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RIDING THE YIELD CURVE: REPRISE

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ABSTRACT

We investigate the efficacy of riding the yield curve. This strategy dictates holding longer-term treasury bills when the yield curve is upward-sloping. We find that the strategy is surprisingly effective. It stochastically dominates buying and holding shorter-term bills for large subperiods, and nearly dominates for the entire sample period, 1949 - 1988. Our empirical results suggest that abnormal profit opportunities are available from selectively increasing the maturity of a short-term portfolio.

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RIDING THE YIELD CURVE: REPRISE

Riding the yield curve is a strategy of buying longer-dated bills when the yield curve is upward-sloping and selling them prior to maturity in the hope or expectation of collecting any term premium that may exist. For example, three ways of holding money for the next 30 days would be: (1) buy a 30-day bill and allow it to mature; (2) buy a 60-day bill and sell it as a 30-day bill 30 days hence; or (3) buy a 90-day bill and sell it as a 60-day bill 30 days hence. Choices (2) and (3) are "riding the yield curve."

While the practitioner literature (e.g., Stigum, 1983) cites this strategy as a common means of enhancing returns, it is by no means obvious that such a strategy ought to be pursued. First, if the expectations hypothesis is valid, riding the yield curve should not improve returns. If the strategy is pursued because the yield curve is upward-sloping, then interest rates should, on average, rise by just enough to equalize holding period returns on all bills. Alternatively, if there is a risk-related term premium, riding the yield curve should simultaneously increase both risk and return. In principle, this strategy ought not improve the risk-reward profile (nor should any costless-to-compute rule enhance performance). Higher-sloped yield curves ought to reflect some combination of increasing expected interest rates and increased interest-rate risk.

Nevertheless, Dyl and Joehnk (1981) provide positive evidence on the efficacy of riding the yield curve. Using data for the

1970-75 period, they find that (1) riding the yield curve gives a small boost to average return without an appreciable increase in risk relative to buying and holding shorter-term bills, (2) that longer-dated bills are better than shorter-dated bills at providing those returns, and (3) that a simple filter rule can enhance the risk-reward profile of the riding strategy. The filter allows one to ride the yield curve only when the curve has a positive slope greater than some critical threshold. These results suggest a useful trading rule, but in view of the extremely short sample period, must be considered only indicative. Since the Dyl and Joehnk study, more extensive data sets have become available, and allow for more definitive testing.

In this paper, we utilize a recently available data set to examine the efficacy of riding the yield curve for the period 1949-1988. Our data also provide evidence of abnormal profit opportunities. Riding the yield curve at some maturities appears to increase average returns with no appreciable increase in risk. The yield pickup, moreover, is well in excess of transaction costs. Our most striking result is that in several subperiods (e.g., the past 10 years or the past 20 years) the sample distribution of returns from riding the yield curve stochastically dominates the distribution from the buy-and-hold strategy. Although the full 1949-1988 sample does not quite yield stochastic dominance, a relative risk aversion parameter exceeding 260 would be necessary for an investor to prefer the buy-and-hold short-term bill distribution to that of the ride. In contrast, estimates in financial research place the typical investor's risk aversion parameter below 2.0. (See for example, Friend and Blume (1974) or Bodie, Kane, and Marcus (1989).)

In Section 1 of this paper, we briefly discuss our data and their reliability. In Section 2 we explain and motivate the trading rules to be tested. Section 3 presents results on the investment performance of riding the yield curve. In Section 4, we conclude and discuss the implications of our results.

1. DATA

Our data come from Coleman, Fisher, and Ibbotson (1989), Table 9-4, Estimated Zero-Coupon prices. Coleman, Fisher, and Ibbotson used prices of Treasury securities from the CRSP tape to estimate a forward interest-rate function.[1] Those forward rates were aggregated into zero-coupon yields, which in turn gave zero-coupon prices. Therefore, while their prices are not taken from direct observations of zero-coupon securities, they are consistent with prices that were (for the most part) available for transactions.

These data differ from Dyl and Joehnk, who collected bid and ask prices from the Wall Street Journal once a week on the 26 regular T-bill issues outstanding. From that rich data set, they were able to compute *ex post* holding period returns for several alternative strategies. In addition, because those prices were effective until noon the next day, their results reflect transactions that could have been executed.

Although one obviously would prefer to use firm dealer quotes to simulate trading strategies, Coleman et al. report that it is no longer possible to gather Treasury prices which necessarily reflect transaction possibilities. As of 1980, interest rates had become so volatile that the dealer quotation sheets used by CRSP contained only indicative prices on Treasury securities instead of available transaction prices. Therefore, it would be impossible to replicate exactly Dyl and Joehnk's research beyond 1979. Moreover, Coleman, Fisher, and Ibbotson (1987) found that the ask prices supplied to CRSP became unreliable after 1979.[2] Therefore, their zero-coupon prices are based on the average of bid and ask prices through 1979 and bid prices alone thereafter.

We utilized their end-of-month prices for three-month, six-month, nine-month, and twelve-month zero-coupon bonds. While these prices were not necessarily available for transactions, there is no reason to suspect that the estimation technique introduces systematic bias in comparisons of returns to the strategies we investigate. To the extent that their zero-coupon prices are biased (for example, by use of only bid prices), returns will not be affected since the return on a zero-coupon security is measured by P_1/P_0, implying that numerator and denominator bias will cancel in the calculation of returns.[3] While random price errors can cause biases in returns via a Jensen's Inequality effect, we show in the Appendix that in this application, such bias is likely to be of negligible magnitude, less than a tenth of a basis point per quarter.

2. METHODOLOGY

We examine non-overlapping three-month returns to two competing strategies. The benchmark strategy is to buy and hold three-month bills.[4] The alternative strategy is to ride the yield curve by holding longer-maturity bills and rolling them over every three months. In most of our simulations, we only ride the yield curve conditional on a filter. If the filter rule is not satisfied, we place our funds for that quarter in three-month bills.

Filter Rule

To illustrate the filter rule used by Dyl and Joehnk, consider a riding strategy using 12-month bills. Because a 12-month bill will have a 9-month maturity in three months, one can calculate the three-month holding period return on the bill as a function of the end-of-period yield on 9-month bills. It is then straightforward to determine the amount by which the 9-month yield must rise from its current level before the holding period return on the 12-month bill is driven below that available on the 3-month bill. If this increase in the 9-month yield exceeds a critical value called the margin of safety, the ride strategy is pursued. Otherwise, one buys and holds three-month bills. Using a margin of safety of zero, one will ride the curve whenever 12-month yields exceed 3-month yields and the yield curve is not humped. This is the usual specification of the riding strategy. For higher margins of safety, the yield curve must be steeper before riding is pursued. While one should be skeptical of a trading rule based on costless information, we consider the filter because of its apparent success in Dyl and Joehnk's work.

Dyl and Joehnk show that the breakeven end-of-period yield that equates the holding period returns on the buy-and-hold and riding strategies is

$$R^*(M-H) = R_0(M) + [R_0(M) - R_0(H)]\ H/(M-H)$$

where

$R_0(n)$ = the discount yield today on bills with maturity n months

M = maturity of the bill ridden (12 months in our example)

H = holding period (3 months in our example)

Therefore, the margin of safety (MOS) for riding a bill of current maturity M is the percentage difference in $R^*(M-H)$ and $R_0(M-H)$.

$$MOS = \frac{R^*(M-H) - R_0(M-H)}{R_0(M-H)} \qquad (1)$$

We examine in the next section the results of investment policies using MOS = -1.0 (always hold the longer maturity bill), 0 (the usual strategy of riding the yield curve when the long rate exceeds the short rate), and 0.025 (a version of the Dyl and Joehnk filter). We consider rides on 6-month, 9-month, and 12-month maturity bills.

Transaction Costs

Before proceeding, however, we note that the riding strategy entails greater transaction costs than the buy-and-hold strategy, since the longer-term bills must be sold at the bid price at the end of the holding period. The bid-ask spread on 3-month bills (where we will focus most of our attention) is virtually always below 6 basis points on a discount basis. Assuming that the "true" bill price is midway between bid and ask prices, the annualized transaction cost to a seller would be 3 basis points. Because maturity is one-fourth of a year, the cost is 0.75 of a basis point when the bill is sold after the 3-month holding period. Therefore, we reduce the calculated return each quarter on the riding strategy by 0.75 of a basis point in months that a ride occurs to account for incremental trading costs. (Transaction costs between 0.80 and 3.25 basis points are considered below.)

3. RESULTS

Table 1 presents evidence on the efficacy of the MOS filter for a 3-month holding period. For each MOS (-1, 0, 0.025), we present in the panels labeled "frequency" the fraction of quarters in each subperiod in which riding the yield curve was pursued and in the panels labeled "success" the percentage of those rides that turned out to be profitable (i.e., provided returns in excess of buy-and-hold). For example, referring to the 1984-1988 panel, we see that with an MOS of 0, the investor would have ridden the yield in 85 percent of the quarters in this 5-year period. Of these rides, 65 percent would have resulted in returns in excess of buying and holding 3-month bills, meaning 35 percent would have resulted in opportunity losses relative to the buy-and-hold strategy.

The screen seems at best weakly effective. While fewer rides are pursued as the filter becomes more stringent, the success rate of the rides pursued does not uniformly increase. For example, looking at the bottom panel for the full period, the frequency of riding 6-month bills falls from 100 percent to 69 percent as the MOS rises from -1.0 to 0.025. The frequency of success increases somewhat from 66 percent to 71 percent as MOS rises to 0, but then falls back to 70 percent when MOS increases to 0.025.

Table 2 presents a different measure of the efficacy of riding the curve. The top entry in each panel is the increment to the average rate of return for the particular subperiod that riding the yield curve provides over the buy-and-hold strategy. The bottom entry is the increment to the standard deviation of holding period returns. All entries are in units of percent per quarter. The table shows that riding the yield curve generally increases both average return and intra-period volatility. Of more interest is the fact that average return is increased in almost all five-year periods. The 6-month ride shows higher average returns in all periods. This result suggests that riding the yield curve might be a beneficial strategy for investors with long horizons but with a desire to invest in the money market, for example, investors placing portions of their retirement savings in money-market accounts. The Dyl and Joehnk screen does not appear to provide risk-free added value.[5] The screen usually lowers average return as well as risk, as it filters out progressively more rides on the curve.

Tables 1 and 2 do not, in themselves, indicate any abnormal performance from riding the yield curve. Indeed, they are broadly consistent with a standard risk-return tradeoff. However a more revealing view of riding the yield curve is provided in Figures 1 and 2. In Figure 1 we plot the cumulative sample distributions of full sample 3-month buy-and-hold returns and returns from riding the yield curve using 6-month maturity bills, a zero margin of safety, and 0.75 basis point transaction costs. Despite the higher volatility of the riding strategy, Figure 1 shows that the returns from riding whenever the yield curve slopes upward (MOS = 0) nearly stochastically dominates the buy-and-hold strategy. In fact, the riding distribution would stochastically dominate[6] the buy-and-hold distribution except for the presence of the single negative return to riding (which occurred in 1958, second quarter). The two lines cross near the (0,0) point.

Figure 2 presents sample return distributions again with MOS = 0, 3-month holding periods, rides using 6-month maturity bills and transaction costs of 0.75 basis points for the most recent

20-year subperiod 1969-1988. Stochastic dominance by the riding strategy in this period is complete.

The 6-month rides using MOS of 0.025 also stochastically dominated the buy-and-hold strategy except for the one crossover in 1958. Because of the similarity of results, the figure is not presented. The always-ride strategy (MOS = -1.0) did not fare as well. There were several cross-overs in the sample return distributions. Rides using maturities other than 6 months are considered below.

Of course, we know a priori that the true population distribution of returns to riding cannot stochastically dominate that of buying and holding, because only the riding strategy poses a possibility of negative returns. Nevertheless, the dominance of riding's sample distribution over such extended periods of time encompassing different interest-rate regimes is striking, and is highly suggestive of historically abnormal returns to the riding strategy. Certainly for these substantial subperiods, riding has provided abnormal risk-adjusted returns.

It also is worth acknowledging again that these results must be interpreted in the context of an investment horizon. For a three-month horizon, the three-month bill is riskless, and it makes no sense to talk about the probability distribution of its returns. However, a long-horizon investor who compares the alternative strategies of rolling three-month versus six-month bills each quarter would be interested in the empirical results presented in the Figures, as these would definitively recommend the riding strategy.

Although the returns distribution over the entire 1949-1988 period do not exhibit stochastic dominance, riding the yield curve still has offered risk-return attributes far superior to the buy-and-hold alternative. An investor with a constant relative risk-aversion utility function would need a risk-aversion parameter exceeding 260 before he or she would avoid riding 6-month bills (with a zero margin of safety) in favor of buying and holding. In contrast, the mean excess return and volatility of the S&P 500 index over Treasury bills have been consistent with a risk-aversion parameter of about two.[7]

These results may be sensitive to the assumed level of transaction costs. To measure the historic advantage of the 6-month riding strategy over buy-and-hold, we calculate the relative risk aversion parameter for which the two strategies are equally attractive under other assumptions for transaction costs. Table 3 presents the risk aversion parameter which equates the expected utility of each strategy for several levels of transaction costs in excess of the already-posited 0.75 basis point per quarter (which corresponds to a reported bid-ask spread of 6.0 basis points). Expected utility is computed using the sample distribution of returns to each strategy over the full 1949-1988 sample period.

Utility falls off rapidly with transaction costs. However, increasing transaction costs by 2.5 basis points from the assumed value of 0.75 basis points (consistent with a bid-ask spread on three-month bills of 26 basis points!) still leaves riding the yield curve as a preferable strategy for risk aversion coefficients below 10. Thus, it appears that for any reasonable specification of risk aversion and transaction costs, riding the yield curve using 6-month bills presents a return distribution superior to that of buying and holding three-month bills. If transaction costs are about 0.75 basis points, as we have argued, then riding the yield curve has provided abnormal risk-adjusted returns in excess of 2.5 basis points per quarter or 10 basis points per year. (Gross return differences--not adjusted for risk-- were closer to 10 basis points per quarter. See Table 2, bottom panel, which shows average incremental returns per quarter over the whole sample.)

MOS filters above zero would have destroyed value instead of creating value. We see this by comparing columns MOS = 0 and MOS = 0.025 in Table 3. For every level of transactions costs in excess of 0.75 basis points, the risk aversion parameter that would leave an investor indifferent between buying and holding and riding the yield curve is lower with the higher screen. This implies that for any given level of risk aversion, investors would prefer returns from the zero screen strategy to returns from an MOS = 0.025 screen.

Rides using longer maturities than six months did not perform as well as the six-month rides. Figure 3 for example, provides full-sample distributions for nine-month rides versus buy-and-hold distributions for MOS of 0.0. While longer-term riding distributions also lie generally to the right of the buy-and-hold distribution, when riding longer-maturity bills fails, as in 1958 second quarter, long-term riding fares much more poorly than the 6-month ride because duration is higher, giving rise to a longer left-hand tail. These results, together with Table 2, suggest that the extra average return to riding beyond maturities of six months increases risk by too much to qualify as a dominant strategy.

Finally, we ask whether riding the yield curve is an effective strategy for holding periods other than three months. In Figure 4, we present return distributions for 6-month buy-and-hold versus 6-month rollovers of 12-month bills for MOS of 0.0. Clearly, the riding strategy is not dominant.

4. CONCLUSION

We have found that riding the yield curve using six-month maturity zeros has been an extraordinarily effective strategy versus rolling over three-month zeros. Riding the yield curve using longer maturity bills for three-month holding periods also outperforms the simple buy-and-hold strategy, but does not incrementally enhance performance versus use of the 6-month bills. In fact, such longer rides perform slightly worse due to increased interest-rate risk. Similarly, riding the yield curve using 12-month bills and 6-month holding periods does not offer a risk-reward profile arguably better than that obtainable from buying and holding 6-month bills.

These results are suggestive of some market segmentation for maturities on either side of 3 months, in that it appears that profitable trading strategies straddling this maturity have gone unexploited. Possibly, maturities less than 3 months are viewed as more liquid and better cash substitutes than longer maturity instruments, even beyond a simple duration effect. In this case, the apparent abnormal performance of longer maturity bills may be viewed as the price of this liquidity attribute. However, this interpretation suggests that modelling prices as solely a function of risk and return attributes is too narrow a view of the market.

APPENDIX

The actual rate of return, r, realized by a trader is defined by $1 + r = P_1/P_0$, where P_0 denotes the price at which the zero-coupon security is purchased, and P_1 is the price at which it is sold. We, however, measure prices with error, in part because of unobserved bid-ask spreads, and in part because of statistical error in the fitting of the yield curve. We therefore measure r with error. If r^* is the measured return, then

$$1 + r^* = \frac{P_1 + e_1}{P_0 + e_0} \qquad (A.1)$$

where e denotes the random measurement error, assumed to have zero mean.

Rewriting (A.1) as

$$1 + r^* = \frac{P_1}{P_0 + e_0} + \frac{e_1}{P_0 + e_0}, \qquad (A.2)$$

it is clear that measurement error in P_1 will not bias returns as long as e_1 and e_0 are independent, since in this case the second term in (A.2) has zero expectation. However, the first term will not provide an unbiased estimate of 1 + r. To see this, expand the first term around P_0 in a second-order Taylor series:

$$1 + r^* \approx \frac{P_1}{P_0} - \frac{P_1}{P_0^2} e_0 + \frac{P_1}{P_0^3} e_0^2$$

Taking expectations over e_0, the expected value of the measured return conditional on the true prices P_0 and P_1 is

$$E(1 + r^*) = \frac{P_1}{P_0} [1 + \frac{\sigma^2(e_0)}{P_0^2}]$$

$$= (1 + r) [1 + \sigma^2(e_0)/P_0^2]$$

Thus, returns will be biased upward by the square of the standard deviation of measurement error expressed as a fraction of the security price.

This bias, however, should be exceedingly small. As noted above, the bid-ask spread is less than 6 basis points annualized, or 3 basis points on a 6-month bill. Moreover, Coleman et al. (1989, Table 10-3) present standard errors of their cross-sectional forward rate curves for each maturity class. Their results imply that for maturities less than one year, the standard error of the implied bill prices is in most cross sections considerably less than 0.25 percent. Together, these data imply that the total value of $\sigma(e_0)$ would be less than 30 basis points, or 0.3 percent of price. If a typical 6-month return is 3 percent, the bias would be determined by

$$E(1 + r^*) = (1.03)(1 + 0.003^2)$$

$$= 1.030009$$

implying a negligible bias of 0.09 basis points. Even if the standard deviation of the measurement error in price is 0.50 percent, a huge amount in the money market, the bias still would be small, only 0.26 basis points:

$$E(1 + r^{*}) = (1.03)(1 + 0.005^{2})$$
$$= 1.030026$$

FOOTNOTES

1. Coleman et al. assume that forward rates are constant over certain time intervals and then use a nonlinear least squares technique to find the sequence of forward rates that best fit the prices of all Treasury securities. They obtain their best fit for short-term securities by allowing the forward rates to change with maturity fairly frequently at the short end of the term structure. In fact, the first five weeks are fit exactly, because they allow different forward rates for each of the first five weeks. The time interval over which the forward rate is assumed constant is short for all maturities less than one year, which means that the inferred prices should be quite accurate for the securities we examine in this paper. The exact scheme for inferring forward rates is as follows:

Period	Span	Period	Span
1. week 1	7 days	8. 3-6 months	92 days
2. week 2	7 days	9. 6-12 mos.	6 months
3. week 3	7 days	10. 1-2 years	1 year
4. week 4	7 days	11. 2-4 years	2 years
5. week 5	7 days	12. 4-8 years	4 years
6. 36-50 days	15 days	13. 8-16 years	8 years
7. 51-90 days	40 days	14. 16-32 years	16 years

2. They report that whereas bid prices for T-bills reported in the _Wall street Journal_ and CRSP are always close (they differ slightly because the former is a 3:00 pm price and the latter is a closing price), the ask prices in CRSP and the _Journal_ vary widely. Because the bid prices are consistent while the ask prices in CRSP imply bid-ask spreads as high as $2.00, Coleman, et al. chose to use only bid prices from CRSP for dates after 1979.

3. The returns on investments held to maturity will be biased upward by the use of a bid price since in this case, the numerator in the return calculation is exactly par value (rather than a calculated quantity) while the denominator is downward biased. However, this property only strengthens our empirical conclusions below, in that we find that riding the yield curve dominates the buy and hold strategy even with the upward bias in buy and hold returns.

4. Strictly speaking, these are not three-month T-bills, but three-month zero-coupon bonds priced based on the Treasury yield curve. However, for expositional ease, we will continue to refer to them as bills.

5. Because these filter rules worked for Dyl and Joehnk, we would like to compare our results to theirs for the sample period in which our data overlap. This, however, is not possible. Our data set contains zero-coupon prices at maturities of 3, 6, 9, and 12 months. Our rides must

therefore be at 3-month increments. In contrast, Dyl and Joehnk have bills with maturities staggered each week. Their rides generally involve very small increments to the maturity of the bill being held, and most of their tables present returns from overlapping periods averaged across rides of different maturities.

6. One investment stochastically dominates another if the cumulative probability distribution of its returns lies strictly to the right of the other's. This means that the dominating investment has a higher probability than the dominated investment of beating any target return. All risk-averse investors will prefer the investment with the dominant distribution in a pairwise comparison (see Ingersoll, 1987).

7. We follow Bodie, Kane, and Marcus (1989). The historical average risk premium and standard deviation in the market portfolio have been about 8.5 percent and 21 percent respectively. In an CAPM-type model, where all investors hold the market portfolio, the risk premium should equal $A\sigma_M^2$ where A is the risk aversion parameter and σ_M^2 is the market variance. These values imply that $A = 0.085/0.21^2 = 1.93$.

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Table 1

FREQUENCY AND SUCCESS RATE
OF RIDING THE YIELD CURVE
(3-month holding period)

Sample Period	MOS:	6-Month bills -1.0	6-Month bills 0.0	6-Month bills 0.025	9-Month bills -1.0	9-Month bills 0.0	9-Month bills 0.025	12-Month bills -1.0	12-Month bills 0.0	12-Month bills 0.025
1984-	Frequency	1.0	0.85	0.65	1.0	1.0	0.70	1.0	1.0	0.55
1988	Success	0.70	0.65	0.46	0.65	0.65	0.57	0.55	0.55	0.55
1979-	Frequency	1.0	0.55	0.30	1.0	0.45	0.15	1.0	0.35	0.05
1983	Success	0.55	0.55	0.67	0.50	0.44	0.33	0.45	0.29	1.0
1974-	Frequency	1.0	0.95	0.85	1.0	0.85	0.80	1.0	0.80	0.65
1978	Success	0.70	0.68	0.76	0.65	0.65	0.69	0.45	0.50	0.62
1969-	Frequency	1.0	0.85	0.85	1.0	0.80	0.50	1.0	0.75	0.45
1973	Success	0.75	0.76	0.76	0.65	0.69	0.60	0.65	0.60	0.67
1964-	Frequency	1.0	1.0	0.85	1.0	0.65	0.50	1.0	0.65	0.25
1968	Success	0.80	0.75	0.71	0.50	0.46	0.30	0.45	0.46	0.40
1959-	Frequency	1.0	0.90	0.85	1.0	0.65	0.60	1.0	0.65	0.65
1963	Success	0.85	0.94	0.94	0.60	0.92	0.92	0.50	0.62	0.73
1954-	Frequency	1.0	0.50	0.50	1.0	0.80	0.80	1.0	0.80	0.65
1958	Success	0.45	0.40	0.40	0.50	0.50	0.50	0.45	0.44	0.46
1949-	Frequency	1.0	0.60	0.65	1.0	0.75	0.75	1.0	0.85	0.70
1953	Success	0.50	0.69	0.69	0.60	0.67	0.67	0.50	0.59	0.64
Full	Frequency	1.0	0.78	0.69	1.0	0.74	0.60	1.0	0.73	0.48
Sample	Success	0.66	0.71	0.70	0.58	0.63	0.60	0.50	0.52	0.60

Frequency = fraction of quarters within the sample period that the investor chooses to ride the yield curve.

Success = fraction of rides that result in higher returns than buying and holding 3-month T-bills.

Table 2

INVESTMENT RESULTS FROM RIDING THE YIELD CURVE: INCREMENT TO AVERAGE QUARTERLY RETURN AND STANDARD DEVIATION OVER BUY-AND-HOLD STRATEGY

ample eriod	MOS:	6-Month bills			9-Month bills			12-Month bills		
		-1.0	0.0	0.025	-1.0	0.0	0.025	-1.0	0.0	0.025
984-	ΔReturn	0.155	0.163	0.099	0.324	0.324	0.258	0.338	0.338	0.225
988	ΔVolatility	0.151	0.140	0.108	0.351	0.351	0.318	0.556	0.556	0.547
979-	ΔReturn	0.137	0.148	0.075	0.123	0.120	0.026	0.138	0.090	0.015
983	ΔVolatility	0.559	0.216	0.276	1.137	0.301	0.622	1.715	0.763	-0.018
974-	ΔReturn	0.152	0.153	0.157	0.172	0.166	0.122	0.128	0.196	0.052
978	ΔVolatility	0.109	0.122	0.062	0.228	0.147	0.256	0.418	0.310	0.472
969-	ΔReturn	0.145	0.124	0.124	0.155	0.142	0.096	0.148	0.098	0.113
973	ΔVolatility	0.116	0.089	0.089	0.279	0.247	0.237	0.547	0.486	0.390
964-	ΔReturn	0.071	0.067	0.051	0.010	0.001	-0.026	-0.018	-0.025	-0.076
968	ΔVolatility	0.067	0.073	0.082	0.156	0.183	0.175	0.281	0.278	0.348
959-	ΔReturn	0.141	0.140	0.140	0.103	0.133	0.143	0.091	0.139	0.030
963	ΔVolatility	0.136	0.139	0.138	0.188	0.173	0.246	0.274	0.318	0.627
954-	ΔReturn	0.009	0.000	0.000	0.039	0.036	0.036	0.029	0.028	0.083
958	ΔVolatility	0.146	0.117	0.117	0.292	0.311	0.311	0.441	0.489	0.300
949-	ΔReturn	0.004	0.004	0.004	0.068	0.064	0.065	0.063	0.063	0.058
953	ΔVolatility	0.026	0.016	0.016	0.110	0.112	0.112	0.150	0.153	0.179
ull	ΔReturn	0.106	0.100	0.081	0.126	0.123	0.090	0.122	0.116	0.123
ample	ΔVolatility	0.131	0.095	0.077	0.274	0.090	0.174	0.453	0.286	0.188

TABLE 3

RISK AVERSION COEFFICIENT AT WHICH RIDING THE YIELD CURVE IS EQUALLY ATTRACTIVE AS BUYING AND HOLDING

Transaction Cost (bp)*	MOS: -1.0	0	.025
6.0	224.4	260.1	251.0
10.0	206.6	237.4	227.1
14.0	172.9	196.1	183.3
18.9	127.2	143.7	126.6
22.0	75.0	87.9	64.8
26.0	28.8	36.2	9.9

* Reported bid-ask spread.

FIGURE 1

CUMULATIVE PROBABILITY THAT ACTUAL INVESTMENT RETURN IS LESS THAN A TARGET RETURN

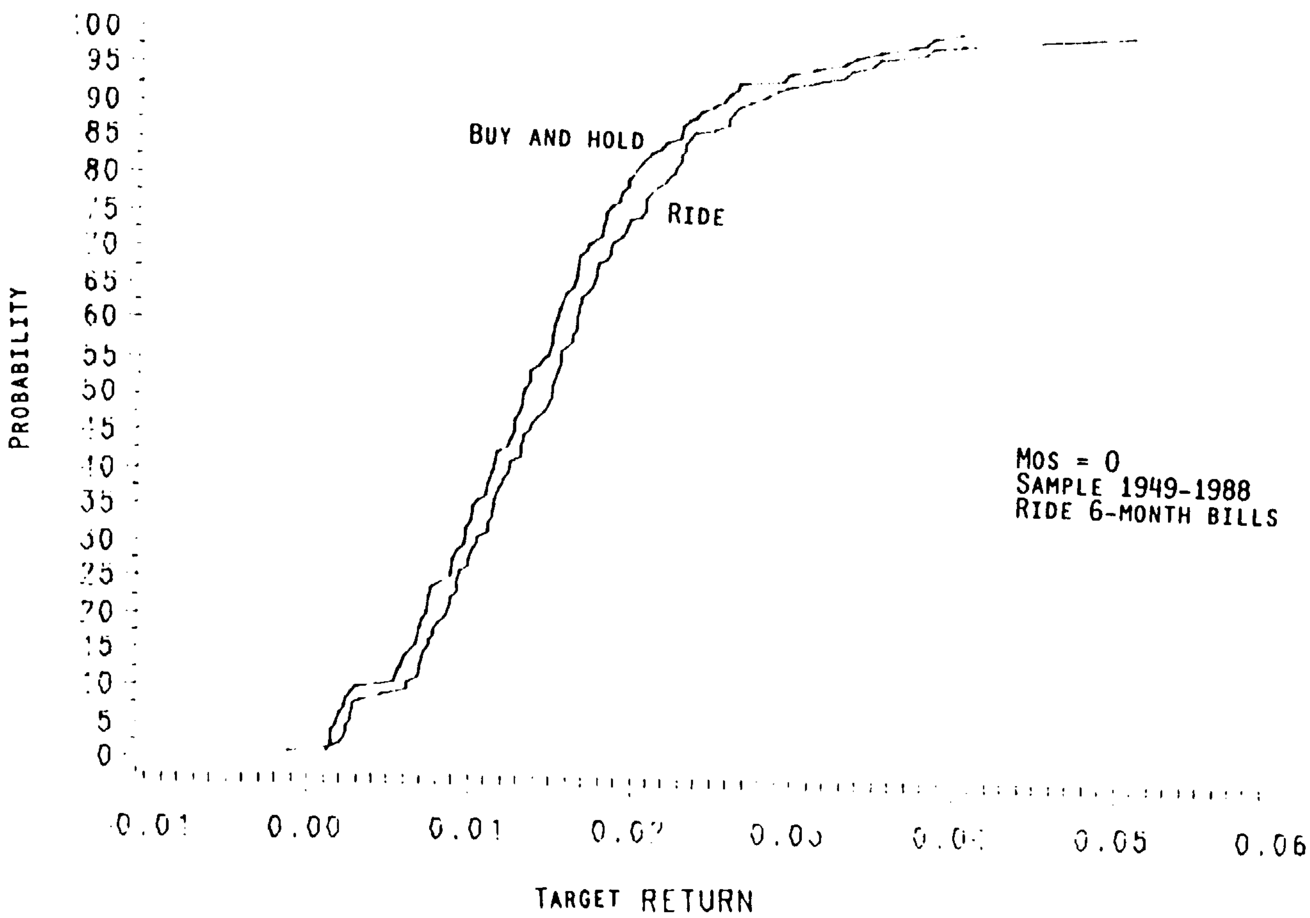

FIGURE 2

CUMULATIVE PROBABILITY THAT ACTUAL INVESTMENT RETURN IS LESS THAN A TARGET RETURN

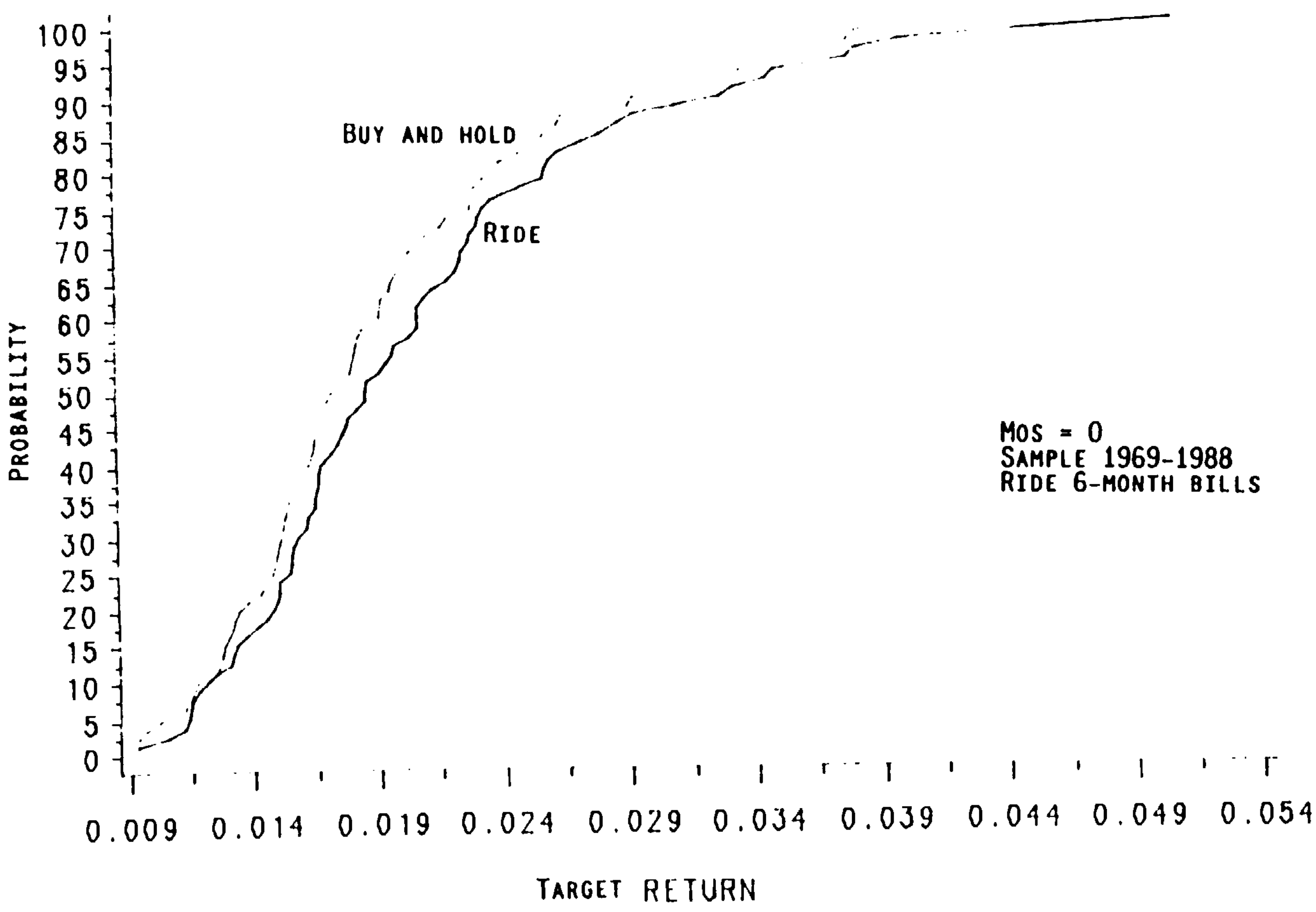

FIGURE 3

CUMULATIVE PROBABILITY THAT ACTUAL INVESTMENT RETURN IS LESS THAN A TARGET RETURN

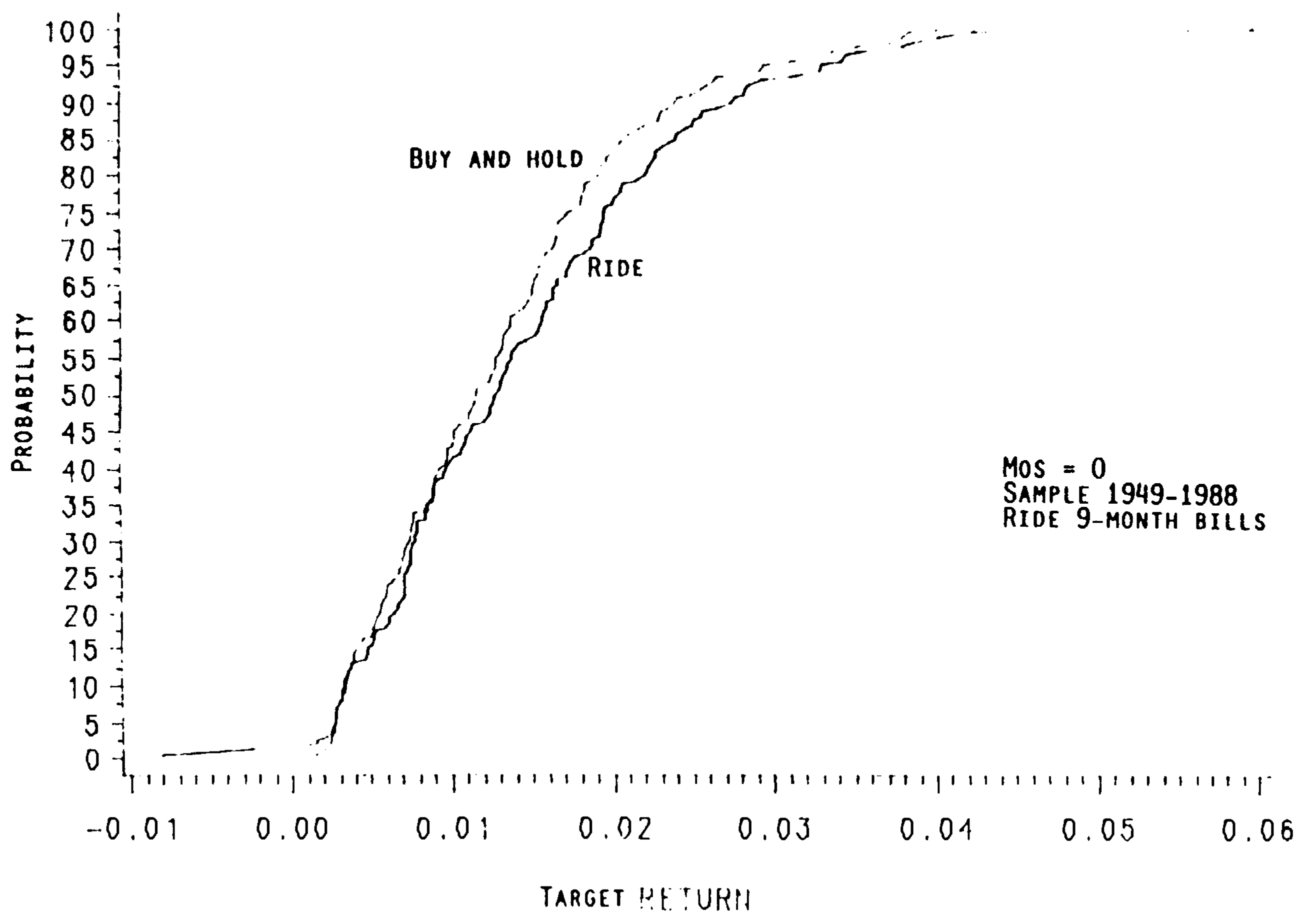

FIGURE 4

CUMULATIVE PROBABILITY THAT ACTUAL INVESTMENT RETURN IS LESS THAN A TARGET RETURN