A NEW APPROACH FOR ESTIMATING
THE CAPITAL MARKET LINE

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ABSTRACT

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The purpose of this study is to develop and empirically test a procedure to more effectively use the Capital Asset Pricing Model (CAPM) in the evaluation of securities. The CAPM is a conceptual tool used in estimating the required rate of return for all risky assets. It combines various portfolio possibilities of a risk-free asset and risky assets.

The population of efficient return and risk combinations is represented by a straight line referred to as the CML. Two problems associated with the estimation of this linear relationship are: 1) The expected return and standard deviation of return used as a risk measure is not instantaneously observable - historical data is relied upon. 2) The CAPM is a static model - a snapshot of an expected risk/return relationship at one point in time. The dynamic consequences are not well understood because of a stable risk/return relationship is implicitly assumed

when historical data is relied upon as a surrogate for current expectations.

The solution attempt for these problems lies in recognizing that we can obtain superior estimates of the expected standard deviation of the market on a daily basis, without relying on historical data.

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CHAPTER I

INTRODUCTION

The current price of risk is obviously of major concern to financial managers. While the existing financial literature provides a wealth of insight into the issue, little is offered with respect to precise quantification of the return/risk tradeoff. Perhaps the central difficulty in quantifying current risk and return stems from the fact that virtually all valuation models for unique assets are cast, by necessity, in an expectational framework. Even though expected risk and return are embedded in current price, it is difficult to extract these expectations when they, like prices, are unstable. In this event, history becomes a less than perfect surrogate for the expected future relationship.

This familiar and ubiquitous problem complicates, in turn, the process of selecting the most appropriate valuation model. With nothing more than historical prices as a basis for reference, the investigator is confronted with the task of deciding over which historical period were expectations stable enough to permit the use of ex post surrogates as reasonable measurement criteria for subsequent events. This problem is, subsequently, often exacerbated by the fact that methodology dictates the use of a significant number of price observations over time to calculate but one risk/return surrogate and its associated subsequent event.

For the novitiate, an appreciation for these problems emerges quickly. Referencing your favorite introductory (or advanced for that matter) financial text, how many pages were devoted to the problem of actually estimating a risk/return relationship for unique assets in nonrelative terms? Expositions rarely proceed much beyond the point of examining the empirical efficancy of competing pricing models. As an example, consider the Capital Asset Pricing Model, commonly referred to as the CAPM. Following a description of the model, most texts are devoted to an examination of its empirical support and a discussion concerning the model's use in relative terms as embodied in the Security Market Line (SML). Techniques for estimating the (nonrelative) price of risk as embodied in the Capital Market Line (CML) are rarely addressed. Rather, the CML is referenced most often with the intent of enhancing the pedagogy of the SML.

The objective of this research is to provide a new method for estimating ex ante return/risk relationships within the context of the CML. The approach is made possible by the existence of: 1) a fifteen month (at the time of this research) history of active markets for market index options, 2) a wealth of recent research concerning the estimation of Implied Standard Deviations (ISDs) using variants of the Black Scholes (BS) option pricing formula (See 1,3 11,12,13, and 28), and a new idea to be described shortly.

An Overview of Previous Research

Several studies have examined the informational content of stock options (See 3,9,11, and 12). This research suggests estimating the ex ante standard deviations from option prices by using the variants of the BS option pricing model. Within the context of the theoretical model developed by Black (2), an option contains an implied estimate of the expected volatility of the underlying asset. Because recent evidence suggests that ISDs are more accurate estimates of ex ante standard deviations expectations than are ex post measures (See 4,8,9,10,15,16, and 18), we no longer have to rely on the implicit assumption that past experience will repeat itself when estimating a security's or portfolio's ex ante standard deviation.

Recently, researchers employ various numerical approximation techniques to estimate the ISD. Latane' and Rendleman (17) have suggested using a simple or weighted average of the last ISD (LISD) of the day. By averaging different options on the same stock, the resulting weighted ISD, they conclude, is close to the estimated time series standard deviation. Research has found, though, that there may be a bias built-in to the LISD directly related to the volatility of the options being traded.

Patell and Wolfson (22) calculate an average ISD (AISD) by employing an equally-weighted arithmetic average of all a stocks' ISDs, regardless of time to maturity. Chiras and Manaster (5) use a relative weighting scale used to reflect how sensitive the option price is to a particular ISD.

Recently, theoretically superior techniques have been developed by Roll (23), Geske (14), and Whaley (28) which calculate a different implied volatility for each maturity. An estimate of standard deviation is determined by minimizing the sum of the squared observed residuals across maturities.

CHAPTER II

METHODOLOGY

Because an ISD is calculated with nothing but current data, many problems associated with estimates of nonstable risk are circumvented. An ISD may change from one minute to the next as a function of nothing more than the passage of time.

This research utilizes a fairly new capital asset, options on market indicies. The first index options, the S&P 100, was introduced in March of 1983. Since then, other index option contracts have begun trading. By using the NYSE Index, a market-weighted index, to conduct our research, we are more confident in our choice of surrogates for the market portfolio which is also a market-weighted portfolio.

Given an acceptable ISD for a market index at any point in time, the practitioner will require an estimate of the expected return premium on the index which is contiguous with the period of time implicit in the associated ISD. This return estimate may be derived as a function of the stability of the historical relationship between changes in ex ante risk and return.

As an example, suppose that historically both risk and return expectations had been stochastic, but that the relationship between the two estimates had been stable, conforming to the equation:

$$E(R_m-R_f) = B_0 + B_1E(\ _m) + B_2E(\ _m)^{B_3} \quad (1)$$

where $E(R_m-R_f)$ and $E(\ _m)$ represent expectations for the market return minus the risk free rate and the risk of the market respectively, and the remaining terms are constants. A knowledge of the constants in equation (1) and an estimate of $E(\ _m)$ would be sufficient for the construction of a CML whose intercepts and slope would be B_0 and B_1, $E(\ _m) + B_2\ E(\ _m)^{B_3} / E(\ _m)$ respectively. (Note that the original CAPM suggests that $B_0 = 0$ while the "zero-beta" version of the CAPM suggests that $B_0 <> 0$ may be possible.) Thus, one would be able to quantify the current risk/return relationship implicit in current prices only, without having to rely on historical data and the attendant assumption that the relationship is stable over time.

Equation (1) suggests the direction of our methodology. We first calculate as many daily ISDs on a market index as possible using the most appropriate methodology to be described subsequently. Using these ISDs as surrogates for $E(\ _m)$, we then estimate the parameters in Equation (1). As a surrogate for the dependent variable, we match ex post index and U.S. Treasury Bill returns which are contiguous with each

ISD observation.

Under the assumptions that: 1) the CAPM is an appropriate specification of risk/return expectations, 2) markets are efficient with respect to the CAPM, and 3) equation (1) is adequate enough to capture stability, if present, between risk and return so specified, an empirical estimation of equation (1) will generate unbiased parameter estimates of the constants. To the extent these estimates are significant and historically stable, the practitioner will be able to estimate possibly stochastic CMLs using nothing more than the current data required in the construction of an ISD.

Justification of the Model

Equation (1) is ad hoc to the extent that the CAPM is relatively unconstrained with respect to differences in the CML at one point in time versus another. Theoretically, the only constraint with respect to the constants in equation (1) is that the right-hand side of the equation is greater than zero. (The zero beta version of the CAPM is unconstrained in even this dimension. If the expected return of the zero beta portfolio was less than the expected risk free rate, there would be nothing to necessarily preclude the R.H.S. of equation (1) from being less than zero.)

Because our model is, to a large extent, ad hoc, this research may be fairly characterized as a "fishing expedition," where the null hypothesis is that $B_0 = B_1 = B_2 = B_3 = 0$ in the empirical counterpart of equation (1). If the risk/return relationship is not stable within the context of equation (1), we will not be in a position to reject the null hypothesis. The extent of the confidence in hypothesizing a stable relationship with respect to return and risk is proportional to the confidence in rejecting the null.

Our inspiration for adopting equation (1) proceeds from two considerations. First, a polynomial of higher order would severely limit the possibility of rejecting the null because our degrees of freedom diminish (proportionally) rapidly as parameter estimates are added to the empirical model. Second, Sharpe (25) implies that a polynomial of second degree may be sufficient to capture the more extreme changes in excess return as compared to changes in uncertainty. Within the context of Sharpe's argument, equation (1) specifies what he calls the "Supply of Risk-bearing." His argument proceeds from the suspicion that changes in perceived risk are likely to occur more often and with greater magnitude than are changes in market-wide risk aversion. Assuming that such aversion may be described as a quadratic function in $E(\ _m)$, changes in

E($_m$) will be associated with proportionally larger changes in $E(R_m - R_f)$, ceteris paribus. This condition, Sharpe suggests, is represented by radical differences in empirical estimates of the slopes of the SML at different points in time.

Experimental Rationale

The Black Scholes Pricing Model was introduced in early 1973, about the same time that listed options began trading. The BS formula determines the option price that is necessary to eliminate the possibility of extraordinary profit opportunities. It is based on the fact that it is possible, subject to a number of noncritical assumptions, to set up a perfectly hedged position between an underlying stock and options on that stock. The option pricing formula has two attractive features: 1) being based on a (persuasive) arbitrage argument, and 2) using variables that are generally easily observable. The five inputs that are generally required are: 1) the stock price, 2) the exercise price of the option, 3) the time to maturity of the option, 4) the risk free rate , and 5) the volatility of the stock (standard deviation). Employing the BS Model, an investor can solve for the variance of the stock rather than the price of the option by taking the observed option as given.

Methodological Detail

Our data base is confined to call options on the NYSE Index since, unlike other indexes, daily dividend entitlements are readily available. Daily dividend entitlements (ex-dividend amounts) for the NYSE Index are calculated as follows: Dividend entitlements for day t are equal to the NYSE spot index closing value on day t-1, minus day t's opening value. We assume that ex post dividends represent the most appropriate surrogate for ex ante estimates of the dividends.

Daily closing call option and underlying index prices were obtained from the Wall Street Journal for the period: September 26, 1983 - December 30, 1984 for options of all maturities which are one, two, and three months. NYSE Index options began trading on September 26, 1983. U.S. Treasury Bill returns with maturities almost identical to each of the three index options were obtained from the same source, and used as surrogates for the risk free rate. Daily ISDs are calculated for each of the three call maturities using the pseudo-American valuation procedure advanced by Black (1) and (2).[2] The use of this procedure is predicated by the large number of dividend entitlements, which normally accrue to the holder of an index portfolio during the life of a call option.

These dividends preclude the use of the theoretically superior model developed by Roll (23), Geske (11), and Whaley (28) (RGW), as well as previous methodologies mentioned above, whose computational burden becomes prohibitively high when more than one ex-dividend date occurs during the life of an option.

Black (1) and Macbeth and Merville (18) report that the pseudo-American approximation is most appropriate when evaluating options on stocks of average risk and when the difference between the exercise price and the market price of the stock is minimal. Sterk (26) finds that the pseudo-American approximation compare favorably with the RGW model under the same conditions when, in addition, ex-dividends payments are relatively small. In defference to these findings, ISDs in this research are computed based on the call option whose exercise price is closest to the current value of the index for each maturity. This maturity should minimize estimation errors resulting from nonsyncronious trading between the components of the index and the index call options because these options possess, on average, maximum liquidity.

The daily returns of the index are regressed against their associated daily ISDs to yield estimates of the constants in equation (1). In each regression, the time to maturity of the option is held constant within the bounds of a calendar week tolerance. Each of thirteen regressions spans fifteen months of data where the time to maturity of the option averages 0.5,1.5,2.5,,,12.5 weeks respectively. If a good fit is not found using a higher order polynomial (specified earlier), the method of least squares will be employed. By assuming a linear relationship, the sample observations are assumed to be of the form:

$$E(R) = B_0 + B_1(\ ). \qquad (2)$$

In the event a linear response is not appropriate, a quadratic regression shall be specified:

$$E(R) = B_0 + B_1(\ )^{B_2}. \qquad (3)$$

CHAPTER III

DATA BASE

This section includes the critical segments of the PL1 program used to analyze the data and compute the required parameter estimates. This listing is in turn followed by an example of the ISDs with their associated returns.

```
STD:    PROCEDURE OPTIONS(MAIN);
        DECLARE (CALLPR(3),INDEX(2,5,30),IRATE(3),
             MPS(3,30),SD(3),D(3,30),TIME(3),RATE)
             FLOAT:
        DECLARE (I,J,K,L,CLOS(6),NUM1,NUM2,YEAR(6),
             EOM(6)) FIXED:
        DECLARE MONTH(6) CHARACTER(10);
        DECLARE ISD ENTRY (FLOAT,FLOAT,FLOAT,FLOAT,
             FLOAT) RETURNS (FLOAT);
        ON ZERODIVIDE BEGIN;
           RE = 0.0;
        END;
     *C THIS SECTION ACCESSES A MONTH OF DATA
        INDEX(*,*,*) = 0.0;
        DO I = 1 TO 3;
            GET LIST (NUM2);
           DO J = 1 TO NUM2
              GET LIST (INDEX(1,I,J),INDEX(2,I,
                 J));
           END;
           G T LIST (MONTH(I),YEAR(I),NUM1);
           CLOS(I) = NUM1 + NUM2;
           EOM(I) = NUM2;
           DO J = NUM2 + 1 TO NUM2 + NUM1;
              GET LIST (INDEX(1,I,J),INDEX(2,I,J));
           END
           DO L = 1 TO 10;
              IF L = 10 THEN DO;
                 GET LIST(NUM2);
                 DO I = 1 TO NUM2;
                    GET LIST (INDEX(1,4,I),INDEX
```

```
                (2,4,I));
           END;
      END;
      MPS(*,*) = 0.0;
      DO I = 1 TO CLOS(1);
      MPS(1,I) = INDEX(2,1,I);
      DO J = I TO CLOS(1) - 1;
         IF INDEX(2,1,J) > 0.0 & INDEX(1,1,J+1)
            0.0 THEN
         MPS(1,I) = MPS(1,I) - INDEX(2,1,J)
            + INDEX(1,1,J+1);
      END;
         IF INDEX(2,1,CLOS(1)) 0.0 &
            INDEX(1,2,1) 0.0 THEN
      MPS(1,I) = MPS(1,I) - INDEX(2,1,CLOS(1)) +
         INDEX(1,2,1);
      D(1,I) = INDEX(2,1,I) - MPS(1,I);
      MPS(2,I) = MPS(1,I);
      DO J = 1 TO CLOS(2) - 1;
         IF INDEX(2,2,J) > 0.0 & INDEX(1,2,J+1)
           0.0 THEN
         MPS(2,I) = MPS(2,I) - INDEX(2,2,J) +
            INDEX(1,2,J+1);
      END;
         IF INDEX(2,2,CLOS(2)) > 0.0 &
            INDEX(1,3,1) 0.0 THEN
      MPS(2,I) = MPS(2,I) - INDEX(2,2,CLOS(2))+
         INDEX(1,3,1);
      D(2,I) = INDEX(2,1,I) - MPS(2,I);
      MPS(3,I) = MPS(2,I);
      DO J = 1 TO CLOS(3) - 1;
         IF INDEX(2,3,J) > 0.0 & INDEX(1,3,J+1)
            0.0 THEN
         MPS(3,I) = MPS(3,I) - INDEX(2,3,J) +
            INDEX(1,3,J+1);
      END;
         IF INDEX(2,3,CLOS(3)) > 0.0 &
            INDEX(1,4,1) 0.0 & L = 10 THEN
      MPS(3,I) = MPS(3,I) - INDEX(2,3,CLOS(3)) +
         INDEX(1,4,1);
      D(3,I) = INDEX(2,1,I) - MPS(3,I);
 END;

*C THIS SECTION CALCULATES THE RETURN AND THEN
*C ANNUALIZES IT FOR REGRESSION PURPOSES

 DO J = 1 TO EOM(1);
    GET LIST (CALLPR(1),CALLPR(2),CALLPR(3),
              STRIKE, TIME(1), TIME(2),
              TIME(3), IRATE(1),IRATE(2),
              IRATE(3));
```

```
      DO I = 1 TO 3;
   RE = (INDEX(2,I,CLOS(I)) - INDEX(2,I,J) +
         D(I,J))/INDEX(2,I,J);
   IF TIME(I) = 1 THEN TIME(I) = TIME(I) - 1;
   RE = (1 + RE) ** (365/TIME(I))-1;
         SD(I)=ISD(CALLPR(I),MPS(I,J),STRIKE,
            TIME(I)/365,IRATE(I));
         PUT SKIP EDIT (CALLPR(I),STRIKE,
            MPS(I,J),TIME(I),
              IRATE(I),D(I,J,),RE,SD(I))(8(X(5),
              F(10,4)));

      END;
   END;

*C THIS SECTION CALCULATES THE MARKET PRICE OF
*C THE UNDERLYING SECURITY TAKING DIVIDENDS INTO
*C CONSIDERATION.

   MPS(*,*) = 0.0
   DO I = 1 TO CLOS(1);
      MPS(1,I) = INDEX(2,1,I);
      DO J = I TO CLOS(1) - 1;
      IF INDEX(2,1,J) > 0.0 & INDEX(1,1,J+1) >
         0.0 THEN
         MPS(1,I) = MPS(1,I) - INDEX(2,1,J) +
            INDEX(1,1,J+1);
      END;
      IF INDEX (2,1,CLOS(1)) > 0.0 & INDEX(1,2,1)
         > 0.0 THEN
      MPS(1,I) = MPS(1,I) - INDEX(2,1,CLOS(1)) +
         INDEX(1,2,1);
      D(1,I) = INDEX(2,1,I) - MPS(1,I);
      MPS(2,I) = MPS(1,I)
      DO J = 1 TO CLOS(2) - 1;
      IF INDEX(2,2,J) > 0.0 & INDEX(1,2,J+1) >
         0.0 THEN
         MPS(2,I) = MPS(2,I) - INDEX(2,2,J) +
            INDEX(1,2,J+1);
      END;

*C THIS SUBROUTINE INPUTS THE STOCK PRICE (MPS),
*C CALL PRICE (CALLPR), EXERCISE PRICE OF CALL
*C (STRIKE), TIME TO EXPIRATION (TIME), AND RISKLESS
*C RATE (IRATE), THEN COMPUTES AND RETURNS THE
*C OPTIONS' IMPLIED STANDARD DEVIATION (ISD).

      ISD:   PROCEDURE (C,S,X,T,R) RETURNS(FLOAT);
             DECLARE (C,S,X,T,R,V1,V2,BSC) FLOAT;
             DECLARE DERIV FLOAT EXTERNAL STATIC;
```

```
            DECLARE I FIXED BINARY;
            DECLARE BS ENTRY(FLOAT,FLOAT,FLOAT,
               FLOAT,FLOAT) RETURNS(FLOAT);
            ON OVERFLOW BEGIN;
            END
            V1 = 0.01;
            V2 = 0.21;
            DO I = 1 TO 10 WHILE (ABS(V1 - V2) >
               0.0001);
            IF I > 9 THEN GO TO S_10;
            V1 =V2
            DERIV = EXP(-R*T)*X*SQT(T)*(EXP(-((LOG
              (S/X)+(R+V1**2/2)*T)/(V1*SQRT(T)))**
              2/2)/SQRT(6.2832));
             BSC = BS(S,X,T,R,V1);'
             V2 = V1 - (BSC - C)/DERIV;
     END;
     RETURN(V2);
S_10:V2 = 0;
     RETURN(V2);
     END ISD;

     *C THIS SUBROUTINE COMPUTES THE BLACK SCHOLES
     *C CALL PRICE.

     BS:  PROCEDURE(S,X,T,R,V) RETURNS(FLOAT);
          DECLARE (S,X,T,R,V,D1,D2,C) FLOAT:
          DECLARE CNORM ENTRY (FLOAT) RETURNS
                      (FLOAT);
          D1 = (LOG(S/X) + (R +V**2/2)*T)/
                      (V*SQRT(T));
          D2 = D1 - V*SQRT(T);
          C = S*CNORM(D1) - EXP(-R*T)*X*CNORM(D2);
          RETURN (C);
          END BS ;

 *C THIS SUBROUTINE IS THE CUMULATIVE NORMAL DIST.
 *C FUNCTION.

     CNORM:  PROCEDURE(Z) RETURNS(FLOAT);
             DECLARE (Z,Z1,Z2,Z3,U) FLOAT;
             U = ABS(Z);
             Z1 = EXP(-U ** 2/2) / SQRT (2 *
                  3.141593);
             Z3 = 1.0 / (1.0 + 0.33267 *U);
             Z2 = 1.0 - Z1 * (0.4361836 * Z3 -
               0.1201676 * Z3 ** 2 + 0.937298 * Z3
               ** 3);
             IF Z > 0 THEN RETURN(Z2);
             ELSE RETURN(1-Z2);
             END CNORM;
```

TABLE 1[3]
OCT '83*

DATE	DAYS TO MATURITY	DIVIDENDS	RETURNS	ISDs
OCT 3	46	0.6500	-0.3818	0.1549
	137	2.2900	-0.1075	0.1792
4	45	0.6100	-0.3776	0.1680
	136	2.2500	-0.1030	0.1692
5	44	0.6100	-0.3974	0.1586
	135	2.2500	-0.1100	0.1696
6	43	0.6100	-0.4444	0.1607
	134	2.2500	-0.1304	0.1834
7	42	0.6100	-0.5166	0.1085
	133	2.2500	-0.1650	0.0568
10	39	0.6000	-0.5554	0.1362
	130	2.2400	-0.1753	0.1593
11	38	0.6000	-0.6015	0.1768
	129	2.2400	-0.1977	0.2115
12	37	0.6000	-0.5602	0.1315
	128	2.2400	-0.1699	0.1511
13	36	0.6000	-0.5506	0.1370
	127	2.2400	-0.1606	0.1505
14	35	0.6000	-0.5635	0.1544
	126	2.2400	-0.1633	0.1447
17	32	0.5900	-0.1593	0.1698
	123	2.2300	-0.1667	0.1594
18	31	0.5700	-0.1927	0.1576
	122	2.2100	-0.1753	0.1725
19	30	0.5600	-0.0395	0.1738
	121	2.2000	-0.1388	0.1841
20	29	0.5600	0.0441	0.1940
	120	2.2000	-0.1221	0.1924
21	28	0.5600	0.0233	0.1952
	119	2.2000	-0.1275	0.1831
24	25	0.5600	0.1207	0.2137
	116	2.2000	-0.1139	0.1735
25	24	0.5500	0.1278	0.2262
	115	2.1900	-0.1146	0.1980
26	23	0.5400	0.0842	0.2158
	114	2.1800	-0.1235	0.2044
27	22	0.5200	0.1971	0.2080
	113	2.1600	-0.1081	0.2087
28	21	0.4800	0.2777	0.2187
	112	2.1200	-0.0995	0.1945
31	18	0.4700	0.5698	0.2244
	109	2.1100	-0.0774	0.2003

* In October 1983, only two contracts were being traded.

TABLE 2
JAN '84

DATE	DAYS TO MATURITY	DIVIDENDS	RETURNS	ISDs
JAN 3	17	0.1000	0.4052	0.1155
	45	1.0000	-0.3096	0.1434
	73	1.9400	-0.1279	0.1738
4	16	0.1000	0.6147	0.0345
	44	1.0000	-0.2855	0.1364
	72	1.9400	-0.1065	0.1601
5	15	0.0800	0.1374	0.1207
	43	0.9800	-0.3796	0.1485
	71	1.9200	-0.1772	0.1677
6	14	0.0800	-0.1625	0.0000
	42	0.9800	-0.4478	0.1452
	70	1.9200	-0.2296	0.1732
9	11	0.0800	-0.2965	0.1103
	39	0.9800	-0.4909	0.1303
	67	1.9200	-0.2541	0.1474
10	10	0.0600	-0.2923	0.1207
	38	0.9600	-0.4945	0.1356
	66	1.9000	-0.2528	0.1476
11	9	0.0600	-0.1647	0.2250
	37	0.9600	-0.4785	0.1640
	65	1.9000	-0.2349	0.2019
12	8	0.0600	-0.1600	0.2242
	36	0.9600	-0.4846	0.1824
	64	1.9000	-0.2354	0.1983
13	7	0.0600	-0.1894	0.1929
	35	0.9600	-0.4953	0.1850
	63	1.900	-0.2395	0.2080
16	4	0.0500	-0.0094	0.1825
	32	0.9500	-0.5051	0.1735
	60	1.8900	-0.2318	0.1982
17	3	0.0300	-0.1402	0.2048
	31	0.9300	-0.5227	0.1825
	59	1.8700	-0.2406	0.1372
18	2	0.0200	-0.5553	0.2917
	30	0.9200	-0.5521	0.2040
	58	1.8600	-0.2593	0.2203
19	1	0.0200	-0.6522	0.2466
	29	0.9200	-0.5558	0.1874
	57	1.8600	-0.2558	0.2033
20	0	0.0000	0.0000	0.0000
	28	0.9000	-0.5520	0.1789
	56	1.8400	-0.2457	0.2083

TABLE 3
JUN '84

DATE	DAYS TO MATURITY	DIVIDENDS	RETURNS	ISDs
JUN 1	14	0.2400	0.1241	0.1591
	49	0.5300	0.0438	0.1418
	77	1.3300	0.5852	0.1465
4	11	0.2100	-0.3382	0.1543
	46	0.5000	-0.0849	0.1445
	74	1.3000	0.4859	0.1497
5	10	0.1800	-0.5282	0.1239
	45	0.4700	-0.1450	0.1312
	73	1.2700	0.4346	0.1387
6	9	0.1500	-0.4954	0.1509
	44	0.4400	-0.1214	0.1399
	72	1.2400	0.4694	0.1543
7	8	0.1400	-0.6717	0.1326
	43	0.4300	-0.1784	0.1331
	71	1.2300	0.4213	0.1520
8	7	0.1300	-0.7249	0.1419
	42	0.4200	-0.1846	0.1294
	70	1.2200	0.4260	0.1405
11	4	0.1100	-0.9131	1.1591
	39	0.4000	-0.2124	0.1350
	67	1.2000	0.4331	0.1482
12	3	0.0400	-0.8424	0.1666
	38	0.3300	-0.1252	0.1161
	66	1.1300	0.5369	0.1309
13	2	0.0200	-0.8568	0.2404
	37	0.3100	-0.0884	0.1382
	65	1.1100	0.5872	0.1483
14	1	0.0100	-0.9737	0.3501
	36	0.3000	-0.0844	0.1431
	64	1.1000	0.6051	0.1564
15	0	0.0000	0.0000	0.0000
	35	0.2900	0.0133	0.1242
	63	1.0900	0.7134	0.1385
18	32	0.2900	0.1112	0.0000
	60	1.0900	0.8477	0.1485
	95	1.5500	0.6432	0.1393
19	31	0.2800	-0.0765	0.1649
	59	1.0800	0.6911	0.1663
	94	1.5400	0.5524	0.1557
20	30	0.2700	-0.1442	0.1422
	58	1.0700	0.6430	0.1484
	93	1.5300	0.5233	0.1441

CHAPTER IV

Empirical Results

Unfortunately, we were unable to reject the null hypothesis that there is no significant relationship between ex-ante risk and return estimates as hypothesized by equations (1), (2), and (3). Our regression results using OLS (equation 2) suggest, in essence, a complete lack of fit within the context of a linear relationship. The R^2s from these regressions never exceeded .02 while our parameter estimates were extremely insignificantly different from zero. With respect to equation (1), we were unable to obtain convergence in the algorithms employed by SAS to fit the nonlinear equation. This finding represents further support for the null hypothesis.

The regression results for equation (3) were very similar to those obtained for equation (1) and (2). For the overall regression using the entire data base and for each regression using quarterly data, we were unable to obtain convergence. However, for the regressions whose data was grouped by maturity, we obtained convergence for maturities of 12-13 weeks, 11-12 weeks, and 9-10 weeks as shown in Tables 4, 5, and 6 respectively. While these reported parameter estimates are all magnificently different from zero, they are highly consistent across reported maturity ranges. Additionally, the regressions suggest the existence of some degree of explanatory power as evidenced by the consistent R^2 values of about .21. Table 7 contains the results of a regression of equation (3) based on all the data whose option maturities range from 9-13 weeks. While the parameter estimates remain insignificantly different from zero, the associated R^2 value is enhanced as a function of increased observations.

TABLE 4

REGRESSION STATISTICS FOR CONTRACTS MATURING ON AND DURING WEEKS 12-13

$[R_M = B_0 + B_1(ISD)^{B_2}]$

PARAMETER	PARAMETER ESTIMATE	ASYMPTOTIC STD. ERROR
B_0	.09471363	.70872476
B_1	.77836127	19.39688910
B_2	1.41005349	17.71439206

R^2 = .2696971

TABLE 5

REGRESSION STATISTICS FOR CONTRACTS MATURING ON AND DURING WEEKS 11-12

$[R_M = B_0 + B_1(ISD)^{B_2}]$

PARAMETER	PARAMETER ESTIMATE	ASYMPTOTIC STD. ERROR
B_0	.06361990	.81156150
B_1	.76724101	20.66010078
B_2	1.41687617	19.61467843

R^2 = .1773623

TABLE 6

REGRESSION STATISTICS FOR CONTRACTS MATURING ON AND DURING WEEKS 9-10

$[R_M = B_0 + B_1(ISD)^{B_2}]$

PARAMETER	PARAMETER ESTIMATE	ASYMPTOTIC STD. ERROR
B_0	.08947825	1.21960249
B_1	.76884776	24.89670286
B_2	1.41673603	25.56705455

R^2 = .2080239

TABLE 7

REGRESSION STATISTICS FOR CONTRACTS MATURING ON AND DURING WEEKS 9-13
$[\ R_M = B_0 + B_1(ISD)^{B_2}\ ]$

PARAMETER	PARAMETER ESTIMATE	ASYMPTOTIC STD. ERROR
B_0	.08004427	.43745210
B_1	.77556108	10.33085964
B_2	1.41200680	9.95691886

R_2 = .2092455

CHAPTER V

CONCLUSION

The consistency of the parameter estimates in Tables 4, 5, 6, and 7 suggest that it may be appropriate to advance some tentative conclusions. The intercept terms (B_0) are all reasonably close to the value hypothesized by the CAPM, the risk free rate. The parameter (B_1) is positive as suggested by the argument advanced earlier by Sharpe. While the parameter (B_2) is also positive as suggested by Sharpe, the values suggest that return increases at a decreasing rather than a increasing rate, relative to risk.

The central problem associated with our failure to find significant parameter estimates stems from the fact that our surrogates for expected return were very divergent while those for risk were quite stable. Our suggestion for future research is that efforts be directed toward reducing the associated variance of expected return surrogates.

FOOTNOTES

[1]The NYSE Composite Index is an average of the price changes - from an established base value - of all the common stocks listed and traded on the New York Stock Exchange. In calculating the Index, the price of each stock is "weighted" by the number of shares outstanding.

[2]Theoretically, dividends should be discounted back to day t. The dividends in this study were not statistically large, so dividends over the maturity of the option were simply totalled.

[3]Our data is corrected for price misprints from the Wall Street Journal on the following days: October 5, 1983; February 16, April 5, April 10, June 1, October 11, and November 16, 1984.

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