Test of the Expectations Hypothesis: Resolving the Anomalies When the Short-Term Rate Is the Federal Funds Rate

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Abstract

The expectations hypothesis (EH) of the term structure plays an important role in the analysis of monetary policy, where shorter-term rates are assumed to be determined by the market's expectation for the overnight federal funds rate. With two exceptions, tests using the effective federal funds rate as the short-term rate easily reject the EH. These exceptions are when the EH is tested over the nonborrowed reserve targeting period and when the test is performed only using data for settlement Wednesdays—the last day of bank's reserve maintenance period. This paper argues that these exceptions are anomalous: In the former case, the failure to reject the EH occurs when economic analysis suggests that the market should be less able to forecast the federal funds rate. In the latter case, it occurs when there are sharp spikes in the funds rate that cannot improve materially the market's ability to forecast the funds rate. Additional analysis shows that these anomalous results are a consequence of the procedure used to test the EH.

JEL Classification: E40, E52
Key Words: expectations hypothesis, settlement Wednesdays, federal funds rate

"The forecasting of short term interest rates by long term interest is, in general, so bad that the student may well begin to wonder whether, in fact, there really is any attempt to forecast."
—Macaulay (1938, p. 33)

1. Introduction

The expectations hypothesis (EH) of the term structure of interest rates—the proposition that the long-term rate is determined by the market's expectation for the short-term rate over the holding period of the long-term asset plus a constant risk premium—plays an important role in economics and finance. Indeed, it is critical to many analyses of monetary policy where shorter-term rates are believed to be determined by the market's expectation for the overnight federal funds rate. Hardouvelis (1988), Simon (1990) and Roberds, Runkle and Whiteman (1996) investigated the expectations hypothesis (EH) using the effective federal funds rate as the short-term rate and the 3-month T-bill rate (or similar rate) as the long-term rate. With two exceptions these authors find little evidence to support the EH when the short-term rate is the federal funds rate.

One exception is when the EH is tested over the period when the Fed was attempting to control M1 using a nonborrowed reserves operating procedure, October 1979 to October 1982. All three authors find that the EH holds during this period. The second exception occurs when Roberds, Runkle and Whiteman (1996) apply the test using only days when banks are required to meet Federal Reserve-imposed reserve requirements—settlement Wednesdays. While, strictly speaking, the EH is rejected when the test is applied to settlement Wednesdays, the results are much more encouraging for settlement Wednesdays than for other days during the same time period.

Fundamentally, the EH is a proposition about the predictability of the short-term rate. Other things the same, the EH should fair better when the short-term rate is more predictable and less well when it is not. From this perspective, I argue that these results are inconsistent with the EH. The federal funds rate should be less predictable when the Fed is targeting monetary aggregates than it is when the Fed is explicitly targeting the federal funds rate. Consequently, the EH should be less likely to hold during the 1979-82 period and more likely to hold during periods before October 1979 and after October 1982—exactly the opposite of what these authors find.

Roberds, Runkle and Whiteman's (1996) settlement Wednesday results are equally anomalous. It is easy to show that the large transient shocks to the funds rate, which occur frequently on settlement Wednesdays, can have at most a modest affect on the market's ability to predict the average level of the short-term rate. Consequently, the improvement in the EH using settlement Wednesdays should be modest at best. Moreover, there is no theoretical or policy-related reason to believe that the behavior of the funds rate on settlement Wednesdays contains special information about the future behavior of interest rates. Indeed, shocks to the funds rate that occur on settlement Wednesdays are idiosyncratic in that they tend not to be reflected in other short-term rates. Consequently, if anything, the behavior of the funds rate on settlement Wednesday is a noisy signal of the future course of monetary policy and, hence, the funds rate.

Noting that the test that these authors employ may generate results that are favorable to the EH in situations where the short-term rate is unusually variable, I present evidence that these results are a consequence of the procedure they use to test the EH rather than evidence of the EH, as has been suggested. While the evidence suggests that

the EH does not hold when the short-term rate is the federal funds rate, this does not mean that longer-term interest rates are not determined by forward-looking behavior. Nor does it imply that longer-term rates are not determined, at least in part, by the market's expectation of Fed policy and, consequently, of the federal funds rate. Indeed, there is evidence (e.g., Poole and Rasche, 2000; Kuttner, 2001; and Poole, Rasche and Thornton, 2002), suggesting that the market anticipates changes in the Fed's target for the federal funds rate and that the market's ability to anticipate these changes has improved in recent years. The lack of support for the EH using the federal funds rate does suggest, however, that there are other determinants of longer-term rates in addition to the market's expectation of the federal funds rate. Exactly what these determinants are is an open issue.[1]

2. Testing the Expectations Hypothesis

While a number of ways of testing the EH have been proposed, perhaps the most popular test is the test that Hardouvelis (1988), Simon (1990) and Roberds, Runkle and Whiteman (1996) used. This test is derived under the null hypothesis that the EH holds. Specifically, the expectations hypothesis asserts that the long-term, n-period interest rate, r_t^n, is determined by the market's expectation for the average level of the short-term, m-period rate, r_t^m, at $n-m = (k-1)m$ periods in the future (where $k = n/m$ is an integer) plus a constant risk premium, π—that is,

(1) $\qquad r_t^n = (1/k)\sum_{i=0}^{k-1} E_t r_{t+mi}^m + \pi .$[2]

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[1] One of the most commonly cited reasons for the failure of the EH is the possibility of a time-varying risk premium.

[2] Shiller, Campbell and Schoenholtz (1983) argue that Equation 1 is exact in some special cases and that it can be derived as a linear approximation to a number of nonlinear expectations theories of the term structure.

To derive a test of the EH from Equation 1, expectations are assumed to be rational, i.e.,

(2) $\quad E_t r^m_{t+mi} = r^m_{t+mi} + v_{t+mi}, \quad i = 0,1,...,k-1,$

where v_{t+mi} is a mean-zero, *iid* white noise error. Equation 2 is substituted into Equation 1, which yields

(3) $\quad r^n_t = (1/k)\sum_{i=0}^{k-1} r^m_{t+mi} + (1/k)\sum_{i=0}^{k-1} v_{t+mi} + \pi.$

The EH is not tested using Equation 3 because the interest rates are unit root, or perhaps more correctly, near unit root processes. Because of this, r^m_t is subtracted from both sides of Equation 3 to yield

(4) $\quad (1/k)\sum_{i=0}^{k-1} r^m_{t+mi} - r^m_t = -\pi + (r^n_t - r^m_t) + \varpi_t,$

where $\varpi_t = -(1/k)\sum_{i=0}^{k-1} v_{t+mi}$. Equation 4 is then *parameterized* to yield

(5) $\quad (1/k)\sum_{i=0}^{k-1} r^m_{t+mi} - r^m_t = \alpha + \beta(r^n_t - r^m_t) + \varpi_t.$

The EH is tested by estimating Equation 5 and testing the null hypothesis $\beta = 1$.

2.1 *Evidence When the Short-Term Rate is the Effective Federal Funds Rate*

Hardouvelis (1988), Simon (1990) and Roberds, Runkle and Whiteman (1996) test the EH using Equation 5 with the effective federal funds rate as the short-term rate and the 3-month T-bill, or similar rate, as the long-term rate.[3] Their findings are illustrated here by estimating Equation 5 using the effective federal funds rate, ff_t, and the 3-month T-bill rate, tb_t. The effective federal funds rate is a weighted average of all daily transactions for a group of brokers who report daily to the Federal Reserve Bank of New York. The T-bill

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[3] Hardouvelis (1988) and Simon (1990) use the 3-month T-bill rate exclusively, while Roberds, Runkle and Whiteman (1996) use several long-term rates, including the 3-month T-bill rate.

rate is the secondary market rate. The observations are daily and cover the period

September 23, 1974, to December 31, 1997.[4]

Equation 5 is estimated over three periods. Two sets of estimates are presented for each period. The first are estimates obtained only using settlement Wednesdays (SW) and the second are the estimates using all days other than settlement Wednesdays (NSW). The first is the period of explicit funds rate targeting, September 23, 1974, to December 31, 1979 (e.g., see Cook and Hahn, 1989 and Thornton, 2004a). The second is the period of monetary aggregate targeting using the nonborrowed reserves operating procedure, October 9, 1979, to October 6, 1982. The third is from October 6, 1982 to December 31, 1997. This is a period of both indirect or *fuzzy* (Goodfriend, 1991) funds rate targeting and direct funds rate targeting. During much of this period, the Fed maintained that it was targeting borrowed reserves. However, evidence (Thornton, 1988 and 2004b, and Feinman, 1993) suggests that the Fed was targeting the funds rate. While it never announced it, in the early 1990s the Fed dropped all pretense of the borrowed reserve operating procedure and began targeting the funds rate directly (Thornton, 2004b). In 1994 the Fed began announcing its target for the funds rate.[5]

Estimates of Equation 5 are presented in Table 1.[6] Consistent with the findings of Hardouvelis (1988), Simon (1990) and Roberds, Runkle and Whiteman (1996), the

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[4] Note that the estimation period is shorter than the sample period of the data.

[5] There is some uncertainty about when the Fed began targeting the rate explicitly. Meulendyke (1998) suggests that the process began in 1987, stating that "the informal move away from borrowed reserve target was speeded by the stock market break on October 19, 1987" (p. 55). Using the verbatim transcripts of Federal Open Market Committee (FOMC) meetings, Thornton (2004b) shows that the last discussion of borrowed reserves in policy deliberations occurred at a January 8, 1991 conference call of the FOMC.

[6] The moving average of the federal funds rate on the left-hand side of Equation 5 is calculated on a calendar-day basis. To do this, the last observation prior to a missing observation (i.e., a weekend or a holiday) was used to fill in missing observations. These observations were not used in the estimation, which used only market observations. Because the regression involves a moving-average term, the residuals from this equation follow a moving-average process of the same duration. Consequently, the estimated covariance is corrected for both serial correlation and heteroskedasticity using a procedure suggested by Hansen (1982).

estimate of β is close to and not significantly different from one during the period of monetary aggregate targeting. This is true whether the equation is estimated using only reserve settlement days or other days.

Roberds, Runkle and Whiteman (1996) only estimate the equation using data after 1983. Consistent with their findings, estimates of β and $\bar{R}^2$ are larger when the equation is estimated using only settlement Wednesdays after October 6, 1982. While, strictly speaking, the EH is rejected, the larger estimates of $\bar{R}^2$ suggest that the term spread explains significantly more of the variation in the future federal funds rate on settlement Wednesdays than on other days. Table 1 shows that their findings are also obtained for the period prior to October 1979. Estimates of β and $\bar{R}^2$ are also larger on settlement Wednesdays during this period. Indeed, the estimate of β is not significantly different from zero only when the equation is estimated using settlement Wednesdays.

3.0 The EH and the Predictability of the Federal Funds Rate

The EH depends critically on the market's ability to predict the average level of the funds rate over the term of the T-bill rate. Generally speaking, the better able the market is to predict the level of the federal funds rate, the more likely it is that the EH will hold when the short-term rate is the federal funds rate. The results shown in Table 1 are ironic in that they indicate more support for the EH in situations when the funds rate is more difficult to predict and less support for the EH in situations where, relatively speaking, the funds rate should be easier to predict.

3.1. *The 1979-82 Period*

Because the number of market days is less than the number of calendar days used to calculate the moving-average term, the maximum order of the process is set at 65, the maximum number of market days in a 3-

During the period from October 1979 to October 1982 the Fed was targeting M1 growth using a nonborrowed reserves operating procedure. When attempting to control monetary aggregates, the Fed offsets the effects of shocks to supply and demand on the quantity of money, thereby, intensifying the effect of such shocks on interest rates. Other things the same, this makes predicting the average level of the federal funds rate more difficult.

In contrast, when the Fed is targeting the federal funds rate, the market should be able to form expectations of monetary policy and, thereby, better predict the level of the funds rate. During the periods before October 1979 and after October 1982, but before February 1994 when the FOMC announced its funds rate target, the market had to determine the level of the funds rate target from the Fed's behavior. This was enhanced by the fact that when targeting the funds rate, the Fed acts to offset the effects of shocks to supply and demand which would otherwise cause the funds rate to deviate from the target level. Such actions tend to induce mean (target) reversion in the funds rate (e.g., Taylor, 2001, and Thornton, 2001). Market analysts monitor the Fed's actions to determine the level of the funds rate that the Fed was defending. In addition, the Fed frequently signaled its intentions to change the funds rate by the specific type of operations used (see, for example, Meulendyke, 1998, and Fienman 1993).

Moreover, the target level of the funds rate is determined by policy considerations. If the market forms rational forecasts of monetary policy, it should also form rational forecasts of the Fed's target for the federal funds rate. If policymakers are concerned about inflation, it is reasonable to anticipate that policymakers will raise the funds rate target in

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month period. There was only one instance (Table 2) where the variance-covariance matrix was not positive semi-definite. In this instance, the Newey-West (1987) correction was employed.

situations where inflation pressures appear to be building. Likewise, concerns about recession or slow growth should cause market participants to anticipate a reduction in the policy rate. Indeed, many policy analysts (e.g., Goodfriend, 1991; Poole, 1991; Rudebusch, 1995; Blinder, et al., 2001; Woodford, 2001) argue that it is important for policymakers to be transparent because it enhances the market's ability to predict the policy rate and, consequently, policymakers' ability to affect long-term rates. Consequently, other things the same, the average level of the federal funds rate should be more predictable when the Fed is targeting the funds rate.[7]

Aware that the EH should work better when the level of the short rate is more predictable, Hardouvelis (1988) and Simon (1990) investigate the relationship between their results and the general predictability of the federal funds rate.[8] They found that the predictability of the funds rate did not vary significantly with the monetary policy operating procedure. Hardouvelis notes that his results support the hypothesis suggested by Mankiw and Miron (1986), who found that the market's ability to predict the funds rate appeared to decline with the Fed's return to interest rate targeting.[9] Simon suggests that "because changes in the federal funds rate were based to a greater extent on discretion rather than on a well-defined rule, federal funds rate changes may have been more difficult to forecast" after October 1982.[10]

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[7] The exception would occur if interest rates had a predictable component in the absence of Fed actions. For example, some have suggested that the better performance of the EH prior to the founding of the Fed occurred because there was a predictable seasonal pattern in interest rates. If the Fed removed the seasonal effect from interest rates, the market's ability to predict short-term rates declined.

[8] Hardouvelis (1988) used a univariate AR model of the funds rate and a VAR. Simon (1990) used the Goldsmith-Nagan *Reporting on Governments and Bonds and Money Market Letter* survey.

[9] Kool and Thornton (forthcoming) show that Mankiw and Miron's (1986) finding that the EH fares better before the Fed's founding also is due to sensitively of estimates of β to extreme observations. They find that when three extreme observations associated with the financial panic of 1907-1908 are properly accounted for, evidence for the EH is no different before the Fed's founding than after.

[10] Simon (1990), p. 576.

3.2. Settlement Wednesdays

It is also difficult to see why the results should be more favorable to the EH on settlement Wednesdays. It is well known that the funds rate sometimes spikes on settlement Wednesdays only to revert to its presettlement-day level the next day. Such spikes in the funds rate tend to be idiosyncratic in the sense that they are generally not reflected in other short-term interest rates, such as T-bill rates. Roberds, Runkle and Whiteman (1996) argue that it is this behavior of the funds rate that accounts for its improved predictability on settlement Wednesdays. Specifically, they argue that

> Our settlement-day results might be considered noteworthy in the sense that they show that the markets are not "spooked" by settlement-day pressures in the overnight Fed funds market. The market believes that the Fed is committed to returning to the presettlement overnight funds rates after settlement Wednesday, no matter how much rates move on settlement Wednesday. Thus yield spreads on settlement Wednesday are good predictors of future movements in short rates. (pp. 49-50)

Rudebusch (1995), who found that transitory deviations in the funds rate accounted for much of the spread's explanatory power in his simulations, put it this way:

> [I]f today's spot rate is unusually high relative to the target, it can be expected that future daily rates will return to the target level. Thus, the current three-month rate is close to the target rate. In this way, the spread between the overnight funds rate and the three-month rate should be a very good predictor of the change from the current daily rate to the average daily rate that prevails over the next three months. (p. 269)

As appealing as this argument sounds, it is easy to show why it is unlikely that it accounts for the marked change in the performance of the EH on settlement Wednesdays. To see why, assume that the Fed targets the funds rate and keeps it close to the funds rate target, i.e.,

(7) $ff_t = ff_t^* + \omega_t$,

where ff_t^* denotes the Fed's funds rate target on day t and $\omega_t \sim iid(0, \sigma_\omega^2)$ denotes the Fed's control error. If the EH holds, the T-bill rate will equal the average level of the expected funds rate plus a constant risk premium, i.e.,

(8) $tb_t = (1/91)\sum_{i=0}^{90} E_t ff_{t+i} + \pi$.

Substituting Equation 7 into 8 yields

(9) $tb_t = (1/91)\sum_{i=0}^{90} E_t(ff_{t+i}^* + \omega_{t+i}) + \pi$.

Now assume, as these authors do, that ff_t is observed before tb_t is determined, so that ω_t is observed. With this assumption, Equation 8 can be written as

(10) $tb_t = (1/91)\sum_{i=0}^{90} ff_{t+i}^* + \omega_t/91 + (1/91)\sum_{i=1}^{90} E_t \omega_{t+i} + \pi$.

Because the EH depends on the market participants' ability to predict the average level of the funds rate over the holding period of the T-bill rate, the important question is: How useful is observing ω_t for predicting the average level of the funds rate? The answer depends on what the market anticipates. If the market expects the Fed to offset the effect of this shock on the average level of the funds rate, the market will expect that $\sum_{i=1}^{90} E_t \omega_{t+i} = -\omega_t$. Under this assumption, Equation 10 becomes

(11) $tb_t = (1/91)\sum_{i=0}^{90} ff_{t+i}^* + \omega_t/91 - \omega_t/91 + \pi = (1/91)\sum_{i=0}^{90} ff_{t+i}^* + \pi$.

In this case, knowledge of ω_t is of no use for predicting the average level of the funds rate over the term of the long-term rate. The T-bill rate is solely determined by the market's expectation of the funds rate target, and there is no reason to believe that knowledge of ω_t improves the market's ability to predict the fund rate target.

If, on the other hand, the market anticipated that the Fed would act to bring the funds rate back to the funds rate target—which is what Roberds, Runkle and Whiteman (1996) and Rudebusch (1995) appear to suggest—Equation 10 becomes

$$(12) \quad tb_t = (1/91)\sum_{i=0}^{90} ff_{t+i}^* + \omega_t / 91 + \pi.$$

In this case, knowledge of the funds rate on settlement Wednesdays would improve the market's ability to predict the average level of the short-term rate. The improvement would be modest, however. For example, a 100-basis-point settlement-day spike in the funds rate would result in about a 2-basis-point improvement in the prediction of the average level of the funds rate. Moreover, other things the same, the improvement in the market's ability to predict the average level of the funds rate declines as the holding period lengthens. It is not certain what the market would anticipate, but, in either case, there is little reason to expect that information about ω_t should result in a marked improvement in the performance of the EH on settlement Wednesdays.

Finally, it should be noted that these explanations assume that the funds rate is observed before the T-bill rate is determined. If this were not the case, $E_t \omega_t = 0$ and there is no way that knowledge of the behavior of the funds rate on settlement Wednesdays could improve market participants' ability to predict the holding-period average funds rate. This point is important because the federal funds rate is a weighted average of federal funds transactions by a group of brokers who report daily to the Federal Reserve Bank of New York. The data are compiled each day, but not reported until the next morning, about 8 a.m. EST. Consequently, strictly speaking, ω_t is not observed.

4. What Accounts for These Anomalous Results?

If the funds rate is more difficult to predict during the 1979-82 period and knowledge of a settlement day shock to the funds rate provides little (or no) information useful for predicting the average level of the funds rate, why does Equation 5 generate results that more favorable to the EH at these times? The most likely explanation is econometric and stems from the fact that the current short-term rate is subtracted from both sides of Equation 3 in driving Equation 5. This feature of Equation 5 generates a positive relationship between the left- and right-hand-sides of Equation 5 whenever the funds rate moves contemporaneously relative to the T-bill rate, whatever the reason.[11]

4.1. *Settlement Wednesday Results Revisited*

The above characteristics of this test suggest the possibility that Roberds, Runkle and Whiteman's (1996) settlement Wednesday results may be the consequence of the relatively large and idiosyncratic shocks to the funds rate that tend to occur on reserve settlement days. Given the sensitivity of least squares to outliers, it would not be surprising to find that estimates of β increase on days when large idiosyncratic shocks to the funds rate cause the left- and right-hand-sides of Equation 5 to increase or decrease simultaneously.

This possibility is investigated by examining the sensitivity of β to the variability of the funds rate. To explore this possibility, days when there are large shocks to the federal funds rate, called *large shock days* (LSDs), are identified. LSDs occur when the federal funds rate changes by 80 basis points or more (approximately two standard deviations of the daily change over the sample period). Not surprisingly, over 35 percent (120) of the 338 LSDs were settlement Wednesdays.

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[11] For a more detailed analysis of this problem see Kool and Thornton (forthcoming) and Thornton (forthcoming).

The effect of LSDs—including settlement Wednesdays—on the estimate of β is illustrated in Figure 1, which shows $(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$ and $tb_t - ff_t$, over the period September 23, 1974, to October 2, 1997. To emphasize their effect, LSDs are highlighted. LSDs that do not occur on a reserve settlement day (LSD-NSW) are denoted with a square, while LSDs that occur on a settlement Wednesday (LSD-SW) are denoted with a triangle. A dual scale is used to make it easier to distinguish between the two series.

The effect of LSDs is dramatic. Large changes in the funds rate are associated with nearly proportionate movements in the left- and right-hand sides of Equation 5. The effect of such large changes in the funds rate on the estimate of β is clearly revealed when Equation 5 is estimated over various subsets of the data over the entire period. These results are presented in Panel A of Table 2. The estimate of β is closer to 1 and $\overline{R}^2$ is larger when Equation 5 is estimated using LSDs. Moreover, the estimate of β gets smaller and estimate of $\overline{R}^2$ falls by nearly 35 percent when LSDs are omitted. When the equation is estimated with LSDs that are settlement Wednesdays, the coefficient is only slightly larger than that for LSDs alone. When Equation 5 is estimated using settlement Wednesdays that are not LSDs, the estimate of β drops to 0.39 and only about 11 percent of the long-term change in the funds rate is explained by the slope of the yield curve.

This tendency also exists, but is less apparent, on days when the funds rate is somewhat less variable. This is illustrated by estimating Equation 5 with daily changes in the funds rate partitioned by size. The results are reported in Panel B of Table 2. The estimates of β and $\overline{R}^2$ increase with the absolute change in the funds rate. Indeed, when the change in the funds rate is sufficiently large, the null hypothesis that $\beta = 1$ is not rejected.

These results leave little doubt that Roberds, Runkle and Whiteman's (1996) settlement Wednesday results are a consequence of (1) the fact there tend to be large and idiosyncratic shocks to the funds rate on settlement Wednesdays and (2), by design, Equation 5 tends to generate larger estimates of β and $\overline{R}^2$ when there are relatively large shocks to the funds rate. Indeed, the fact that the estimates of β and $\overline{R}^2$ are very low on settlement Wednesdays that are not LSDs is consistent with the idea that there is nothing special about settlement Wednesdays other than large idiosyncratic changes in the funds rate tend to occur on these days.

4.2. *1979-82 Results Revisited*

Estimates of Equation 5 over the nonborrowed reserves period show that the EH is not rejected whether the equation is estimated on settlement Wednesdays or other days. Hence, the results during this period are not due to the sensitivity of β and $\overline{R}^2$ to large, idiosyncratic shocks to the funds rate. Nevertheless, the results for this period are also a consequence of the fact that ff_t appears symmetrically on both the left- and right-hand-sides of Equation 5.

This is illustrated in Figure 2, which plots $(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$ and $tb_t - ff_t$, and tb_t and ff_t over the 1979-82 period. During this period, the federal funds rate tends to rise relative to the T-bill rate when interest rates are rising and falls relative to the T-bill rate when interest rates are falling. The increased variability of the funds rate relative to the T-bill rate over the interest rate cycle creates a counter-cyclical pattern in $tb_t - ff_t$. Specially, $tb_t - ff_t$ falls when rates rise and rises when rates fall. The behavior of the funds rate relative to the T-bill rate creates a similar counter-cyclical pattern in

$(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$. When interest rates rise, the moving-average term,

$(1/91)\sum_{i=0}^{90} ff_{t+i}$, rises more slowly than the funds rate. Consequently,

$(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$ tends to fall when interest rates rise. For analogous reasons

$(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$ tends to rise when interest rates fall. While the counter-cyclical

behavior of this term is always present, it is much more pronounced during the period of

nonborrowed reserves because interest rates varied more dramatically during this period

than in the others.

Estimates of β close to 1, as well as the larger estimates of $\overline{R}^2$, are due to the

common cyclical patterns these variables caused by the funds rate moving relative to the T-

bill rate, rather than the other way around, as would be the case if the EH were the reason

for the larger estimate of β. Specifically, $tb_t - ff_t$ changed—not because the T-bill rate

changed, portending a change in the funds rate, but rather because $tb_t - ff_t$ changed as the

funds rate moved relatively more than the T-bill rate over a common interest rate cycle.

The federal funds rate averaged 200 basis points above the T-bill rate during this

period, nearly four times the average spread over the rest of the sample period.[12] Exactly

why the spread was so large and why it tended to widen when interest rates rose and

narrow when interest rates fell is unclear. Whatever the explanation, it is clear that the

failure of the conventional test to reject the null hypothesis $\beta = 1$ during this period is due

to this fact and not because the T-bill rate was adjusting in anticipation of movements in

the funds rate.

6. Conclusions

The expectations hypothesis of the term structure is the proposition that the long-term rate is equal to the market's expectation of the short-term rate over the holding period of the long-term rate plus a constant risk premium. The EH plays a particularly important role in discussions of monetary policy, where it is assumed that shorter-term interest rates are determined by the market's expectation for the overnight effective federal funds rate. Hardouvelis (1988), Simon (1990) and Roberds, Runkle and Whiteman (1996) test the EH using the effective federal funds rate as the short-term rate. They find that, with two exceptions, the EH is easily rejected using the effective federal funds rate. All of these authors find that the EH is not rejected during the period when the Fed was targeting M1 using a nonborrowed reserves operating procedure. In addition, Roberds, Runkle and Whiteman (1996) find that the EH performs much better when they only use observations for the last day of the reserve maintenance period, called settlement Wednesdays.

I argue that these results are anomalous in that they suggest that the funds rate is more predictable (1) during periods when the Fed is targeting monetary aggregates than when it is explicitly targeting the federal funds rate and (2) on days when there are large idiosyncratic shocks to the federal funds rate. I argue that the funds rate should be more predictable when the Fed is explicitly targeting it than when the Fed is targeting monetary or reserve aggregates. In addition, I show that settlement-Wednesday changes in the funds rate can, at best, account for a very modest improvement in the market's ability to predict the funds rate.

I then show that these author's results are due to the fact that the test that they use can generate results that appear favorable to the EH solely because the short-term rate appears symmetrically on both the left- and right-hand-sides of the regression equation.

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[12] The average spread over the remainder of the sample period was 52 basis points.

This characteristic of this test generates results that appear favorable to the EH on settlement Wednesdays because of the tendency of large changes in the funds rate to occur on those days. It also generates results that appear favorable to the EH during the period of monetary aggregate targeting because the funds rate rose relative to the T-bill rate when interest rates were rising and fell relative to the T-bill rate when interest rates were falling over this period.

The results suggest that the T-bill rate is not determined solely by the market's expectation for the effective federal funds rate. This does not imply that longer-term rates are not forward looking or that they are not affected greatly by the market's expectation of Fed policy. Indeed, there is some evidence to the contrary. These results do suggest, however, that there are factors, other than the market's expectation for the effective federal funds rate, that determine the T-bill rate. That the market's expectation for the short-term rate is not the sole determinant of the long-term rate is perhaps not too surprising in light of evidence on the difficulty of predicting interest rates (e.g., Rudebusch, 2002; Poole, Rasche and Thornton, 2002; Diebold and Li, 2003; and Duffee, 2002).

Finally, these results suggest that researchers should be careful in interpreting the results of this test. Researchers should be particularly wary if the results are, a priori, difficult to reconcile with the EH.[13] Indeed, researchers may want to use other tests such as the vector autoregression (VAR) test proposed by Campell and Shiller (1987), which

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[13] In this regard, it should also be noted that the probability limit of estimates of β goes to one as the variance of the short-term rate relative to the long-term rate increases without bound (see, Kool and Thornton, forthcoming, Campbell, Lo, and McKinlay, 1997). Also, see Hardouvelis (1988) for similar results for a different test of the EH. Moreover, Thornton (forthcoming) shows that Equation 5 generates estimates of β that are positive and statistically significant using data, which have characteristics similar to U.S. time series on long-term and short-term rates, but are generated in such a way that the EH does not hold.

was recently made operational by Beckeart and Hodrick (2001). The VAR test is much

more difficult to implement, however.

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	Estimates			
Sample	β	$\overline{R}^2$	Test $\beta = 0$	Test $\beta = 1$
9/23/74-10/5/79				
SW	0.3653	0.1436	2.06*	3.58*
NSW	0.1846	0.0370	0.55	2.43*
10/9/79-10/6/82				
SW	1.0598	0.4518	9.43*	0.53
NSW	1.2181	0.4053	4.09*	0.73
10/7/82-10/2/97				
SW	0.7777	0.6754	65.73*	18.79*
NSW	0.4301	0.2283	4.43*	5.87*

Table 1: Estimates of Equation 5: September 23, 1974 -- October 2, 1997

*Indicates statistical significance at the 5 percent level. SW indicates a settlement Wednesday and NSW indicates days other than settlement Wednesdays.

Table 2: The Effect of Shocks to the Funds Rate				
Panel A				
	β	$\overline{R}^2$	Test $\beta= 0$	Test $\beta= 1$
all days (5,805)	0.5415	0.2253	5.20*	4.40*
LSD (338)	0.8804	0.4804	7.09*	0.96
not LSD (5467)	0.4262	0.1396	5.06*	6.81*
LSD and SW (120)	0.9167	0.5757	9.44*	0.86[1/]
SW but not LSD (725)	0.3940	0.1089	4.75*	7.31*
Panel B				
$|\Delta ff| < 0.2$ (4005)	0.3774	0.1121	3.66*	6.03*
$0.2 \leq |\Delta ff| < .4$ (912)	0.4230	0.1085	19.88*	27.13*
$0.4 \leq |\Delta ff| < 0.6$ (347)	0.4821	0.1733	6.89*	7.41*
$0.6 \leq |\Delta ff| < 0.8$ (203)	0.6837	0.3184	7.58*	3.51*
$|\Delta ff| \geq 0.8$ (338)	0.8804	0.4804	7.09*	0.96
$|\Delta ff| \geq 1.0$ (223)	0.9063	0.5170	12.94*	1.34
$|\Delta ff| \geq 1.2$ (161)	0.9428	0.551	6.52*	0.40

The number of days in parentheses.

1/ The variance-covariance matrix was not positive semi-definite without the New-West correction, so the New-West correction was employed for this specification.

Figure 1: The Independent and Dependent Variables of Equation 5
(September 23, 1974 - October 2, 1997)

Legend

$(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$

$tb_t - ff_t$

LSD-NSW

LSD-SW
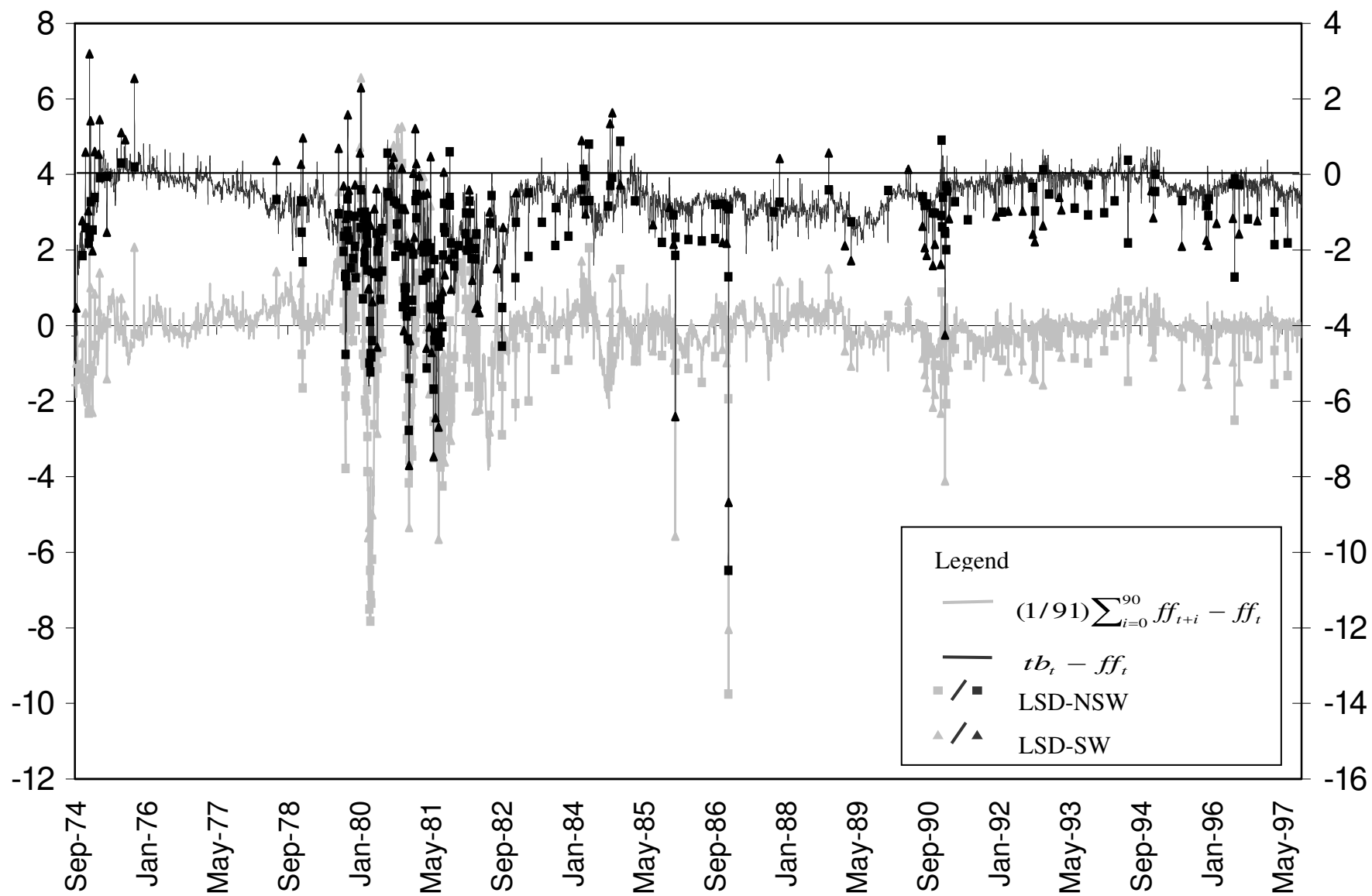
Figure 2: The Independent and Dependent Variables of Equation 5 and the T-Bill and Federal Funds Rates (October 9, 1979 - October 6, 1982)

Legend

— $(1/91)\sum_{i=0}^{90} ff_{t+i} - ff_t$

--- $tb_t - ff_t$

— ff_t

--- tb_t

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