Combined Leverage and Stock Risk

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Abstract

A firm's degree of total leverage commonly is considered to be the product of degrees of operating and financial leverage. Mandelker and Rhee's empirical evidence supports such a view. O'Brien and Vanderheiden question conventional leverage proxies and suggest the improved measures used here.

Mandelker and Rhee do not test against a competing alternative. L. Huffman provides such an alternative. These results support Huffman's theory. Interactions between investment and financing can either increase or decrease the impact of leverage on stock risk. Combined leverage, estimated without regard to levels of its operating and financing components, better explains stock risk.

Introduction

The way in which a firm finances and the extent to which its operations involve fixed costs affect the variability of firm earnings. This influences the riskiness of its stock. Many popular financial management texts[1] indicate that the degree of total leverage (DTL) is the product of the degrees of operating (DOL) and financial leverage (DFL); most prior empirical work presumes this to be correct. Theory developed by L. Huffman (1983), however, suggests that the degree of combined leverage (DOCL) is not simply the product of DOL and DFL.

The issue is whether L. Huffman's combined leverage better explains stock risk than the use of separate measures for operating and financial leverage in an estimation equation that assumes the two are strictly multiplicative. The results in this paper support L. Huffman's theory. Combined leverage, estimated without regard to levels of its operating and financing components, better explains total stock risk for the sample. The impact of combined leverage on equity risk varies with industry growth, as may be expected given L. Huffman's

[1] See, e.g., Weston and Brigham (1981, pp. 571-574).

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theory. DOCL and DTL explain about equal proportions of the variation in systematic risk for the sample. Statistically, DOCL performed slightly better.

Related Literature

Considerable effort has been expended to explain the relationship between a firm's real asset risk and the riskiness of its equity. Theoretical and empirical justification exists for relating stock risk to leverage. Percival (1974) explores the fixed-variable cost relationship and the theory related to DOL, suggesting weaknesses in this measure. This paper is criticized by Gahlon (1981), who shows that, in general, a firm's systematic risk should increase with increases in its DOL. Using Rubinstein's analytical model as a basis, Lev (1974) provides empirical evidence that operating leverage is positively associated with market risk.[2]

Hamada (1972) and Rubinstein (1973) demonstrate that a firm's beta should increase if the firm finances more heavily with debt. These theories are extensions of the pre-CAPM work of Modigliani and Miller (1969), who show that use of debt increases equity return variability. In his analysis of market risk, Hamada concludes that 21 percent to 24 percent of a firm's systematic risk could be explained by the nature of its financing. Later papers by Hill and Stone (1980) and Chance (1982) extend Hamada's risk decomposition approach.

Gahlon and Gentry (1982, p. 17) analyze the relationship between firms real asset risk and their market risk. The coefficient of variation of profits $CV(\pi)$ is a function of a coefficient of variation of revenue as follows:

$$(1)\quad CV(\pi) = DOL \bullet DFL \bullet CV(REV)$$

Gahlon and Gentry also investigate the relationship between beta and leverage. Mandelker and Rhee's (1984) analytical model, however, better illustrates the DOL-DFL multiplicative relationship. They state:

$$(2)\quad \beta_j = DOL \bullet DFL \bullet \beta_j^O$$

where

β_j = systematic risk of firm j, as traditionally defined, and

[2]Lev's sampling process and operating leverage proxy are criticized by Subrahmanyam and Thomadakis (1980).

$$\beta_j^O = COV\,[(\pi_{jt-1}/S_{jt-1})(S_{jt}/E_{jt-1}),\, R_{mt}]/\sigma_m^2,$$

which Mandelker and Rhee identify as a firm's *intrinsic business risk,*

and where

π_{jt-1}	= net income of firm j in period t - 1,
S_{jt-1}	= sales revenue of firm j in period t - 1,
S_{jt}	= sales in period t,
E_{jt}	= market value of common equity in firm j at time t,

and where DOL, DFL, R_{mt}, and σ_m^2 are conventionally defined.

Equation (2) indicates that a firm's market beta is a leverage-adjusted function of its intrinsic business risk (β_j^O). The Mandelker and Rhee beta has several subtle, and ingenious, nuances that allow translation of accounting measures into market measures. The covariance is between a lagged net profit margin (π_{jt-1}/S_{jt-1}) multiplied by a contemporaneous equity turnover (S_{jt}/E_{jt}) and the market return. Operationalizing an effective empirical proxy for this covariance expression could be difficult. Fortunately, both Mandelker and Rhee and the current research are concerned primarily with the impact of leverage on capital market riskiness.

Gahlon and Gentry suggest that total and systematic risk of a stock should be related functionally to the product of DOL and DFL--presuming that the coefficient of variation of stock price is a function of CV(π). Mandelker and Rhee indicate that beta should be a direct function of the DOL-DFL product. Both models assume that total leverage equals the product of DOL and DFL, which is consistent with current financial management pedagogy. Mandelker and Rhee's empirical results provide support for such an interpretation.

Mandelker and Rhee (1984) find both DOL and DFL to be associated positively with the betas of common stocks in a sample of 255 manufacturers using data from the 1957-1976 period. Degree of leverage measures are elasticities that Mandelker and Rhee estimate as follows:

(3) $\ln x_{jt} = a_j + c_j \ln S_{jt} + u_{jt}$

(4) $\ln \pi_{jt} = b_j + d_j \ln x_{jt} + e_{jt}$

j = 1-255
t = 1957-1976

where:

x_{jt}	= earnings before interest and taxes;
c_j	= degree of operating leverage;
S_{jt}	= sales;
π_{jt}	= earnings after tax;
d_j	= degree of financial leverage;
a_j, b_j	= intercept terms;
ln	= natural log operator; and
u_{jt}, e_{jt}	= disturbance terms.

After using the market model to estimate betas for each stock, Mandelker and Rhee investigate the relationship between leverage and risk in a second regression:

(5) $\ln \text{Beta} = \lambda_0 + \lambda_1 \ln DOL_p + \lambda_2 \ln DFL_p + e$

where:

Beta	= systematic risk of portfolio,
DOL_p	= degree of operating leverage (c_j),
DFL_p	= degree of financial leverage (d_j).

The subscript p indicates these equations were estimated for portfolios of stocks.

Mandelker and Rhee's results are consistent with the hypothesized relationship: regression coefficients of DOL and DFL are consistently positive, suggesting that both are positively associated with the relative riskiness of common stock. DOL and DFL explain a significant portion of the variation in beta. Mandelker and Rhee also find support for their hypothesis that firms engage in tradeoffs between DOL and DFL--there was a statistically significant negative correlation between the two types of leverage. Mandelker and Rhee's findings support the traditional relationships hypothesized in equations (1) and (2).

A recent paper by S. Huffman (1989) updates and replicates the Mandelker and Rhee study. Although the data are more recent, his methodology closely follows the Mandelker and Rhee procedures.[3] He uses exactly the same proxies for DOL and DFL and constructs portfolios as Mandelker and Rhee did. S. Huffman's results differ from those of Mandelker and Rhee, however. Although

[3] S. Huffman's betas were estimated using twenty years of monthly data. Betas estimated over such a long period are conceivably biased, which could have influenced his findings.

he found a significant positive β-DFL relationship (consistent with Mandelker and Rhee), he found a significant negative β-DOL relationship (the opposite of what Mandelker and Rhee report). In addition, Mandelker and Rhee found a significant negative correlation between the DOLs and DFLs of ranked portfolios. In contrast, S. Huffman's results "indicate that there is not enough consistency in the results to support the tradeoff hypothesis" (1989, p. 90).

Mandelker and Rhee and S. Huffman use the same leverage proxies. The DOL measure is an elasticity estimated from a double log OLS time-series regression of EBIT (earnings before interest and taxes) on sales. The DFL measure involves a similar regression of earnings after taxes (EAT) on EBIT.

Unfortunately, the validity of these proxies is questionable. O'Brien and Vanderheiden (1987) show that failure to remove secular growth trends from the EBIT, sales, and EAT series results in regression slope estimates that are biased.[4] Correlation between the trends in the series results in slope estimates that tend toward one, reflecting the association between the trends in the time series over time rather than the sensitivity of the dependent variables(s) to changes in the independent variable(s) at a given time--the intended purpose of the degree of leverage measures.

O'Brien and Vanderheiden support their theoretical arguments with simulations and a comparison of their measures with the corresponding Mandelker and Rhee estimates for 100 firms. The absolute and relative values of the leverage measures suggest that the O'Brien and Vanderheiden measures provide better proxies for DOL. This study uses the O'Brien and Vanderheiden measures to test the relative merit of the traditional DTL arguments (as tested by Mandelker and Rhee and S. Huffman) against a new leverage theory proposed by L. Huffman.

Huffman's Leverage Theory

L. Huffman's theory (1983) provides a new, alternative view of leverage. Using the Brennan (1979) option pricing model (OPM) to investigate the impact of leverage on equityholders' risk, she reaches some unusual, though intuitively appealing, conclusions.

Stock is viewed as an option, and its value is expressed in familiar option notation as:

$$(6)\quad E(C,t) = r^{-1}\,[R(C) \bullet N(d_1) - (vC+D) \bullet N(d_2)]$$

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[4]O'Brien and Vanderheiden examined only the effects on DOL measures, but the same logic applies to the other leverage measures.

where:

E(C,t)	=	the value of the option (equity) is a function of capacity in units, C, and time to maturity, where Huffman employs a one period model, $t \equiv 1$, and depends upon
r	=	one plus the risk free rate;
R	=	revenue, which is a function of productive capacity through its effect on sales price (p);
N(d)	=	the standardized normal cumulative probability density function;
v	=	variable cost per unit;
D	=	the promised payment to debtholders; and
d_1	=	$1/\sigma\ [\ln R(C)/(vC + D) + \sigma/2]$;
d_2	=	$d_1 - \sigma\sqrt{t}$;
where σ^2	=	the variance of percentage changes in revenues.

L. Huffman optimizes the capacity decision by imposing first and second order conditions on equation (3). She then examines the relationship between optimal capacity (C*) and debt (D) and the firm's business risk--σ, the variability of firm revenues.

L. Huffman proposes a new measure of leverage, called the degree of combined leverage (DOCL). She uses the symbol η as shorthand for the DOCL where:

η = percentage change in value of equity divided by the percentage change in revenues,

$$(7) \quad = 1/\left[\ 1 - \frac{(vC+D) \bullet N(d_2)}{C \bullet p(C) \bullet N(d_1)}\ \right]$$

L. Huffman examines the effect of debt on induced equity variability by taking the derivative of equation (4) with respect to D. The result is:

$$(8) \quad \frac{d\eta}{dD} = \frac{\partial\eta}{\partial D} + \frac{\partial\eta}{\partial C^*}\frac{\partial C^*}{\partial D}$$

The direct effect of an increase in debt, $\partial\eta/\partial D$, is shown to be positive (L. Huffman, 1983, Appendix C, Equation C.6). The indirect effect, the second term in equation (5), can serve to mitigate the direct effect. The sign of $\partial C^*/\partial D$ is always negative. The sign of $\partial\eta/\partial C^*$ can be either positive or negative. For D below a critical level (denoted D+), the sign is positive; above that, the sign is negative.

In practical terms, this analysis indicates that changes in debt do not create strictly linear changes in equity risk. L. Huffman finds that the direct effect of an increase in debt on equity risk is offset partially by an attendant change in operating capacity. This ability of increased capacity to reduce the debt-induced increase in stock risk is lost above a critical debt level.

The analysis of operating leverage follows a similar pattern. Changes in equity risk with respect to changes in business risk are examined by taking the derivative of equation (4) with respect to σ, yielding:

$$(9)\quad \frac{d\eta}{d\sigma} = \frac{\partial\eta}{\partial\sigma} + \frac{\partial\eta}{\partial C^*}\frac{\partial C^*}{\partial\sigma}$$

The direct effect is negative (L. Huffman, 1983, Appendix C, Equation C.4). Increased variability of revenues dictates changes in optimal capacity. This dictated decrease in fixed costs reduces equity risk.

The sign of the indirect effect is ambiguous. The sign of $\partial\eta/\partial C^*$ will generally be positive--greater capacity commitments increase the equity risk. The sign of $\partial C^*/\partial\sigma$ again depends upon whether the firm has more or less than the critical level of debt, D+. The effect of an increase in revenue risk on equity risk also is offset partially by changes in capacity in response to the increased revenue risk. Capacity changes lose their ability to mitigate equity risk if revenue is below a critical level or if debt is above a critical level.

The Effect of Growth

Huffman's theory also suggests another consideration that could affect the DOCL-stock risk relationship: industry growth rate. Different industries have different sales and cost stabilities, so DOCL may have varying impacts on the stability of earnings per share in different industries.[5] This result can be identified by examining equation (6). Revenue risk (σ) varies from industry to industry (partially reflecting the industry's stage in its life cycle), dictating different capacity decisions in those industries. Consequently, the direct effect, $\partial\eta/\partial\sigma$, will differ across industries. Further, different industries developed at different times, which should influence the manner in which they were financed (in response to market conditions at those times). The level of debt financing determines whether D is less than D+, and, in turn, whether the indirect effect is positive or negative.

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[5]See Gale (1972).

High industry growth rates should increase the effect of DOCL on stock risk. Higgins (1977) suggests, in a study of sustainable growth, why this result may be anticipated. He defines sustainable growth as the maximum increase in sales consistent with the firm's established financial policies. If sales expand any more rapidly, something must give--usually to the detriment of financial soundness. The steps a company can take to balance actual growth with sustainable growth are reducing dividends, increasing leverage, improving operating performance, or selling new equity.

At times of high inflation, stock prices may be declining, making a company unable or unwilling to sell new equity; firms may be forced to depend on debt financing. Growth firms that finance with debt magnify returns to equity. If sales growth exceeds sustainable growth, firms become more levered. Growth industries also tend to have high operating leverage. Firms in high growth industries tend to have both high operating and high financial leverage. If the interaction that L. Huffman posits is present, it would suggest that the impact of DOCL on stock risk would be stronger in industries where D > D+, which makes the indirect effect magnify the direct effect. This can be identified by reference to equation (9).

DOCL versus DTL

DTL denotes the traditional textbook measure, which assumes that DOL and DFL are strictly multiplicative, (DTL = DOL x DFL). According to L. Huffman (and Myers, 1975), however, there is more interaction between DOL and DFL. A capacity decision is endogenous to the firm's financing decision, and capacity changes partially offset the risk from more debt.

According to L. Huffman, DOCL and DTL are different in three important ways. First, DOCL (η) is not timeless; it varies with the time-related arguments of the OPM probability density functions. These arguments change with changes in the firm's output capacity. Second, because optimal capacity also is a function of debt, η is a more complex function of debt than captured in the traditional DTL. Third, η is not independent of revenue risk.

The behavior of η with respect to debt (an exogenous parameter) is given by a total derivative, which is the sum of two effects. The direct effect is positive. The indirect effect arises from a change in optimal capacity as debt changes. The indirect component is a product of two partials: the first, which is always negative, and the second, whose sign depends upon the level of debt. For debt below the critical level, the sign is positive. Therefore, the sign of the indirect component (product) is negative, which mitigates the direct effect. That is, capacity changes offset the impact of debt changes. In the case of more debt than the critical level, the capacity effect magnifies rather than attenuates the risk of equity.

The relationship between DOCL and revenue risk also is the result of two effects. The direct effect of an increase in revenue risk on equity risk is offset partially by changes in capacity in response to an increase in the revenue risk. This ability of capacity changes to offset revenue risk is lost if revenue is less than the present value of operating costs plus debt.

The Issue

Mandelker and Rhee's empirical findings, tempered by the criticisms of L. Huffman and O'Brien and Vanderheiden, represent the best of what is known about the effects of leverage on stock risk. Mandelker and Rhee's regression assumes DOL and DFL are independent of each other and strictly multiplicative. If interactions exist between DOL and DFL, however, Mandelker and Rhee's model specification is incomplete. L. Huffman postulates such an interrelationship, with a theory that may refine understanding of the leverage-risk relationship. If she is correct, current thinking about leverage needs revision.

Methodology

The purpose of this study is to test whether DOCL helps explain stock risk. Further, does DOCL better explain such risk than the use of separate DOL and DFL measures? Specifically, is L. Huffman's DOCL better than the textbook DTL? Industry growth dummy variables are tested, because L. Huffman's theory would suggest that the DOCL-stock risk relationship should change with industry growth.

Hypotheses

The null hypotheses are that:

1. Stock risk (CVprice and/or β) is not related to DOCL,
2. Industry growth rates do not affect the DOCL-risk relationship,
3. DOCL does not better explain stock risk than DOL and DFL together (or DTL), and
4. There is no interaction effect between DOL and DFL.

Hypotheses Tests

The four hypotheses were tested by running cross-sectional regressions of stock risk on DOCL and (where comparisons were made) on DOL and DFL.

Two measures of risk were tested: (1) coefficient of variation of price (CV price) as a measure of total risk, and (2) beta. The total risk results are emphasized because L. Huffman's theory is cast in terms of total risk. The beta results are included because they are interesting in their own right and because considerable prior empirical work has considered only systematic risk. The pattern of results is slightly different for the two risk measures.

The first hypothesis--that stock risk is a function of DOCL--is tested with Model I:

(Model I) $\text{Risk} = \beta_0 + \beta_1 \text{ DOCL} + e$

The second hypothesis--there is an industry growth effect on the DOCL-stock risk relationship--is tested with Model II:

(Model II) $\text{Risk} = \lambda_0 + \lambda_1\text{DOCL} + a_{1,g}G_1 + a_{2,g}G_2 + b_{1,\eta}G_1 \bullet \text{DOCL} + b_{2,\eta g}G_2 \bullet \text{DOCL} + e$

where:

G_1	=	high growth rate industry dummy (0,1),
G_2	=	medium growth rate dummy,
g	=	subscript for growth rate dummy,
a_{1g} and a_{2g}	=	differential intercept coefficients,
$G_1 \bullet$ DOCL and $G_2 \bullet$ DOCL	=	interaction variables between industry growth rates and DOCL, and
$b_{1,\eta g}$ and $b_{2,\eta g}$	=	differential slope coefficients.

The third hypothesis is that DOCL is a better risk measure than DOL and DFL together (DTL). This is tested by comparing the results for Model I with those for Model III:

(Model III) $\text{Risk} = a_0 + b_1\text{DOL} + b_2\text{DFL} + e$

The adjusted R^2s, F-value probabilities, and standard error of estimates are compared between the two models. Total squared error was the criterion for goodness of fit. A Cp statistic was used to measure the sum of the squared biases plus the squared random errors in the dependent variable for n data points. The best set of independent variables produces the smallest Cp value.[6] PRESS

[6]See Neter and Wasserman (1974, pp. 371-392) and Daniel and Wood (1980, pp. 83-148) for elaboration and explanation of the Cp statistic.

(prediction error sum of squares) statistics indicate which model predicts the best on out-of-sample data.[7]

To test the fourth hypothesis--that significant interaction exists between DOL and DFL--an interaction variable (DOL·DFL) was added to Mandelker and Rhee's model. If the interaction variable is statistically significant, Mandelker and Rhee's model is incomplete:

(Model IV) $\quad \text{Risk} = a_0 + b_1\text{DOL} + b_2\text{DFL} + b_3\text{DOL} \bullet \text{DFL} + e$

Proxy Measures

The proxies for stock risk were the coefficient of variation of stock prices (CVprice) and beta. Data for the period 1969 to 1986 were used to calculate CVprice and the degree of leverage measures. Betas are December 1981 Value Line betas.

All the degree of leverage measures were estimated using O'Brien and Vanderheiden procedures. These procedures eliminate the secular trend in the series by regressing the logs of EBIT, sales, and EAT on time, as follows:

(10) $\quad \ln x_{jt} = \ln x_{jo} + g_{xt} + \mu_{xt}$

(11) $\quad \ln S_{jt} = \ln S_{jo} + g_{st} + \mu_{st}$

(12) $\quad \ln \pi_{jt} = \ln \pi_{jo} + g_{\pi t} + \mu_{\pi t}$

The degrees of leverage are measured by estimating the relationship between the deviations of EBIT, sales, and EAT from their time trends, as follows:

(13) $\quad \mu_{xt} = \text{DOL} \bullet \mu_{st} + \varepsilon_t$

(14) $\quad \mu_{\pi t} = \text{DFL} \bullet \mu_{xt} + \varepsilon_t$

(15) $\quad \mu_{xt} = \text{DOCL} \bullet \mu_{st} + \varepsilon_t$

DOL is the average sensitivity of the percentage deviation of EBIT from its trend relative to the percentage deviation of sales from its trend. The interpretations of DFL and DOCL are analogous.

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[7]Younger (1979, pp. 483-493) provides a discussion of the PRESS statistic.

Industry growth is the estimate g_S from equation (11). A high growth rate industry is defined as one with a sales growth rate greater than 0.15 standard deviations above the all industry mean. A low growth rate industry has a sales growth rate of more than 0.15 standard deviations below the all industry mean. Those remaining are medium growth.

The Sample

Data were from COMPUSTAT tapes. Various issues of *Moody's Industrial Manual* were used to verify some ambiguous or missing data. Companies with negative operating income or earnings were omitted because the log transformations for equations (10) and (12) are impossible with negative numbers. Sample size (n) is indicated in the tables.

Results

The results for Model I are presented in Table 1. They establish the expected significant positive association between DOCL and stock risk. DOCL, however, explains only a small portion of stock risk--regardless of whether it is total risk or systematic risk.[8]

The test of the second hypothesis introduces industry growth as an interacting variable to determine whether the effect of DOCL and CVprice is stronger in certain industries. The Model II results are presented in Table 2. The DOCL-CVprice relationship is growth-sensitive, as L. Huffman's theory would predict. The relationship was stronger in medium growth industries; in Table 2 there is a significant coefficient ($p = 0.0201$) on the G(2) • ln DOCL variable. It was anticipated that the effect would be strongest in high growth industries. In the absence of being able to determine the values for D and D+, however, that was merely conjecture.

The beta results were different. Inclusion of the high growth dummy, G_1, markedly improved the R^2s of the beta regressions, but none of the interaction dummies was statistically significant.

The third hypothesis is that combined leverage (DOCL) is a better risk measure than total leverage. The results for Model III are presented in Table 3. DOL and DFL explain a small but statistically significant proportion of the

[8]The higher R^2s reported by Mandelker and Rhee and S. Huffman are due in part to their use of portfolios formed using instrumental variables. For cross-sectional regressions, Mandelker and Rhee reported an R^2 of 0.1081 (1984, p. 54, n. 12). S. Huffman reports that his R^2 for cross-sectional regression including utilities (like Mandelker and Rhee) was 0.099. For cross sections excluding utilities, his R^2 was 0.053 (1989, p. 93, n. 14).

variation in stock-price risk. DOL is significant in the CVprice regressions; DFL is not. In the beta regression, statistically significant positive coefficients were found for both DOL and DFL--consistent with the findings of Mandelker and Rhee. For total risk, the R^2 was slightly higher using DTL as the explanatory variable; for systematic risk, DOCL (measured without the two components) produced higher R^2s.

Model I and Model III were used to compare the effectiveness of DOCL versus DTL, based on goodness of fit. Table 4 presents the comparisons. Although most of the differences are small, the results support L. Huffman's theory.

The Cp criterion is concerned with the total squared error of n fitted observations for any given regression model. The total squared error has a bias component and a random error component. The smaller the Cp value, the better the model. The Cp value for DOCL is lower, so DOCL is a marginally better risk measure than DTL. The same analysis also was performed for beta, with similar but slightly stronger results; DOCL outperformed combined use of DOL and DFL.

PRESS statistics also can be used to compare DOCL versus DTL. The procedure holds out one observation, fits the model, and tests how well the equation predicts the withheld observation by looking at its residual. This procedure is performed for each observation in turn. Summing these (squared) residuals allows assessment of the model's predictive (PRESS) value. The smaller the PRESS, the better the model. The results are the same as with the Cp--DOCL again is a marginally better risk measure.

The R^2s of both models are low. Use of DOL and DFL together explains slightly more of the variation in CVprice, although not enough to establish DTL (DOL and DFL) as a better explanatory model given the inclusion of an additional explanatory variable. Further, the DFL coefficient is not statistically significant in the total-risk regression.

For beta, DTL produces a lower adjusted R^2 than DOCL. Separating the effects of operating and financial leverage does not explain any greater proportion of the variation in beta.

The fourth hypothesis is that an interaction exists between DOL and DFL, in which case Model III is statistically suspect. The results for Model IV are presented in Table 5.

The interaction variable has a negative influence on total stock risk, CVprice. The interaction variable has a significantly negative coefficient. These results support L. Huffman's theory. For debt below the critical level, the capacity effect apparently decreases the impact of added operating leverage on equity risk. The traditional DTL model is deficient in that it does not consider the endogenous nature of the capacity decision. The interaction variable was not significant in the beta regression. Although the interaction variable helped explain variations in total risk, there is no evidence to indicate that it does the same for betas.

Summary and Conclusions

In the cases tested, the results are consistent with L. Huffman's predictions for total risk, which this research measured as CVprice:

1. The relationship between stock-price risk and degree of combined leverage is positive and statistically significant.
2. There is an industry-growth rate interaction. The influence of DOCL on stock risk is greater for the medium growth industries in the sample.
3. DOCL is as a good a risk measure as DOL and DFL measured separately and used together.
4. There was a statistically significant negatively signed coefficient on the interaction between DOL and DFL, which suggests that using these two variables separately in a regression model as a proxy for total leverage is statistically invalid where the dependent variable is total risk (CVprice).
5. For systematic risk (beta), the interactions noted above are absent. Mandelker and Rhee's estimation equation was found to be satisfactory. For beta, the same results as Mandelker and Rhee were obtained. Both DOL and DFL have significant positive coefficients.[9] The current results support Mandelker and Rhee and are inconsistent with the interpretation of S. Huffman.[10] The explanatory power of the DOCL variable, however, was greater than the combined DOL and DFL variables. Partitioning leverage into its operating and financing components explained no greater portion of the variation in firm betas.

L. Huffman's theory is cast in terms of total stock risk. To the extent that this study provides statistical support for L. Huffman's theory, it appears that the impact of the component elements of leverage on a firm's total stock price risk deserves some rethinking.

On the other hand, support was found for the existing evidence on the relationship between beta and DTL. The current results and those of Mandelker

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[9]The significance of the DFL variable is comparatively low (0.0742), but it is below ten percent and consistent with MR's findings. The DFL coefficient is not significant at any reasonable level in the total risk regression.

[10]S. Huffman's results when negative earnings firms are omitted are the same as the current results and those of Mandelker and Rhee.

and Rhee are consistent. The comparison results (Cp and PRESS statistics) suggest that the model is not parsimonious--but it is not necessarily wrong.

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Table 1
Regression Coefficients for Model I
[t values in brackets]
(p values in parentheses)

Risk-DOCL(OV) Relationship

$$\ln CVprice = \underset{\substack{[136.785] \\ (0.0001)}}{3.65} + \underset{\substack{[2.382] \\ (0.0182)}}{0.07} \ln DOCL$$

Adjusted R Square	0.0246
Standard Error of the Estimate	0.3643
Overall F	5.675
p value	(0.0182)
n	185

$$\ln Beta = \underset{\substack{[-5.241] \\ (0.0001)}}{-0.09} + \underset{\substack{[3.204] \\ (0.0015)}}{0.05} \ln DOCL$$

Adjusted R Square	0.0306
Standard Error of the Estimate	0.2666
Overall F	10.267
p value	(0.0015)
n	294

Table 2
Regression Coefficients for Model II
[t values in brackets]
(p values in parentheses)

Growth Interaction

ln CVprice =	3.68	- 0.02 ln DOCL	- 0.02 G(1)	+ 0.05 G(2)	+ 0.05 G(1) • ln DOCL	+ 0.28 G(2) • ln DOCL
	[63.390]	[-0.345]	[-0.191]	[0.637]	[0.501]	[2.370]
	(0.0001)	(0.7308)	(0.8492)	(0.5259)	(0.6176)	(0.0201)

Adjusted R Square	0.0413
Standard Error of the Estimate	0.3340
Overall F	1.755
p value	(0.1256)
n	90

ln Beta =	-.22	+ 0.08 ln DOCL	+ 0.34 G(1)	+ 0.00 G(2)	- 0.01 G(1) • ln DOCL	+ 0.02 G(2) • ln DOCL
	[-6.256]	[1.921]	[5.786]	[0.000]	[-0.094]	[0.290]
	(0.0001)	(0.0576)	(0.0001)	(0.9999)	(0.9254)	(0.7724)

Adjusted R Square	0.2966
Standard Error of the Estimate	0.2357
Overall F	9.772
p value	(0.0001)
n	104

Table 3
Regression Coefficients for Model III
[t values in brackets]
(p values in parentheses)

Risk-Leverage Relationship

ln CVprice	= 3.64	+	0.10 ln DOL	+	0.02 ln DFL
	[132.583]		[2.690]		[0.343]
	(0.0001)		(0.0078)		(0.7316)

Adjusted R square	0.0276
Standard Error of the Estimate	0.3638
Overall F	3.628
p value	(0.0285)
n	185

ln Beta	= -0.08	+	0.05 ln DOL	+	0.04 ln DFL
	[-4.377]		[2.613]		[1.792]
	(0.0001)		(0.0094)		(0.0742)

Adjusted R square	0.0274
Standard Error of the Estimate	0.2671
Overall F	5.144
p value	(0.0064)
n	294

Table 4
DOCL versus DTL
(Model I versus Model III)

R square (adjusted)	Cp	Press	Variable(s) in Model
	Dependent Variable ln CVprice		
0.0246	1.91	25.0	DOCL
0.0276	2.35	25.1	DTL
	Dependent Variable ln Beta		
0.0306	0.88	21.1	DOCL
0.0274	2.83	21.2	DTL

Table 5
Regression Coefficients for Model IV
[t values in brackets]
(p values in parentheses)

ln CVprice	= 3.64	+	0.10 ln DOL	+	0.03 ln DFL	-	0.16 ln DOL	•	ln DFL
	[132.732]		[2.674]		[0.449]		[-1.851]		
	(0.0001)		(0.0082)		(0.6539)		(0.0658)		

Adjusted R Square	0.0403
Standard Error of the Estimate	0.3614
Overall F	3.593
p value	(0.0148)
n	185

ln Beta	= -0.08	+	0.05 ln DOL	+	0.05 ln DFL	-	0.01 ln DOL	•	ln DFL
	[-4.328]		[2.452]		[1.802]		[-0.361]		
	(0.0001)		(0.0148)		(0.0725)		(0.7183)		

Adjusted R Square	0.0245
Standard Error of the Estimate	0.2675
Overall F	3.463
p value	(0.0167)
n	294