slope shocks). My results agree that there are business-cycle-length mean-reverting swings in the spot rate. But the evidence suggests that mean reversion is toward a nonstationary long-term mean. In other words, the level shocks in the quote above are permanent not near permanent.

Similar comments apply to Balduzzi, Das, and Foresi (1998). They estimate a model for the spot rate like the one that emerges from the dynamic multifactor term structure literature. In their world, the spot rate reverts toward a moving mean, which is a continuous time version of a stationary but slowly mean-reverting first-order autoregression (AR1). Again, this is in contrast to my evidence that the spot rate is indeed mean reverting but toward a nonstationary mean, which is the result of a sequence of permanent shocks.

Another strand of the term structure literature merits discussion. Spurred by Hamilton (1988), many papers estimate regime-switching models for the spot rate [for example, Gray (1996), Ang and Bekaert (2002)]. In these models, the number of parameters to be estimated grows rapidly with the number of spot rate regimes. As a result, two or at most three regimes are allowed. Perhaps because estimating many parameters implies low power, identifying regimes is typically mired in uncertainty. Moreover, if I am right and the spot rate is subject to a sequence of permanent shocks, two or three regimes may not suffice. Simpler but more flexible approaches to allowing for regimes, like that used here, may better capture the process.

Finally, the term structure literature has become quite formal, with high barriers to entry. (Those not facile with continuous time models and their estimation need not apply.) This is unavoidable, given the ambitious tasks undertaken. For example, as noted above, dynamic multifactor term structure models attempt to explain all the stylized facts about the term structures of one-period expected returns and yields. Capturing everything in one model requires lots of structure and advanced statistical methods. One of my goals is to show that when the task (understanding the behavior of the spot interest rate and the forecasts of spot rates in forward rates) is more limited, simple transparent methods can still provide evidence that poses new challenges to be absorbed by more all-encompassing formal models.

The article proceeds as follows. Section I sets up the logic of the tests of forward rates as predictors of spot rates. Section II updates the evidence in Fama and Bliss (1987) that over longer horizons forward rates forecast future spot rates. The important new result is that this forecast power is not due to the long up and down swing of the spot rate during 1952–2004, which is largely missed by the forecasts in forward rates. Thus, if bond pricing is rational, the long-term swing in the spot rate during the sample period must be the result of shocks viewed as permanent by market participants. Section III tests a model in which the spot rate indeed has a time-varying long-term expected value, and all predictability of the spot rate is due to mean reversion toward the current long-term expected value. The model is simple, but it provides a powerful explanation of the behavior of the spot rate, and the local mean reversion it documents seems to fully capture the forecasts of spot rates in forward rates. Section IV tests the model of section III against the alternatives of Baludzzi, Das, and Foresi (1998) and Duffee (2002) in which local mean reversion is toward a long-term expected value that is slowly mean reverting rather than nonstationary. The evidence seems to favor nonstationarity. Section V concludes.

1. The Logic of Forward Rate Predictions of the Spot Rate

The data [from the Center for Research in Security Prices (CRSP) of the University of Chicago] are imputed end-of-month prices, $P(1{:}t)$,..., $P(5{:}\ t)$, of one-year to five-year US Treasury discount bonds that pay \$1 at maturity. [Bliss (1997) details how the prices are calculated and provides empirical comparisons with alternative methods.] The sample period is from June, 1952 to December, 2004 (henceforth 1952–2004).

My term structure notation follows Fama and Bliss (1987). The continuously compounded return on an x-year bond bought at time t and sold at $t + x - y$, when it has y years to maturity is

$$h(x,y : t + x - y) = p(y : t + x - y) - p(x : t), \tag{1}$$

where $p(x : t)$ is the natural log of $P(x : t)$. Symbols before a colon are the maturities that define a variable, and the symbol after the colon is the time when the variable is observed. For example, $h(5, 1{:}t + 4)$ is the four-year return from t to $t + 4$ on a bond with five years to maturity at t.

The x-year yield to maturity, $r(x : t)$, on a bond with x years to maturity at t is

$$r(x : t) = -p(x : t). \tag{2}$$

The yield on a one-year bond, called the spot rate, is $r(1{:}t)$. Understanding the behavior of the spot rate and the predictions of the spot rate in forward rates is the goal of the article. To simplify the notation, r(1:t) is henceforth $r(t)$.

The time t forward rate for the year from $t + x$–1 to $t + x$ is

$$f(x : t) = p(x - 1 : t) - p(x : t) = r(x : t) - r(x - 1 : t). \tag{3}$$

For example, the five-year forward rate, $f(5{:}t)$, is the rate for the year from $t + 4$ to $t + 5$.

The definition of a return in Equation (1) implies that the price of an x-year bond can be expressed in terms of the one-year returns to be observed over the life of the bond,

$$\begin{aligned} p(x : t) = &- h(x, x - 1 : t + 1) - h(x - 1, x - 2 : t + 2) - \dots \\ &- r(t + x - 1). \end{aligned} \tag{4}$$

Or, taking expected values, E_t, at time t,

$$\begin{aligned} p(x : t) = &-E_t h(x, x - 1 : t + 1) - E_t h(x - 1, x - 2 : t + 2) - \dots \\ &- E_t r(t + x - 1). \end{aligned} \tag{5}$$

In words, the raw price $P(x : t)$ is the present value of the \$1 to be received at $t + x$, discounted at the expected returns on the bond over the remaining years of its life.

Like Equation (4), Equation (5) is a tautology, implied by the definition of returns. Equation (5) nevertheless has economic content, and it is the foundation for the tests of forward rates as predictors of spot rates. Thus, if we interpret the expected values in Equation (5) as rational (the best possible, given information available at t), then Equation (5) says that the price contains rational forecasts of the returns on the bond over the remaining years of its life. The forecast of specific interest here is $E_t r(t + x - 1)$, the expected value of the spot rate to be observed at the beginning of the last year in the life of the x-year bond.

To focus on $E_t r(t + x - 1)$, group (sum) the first $x - 1$ terms in Equation (5) and write the price as

$$p(x : t) = -E_t h(x, 1 : t + x - 1) - E_t r(t + x - 1). \tag{6}$$

Substituting Equation (6) into the forward rate expression Equation (3) and subtracting the spot rate gives

$$\begin{aligned} f(x : t) - r(t) = {} & [E_t r(t + x - 1) - r(t)] \\ & + [E_t h(x, 1 : t + x - 1) - r(x - 1 : t)]. \end{aligned} \tag{7}$$

In words, the forward-spot spread, $f(x : t) - r(t)$, is the expected change in the spot rate from t to $t + x - 1$, plus the spread of the expected $(x - 1)$-year return on an x-year bond from t to $t + x - 1$ over the time t yield on an $(x - 1)$-year bond.

Equation (4) implies that Equation (7) holds for realized returns as well as for expected values,

$$\begin{aligned} f(x : t) - r(t) = {} & [r(t + x - 1) - r(t)] \\ & + [h(x, 1 : t + x - 1) - r(x - 1 : t)]. \end{aligned} \tag{8}$$

Equation (8) implies that there are two complementary regressions that split the information in the forward-spot spread between the two terms of Equation (7),

$$r(t + x - 1) - r(t) = a + c[f(x : t) - r(t)] + e(t + x - 1) \tag{9}$$

$$\begin{aligned} & h(x, 1 : t + x - 1) - r(x - 1 : t) = -a + (1 - c) \\ & \quad [f(x : t) - r(t)] - e(t + x - 1). \end{aligned} \tag{10}$$

The slope c in Equation (9) measures the proportion of the variation through time in the forward-spot spread, $f(x : t) - r(t)$, that can be attributed to variation in $E_t r(t + x - 1) - r(t)$, the rational forecast of the change in the spot rate from t to $t + x - 1$. A reliably positive c implies that the forward-spot spread has power to forecast the change in the spot rate. Variants of regression Equation (9) provide the tests of the information in forward rates about future spot rates.

As indicated by the notation, Equation (8) implies that the intercepts in Equation (9) and (10) sum to zero, the slopes sum to 1.0, and the residuals sum to zero period by period. In this sense, the two regressions provide an exact split of the variation in the forward-spot spread between the expected change in the spot rate and the expected value of the $(x - 1)$-year return premium in Equation (7). We shall see, however, that for forecasts of the spot rate more than a year ahead ($x > 2$), the slopes in Equation (9) are not distinguishable from 1.0; that is, we cannot reject the hypothesis that all variation in forward-spot spreads is due to expected changes in the spot rate.

A potential problem in regressions Equation (9) and (10) is that the split of variation in the forward-spot spread between the expected change in the spot rate and the expected value of the $(x - 1)$-year return premium need not be constant through time. This issue is discussed in detail in Fama and Bliss (1987). Suffice it to say that if c is time varying, estimating it as a constant understates the extent to which forward rates forecast future spot rates.

2. Forecasting Changes in the Spot Rate with Forward-Spot Spreads

Table 1 summarizes estimates of regression Equation (9) to forecast changes in the spot rate. Look first at the pre-1986 period of Fama and Bliss (1987). The slope in the regression of the one-year change in the spot rate, $r(t + 1) - r(t)$, on the two-year forward-spot spread, $f(2{:}t) - r(t)$, is 0.22 ($t = 0.65$). Thus, there is not much evidence that the forward-spot spread predicts the change in the spot rate a year ahead. As the forecast horizon is extended, the slopes in Equation (9) increase. In the regression to predict four-year changes in the spot rate, the slope is 1.46 ($t = 4.72$). Thus, the five-year forward-spot spread, $f(5{:}t) - r(t)$, shows power to predict the change in the spot rate four years ahead. The regression R^2 also increase from 0.01 for forecasts of one-year changes in the spot rate to 0.39 for four-year changes. Thus, during 1953–1985, $f(5{:}t) - r(t)$ captures 39% of the variance of four-year changes in the spot rate.[1]

[1] The method of Hansen and Hodrick (1980) is used to adjust the standard errors of regression coefficients for residual autocorrelation due to the overlap of monthly observations on annual and multi-year variables. There is evidence that the volatility of interest rates changes through time, and the variation seems to be related to the level of interest rates [for example, Ang and Bekaert (2002)]. Thus, there is a potential heteroscedasticity problem in regressions like those in Table 1, which suggests that the method of Newey and West (1987) should be used to adjust for residual heteroscedasticity as well as autocorrelation. The Newey–West method is unattractive here, however, because it down-weights residual autocorrelations that should be taken at face value since they are the result of observation overlap. More important, in the regressions in Table 1 and Table 3 (below), changes through time in residual volatility seem to be unrelated to the explanatory variables, so they do not pose inference problems. The correlations between squared values of the regression residuals and the regression-fitted values are close to zero, typically less than 0.005. This is probably due to the fact that the main explanatory variables are forward-spot spreads (and, later, other spread variables), not levels of interest rates, and there seems to be little relation between variance changes and such spread variables. Finally, Cochrane and Piazzesi (2005) find that in term structure regressions for 1953–2003 with observation overlap like the regressions presented here, Hansen–Hodrick standard errors are close to those produced by bootstrap procedures.

Table 1
Regressions to explain one-year to four-year changes in the spot rate
$r(t+x-1) - r(t) = a + bD + c[f(x:t) - r(t)] + d[r(t) - K(t)] + e(t+x-1)$

	a	b	c	d	$t(a)$	$t(b)$	$t(c)$	$t(d)$	R^2
The period for the one-year change (x = 2) is June, 1953–December, 2004, 619 months									
$x = 2$	–0.05		0.11		–0.19		0.41		0.00
$x = 3$	–0.26		0.36		–0.55		1.08		0.02
$x = 4$	–0.49		0.61		–0.74		1.64		0.07
$x = 5$	–0.63		0.84		–0.79		2.26		0.12
The period for the one-year change (x = 2) is June, 1953–December, 1985, 391 months									
$x = 2$	0.14		0.22		0.48		0.65		0.01
$x = 3$	0.23		0.61		0.48		1.65		0.07
$x = 4$	0.27		1.20		0.50		3.16		0.23
$x = 5$	0.47		1.46		0.96		4.72		0.39
The period for the one-year change (x = 2) is January, 1986–December, 2004, 228 months									
$x = 2$	–0.60		0.37		–1.27		0.81		0.02
$x = 3$	–1.74		0.96		–2.19		1.85		0.17
$x = 4$	–2.88		1.38		–3.97		3.44		0.44
$x = 5$	–3.21		1.56		–5.80		4.09		0.57
The period for the one-year change (x = 2) is June, 1953–December, 2004, 619 months									
$x = 2$	–0.88	1.19	0.49		–2.29	2.59	1.80		0.10
$x = 3$	–1.89	2.25	0.83		–3.00	3.11	2.74		0.22
$x = 4$	–3.13	3.58	1.26		–4.57	4.60	4.49		0.44
$x = 5$	–3.49	4.06	1.38		–5.45	5.43	5.47		0.55
The period for the one-year change (x = 2) is June, 1958–December, 2004, 559 months									
$x = 2$	–0.02			–0.16	–0.06			–1.33	0.03
$x = 3$	–0.03			–0.34	–0.07			–1.63	0.07
$x = 4$	–0.05			–0.45	–0.08			–1.69	0.10
$x = 5$	–0.01			–0.53	–0.01			–1.71	0.11
The period for the one-year change (x = 2) is June, 1958–December, 2004, 559 months									
$x = 2$	–0.86	1.62		–0.36	–2.44	3.16		–3.00	0.21
$x = 3$	–1.52	2.85		–0.69	–2.64	3.46		–3.78	0.36
$x = 4$	–2.11	3.90		–0.92	–3.17	4.17		–4.59	0.50
$x = 5$	–2.53	4.71		–1.07	–3.75	5.02		–5.27	0.60
The period for the one-year change (x = 2) is June, 1958– December, 2004, 559 months									
$x = 2$	–0.74	1.58	–0.22	–0.42	–1.90	3.07	–0.65	–2.86	0.21
$x = 3$	–1.21	2.81	–0.39	–0.86	–1.82	3.43	–0.97	–3.45	0.36
$x = 4$	–2.52	3.97	0.41	–0.72	–3.33	4.29	1.11	–2.73	0.51
$x = 5$	–3.08	4.73	0.63	–0.73	–4.51	5.40	1.86	–2.63	0.62

$r(t)$ is the one-year spot rate observed at t. $f(x:t)$ is the forward rate observed at t for the year from $t+x-1$ to $t+x$. D is a dummy variable that is 1.0 for June, 1953 to August, 1981. $K(t)$ is the average value of the spot rate for the 60 months ending in month t–1. The variables cover annual periods, but they are observed monthly. The standard errors of the regression coefficients are adjusted for autocorrelation due to the overlap of monthly observations on the change in the spot rate with the method of Hansen and Hodrick (1980). The t-statistics, $t(a)$ to $t(d)$, are the regression coefficients divided by their standard errors. The regression R^2 are adjusted for degrees of freedom.

At first glance, the regressions seem to fall apart when the data are extended to 2004. The slopes in Equation (9) for the full 1953–2004 period are again positive, and they increase with the forecast horizon. But they are smaller than the slopes for 1953–1985, and only the slope for four-year changes in the spot rate is more than two standard errors from 0.0.

The regression R^2 are also rather trivial in the results for the overall period.

Do the full-period results imply that forward rates lose their power to forecast the spot rate after 1985? Table 1 shows that, if anything, the evidence of forecast power is stronger for 1986–2004 than for 1953–1985. The regression slopes and R^2 in the estimates of Equation (9) for 1986–2004 are larger than for 1953–1985. In the 1986–2004 regressions, R^2 rises from 0.02 for forecasts of one-year changes in the spot rate to 0.57 for four-year changes.

2.1 The Problem and a fix

Why do the estimates of regression (9) for 1953–1985 and 1986–2004 turn out much stronger than the estimates for the combined 1953–2004 period? The answer is in the regression intercepts in Table 1 and the path of the spot rate in Figure 1. The intercept in Equation (9) is the average change in the spot rate left unexplained by the forward-spot spread. The intercepts for 1953–1985 are positive, and the intercepts for 1986–2004 are strongly negative. This suggests that the upward movement in the spot rate during much of 1953–1985 (Figure 1) is largely a surprise to market participants as is the decline during 1986–2004.

Additional support for this view is in Table 2, which shows average values of forward-spot spreads and changes in the spot rate. Average forward-spot spreads increase with maturity during 1952–1984, which is in line with the fact that the spot rate on average increases. The positive intercepts in the spot rate change regressions for 1953–1985 say, however, that some of the average increase in the spot rate is missed by the forecasts of changes in the spot rate in forward-spot spreads. Bigger problems arise in the subsequent period, when the spot rate on average falls, but average forward-spot spreads are larger and increase more with maturity than in the earlier period. As a result, the intercepts in the spot rate change regressions for 1986–2004 (the average changes in the spot rate missed by forward-spot spreads) are more negative than the average changes in the spot rate.

The problem in the spot rate change regressions for the full sample period is that they fit to the average change in the spot rate for the period, which is close to zero (–0.00% per year) and in sharp contrast to the offsetting average changes for 1953–1985 (0.19%) and 1986–2004 (–0.34% per year). As a result, the full-period regressions do not allow for the underestimates of changes in the spot rate from forward-spot spreads during the period to mid-1981 when the spot rate rises and the overestimates during the subsequent period when the spot rate declines. This leads to the false impression that forward-spot spreads have little power to predict changes in spot rates during 1953–2004. The separate regressions for 1953–1985 and 1986–2004 partially solve the problem by

Table 2
Summary statistics for annual forward-spot spreads, $f(x:t)$ - $r(t)$, and annual changes in the spot rate

	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Monthly values of annual forward—spot spreads	June, 1952–December, 2003		June, 1952–December, 1984		January, 1985–December, 2003	
$x = 2$	0.41	0.70	0.23	0.70	0.71	0.59
$x = 3$	0.72	1.00	0.45	0.97	1.18	0.88
$x = 4$	0.89	1.20	0.51	1.05	1.53	1.17
$x = 5$	0.89	1.29	0.56	1.19	1.47	1.24
Monthly values of annual changes in the spot rate	June, 1953–December, 2004		June, 1953–December, 1985		January, 1986–December, 2004	
$r(t+1) - r(t)$	−0.00	1.64	0.19	1.73	−0.34	1.41

The forward-spot spread for maturity x is $f(x:t) - r(t)$, where $f(x:\mathrm{t})$ is the forward rate observed at t for the year from $t + x - 1$ to $t + x$, and $r(t)$ is the one-year spot rate observed at t. The variables cover annual periods, but they are observed monthly. Mean indicates an average.

allowing the different average unexpected changes in the spot rate for the two periods to be absorbed by the regression intercepts, in this way somewhat absolving forward rates for their failure to pick up the two long swings in the spot rate.

If this story has merit, there is a simple way to fix the spot rate regressions for the overall period so they can better isolate the variation in the spot rate that is predicted by forward spot spreads from variation left unexplained. Specifically, add a dummy variable, D, to Equation (9) which is one for the period up to August, 1981 when the spot rate peaks and zero otherwise,

$$r(t+x-1) - r(t) = a + bD + c[f(x:t)r(t)] + e(t+x-1). \qquad (11)$$

The dummy variable allows for different average unexpected changes in the spot rate before and after August, 1981. In this way, the regression for the full 1953–2004 period can abstract from the failure of forward-spot spreads to predict the long upswing in the spot rate to August, 1981 and the subsequent long decline. The slope c in Equation (11) can then better identify variation in the spot rate that is predicted by forward-spot spreads. In effect, the dummy variable in Equation (11) takes a similar but more direct approach to forgiving forward rates for their failures, to better unmask their successes, than the intercepts in the subperiod estimates of Equation (9).

The strategy of regression Equation (11) works. The intercepts in the estimates of Equation (11) are strongly negative, and the slopes for the dummy variable are strongly positive (Table 1). This is in line with the hypothesis that the long upswing in the spot rate to mid-1981, and the subsequent long decline are largely unexpected; that is, they are missed by the forecasts of spot rates in forward rates. Moreover, unlike the estimates of Equation (9) (no dummy variable) for 1953–2004, the full-period estimates of Equation (11) (with dummy) show that forward-spot spreads have power to forecast changes in the spot rate. The slopes for the forward-spot spread in Equation (11) rise from 0.49 ($t = 1.80$) in the regression for one-year changes in the spot rate to 1.38 ($t = 5.47$) for four-year changes. The regression R^2 in Equation (11) are also much larger than those from the full-period estimates of Equation (9), rising from 0.10 in the regression for one year changes in the spot rate to 0.55 for four-year changes.

I emphasize that the choice of August, 1981 as the break date for the dummy variable in Equation (11) is dictated by the hypothesis that the long run up in the spot rate before this date is largely unexpected by market participants as is the subsequent long decline. As noted above, the strong positive slopes for the dummy and the strong negative intercepts in Equation (11) are in line with this hypothesis. More important, however, is the fact that including the dummy variable enhances the slopes on the forward-spot spreads in Equation (11) relative to the full-period estimates of Equation (9). This confirms that the dummy variable improves the identification of the variation in the spot rate captured by forward rates. And this outcome is not foreordained. For example, suppose (contrary to my hypothesis) the forecast power of forward rates is due to prediction of the long up and then down swing in the spot rate during the sample period. In this scenario, introducing the dummy variable is likely to spuriously absorb part or all of the forecasts of spot rates in forward rates. The fact that the dummy variable has the opposite effect then seems like strong support for my view that the long swing up in the spot rate to August, 1981 was largely unanticipated by market participants as was the subsequent long decline.

It is also pertinent to note that the slopes for forward-spot spreads from the full-period estimates of Equation (11) (with dummy) are similar to the separate estimates from Equation (9) (no dummy) for 1953–1985 and 1986–2004. This is not surprising since the subperiod intercepts in Equation (9) are just a less precise way to allow the regressions to abstract from the failure of forward rates to capture the long up and down swing of the spot rate during the sample period, to show that forward rates do predict other variation in spot rates. Still, the fact that the subperiod estimates of Equation (9) (which split the data in 1985) and the full-period estimates of Equation (11) (which in effect split the data in August of 1981) support the same conclusions about spot rate variation captured and missed by forward rates says that the inferences are not sensitive to the choice of the break point.

Finally, economic justification for the choice of August, 1981 as the break date for the dummy variable in Equation (11) is offered later, in the course of developing an economic story for the evolution of the spot rate.

2.2 Perspective

Regressions like (9) are common in the literature testing the expectations hypothesis of the term structure, for example, Campbell and Shiller (1991), Bekaert, Hodrick, and Marshall (1997), Backus, Foresi, Mozumdar, and Wu (2001). In the world of the expectations hypothesis, the forward-spot spread, $f(x : t) - r(t)$, is the expected change in the spot rate, $E_t r(t + x - 1) - r(t)$ in (7), so the slope on the forward-spot spread in regression Equation (9) or (11) should be 1.0. This prediction does fairly well in the estimates of Equation (9) for 1953–1985 and 1986–2004 and in the estimates of Equation (11) for 1953–2004, except for $x = 2$ (forecasts of the spot rate one year ahead). Thus, as predicted by the expectations hypothesis, for forecast horizons beyond a year, variation in forward-spot spreads seems near entirely due to forecasts of changes in the spot rate.

The estimate of Equation (9) for 1953–2004 for $x = 2$, however, produces a slope, 0.11 ($t = 0.41$), which says that almost none of the variation in the two-year forward-spot spread $f(2{:}t) - r(t)$ is about changes in the spot rate one year ahead. We can then infer that in the complementary regression (10) of the term premium in the one-year return on two-year bonds, $h(2, 1{:}t + 1) - r(t)$, on $f(2{:}t) - r(t)$ the slope is 0.89 and 0.41 standard errors from 1.0. Without showing the details, I can also report that for all maturities x from two to five years, full-period regressions of one-year term premiums, $h(x, x - 1{:}\ t + 1) - r(t)$, on the corresponding forward-spot spreads, $f(x : \mathrm{t}) - r(t)$, also produce slopes indistinguishable from 1.0 and reliably different from zero. This updates and confirms the evidence in Fama and Bliss (1987) on time-varying term premiums in the one-year expected returns on bonds. Many other papers also find that when one focuses on variation in near-term expected returns, the expectations hypothesis is rejected, for example, Fama (1984), Stambaugh (1988), Campbell and Shiller (1991), Bekaert, Hodrick, and Marshall (1997), Backus, Foresi, Mozumdar, and Wu (2001), Cochrane and Piazzesi (2005).

Overall, the evidence here and elsewhere says that expected term premiums in one-year returns on longer-term bonds vary through time, which is inconsistent with the expectations hypothesis. As in Fama and Bliss (1987), however, the evidence here also says that forward rates forecast the one-year spot interest rate more than a year ahead. For forecast horizons beyond a year, one can not reject the hypothesis that all the information in forward-spot spreads is about changes in the spot rate. The interesting remaining task is to test a story for the predictability of the spot rate—a story much different from that of Fama and Bliss (1987).

3. The Spot Rate: Local Mean Reversion

The spot rate is the sum of an expected inflation rate and the expected real return on a one-year bond. Economic logic suggests that the expected real return (the real marginal product of riskless capital) is probably a stationary (mean reverting) process. But with a fiduciary currency (that is, a currency that is not exchangeable for a commodity), the expected inflation rate may be nonstationary. In this case, there is no single expected inflation rate toward which inflation always tends to move.

I posit that during 1952–2004, the one-year spot rate experiences permanent shocks that are on balance positive to mid-1981 and on balance negative thereafter. These shocks to the spot rate are largely due to shocks to expected inflation. Within regimes, however, the spot rate tends to revert to its current long-term expected value. The result is "local mean reversion" of the spot rate.

3.1 The model

In formal terms, I suggest that the spot interest rate is the sum of two processes, (i) a long-term expected value, $K(t)$, which is subject to periodic permanent shocks and (ii) a mean-reverting component, $X(t)$, that has unconditional mean equal to zero,

$$r(t) = K(t) + X(t). \tag{12}$$

The mean reversion of $X(t)$ is in part due to the mean reversion of the expected real return on a one-year bond (toward its constant expected value) and in part to the local mean reversion of the expected inflation rate (toward its current long-term expected value). The spot rate is thus mean reverting but toward a nonstationary mean. This local mean reversion of the spot rate accounts for the forecast power of forward-spot spreads. Shocks to $K(t)$ are, however, permanent. Thus, variation in the spot rate from this source is unpredictable and so missed by forward-spot spreads; indeed, it may obscure the forecasts of spot rates in forward rates. Since the shocks to $K(t)$ are on balance positive until mid-1981 and on balance negative thereafter, including the dummy variable for the period of rising rates in the spot rate change regression (11) picks up (albeit crudely) the effects of shocks to $K(t)$, allowing the regression to expose the forecast power of forward rates due to the mean reversion of $X(t)$.

This story gets visual support in the plots of the spot rate and the five-year forward-spot spread in Figure 1. The forward-spot spread is low when the spot rate is locally high (relative to recent past and near future values), and the forward-spot spread is high when the spot rate is locally low—a pattern that can account for the forecast power of the spreads.

The story gets more formal support in Goto and Torous (2003). They posit that there are regime shifts in the process generating inflation due to the money supply actions of the Federal Reserve. Their tests for a regime shift indicate that it occurs near the point (mid-1981) when the spot rate peaks. They argue that the Fed was surprised by the high inflation that resulted from its policies in the 1970s and subsequently took successful actions to control inflation. My story agrees with theirs, and in addition posits that both the long upswing in inflation (due to the failure of the Fed's policies) and the subsequent decline (due to successful policy changes) are largely a surprise to bond market participants.

The proposition that the long up and down swing of the spot rate during the sample period is due to permanent shocks may seem tenuous. The long-term pattern suggests mean reversion. My view is that this is hindsight. A fiduciary currency was relatively new when introduced in 1971, and it is likely that the high inflation and interest rates that followed were a surprise, both to the Federal Reserve and to the bond market participants. It is also reasonable that the experience led market participants to rationally predict that a fiduciary currency implied permanently higher expected inflation. It turns out, however, that the Federal Reserve (and other central banks) won what seemed a long-odds game; they learned how to manage a fiduciary currency to bring about low inflation and interest rates. The result is a $K(t)$ series that cumulates permanent shocks that are on balance positive to mid-1981 and on balance negative thereafter, a path that, after the fact, looks like mean reversion. This story can explain why the spot rate change regressions in Table 1 suggest that the long upswing in the spot rate to mid-1981 and the subsequent long decline are largely missed by the forecasts of the spot rate in forward rates, even though, ex post, the swing in the spot rate looks predictable.

The evidence presented later (section IV) leans toward the conclusion that the long-term expected spot rate, $K(t)$, is nonstationary but not conclusively. Nonstationarity, however, is not critical for my view that the path of $K(t)$ during the sample period was unpredictable and so rationally missed by the forecasts of spot rates in forward rates. An alternative story, consistent with my view, is that $K(t)$ turns out to be stationary (mean reverting), but this itself was a surprise. In particular, if the success of the Federal Reserve in taming inflation and interest rates during the 1980s was a low probability event, the result may be a $K(t)$ series that is *ex post* mean reverting, but this was not predictable *ex ante* (the process itself is new). This version of the story can also explain why the spot rate seems to be slowly mean reverting in Figure 1, but the mean reversion is missed by the forecasts of changes in the spot rate in forward-spot spreads.

3.2 Tests

How can we test the local mean reversion model of Equation (12)? I take a simple approach that bypasses strong assumptions about $K(t)$ and allows for substantial flexibility in the nature of the process. I first estimate $K(t)$ as a moving average of the most recent past five years of the spot rate. (Using ten years produces similar results.) I then estimate regressions of future changes in the spot rate on the deviation of the current spot rate from this proxy for $K(t)$, also including the dummy variable D for the period of rising spot rates,

$$r(t + x - 1) - r(t) = a + bD + d[r(t) - K(t)] + e(t + x - 1). \tag{13}$$

In mechanical terms, the intercept and the dummy variable in Equation (13) allow for the part of the long swing in the spot rate during the sample period that is not due to local mean reversion. In terms of my model for the spot rate, the intercept and the dummy are a simple (but crude) way to absorb some of the effects of permanent shocks to the long-term expected spot rate, $K(t)$, so as to better allow the slope d for $r(t) - K(t)$ to capture local mean reversion of the spot rate. If there is local mean reversion, the slope d in Equation (13) is negative; the spot rate tends to fall when it is above $K(t)$ and to rise when it is below. And d should approach –1.0 for longer forecast horizons.

The estimates of Equation (13) for 1953–2004 in Table 1 support these predictions, in striking fashion. The d slopes are negative and more so for longer forecast horizons, falling from –0.36 ($t = -3.00$) for one-year changes in the spot rate to –1.07 ($t = -5.27$) for four-year changes. Thus, local mean reversion seems to completely work itself out over a four-year period. This is like the transitory business-cycle-length swings in the spot rate identified by dynamic multifactor term structure models. [See the earlier quote from Duffee (2002).] The regression R^2 from Equation (13) rises from 0.21 for one-year changes in the spot rate to 0.60 for four-year changes. Thus, local mean reversion of the spot rate, along with the variation in its long-term expected value captured by the intercept and the dummy variable in regression (13), accounts for 60% of the variance of four-year changes. In short, it seems that we have a successful model for variation in the spot rate.

The dummy variable D is important in Equation (13). Table 1 shows that when it is dropped, the explanatory power of the local mean reversion variable is much weaker; the slopes on $r(t) - K(t)$ are about half the values observed when the dummy is included, and the regression R^2 fall below 0.12. This is much like the effect of the dummy on the full-period regressions (Table 1) that forecast changes in the spot rate with the forward-spot spread. Using the dummy variable to capture the unexpected part of the long up and then down swing of the spot rate is thus important in isolating both local mean reversion and the forecast power of forward-spot spreads.

My hypothesis is that the forecast power of forward-spot spreads is in fact due to local mean reversion of the spot rate. A test is obtained by adding the forward-spot spread to Equation (13),

$$\begin{aligned} r(t+x-1) - r(t) = a + bD + c[f(x:t) - r(t)] \\ + d[r(t) - K(t)] + e(t+x-1). \end{aligned} \tag{14}$$

The estimates of Equation (14) in Table 1 show that the local mean reversion variable, $r(t) - K(t)$, largely absorbs the strong forecast power of the forward-spot spread observed in the estimates of Equation (11). The slopes on the forward-spot spread in the estimates of Equation (14) for one-, two-, and three-year changes in the spot rate are less than 1.2 standard errors from zero, and the slopes on the local mean reversion variable are more than 2.7 standard errors from zero. The forward-spot spread has a hint of marginal explanatory power in the estimate of Equation (14) for the four-year change in the spot rate. But the R^2 for this regression [and for the estimates of Equation (14) for shorter forecast horizons] are near identical to those from regression (13), which does not include the forward-spot spread. This is all consistent with the hypothesis that the forecast power of forward-spot spreads is due to local mean reversion of the spot rate.

The estimate of $K(t)$, the long-term expected value of the spot rate, is crude (a five-year moving average of past spot rates), so it may seem surprising that the local mean reversion variable, $r(t) - K(t)$, absorbs the forecast power of forward-spot spreads in Equation (14). Equation (7) tells us, however, that if the expectations hypothesis does not hold, the forecasts of the spot rate in forward-spot spreads are contaminated by variation in expected return premiums, which acts like measurement error in the forecasts. The estimates of Equation (14) suggest that measurement error in forward-spot spreads as estimates of expected changes in the spot rate is more serious than measurement error in the estimates of $K(t)$.

Finally, the fact that the local mean reversion variable in regression (14) absorbs the forecast power of forward-spot spreads observed in Equation (11) implies that $r(t) - K(t)$ and $f(x:t) - r(t)$ are correlated. The correlations are strong, ranging from –0.72 (for $x = 2$) to –0.83 ($x = 5$).

4. Other Models for the Spot Rate

Our last task is to test the local mean reversion model of Equation (12) against other models for the behavior of the spot rate.

Fama and Bliss (1987) argue that the spot rate is a stationary AR1. Recent evidence (Balduzzi, Das, and Foresi 1998; Duffee 2002) suggests, however, that an AR1 does not fully capture the process for the spot rate. To set the stage for these new alternatives, I first update the results of Fama and Bliss (1987).

The first four autocorrelations (at annual lags) of the one-year spot rates of 1952–2004, 0.84, 0.67, 0.56, and 0.50, are consistent with an AR1. The fact that the spot rate ends the period near where it started (Figure 1) also suggests slow mean reversion. If the spot rate is an AR1, we can capture its predictability with regressions of changes in the spot rate on its lagged level,

$$r(t+x-1) - r(t) = a + dr(t) + e(t+x-1). \tag{15}$$

The slopes d on the spot rate should be negative, they should approach –1.0 as the forecast horizon increases, and the regression R^2 should approach 0.5. [See the Appendix in Fama and Bliss (1987).] The lagged spot rate is in general a good way to identify predictability of the spot rate due to global mean reversion. Thus, if the spot rate is mean reverting, it should tend to increase when it is below its long-term mean and decrease when it is above. This again implies that the slopes in Equation (15) should be negative and approach –1.0 for longer forecast horizons.

The estimates of Equation (15) for 1958–2004 in Table 3 are consistent with these predictions.[2] The slope d is negative, and it falls from –0.18 ($t = –2.09$) in the regression for the change in the spot rate one year ahead to –0.58 ($t = –2.46$) for four-year changes. The regression R^2 increase from 0.08 for one-year changes to 0.26 for four-year changes. The slopes do not reach –1.0, and R^2 does not reach 0.5 as the forecast horizon is extended, but Figure 1 and the autocorrelations of the spot rate reported above suggest that any long-term mean reversion is slow, so a four-year horizon may not be long.

Still, the evidence for mean reversion from the estimates of Equation (15) is at best marginal, even ignoring the well-known negative bias of the slopes when the series is nonstationary. Goto and Torous (2003) report that Phillips-Perron and augmented Dickey-Fuller tests for nonstationarity of the spot rate also leave the issue open, and they cite similar evidence from other studies. Nonstationarity is thus a real possibility.

Balduzzi, Das, and Foresi (1998) and Duffee (2002) suggest that the spot rate has two mean-reverting components, one quite slow and the other of intermediate duration. In terms of Equation (12), these models posit that the long-term expected spot rate, $K(t)$, is slowly mean reverting. This is in contrast to my hypothesis that $K(t)$ is nonstationary—subject to permanent shocks that are on balance positive to mid-1981 and on balance negative thereafter. My model and the alternatives agree, however, that there is local

[2] For consistency with the tests that follow, the sample period for the estimates of (15) begins in June 1958. Starting in June 1952 produces near identical results.

Table 3
Regressions to test competing models for the spot rate

	a	b	c	d	$t(a)$	$t(b)$	$t(c)$	$t(d)$	R^2
Part A $r(t+x-1) - r(t) = a + dr(t) + e(t+x-1)$									
1 year	1.04			–0.18	1.86			–2.09	0.08
2 years	2.09			–0.35	2.04			–2.30	0.16
3 years	2.81			–0.47	2.05			–2.33	0.21
4 years	3.56			–0.58	2.18			–2.46	0.26
Part B $r(t+x-1) - r(t) = a + bD + c[r(t) - K(t)] + dK(t) + e(t+x-1)$									
1 year	0.97		–0.20	–0.16	1.44		–1.67	–1.57	0.08
2 years	1.84		–0.42	–0.31	1.47		–2.10	–1.59	0.16
3 years	2.47		–0.58	–0.41	1.48		–2.30	–1.60	0.22
4 years	3.22		–0.70	–0.52	1.63		–2.49	–1.73	0.27
1 year	–0.86	1.62	–0.36		–2.44	3.16	–3.00		0.21
2 years	–1.52	2.85	–0.69		–2.64	3.46	–3.78		0.36
3 years	–2.11	3.90	–0.92		–3.17	4.17	–4.59		0.50
4 years	–2.53	4.71	–1.07		–3.75	5.02	–5.27		0.60
1 year	–0.63	1.54	–0.36	–0.03	–0.73	2.69	–2.98	–0.29	0.21
2 years	–1.05	2.69	–0.69	–0.06	–0.72	2.86	–3.77	–0.35	0.36
3 years	–1.66	3.75	–0.92	–0.06	–0.97	3.48	–4.60	–0.28	0.50
4 years	–1.83	4.47	–1.08	–0.09	–1.05	4.13	–5.31	–0.43	0.60

$r(t)$ is the one-year spot rate observed at t. D is a dummy variable that is 1.0 for June, 1958 to August, 1981. $K(t)$ is the average value of the spot rate for the 60 months ending in month $t-1$. The variables cover annual periods, but they are observed monthly. The standard errors of the regression coefficients are adjusted for autocorrelation due to the overlap of monthly observations on the change in the spot rate with the method of Hansen and Hodrick (1980). The t-statistics, $t(a)$ to $t(d)$, are the regression coefficients divided by their standard errors. The regression R^2 are adjusted for degrees of freedom. The time period for the one-year change in the spot rate is June, 1958 to December, 2004, 559 months.

mean reversion of the spot rate toward $K(t)$, captured by $X(t)$, the transitory component of the spot rate in Equation (12).

A simple way to test for the two sources of mean reversion of the spot rate posited by Balduzzi, Das, and Foresi (1998) and Duffee (2002) is to explain changes in the spot rate with the local mean reversion variable, $r(t) - K(t)$, and a proxy for the long-term mean, $K(t)$. My proxy is the five-year moving average of lagged spot rates. Thus, we have the regression,

$$r(t+x-1) - r(t) = a + R[r(t) - K(t)] + dK(t) + e(t+x-1). \quad (16)$$

The idea behind Equation (16) is that changes in the spot rate are predictable for two reasons, (i) local mean reversion of the spot rate toward its time-varying long-term expected value, $K(t)$, and (ii) slow mean reversion of $K(t)$ itself. The prediction is that the slopes b and d in Equation (16) are negative and more so in regressions to explain longer-term changes in the spot rate.

The estimates of Equation (16) in Table 3 offer only weak support for these predictions. The slopes c for the local mean reversion variable,

$r(t) - K(t)$, are negative and more so in the regressions for longer-term changes in the spot rate, ranging from –0.20 (t = –1.67) for two-year changes to –0.70 (t = –2.49) for four-year changes. The slopes d for $K(t)$ are also negative, falling from –0.16 (t = –1.57) in the regression for two-year changes in the spot rate to –0.52 (t = –1.73) for four-year changes. The evidence for local mean reversion of the spot rate seems stronger than the evidence that mean reversion of its long-term expected value also implies predictability of changes in the spot rate, but this is plausible if the mean reversion of $K(t)$ is quite slow.

There are, however, two ways to interpret the estimates of Equation (16), (i) literally, as above, or (ii) as an indirect way to allow different slopes for $r(t)$ and $K(t)$. In the latter view, the fact that the b and d slopes in Equation (16) are similar in value implies that in regressions of changes in the spot rate on $r(t)$ and $K(t)$, we cannot reject the hypothesis that the true $K(t)$ slopes are equal to zero. The estimates of Equations (15) and (16) in Table 3 confirm that the spot rate alone forecasts changes in the spot rate with near exactly the same power (R^2) as the two-variable model of (16). In short, there is a quandary as to whether we should interpret the estimates of Equation (16) as support for the model of Balduzzi, Das, and Foresi (1998) and Duffee (2002) in which the spot rate has two sources of mean reversion or as support for the AR1 of Fama and Bliss (1987).

Choosing between interpretations of Equation (16) is, however, unnecessary. Table 3 repeats the estimates of regression (13), which tests my hypothesis that there is local mean reversion of the spot rate but toward a nonstationary long-term mean, $K(t)$. Regression (13) substitutes the dummy variable D, which allows for different average unexpected changes in the spot rate before and after August, 1981, for the estimate of $K(t)$ in Equation (16), meant to pick up predictability of the spot rate due to slow mean reversion of $K(t)$. Regression (13) dominates, producing R^2 values more than twice those from Equation (16).

The higher explanatory power of Equation (13) comes in part from slopes on the dummy variable D that are stronger (in terms of t-statistics) than the slopes for $K(t)$ in Equation (16), and in part from more extreme negative slopes on the local mean reversion variable in Equation (13). Thus, using the dummy variable to allow for permanent shocks to $K(t)$ that are on balance positive to August, 1981 and on balance negative thereafter produces a more powerful model for the spot rate, and stronger evidence of local mean reversion, than using an estimate of $K(t)$ to capture predictability of the spot rate due to slow mean reversion of its long-term expected value. These results suggest that nonstationarity is a better model for $K(t)$ than slow mean reversion.

A final direct test of the two competing stories for the behavior of $K(t)$ is obtained by adding the estimate of the long-term mean of the spot rate, $K(t)$, to regression (13),

$$r(t+x-1) - r(t) = a + bD + c[r(t) - K(t)] + dK(t) + e(t+x-1). \tag{17}$$

The estimates of the local mean reversion coefficient *c* from Equation (17) (Table 3) are near identical to their values in Equation (13), which is consistent with the presence of local mean reversion predicted both by my view of Equation (12) and by the models of Balduzzi, Das, and Foresi (1998) and Duffee (2002). More important, the estimates of the slope *b* for the dummy variable *D* in Equation (17) are only a bit attenuated relative to their values in Equation (13), and they are large relative to their standard errors. In contrast, in the estimates of Equation (17), the slopes for $K(t)$ fall to values near zero (–0.03 to –0.09), and all are within 0.45 standard errors of zero. These results again suggest that nonstationarity is a better model for the behavior of $K(t)$ than slow mean reversion.

Another result favors this conclusion. If bond pricing is rational, slow mean reversion of the long-term expected spot rate, $K(t)$, would be picked up by the forecasts of changes in the spot rate in forward-spot spreads. But Figure 1 and the regressions in Table 1 say that the long up and then down swing in the spot rate during 1952–2004 is largely missed by forward-spot spreads.

There is, however, no need to push hard on nonstationarity as the story for the long-term expected spot rate. As discussed earlier, if the taming of inflation in the 1980s was a low probability outcome, it is possible that $K(t)$ turns out to be stationary, but this was not predictable. This story can also explain why the spot rate appears to be slowly mean reverting in Figure 1, but the apparent mean reversion is missed by the forecasts of changes in the spot rate in forward-spot spreads. The fact that the dummy variable *D* dominates my proxy for $K(t)$ in Equation (17) may then just imply that allowing for different average changes in the spot rate before and after August, 1981 captures the long-term mean reversion of the spot rate better than the $K(t)$ proxy.

5. Conclusions

The evidence in Fama and Bliss (1987) that forward-spot spreads forecast changes in spot rates for forecast horizons beyond a year repeats in the out-of-sample 1986–2004 period. But their inference that this forecast power is due to mean reversion of the spot rate toward a constant expected value no longer seems valid. In particular, the sample path of forward-spot spreads cannot account for the long upswing of the spot rate to mid-1981 and the subsequent long decline. Instead, the forecast power of forward-spot spreads seems to be due to local mean reversion of the spot rate toward an expected value that either (i) is subject to periodic permanent shocks or (ii) turns out to be mean reverting but in a way that was not predictable in advance.

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