Implied Penalties for Financial Leverage: Theory Versus Empirical Evidence

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This study reexamines empirically the use of leverage adjustment techniques for beta in determining costs of equity capital. In particular, the relationship between beta and financial leverage is examined for two- and four-digit industry classes over three subperiods spanning 1974-1988. The results suggest that the implied penalty for financial leverage falls below that posited by the Hamada/Bowman leverage adjustment models (with and without taxes) in most cases. Such results call into question the application of these techniques using industry classes to define like operating risk. To control more stringently for operating risk, matched pairs of firms are constructed to minimize intraindustry differences in this characteristic. The results of tests on these pairs still suggest, however, that application of popularly proposed techniques for unlevering betas will tend in many cases to over-penalize beta for increases in financial leverage.

INTRODUCTION

This study takes a new look at an old issue—the relationship between financial leverage and beta and, hence, between financial leverage and required return. Our motivation for returning to this question is based on three concerns: the conflicting results in extant empirical work, the recent controversy in the validity of beta as a discriminating measure of security risk (Fama and French, 1992), and the use of Hamada (1972) and similar techniques for unlevering and relevering betas for purposes of estimation of the cost of equity.

The theoretical literature dictates a positive and linear relationship between required return and leverage, as formulated by Modigliani and Miller (1858, 1963) within a constant risk class framework. Modigliani and Miller show, on both a no tax and after corporate tax basis, that the required return on equity of a levered firm increases in proportion to the debt-to-equity ratio. Hamada (1969, 1972) rederives the Modigliani and Miller propositions within a portfolio theoretic framework and shows that parallel relationships hold between equity betas and leverage as well. The major implication of the above works is that firms with the same asset risk but different degrees of leverage should have different costs of equity, with the market requiring higher returns on the more highly levered firm.

Opposing such paradigms is the traditionalist view. The traditionalists maintain that the market does not require higher returns for more highly levered firms until some critical leverage point is reached. At that point, required return will increase more dramatically

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with increases in financial leverage than that suggested by the later models of Modigliani and Miller and Hamada. Thus, within this framework, the cost of equity for firms within a given risk class will be constant across firms as long as critical leverage is not reached. [For one discussion of the traditionalist position, see Barges (1963).] While the arguments for the traditionalist position lack strong theoretical support (Brealey and Myers, 1988, pp. 396-397), the position nonetheless may reflect the perceptions of investors and analysts and the workings of financial markets. Surprisingly, while there has been a plethora of empirical research relating beta to financial leverage and a host of other variables, little research has tested how closely the actual Hamada relationships hold or has tested the Hamada relationship vis-á-vis the traditional position.

This article examines this issue from several perspectives. First, using ordinary least squares regression, we consider the Hamada proposition of a linear relationship between beta and financial leverage. Consistent with other studies, we find inconclusive results using this fairly simple test. We then relax the linearity assumption, and we use switching regime regressions to test for the nonconstant relationship between leverage and required return posited by traditionalist theories. Again, we find inconsistencies in the results of the switching regime models. Given the inconsistent results in tests of both the Hamada and the traditionalist models, we attempt to disentangle these mixed results by constructing a carefully controlled matched pair sample.

Examination of this issue is important for several reasons. Most managerial finance texts emphasize that a firm's equity risk arises from two components—operating risk and financial risk—and that market measures of equity risk, such as beta, should be delevered (typically with the Hamada adjustment) from the effects of financial risk in order to determine the asset risk premium applicable to the average firm project. To the extent that the Hamada adjustment for leverage fails to hold in practice, asset betas will be biased, leading to incorrect divisional costs of capital and capital budgeting decisions. Additionally, in the event the traditionalists are correct, firms that strive for a target beta would want to monitor more closely changes in operating risk over changes in financial risk.

RELATED LITERATURE

RELATED THEORETICAL WORK

The theoretical foundation for the relationship between financial leverage and equity required returns lies in the seminal work of Modigliani and Miller (1958, 1963) that shows that required return will increase linearly with a firm's debt-to-equity ratio. The Modigliani and Miller propositions are extended to a portfolio theoretic framework by Hamada (1969). In later work Hamada (1972) derives a direct relationship between the beta for an unlevered firm and the beta for the same firm if levered:[1]

(1) $Bu = (El/Eu)_{t-1}\ Be$

where:

[1] Rubeinstein (1973) also derives an analytical synthesis of portfolio and corporate financial theory.

Bu	=	Unlevered beta (asset beta);
El	=	Market value of (levered) common stock at t - 1;
Eu	=	Market value of common stock if no debt or preferred stock were used in the capital structure at t - 1; and
Be	=	Levered beta which equals beta of the common stock.

Using a slightly different paradigm but drawing on Hamada's work, Bowman (1980) shows that equation (1) also implies that the market value of equity for an unlevered firm will equal the market value of equity plus debt of the same firm if levered such that:

(1a) $Be = Bu\ (1 + D/E) = Bu + Bu\ D/E$

where:

D	=	Market value of debt of the levered firm;
E	=	Market value of equity of the levered firm; and

other variables are as defined previously. If one alternatively assumes that the Modigliani and Miller (1963) tax subsidy associated with debt financing is correct, the comparable relationship is:

(1b) $Be = Bu + Bu\ (1 - T)D/E$

where:

T = Corporate tax rate.

While equations (1a) and (1b) assume default-free (riskless) debt, Conine (1980) has developed a variant to allow for risky debt.[2] In this latter framework, the penalty for increased leverage is lower because the debt holders assume some of the risk, and the relationship between beta and financial leverage becomes:

(1c) $Be = Bu + (Bu - Bd)(1 - T)D/E$

where:

Bd = The beta for debt.

In contrast to the proportional increases in measures of equity risk with increases in leverage in the above paradigms, the relationship between equity risk and financial leverage in the traditional framework consists of two different regimes. In the first regime, the

[2] In a separate model, Bowman (1980) uses an option pricing framework to incorporate risky debt.

penalty for leverage (coefficient on D/E) is hypothesized to be zero.[3] In the second regime (after critical leverage), this penalty increases dramatically. Thus, in the context of the traditionalist's world, the relationship between beta (Be) and financial leverage (D/E) can be characterized as follows:

(2) $\text{Be} = \text{Bu} + \gamma_1 \text{ D/E}$, D/E < critical leverage, $\gamma_1 = 0$ or close to 0

$\text{Be} = \text{Bu} + \gamma_2 \text{ D/E}$, D/E $\geq$ critical leverage, $\gamma_2 > \gamma_1$.

RELATED EMPIRICAL LITERATURE

There has been little empirical research that tests if the penalty for financial leverage is of the magnitude suggested by the Hamada/Bowman models. This is a primary goal of the present study. The only known studies that test directly the relationship between equity betas and financial leverage posited by these models are earlier studies by Hamada (1972) and Chance (1982) that examine no data after 1978 and that employ a different methodology than that followed here.[4]

Far more numerous are empirical studies that relate beta to financial leverage and numerous other variables, including operating risk, dividend payout, liquidity, size, and others. [See Ang, Peterson, and Peterson (1985) for a review of many of these studies.] While this research typically (though not uniformly) finds a positive relationship between financial leverage and beta, such research is also typically subject to the criticism that there is no theory directly relating the dependent and independent variables (Bowman, 1979). Coupled with the lack of a theoretical foundation, differences in model formulations and inconsistency in the results over time render these studies unsuitable for practical use by researchers and corporate managers. In addition, by assuming a linear relationship between beta and debt-to-equity, none of the studies has tested for the possibility of a critical leverage point as suggested by the traditionalists.[5]

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[3] In some interpretations of the traditionalist position, the slope in regime one does not have to be perfectly horizontal (e.g., slope = 0; see Barges, 1963), but it generally is interpreted to be fairly flat and definitely less steep than that depicted in the Hamada/Bowman paradigms. Correspondingly, the slope in the second regime is predicted to be greater than that depicted by such paradigms.

[4] Assuming equity is valued according to a Modigliani and Miller world with taxes, Hamada (1972) and Chance (1982) calculate the yearly (or quarterly) unlevered equity returns for a sample of firms and derive estimates of unlevered betas, Bu, using this time series of unlevered returns. Both find that the average levered equity beta exceeds the average unlevered beta estimate. Chance (1982) segregates the sample into like Bu groups (e.g., all firms with Bu between .65 and .75 constitute a risk class, etc.) and examines the relationship between levered betas and debt/equity ratios for each of these groups, with mixed results. These results, however, are based on small, overlapping samples (24 to 31 firms) and are confined to the 1974-1978 period. In contrast, our approach follows the manner in which we have observed the model to be taught and used in practical applications: grouping firms into risk class based on industry or industry subsets. This approach allows us to discern whether such practices tend to over- or underestimate the penalty for leverage. Further, we examine three economically different and non-overlapping time periods, including two periods after the Chance (1982) and Hamada (1972) studies.

[5] We did find reference in a book discussing studies in nonlinear estimation to an older working paper (Hierl and Jen, 1975) in which the authors test the Modigliani and Miller propositions via switching regressions. Their approach differs from ours, as it examines a time series of leverage (versus the cross sectional differences in leverage). Further, there is apparently no control for changes in operating leverage.

METHODOLOGY AND DATA

We initially describe our methodology in terms of equation (1a), i.e., before consideration of corporate taxes and risky debt. Our hypotheses and results will be discussed in the context of all three models. To test equation (1a), estimates for levered beta (Be), leverage (D/E), and a definition of *risk class* are needed. For comparison purposes, we employ two different estimates of equity beta as the dependent variable. We initially estimate beta from the market model using Center for Research in Security Prices (CRSP) individual monthly returns and the corresponding return on an equal-weighted index of NYSE and AMEX securities. We refer to this beta estimate in the text and exhibits as Be_{Equal}. We repeat our estimation employing the value-weighted index (Be_{Value}).

Theory calls for the measure of the debt-to-equity ratio in equation (1a) to be the ratio of market value of total debt plus preferred stock to the market value of total common equity. Given difficulties in calculating market value measures of debt, most empirical work and practical applications rely on the book value of debt to the market value of equity ratio (D/E_M) as a proxy for market leverage. We follow that procedure here.[6] In addition, given financial managers' attention to book value leverage measures (Scott and Johnson, 1982), we employ the total book debt to total book equity ratio (D/E_B) as an alternative measure of financial leverage. Debt and equity values (both market and book) are obtained from the Compustat file.

Finally, to proxy constant risk class we again employ two different measures. Our first approach follows the early work examining the relationship between required returns and leverage by defining constant risk class as all firms in the same two-digit SIC. To provide a more precise definition of risk class, we also screen on a four-digit SIC classification, where the four-digit SIC codes represent subsets of the two-digit industries.[7] The trade-off is that there are fewer observations at the four-digit level on which to base estimates. We further restrict the study to nonfinancial NYSE- and AMEX-listed securities to ensure greater homogeneity of firms, and we require that firms have the requisite data from CRSP and Compustat.

Balancing criteria for sufficient data for estimation and diverse industry representation leaves six industries for examination at the two-digit SIC level and five industries at the four-digit level.[8] The two- and four-digit risk classes, associated number of observations, and summary statistics are provided in Table 1.

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[6] In an extensive examination of the use of book debt to proxy market debt, Bowman (1980) concludes book debt/market equity and market debt/market equity are statistically not differentiable in terms of the relationship to beta. Mulford (1985) finds the use of market debt is preferable in periods of high interest rates, but that finding is stronger at the portfolio level than at the individual security level. As in Bowman and Mulford's studies, our definition of debt includes the book value of preferred stock. We also estimate results excluding preferred stock from the definition of debt and find similar results. If preferred stock is classified as equity, statistical significance is not measurably affected.

[7] Our approach of controlling for operating risk using risk classes versus specific measures of operating leverage in models such as that of Mandelker and Rhee (1984) is motivated by our desire to test the accuracy of models generally prescribed by financial texts and employed in case studies.

[8] We first scan Compustat for a sample year (1980) to determine which industries have the greatest membership of NYSE and AMEX firms and then apply data requirements and diversity considerations in determining our final industries. We examine a 15-year pooled sample period plus three subperiods. Our aim is to have at least 30 observations per sample, but there are a few subperiods in which the number of available observations falls to the mid 20s. For four-digit SIC 2834, the subperiod results are based on even fewer observations and should be interpreted with caution.

Table 1—Summary Statistics of Two/Four-Digit SIC Code Sample Pooled Over Three Sample Periods

Variable	All N = 1230	SIC Code 13 N = 90	SIC Code 28 N = 199	SIC Code 29 N = 82	SIC Code 35 N = 239	SIC Code 36 N = 214	SIC Code 49 N = 406	SIC Code 1311 N = 66	SIC Code 2834 N = 52	SIC Code 2911 N = 79	SIC Code 4911 N = 151	SIC Code 4931 N = 122
D/E_B												
Mean	1.611	1.725	0.995	1.675	1.430	0.974	2.318	1.778	0.821	1.669	2.366	2.280
Std. Dev.	1.057	1.232	0.567	0.868	1.263	0.899	0.680	1.281	0.513	0.881	0.583	0.410
Q1	0.828	0.785	0.592	1.094	0.740	0.492	1.989	0.802	0.498	1.078	2.059	1.995
Q2	1.435	1.272	0.921	1.495	1.071	0.791	2.267	1.319	0.664	1.494	2.368	2.236
Q3	2.232	2.505	1.245	1.902	1.639	1.252	2.547	2.677	1.014	1.846	2.567	2.508
D/E_M												
Mean	1.624	1.297	0.862	1.683	1.515	0.824	2.544	1.122	0.448	1.690	2.701	2.649
Std. Dev.	1.348	1.413	0.791	0.973	1.609	0.825	1.094	1.150	0.646	0.990	0.995	0.997
Q1	0.572	0.541	0.258	0.992	0.491	0.316	1.813	0.552	0.170	0.943	2.008	2.059
Q2	1.310	0.876	0.707	1.455	1.019	0.570	2.463	0.822	0.252	1.441	2.688	2.544
Q3	2.395	1.482	1.220	2.169	1.919	0.945	3.094	1.197	0.464	2.171	3.196	2.978
Be_{Equal}												
Mean	0.831	0.978	0.880	0.778	1.105	1.154	0.454	0.959	0.774	0.755	0.377	0.382
Std. Dev.	0.430	0.360	0.343	0.309	0.368	0.377	0.233	0.294	0.421	0.288	0.166	0.179
Q1	0.481	0.723	0.644	0.564	0.833	0.902	0.290	0.732	0.453	0.556	0.261	0.265
Q2	0.799	0.957	0.856	0.750	1.093	1.149	0.402	0.919	0.688	0.739	0.349	0.340
Q3	1.132	1.205	1.091	0.987	1.362	1.369	0.574	1.186	0.974	0.929	0.471	0.489
Be_{Value}												
Mean	0.991	1.195	1.091	1.042	1.252	1.266	0.587	1.121	1.067	1.022	0.511	0.494
Std. Dev.	0.460	0.450	0.337	0.330	0.384	0.415	0.291	0.425	0.373	0.316	0.216	0.211
Q1	0.639	0.886	0.868	0.794	0.972	0.999	0.388	0.801	0.860	0.793	0.354	0.350
Q2	0.972	1.134	1.089	1.025	1.233	1.228	0.510	1.102	1.069	1.002	0.461	0.457
Q3	1.284	1.502	1.267	1.242	1.469	1.491	0.723	1.411	1.199	1.204	0.649	0.631

D/E_B = Leverage calculated as the average (over five year period) of book value of debt/book value of equity
D/E_M = Leverage calculated as the average (over five year period) of book value of debt/market value of equity
Be_{Equal} = Beta calculated from regression of returns on equal-weighted market index (over a 60 month period)
Be_{Value} = Beta calculated from regression of returns on value-weighted market index (over a 60 month period)
Industry Classifications: SIC 13 oil and gas extraction; SIC 28 chemicals and allied products; SIC 29 petroleum refining and related industries; SIC 35 industrial/commercial machinery; SIC 36 electrical equipment; SIC 49 electric, gas, sanitary services; SIC 1311 crude petroleum and natural gas; SIC 2834 pharmaceutical; SIC 2911 petroleum refining; SIC 4911 electrical services; SIC 4931 electric and other services

We examine the relationship between leverage and beta for each risk class over the period 1974-1988 by subdividing these 15 years into three five-year sample periods. Our rationale in examining the time periods 1974-1978, 1979-1983, and 1984-1988 is that these represent three distinct economic environments, e.g., the 1975-1976 recession, the 1979-1983 period of high interest rates, and the 1984-1988 economic boom and period of increased financial leverage. Dividing the sample period into three five-year subperiods also allows us to compute the beta and leverage measures over matching time frames. For example, in the first subperiod, we estimate beta over the 60 months 1974-1978.[9] We then average the annual book and market leverage measures over this same five-year period to smooth both potential outlier years and the considerable variation in market leverage measures. Further, we eliminate firms with negative leverage or those whose debt-to-equity ratio is greater than ten, because such firms are technically bankrupt or are close to bankruptcy. We repeat these same procedures for 1979-1983 and 1984-1988. Thus, the three subperiods are composed of non-overlapping observations and enable us to perform estimation for a pooled sample over 1974-1988 as well as for the subperiods.

In sum, the following empirical equation is estimated using OLS for each of the above time periods and for each of the six two-digit SIC and five four-digit SIC risk classes:

(3) $\tilde{B}e_j = \gamma_0 + \gamma_1 \, D/E_j + \tilde{e}_j$

where:

j = An index of the firms; and
e = A normal random variable.

Assuming a Modigliani and Miller world without taxes (equation 1a), γ_0 and γ_1 are hypothesized to equal Bu and thus should be equal. Under corporate taxation γ_0 = Bu and γ_1 = Bu(1 - t). Finally, with taxes and risky debt, γ_0 is hypothesized to equal Bu, but the hypothetical value of γ_1 becomes (Bu - Bd)(1 - T).[10]

Equation (3) assumes a constant penalty for financial leverage across all levels of debt to equity; to test for a dual penalty system as advocated by the traditionalists, we also estimate the following empirical scenario via switching regressions:

(4a) $\tilde{B}e_{jl} = \gamma_{0l} + \gamma_{1l} \, D/E_{jl} + \tilde{e}_{jl}$

(4b) $\tilde{B}e_{jh} = \gamma_{0h} + \gamma_{1h} \, D/E_{jh} + \tilde{e}_{jh}$

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[9] To estimate beta, we require that each firm have at least 36 months of CRSP return data within the 60 month period. In most cases, however, data for the full 60 months are available.

[10] The model incorporating taxes and risky debt is curvilinear, assuming Bd is a function of financial leverage; thus, estimation of a linear model such as equation (3) would not provide a strictly appropriate test of this model. For practical purposes, we assume a constant Bd for all firms. (See footnote 15.) Therefore, we can not (and do not) claim to provide a direct test of equation (1c). Rather, our goal is to provide a rough benchmark against which to compare equations (1a) and (1b) which are employed more frequently in practical applications.

where l and h index low (pre-critical) and high (post-critical) leverage, respectively. If the traditionalists are correct, then γ_{1l} is approximately zero and less than γ_{1h} and $\gamma_{1h} > 0$ and $> \gamma_{1l}$.

Switching regressions are well suited for testing this paradigm as they allow for a potential jump (or break) in the relationship between beta and debt/equity, where such a breakpoint is not known *a priori*. This is precisely the argument of the traditionalists, who maintain the existence of an unspecified critical leverage point at which the relationship between required return and financial leverage becomes more steep. Using a switching formulation, estimation of equation (5) is accomplished by ranking firms on either book or market leverage and maximizing the following likelihood function:

$$(5)\ L(Be_j^{l*}) = (1/2\pi)^{n/2}\, \sigma_l^{-jl*}\, \sigma_h^{-(n-jl*)} \exp[-1/2\sigma_l^2\, \Sigma(Be_{jl} - \gamma_{0l} - \gamma_{1l}D/E_{jl})^2 - 1/2\sigma_h^2$$

$$\Sigma(Be_{jh} - \gamma_{0h} - \gamma_{1h}D/E_{jh})^2]$$

where:

j^{l*}	=	Point of critical leverage;
σ_l^2	=	Variance of errors for firms with D/E ratios less than or equal to critical leverage ($j = 1 \ldots j^{l*}$);
σ_l^2	=	Variance of errors for firms above critical leverage ($j = j^{l*+1}, \ldots, n$); and all other variables are as defined previously.

The point of critical leverage is defined as the value for j^{l*} that maximizes $L(Be_j^{l*})$. To test whether there is a significant switch (i.e., two regimes) the Quandt likelihood ratio test is used, with the likelihood ratio given as $\mu = \hat{\sigma}_l^{-jl*}\hat{\sigma}_h^{-(n-jl*)}/\hat{\sigma}_n$, $\hat{\sigma}_n$ = the estimated standard deviation of residuals obtained from a single regression pooling all of the data.

RESULTS

The summary statistics (presented in Table 1) for the sample firms pooled over the 1974-1978 time period reveal plausible estimates for both definitions of financial leverage and beta. The average beta (Be_{Equal}) calculated from an equal-weighted index is less than 1.0 (.83), while the arithmetic mean beta calculated from a value-weighted index (Be_{Value}) is almost 1.[11] Table 1 also shows that mean book and market debt/equity ratios (D/E_B and D/E_M, respectively) are remarkably similar within each SIC group except for oil/natural gas (SIC 13, 1311) and pharmaceuticals (SIC 2834), although the standard deviation of the market-based measures tends to be greater. Finally, the various quartile statistics reveal a good deal of variability in beta and leverage not only across industries, but intraindustry as well. The intraindustry relationship between beta and financial leverage is explored in Tables 2 through 4.

[11] The value-weighted average of Be_{Value} also likely would be less than 1.0, however, as smaller firms have tended to have higher betas than have larger firms in empirical studies.

Table 2—Results of Regressions of Beta on Financial Leverage for Two-Digit SIC Risk Classes

Panel A: Beta Calculated Using Equal-Weighted Returns (Be_{Equity})

Two Digit	All Periods 1974-1988				Period 1974-1978				Period 1979-1983				Period 1984-1988			
SIC Code	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N
13	.961**	.012	.00	90	.842**	-.042	.02	26	1.115**	.057	.04	29	.878**	.058*	.07	35
28	.802**	.090**	.04	199	.544**	.170**	.27	63	.792**	.052	.01	66	1.008**	.076	.02	70
29	.541**	.143**	.19	82	.380**	.151**	.17	27	.698**	.105**	.14	27	.576**	.146**	.30	28
35	1.033**	.047**	.04	239	.799**	.095**	.18	69	1.041**	.037	.02	81	1.171**	.026	.00	89
36	1.069**	.102**	.05	214	.906**	.165**	.11	56	1.095**	.097*	.04	69	1.130**	.071	.02	89
49	.367**	.034**	.02	406	.300**	.080**	.20	125	.505**	-.037	.02	133	.313**	.062**	.07	148

Panel B: Beta Calculated Using Value-Weighted Returns (Be_{Value})

Two Digit	All Periods 1974-1988				Period 1974-1978				Period 1979-1983				Period 1984-1988			
SIC Code	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N
13	1.186**	.007	.00	90	1.212**	-.042	.02	26	1.434**	.073	.03	29	.886**	.057	.05	35
28	1.041**	.058*	.01	199	1.064**	.067*	.04	63	.909**	.074	.01	66	1.142**	.032	.00	70
29	.929**	.067*	.03	82	.894**	.062	.06	27	1.177**	.042	.01	27	.657**	.115**	.19	28
35	1.212**	.026*	.01	239	1.215**	.047*	.04	69	1.220**	.010	.00	81	1.236**	-.011	.00	89
36	1.181**	.103**	.04	214	1.266**	.100	.03	56	1.176**	.107	.03	69	1.169**	.053	.01	89
49	.526**	.023*	.00	406	.591**	.040**	.04	125	.709**	-.069	.04	133	.432**	.051**	.05	148

** $p < .01$
* $p < .05$
Be_{Equal} = Beta calculated from regression of returns on equal-weighted market index (over a 60 month period)
Be_{Value} = Beta calculated from regression of returns on value-weighted market index (over a 60 month period)
D/E_M = Leverage calculated as the average (over five year period) of book value of debt/market value of equity

Results of OLS Regressions:

Panel A: $Be_{Equalj} = \gamma_0 + \gamma_1 D/E_{Mj} + \tilde{e}_j$

Panel B: $Be_{Valuej} = \gamma_0 + \gamma_1 D/E_{Mj} + \tilde{e}_j$

Table 3—Results of Regressions of Beta on Financial Leverage for Four-Digit SIC Risk Classes

Panel A: Beta Calculated Using Equal-Weighted Returns (Be_{Equal})

Four Digit	All Periods 1974-1988				Period 1974-1978				Period 1979-1983				Period 1984-1988			
SIC Code	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N
1311	1.010**	-.045	.03	66	.842**	-.042	.02	26	1.236**	-.083	.08	19	.888**	-.017	.01	29
2834	.647**	.283**	.18	52	.368**	.348**	.59	16	.446**	.637	.14	16	.958**	.133	.05	20
2911	.506**	.147**	.25	79	.326**	.163**	.28	26	.689**	.103**	.14	26	.531**	.155**	.44	27
4911	.134**	.090**	.29	151	.246**	.094**	.25	49	-.012	.095**	.54	49	.117**	.099**	.54	53
4931	.118**	.099**	.30	122	.123	.137**	.44	39	.026	.081**	.16	41	.144**	.103**	.72	42

Panel B: Beta Calculated using Value-Weighted Returns (Be_{Value})

Four Digit	All Periods 1974-1988				Period 1974-1978				Period 1979-1983				Period 1984-1988			
SIC Code	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N	Intercept	Slope	R^2	N
1311	1.196**	-.067	.03	66	1.212**	-.043	.02	26	1.498**	-.05	.01	19	.908**	-.036	.03	29
2834	.937**	.290**	.25	52	.998**	.330**	.67	16	.656**	.445	.11	16	1.132**	.088	.02	20
2911	.899**	.073**	.05	79	.845**	.090*	.11	26	1.173**	.042	.01	26	.610**	.125**	.29	27
4911	.286**	.083**	.14	151	.605**	.044	.04	49	.040	.103**	.47	49	.272**	.080**	.32	53
4931	.259**	.088**	.17	122	.343**	.117**	.23	39	.126	.074*	.08	41	.285**	.083**	.65	42

** $p < .01$
* $p < .05$

Be_{Equal} = Beta calculated from regression of returns on equal-weighted market index (over a 60 month period)
Be_{Value} = Beta calculated from regression of returns on value-weighted market index (over a 60 month period)
D/E_M = Leverage calculated as the average (over five year period) of book value of debt/market value of equity

Results of OLS Regressions:

Panel A: $Be_{Equalj} = \gamma_0 + \gamma_1 D/E_{Mj} + \tilde{e}_j$
Panel B: $Be_{Valuej} = \gamma_0 + \gamma_1 D/E_{Mj} + \tilde{e}_j$

Table 4—Comparison of Hamada Estimates to Observed Parameters

Panel A: Beta Calculated Using Equal-Weighted Index (Be_{Equal})

Four Digit SIC Codes	Hamada Model 1(a) Intercept	Hamada Model 1(a) Slope	Hamada Model With Taxes 1(b) Intercept	Hamada Model With Taxes 1(b) Slope	Hamada Model With Taxes and Risky Debt 1(c) Intercept	Hamada Model With Taxes and Risky Debt 1(c) Slope	Observed in This Study Intercept	Observed in This Study Slope
1311	.451	.451	.605	.314	.716	.216	1.010	-.045
2834	.534	.534	.627	.326	.684	.200	.647	.283
2911	.281	.281	.402	.209	.542	.126	.506	.147
4911	.102	.102	.156	.081	.332	.017	.134	.090
4931	.104	.104	.160	.083	.334	.018	.118	.099

Panel B: Beta Calculated Using Value-Weighted Index (Be_{Value})

Four Digit SIC Codes	Hamada Model 1(a) Intercept	Hamada Model 1(a) Slope	Hamada Model With Taxes 1(b) Intercept	Hamada Model With Taxes 1(b) Slope	Hamada Model With Taxes and Risky Debt 1(c) Intercept	Hamada Model With Taxes and Risky Debt 1(c) Slope	Observed in This Study Intercept	Observed in This Study Slope
1311	.520	.520	.764	.397	.875	.299	1.196	-.067
2834	.787	.787	.865	.450	.922	.323	.937	.290
2911	.379	.379	.543	.282	.684	.200	.899	.073
4911	.138	.138	.212	.110	.387	.045	.286	.083
4931	.135	.135	.207	.108	.381	.044	.259	.088

Intercepts and slopes for Hamada models are estimated from the following equations:

2(a) Be = Bu(1 + D/E) = Bu + Bu D/E

2(b) Be = Bu + Bu(1 - T) D/E

2(c) Be = Bu + (Bu - Bd)(1 - T)D/E

(For simulation: Bd = .3, T = .48)

Table 2 presents results of an OLS regression of equity beta on financial leverage for two-digit SIC code risk classes. Results using market leverage (D/E_M) and betas calculated against an equal-weighted index of market returns are presented in panel A, while those using beta calculated against a value-weighted market index are presented in panel B. Because the results obtained using book value leverage are similar, we do not report them separately. For both panels A and B, the pooled results (column 1) show that with the exception of oil and gas extraction companies (SIC 13), there is a statistically significant relationship ($p < .05$) between leverage and beta for all the industries examined and for both definitions of beta. Panel A shows in addition that the slope coefficient is uniformly positive across subperiods with the exception of SIC 13 in 1974-1978. The magnitude and significance of the coefficient, however, are unstable over time. Panel B shows that the significance of γ_1 also varies somewhat across definitions of beta, with financial leverage more strongly related to Be_{Equal} than to Be_{Value} in most cases.[12] Both panels A and B depict that, overall, only a small amount of variation in betas is explained by debt/equity.

The generally weak relationship between beta and financial leverage exhibited in Table 2 could result from an inadequate control for operating risk. To address the possibility that our two-digit SIC code may be too crude a proxy for industry, Table 3 present the results of the same tests using four-digit SICs to control for risk class more closely.[13, 14]

Table 3 shows that results using the four-digit code are more significant in both statistical and economic terms. For example, the R^2s reveal that in all cases but SIC 1311 D/E is able to explain more of the variation in betas at the four-digit than at the two-digit level.

To examine how closely the estimated values approximate theoretical values, we use the average equity beta and leverage measures for each industry documented in Table 1 to derive the implied numerical values for the intercept and slope assuming equation (1a) holds true. We also simulate parameter values assuming corporate taxation [equation (1b)] and assuming both taxes and risky debt [equation (1c)]. We presume a 48 percent tax rate for these latter calculations because this was the marginal corporate tax rate in effect for the majority of the sample period. For equation (1c) we presume a debt beta of .30.[15]

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[12] There are bigger differences between the intercepts in panel A versus panel B than between the slopes. The larger intercepts in panel B result from the larger estimates of beta (dependent variable) derived when the value-weighted market index is employed.

[13] There are no industry subset (e.g., four-digit SIC) results for the two-digit classifications SIC 35 or SIC 36 due to insufficient data.

[14] We examine plots of the dependent versus independent variables and plots of the residuals of the regressions reported in Tables 2 and 3 to investigate for evidence of heteroskedasticity or influential outliers. Review of these plots neither lead us to suspect any significant problems with heteroskedasticity nor to believe that our results are driven solely by outlier effects. Furthermore, because we have eliminated firms with high or negative leverage from our sample, there is little economic justification for further elimination of outlying firm observations.

[15] Obviously, these are crude approximations. The corporate tax rate dropped slightly from 48 percent to 46 percent in 1982 and more significantly to 34 percent in 1986. (Both occurred in the middle of our sample periods. Further, the actual tax rate paid by an individual company could have been lower than these rates because of investment tax and other credit, but such a rate would be difficult to determine from accounting data. Butler, Mohr, and Simonds (1991) examine the use of both firm-specific and constant (40 percent) tax rates in beta adjustments for leverage and find that the betas adjusted for leverage using a constant tax rate

Comparisons of the hypothesized values versus the observed estimates are presented in Table 4. Given the weak regressions results for the two-digit risk classes, only results for the four-digit classes are presented.

Table 4 shows that the observed penalty for leverage falls below that implied by the Hamada/Bowman model without taxes [equation(1a)] in every case. This result also holds true for the Hamada/Bowman model with taxes [equation (1b)] except for risk classes 4911 and 4931 when beta is calculated against an equal-weighted index (panel A). For risk classes 2834 and 2911 the penalty for leverage observed in this study falls between that implied by equations (1b) and (1c) if beta is calculated against an equal-weighted index (panel A); however, it is lower than that implied by *any* of the three models when beta is calculated against a value-weighted index (panel b). Thus, while the results in Table 4 are mixed, in general it appears that the use of equation (1a) or equation (1b) in practical applications based on industry risk classes would over-penalize equity beta for increased leverage in most cases.

Several explanations are possible for such a finding. One is the failure of equations (1a) and (1b) to incorporate risky debt, leading to theoretical penalties for leverage that are biased upward relative to a risky debt scenario. While some of the results in Table 4 tend to support this explanation, the results are not consistent across risk classes and beta definitions. A second possibility is that we still have not eliminated all differences in operating risk, confounding the true relationship between leverage and beta. A third explanation is that the relationship between financial leverage and beta is explained more appropriately by the traditionalist paradigm than by a Hamada/Bowman-based paradigm. In this case, the actual slope would be relatively flat over low values of leverage and steeper over higher leverage values, with the linear model simply compromising these values.

We directly test this last hypothesis via switching regressions, and these results are reported in Table 5. Given our earlier findings, results are reported for the four-digit SIC risk classes only. Further, because the switching paradigm estimates the low leverage regime and high leverage regime results separately, we require at least 60 observations with at least 25 to 30 observations per regime for estimation purposes.[16] Thus, estimation is for the pooled sample and for the four, four-digit risk classes in which there are least 60 observations.

Panel A (using Be_{Equal}) shows, as hypothesized, that the slopes are higher for regime H (the more highly leveraged firms) for each risk class except SIC 4931 (although for

are both more stable and better predictors. We repeat our calculations assuming a lower constant tax rate (40 percent) with no major changes in our conclusions.

Our estimate of Bd = .3 for all firms also follows Butler, Mohr, and Simonds (1991). While actual debt betas could vary across firms, the estimation of betas for individual firm debt issues is fraught with empirical difficulties and is beyond the scope of the current work. If anything, .3 is too high an estimate, as it is based on an index of stocks and bonds and our index is equity only. Use of a relatively high beta for debt would put a cap on the lowest slope estimate that is reasonably implied by any of the theoretical models, however, and provides the type of comparison for which we are looking.

[16] The trade-off is between preciseness of parameter estimates and allowable range for critical leverage to occur. For the utility risk classes, where we have considerably more observations, we require 30 observations per regime; for the other risk classes we require 25 observations.

Table 5—Results of Switching Regime Model

Panel A: Beta Calculated Using Equal-Weighted Index (Be_{Equal})

Four-Digit SIC Code	Regime	Constant	Std. Dev.	Slope	Std. Dev.	Quandt LR	N	Switch D/E
1311	L	1.069	(.166)	-.151	(.276)	17.21**	38	.901
	H	1.009	(.070)	-.044	(.029)		28	
2911	L	.511	(.132)	.168	(.123)	8.67	45	1.605
	H	.300	(.108)	.214	(.040)		34	
4911	L	.177	(.057)	.065	(.032)	33.68**	50	
	H	.123	(.063)	.093	(.019)		101	
4931	L	.100	(.073)	.124	(.042)	38.78**	37	2.185
	H	.060	(.064)	.115	(.020)		85	

Panel B: Beta Calculated Using Value-Weighted Index (Be_{Value})

Four-Digit SIC Code	Regime	Constant	Std. Dev.	Slope	Std. Dev.	Quandt LR	N	Switch D/E
1311	L	1.121	(.243)	-.107	(.402)	5.786	38	.901
	H	1.195	(.098)	-.066	(.041)		28	
2911	L	1.406	(.163)	-.483	(.172)	153.648**	36	1.293
	H	.810	(.133)	.110	(.053)		43	
4911	L	.145	(.120)	.191	(.076)	107.60**	35	
	H	.237	(.073)	.096	(.023)		116	
4931	L	.203	(.080)	.137	(.048)	58.63**	32	2.063
	H	.214	(.078)	.101	(.025)		90	

** $p < .01$
* $p < .05$

Using a switching formulation, estimation is accomplished by ranking firms on either book or market leverage and maximizing the following likelihood function:

$$L(Be_j^{l*} = (1/2P)^{n/2}\, \sigma_l^{-jl*}\, \sigma_h^{-(n-jl*)} \exp[-1/2\sigma_l^2\, \Sigma(R_{jl} - \gamma_{0l} - \gamma_{1l}D/E_{jl})^2 - 1/2\sigma_h^2\, \Sigma(R_{jh} - \gamma_{0h} - \gamma_{1h}D/E_{jh})^2]$$

Quandt LR = Quandt likelihood ratio statistic which tests where a regime shift has occurred
Switch D/E = Critical level of debt to equity, i.e., the point defining the low versus high leverage firms
N = Number of observations per regime

SIC 2911, the likelihood ratio (Quandt LR) is only significant at the .10 level). Panel A also shows that intercepts are lower for regime H than for regime L, suggesting that the more highly leveraged firms have less operating risk, even within a four-digit SIC classification.[17] With varying Bu's across regimes, it is difficult to interpret the greater slope coefficient as strong support for the traditionalist position. The value-weighted results (panel B) question the traditional paradigm more directly. For example, in the case of SIC 4931, the intercepts are similar, but the penalty for leverage is lower in the second regime. For SIC 1311, the Quandt LR reveals no significant difference in the two regimes. For the final two SIC risk classes, higher slopes are accompanies by lower intercepts and vice versa.

Unfortunately, the results of the switching regressions present no conclusive support for either the Hamada/Bowman or the traditional position; however, they do suggest that even at the four-digit SIC level there are differences in operating risk that confound tests of any theory based on constant risk class.

[17] It is difficult to conclude this definitively, as there are no debt-equity ratios near zero for the more high leveraged firms. Thus, the intercept is out of the range over which the observations are estimated.

Faced with this finding, we decide to take one final tack in defining risk class. With the goal of controlling for operating risk as stringently as possible, we form a matched pairs sample in which the matching procedure is devised to choose pairs of firms equal in every respect but financial risk. First, we require that firms be classified by the same four-digit SIC code.[18] Second, we require that the standard deviations of operating income before depreciation (Compustat variable 13), scaled by total assets, be within 10 percent of each other.[19] As a third control for operating risk, we require that the matched firms be within 20 percent of each other in size, as measured by total assets. This last criterion is added to control for the small firm anomaly and related empirical evidence that smaller firms tend to have higher betas (Reinganum, 1981; Barry and Brown, 1984). Finally, to ensure that there would be material differences in capital structure to facilitate the examination of the effect of financial leverage on beta, we screen pairs that are less than 20 percent apart in terms of both our book and market leverage measures. We also eliminate pairs that do not have fiscal year ends within three months of each other or that have different data years as classified by Compustat for the time period investigated in order to ensure reasonable comparability of the accounting and CRSP data.

In applying the above screens, it becomes clear how different (in terms of size and operating income variability) firms within the same industry can be. The above screens leave a sample of only 24 pairs, even searching for matched pairs over the 1974-1978, 1979-1983, and 1984-1988 time periods. For this part of the study we examine the years 1969-1973 as well in order to obtain additional pairs. After applying the above screens to this time period as well, we are left with 30 pairs. The paired firms, with their matched attributes are presented in the appendix. Summary characteristics for the matched sample are presented in Table 6.

Table 6 shows how similar these firms are in terms of their operating risk characteristics and how different they are, on average, in terms of their leverage. It is also evident that the average beta (both mean and median) for the more highly leveraged firms exceeds that of the less highly leveraged group. To examine the statistical significance of this difference, we subtract the beta for the less highly leveraged firm from the more highly leveraged firm for each pair. We then perform a t-test on the mean difference, and we also conduct a nonparametric test (Wilcoxon) to mitigate the effect of outliers on the mean difference. These results are presented in the middle panel of Table 6. Even with our fairly small sample, the mean beta of the more highly leveraged firm is significantly greater than that of the less highly leveraged firm, supporting the hypothesis that higher returns are required for more highly leveraged firms, holding operating risk constant. This holds true for the Be_{Equal} and Be_{Value} measures, with the mean difference for the Be_{Equal}

[18] Unfortunately, SIC classification is reported by Compustat only for the latest year. Because SIC codes often change over time, we examine the SIC classification manually (using various volumes of the *Standard & Poor's Register of Corporations*) over the time periods for which the various firms are matched, and we eliminate those pairs that are not involved in at least some similar lines of business over the earlier periods.

[19] The standard deviation of operating income may be considered a measure of total operating risk even though portfolio theory indicates that only systematic operating risk is relevant. Beaver, Kettler, and Scholes (1970) contend that the evidence shows a positive correlation between the two measures. Further, they note that total earnings variability is suggested as an operating risk measure in the literature and is likely to be used by investors as a proxy for risk. In our sample, we have controlled for industry, so the systematic risk of the operating income as well as the total risk should be similar.

Table 6—Matched Pair Sample Statistics

Panel A: Operating and Financial Characteristics

	High Leveraged Firms		Low Leveraged Firms	
	Mean	Median	Mean	Median
Total Assets	2281.350	926.730	2263.580	900.940
Std. Dev. of Earnings	0.031	0.026	0.031	0.027
D/E_B	2.568	2.453	1.172	1.191
D/E_M	2.724	2.067	1.042	0.952
Be_{Equal}	0.860	0.777	0.675	0.592
Be_{Value}	1.085	0.997	0.927	0.875

Panel B: Average Beta

	Mean High	Mean Low	Difference	Std. Dev.	t-stat.
Be_{Equal}	0.860	0.675	.185**	.318	3.179
Be_{Value}	1.085	0.927	.157**	.421	2.044

** p < ,01 (* p < .05) for Wilcoxon signed rank test
(Z-statistics for Wilcoxon 3.239 and 2.355, respectively)

Panel C: Estimates for Bu Under Various Models

	Mean High	Mean Low	Difference	Std. Dev.	t-stat.
Be_{Equal}					
Eq. (1a)	.297	.395	-0.098	.159	-3.382
Eq. (1b)	.411	.474	-0.063	.188	-1.1841
Eq. (1c), Bd = .3	.569	.567	.002	.168	0.059
Eq. (1c), Bd = .195	.513	.534	-.021	.173	-0.653
Be_{Value}					
Eq. (1a)	.393	.553	-.160	.256	-3.413
Eq. (1b)	.540	.660	-.120	.288	-2.149
Eq. (1c), Bd = .3	.699	.752	-0.54	.263	-1.126
Eq. (1c), Bd = .195	.643	.719	-.076	.269	-1.557

** p < .01 (* p < .05) for Wilcoxon signed rank test
(Z-statistics for Wilcoxon -2.787, -1.676, .051, -.875, -3.281, -2.149, -.730, -1.265, respectively)

being .185 and for Be_{Value} .157. The parametric t-test and the nonparametric Wilcoxon results are significant at $p < .01$.

Given that the levered betas are different, as hypothesized, we next test whether the unlevered betas of the matched pairs are equal, as theory also would dictate. For this test, we unlever betas via equations (1a) and equation (1b), which commonly are used in practice. [For example, see finance cases such as Marriott (1992), Iskall Arno (1988), and Bumble Bee Seafoods (1985).] Because we are estimating Bu for individual firms in a given time period rather than for an industry average pooled over time, we adjust the tax rate used in equation (1b) according to the time period in which the firms are matched. For pairs matched during 1969-1973 and 1974-1978 we assume a 48 percent tax rate. For pairs matched during 1979-1983 we drop the rate to 47 percent (a compromise between 48 percent in effect for 1979-1981 and the 46 percent in effect for 1983-1983). For matched pairs in the 1984-1988 period we assume a 40 percent tax rate as a compromise between the 46 percent rate in effect for the first two years of the period and the 34 percent rate in effect for the last three years.

Using equation (1a) and the market debt-to-equity measure to unlever the equity betas for each pair produces a mean difference in the unlevered beta estimates (high minus low) of -.098 for Be_{Equal} and -.160 for Be_{Value}, both of which are significantly different from zero at the .01 level. The mean difference in Bu indicates that on average the penalty for leverage implied by equation (1a) is too great. When we unlever the equity betas for each pair according to equation (1b), the mean difference of the unlevered betas (high minus low) calculated against an equal-weighted index is -.063, which is not statistically different from zero at the .05 level. For the Be_{Value} estimates, the mean difference of -.120 is more negative than for Be_{Equal} and is significantly less than zero at the .05 level. Thus, use of equation (1b) offers an improvement over equation (1a), although there is still a tendency (especially with Be_{Value}) for more highly leveraged firms to be penalized too much for their use of financial leverage relative to the less high leveraged firms.[20] Such a finding is consistent with a risky debt scenario as the penalty to equity holders for leverage is reduced by a factor equal to Bd(1 - t)D/E in this case. As long as Bd does not decline as D/E is increased (which seems unlikely; Weinstein (1981) finds Bd positively related to interest rate risk and, more weakly, to default risk), the reduction in the penalty for leverage will be greater for firms with higher debt/equity ratios. To test the effect of risky debt in our results, we unlever the equity betas for equation (1c) assuming a Bd of .3 as in our earlier tests. As shown in Table 6, the unlevered betas are not significantly different from each other for either Be_{Equal} or Be_{Value}. As our .3 estimate of Bd is based on an index of stocks and bonds (see footnote 15), we repeat the unleveraging of equation (1c) assuming a Bd of .195, which is an estimate from Weinstein (1981) based on a value-weighted stock index. The differences in the unleveraged betas are not significantly different from zero at the 5 percent significance level in this case. These tests are based on a constant debt beta across firms and small sample size; thus, further work in this area is encouraged.

SUMMARY REMARKS AND CONCLUSIONS

The use of leverage adjustment techniques for estimating divisional cost of equity and for capital budgeting decisions coupled with conflicting results in extant work warrants analysis of the validity of these adjustment models.

This study reexamines the relationship between financial leverage and measures of beta from several perspectives and leads to the following conclusions and opportunities for further research. First, in using linear leverage adjustment techniques, such as those posited by Hamada (1972) and Bowman (1980), one needs to be careful in defining operating risk. We find that any economically significant relationship between financial leverage and beta is masked by nonleverage differences across firms grouped by two-digit SIC codes; thus, such a classification for operating risk should be avoided in practical and research-related applications of these models.

There is a much stronger relationship between financial leverage and beta for risk classes defined at the four-digit SIC level; however, in most cases, the penalty for financial leverage continues to fall below that posited by both the no tax and corporate tax versions of the Hamada/Bowman models. Such a result calls into question the application of

[20] Further, if one were to consider a scenario in which the sample firms had actual tax rates that were lower than the statutory rate, the differences between the two beta estimates would become even larger, as a higher tax rate is more beneficial for the more highly leveraged firm. This assumes that the actual tax rates for the less highly leveraged firms are not systematically lower than those for the more highly leveraged firms.

these techniques using even narrowly defined industries, as they will tend to overestimate resulting costs of equity capital for increases in leverage. Upon further investigation, it appears that there are considerable differences in operating risk across firms, even at a four-digit SIC level, that could explain our weak support for the Hamada/Bowman models. As a final control for operating risk, we construct matched pairs of firms that minimize intraindustry differences in operating risk while ensuring material differences in financial leverage. Although we must caution that the strict screens we impose result in a fairly small sample size, we find that in most cases the more highly leveraged firm within each pair has a higher equity beta and that the difference (high minus low) between the betas is statistically significant. When we unlever the betas according to the models of Hamada/Bowman, we find that the Hamada/Bowman adjustment without taxes tends to unlever the beta of the more highly leveraged too much relative to that of the less highly leveraged firm. When we include taxes, this finding is still significant at the .05 level using the betas calculated against a value-weighted index but only at the .10 level using betas calculated against an equal-weighted index. The tendency to penalize more highly leveraged firms too stiffly is consistent with a model incorporating risky debt. Using a constant beta for debt of .3 and, alternatively, of .195 and unlevering the betas according to equation (1c) results in no significant difference in the unlevered betas. As we assume a constant debt beta for all firms and because of our limited sample size, however, additional work along these lines is needed. Further, the sensitivity of results to the definition of beta (we found less support for leverage adjustment techniques using betas calculated against a value-weighted index versus an equal-weighted index throughout this paper) warrants further attention.

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APPENDIX A—MATCHED PAIR SAMPLE

Pair	Rank	Year	SIC	Company Name	TAST	SCOIBD	D/E_B	D/E_M	Be_{Equal}	Be_{Value}
1	H	69-73	2800	FMC Corp.	1143.3	0.0191	0.81	0.76	1.01	1.58
1	L	69-73	2800	American Cyanamid Co.	1235.1	0.0193	0.51	0.33	0.57	0.90
2	H	69-73	3241	Southdown Inc.	229.7	0.0329	1.89	2.68	1.26	1.85
2	L	69-73	3241	Ideal Basic Industries Inc.	263.9	0.0361	0.65	0.54	0.82	0.80
	1.31									
3	H	69-73	3613	Cooper Industries Inc.	199.1	0.0312	1.15	0.82	0.80	1.31
3	L	69-73	3613	Square D Co.	199.1	0.0289	1.02	0.61	1.21	1.82
4	H	69-73	3663	General Instrument Corp.	324.5	0.0266	1.72	1.64	1.33	1.85
4	L	69-73	3663	Harris Corp.	338.0	0.0289	1.02	0.61	1.21	1.82
5	H	69-73	3674	Alpha Industries	4.9	0.0639	1.25	0.74	1.52	1.94
5	L	69-73	3674	Semtech Corp.	5.2	0.0682	0.22	0.11	1.30	1.96
6	H	69-73	4931	Orange & Rockland Utilities	324.4	0.0111	2.88	2.21	0.28	0.44
6	L	69-73	4931	Montana Power Co.	356.1	0..0102	1.44	0.89	0.38	0.60
7	H	74-78	2834	Pfizer	2213.3	0.0084	1.13	0.56	0.25	1.11
7	L	74-78	2834	Johnson & Johnson	1818.0	0.0092	0.37	0.11	0.27	0.86
8	H	74-78	3011	Cooper Tire & Rubber	116.9	9.0602	2.01	4.32	1.19	1.24
8	L	74-78	3011	Bandag	136.1	0.0557	0.33	0.16	0.64	1.29
9	H	74-78	4512	HAL	55.9	0.0434	3.83	6.98	0.65	0.71
9	L	74-78	4512	Southwest Airlines	56.5	0.0453	2.14	1.59	1.13	1.56
10	H	74-78	4911	Energy	4226.5	0.0048	3.06	3.57	0.40	0.89
10	L	74-78	4911	Texas Utilities	3924.1	0.0049	2.08	1.82	0.29	0.69
11	H	74-78	4931	Public Service of Colorado	1479.7	0.0069	2.49	2.72	0.42	0.60
11	L	74-78	4931	Wisconsin Energy	1364.4	0.0075	1.85	1.82	0.17	0.53
12	H	74-78	5065	Astrex	17.8	0.0758	1.66	3.39	1.58	2.07
12	L	74-78	5065	Marshall Industries	21.0	0.0747	1.17	2.53	1.10	1.35
13	H	79-83	1381	Zapata	1051.6	0.0409	2.04	1.90	1.46	1.87
13	L	79-83	1381	Reading & Bates	899.3	0.0402	1.32	1.18	1.52	2.32
14	H	79-83	3011	Cooper Tire & Rubber	196.3	0.0441	1.38	1.96	0.75.	1.03
14	L	79-83	3011	Bandag	220.0	0.0407	0.37	0.19	0.79	0.90
15	H	79-83	3531	CMI Corp.	135.2	0.0948	6.27	2.08	2.11	2.29
15	L	79-83	3531	Portec Inc.	115.2	0.0930	0.79	0.97	0.8	90.88
16	H	79-83	3570	NCR Corp.	3320.9	0.0160	0.85	0.80	1.18	1.38
16	L	79-83	3570	Hewlett-Packard	2925.2	0.0160	0.48	0.15	1.01	1.31
17	H	79-83	3585	LSB Industries Inc.	82.7	0.0611	8.43	8.89	1.06	0.81
17	L	79-83	3585	Kysor Industrial Corp.	85.0	0.0613	1.20	1.62	0.83	0.89
18	H	79-83	3714	Eaton Corp.	2259.9	0.0376	1.391,48		0.71	0.85
18	L	79-83	3714	Dana Corp.	1947.5	0.0388	0.93	0.90	0.60	0.67
19	H	79-83	4911	Northeast Utilities	3890.2	0.0129	2.66	3.64	0.32	0.38
19	L	79-83	4911	Central & Southwest Corp.	4677.5	0.0129	2.10	2.50	0.21	0.27
20	H	79-83	4911	Minnesota Power & Light	970.4	0.0237	2.52	3.02	0.25	0.32
20	L	79-83	4911	Atlantic Energy Inc.	978.2	0.0223	1.98	2.43	0.34	0.47
21	H	79-83	4931	Cilcorp Inc,	899.1	0.0089	2.733,58		0.40	0.44
21	L	79-83	4931	Washington Water Power	902.4	0.0090	1.76	2.20	0.14	0.19

APPENDIX A—MATCHED PAIR SAMPLE (CONT.)

Pair	Rank	Year	SIC	Company Name	TAST	SCOIBD	D/E_B	D/E_M	Be_{Equal}	Be_{Value}
22	H	84-88	1311	Alamco Inc.	65.2	0.0447	4.78	8.38	0.73	0.56
22	L	84-88	1311	Prairie Oil Royalties Co. Ltd.	66.4	0.0473	0.61	0.56	0.49	0.42
23	H	84-88	3825	Sun Electric Corp.	156.8	0.0306	1.16	1.26	1.66	1.78
23	L	84-88	3825	Fluke (John) Mfg. Co.	171.2	0.0325	0.48	0.31	1.07	1.08
24	H	84-88	4011	Soo Line Corp.	932.6	0.0196	2.41	3.54	0.99	0.97
24	L	84-88	4011	Kansas City Southern Inds.	966.4	0.0211	1.71	1.44	1.39	1.42
25	H	84-88	4813	GTE Corp.	28034.5	0.0086	2.71	1.85	0.59	0.72
25	L	84-88	4813	Bellsouth Corp.	26157.6	0.0088	1.39	1.00	0.48	0.70
26	H	84-88	4833	CBS Inc.	3691.6	0.0457	2.76	0.81	0.86	1.01
26	L	84-88	4833	Capital Cities/ABC Inc.	3950.3	0.0465	1.17	0.47	0.79	0.92
27	H	84-88	4911	Central & Southwest Corp.	7219.7	0.0095	2.08	1.79	0.26	0.42
27	L	84-88	4911	Duke Power Co.	8334.4	0.0092	1.69	1.34	0.20	0.35
28	H	84-88	4911	Eastern Utilities Assoc.	920.8	0.0146	2.77	2.01	0.24	0.39
28	L	84-88	4911	Nevada Power Co.	882.9	0.0148	1.62	1.18	0.25	0.36
29	H	84-88	4923	Enserch Corp.	3252.1	0.0258	3.17	2.28	1.08	1.17
29	L	84-88	4923	Consolidated Natural Gas	3837.0	0.0267	1.47	0.93	0.54	0.70
30	H	84-88	4931	Midwest Energy Co.	1023.8	0.0062	2.92	2.06	0.33	0.43
30	L	84-88	4931	WPL Holdings Inc.	1081.3	0.0058	1.84	1.30	0.23	0.31

TAST = Total asset
SCOIBD = Standard deviation of operating income before depreciation
D/E_B = Debt/book value of equity
D/E_M = Debt/market value of equity
Be_{Equal} = Equity beta calculated from equal-weighted index
Be_{Value} = Equity beta calculated from value-weighted index