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ON U.S. TREASURY BILLS

by

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ABSTRACT

This paper examines the behavior of forward premiums on U.S. T-bills under the maintained hypothesis that the T-bills futures market is the forecast of expected future spot rates used by participants in the spot bill market. Two hypotheses are examined: the money substitute, or liquidity, hypothesis and the risk hypothesis. The liquidity explanation of forward premiums appears to be more consistent with the data but this result is tentative given the shifts that appeared in the relationship over the sample period.

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I. INTRODUCTION

This paper examines the behavior of forward premiums on U.S. Government Treasury Bills (T-bills) for the period June 1976 to September 1982. Forward premiums are one measure of the increase in yield required by investors if they are to hold a "long-term" security instead of a sequence of "short-term" securities. I consider two explanations that have been suggested to explain the existence and movements in this premium: the risk hypothesis that the forward premium represents a return to bearing the greater risk of holding longer-term securities; and the money substitute, or liquidity, hypothesis that maintains that the premium represents the decreased monetary services provided by longer-term securities relative to short-term assets.

This study differs from past studies of forward premiums in its method of generating expected future spot rates of return. Past studies by the use of rational expectations, have assumed that forecasts of future spot rates have been, on average, correct, and therefore, the average difference between forward yields and the actual spot yields can be used as a measure of the forward premium.¹ This approach to generating forward premiums has at least two deficiencies, however. First, there is no necessary reason why, for any short sample period, expectations should, on average, be correct;² and secondly, little allowance is provided for variations in forward premiums.³

A second method of estimating forward premiums that does permit variations is that employed by Modigliani and Shiller (1973) and Pesando (1975). This method also makes use of the rational expectations hypothesis. In this method, a forecast of future spot rates is generated using, as independent variables, past short rates and the inflation rate. The synthetic series
of interest rates generated in this manner would represent a rational expectations forecast if the market information set consisted only of past interest and inflation rates. Then, comparing forward yields with these forecasted spot rates generates a measure of forward premiums. The problem with this method is that it restricts the assumed information set to what must realistically be supposed is a subset of the information that the market actually uses in forming its expectations.

This paper adopts a different method of generating rationally expected future spot rates that does not suffer from researcher-imposed constraints on the information set of market participants. The maintained hypothesis will be that the rate of interest on three-month treasury bill futures represents the "market" forecasts of expected future spot rates for three-month treasury bills that are used by participants in the spot T-bill market. Because participants in the treasury bill market can, and do, participate in the futures market, the information available in each market should be the same and, indeed, will represent the "market" information set. Thus, minimal restrictions are imposed by the researcher himself on what constitutes the "appropriate" information set used by the "market". Under the maintained hypothesis any difference between the forward yield and the futures market yield for the same bill must be the forward premium on spot T-bills. Over the sample period of this study this premium has averaged almost 40 basis points.

In the absence of arbitrage costs the forward yield and the futures rate would have to be (approximately) the same, since both the forward price and futures price represent the delivery of the same good. However, as Capozza and Cornell (1979) document, the cost of arbitraging away any
differences in forward and futures market prices is quite high due to the cost of going short in the spot market. Because the bulk of these costs are associated with the forward position it means that agents will not force the forward rate into equality with the expected spot rate and arbitrage the forward premium away. In the futures market, however, the cost of entering or liquidating a contract is quite small ($25 per round turn is used by Capozza and Cornell (1979)) and any divergences in the futures rate from the expected future spot rate on the deliverable bill can be expected to be quite small before speculators begin to respond to those differences. Thus, while information is assumed to be the same in the spot and futures markets, the futures market permits the participation of more agents who are willing to speculate on any differences in the futures market over expected future spot rates. In addition, with the possible exception of tax rulings over this period, the costs of holding a long or short position in the futures market are (approximately) the same, so there would appear to be no reason why speculative activity would generate a persistent bias in futures market prices that differed from the price expected on delivery of that bill. In the next section I analyze more fully the meaning of the difference between the futures and forward rates.

In Section III of this paper I examine two hypotheses of the determinants of forward premiums, the risk hypothesis and the money substitute or "liquidity" hypothesis. The former argues that the forward premium is a reward for risk-bearing: the longer the term to maturity, the greater the degree of uncertainty in forecasting future yields and the greater the volatility of holding period yields. Hence the greater the yield must be to induce agents to commit funds on a long-term basis.
The liquidity hypothesis argues that the forward premium reflects the absence of "moneyness" of longer-term securities relative to short-term securities: factors affecting the demand for money will also affect the relative yields of assets with different terms to maturity. It is also pointed out that these hypotheses are not mutually exclusive and that the risk attached to liquid assets may, in fact, alter the quality of the monetary services provided by these assets.

Section IV provides the empirical tests of these two hypotheses using data over the 1976-1982 period. In addition, the stability of the estimated relationships is examined. This latter examination provides some evidence on the behavior of financial markets during a period of rapid financial innovation and change in the operation of monetary policy. The results suggest the change in Federal Reserve operating procedures in October 1979 may have been instrumental in altering the level of forward premiums.

II. FORWARD RATES, FUTURES MARKET RATES, AND FORWARD PREMIUMS

To define forward premiums, let \( r_t(1) \) denote the one-period rate of interest prevailing at time \( t \), \( \hat{r}_t(i) \) be the one-period rate of interest expected at time \( t \) to prevail on a one-period bill maturing at the beginning of period \( t+1 \), \( \Delta_t(k) \) be the one-period term premium on a \( k \)-period bill and \( f_{d_t}(k) \) the one-period forward rate for period \( t+k \) as seen at date \( t \). By definition, the price at date \( t \) of a bill paying one dollar at date \( t+i \) is

\[
PS_t(i) = 1/(1 + r_t(1)) \prod_{j=2}^{i} (1 + f_{d_t}(j)). \tag{1}
\]

The forward rate can be calculated from the observable market prices of two bills of adjacent maturity, i.e.,
\[ fd_t(k) \equiv \frac{PS_t(k-1)}{PS_t(k)} - 1. \quad (2) \]

The one-period term premium is defined by the relationship

\[ \lambda_t(k) = \frac{(1+fd_t(k))}{(1+\hat{r}_t(k))} - 1. \quad (3) \]

To make the best use of the available data, I shall define a period as one week.

The concern of this paper is with the "forward premium" on 13 week T-bills which is the increase in yield obtained by purchasing a 13 week bill forward in the spot market relative to the expected yield of that bill. At date \( t \) the forward premium for a 13 week bill to be delivered at the end of period \( t+j \), \( fp_t(j) \), is defined as

\[ fp_t(j) \equiv \left[ \frac{PS_t(j) \times E_t(PS_{t+j}(13))}{PS_t(j+13)} \right]^{1/13} - 1 \quad (4) \]

Using logs and equations (2), (3) and (4), the relationship between the forward premium and the one week term premiums can be expressed as

\[
\ln(1+fp_t(j)) = \frac{1}{13} \left\{ \sum_{i=1}^{13} \ln(1+fd_t(j+i)) + \ln E_t(PS_{t+j}(13)) \right\}
\]

\[
= \frac{1}{13} \left\{ \sum_{i=1}^{13} \left( \ln(1+\hat{r}_t(j+i)) + \ln E_t(PS_{t+j}(13)) \right) \right\}
\]

(5)

Also note that

\[
\ln E_t(PS_{t+j}(13)) \approx - \sum_{i=1}^{13} \left( \ln(1+\hat{r}_t(j+i)) + \ln(1+\hat{r}_{t,j}(i)) \right)
\]

(6)

where \( \hat{r}_{t,j}(i) = E_t(\hat{r}_{t+j}(i)) \). Thus

\[
\ln(1+fp_t(j)) \approx \frac{1}{13} \sum_{i=1}^{13} \left( \ln(1+\hat{r}_t(j+i)) - \ln(1+\hat{r}_{t,j}(i)) \right)
\]

(7)

The last term in (7) describes the expected increase in return from holding a 13 week T-bill to maturity instead of rolling over a sequence of 13 one week bills.
At any date, t, spot prices, $P_{t}^{(j)}$ and $P_{t}^{(j+13)}$, are observable but, from (4), some measure of $E_{t}^{(PS_{t+j}^{(13)})}$ must be obtained to measure the forward premium. As indicated in the introduction, I shall use prices on the 13 week T-bill futures market as market forecasts of future spot prices.

The futures market for 13 week T-bills began operation on January 7, 1976 on the International Money Market of the Chicago Mercantile Exchange. In this market, individuals and/or institutions can enter contracts to deliver (go short) or receive (go long) 13 week T-bills at specified dates in the future. These contracts, in combination with spot market Treasury bills up to one year in maturity, can be used by market participants to speculate across different maturities of T-bills. Because many of the major participants in the T-bill futures market hold large portfolios of spot T-bills as well, it is reasonable to suppose that information regarding the future spot prices of T-bills available to participants in both the futures and the spot markets is the same: If the futures market for T-bills uses information efficiently, then so too would the spot market for T-bills; if the futures market uses information inefficiently, this would also be true of the spot market. In any case, there is no reason to believe that in a developed futures market the information on one side of the market is consistently better or worse than that on the other side. Moreover, the minimal level of transactions costs permits any agent to use existing information on either side of the market. It remains, however, to determine whether or not the futures market price would represent the expected future spot price in both spot and futures markets.
Let \( PF_t(i) \) be the price at date \( t \) of a futures contract for the delivery of a 13 week T-bill at date \( t+i \) and define

\[
PF_t(i) = E_t(PS_{t+i}(13)) + D_t(i)
\]

where \( D_t(i) \) is defined as the difference at date \( t \) of the futures price and the expected spot price of the deliverable bill.

The nature of the futures contract is such that

\[
PF_{t+i}(0) = PS_{t+i}(13)
\]

so that, if the futures market provides an unbiased forecast of the deliverable bill, \( D_t(i) \) will equal zero.

There are, however, at least three possible reasons why \( D_t(i) \) might not equal zero. These are taxes, carrying costs, and "thinness" in the futures market. Taxes might cause \( D(i) \) to differ from zero if the tax treatment of profits and losses was not symmetric for holders of long and short position in futures contracts. In November 1978 the Internal Revenue Service did, in fact, rule that T-bill futures purchased as an investment rather than as a hedge or for sale to customers were capital assets and, as such, provided some holders of long positions more favourable tax treatment than holders of short positions. This ruling was in force until the middle of 1981 when it was altered to provide symmetric treatment for long and short positions. Prior to the ruling, futures market profits were treated as ordinary income for all market participants. These institutional changes imply that, for a period beginning some time in 1978 and ending in mid-1981, some futures market participants would have had an incentive to hold long positions in the market even if they believed that the expected future spot price was less than the current futures market price. If these agents were the marginal investors then,
over this period, the futures market yield would be relatively lower than
the expected future 3 month yield, increasing the measured forward premium
in this period. The significance of these tax changes will be examined
in Section IV.

Carrying costs for long and short positions in the futures market are
virtually the same. Both sides of the market must put up the same margin
and face essentially the same risks. There is, however, one qualification
pointed out by Cox, Ingersoll and Ross (1981) that distinguishes futures
from forward contracts. Futures contracts require that, if the price of the
contract changes, the agent in whose favor the price change occurred must
immediately be paid the full amount of the change by the losing agent.
Because the price of T-bill futures is negatively correlated with borrowing
and lending rates of interest, this means that long (short) positions suffer
losses when rates are rising (falling). To this extent it would imply that
expected carrying costs are somewhat greater for long positions than for
short positions. Because the expected profits for the marginal investor
must be the same for a long or a short position, it means that the futures
price will be a downward biased measure of the future expected spot rates
and will tend to understate the forward premium. However, using the formula
indicated by Cox, Ingersoll and Ross (1981), the magnitude of this bias is,
at most, two basis points and will be ignored in the subsequent analysis.

Almost by definition, a thin market for a financial asset is one in
which individual agents, who may or may not have the same information
relevant for financial spot and futures markets, may influence the price
on the specific market. If this were the case for the T-bill futures market,
then the rate in this market may be a poor indicator of expected future
spot rates held by the representative agent in the spot Treasury bill market. While this may not lead to a consistent non-zero value for $D(i)$, it would mean that the futures rate could introduce such noise into the measure of the forward premium that the relationship between the premium and the independent variables is obscured. The T-bill futures market may have been described as a thin market when it initially began in January 1976, but by April 1977 the average daily volume had reached $1$ billion (1000 contracts) and the value of outstanding contracts was more than $5$ billion. By May 1981 the daily volume was over $20$ billion. Thus, during most of the life of the T-bill futures market, the market has been anything but thin. Nonetheless, in the subsequent empirical work, I begin the sample on June 23, 1976, roughly six months after trading began on the grounds that prior to this point the market might have been so thin that futures market yields were unrepresentative of the expected future spot rates relevant for the spot T-bill market.  

III. THEORIES OF THE FORWARD PREMIUM

There are two explanations of the behavior of forward premiums that I shall examine: The risk explanation that argues that the forward premium is a payment for risk-bearing and the liquidity explanation that argues that short-term liquid assets command a higher price than longer-term securities because they serve better as money substitutes in the provision of transaction services. I consider the implications of each of these in turn.
The Risk Hypothesis

There are at least two ways that forward premiums may be affected according to the risk explanation. First, according to Modigliani and Shiller (1973), increased volatility of short-term rates should increase the forward premium because it increases the forecast error for future short-term rates of interest and thus the uncertainty about future long-term security prices. The increase in uncertainty means that investors would require a higher premium to lend long-term. A second variable that has been suggested by Cagan (1969) and by Nelson (1973) is the rate of interest, which should be negatively related to the forward premium. This argument relies on skewness preference. According to this view, for any given expected return and risk (measured by the second moment of the subjective distribution of returns), the agent would prefer a low-median return with a chance of large profits to a high median return with the chance of large losses. When interest rates are (relatively) low, there is a greater chance of large capital losses than when rates are relatively high. Thus, for any given expected return (and risk) a high yield is preferred to a low yield on a security. This preference is therefore reflected in a reduced forward premium when yields are high, and an increased premium when yields are low. This argument thus implies that forward premiums should vary inversely with some measure of the level of interest rates.

The Liquidity Hypothesis

This hypothesis argues that short-term securities are quite similar to money and provide the holder of those assets a similar form of services; that is, short-term liquid financial assets can be viewed as temporary
abodes of purchasing power that can be converted quickly into the medium of exchange at very low cost. These liquidity services constitute an implicit yield. Thus the total yield on these assets consists of their actual market rate of interest plus the implicit liquidity yield. In equilibrium, the total yield on short-term securities must equal that on assets that do not provide these liquidity services. Therefore, market rates on short-term securities will be below those of long-term market rates by the amount of this liquidity yield. This implicit yield is the forward premium. Under this interpretation, forward premia should be related to factors that affect money demand. Two factors that would therefore be important in determining the forward premium are the level of income and the level of interest rates. Increases in income should increase the forward premium: An increase in income increases the demand for monetary services. Since short-term liquid assets can provide some of these services, this increases the liquidity yield on short-term securities and thus increases measured forward premiums.

An increase in the interest rate would also increase the forward premium because such an increase makes short-term treasury bills a more attractive source of monetary services relative to money. Thus, there is a substitution out of money and into short-term bills, driving the yields on these liquid assets down relative to the yields on securities that offer less, or no monetary services.

A third factor that is suggested by the liquidity explanation is the relative supplies of alternative types of monetary assets, the most obvious distinction being that between M1 and other liquid assets insofar as the distinction between means of payment and temporary
abodes of purchasing power is meaningful. To include this in the empirical analysis, the ratio of M1 to interest-bearing government securities maturing within a year is included in the regression analysis. However, an increase in the ratio of M1 to other liquid assets could increase or decrease the forward premium depending upon the technology of exchange. As a consequence, there are no sign predictions attached to this variable.

While the risk and liquidity hypotheses may be treated as separate theories of forward premiums, I do not regard them as mutually exclusive. If, for instance, the reason an asset is less liquid is that the market for it is quite thin and the cost of finding a purchaser is, as a consequence, quite high and variable, then the realizable net rate of return after transactions costs will be more variable than if the asset were more liquid. Alternatively, in a well developed market where an asset can be converted quickly into the medium of exchange at low cost, an increase in the volatility of return may make a unit of the asset less acceptable as a temporary abode of purchasing power. In other words, an increase in the variance of the return reduces the "quality" of the monetary services obtained from the asset. An implication of this is that an increase in the volatility of short-term T-bill rates would decrease the forward premium on longer term T-bills. The reason for this is that short-term bills provide greater monetary services and the increase in volatility should decrease the value of these services by a greater absolute amount than on longer term bills which generated fewer of these services originally. This implication is the opposite of what has been implied by the "pure" risk hypothesis discussed earlier. If the pure risk hypothesis is correct then the coefficient on the variability of rates should be positive and significant; if it is not then the "mixed" explanation is most likely the cause.
IV. EMPIRICAL RESULTS

In this section two things are done. First, the variables used in the test of the two hypotheses are described and the empirical results are reported. Second, the issue of stability is examined and possible explanations for the observed shifts discussed.

Tests of the Liquidity and Risk Hypotheses

Data on futures markets prices were obtained from the IMM Yearbook and from the Wall Street Journal. The daily Federal Reserve Bank of New York Quote Sheet was used to obtain data on treasury bill prices. Spot and futures market observations relate to the same date. For futures market yields, the IMM settle price for each Wednesday from June 23, 1976 to September 8, 1982 was used to generate a futures market price for a 91 day T-bill. For spot market prices, the closing Wednesday bid and ask yields were used to generate bid and ask prices. The average of these two prices was then used as the Wednesday closing price. Since spot and futures prices were collected for calendar dates that coincided, the market information used in setting these prices was virtually the same.

There are weekly auctions of 13 and 26 week T-bills, but 1 year T-bills are auctioned only every 4 weeks. Thus forward prices for bills deliverable in over 13 weeks did not generally coincide with futures markets contracts. A synthetic price series for T-bills over 6 months in maturity therefore was constructed using bid and asked prices on the 2 bills that matured most closely to each of the delivery and maturity dates of bills delivered in the futures market.
In the total sample there were 966 observations on forward premiums for periods from 1 week to 39 weeks to delivery of the relevant futures contract. The dependent variable used in the regression is $L_t(w)$ defined as

\[
L_t(w) = \ln PS_t(w) + \ln PF_t(w) - \ln PS(t+13) = 13 \ln(1+fp_t(w)) \tag{10}
\]

where $w$ is the number of weeks to delivery of the futures and forward contracts.

The independent variables used to examine the liquidity hypothesis are $R_t$, the log of one plus the current 3 month T-bill rate (in basis points); $\hat{\pi}_t$, the log of one plus the expected rate of inflation for the next three months (in basis points); $Y/G_t$, the ratio of personal income to outstanding marketable government securities maturing within 1 year; and $M/G_t$, the ratio of M1 to government securities maturing within 1 year. The hypothesis implies that $R_t$ and $Y/G_t$ should affect $L_t(w)$ positively. The theory does not require a specific sign for the relationship between $L_t(w)$ and $M/G_t$. Expected inflation is included to determine whether it matters for forward premiums if changes in the nominal rate of interest are caused by real interest rate changes or by changes in expected inflation. A significant positive coefficient on $\hat{\pi}_t$ would imply that increases in nominal rates due to inflation increases the premium more than if the change was caused by an increase in real rates.

The risk hypothesis for forward premiums requires that the measure of the variability of interest rates be positively related to the premium
and that the level of rates be negatively related to the premium. The measure of variability used here is \( \sigma_t \), the log of one plus the 26 week moving standard deviation of 3 month T-bill rates. For the level of interest rates the 3 month T-bill rate could have been used. However, I have included an additional interest rate variable, \( A_t \), the log of the ratio of the current 3 month T-bill rate to a 26 week moving average of past 3 month T-bill rates, in an attempt to distinguish the rate variables for the liquidity and risk hypotheses. The use of this interest rate variable implicitly supposes the subjective distribution of expected future interest rates is skewed toward the "normal" rate of interest, as measured by the average of rates over the previous 6 months. As a result, the risk hypothesis implies that this new interest rate variable also is negatively correlated with the forward premium.

Rather than estimate separate equations for each of the 39 forward premiums corresponding to \( w = 1, 2, \ldots, 39 \), I have constrained the forward premium relationship to be a continuous function of \( w \). Two additions have been made to handle this restriction. First, because the forward premium describes the term premium of a \( w \) week T-bill held 13 weeks relative to the term premium of a 13 week T-bill held to maturity, the independent variables associated with the risk and liquidity hypotheses should affect the slope of the forward premium relationship rather than its absolute level. Consequently, in the regression, these independent variables were multiplied by \( w \). Second, the variables \( w \) and \( 1/w \) have been added as independent variables to reflect the general shape of the forward premium relationship. The regression that is estimated is thus
\[ L_t(w) = b_0 + b_1 w R_t + b_2 w \hat{\Delta}_t + b_3 w Y/G_t + b_4 w M/G_t + b_5 w \hat{\Delta}_t + b_6 w \hat{\Delta}_t + b_7 w + b_8/w + u_t \]  

(11)

where \( u_t \) is the residual error and the \( b_i \) are the coefficients to be estimated.

The data are such that, at any date \( t \), there are three forward premiums that can be observed: the "near" forward premium on T-bills maturing within 26 weeks (\( w \leq 13 \)), the "intermediate" forward premiums (\( 13 < w \leq 26 \)) and the "distant" forward premiums (\( 26 < w \leq 39 \)). To make use of this additional information the method of estimation used was that of Seemingly Unrelated Regressions. The results for OLS (not reported) were qualitatively the same in terms of both coefficient signs and significance levels.  

The results of estimating (11) for the entire sample period are given in line 1 in Table 1. For the liquidity explanation, both \( R \) and \( Y/G \) had coefficients of the correct sign and were significant at the 1% level. The coefficient on \( \hat{\Delta} \) was negative but insignificant suggesting that changes in both the real interest rate and the expected inflation rate have quantitatively the same impact on forward premiums. The forward premium does not appear to be significantly related to the money-bond ratio.

For the risk hypothesis, skewness preference was confirmed at the 1% significance level: if the rate of interest rises above its short-term "normal" level, forward premiums are reduced since the possibility of large capital losses declines.  

It should be noted, however, that skewness preference is not confirmed for the level of rates, where the liquidity explanation appears to dominate the risk explanation as evidenced by the positive sign on \( R \).
In addition, the hypothesis that forward premiums are positively related to the variability of interest rates is rejected: the coefficient on \( \omega \) is significantly negative at the 1% level. There are two possible explanations for this. Either the use of the historical variance of returns is a poor proxy for the measure of (subjective) risk for rates of return in the future, or that variability of the return on an asset affects more the quality of the monetary services of the asset than it does risk aversion due to a reduced ability to forecast. If it is this latter explanation, this result provides more evidence suggesting short-term T-bills serve as a money substitute. Furthermore, it suggests that the risk and liquidity hypotheses cannot be treated as mutually exclusive explanations of forward premiums.

**Stability**

It turns out that the forward premium relationship was not stable over the period June 23, 1976 to September 9, 1982. Using the Quandt test to determine major structural changes in the time series, two major breaks were indicated. These occurred at approximately mid-August 1978 and mid-October 1979. The regressions for the various subperiods are given in rows 2 to 6 of Table 1. A general way to characterize the entire sample period is that of increasing forward premiums. 23 This was especially true the longer the term to delivery. One might therefore ask whether or not the structural shifts could account for these changes. If the shifts did account for the secular rise in premiums, then it would be expected that regression coefficients generated in the earlier sample periods, and used with the independent variables that actually prevailed in the later periods, would forecast lower forward premiums than actually prevailed.
Table 2 shows the average actual and forecasted values of the forward premium for the periods August 16, 1978-September 8, 1982 and October 24, 1979-September 8, 1982, broken down by nearness of the forward contract to delivery. For the August 1978-September 1982 period the forecasted levels of the forward premium were substantially above the levels that actually prevailed during this time, indicating that, whatever the cause of the structural shift, it caused forward premiums to decline relative to what they would otherwise have been. This shift, at least, cannot be used to explain the general rise in forward premiums.

The shift occurring in October, 1979 does appear to have increased forward premiums by 30 basis points almost uniformly across terms to maturity. The actual rise in forward premiums between the pre and post October 1979 periods was 38.6 basis points. Consequently, around three-quarters of this actual increase could be attributed to the structural shift that occurred in October 1979.

While it is not possible to know why the structure changed, it is possible to catalogue major government policy changes that may have contributed to the changes picked up in the data. Of the two breaks observed using the Quandt test, the latter, occurring in October 1979, seems to have the more transparent explanation. In October 1979 the Federal Reserve announced that it was changing its method of monetary control and indicated that it would pay more attention to monetary aggregates and less to interest rate fluctuations in the setting of that policy. Because the Fed plays such a large role in financial markets, changes in its behavior can be expected to have some influence on those rates. This in itself would alter the relationship determining forward premiums.
Furthermore even if the Fed's direct role was insufficient to alter magnitudes to any major extent, the rational expectations literature suggests that major policy shifts will alter agents' profit-maximizing responses to policy. Thus all market participants will alter their behavior which will, in general, change the empirical relations that existed prior to the policy shift. Indeed, given that the policy shift was believed to be significant, and the extent that the change impacted on the behavior of interest rates themselves, it would have been surprising if no change could be detected in the data.

The other change, occurring in August 1978 cannot so easily be identified with a major policy shift. However two events occurred around that time that may have affected spot and futures rates. First, a new financial instrument, money market certificates (MMCs), was created in June 1978 and represented a new regulatory response to "high" interest rates and financial disintermediation (see Gilbert (1979)). Second, in November 1978, the Internal Revenue Service ruled that T-bill futures purchased as an investment rather than as a hedge or for sale to customers were capital assets (see Arak (1983)). The second of these provided some holders of long positions in futures contracts an opportunity to be taxed at the lower capital gains rate if they made profits and at ordinary income tax rates if they suffered losses. Income from short positions in the futures market and purchases of spot bills were taxed at ordinary rates. If agents having the preferential tax treatment were the marginal investors then this should tend to decrease futures rates relative to spot rates on T-bills, increasing the measured premiums on the period following the tax change.
In the absence of the explanatory variables of this analysis one might be inclined to attribute the rise in measured premiums to this tax policy; with them, the effect of that policy is contrary to the shift that did occur.

The introduction of MMSs, on the other hand, could cause the forward premium to fall. These instruments provided individuals and non-financial institutions a very good substitute for T-bills: minimum denominations were $10,000, the same as for T-bills, and the ceiling rate was set at the T-bill rate if issued by a commercial bank, or 25 basis points higher if issued by thrift institutions. In addition it provided banks and thrifts an alternative source of funds so that their demand for liquid assets to meet transitory shifts in loan demand or deposit levels would fall also reducing forward premiums. Thus both institutions and individuals would decrease their demand for monetary services from short-term T-bills, decreasing the forward premium. Nevertheless, a complete explanation of this shift would require much more research, and the explanations provided here can only be regarded as possible suggestions for the direction of that research.

V. CONCLUSIONS

In this paper the determinants of forward premiums on U.S. government Treasury bills over the period June 23, 1976-September 8, 1982 were examined in the light of the liquidity and risk hypotheses for the existence of these premiums. The maintained hypothesis throughout the analysis was that futures market rates on 3 month T-bills accurately reflect the expected future spot
rate on these bills. It was found that, for the period as a whole, the behavior of forward premiums was consistent with the liquidity explanation: forward premiums depended positively on the level of interest rates and the income to short-term government securities ratio. Further, the liquidity hypothesis was consistent with the negative relationship between the variability of interest rates and the forward premium and with the financial innovation interpretation of the structural shift occurring in August 1978.

The risk hypothesis fared less well. It was inconsistent with the negative relationship between the premium and the variability of interest rates as measured in this paper. It was however consistent with the negative relation between the premium and the deviation of the three-month bill rate from its "normal" level as measured by a six-month moving average of that rate.

However, the above results must be viewed as only tentative, for the relationship exhibited considerable instability over the period studied. Two major shifts appear to have occurred, one about August 1978 and the other about October 1979. The second coincides with a major change in the conduct of Federal Reserve policy and is consistent with the Lucas critique: policy changes known to have occurred to market participants will in general be reflected in changes in empirical relationships. The first change may be associated with the introduction of money market certificates and/or tax policy. However, the tax changes would have caused the forward premium to change in a direction opposite to that which occurred given the changed values of the explanatory variables used in this study.
Footnotes

1 See McCulloch (1975).

2 Cf. Friedman and Schwartz (1982), pp. 556-557. Also see Flavin (1983) for a discussion of this point in a slightly different context.

3 McCulloch (1975) does use a crude test to see if premiums did change between various subperiods of his sample period. What he is unable to do is permit the premium at any date to depend on contemporaneous variables.

4 See Cox, Ingersoll and Ross (1981) on the exact nature of this approximation.

5 Capozza and Cornell (1979) calculate that the yield difference between forward and futures market rates can change up to 3.85 basis points per week before arbitrage is profitable.

6 Kessel (1965) appears to be the first to examine this hypothesis in detail. It has also come up in recent work on divisia indices for the money supply (see Barnett (1982)) and has been spelled out more formally by Fried and Howitt (1983).

7 Equation (5) holds only approximately for two reasons. First, because of Jensen's inequality, $E_t [(\tilde{x}_1 \tilde{x}_2)^{-1}] \geq [E_t (\tilde{x}_1 \tilde{x}_2)]^{-1}$, and second, because $E_t (\tilde{x}_1 \tilde{x}_2) - E_t (\tilde{x}_1)E_t (\tilde{x}_2) = \text{cov}(\tilde{x}_1 \tilde{x}_2)$, where $\tilde{x}_i$ is a random variable. These approximations are ignored in the remainder of the paper.

8 In particular, at any point in time agents have a choice of 8 possible futures contracts deliverable up to 2 years in the future, with delivery taking place in the third week of March, June, September and December.
Studies of the efficiency of the T-bill futures market in the early period of its operation appear to be mixed. For a representative study see Rendleman and Carabini (1979).

See Kraus and Litzenberger (1976) for a discussion of skewness preference and the empirical evidence supporting it.

Such a distinction, for instance, is implied by the work of Feige and Parkin (1971) and Orr (1971).

See Fried and Howitt (1983).

Klein (1977) provides an argument regarding the quality of monetary services derived from money in the face of increased uncertainty about future prices. Inflation uncertainty is common to all nominal securities. What is discussed here is an additional increase in uncertainty due to interest rate fluctuations. This variability induces a substitution effect out of bills and into money assets. The "income" effect discussed by Klein is absorbed by both money and T-Bills. The argument presented in the text presumes the substitution effect dominates for T-Bills. It should also be noted that this interpretation is also consistent with the finding that money demand is positively related to interest rate volatility (see Slovin and Sushka (1983)).

If either of the Wednesday spot or futures prices were not available then the Tuesday settle and closing yields were used for both spot and futures prices.

It should be noted that the spot market closes approximately one hour after the close of the futures market. This may give rise to some differences in information available in the two series.
16 In the sample period used here there was only one 1 year T-bill that had the same delivery date as the futures contract.

17 Over the sample period there were 972 observations of forward premiums that could have been used. However on three dates there were only two observations of forward premiums of 39 weeks or less. These six observations were excluded in the Generalized Least Squares estimation reported in this paper.

18 A 4 quarter AR process was used to generate the series for expected inflation. Use of the previous annual inflation rate was used in other regressions (not reported) and generated similar results.

19 The interest rate and money supply series were collected weekly while short-term governments, expected inflation, and personal income change monthly.

20 The results (also not reported) from restructuring the data into three time series consisting of every third contract and using seemingly unrelated regressions estimation also gave the same qualitative results.

21 An alternative explanation of this could be that participants in the spot T-bill market do not act as quickly as future market participants when new information is received. If this were the case, then as rates are increasing ($\Delta$ is positive), futures market rates rise more rapidly than spot rates to reflect this new information. This would cause the measured forward premium to fall. This explanation violates the maintained hypothesis of this paper that the futures rate represents the market forecasts of expected future rates in the spot market.
22 When $\Delta_t$ was excluded from the regression the coefficient on $R_t$ remained negative and significant.

23 Prior to August 1978 the forward premium averaged 3.3 basis points, between that date and October 1979 it averaged 44.7 basis points, and after October 1979, it averaged 66.3 basis points.

24 There is some dispute as to whether or not those individuals were the marginal investors. Cornell (1981) has examined this issue most carefully and concludes that they were not. See Arak (1983) for the alternative view.

25 See Modigliani and Sutch (1966) for a similar argument regarding the introduction of certificates of deposits on forward premiums. Also see Judd and Scadding (1982) for a more general discussion of financial innovation and the demand for monetary services.
Bibliography


TABLE 1

Determinants of Forward Premiums: Seemingly Unrelated Regression Estimation

<table>
<thead>
<tr>
<th>Period</th>
<th>Intercept</th>
<th>wR</th>
<th>( \hat{\eta} )</th>
<th>WY/G</th>
<th>WM/G</th>
<th>w\Delta</th>
<th>w\sigma</th>
<th>w</th>
<th>1/w</th>
<th>No. of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 6/23/76-9/8/82</td>
<td>0.00117</td>
<td>0.00127</td>
<td>-0.00279</td>
<td>0.000381</td>
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<td></td>
<td>(17.06)</td>
<td>(5.40)</td>
<td>(-1.79)</td>
<td>(3.10)</td>
<td>(-0.58)</td>
<td>(-4.24)</td>
<td>(-3.76)</td>
<td>(-7.97)</td>
<td>(-9.75)</td>
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<tr>
<td>2) 6/23/76-10/17/79</td>
<td>0.000763</td>
<td>0.00107</td>
<td>0.00167</td>
<td>0.000093</td>
<td>0.00120</td>
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<td>-0.000426</td>
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<td></td>
<td>(14.52)</td>
<td>(3.47)</td>
<td>(1.11)</td>
<td>(0.54)</td>
<td>(1.30)</td>
<td>(-3.22)</td>
<td>(-0.02)</td>
<td>(-7.84)</td>
<td>(-8.66)</td>
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<tr>
<td>3) 10/24/79-9/8/82</td>
<td>0.00165</td>
<td>0.00131</td>
<td>0.000366</td>
<td>0.00144</td>
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<td>-0.000648</td>
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<tr>
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<td>(13.06)</td>
<td>(3.84)</td>
<td>(-1.30)</td>
<td>(4.40)</td>
<td>(-3.20)</td>
<td>(-1.78)</td>
<td>(-1.59)</td>
<td>(-6.61)</td>
<td>(-7.20)</td>
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<tr>
<td>4) 6/23/76-8/9/78</td>
<td>0.000880</td>
<td>0.00218</td>
<td>-0.000332</td>
<td>0.000174</td>
<td>0.000267</td>
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<td>(25.91)</td>
<td>(1.70)</td>
<td>(-0.69)</td>
<td>(3.34)</td>
<td>(1.03)</td>
<td>(-3.24)</td>
<td>(1.01)</td>
<td>(-5.43)</td>
<td>(-9.53)</td>
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<tr>
<td>5) 8/16/78-9/8/82</td>
<td>0.00131</td>
<td>0.00123</td>
<td>-0.00030</td>
<td>0.000850</td>
<td>-0.00221</td>
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<td></td>
<td>(12.86)</td>
<td>(3.88)</td>
<td>(-1.41)</td>
<td>(3.43)</td>
<td>(-1.98)</td>
<td>(-2.42)</td>
<td>(-3.43)</td>
<td>(-6.48)</td>
<td>(-7.48)</td>
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<td>6) 8/16/78-10/27/79</td>
<td>0.000479</td>
<td>-0.00077</td>
<td>0.00353</td>
<td>0.0000382</td>
<td>0.000409</td>
<td>0.000092</td>
<td>0.0166</td>
<td>0.000683</td>
<td>0.000837</td>
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<td></td>
<td>(4.06)</td>
<td>(-0.78)</td>
<td>(5.58)</td>
<td>(-0.76)</td>
<td>(1.53)</td>
<td>(-0.10)</td>
<td>(0.68)</td>
<td>(-4.70)</td>
<td>(-3.22)</td>
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NOTE: T statistics in parentheses
TABLE 2

Average Actual and Forecasted Forward Premiums (Basis Points)

<table>
<thead>
<tr>
<th></th>
<th>Near Premium</th>
<th>Intermediate Premiums</th>
<th>Distant Premium</th>
<th>All Premiums</th>
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<tr>
<td>1) Actual Forward Premium</td>
<td>39.2</td>
<td>67.1</td>
<td>71.7</td>
<td>59.3</td>
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<tr>
<td>2) Forecasted Forward Premium*</td>
<td>58.2</td>
<td>125.5</td>
<td>186.8</td>
<td>123.5</td>
</tr>
<tr>
<td>3) Difference</td>
<td>-19.0</td>
<td>-58.4</td>
<td>-115.1</td>
<td>-64.2</td>
</tr>
<tr>
<td><strong>10/24/79-9/08/82</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Actual Forward Premium</td>
<td>48.9</td>
<td>72.2</td>
<td>77.9</td>
<td>66.3</td>
</tr>
<tr>
<td>5) Forecasted Forward Premium**</td>
<td>23.4</td>
<td>38.4</td>
<td>45.9</td>
<td>35.9</td>
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<tr>
<td>6) Difference</td>
<td>25.5</td>
<td>33.8</td>
<td>33.8</td>
<td>30.4</td>
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</tbody>
</table>

*Forecasts used coefficient estimates given in row 4 of Table 1.

**Forecasts used coefficient estimates given in row 2 of Table 1.