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The Effects of Beta, Bid-Ask Spread, Residual Risk, and Size on Stock Returns

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ABSTRACT

Merton's [26] recent extension of the CAPM proposed that asset returns are an increasing function of their beta risk, residual risk, and size and a decreasing function of the public availability of information about them. Associating the latter with asset liquidity and following Amihud and Mendelson's [2] proposition that asset returns increase with their illiquidity (measured by the bid-ask spread), we jointly estimate the effects of these four factors on stock returns.

ACCORDING TO THE CAPITAL Asset Pricing Model (CAPM), expected asset returns are determined solely by the systematic (β) risk. Inconsistencies between the dictum of the theory and the empirical findings led Merton [26] to suggest a more general model of asset pricing, assuming that each investor has information only about a subset of the available assets and composes his or her portfolio only of this subset. The resulting portfolio will differ from the CAPM portfolio, and the expected return on each asset will be as follows:

(i) an increasing function of its systematic (β) risk;
(ii) an increasing function of its residual risk (due to imperfect diversification of this risk);
(iii) an increasing function of the fraction of the market portfolio invested in the asset, which can be measured by the asset's value or size; and
(iv) a decreasing function of the fraction of all investors who buy the asset, reflecting public availability of information about the asset.

Some of the above relations have been examined in isolation in various contexts.[1] Relation (i) is consistent with the traditional CAPM and has been generally validated in numerous studies, notably Fama and MacBeth [16]. Relation (ii), which deviates from the CAPM, is controversial. While Fama and MacBeth [16] rejected the dependence of stock returns on residual risk given β, Friend, Westerfield, and Granito [17] found a significant relation (usually positive) between the two in addition to (i). Relation (iii) seems to be contradicted by Banz [7] and Reinganum [27], who found a *negative* size effect on stock returns. However, these studies controlled only for β, whereas Merton derived

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[1] Levy [22] proposed a model where the number of assets in an investor's portfolio is constrained, derived relation (ii), and suggested a relationship with firm size.

relation (iii) *conditional* on the other three variables; that is, all four relations have to be estimated jointly. Relations (i), (ii), and (iii) were estimated jointly by Tinic and West [30], who found that, in general, only (i) holds.

An asset-pricing model which focuses on the role of illiquidity, measured by the bid-ask spread, was suggested by Amihud and Mendelson [2] (hereafter, A-M). In A-M's model, assets have bid-ask spreads which reflect their transaction (or illiquidity) costs, and investors have heterogeneous liquidation plans or holding periods. Rational investors select assets to maximize their expected return net of trading costs, and, in equilibrium, higher-spread assets are allocated to investors with longer holding periods ("spread clientele"). As a result, the market-observed expected return is an increasing and concave function of the (percentage) bid-ask spread. This proposition was supported by empirical tests which showed a strong and significant effect of the spread on stock returns.

The bid-ask spread is related to the number of investors holding the asset, which, by Merton [26], reflects the availability of information about it. Demsetz [15] found that a larger number of shareholders brings about a narrower spread. Subsequent studies found the transaction volume (which is more readily available than the number of shareholders) to be highly correlated with the spread (cf. Garbade [18]). The bid-ask spread also decreases when more information is publicly available about the asset (Bagehot [6], Copeland and Galai [14], Glosten and Milgrom [19]) since market makers set the spread so as to compensate for their losses to better informed investors. Thus, the incompleteness of public information about an asset, which Merton [26] suggested as a factor in asset pricing, is reflected in its bid-ask spread. This links Merton's relation (iv) to A-M's spread effect. In addition, since the spread is negatively correlated with the firm size (cf. Stoll and Whaley [29]), A-M's results may also be associated with Merton's relation (iii).

The bid-ask spread is also related to the residual risk, which may serve as another measure of incomplete information. Benston and Hagerman [8] suggested that the residual risk reflects price response to firm-specific information and is positively associated with insiders' opportunities to profitably trade against dealers. Stoll [28] proposed that risk-averse market makers charge a higher spread on assets with higher variance to compensate for the risk of their stock positions, and Copeland and Galai [14] modeled the spread as a pair of options offered by the market maker, implying that it is an increasing function of the asset's total risk.[2] In sum, there are a number of interrelated hypotheses on the factors affecting expected returns. Since only subsets of these hypotheses have been tested so far, the test results may be misconstrued. Merton's relations (i)–(iv) were derived from the partial derivatives of the expected return with respect to each of the four variables; hence, the effect of each must be evaluated while "holding constant" the other variables.[3] Thus, a well-specified test of these relations should be carried out *jointly* for all four explanatory variables. This is the task taken on here.

[2] For other studies relating volatility, spread, and asset characteristics, see Amihud and Mendelson [1, 3, 5], Cohen, Maier, Schwartz, and Whitcomb [11], and Mendelson [23–25].

[3] For example, as shown by Merton [26], while (iii) suggests a positive relation between expected return and market value, the total derivative of the excess return with respect to this variable can be negative.

I. Testing the Hypotheses

According to the CAPM, asset returns are determined by their systematic (β) risk. The market model depicts the return on asset j in period t, R_{jt}, as a function of the market return R_{mt};

$$R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt}, \tag{1}$$

where α_j and β_j are constants and ε_{jt} is the residual return, assumed to be serially and cross-sectionally independent as well as independent of R_{mt}. The standard deviation of the market-model residuals (= residual risk) of stock j is $\sigma_j = \sigma(\varepsilon_{jt})$. By the CAPM, assets will be priced so that $E(R_j) = R_f + \beta_j \cdot [E(R_m) - R_f]$, where $E(\cdot)$ denotes expectation and R_f is the riskless rate. The diversifiable residual standard deviation, σ_j, should not affect asset returns.

The discussion in Section I suggests testing a more comprehensive asset-pricing model. It calls for a joint test with all the variables hypothesized to affect expected returns: systematic (β) risk, residual risk, size, and the bid-ask spread. Our size variable is the market value of the stock (the product of the stock price by the number of outstanding shares), which is proportional to the fraction of the market portfolio invested in the stock in Merton's [26] model. The spread variable is intended to test the A-M model, and (as discussed above) it is also consistent with Merton's fourth variable, the fraction of all investors holding the asset.

A. Data and Test Methodology

Our empirical tests follow the methodology developed by Black, Jensen, and Scholes [9], Fama and MacBeth [16], and Black and Scholes [10] to test the CAPM, applying a pooled cross-section and time-series estimation as in A-M.[4] The return data were obtained from the University of Chicago CRSP monthly series. The percentage bid-ask spread (= dollar spread divided by the stock price) was calculated from data in *Fitch's Stock Quotations on the NYSE*, giving one spread observation per stock for each of the years 1960–1979.[5]

The test procedure consists of forming stock portfolios, calculating for each its β coefficient, residual standard deviation, size, and bid-ask spread, and then testing the cross-sectional relation between the average returns and these portfolio characteristics over the period 1961–1980. Each of the test years is preceded by two five-year periods. In the first period we estimated the stocks' β coefficients from the market model regression (1) and formed forty-nine equal portfolios by dividing the stocks into seven groups ranked by the spread and subdividing each into seven portfolios ranked by β. In the second five-year period, we calculated the average return on each portfolio and estimated by (1) the portfolio β and residual risk. We thus have, for each portfolio p ($p = 1, 2, \cdots, 49$) in each test period n ($n = 1961, 1962, \cdots, 1980$), the portfolio beta, β_{pn}, its residual standard deviation, σ_{pn}, the portfolio average spread, S_{pn}, and the average market value of the stocks in the portfolio, SZ_{pn}. In each of the test years n we calculated the portfolio average monthly excess[6] returns, R_{pn}, and finally estimated the cross-

[4] See, e.g., Kmenta [21].

[5] The spread data were kindly provided by Hans Stoll and Robert Whaley.

[6] All returns are measured in excess of the T-bill rate.

sectional relation between R_{pn} and the portfolio characteristics obtained from the preceding period.

B. The Results

Correlations between the portfolio characteristics are presented in Table I. The excess return is positively correlated with β, with the residual risk, and with the spread and is negatively correlated with size. The spread effect is positive as in A-M, and, given the negative relation between the fraction of shareholders holding the asset and the spread, this is consistent with Merton's [26] hypothesis. All four explanatory variables are correlated, highlighting the importance of a joint estimation of their effects. Omitting a variable from the regression model is well known to bias the estimated coefficients when the omitted variable is correlated with those included in the model since the estimated coefficients of the included variables will also reflect the effect of the excluded one.

We estimated the equation

$$R_{pn} = \gamma_0 + \gamma_1\beta_{pn} + \gamma_2\sigma_{pn} + \gamma_3 SZ_{pn} + \gamma_4 S_{pn} + \textstyle\sum_{n=1}^{19} d_n DY_n + \varepsilon_{pn}, \tag{2}$$

using the pooled time-series and cross-section approach. The coefficient γ_1 represents the market risk premium, expected to be positive. The coefficient γ_2 measures the effect of residual risk on portfolio returns; the null (CAPM)

Table I

Correlation Coefficients between the Variables Studied

For each portfolio p and in each year n, we have the portfolio excess return R_{pn} (the average monthly return on the stocks in portfolio p in excess of the monthly T-bill rate), the systematic risk β_{pn}, the residual risk σ_{pn}, the average size SZ_{pn} (the average market value of the common stock of the firms in portfolio p), and the average bid-ask percentage spread, S_{pn}. β_{pn} and σ_{pn} are estimated from the market model, where the equally weighted portfolio excess returns are regressed on the market equally weighted excess return over the sixty months prior to year n. SZ_{pn} and S_{pn} are estimated from data in the year just preceding n. There are forty-nine portfolios in each year, and n = 1961, 1962, . . . , 1980.

	Period	R	β	σ	SZ
β	1961–1980	0.124			
	1961–1970	0.132			
	1971–1980	0.118			
σ	1961–1980	0.125	0.301		
	1961–1970	−0.007	0.481		
	1971–1980	0.236	0.312		
SZ	1961–1980	−0.126	−0.361	−0.017	
	1961–1970	−0.135	−0.252	−0.141	
	1971–1980	−0.120	−0.446	−0.020	
S	1961–1980	0.239	0.361	0.357	−0.419
	1961–1970	0.179	0.163	0.440	−0.413
	1971–1980	0.285	0.540	0.339	−0.428

hypothesis is $\gamma_2 = 0$, and the alternative is $\gamma_2 > 0$. The third variable, size, is hypothesized by Merton to have a positive effect *given* the other variables, i.e., $\gamma_3 > 0$. Finally, the model includes the spread variable, S_{pn}, the coefficient γ_4 of which is hypothesized to be positive. The dummy variables DY_n account for differences in returns between years: $DY_n = 1$ in year n and zero otherwise.[7]

The OLS estimation results for model (2) are presented in Table II, Section A. The only variables the coefficients of which have the sign and significance consistent with the hypotheses are β and the bid-ask spread. The residual risk coefficient is negative and significant, and the size coefficient is positive but insignificantly different from zero. The size coefficient is inconsistent in sign, being negative in the first subperiod and positive in the second. Although the return-size relation in Merton's model is linear, we also applied the traditional transformation of the size variable into its logarithm and re-estimated model (2) with $\log(SZ)$ replacing SZ. The coefficient of $\log(SZ)$ was -0.00039 with $t = 1.05$, still insignificant, while all other coefficients preserved their signs and significance. In the first subperiod, the coefficient of $\log(SZ)$ was negative and significant, and, in the second, it was positive and insignificant, whereas β and the bid-ask spread always retained their signs and significance.

These results are consistent with the A-M hypothesis that the principal factors affecting asset returns are the β risk and illiquidity, measured by the bid-ask spread. The hypotheses on the effects of size and residual risk are not supported. Interestingly, the estimated effect of the residual risk is consistent with the tax-trading hypothesis, which suggests that the different tax rates on long-term and short-term capital gains and losses gave investors a timing option to realize losses short term and gains long term. The option value increases with the return variance; hence, an increase in the residual risk "increases the probability of a realized capital loss, and, therefore, increases welfare for those already holding the stock" (Constantinides and Scholes [13, p. 449]). By this hypothesis, a higher residual risk is associated with lower expected return.[8]

We re-estimated the effects of the four variables by the Generalized Least Squares (GLS) method to account for possible heteroscedasticity and cross-sectional correlations among the residuals.[9] The results are presented in Table II, Section B. The general pattern of the OLS estimation is preserved, although the estimated coefficient of the residual risk, while still negative, is not significantly different from zero. We again replaced SZ with $\log(SZ)$ and re-estimated the model. The estimated coefficient of $\log(SZ)$ was -0.003 with $t = 1.12$, still insignificant. The systematic risk β and bid-ask spread S preserved their sign and significance.

Our contribution by way of a joint estimation of the effects of all four variables on expected returns is apparent when comparing our results to those obtained when a partial set of variables is included. When only σ is included in the regression equation, its coefficient is positive and highly significant, in contrast

[7] Our estimation applies the classical methodolgoy of covariance analysis and pooling of time-series and cross-section data. See, e.g., Kmenta [21, Chapter 12] and Judge et al. [20, Chapter 8].

[8] Constantinides [12] proposed a positive relation between expected return and residual risk, also suggesting that the illiquidity effect is negligible.

[9] For details, see Amihud and Mendelson [2].

Table II

Results for the Regression of Average Monthly Portfolio Excess Return in Year n, R_{pn}, on the Portfolio Systematic Risk, β_{pn}, the Portfolio Residual Risk, σ_{pn}, the Average Market Value of the Common Stock of the Firms in Portfolio p, SZ_{pn}, and the Average Percentage Bid-Ask Spread, S_{pn}:

$$R_{pn} = \gamma_0 + \gamma_1\beta_{pn} + \gamma_2\sigma_{pn} + \gamma_3 SZ_{pn} + \gamma_4 S_{pn} + \textstyle\sum_{n=1}^{19} d_n DY_n + \varepsilon_{pn} \quad (2)$$

DY_n are dummy variables which control for differences in the mean returns between years. There are forty-nine portfolios in each year, and results are reported for the entire twenty-year period and for its two ten-year subperiods. The estimation applies both the Ordinary Least Squares (Section A) and Generalized Least Squares (Section B) methods. t-Values are in parentheses.

	Regression Variables			
Period	β	σ	SZ	S
Section A: Ordinary Least Squares Estimation				
1961–1980	0.0079	−0.1607	$0.18 \cdot 10^{-6}$	0.2411
	(6.55)	(2.63)	(0.59)	(6.96)
1961–1970	0.0081	−0.2562	$-0.23 \cdot 10^{-6}$	0.2601
	(4.76)	(2.40)	(0.52)	(4.89)
1971–1980	0.0086	−0.1299	$0.49 \cdot 10^{-6}$	0.2286
	(4.59)	(1.69)	(1.20)	(4.62)
Section B: Generalized Least Squares Estimation				
1961–1980	0.0053	−0.0431	$0.29 \cdot 10^{-8}$	0.2640
	(3.18)	(0.92)	(0.01)	(5.10)
1961–1970	0.0042	−0.1354	$-0.51 \cdot 10^{-8}$	0.2201
	(2.02)	(1.76)	(0.02)	(3.15)
1971–1980	0.0075	0.0057	$0.25 \cdot 10^{-8}$	0.2940
	(2.59)	(0.09)	(0.01)	(3.75)

to the insignificant coefficient of σ in the joint estimation. Furthermore, the "size effect" appears strongly negative in an equation which includes only β and $\log(SZ)$, but it is rendered insignificant when the spread and σ are added. The reason is apparent from the correlation matrix: the bid-ask spread is positively correlated with the residual risk and negatively correlated with size. Omission of the spread from the regression equation, given its positive effect on expected returns, naturally biases the estimated coefficients of the residual risk and size.

II. Conclusion

This study provided a *joint* test of a number of hypotheses on factors affecting asset returns. By the standard CAPM, expected return should be an increasing function of the systematic (β) risk, and Amihud and Mendelson [2] suggested that return is increasing in the bid-ask spread which measures asset illiquidity. Merton [26] proposed that the expected return is increasing in the asset's systematic risk (β), residual risk, and market value and is decreasing in the number of investors who have access to information about it and invest in it. So far, only subsets of these hypotheses were tested. Given the documented correlations between the above variables, a joint test is called for. Our results support the hypotheses that expected return is an increasing function of β and of the bid-ask spread but provide no support to the hypotheses on the effects of residual risk and firm size.

Merton [26, p. 507] argued that a growing awareness of professional money managers to the higher expected returns on stocks with a smaller investor base will make these extra returns disappear. A similar argument applies to the effect of residual risk which investors can reduce by diversification. The effect of illiquidity, however, is nondissipative since it can hardly be eliminated by investors. An investor who wishes to take advantage of the excess (gross) return on high-spread securities has to pay the bid-ask spread in the process, thus reducing his or her return. Further, a portfolio of illiquid securities remains illiquid since (unlike diversifiable risk) the associated costs are additive and do not cancel out. Thus, our results are consistent with the proposition that factors the effect of which is dissipative are not priced in the market.

Unlike the individual investor, firms often find it feasible as well as desirable to increase the liquidity of their financial claims. Our results imply that firms have an incentive to increase the liquidity of the claims they issue since this will lower their cost of capital and increase their market value. Amihud and Mendelson [4] proposed that a number of observed corporate policies can be viewed as liquidity-increasing investments. These policies include going public, issuing securities with standard claim features, instituting limited liability on equity claims, listing on organized exchanges, making inside information readily available to the public, and distributing ownership among many shareholders. Pointing out that the implementation of these policies is costly, Amihud and Mendelson [4] showed how the firm can balance the costs against the added value produced by the higher liquidity of its claims. In such a setting, the bid-ask spread is endogenously determined (at least in part) by the firm, and then firm characteristics may have a significant effect on the spread and thereby on expected stock returns. An interesting avenue for future theoretical and empirical research is to derive such a comprehensive model and to study the associated empirical relations.

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