COMBINED LEVERAGE AND THE VOLATILITY OF STOCK PRICES

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By

Rong-Jen Li, B.B.A., M.B.A.

Denton, Texas

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hVH

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Much has been written during the past decade to explain the relationship between financial and operating leverage and stock-price volatility. However, the relationship between combined leverage and stock-price volatility has yet to be fully explored. Mandelker and Rhee's (MR) recent study uses both operating and financial leverage in a regression (equivalent to the traditional total leverage--DTL) and shows that both types of leverage are positively associated with common stock betas.

Huffman recently demonstrated that there are interactions between operating leverage and financial leverage. Therefore, MR's model could be oversimplified.

This study examines the relationship between firms' combined leverage and their stock-price volatility. The study also examines industry and industry growth to see if the relationship is influenced by these factors. The question is whether DOCL is a better risk measure than DTL and whether there is an interaction between operating and financial leverage.

The inferences that can be drawn from the study's results are as follows: (a) Stock risk is a function of combined leverage; (b) Industry significantly influences the relationship between stock risk and DOCL; (c) High growth increases the relationship between stock risk and DOCL; (d) Combined leverage (DOCL) is a better risk measure than total leverage (DTL). Further, the problem with the traditional total leverage measure is the omission of the interaction between DOL and DFL. This is consistent with Huffman's theory and suggests Mandelker and Rhee's model is oversimplified.

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CHAPTER I

INTRODUCTION

Objective of the Research

The purpose of this study is to examine the relationship between firms' combined leverage and volatility of their stock prices. The study also examines industry and industry growth rates to see if the relationship is influenced by these factors.

Background

Business risk partially depends on a firm's fixed costs. If fixed costs are high, small declines in sales can lead to larger decline in EBIT (earnings before interest and taxes). Consequently, high fixed costs imply greater business risk. High fixed costs are generally associated with capital intensive industries. A business that employs highly skilled workers who must be retained during recessions also have high fixed costs. A firm with high fixed costs is said to have a high degree of operating leverage. A high degree of operating leverage implies that small changes in sales result in large changes in operating income. The higher the degree of operating leverage, the greater the business risk, as measured by variability of EBIT.

Most earlier studies of the effects of changes in a firm's financing mix on its stock prices have utilized partial equilibrium analysis in which the investment or degree of operating leverage and dividend decisions of the firm is held constant and an attempt is made to determine the effect of a change in financing mix on share prices. The issue has been whether a firm could affect its value (and its cost of capital) when the debt to equity ratio, or degree of financial leverage, is changed.

The Problem

A great deal of finance literature written during the past decade has been devoted to explaining the relationship between financial leverage and volatility of stock prices or to explaining the relationship between operating leverage and volatility of stock prices. However, the relationship between degree of combined leverage (DOCL) and stock-price volatility has yet to be fully explored.

Few papers discuss the effect of operating leverage on stock-price volatility. All other things being equal, the higher the operating leverage (i.e., the lower the unit variable costs), the larger the overall and systematic risk of a stock.

The effect of financial leverage on stock-price variability is inconclusive, both theoretically and empirically. Partial equilibrium analysis is the norm in which firm investment and dividend decisions are held constant to try to determine the effect of a change in financing mix on share prices, i.e., whether the firm can affect its total value and its cost of capital by changing its capital structure.

The question is whether combined leverage affects variability of stock prices and to what degree. There are at least two factors obscuring the issue. Huffman notes 1) the direct effect of an increase in financial leverage on the risk of cash flow to equity is partially offset by the change in capacity (operating leverage) in response to the increase in financial leverage, and 2) the direct effect of an increase in revenue risk on risk of cash flow to equity of a levered firm is partially offset by the change in operating leverage in response to the increase in revenue risk.[1]

The ability of the operating leverage decision to attenuate the increase in risk of cash flow to equity, due to the increased financial leverage, is lost above a certain critical level of debt; the impact of financial leverage on risk of cash flow to equity can be reduced by changing operating leverage. The ability of the operating leverage to attenuate the effect on risk of cash flow to

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[1]Lucy Huffman, "Operating Leverage, Financial Leverage, and Equity Risk," Journal of Banking and Finance, 7 (June, 1983), 197-212.

equity is lost if revenues are less than the discounted value of operating cost plus debt.

Huffman argues that the traditional total leverage (DTL) measure is incorrect. She suggests an alternative calculation in which the capacity decision effects on cash-flow to equity risk are incorporated.

Hypotheses

The hypotheses are that the risk (as measured by) coefficient of variation of price, CV price, or BETA) of a common stock is related to the degree of combined leverage, there is a difference among different types of industries and different growth-rate industries on the degree of the effect of combined leverage on stock prices, combined leverage (DOCL) is a better risk measure than the traditional DTL (or DOL and DFL together), and an interaction effect exists between DOL and DFL.

Delimitations

The study considers only the U.S. stock market and corporations; foreign markets and corporations will be excluded because of the differences in accounting systems and the unavailability of reliable data. The period 1964-1981 is examined.

This study considers only sales volatility's impact on the DOCL-risk relationship. Cost instabilities are not considered when examining firms' riskiness. Also the study uses BETA as a measure of systematic risk--the validity of such a measure is not examined. Those companies with negative earnings in any year between 1964 and 1981 will not be tested. The reason is that firm's earnings loss usually causes stock prices to drop sharply (investor's psychological effect) which is unexplainable by degree of combined leverage.

Significance of the Study

The study should contribute to our understanding of firm riskiness by better defining the relationship between the relative variability of stock price and the combined leverage which should help quantify an important aspect of firm risk.

Utility regulation is supposed to allow utility firms to earn equity rates of return comparable to unregulated firms of comparable risk. The difficulty with this mandate is specifying, in quantitative terms, the riskiness of utilities and nonutilities. The degree of combined leverage could be such a measure.

The study tests the impact of combined leverage on the stability of stock prices; by using industry interaction variables, the study tests whether combined leverage effects are stronger in certain industries. The other interaction variable (industry growth rate) may help explain why stock prices of growth industries are more volatile.

Methodology

To examine interaction effects, this study introduces industry and industry growth rate variables into the regression model which may interact with combined leverage in influencing the stability of stock prices. An interactions approach requires more exact theory which, in turn, leads to better defined, testable implications.[2]

The relative effectiveness of the DOCL and DTL risk measures both are regressed on measures of equity risk. Two measures of risk are tested: 1) CV price and 2) BETA. The question is which of the proposed leverage measures better explains investor risk.

Outline of the Essay

This essay will contain five chapters. The first chapter is an introduction. Chapter II examines the effect of operating leverage on the stability of stock prices and the effect of financial leverage on the stability of stock prices. In discussing the two types of leverage, the concept of combined leverage is introduced. This chapter will emphasize the ability of operating leverage to offset the risk of cash flow to equity as financial leverage increases. The ability to

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[2]Bradley T. Gale, "Market Share and Rate of Return," _Review of Economics and Statistics_, LIV (November, 1972); Gale, "The Existence and Direction of Causality in Cross-Section Analysis of Hypotheses," 1972 Business and Economics Section (Washington, D.C.): Proceedings of the American Statistical Association, 314-319.

attenuate the increase in risk of cash flow to equity due to the increased outstanding debt, together with unknown effects of financial leverage on the volatility of stock prices, raises questions as to the impact of combined leverage on the volatility of stock prices.

Chapter III describes the research technique, which uses the interaction approach to spell out the theory more completely and to thereby develop more testable implications of the theory. Chapter IV will describe and summarize the results. Chapter V will conclude this study.

CHAPTER II

LITERATURE REVIEW

Introduction

Authors who discuss the relationship between operating leverage and volatility of stock prices and that between financial leverage and volatility of stock prices frequently hold other factors constant. It may be, however, that this is inaccurate since an interaction exists between investment and financing decisions. Myers (1974) suggests that adjusted present value rather than net present value be used because, in the former method, the project's direct contribution is "adjusted for" the project's side-effects on other investment and financing options.[1] He claims that these side-effects occur as a result of the project's effect on debt capacity and sources and uses constraints.

When a project is to be undertaken, a firm may need external financing. The choice of debt or equity financing may affect the cost of capital and debt capacity, which will in turn affect opportunities for other projects in the future. Further, the project being considered is expected

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[1] Stewart C. Myers, "Interaction of Corporate Financing and Investment Decision-implications for Capital Budgeting," _Journal of Finance_, 29(March, 1974), 1-25.

to make a permanent contribution to the firm's earning and future debt capacity.[2]

In other words, decisions concerning degree of operating leverage will have side-effects on debt capacity and sources and uses of fund constraints. In this regard, it is clear that a decision on DOL will have an impact upon degree of financial leverage (DFL) and upon future project selections.

Huffman suggests that the direct effect of an increase in financial leverage on the risk of cash flow to equity is partially offset by change in capacity (operating leverage) in response to the increase in financial leverage. This supports the claim that it is both impossible and incorrect to separate DOL and DFL when the volatility of stock prices is tested.

The first section of this chapter reviews studies of the effect of operating leverage alone on volatility of stock prices. Although this approach is theoretically unjustified, as indicated above, the direction of the effect is likely to be correct even if its degree is misspecified. The second section reviews research that describes the effect of financial leverage on the volatility of stock prices. The third section reviews articles that

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[2]Myers, op. cit., p. 14.

discuss the effect of combined leverage on the volatility of stock prices.

Operating Leverage and the Risk of Stock Prices

Percival (1974) supports the general view that an increase in operating leverage involves an increase in fixed costs and a decrease in variable costs per unit (i.e., a substitution of fixed for variable costs[3]). He attempts to demonstrate the conditions under which such a substitution leads to increased risk to the firm's stockholders and the extent to which the firm should be willing to make such a substitution.

Lev (1974) investigated the relationship between operating leverage and the risk in order to advance the understanding of the risk-generating process operating in capital markets.[4] Knowledge of the real determinants (i.e., those resulting from the firm's input and output decisions) of a stock's risk is crucial for decisions at both firm and investor levels. His research concerned the effect of the firm's operating leverage on its riskiness and, hence, the market value of its shares.

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[3]John R. Percival, "Operating Leverage and Risk," Journal of Business Research, 2 (April, 1974), 223-227.

[4]Baruch Lev, "On the Association Between Operating Leverage and Risk," Journal of Financial and Quantitative Analysis, 9 (September, 1974), 627-641.

Gahlon and Gentry (GG) studied the relationship between a security's systematic risk and its underlying real assets by developing and analyzing a model that demonstrates how the degrees of operating and financial leverage, along with the coefficient of variation of revenue and a cash flow correlation coefficient, affect a security's systematic risk, expected return, and value.[5] While the standard textbook discussion of operating and financial leverage does little to link DOL and DFL explicitly to systematic risk, GG's model suggests use of DOL and DFL as financial-asset risk measures.

Operating Leverage

Percival attempted to demonstrate the conditions under which the substitution of fixed for variable costs leads to increased risk to the firm's stockholders, and the extent to which the firm should be willing to make such a substitution. He assumed management makes decisions to maximize the value of the firm's equity; this leads to consideration of the effects of a change in operating leverage on equity holders. Percival calculated the rate of return on equity for an all-equity firm as follows:[6]

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[5]James M. Gahlon and James A. Gentry, "On the Relationship Between Systematic Risk and the Degree of Operating and Financial Leverage," Financial Management, 11(Summer, 1982), 15-23.

[6]Percival, op. cit., p. 223.

$$r = \frac{PQ - VQ - F}{S}$$

$$= \frac{(P - V)\ Q - F}{S} = \frac{CQ - F}{S} \qquad (1)$$

where:[7] r is the rate of return generated on equity;

Q is the number of units produced and sold;

P is the price per unit sold (assumed constant);

V is the variable cost per unit (assumed independent of Q);

C is the contribution to fixed cost and profit per unit sold;

F is the fixed cost; and

S is the total value of the firm's equity.

Percival further shows that:

> If Q is a random variable distributed with Mean, $\bar{Q}$, and variance, $\sigma^2(Q)$, $\sigma(r)$ as one possible measure of risk can be expressed as:
>
> $$\sigma(r) = \frac{C\ \{\sigma(Q)\}}{S} \qquad (2)$$
>
> If the firm proceeds to increase fixed costs with a concomitant decrease in variable costs, the new rate of return generated on equity, r', given the increase in contribution, c' and the increase in fixed costs, F', can be expressed as:
>
> $$r' = \frac{CQ + C'Q - (F + F')}{S} \qquad (3)$$

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[7] A glossary of all symbols is provided in Appendix A.

Substituting from equation (1) gives:

$$r' = r + \frac{C'Q - F'}{S} \tag{4}$$

and σ (r') can be expressed as

$$\sigma(r') = \frac{(C + C')\ \sigma(Q)}{S}$$

$$= \sigma(r) + \frac{C'\ \sigma(Q)}{S} \tag{5}$$

Thus, with σ (r') as a measure of risk, risk increases by a factor directly proportional to the new contribution,[8] that is, when fixed cost increases, both contribution margin and risk increase.

It has been proposed that profit elasticity might be measured by the DOL, as is typically defined:[9]

$$\text{Degree of operating leverage} = \frac{\%\Delta \text{ in operating income}}{\%\Delta \text{ in sales}}$$

$$= \frac{\%\Delta\ \text{EBIT}}{\frac{\Delta Q}{Q}} \tag{6}$$

In order to see how the value calculated from this equation changes when fixed costs increase and variable costs decrease, Percival discussed "break-even point,"

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[8] Percival, op. cit., p. 224.

[9] J. Fred Weston and Eugene F. Brigham, Managerial Finance (New York, 1981), p. 571.

B--i.e., the number of units sold such that total costs equal total revenues and profits are zero. Then, his equation (6) can be rewritten as:

$$\text{Degree of operating leverage} = \frac{\frac{C\cdot(\Delta\ Q)}{C\cdot(Q - B)}}{\frac{\Delta Q}{Q}} \tag{7}$$

which simplifies to

$$\text{Degree of operating leverage} = \frac{Q}{Q - B} \tag{8}$$

Percival concludes therefore:

> Thus, if the firm increases fixed costs and decreases variable costs (and thus increases contribution), its 'degree of operating leverage' may increase, decrease, or remain the same depending on the new break-even point. The implication is that this definition of operating leverage as a risk index is inconsistent with the preceding analysis, which suggests that the perceived risk and, therefore, the required return of equity holders, increase, in direct proportion to the increase in contribution regardless of the change in the break-even point.
>
> The weakness in the 'degree of operating leverage' measure is its ad hoc nature. It is not derived from any specific valuation function and therefore its use can lead to faulty conclusions.[10]

Conclusion.--Operating leverage concerns the level of fixed costs used in a firm's operation. Leverage affects the profit structure of the firm. Leverage is a double-edged sword. It will magnify losses during periods of

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[10]Percival, op. cit., p. 227.

low sales, since fixed costs must be paid even if sales do not reach the expected level.

Percival stated that if the firm increases fixed costs and decreases variable costs (and thus increases contribution), its "degree of operating leverage" may increase, decrease, or remain the same depending on the new breakeven point. This statement is true because

$$\text{breakeven quantity (B)} = \frac{\text{fixed cost}}{\text{price} - \text{variable cost per unit}}$$

$$= \frac{\text{fixed cost}}{\text{contribution margin}} \tag{9}$$

When fixed cost goes up, variable cost generally decreases (contribution margin increases). Because both fixed cost and contribution margin increase, the ratio (breakeven) can go up, down, or remain unchanged.

Percival's contention, which suggests that the perceived risk and required return on equity increases in proportion to increases in contribution, regardless of the changes in the breakeven point, is incorrect. Percival oversimplified the formulas of standard deviation of return on equity ($\sigma(r')$). From his formula (4), $r' = r + \frac{C'Q - F'}{s}$ we should derive $\sigma(r') = \frac{(C + C') \quad \sigma(Q) \; - \; \sigma(F')}{s}$, call this (5'), instead of his formula (5); $\sigma(r') = \frac{(C + C') \quad \sigma(Q)}{s}$. F' and Q are both random variables--not constants, therefore $\sigma(r')$ could go up or down depending on the relationship between

C' and F'. This same relationship also determines whether the breakeven goes up or down.

The traditional breakeven formula, (9), tells us that F and C determine whether the breakeven quantity goes up or down. Equation (9) and the expression called (5') are not inconsistent. In short, the degree of operating leverage is not decided by fixed cost alone. Increasing fixed cost does not necessarily increase the degree of operating leverage. If fixed cost increases, the contribution margin could also increase, and the breakeven quantity could go down (or up). That is to say, when fixed cost increases, the degree of operating leverage could go up or down depending on the level of fixed cost and the contribution margin. The degree of operating leverage increases when the breakeven increases, and it decreases when the breakeven decreases.

Lev's objective in investigating the relationship between operating leverage and risk is to advance an understanding of the risk-generating process operating in capital markets, a process about which little is yet known. Knowledge of the real determinants (i.e., those resulting from the firm's input and output decisions) of a stock's risk is obviously critical for decisions on both the firm and investor levels. At the firm level, the relationship between operating decisions and risk (and, hence, stock prices) is important, since it is generally assumed that management attempts to maximize stockholders' wealth. On the investor level, knowledge of the relationship improves the prediction of <u>ex ante</u> risk (and, hence, portfolio selection), given information on expected operational changes.

Lev concludes as follows:

> A link between the firm's operating decisions and the riskiness of its stock was established. Difference in the production process affecting the relative shares of fixed and variable costs (i.e., the operating leverage) were found, both analytically and empirically to be associated with risk differentials. Specifically, other things being equal, the higher the operating leverage (i.e., the lower the unit variable costs) the larger the overall and systematic risk of the stocks.
>
> Various practical implications are suggested by these findings. On the firm level, it can be expected that large capital expenditures associated with an operating increase will increase stock riskiness. In these cases, the cut-off rate used for the capital budgeting decision (i.e., the cost of capital) should allow for the increased risk. The use of the current cost of capital as the cut-off rate would probably result in a decrease in stock prices, adversely affecting stockholders' wealth. On the investor level, these findings might assist in the estimation of common stocks' risk, given expected changes in the firm's operating leverage. Specifically, they suggest that, if a firm will experience a significant operating leverage changes, the estimation of risk measures based exclusively on historical returns would be inappropriate.[11]

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[11]Baruch Lev, "On the Association Between Operating Leverage and Risk," <u>Journal of Financial and Quantitative Analysis</u>, 9(September, 1974), 627-641.

Gahlon and Gentry specify a model for calculating β that includes DOL and DFL as explicit variables.[12] The development of β's (beta) functional relationship to the firm's existing degree of operating and financial leverage utilizes the investment opportunities approach to valuing the firm's equity. Gahlon and Gentry's approach partitions the present equilibrium market value of the firm's equity, V, into two components:

$$V = V_{\pi} + V_G \qquad (10)$$

V_{π} is the present value of the next period's after-tax cash flow to the owners from existing assets. It is affected by the firm's current earning power and financial policy. The present value of growth opportunities, V_G, is that portion of the value of the firm's equity attributable to opportunities to make profitable investments in real assets. Typically, the one-period percentage return on equity is stated as

$$R = (D + \Delta V)/V \qquad (11)$$

where the numerator of the right-hand side (RHS) is the dollar holding period return, consisting of dividends,

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[12] James M. Gahlon and James A. Gentry, "On the Relationship Between Systematic Risk and the Degree of Operating and Financial Leverage," Financial Management, 11 (Summer, 1982), 15-22.

D, and the change, ΔV, in the market value of the equity.

Gahlon and Gentry indicate that the investment opportunities approach and the valuation process implied in equation (11) mean that the one-period percentage return on equity may be restated as $R = (\pi + \Delta V_G)/V$. π in this equation equals the next period's after-tax cash flow to the owners from existing investments, and ΔV_G equals the changes over the period in the present value of growth opportunities.[13] The firm's existing DOL and DFL are embedded in π. Using the above equation to define R permits isolation of the effects of DOL and DFL on systematic risk while, at the same time, recognizing the impact of growth opportunities. Gahlon and Gentry obtained the following results:[14]

$$\begin{aligned}\beta &= (V_\pi/V)\ \{COV(R_\pi, R_M)/\sigma^2(R_M)\} + \\ &\quad (V_G/V)\ \{COV(R_G, R_M)/\sigma^2(R_M)\} \\ &= (V_\pi/V)\ \beta_\pi + (V_G/V)\ \beta_G. \end{aligned} \tag{12}$$

where:

β = system risk.

V_π = the present value of next period's after-tax cash flow to the owners from existing assets.

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[13] Gahlon and Gentry, _op_. _cit_., p. 17.

[14] _Ibid_., p. 17.

V = the present equilibrium market value of the firm's equity.

π = next period's after-tax cash flow to the owners from existing investments.

R_π = π/V_π

R_M = return on the market folio.

V_G = that portion of the value of the firm's equity attributable to potential opportunities to make future investments in real assets at expected rates of return greater than required rates of return.

ΔV_G = change of V_G.

R_G = $\Delta V_G/V_G$.

β_π = systematic risk associated with the return derived from its existing after-tax cash flow.

β_G = systematic risk associated with the return derived from its growth opportunities.

Thus, the systematic risk borne by the firm's common stockholders is a weighted average of the systematic risk associated with the return derived from its existing, after-tax cash flow (β_π), and that associated with the return derived from its growth opportunities[15] (β_G). The weights are the present equilibrium market values of π and

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[15] _Ibid._, p. 17.

ΔV_G divided by their sum, which equals the present equilibrium market value of the equity.

Gahlon and Gentry also derived a measure of existing risk,[16]

$$\beta_\pi = \frac{R_F \cdot DOL \cdot DFL \cdot CV(REV) \cdot \rho(\pi, \pi_M)}{\sigma(R_M) - \{\lambda' \cdot DOL \cdot CV(REV) \cdot \rho(\pi, \pi_M)\}}. \quad (13)$$

where:

- R_F = risk-free rate of interest,
- DOL = degree of operating leverage,
- DFL = degree of financial leverage,
- CV (REV) = coefficient of variation of revenue,
- $\rho(\pi, \pi_M)$ = the correlation coefficient, which quantifies the degree of sensitivity of the firm's cash flow to changes in the economic and financial climate,
- $\sigma(R_M)$ = standard deviation of market portfolio rate of return,
- $E(R_M)$ = expected market rate of return,
- λ' = $E(R_M) - R_F$, and

all other terms are defined as in equation (12). This expression shows that the systematic risk inherent in that portion of the common stockholder's return that

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[16] Ibid., p. 18.

derives from the firm's existing after-tax cash flow, β_π, is a function of three macroeconomic variables and four types of real-asset risk. The macro-economic variables R_F, $\sigma(R_M)$, and λ' are the same for all firms. Therefore, the differences in β_π among firms arise from differences in real-asset risk reflected in the product, ϕ = DOL . DFL . CV(REV) . $\rho(\pi, \pi_M)$. DOL and DFL measure the risks that stockholders bear because the firm uses operating and financial leverage. CV(REV)--revenue variability scaled by size in terms of expected revenue--captures the risk inherent in the demand for the firm's output. With the dollar return from the market portfolio interpreted as an index of economic and financial conditions, the correlation coefficient, $\rho(\pi, \pi_M)$, quantifies the degree of sensitivity of the firm's cash flow to changes in the economic and financial climate.[17]

Conclusion.--Lev shows, all other things being equal, higher operating leverage (i.e., the lower the unit variable costs) increases overall and systematic risk of the stock prices. Gahlon and Gentry and Percival indicate that operating leverage should affect the variability of stock prices. Gahlon and Gentry indicate that the effects of the firm's operating and financial leverage are embodied in CV(π), which is risk of profit, and equals DOL · DFL ·

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[17] Ibid., pp. 18-19.

CV (Revenue). Gahlon and Gentry show that operating leverage affects the risk of cash flow to stockholders. Percival suggests that the risk of cash flow to stockholders increases by a factor directly proportional to the operating leverage increases. However, Percival did not treat operating leverage as an endogenous variable either. An article by Huffman[18] indicates that these conclusions are subject to question.

Empirical Evidence of Operating Leverage Effect on Stock Prices

Lev uses three homogeneous (with regard to product) industries for testing the effect of operating leverage on stock prices: the electrical utility industry and steel and oil production.[19] The first stage of Lev's analysis finds average variable costs for each firm to be inversely associated with risk. These data cannot be obtained directly from the firm's financial statements since most reported cost items (e.g., cost of sales, maintenance, etc.) include both variable and fixed components.[20] Lev breaks down total operating costs into the variable and fixed elements using a time-series regression for each firm as follows:

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[18] Huffman, op. cit., pp. 197-212.

[19] Lev, op. cit., pp. 633-637.

[20] Ibid., p. 633.

$$TC_{jt} = a_j + V_j\ Q_{jt} + U_{jt} \quad t = 1, \ldots 20 \tag{14}$$

where

TC_{jt} = total operating costs of firm j during year t,

Q_{jt} = physical output (e.g., kilowatt-hours) of firm j during year t, and

U_{jt} = residual

The estimated coefficient V_j is a surrogate for the firm's average variable costs per unit of output. It indicates the change in total operating costs induced by a unit of volume change which is equal to average variable costs per unit.

Lev's overall volatility of stock prices was measured as the standard deviation of monthly return over the 10-year period, 1958-1967. Systematic risk estimates, β_j's, were obtained from the market model. The two risk measures were then regressed cross-sectionally (for each industry) on the unit variable cost estimate, V_j, obtained from equation (14):

$$\sigma(r_j) = a_1 + b_1\ V_j + E_{1j}, \text{ and} \tag{15}$$

$$\beta_j = a_2 + b_2\ V_j + E_{2j}. \tag{16}$$

Lev found empirical results that are consistent with the hypothesized relationships: average variable cost components were negatively associated with both the overall and systematic risk measures for all three industries examined.[21] Lev concludes that higher operating leverage (lower unit variable costs) increases overall and systematic risk of stock prices.[22]

Mandelker and Rhee's (MR) empirical test uses log beta as dependent variable and log DOL, log DFL as independent variables.[23] MR's empirical 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 (β).

Conclusion.--Lev and Mandelker and Rhee reach the same conclusion. Both claim that DOL is positively associated with relative riskiness of stock prices (β).

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[21] Ibid., p. 636.

[22] Ibid., p. 638.

[23] Gershon N. Mandelker and S. Ghon Rhee, "The Impact of the Degree of Operating and Financial Leverage on Systematic Risk of Common Stock," Journal of Financial and Quantitative Analysis, 19 (March, 1984), 45-57.

Theory of Financial Leverage and Risk

Modigliani and Miller have shown, without taxes, that:

1. The value of the firm is established by capitalizing net operating income (NOI = EBIT) at a rate appropriate for the firm's risk class: $V = \frac{EBIT}{K_a}$ where K_a is the weighted average cost of capital (Proposition I).

2. The cost of equity is equal to the all-equity cost of capital plus a risk premium which depends on financial leverage (Proposition II):

$$K_s = K_a + \text{Risk Premium}$$
$$= K_a + (K_a - K_d)\ (D/_S)$$

where K_s is cost of equity, K_a is weighted average cost of capital, K_d is cost of debt, D is market value of debt, and S is market value of equity. MM used an arbitrage proof to support their proposition, concluding that the total value of the firm is the same regardless of its financing mix.[24]

MM corrected their 1958 paper in 1963.[25] In the "corrections" paper, MM corrected one sentence: "the market values of firms in each class must be proportional

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[24]Franco Modigliani and M. H. Miller, "Reply to Heins and Sprenkle," American Economic Review, 59 (September, 1969), 592-595.

[25]Franco Modigliani and M. H. Miller, "Corporate Incomes Taxes and the Cost of Capital: A Correction," American Economic Review, 53 (June, 1963), 433-442.

in equilibrium to their expected return's net of taxes (that is, to the sum of the interest paid and expected net stockholder income)." MM argue that arbitrage will make values within any class a function not only of expected after-tax returns, but also of the tax rate and the degree of financial leverage.

Brennan and Schwartz analyze the tradeoff between the incremental tax savings that additional debt affords if the firm survives and the increased probability of bankruptcy and loss of tax savings.[26] The authors show that an optimal capital structure may exist as a result of bankruptcy costs and tax savings.

Kim also analyzes how the value of the firm increases for a low level of debt and decreases as financial leverage becomes extreme.[27] With linear bankruptcy costs, a simple method to approximate the optimal capital structure was derived.

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[26] M. J. Brennan and E. W. Schwartz, "Corporate Income Taxes, Valuation, and the Problem of Optimal Capital Structure," Journal of Business, 51(January, 1978), 103-115.

[27] E. Han Kim, "A Mean-Variance Theory of Optimal Capital Structure and Corporate Debt Capacity," The Journal of Finance, 33(March, 1978), 45-64.

Farrar and Selwyn (1967)[28] and Brennan (1970)[29] argue that the presence of personal income taxes may reduce the tax advantage associated with debt financing. If the return of debt to the investor is taxed at a higher rate than his return on common stock, then the overall tax advantage associated with corporate debt is reduced.

Miller (1977) reopened the question with a startling demonstration that capital structure was a matter of indifference to the individual firm even in the presence of taxes.[30] There is a macroeconomic leverage optimum, but for the individual firm there are no financial structure decisions.

Kraus and Litzenberger, using a state-preference approach in a world of taxes and bankruptcy costs, showed that with discrete states of nature the relationship between the value of the firm and the amount of debt is jagged.[31] Kraus and Litzenberger show that the total market value of

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[28] Donald E. Farrar and Lee Selwyn, "Taxes, Corporate Financial Policy and Return to Investors," National Tax Journal, 20(December, 1967), 444-454.

[29] M. J. Brennan, "Taxes, Market Valuation and Corporate Financial Policy," National Tax Journal, 23(December, 1970), 417-427.

[30] Merton H. Miller, "Debt and Taxes," Journal of Finance, Vol. 33, No. 2 (May, 1977), 261-275.

[31] Alan Krause and Robert H. Litzenberger, "A State-Preference Model of Optimal Financial Leverage," Journal of Finance, 28(September, 1973), 911-922.

the firm is not, in general, a concave function of financial leverage.

Haugen and Senbet argue that bankruptcy costs are unimportant.[32] They assume that rationality prevails on the part of customers, suppliers, employers, and creditors so that when bankruptcy approaches, the company simply reorganizes by selling stock and repurchasing debt.

Lee and Barker tried to determine the optimal capital structure of a firm in the face of positive taxes and bankruptcy costs. Lee concludes that everything else being equal, an investment with a higher expected return or a lower variance implies not only a lower probability of crisis/bankruptcy but also the avoidance of crisis/bankruptcy costs. The result is a lower risk-adjusted cost of crisis/bankruptcy. Therefore a much higher level of debt capacity is required to achieve the optimality condition.[33]

Jensen and Merckling suggest that given increasing agency costs with a higher proportion of equity on one hand and a higher proportion of debt on the other, there is an optimal combination of outside debt and equity that will be

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[32]Robert A. Haugen and Senbet Lemma, "The Insignificance of Bankruptcy Costs to the Theory of Optimal Capital Structure," Journal of Finance, 33 (May, 1978), 383-393.

[33]Wayne Y. Lee and Henry H. Barker, "Bankruptcy Costs and the Firm's Optimal Debt Capacity," Southern Economic Journal, 43 (April, 1977), 1453-1465.

chosen because it minimizes the total agency costs.[34] In this way it is possible to argue for the existence of an optimum capital structure even in a world without taxes or bankruptcy costs.

Stiglitz[35] and Lloyd-Davies[36] both argue that corporate and homemade leverage can be almost perfect substitutes if the free entry of financial intermediaries without costs assures the efficient functioning of the arbitrage process, which in turn will result in the irrelevance of corporate leverage.

Glenn argues that restrictions of investor behavior may inhibit the arbitrage process. Restricted short sales, will result in there being an optimal capital structure.[37]

Financial Leverage

In 1958, MM argued that the total risk for all security holders of a firm is not altered by changes in its capital

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[34] Michael C. Jensen and William E. Merckling, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," Journal of Financial Economics, 3(October, 1976), 305-360.

[35] Joseph E. Stiglitz, "On the Irrelevance of Corporate Financial Policy," American Economic Review, 64 (December, 1974), 851-866.

[36] Peter R. Lloyd-Davies, "Optimal Financial Policy in Imperfect Markets," Journal of Financial and Quantitative Analysis, 10(September, 1975), 457-482.

[37] David W. Glenn, "Super Premium Security Prices and Optimal Corporate Financing Decisions," Journal of Finance, 31(May, 1976), 507-524.

structure. Therefore, the value of the firm must be the same regardless of its financing mix. The proof of the MM hypothesis is based on the arbitrage process.[38] They argue that if two companies differ only (1) in the way they are financed and (2) in their total market values, investors will sell shares of the over-valued firm, buy those of the undervalued firm, and continue this process until the companies have the same market value.

The traditional approach to valuation and leverage assumes that there is an optimal capital structure and that the firm can increase its total value through the judicious use of leverage. The traditional approach implies that beyond some point, cost of equity (K_s) rises at an increasing rate with leverage. Also, the cost of debt K_d also may rise beyond some point.

MM in their article "Reply to Heins and Sprenkle" made a further arbitrage proof. They considered two firms that comprise a single risk class. These two firms are identical in every respect except that firm A is not levered and firm B is levered. According to the traditional theory, firm B may have a higher total value and lower average cost of capital than firm A (debt financing advantage, but not a huge debt). MM argued that this situation cannot continue, for arbitrage will drive the total values of the two firms

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[38] Modigliani and Miller, _op_. _cit_., pp. 270-272.

together. Firm B cannot command a higher total value simply because it has a different capital structure than firm A. MM argued that investors in firm B are able to obtain the same dollar return with no increase in financial risk by investing in firm A. Moreover, they are able to do so with a smaller investment outlay.[39] Because investors would be better off with the investment requiring the lesser outlay, they would sell their shares in firm B and buy shares in firm A. This arbitrage process would continue until firm B's shares declined in price and firm A's shares increased in price enough so that the total value of the two firms was identical.

MM's 1963 paper corrects an error in their first paper. In their discussion of the effects of the present method of taxing corporations on the valuation of firms, they said (1958):

> The deduction of interest in computing taxable corporate profits will prevent the arbitrage process from making the value of all firms in a given class proportional to the expected returns generated by their physical assets. Instead, it can be shown (by the same type of proof used for the original version of proposition I) <u>that the market values of firms in each class must be proportional in equilibrium to their expected returns net of taxes (that is, to the sum of</u>

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[39]Franco Modigliani and Merton H. Miller, "Reply to Heins and Sprenkle," <u>American Economic Review</u>, 59(September, 1969), 593-594.

> the interest paid and expected net stockholder income.[40] (italics added)

MM thought that the statement italicized above is wrong. They argued that even though one firm may have an expected return after taxes twice that of another firm in the same risk-equivalent class, it will not be the case that the actual return after taxes of the first firm will always be twice that of the second, if the two firms have different degrees of financial leverage. Since the distribution of returns after taxes of the two firms will not be proportional, there can be no "arbitrage" process which forces their values to be proportional to their expected after-tax returns. It can be shown that "arbitrage" will make values within any class a function not only of expected after-tax returns, but also of the tax rate and the degree of leverage. This means, among other things, that the tax advantages of debt financing are somewhat greater than MM originally suggested and, to this extent, the quantitative difference between the valuations implied by their positions and by the traditional view is narrowed. MM contend that under their analysis the tax advantages of debt are the only permanent advantages, so that the gulf between the two views in matters of interpretation and policy is as wide as ever.[41]

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[40] Franco Modigliani and Merton H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," American Economic Review, 48 (June, 1958), 272.

[41] Modigliani and Miller (1963),

MM remind readers that the existence of a tax advantage for debt financing--even the larger advantage of the corrected version--does not necessarily mean that corporations should at all times seek to use the maximum possible amount of debt. Other forms of financing, notably retained earnings, may be cheaper still when the tax status of investors under the personal income tax is taken into account. More importantly, there are limitations imposed by lenders, as well as many other dimensions (and kinds of costs) in real world problems of financial strategy, which are not fully included is static equilibrium models.

Brennan and Schwartz analyze the tradeoff between the incremental tax savings that additional debt affords if the firm survives and the increased probability of bankruptcy and loss of tax savings.[42] Their paper was concerned mainly with relaxing the assumption that the tax savings due to debt issuance constitutes a "sure stream." MM themselves acknowledge that "some uncertainty attaches even to the tax savings, though, of course, it is of a different kind and order from that attaching to the stream generated by the assets.[43] They attribute this uncertainty to two causes: 1) the possibility of future changes in the tax rate, and 2) the possibility that at some future date the firm may

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[42]Brennan and Schwartz, op. cit., p. 104.

[43]Modigliani and Miller, op. cit., p. 435.

have no taxable income against which the interest payments on the debt may be offset.

In Brennan and Schwartz's paper they considered the latter possibility, noting in particular that once a firm has gone bankrupt the tax savings on interest cease. Once this possibility is acknowledged, it is apparent that the issue of additional debt has two effects on firm value: on one hand, it increases tax savings as long as the firm survives; on the other, it reduces the probability of the firm's surviving for any given period. Depending on which of these conflicting influences prevails, the value of the firm may increase or decrease as additional debt is issued. It seems reasonable to suppose *a priori* that, as additional debt is issued from a small base, the survival probabilities of the firm will not be substantially affected, so that the former influence will outweigh the latter and the value of the firm will increase. At high initial levels of debt, further increments may so affect the survival probabilities that the value of the firm will decrease. Brennan and Schwartz conclude that an optimal capital structure may exist even without bankruptcy costs.[44]

Two features of the personal tax structure are important to valuation theory. First the existing tax code which permits individuals (and corporations) to deduct

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[44] Brennan and Schwartz, *op. cit.*, pp. 104-114.

interest payments. Second is the asymmetric tax treatment of income received in the form of dividends and capital gains. The difficulty of introducing these institutional imperfections into the analysis arises from the progressive nature of the personal tax structure, which causes the relevant marginal tax rates to vary between investors in different income classes. An important step towards recognizing the effects of the personal tax structure on corporate financial policy was made by Farrar and Selwyn.[45] Their analysis is limited by its concentration on the net income received by an investor with given tax rates from a share in a corporation, as that corporation pursues alternative financial policies. Their use of this net income concept as a optimality criterion suffers by its implicit neglect of the market exchange opportunities open to an investor who does not find a particular set of financial policies congenial.

Brennan indicates that such opportunities require development of a valuation model, so that the impact of alternative financial policies on the value of the corporation may be determined. The Farrar-Selwyn paper lacks such a valuation model.[46] Market trading opportunities open to

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[45] Farrar and Selwyn, op. cit., p. 444.

[46] Brennan, op. cit., p. 417.

investors requires that the welfare of all investors in the corporation be maximized taking into account the diversity of investors' marginal tax rates. From this equilibrium condition a market valuation is developed. This is then used to discuss the effects of alternative dividend policies on the valuation of the corporation. The effects of alternative capital structure are discussed within the framework of the same valuation model. Finally, attention was directed to the interaction of capital structure and dividend policies when the firm is subject to a share repurchase constraint. It was concluded that the advantage of issuing corporate debt may be substantially reduced by the consequent need to pay out the proceeds in dividends.[47]

Miller (1977) explained that when the personal income tax is taken into account along with the corporation income taxes, the gain from leverage G_L, for the stockholders is as follows:

$$G_L = \{1 - \frac{(1 - t_c)\ (1 - t_{ps})}{1 - t_{PB}}\}\ B_L \qquad (17)$$

where t_c is the corporate tax rate, and t_{ps} is the personal income tax rate applicable to income from common stock. T_{PB} is the personal income tax rate applicable to income

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[47] *Ibid.*, p. 426.

from bonds and B_L is the market value of the levered firm's debt.[48]

If all tax rates are zero, the expression reduces to the MM no-tax result of $G_L = 0$. When the tax rate on income from shares is less than the tax on income from bonds, then the gain from leverage will be less than $t_C B$. In other words, if t_{PB} is greater than t_{PS}, the tax advantage of debt is less than $t_C B$.[49] Miller argued that for a wide range of values for t_C, t_{PS}, and t_{PB}, the gain from leverage vanishes entirely or even turns negative. Basically, Miller's argument is based on a corporation's adjusting the supply of corporate debt to take advantage of clienteles of investors with different tax brackets. In market equilibrium, Miller claims that $(1 - t_C)(1 - t_{PS}) = 1 - t_{PB}$ and the tax advantage of corporate debt is eliminated in market equilibrium. Under these conditions the value of the firm and its cost of capital are independent of its capital structure (even with taxes).[50]

Kraus and Litzenberger analyzed the question of optimal capital structure by using the state-preference model. Their

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[48] Miller, op. cit., p. 267.

[49] In a world of corporate but not personal taxes, the value of the firm is $V = \frac{NOI\ (1 - t_C)}{\rho k} + t_C B$. Where $t_C B$ is the tax advantage of leverage, ρk is a given risk class and NOI is the expected net operating income.

[50] Miller, op. cit., p. 268.

paper introduces corporate taxes and bankruptcy penalties into a single-period valuation model in a complete capital market. The firm's financing mix determines the states in which the firm will honor its debt obligation and receive the tax savings attributable to debt financing. The firm's financing mix also determines the states in which the firm is insolvent and incurs bankruptcy penalties. The problem of optimal capital structure is, therefore, formulated as the determination of that level of debt such that the resulting division of states (into those in which the firm is solvent and those in which it is insolvent) yields the maximum market value of the firm. That is, the value of the firm increases with leverage up to the point where a further debt increase causes a change in the states under which the firm would be insolvent. At that point, the market value of the firm drops due to bankruptcy penalties.[51] Also, they argue that if the firm's debt obligations exceed earnings in some states, the firm's market value is not necessarily a concave function of its debt obligations, contrary to the traditional valuation approach. Kraus and Litzenberger conclude that the taxation of corporate profits and the existence of bankruptcy penalties are market imperfections central to a positive theory of the effect of leverage on the firm's market value.

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[51]Kraus and Litzenberger, op. cit., p. 912.

Stiglitz[52] analyzes the effect of the chance of bankruptcy on the cost of capital, even in the absence of bankruptcy costs. He contends that because of a divergence in expectations as to the change of bankruptcy between the lender and the borrower, the interest rate is an increasing function of the debt/equity ratio.

Haugen and Senbet, however, argued that bankruptcy cost is irrelevant to capital structure. They consider a market in which there are a large number of participants (buyers, sellers, and issuers of financial securities) who are all price takers and rational in their behavior. This paper is purely theoretical and fundamentally different from those which undermine the magnitude of bankruptcy costs on empirical grounds. They distinguish between bankruptcy (transfer of the ownership to the creditors) and liquidation (dismantling the unprofitable firm). In particular, they indicate that all costs associated with liquidating or dismantling the assets of the unprofitable firm are unrelated to capital structure.[53] That is, liquidation is a capital budgeting abandonment decision on the part of the firm. If rationality prevails on the part of participants (buyers,

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[52] Joseph E. Stiglitz, "Some Aspects of the pure Theory of Corporate Finance: Bankruptcies and Takeovers," <u>Bell Journal of Economics and Management Science</u>, 3(Autumn, 1972), 458-482.

[53] Haugen and Senbet, <u>op</u>. <u>cit</u>., p. 384.

sellers, and creditors and issuers of financial securities), when bankruptcy approaches, all parties have an incentive to avoid the bankruptcy procedure and seek informal reorganization instead. The costs of avoiding the transfer of ownership are given by the transaction costs associated with selling new shares (at a fair market price) and using the proceeds to repurchase (at a fair market price) all fixed claims on the assets of the firm. The present value of these expected transaction costs is likely to be quite small relative to the government subsidy associated with debt financing. In short, they argue that the truly significant "penalty" costs that are commonly attributed by others[54] to bankruptcy are more appropriately attributed to liquidation. If all parties are rational, bankruptcy cost should be irrelevant to capital structure.

Kim (1978) analyzed the trade off between the incremental tax savings that additional debt affords and the increased probability of bankruptcy costs. He shows that when firms are subject to bankruptcy costs, their debt capacities will be reached prior to 100 percent debt financing. He makes it clear that optimal capital structures involve less than maximum debt financing and shareholder-wealth-maximizing firms will search for optimal capital

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[54] Kraus and Litzenberger, op. cit., pp. 911-922; James H. Scott, "A Theory of Optimal Capital Structure," Bell Journal of Economics, 8(Spring, 1976), 33-54.

structures rather than simply maximizing their borrowing. Kim provided a numerical example, illustrating that not only is a firm's value a strictly concave function of its end-of-period debt obligations with a unique global maximum, but also that the maximum is reached prior to the firm's debt capacity. He concludes that in a perfect capital market where firms are subject to income taxes and costly bankruptcies, debt capacity occurs at less than 100 percent debt financing; firms do have optimal capital structures. The market value of the firm increases for low levels of debt and decreases as financial leverage becomes extreme.

Jensen and Meckling extended the analytical formulations of the relationships between owners and managers.[55] They examine the agency problem which arises when a manager owns less than the total common stock of the firm. Private and individual consumption by the manager of the firm's wealth costs him only in proportion to the fraction of his ownership of the firm, the remainder being borne by the other owners. Agency costs occur because the manager's incentives diverge from those of the firm as a whole. Jensen and Meckling define agency costs as the sum of (1) the monitoring expenditures by principals, (2) the bonding

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[55] Michael C. Jensen and William H. Meckling, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," Journal of Financial Economics, 3(October, 1976), 305-360.

expenditures by the agent, and (3) the residual loss. The term monitoring includes more than just measuring or observing the behavior of the agent. It includes efforts on the part of the principal to 'control' the behavior of the agent through budget restrictions, compensation policies, operating rules, etc.[56] They show that regardless of who makes the monitoring expenditures, these costs ultimately are borne by the stockholders. This is due to debtholders taking account of potential monitoring costs in the interest rate charged. The greater the likely monitoring costs by debtholders, the higher the interest rate, and the lower the value of the firm to its shareholders, all other things being equal. There are two agency costs: one is agency costs of debt and the other is agency costs of external equity. To prevent machinations, bondholders insist on protective covenants and monitoring devices of various types, to protect their wealth from expropriation. However, the cost of writing and enforcing such covenants may be considerable.[57] The new shareholders will have to incur monitoring costs of one form or another to ensure that the original owner-manager acts in their interest. Jensen and Meckling suggest that given increasing agency costs with higher proportion of equity on one hand and higher proportion

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[56] _Ibid._, p. 308.

[57] _Ibid._, p. 310.

of debt on the other, there is an optimal combination of outside debt and equity that will be chosen because it minimizes total agency costs. In this way it is possable to argue for the existence of an optimal capital structure even in a world without taxes or bankruptcy costs.[58]

Other Imperfections of Capital Market

Homemade leverage.--MM's proof is based on an arbitrage process. Implied in the MM's arbitrage proof is the idea that the personal and corporate leverage are perfect substitutes. However, there are reasons for suspecting that this may not be the case. The individual investing in a levered firm has only limited liability. If, however, one engages in arbitrage transactions, there is the possibility of losing not only the holdings in the unlevered firm but of losing other assets as well. Also, individuals borrow personally and pledge their stocks as collateral, they are subject to margin calls. These reasons suggest that the risks of corporate leverage and personal leverage are different and personal leverage may not be a perfect substitute for corporate leverage in the minds of many investors.[59]

Moreover, the arbitrage process is not confined to individuals. If opportunities for profit exist, financial

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[58] Ibid., p. 357.

[59] David Durand, "The Cost of Capital, Corporation Finance, and the Theory of Investment: Comment," American Economic Review, 49(September, 1959), 639-654.

intermediaries may enter the scene and replicate the financial claims of either the levered or the unlevered company and buy the stock of the other. The free entry of financial intermediaries without cost will result in the irrelevance of corporate leverage.[60] Also, the impact of margin requirements by the Federal Reserve prevents a person from borrowing the full value of the stock pledged as collateral. Thus, the margin requirement restricts the ability of arbitragers to substitute "homemade" leverage for corporate leverage.[61]

Differing costs of borrowing.--Baron analyzed the effects of default risk and differences in the nominal interest rates for firm and individual borrowing as considered for classes of expected-utility maximizing investors who may or may not be risk averse.[62] His paper interprets the MM theorem using stochastic dominance. Due to capital market imperfections, the effective cost of borrowing may be higher for the individual than for the corporation. Using stochastic dominance arguments, the MM theorem can be shown to be valid if all investors are able to borrow

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[60] Joseph E. Stiglitz, "On the Irrelevance of Corporate Financial Policy," American Economic Review, 64(December, 1974), 851-866.

[61] David W. Glenn, "Super Premium Security Prices and Optimal Corporated Financing Decisions," Journal of Finance, 31(May, 1976), 508-512.

[62] David P. Baron, "Default Risk, Homemade Leverage, and the Modigliani-Miller Theorem," American Economic Review, 64 (March, 1974), 176-182.

at the same nominal interest rate as firms by pledging the securities in the unlevered firm as collateral. If because of margin restrictions, the investor is required to pledge additional collateral, the default risk to the lender is reduced, and the nominal interest rate paid by the investor may be less than the nominal interest rate paid by the levered firm. The value of the levered and unlevered firms will be equal if all economic agents are risk neutral. However, if investors and lenders are risk averse, the value of the levered firm may be greater than the value of the unlevered firm.

Institutional restrictions.--Glenn analyzed super premium security prices and optimal corporate financial decisions demonstrating that the combination of restrictions on investment behavior of financial institutions, together with restrictions on short sales, results in optimal capital structures for firms.[63] A short sale is any sale of security which is completed by delivery of borrowed shares or bonds. The seller sells something not owned in the hope of buying later at a lower price and delivering the later purchase against the short sale. The presence of restrictions on the investment behavior of institutions will result in those securities being approved for investment selling at higher

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[63] David W. Glenn, "Super Premium Security Prices and Optimal Corporate Financing Decisions," Journal of Finance Vol. 31, No. 2 (May, 1976), 507-524.

prices than otherwise would be the case. Many institutional investors, such as pension funds and life insurance companies, are not allowed to engage in this "homemade" leverage which may retard the arbitrage process. If unrestricted investors could freely engage in short selling, they would eliminate the higher relative prices for these securities. Unrestricted investors would sell short the approved securities and use the proceeds of the short sale to buy other securities that were more favorably priced in the market, given their expected return and systematic risk. The action of a number of unrestricted investors behaving in this manner would drive down the prices of approved securities and drive up the prices of other securities until equilibrium was achieved. However, this process depends on there being no restriction on short sales. In practice, the proceeds of a short sale are not available to the party selling the security short, but rather are held in escrow. Moreover, there is a margin requirement. These impediments to short selling result in unrestricted investors not being able to eliminate the premiums in prices for securities that are approved investments for restricted institutional investors. Under these circumstances, an optimal capital structure exists.[64]

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[64] Ibid., pp. 515-520.

Asymmetric information, signalling.--Ross suggests that implicit in the Modigliani-Miller irrelevancy of financial structure is the assumption that the market knows the (random) return stream of the firm and values this stream to set the value of the firm.[65] What is valued in the marketplace, however, is the perceived stream of returns for the firm. This way raises the possibility that changes in the financial structure can alter the market's perception; by changing its financial structure the firm alters its perceived risk class, even though the actual risk class remains unchanged. Ross suggests that if managers possess inside information, however, then the choice of a managerial incentive schedule and of a financial structure signals information to the market, and in competitive equilibrium the inferences drawn from the signals will be validated.

One empirical implication of this theory is that in a cross section, the value of the firm will rise with leverage, since increasing leverage increases the market's perception of value. In other words, Ross's incentive-signalling approach suggests that management might choose real financial variables, such as financial leverage or dividend policy, as a means of sending unambiguous signals to the public about the future performance of the firm.

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[65] Stephen A. Ross, "The Determination of Financial Structure: The Incentive-Signalling Approach," *The Bell Journal of Economics*, 8(Spring, 1977), 23-40.

These signals cannot be mimicked by unsuccessful firms because they do not have sufficient cash flow to back them up. Further, managers have incentives to tell the truth. A firm which increases dividend payout is signalling that it has expected future cash flows which are sufficiently large to meet debt payments and dividend payments without increasing the probability of bankruptcy.[66]

Talmor explains there is an asymmetry of information that is assumed to exist between corporate insiders who possess superior information about the firm's future earnings prospects and outside investors.[67] Financial instruments can serve as signalling devices through which the true value of the firm can be revealed to the market without normal hazards or disclosure of confidential information. Although the signalling process is typically considered to be costly, it is advocated that firms may be better off if they employ this mechanism rather than reveal reliable, but confidential, information or not disclose at all.

Talmor's study presents an attempt to develop a general signalling theory in corporate finance that is consistent with the objective of market value maximization. His paper

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[66] Ibid., pp. 38-39.

[67] Eli Talmor, "Asymmetric Information, Signalling and Optimal Corporate Financial Decisions," Journal of Financial and Quantitative Analysis, 16(November, 1981), 413-435.

extends the work of Bhattacharya[68] by developing a financial signalling equilibrium model for the general case of several unknown (to the outside market) valuation parameters and several signalling instruments. The general model allows for several financial decisions to be determined simultaneously by considering for each decision both its direct impact on the value of the firm and its signalling property. Talmor investigates in detail two financial decisions--dividend policy and capital structure. These two financial decisions are relevant, in the sense that they affect the value of the firm, and their value depends on the type of firm. Since the financial package of the firm is freely observable, it is recognized by the market as a set of signalling instruments.[69] The signalling mechanism works as follows: knowing the functional form of optimal financial activities, the market assesses the firm's type from the observed financial structure. The manager realizes the signalling value of his decision and has an incentive to deviate from the first-best optimality to the "positive" direction. The signaling benefits is traded off against the cost of signaling that stems from deviating from the rules of optimal financial decisions that suit behavior in

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[68] S. Bhattacharya, "Imperfection Information, Dividend Policy, and the 'Bird in the Hand' Fallacy," Bell Journal of Economics, 10(Spring, 1979), 259-270.

[69] Talmor, op. cit., p. 414.

a perfectly informed capital market. While there is not necessarily a direct correspondence from each activity to each parameter, the market determines the firm's earnings distribution movements by observing both activities simultaneously.[70]

Talmor concludes that focusing on informational asymmetries holds great promise in exploring the financial behavior of the firm. Such asymmetries might provide an explanation of phenomena that cannot be easily explained under perfect market assumptions. With regard to debt, signalling provides a new role for the firm's capital structure; an optimal capital mix can be derived even if there is no tax benefit from debt financing.[71]

Lee et. al. (LTV) develop an equilibrium model in which informational asymmetries about the qualities of products offered for sale are resolved through a mechanism which combined the signalling and costly screening approaches.[72] There are important quality differences between different securities and products. The identification of these

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[70] Ibid., pp. 423-424.

[71] Talmor, op. cit., p. 434.

[72] Wayne L. Lee, Anjan V. Thakor, and Gautam Vora, "Screening, Market Signalling, and Capital Structure Theory," Journal of Finance, Vol. 38, No. 5 (December, 1983), 1507-1518.

qualities is called screening, and devices that sort commodities according to quality are called screening devices. Screening has both productivity returns and costs. LTV's model is developed in a capital market setting in which bondholders produce costly information about a firm's imperfectly known earnings distribution and use this information in specifying a bond valuation schedule for the firm. The uniqueness of LTV's approach is that the onus for making the decision to generate the necessary information shifts from the firm to the initially uninformed outsiders. Thus, although costly information production is allowed, their model differs from those in the signalling literature. However, some resemblance to the signalling model is preserved, because in choosing how to transact with outsiders who have produced information, the firm still controls the actual transmittal of information to the rest of the market. They made this possible by allowing the firm's transactions with information producers to operate as signals. Taking the debt valuation schedule into account, and in conjunction with the perceived impact of the firm's debt policy on the price of new shares, current stockholders determine the optimal mix of debt and equity and the maturity of debt for financing incremental investment. The firm's (marginal) debt policy denotes the promised payment to bondholders in each future time period. In other words, given the bond valuation schedule, the firm's optimal choices of debt-equity ratio and debt maturity structure subsequently signal to prospective shareholders the relevant parameters of the firm's earnings distribution.[73]

Conclusion.--The papers discussed in this section examine the theoretical effects of capital structure (or financial leverage) on the value of the firm and cost of capital. They lack a clear consensus.

The traditional presumption is that a firm's value is a concave function of its financial leverage and that an optimal financial leverage exists where the slope of the function is zero. Modigliani and Miller (MM) provided the foundation for studying the effect of financial structure on the valuation of firms in equilibrium. MM (1958) established that the total value of the firm, in the absence of taxes, remains constant across all degrees of financial leverage. Building on MM's foundations, numerous authors confirm the MM no-tax proposition. MM (1963) and others show further that a proportional corporate income tax provides sufficient economic incentive for firms to maximize their use of debt financing.

Arguments for the relevance of capital structure decisions must be rooted in capital markets being less than perfect. Several authors examined market imperfections,

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[73] *Ibid*., p. 1508.

including bankruptcy costs, differences between corporate and homemade leverage, institutional restrictions on investors, and corporate and personal taxes. With corporate taxes, debt has a tax advantage and serves to lower the cost of capital, even in the MM case. This effect is reduced if there are personal income taxes and if the personal tax on debt income is higher than that on common stock income. Therefore, the combination of corporate income taxes and bankruptcy costs may result in a optional capital structure. Kraus and Litzenberger (1973) provide a state-preference model with income taxes and bankruptcy costs, and suggest a stochastic dynamic programming approach to search for an optimal capital structure. Although Kraus and Litzenberger's study provides insight into the theory of optimal capital structure, their model is too complex to implement. Jensen and Meckling suggest that given increasing agency costs with a higher proportion of equity on one hand and a higher proportion of debt on the other, there is an optimal combination of outside debt and equity that will be chosen because it minimizes total agency costs. In this way it is possible to argue for the existence of an optimum capital structure even in a world without taxes or bankruptcy costs. There is a potential role for information asymmetry and signalling in the area of optimal capital structure. While contributions in these areas have suggested promise, little empirical testing has yet taken place. The effect of financial leverage on stock prices is still unresolved.

Empirical Studies of the Financial Leverage Effect on Stock Prices

The empirical evidence on financial leverage and risk of stock prices is inconclusive. The empirical literature on financial leverage, the cost of capital and value of the firms has focused on the theory provided by MM (1958, 1963). The question is whether or not the value of the firm can be affected by changing its financing mix.

Beranek studied leverage's influence on the market value of common stock.[74] He used control variables, such as current earnings and current dividends, and also inserted a variable which would control the risk in the gross-income stream, the so-called non-financial risk. His model, which is expressed on a per-share-annual-cross-section basis, has the form:[75]

$$P_t = a_0 + a_1 d_t + a_2 d_t^2 + a_3 Y_t + a_4 Y_t^2 + a_5 L_t + a_6 L_t^2 + a_7 V_t. \qquad (18)$$

[74]William Beranek, "The Effect of Leverage on the Market Value of Common Stock," Madison, WI: Bureau of Business Research and Service, University of Wisconsin, 1964.

[75]*Ibid.*, p. 22

where

P_t = price per share

d_t = dividend per share

Y_t = earnings per share

L_t = ratio of debt to equity at end of period t

V_t = a variable controlling risk in the gross income stream

Beranek finds that financial leverage decreases the market value of stock. He also found that the influence of leverage on market value appears to be most marked in the electric power and light and railroad industries.[76]

Wippern offered an empirical approach to determining the relationship between risk, financial structure, and capital costs for industrial firms.[77] The objective of this empirical analysis was to determine, by regression analysis, the relationship between equity capitalization rates and leverage within a sample of industrial firms, and to interpret the observed relationships in the context of the opposing theoretical positions. Multiple regression analysis of the sample firms was performed for each of the cross-section years using the equation:

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[76] Ibid., p. 73.

[77] Ronald F. Wippern, "Financial Structure and the Value of the Firm," Journal of Finance, Vol. 21 (December, 1966), 615-633.

Earnings/price ratio = $a + b_1$ leverage + b_2 growth + b_3 payout + b_4 log size + b_I ($I = 1 \ldots n$, industry dummy variables).

Wippern's empirical results revealed that shareholders' wealth increases with leverage through the ranges observed.

Robicheck and others empirically examined the effect of leverage on the cost of equity capital for electric utility firms.[78] The form of their test equation was:

$$K = a_0 + a_1(D/S) + a_2 \text{ (flow-through dummy)}. \quad (19)$$

where

K = cost of equity

D/S = long-term debt plus short-term debt plus preferred stock divided by common equity.

Stable, statistically-significant parameters were found measuring the influence of leverage on the cost of equity capital. The authors point out these findings are of considerable practical importance, but they neither support nor reject any specific theoretical propositions regarding the effect of leverage on the cost of capital.

Hamada tested the effect of the firm's capital structure on the systematic risk of common stocks and found that approximately 21 to 24 percent of the observed systematic risk of common stocks (when averaged over 304 firms) can be

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[78] Alexander A. Robichek, Robert C. Higgins, and Michael Kinsman, "The Effect of Leverage on the Cost of Equity Capital of Electric Utility Firms," Journal of Finance, 28 (May, 1973), 353-366.

explained merely by the added financial risk taken on by the underlying firm with its use of debt and preferred stock.[79] He argued that corporate leverage does count considerably. However, in order to conduct this testing, Hamada had to assume that the MM corporate tax leverage propositions are correct. If the MM theory is not correct the issue remains in doubt.

Copeland and Weston discuss the empirical evidence for the effect of capital structure on the cost of capital and conlude that it is inconclusive.[80] They also criticized previous empirical test as follows:[81]

> As was mentioned earlier, all the aforementioned empirical tests suffer from the impossibility of measuring future earnings and the fact that changes in the ratio of debt to assets usually are accompanied by changes in the asset structure of the firm, which in turn may imply changes in risk. None of the above papers attempts to adjust for risk directly. Instead, they rely on assumptions about the homogeneity of business risk across different firms within the electric utility industry.[82]

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[79] Robert S. Hamada, "The Effect of the Firm's Capital Structure on the Systematic Risk of Common Stock," *Journal of Finance*, 27 (May, 1972), 435-452.

[80] Thomas E. Copeland and J. Fred Weston, *Financial Theory and Corporate Policy* (Massachusetts, 1983), pp. 453-458.

[81] These statements suggest that financial leverage and operating leverage cannot be separated when testing the relationship between either of them and the value of stock prices.

[82] Copeland and Weston, *op cit*., p. 456.

Masulis used corporate exchange offers to study the effects of capital structure changes on security prices.[83] His study tests the predictions of many of the currently held theories by analyzing the effects which particular capital structure changes should have on the market prices of the firms' securities. Other studies have not been controlled for asset structure changes which occur at the time of capital structure changes. For instance, a new issue of debt involves a cash inflow, while a repurchase of equity causes a cash outflow. These simultaneous cash flows result in equal changes in the value of the firm's assets and, in general, change the distributional properties of the firm's asset structure at the exact moment of the capital structure change.[84]

Masulis's study avoids this problem by analyzing two instances where corporate financial decisions resulted in close approximations to pure capital structure changes: intrafirm exchange offers, and recapitalizations.[85] These two events are unique in that they do not entail any firm

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[83]Ronald W. Masulis, "The Effects of Capital Structure Change on Security Prices: A Study of Exchange Offers," _Journal of Financial Economics_, 8 (June, 1980), 139-178.

[84]_Ibid._, p. 140.

[85]Copeland and Weston, _op cit._, p. 456. The redistribution effect can be referred to as capital structure theory in an option pricing model framework.

cash inflows or outflows (with the exception of expenses) while they cause major changes in the firm's capital structure. These changes are effected through a private exchange between the firm and one or more classes of its securityholders. An example given by Masulis of a typical exchange offer is CIT Financial Corporation's January 1968 offer to exchange $100 face value of 6.78% non-convertible debentures for each share of outstanding $5 per non-convertible preferred stock tendered. CIT Financial preferred stockholders' acceptance of this offer resulted in the issuance of $46 million in debentures and the retirement of 462,500 shares of preferred stock.

If protective covenants written into bond indenture provisions are incomplete because the cost of monitoring and enforcing them exceeds their likely benefit, then it may be possible for management occasionally to alter the firm's capital structure in such a way that a redistribution of wealth among the various classes of securityholders may result.[86] If, for example, debt is issued to retire equity, existing bondholders may suffer a wealth loss if the claim of the new debt on the assets of the firm is not subordinated. The effect is to make existing debt riskier without any compensation. Consequently, the market value of the debt claim will fall. Simultaneously, shareholders may

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[86]Masulis, _op_. _cit_., p. 146-148.

benefit in two ways: (1) directly from the redistribution effects, and (2) from any tax shield provided by the new debt. For 20 percent of the firms in Masulis's sample, indentures of outstanding debt issues do not preclude or require compensation for the issuance of new debts of either equal or senior standing.

Analyzing a sample of relatively pure capital structure change announcements, evidence was found of statistically significant effects on the portfolio returns of the firm's common stock, preferred stock, and debt. This evidence indicated both a corporate debt tax shield effect and a wealth redistribution effect across security classes. In other words, these results are consistent with (1) a tax shield benefit from debt, and (2) a redistribution of debt-holders to equityholders.

Masulis (1983) estimated the impact of a change in debt level on firm values.[87] Two forms of capital structure change were examined: issuer exchange offers and recapitalizations, because they do not involve simultaneous asset structure changes. Since an efficient capital market capitalizes on the effects of an unanticipated capital structure change at the initial announcement rather than at the effective date of the change; the dependent variable below was

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[87]Ronald W. Masulis, "The Impact of Capital Structure Change on Firm Value: Some Estimates," Journal of Finance, Vol. 38, No. 1 (March 1983), 107-126.

defined by Masulis as the primary announcement period stock return. After separating classes of senior securities and introducing an error term, he obtained the following statistical model of a common stock's return on the occurrence of an exchange offer announcement:[88]

$$\text{Ret} = B_0 + \delta_1 \Delta DEBT_1 + \delta_2 \Delta DEBT_2 - e_1\, D_1{}^* - e_2\, D_2{}^* - e_3\, D_3{}^* - e_4\, D_4{}^* - e_p\, P^* + e \qquad (20)$$

where

Ret	$= \frac{\Delta S}{S}$ = the change in the value of equity
B_0	= normal rate of return on the firm's equity
$\Delta DEBT_1$	= debt level decrease
$\Delta DEBT_2$	= debt level increase
$D_1{}^*$	= short-term debt
$D_2{}^*$	= nonconvertible protected debt
$D_3{}^*$	= nonconvertible unprotected debt
$D_4{}^*$	= convertible debt
P^*	= preferred stock

The change in the value of equity, return, is $\frac{\Delta S}{S}$; it is hypothesized to be a function of three major classes of variables. First, return will depend on the normal rate of return on the firm's equity, B_0. Second, return will depend

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[88] *Ibid.*, p. 118.

on debt-level change variables ($\delta_1 \Delta DEBT_1$ for debt decrease and $\delta_2 \Delta DEBT_2$ for debt increases). The third category of effects is wealth transfer effects, which will depend on the market values of senior security classes, relative to common stock outstanding and the percent changes in leverage. The effects on debt outstanding are all expected to be negatively related to equity return and are divided into (a) short-term debt, $e_1D_1^*$, (b) nonconvertible protected debt, $e_2D_2^*$, (c) nonconvertible unprotected debt, $e_3D_3^*$, and (d) convertible debt, $e_4D_4^*$. The preferred stock wealth transfer effect, e_pP^*, can be positive or negative because the sample contains both convertible and nonconvertible preferred.

This model was developed to estimate firm valuation effects of exchange offer announcements and capital structure changes. This linear model was then estimated using ordinary least squares. The result was a statistically significant regression equation having parameter estimates consistent with model predictions and explaining more than half the cross-sectional variations in stock announcement returns. Evidence was obtained indicating that (a) changes in stock prices are positively related to leverage changes, (b) changes in firm values are positively related to changes in firm debt level, (c) changes in nonconvertible senior security prices are negatively related to leverage changes, (d) the magnitude of leverage-induced, nonconvertible senior security price changes is substantially greater when leverage changes involve senior securities of equal or greater seniority to those outstanding. This evidence was shown to be consistent with tax based models of optimal structure and leverage induced wealth transfer across security classes, as well as with information effects concerning firm values which are positively related to changes in firm debt level.[89]

Conclusion.--The empirical evidence on financial leverage and value of the firm is inconclusive. Wippern's evidence of the effects of capital structure on the value of the firms provided support for the traditional view that shareholder wealth is enhanced by the firm's judicious use of fixed commitment financing. However, his study employed earnings yield as the measurement of cost of equity, which could cause a number of difficulties.

Robicheck et. al. found stable, statistically significant parameters indicating leverage affects the cost of equity capital. However, their study was limited to the electric utilities. This, like previous empirical work, suffers from concurrent changes in the ratio of debt to assets and changes in the firm's asset structure.

Masulis looked at the relationships among the cost of capital, capital structure changes, and the value of the

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[89] Ibid., p. 125.

firm's securities. His evidence suggests several sources of leverage benefits.

Combined Leverage and the Risk of Stock Prices

Huffman argues that the direct effect of an increase in debt on equity risk is partially offset by the change in capacity in response to the increase in debt. The ability of the capacity decision to attenuate the increase in equity risk, due to the increased outstanding debt, is lost above a critical level of debt D^+. She also concluded that the effect of an increase in revenue risk on equity risk of the levered firm is partially offset by the change in capacity in response to the increase in revenue risk. This ability of the capacity decision to attenuate the effect of the risk of cash flow to equity is lost if revenue is less than the discounted value of operating costs plus debt. The procedure used by Huffman to derive these two conclusions is explained as follows.

Huffman uses Black-Scholes[90] option pricing model, $S = V\,N(d_1) - ce^{-rFT}N(d_2)$, to derive the optimal capacity level X^*. Black-Scholes visualize the debtholder-equityholder relationship as being essentially an option arrangement.[91]

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[90] Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," Journal of Political Economy, 91(May-June, 1973), 644.

[91] Ibid., 649-651.

In Huffman's view, the equity cash flow follows the pattern of returns to a simple option with exercise date t = 1. At the time cash flow to equity is zero, unless demand is such that revenue exceeds operating costs plus debt. If demand levels are such that revenue exceeds operating costs plus debt, equity cash flow is linearly proportional to the realization of the demand parameter. If demand is such that revenue does not exceed operating costs plus debt, then the equity receives nothing.

At time t = 0 equity possesses an option on the underlying revenue from a demand realization at time t. The exercise time is t = 1, and the exercise price is operating costs (CX) plus debt (D). Huffman assumes that the variance of revenue is known, that revenue and aggregate wealth are jointly lognormally distributed, and that utility functions exhibit constant proportional risk aversion. Huffman expressed the value of this option S (X, t) at t as follows:[92]

$$s(X,t) = r^{-1}\{R(X)N(d_1) - CX + D)N(d_2)\}, \tag{21}$$

where R(X) = P(X)X = the current value of revenue from production, given the current demand realization

N(d) = the standardized normal cumulative probability density function

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[92] Lucy Huffman, "Operating Leverage, Financial Leverage, and Equity Risk," Journal of Banking and Finance, 7 (June, 1983), 202-203.

$d_1 = 1/\sigma \{\ln R(X)/(cX + D) + \sigma^2/2,$

$d_2 = d_1 - \sigma t,$

t = number of periods to expiration (equal 1 in this model,

σ^2 = the variance of ln {1 + the rate or change in R(X)},

r = one plus the risk free rate of return over the period.

The optimal capacity commitment is determined at a level X* such that the NPV of the decision is maximized. Huffman explained that this decision is made so as to maximize the net value to equity, not to the firm, since it arises prior to the time at which the debt legally assumes control. If production capacity is assumed to cost K (per unit production cost) at t = 0, the NPV of the decision to the equity is S (X) - KX. Thus the optimal capacity X* is the solution to the first-order condition for equation (21).

$$\partial S(X^*)/\partial X = K \tag{22}$$

Based on equation (21) and (22), Huffman obtains the optimal capacity level (X*) as:[93]

$$r^{-1} \{P(X^*)N(d_1^*) - CN(d_2^*)\} = K \tag{23}$$

[93]Huffman, op cit., p. 208.

The effect of debt.--The effect of the presence of D on the capacity decision (X*) made by the equity owner at t = 0 can be analyzed by examination of the derivative $\partial X^*/\partial D$. Since X* is not explicitly obtained, the effect is examined by taking the implicit derivative of equation (23) with respect to D and substituting equation (24)[94] from her appendix B, yielding equation (25)

$$\frac{\partial X^*}{\partial D} = \frac{-(\partial/\partial D)\ \{\partial S(X^*)/\partial X^*\}}{(\partial/\partial X^*)\ \{\partial S(X^*)/\partial X^*\}} = \frac{r^{-1}\ N(d_2{}^*)}{\partial^2\ S/\partial X^{*2}} \qquad (25)$$

Huffman shows that $\partial X^*/\partial D$ is negative, meaning an increase in outstanding debt (D) causes a decrease in the optimal fixed capacity commitment.

The effect of σ (revenue risk).--The effect of a change in the levered firm's revenue risk is given by the derivative $\partial X^*/\partial \sigma$. The partial $\partial X^*/\partial \sigma$ is again developed by taking the implicit derivative of equation (23) with respect to σ, yielding equation (26) as:[95]

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[94] In Huffman's appendix B, she takes the derivative of $\partial S/\partial X$ with respect to D and obtains:

$$\frac{\partial}{\partial D}\ \frac{(\partial S)}{(\partial X)} = -r^{-1}\ \frac{DZ(d_2)}{X(CX + D)}\ . \qquad (24)$$

[95] Huffman, *op. cit.*, p. 204.

$$\frac{\partial X^*}{\partial \sigma} = \frac{-\ (\partial/\partial\sigma)\ \{\partial S(X^*)/\ X^*}{(\partial/\partial X^*)\ \{\partial S(X^*)/\ X^*}$$

$$= \frac{\gamma^{-1}\ \ Z(d_2^*)\ \ (D/X^*\sigma)\ \ \ (d_2^* - \sigma c X^*/D)}{\partial^2\ S(X^*)/\partial X^{*2}} \tag{26}$$

Since the denominator of equation (26) $(\partial^2\ S(X^*)/\partial X^{*2})$ is less than zero, it can be seen from equation (26) that $\partial X^*/\partial\sigma < 0$ so long as $d_2^* < \sigma\ c\ X^*/D$. That is, whether $\frac{\partial X^*}{\partial\sigma}$ is positive or negative depends on the level of debt (D). If debt (D) increases up to a level (when $d_2^* - \sigma c X^*/D > 0$), the partial $\frac{\partial X^*}{\partial\sigma} < 0$ because $\partial^2\ S(X^*)/\partial X^{*2}$ is less than zero. In other words, when revenue risk (σ) increases, the optimal capacity (X^*) will decrease if debt increases up to a certain level (when $d_2^* - \sigma c X^*/D > 0$). Therefore, the effect of a change in the levered firm's revenue risk (σ) on the optimal level of capacity (X^*) depends on the level of debt (D).

<u>The development of η (combined leverage)</u>.--The correct formulation of η was given by Huffman as:[96]

η = percentage change in value of equity divided by percentage change in revenue,

$$= (dS/S)/d(Xp(X)/p(X)),$$

$$= 1/\ \left[1 - \frac{(cX + D)\ N(D_2)}{X\ \ p(X)\ N(d_1)}\right] \tag{27}$$

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[96] <u>Ibid.</u>, p. 205.

<u>DOCL (degree of combined leverage) versus DTL (degree of total leverage)</u>.--DOCL is defined exactly in the same manner as Huffman's combined leverage,

$$\eta = \frac{\text{\% change of earnings after tax and preferred dividend}}{\text{\% change of sales}},$$

and DTL is the traditional measure of combined leverage (or total leverage). In textbooks,[97]

$$\begin{aligned} DTL &= DOL \times DFL \\ &= \frac{X \cdot (P - V)}{X \cdot (P - V) - F - D} \end{aligned} \qquad (28)$$

where

X = units sold

P = unit price

V = unit variable cost

F = fixed cost

D = debt

According to Huffman and Myers,[98] there exists an interaction effect between DOL and DFL. Huffman further points out that F (operating leverage or capacity decision) is endogenous to the firm's decision process. Huffman's analysis reveals that the capacity decision partially offsets the effect on the risk of cash flow to equity of increasing debt or revenue risk.

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[97] J. Fred Weston and Eugene F. Brigham, <u>Managerial Finance</u> (Hinsdale, 1981), p. 572, n. 14 and p. 573, n. 15.

[98] Myers, <u>op</u>. <u>cit</u>., pp. 1-25.

Although textbooks' total leverage formula, equation (28), do express DTL = DOL X DFL, the concept it implies is quite different from that of Huffman and Myers. Both Huffman and Myers claim that an interaction exists between DOL and DFL. In short, the traditional measure (concept) of combined leverage is incorrect. In other words, DOCL $\neq$ DOL X DFL.

Huffman argues that her formula (equation 27) is different from the traditional DOL - DFL analysis, DTL (degree of total leverage) = $\frac{X \cdot (p - v)}{X \cdot (p - v) - F - D}$, in three essential ways. First, η is not timeless; it varies with the time-related arguments d_1 and d_2 of the cumulative normal probability density functions. The arguments arise from the effect of the fixed capacity production decision on output. Second, η is not independent of revenue risk. Third, since X^* is also a function of debt D, η is a more complex function of D than specified by the traditional DTL.

The behavior of η (combined leverage) with respect to debt.--The behavior of η with respect to debt (the exogenous parameter) is given by the total derivative $d\eta/dD$, presented in equation (29).

$$\frac{d\eta}{dD} = \frac{\partial \eta}{\partial D} + \frac{\partial \eta}{\partial X^*} \frac{\partial X^*}{\partial D} \qquad (29)$$

The total derivative is the sum of two effects. The direct effect is $\partial\eta/\partial D$. The indirect effect on η, $\partial\eta/\partial X^* \cdot \partial X^*/\partial D$, arises from an optimal change in X^* as D is increased.

The direct effect component $\partial\eta/\partial D$ is shown by Huffman to be greater than zero.[99]

The indirect component $(\partial\eta/\partial X^* \cdot \partial X^*/\partial D)$ is a product of equation (25) and $\partial\eta/\partial X^*$. The sign of equation (25) is negative. The sign of $\partial\eta/\partial X^*$ is a function of the magnitude of D. For debt D less than $D^+ = |P'(X)|\ cX^2/P(X) - X\ |P'(X)|$ the sign is positive.[100] Conversely, for $D > D^+$, the sign is negative and operates in opposition to the direct effect. That is, the capacity decision (operating leverage), X^*, is altered so as to offset the effect of the increase in outstanding debt. However, for $D > D^+$, the optimal capacity decision magnifies rather than attenuates, the effect of the increase in outstanding debt on the risk of cash flow to equity.

The behavior of η with respect to σ (revenue risk).--The behavior of η of a levered firm with respect to σ is given by Huffman, and presented in equation (30):

$$\frac{d\eta}{d\sigma} = \frac{\partial\eta}{\partial\sigma} + \frac{\partial\eta}{\partial X^*} \cdot \frac{\partial X^*}{\partial\sigma} \tag{30}$$

She concludes that the direct effect of an increase in revenue risk on the risk of cash flow to equity of the levered firm is partially offset by the change in capacity in response to the increase in σ. This ability of the

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[99] Huffman, op. cit., p. 212 [100] Ibid., p. 205.

capacity decision to attenuate the effect on the risk of cash flow to equity is lost if the revenue is less than the discounted value of operating costs plus debt.

Very little has been done on combined studies of DOL, DFL, or DOCL. Mandelker and Rhee's (MR) recent study shows that both two types of leverage are positively associated with the systematic risk of common stock.[101] Their empirical test is based on a sample of 255 manufacturing firms during a period from 1957 to 1976.

The first stage of MR's analysis involves the estimation of the degree of operating and financial leverage of the sample firms. Since the degree of leverage built on the concept of elasticity, MR use the following time-series regressions.[102]

$$\ln X_{jt} = a_j + c_j \ln S_{jt} + U_{jt} \qquad j = 1 - 255 \qquad t = 1957 - 1976 \tag{31}$$

$$\ln \Pi_{jt} = b_j + d_j \ln x_{mt} + e_{jt} \qquad j = 1 - 255 \qquad t = 1957 - 1976 \tag{32}$$

where

X_{jt} = earning before interest and tax

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[101] Mandelker and Rhee, op. cit., p. 46. [102] Ibid., p. 50.

S_{jt} = sales

C_j = degree of operating leverage

U_{jt} = disturbance terms

π_{jt} = earnings after tax

d_j = degree of financial leverage

e_{jt} = disturbance terms

MR uses the market model to estimate the beta of each common stock. MR then investigate the effect of the degrees of the two types of leverage on systematic risk by using the following equation.[103]

$$\ln \text{BETA} = \gamma_0 + \gamma_1 \ln \text{DOL}_p + \gamma_2 \ln \text{DFL}_p + e_p \qquad (33)$$

where

BETA = systematic risk of stock

DOL_p = degree of operating leverage

DFL_p = degree of financial leverage

e_p = disturbance terms

MR's empirical 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 (β).[104]

Mandelker and Rhee's empirical findings suggest that the degree of operating and financial leverage explains a

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[103] Ibid., p. 48. [104] Ibid., p. 54.

large portion of the variation in beta. Their findings also suggest that firms engage in trade-offs between DOL and DFL. That is, they found a significant negative correlation between the two types of leverage.[105] MR's findings partially confirm Gahlon and Gentry's[106] (GG) theory, as discussed earlier. GG show that if (DOL · DFL) increases, β_{π} should increase. MR's empirical results are consistent with such a relationship.

Conclusions.--Huffman's paper suggests that the direct effect of an increase in financial leverage is partially offset by the change in capacity (operating leverage) in response to the change in financial leverage. The ability of the operating leverage to attenuate the increase in the risk of cash flow to equity is lost above a critical level of debt.

Mandelker and Rhee's (MR) multiple regression assumes DOL and DFL are independent of each other. According to Huffman (and Myers) there are interactions between DOL and DFL, therefore MR's model specification is incorrect.

Existing evidence suggests that DOL has an effect on the stability of stock prices; evidence with regard to DFL is inconclusive. Huffman's analysis raises questions as to whether there exists a significant relationship between combined leverage and stock-price variability.

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[105] Ibid. [106] Gahlon and Gentry, op. cit., p. 21.

Summary

Evidence shows that operating leverage increases stock price variability. The effect of financial leverage on the risk of stock prices is unclear--both theoretically and empirically.

The effect of combined leverage on the stability of stock prices remains largely unknown. Huffman's conclusions provide some reasons for this. The direct effect of an increase in financial leverage on equity risk (risk of cash flow to equity) is partially offset by the change in capacity (operating leverage) in response to the increase in financial leverage. The ability of the operating leverage decision to attenuate the increase in risk of cash flow to equity, due to the increased financial leverage, is lost above a critical level of debt, D^+. This suggests that the impact of financial leverage on equity risk (risk of cash flow to equity) can be offset by changes in operating leverage.

Huffman also shows that the direct effect of an increase in revenue risk on risk of cash flow to equity of a levered firm is partially offset by the change in operating leverage in response to the increase in revenue risk. This ability of operating leverage to diminish risk of cash flow to equity is lost if the revenue is less than the discounted value of the operating costs plus debt, the risk of cash flow to equity of a levered firm does not increase proportionately to revenue risk.

Huffman's paper suggests that the risk of cash flow to equity is less than suggested by the DTL, because the effect of DFL on risk of cash flow to equity could be offset by changing DOL. This raises the issue of whether combined leverage has a significant effect on the stability of stock prices, because combined leverage has less effect on risk of cash flow to equity than previously thought. The issue then becomes empirical.

Previous tests involved partial equilibrium analysis where the DOL (or DFL) is held constant, and the attempt is made to determine the effect of a change in DFL (or DOL) on share price. Huffman's analysis suggests that partial equilibrium analysis is insufficent. If capacity (DOL) is endogenously determined, it cannot be the same for different levels of outstanding debt.

Therefore, the question is whether combined leverage (DOCL) affects variability of stock prices and to what degree. Also, what has still not been done is to determine if DOCL is a better measure than DOL and DFL (or DTL) together. The next chapter describes how that is to be tested.

CHAPTER III

METHODOLOGY

Introduction

The degree of combined leverage could represent the overall risk of a firm because it is a complete factor which can influence the risk of earnings. This is the reason why more and more papers[1] discuss the relationship between combined leverage and risk.

The purpose of this research is to test whether DOCL helps explain stock risk--either total or systematic. It is hypothesized that a functional relationship exists between the relative variability in stock prices and combined leverage (DOCL) (and other control variables). Industry and industry growth rates are used as dummy variables

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[1] See, e.g. Stewart C. Myers, "Interaction of Corporate Financing and Investment Decision--Implications for Capital Budgeting," *Journal of Finance*, 29 (March, 1974), 1-25; James M. Gahlon and James A Gentry, "On the Relationship Between Systematic Risk and the Degree of Operating and Financial Leverage," *Financial Management*, 11 (Summer, 1982), 15-23; Gershon N. Mandelker and Ghon Rhee, "The Impact of the Degree of Operating and Financial Leverage on Systematic Risk of Common Stock," *Journal of Financial and Quantitative Analysis*, 19 (March, 1984), 45-57.

because one needs to know what type of industries[2] and with what growth rates stock-price stability is most influenced by combined leverage. Combined leverage might effectively quantify firms' riskiness. In this study, DOCL will represent the degree of combined leverage and DTL represent the traditional degree of total leverage.

Combined leverage (DOCL) equals percentage change of earning after tax divided by percentage change of sales. Although DOCL is a combination of operating leverage (DOL) and financial leverage (DFL), it considers the interaction effect between DOL and DFL. Degree of total leverage, (DTL)--the traditional formulation, equals DOL times DFL.

Hypotheses

The null hypotheses are that: (1) the relative price variability (CV price and/or β) of a common stock is not related to the degree of combined leverage of the firm, (2) there is no difference among different types of industries, (3) industry growth rates are not related to the impact of combined leverage on stock prices, (4) combined leverage (DOCL) is not a better measure than DOL and DFL

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[2]Utilities are an industry of some importance. DOCL might be of use in rate cases. Prior evidence suggests that utilities use of financial leverage is atypical. See David Scott, Jr., "Evidence of the Importance of Financial Structure," Financial Management, 1 (Summer, 1973), 46; David F. Scott, Jr. and John D. Martin, "Industry Influence on Financial Structure," Financial Management, 4 (Spring, 1975), 67-73.

together (or DTL), and (5) there is no interaction effect existing between DOL and DFL.

Variables and the Model

A positive correlation from a cross sectional sample is probably best interpreted as representing the hypothesis that combined leverage affects stability of stock prices--the higher DOCL the greater the risk. This interpretation of the above relationship can be further refined by the introduction of interaction hypotheses. Two interaction variables are used in this research; one is industry and the other is industry growth rate.

Industry Interaction

The industry interaction hypothesis is illustrated in Figure 1.

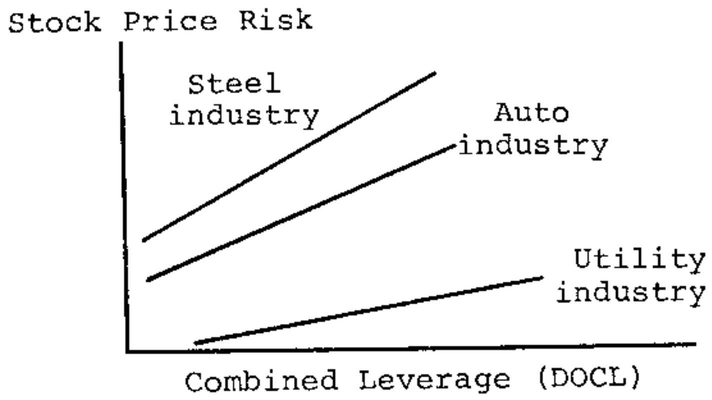

Fig. 1--Industry interaction

The question is whether the effect of combined leverage on stock-price variability tends to be stronger in certain industries. Different industries have different sales and cost stabilities; thus, DOCL might create different impacts on earning-per-share stability in different industries.[3] The degree of sales instability varies from industry to industry and business cycle to business cycle. For example, the utility industry's sales revenue is based on residential and commercial use, which is relatively stable. Steel industry sales are cyclical, and production costs are difficult to control because cost-volume-profit relationships change with capacity. The steel industry, for example, has been constantly hampered by cyclical demand, capital intensity, high operating leverage, and strong foreign competition. Because of steel's erratic sales and high combined leverage, the coefficient of variation of steel stock prices would be expected to be among the highest of all industries.

To recap, the effect of combined leverage on the stability of stock prices depends on the type of industry in question. If an industry's sales are volatile, its variation of stock prices should also be high. Higher combined leverage would accentuate such variability. In the industry interaction, it is reasoned that the effect

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[3]Bradley T. Gale, "The Existence and Direction of Causality in Cross Section Analysis of Hypothesis: A Paper in Research Strategy," 1972 Business and Economics Section (Washington, D.C.: Proceedings of American Statistical Association, 314-319; Gale, "Market Share and Rate of Return," Review of Economics and Statistics, 54 (November, 1972), 412-423.

of combined leverage on the stability of stock prices increases monotonically as the level of industry sales instability increases.

Growth Interaction

The growth interaction hypothesis is illustrated in Figure 2. It is more complicated than the industry interaction.

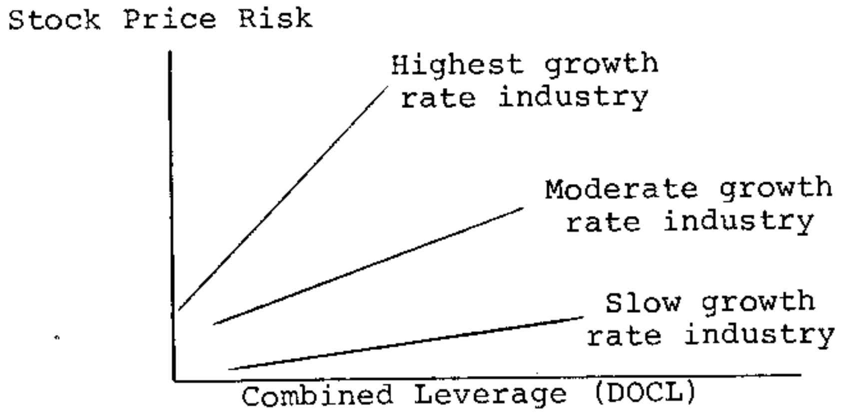

Fig. 2--Growth interaction

The sample will be split into three subgroups depending on whether the interaction variable is low, medium, or high. The question is whether the effect of combined leverage on variability of stock prices tends to be stronger in slow, moderate, or rapid growth industries. The anticipated growth interaction is as follows: the effect of combined leverage on the stability of stock prices will be the greatest in rapid growth industries. Higgins suggests a method for calculating the sustainable growth rate (g*) by equating the addition of assets (to support increased sales).[4] He obtains the g* as follows:

$$g^* = \frac{P \cdot (1 - d)\ (1 + L)}{t - P \cdot (1 - d)\ (1 + L)}, \tag{1}$$

where

g^* = sustainable growth rate,

P = the profit margin on new and existing sales after taxes,

d = the target dividend payout ratio { (1 - d), therefore, is the target retention ratio},

L = the target total debt to equity ratio,

t = the ratio of total assets to net sales on new and existing sales,

s = sales at the beginning of the year, and

ΔS = increase in sales during the year.

For companies that wish to maintain a target payout ratio and capital structure without issuing new equity, sustainable growth is defined by Higgins as the maximum percentage increase in sales that is consistent with the firm's established financial policies. If sales expand at any greater rate, something in the company's financial objectives will have to give--usually to the detriment of financial soundness.[5] From

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[4] Robert C. Higgins, "How Much Growth Can a Firm Afford," Financial Management, 6 (Fall, 1977), 7-16.

[5] Ibid., p. 7.

Higgins's g* equation, if actual growth in sales (g) exceeds g*, P (profit margin) and L (leverage) must increase or d (payout ratio) must decrease--or the firm must sell new shares. In other words, the steps a company can take to balance its growth targets and its sustainable growth rate are a reduction in the firm's dividend payout ratio, an increase in its leverage, an improvement in operating performance, or a sale of new equity shares.[6]

During inflationary periods, however, when stock prices drop and many enterprises are either unable or unwilling to sell new equity, problems of sustainable growth are very real ones.[7] This implies that during inflationary periods firms are more likely to be forced to depend on debt financing. In addition, rapid growth firms which financed with debt should magnify the returns on equity. Therefore, as actual growth in sales (g) greatly exceeds g*, firms tend to be more levered, especially during inflationary periods.

Rapid growth industries tend to incur high operating leverage. For example, a conversion from a less capital intensive operation to a more capital intensive operation implies high product demand.

According to industry life cycle theory, the first stage is development, during which the infant industry develops a new product. Marketing costs in this development

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[6] Ibid., p. 8. [7] Ibid., p. 9.

stage are high because of the introductory expenses involved, especially those dealing with promotional activities which encourage dealers to carry inventories of new products.[8]

The second stage of industry life cycle is growth. Goodman states,

> This tendency toward competition generally produces some ancillary effects. Once the skimming policy of pricing which was developed in the development stage of the life cycle has taken the initial consumer demand for the product from the market, tendencies toward price softening begin to occur, despite the fact that distribution becomes more broad-based. At the same time, if there is evidence that the product does have the potential of catching on with respect to consumer demand, it is probably that the producer will begin to look beyond the pilot equipment facilities which are being used to produce the product and, instead, will begin to think in terms of longer term equipment which will introduce efficiencies in manufacturing.[9]

According to Goodman's description, the characteristics of the growth stage are that demand for a product is strong, competition is severe, and management tries to top and expand the market by reducing costs and improving quality. Management introduces efficiencies in manufacturing to reduce costs, to improve productivity, and to lower sale

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[8]Sam R. Goodman, Techniques of Profitability Analysis (New York, 1970), pp. 73-78; Theodore Levitt, "Exploit the Product Life Cycle," Harvard Business Review, 43 (November-December, 1964), 43-62.

[9]Goodman, p. 78.

prices.[10] This leads to overcapacity since, although demand for the product is rising, productive capacity increases more rapidly.

The above discussion shows why growing firms tend to increase both their financial and their operating leverage: in other words, the faster the growth, the higher the combined leverage. Rapid growth results in secular price declines and higher combined leverage. In short, rapid-growth industries' DFL and DOL are often too large because of the large debt financing undertaken to build up excess capacity. This combination of product price decline and large DOCLs makes profitability fluctuate even more severely. Further, the value of a growth stock is difficult to estimate because both future earnings growth and its duration must be estimated. The above analysis suggests that the effect of combined leverage on stock prices volatility should be greater in the higher growth industries.

Hypothesis Tests

The first hypothesis is that stock risk is a function of combined leverage. Symbolically:

H_{01}: Stock risk is not a linear function of DOCL.

H_{a1}: Stock risk is a linear function of DOCL.

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[10]Sam R. Goodman, "Improved Marketing Analysis of Profitability, Relevant Costs, and Life Cycles," Financial Executive, (June, 1967), 72; Theodore Levitt, Marketing for Business Growth (New York, 1974), pp. 158-168.

This hypothesis is tested with model I;

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

where

Risk = coefficient of variation of stock price or BETA, CV price measures total risk and BETA measures systematic risk--both are tested,

DOCL = degree of combined leverage, the sales elasticity of earnings (see p. 94),

β_0 = intercept,

β_1 = coefficient of DOCL, and

e = residual.

Using two measures of risk results in two alternative forms of Model I. They are

$$\text{CV price} = \beta_0 + \beta_1 \text{ DOCL} + e \qquad \text{(Model } \mathrm{I}_a\text{)}$$

$$\text{BETA} = \beta_0 + \beta_1 \text{ DOCL} + e \qquad \text{(Model } \mathrm{I}_b\text{)}$$

Each hypothesis has a related model. Hypothesis two is tested with Model II, hypothesis three with Model III, etc. Each model had two forms; form "a" uses CV price as the risk measure and form "b" uses BETA as the risk measure.

The second hypothesis is that there is no difference among different types of industries on the effect of the DOCL on stock price risk. Symbolically:

H_{02}: $\alpha_{1,d} = \alpha_{2,d} \cdot \cdot \cdot = \alpha_{n-1,d}$ or

$\beta_{1,\eta d} = \beta_{2,\eta d} \cdot \cdot \cdot = \beta_{n-1,\eta d}$

where 1 to n-1 denote different types of industries

H_{a2}: not all α's are equal or not all β's are equal

This hypothesis is tested with Model II (in its two subforms):

$$\text{Risk} = A_0 + A_1 \text{ DOCL} + \alpha_{1,d} D_1 + \alpha_{2,d} D_2 + \cdot \cdot \cdot$$
$$\alpha_{n-1,d} D_{n-1} + \beta_{1,\eta d} D_1 \cdot \text{DOCL} + \beta_{2,\eta d} D_2 \cdot \text{DOCL} \cdot \cdot \cdot$$
$$\beta_{n-1,\eta d} D_{n-1} \cdot \text{DOCL} + e \qquad \text{(Model II)}$$

where

Risk	= Same as Model I,
A_0	= intercept,
DOCL	= the degree of combined leverage,
A_1	= the coefficient of DOCL,
D_1 to D_{n-1}	= industry dummy variables (type of industries),

$\alpha_{1,d}$ to $\alpha_{n-1,d}$ = differential intercept coefficient,

η = subscript for DOCL (η is Huffmann's notation for this measure of combined leverage),

d = subscript for dummy variable (type of industry),

$D_1 \cdot DOCL$ to $D_{n-1} \cdot DOCL$ = interacting variables between industries and DOCL, and

$\beta_{1,\eta d}$ to $\beta_{n-1,\eta d}$ = differential slope coefficients.

In Model II, D_1 to D_{n-1} represent n industries. The statistical rule is that, if a qualitative variable has n categories, only n-1 dummy variables should be introduced. The coefficients $\alpha_{1,d}$ to $\alpha_{n-1,d}$ attached to those dummy variables D_n to D_{n-1} can be called the differential intercept coefficient because it indicates by how much the value of the intercept term of the category that receives the value of 1 differs from the intercept coefficient of the base category. $\beta_{1,\eta d}$ to $\beta_{n-d,\eta d}$ are those differential slope coefficients indicating by how much the slope coefficient of an industry's stock price variation function differs from the slope coefficient of a base category's (base industry) stock price variation function.[11] The introduction of the dummy

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[11]Paul E. Green, Analyzing the Multivariate Data (Hinsdale, 1978), pp. 94-141; Damodar Gujarati, Basic Econometrics (New York, 1978), pp. 287-309.

variables D_1 to D_{n-1} in the multiplicative form (D_i where $i = 1, \ldots n-1$, multiplied by DOCL) enables us to differentiate between slope coefficients of the two groups, just as the introduction of the dummy variables in the additive form enables us to distinguish between the intercepts of the two groups. Therefore, if any industry's differential intercept coefficient or differential slope coefficient is positive, it means this particular industry's intercept or slope is larger than the base industry's intercept or slope by the amount of that positive coefficient.

Different industries have different sales and cost stabilities; thus, DOCL might create different impact on earning-per-share stability, in different industries. The degree of sales instability varies from industry to industry and business cycle to business cycle. Therefore, the question is whether the effect of combined leverage on stock-price-variability tends to be stronger in certain industries.

The third hypothesis is that industry growth rates do not affect the impact of combined leverage on stock price risk. Symbolically:

$$H_{03}: \quad a_{i,g} = a_{j,g} \text{ or }$$
$$b_{i,ng} = b_{j,ng}$$

for all i, j, where i and j denote different growth-rate industries

H_{a3}: Not all a's are equal or
not all b's are equal

This hypothesis is tested with Model III:

$$\text{Risk: } \lambda_0 + \lambda_1 \text{ DOCL} + a_{1,g} G_1 + a_{2,g} G_2 + b_{1,ng} G_1 \cdot \text{DOCL} + b_{2,ng} G_2 \cdot \text{DOCL} + e \qquad \text{(Model III)}$$

where

Risk	= same as Model I,
λ_0	= intercept,
DOCL	= same as Model I,
λ_1	= coefficient of DOCL,
G_1	= 1 of high-growth rate industry (industries with sales growth rates greater than .15 standard deviations above the all-industry mean)
	= 0 otherwise
G_2	= 1 of medium-growth rate industry (industries with sales growth rates between the all-industry growth rate mean ± .15 standard deviations)
	= 0 otherwise
g	= subscript for growth rate dummy
$a_{1,g}$ and $a_{2,g}$	= differential intercept coefficient

$G_1 \cdot$ DOCL and $G_2 \cdot$ DOCL = interaction variables between industry growth rates and DOCL, and

$b_{1,ng}$, $b_{2,ng}$ = differential slope coefficients.

In Model III, G_1 and G_2 are zero-one growth dummy variables which reflect whether the level of growth interaction variable is a high-growth rate industry or a medium-growth rate industry. Therefore, when both G_1 and G_2 are zero, this represents a low-growth rate industry.

DOCL vs. DTL as combined leverage measures.--The fourth hypothesis is that combined leverage (DOCL) is a better measure (e.g., lower Cp and lower PRESS value) than DOL and DFL together (or DTL). This is tested in the null form; symbolically:

H_{04}: DOCL does not provide better risk prediction accuracy than do DOL and DFL together.

H_{a4}: DOCL provies better risk prediction accuracy than do DOL and DFL together.

This hypothesis is tested with Model IV:

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

where

Risk = same as Model I

DOCL = same as Model I

DOL = degree of operating leverage

DFL = degree of financial legerage

e = residual

In order to compare with Mandelker and Rhee's[12] (MR) study, exactly the same traditional total leverage was used. Textbooks say DTL = DOL · DFL. Using both DOL and DFL in regression model is equivalent, therefore, to using DTL. That is, like MR's paper, both DOL and DFL will be included in the regression model as total leverage (DTL).

Model IV, which is obtained from MR's paper, and Model (I) are used in comparing the effectiveness of the combined leverage measures between DOCL and DTL (DOL and DFL together). The value of adjusted coefficients of determination (adjusted R^2), probabilities of F values, standard error estimates of both models will be used to compare these two models. Also, the total squared error as a criterion for goodness of fit--Cp[13] and the prediction error sum of squares, PRESS[14] statistic, will be utilized. Cp measures the sum of the squared

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[12]Gershon N. Mandelker and S. Ghon Rhee, "The Impact of the Degrees of Operating and Financial Leverage on Systematic Risk of Common Stock," Journal of Financial and Quantitative Analysis, 19 (March, 1984), p. 49.

[13]John Neter and William Wasserman, Applied Linear Statistical Models (Homewood, 1974), pp. 371-392; Cuthbert Daniel and Fred S. Wood, Fitting Equations to Data (New York, 1980), pp. 83-148.

[14]Mary Sue Younger, A Handbook for Linear Regression (North Scituate, Massa., 1979), pp. 483-493.

biases plus the squared random errors in Y (dependent variable) and N data points. When using the Cp criterion, one seeks to identify the set of independent variables that leads to the smallest Cp value. PRESS statistic tells which model will predict the best on out-of-sample data.

Interaction effect.--To find out whether a significant interaction effect exists between DOL and DFL, an interaction variable DOL · DFL is added in MR's model, called Model V. If the interaction variable, DOL · DFL, is statistically significant, it means MR's model is oversimplified. Therefore, the fifth hypothesis is that there is no interaction effect between DOL and DFL. Symbolically:

$$H_{05}: \ b_3 = 0$$

$$H_{a5}: \ b_3 \neq 0$$

This hypothesis is tested with Model V.

$$\text{Risk} = a_0 + b_1 \text{ DOL} + b_2 \text{ DFL} + b_3 \text{ DOL} \cdot \text{DFL} + e \qquad \text{Model V}$$

where

Risk = same as Model I,

DOL = degree of operating leverage,

DFL = degree of financial leverage,

DOL · DFL = interaction variable (DOL and DFL), and

e = residual.

Proxy Measures

Measuring of combined leverage.--DOCL is the degree of combined leverage. It can be derived as follows:

$$\text{DOCL} = \frac{\%\ \Delta\text{EAT}}{\%\ \Delta\text{Sales}}$$

DOCL may also be estimated alternatively as β_1 in the following model.

$$\ln \text{EAT} = \alpha_0 + \beta_1 \ln \text{sales} + e, \qquad (2)$$

where ln denotes natural log. This model is linear in the parameters α_0 and β_1 and linear in the logarithms of the variables EAT (earnings after tax and preferred dividend) and sales, hence the name double-log or log-linear model. In this study, DOCL will be estimated by the method of OLS, using company earnings after taxes and preferred dividend (EAT) and sales data for eighteen years (1964-1981).

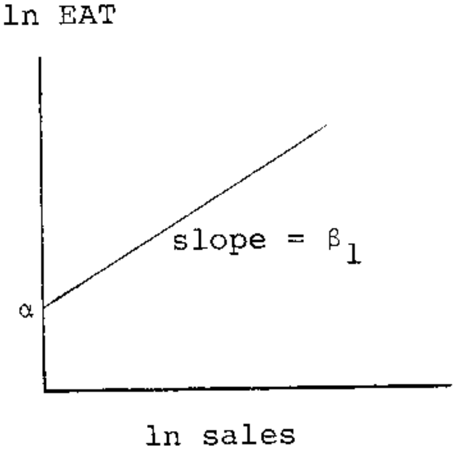

Fig. 3--Measurement of DOCL

β_1 indicates that, when sales change 1%, on the average

EAT changes β_1%. Therefore, β_1, which represents DOCL, is an average elasticity coefficient. The traditional measure of combined leverage, DTL, is a point elasticity. Averaging the degree of combined leverage for a number of years can minimize both the effect of any short-term fluctuations and management's selection among alternative accounting procedures. More importantly, average combined leverage is used instead of any particular year's combined leverage because of fluctuations in the business cycle.

Measurement of growth rate.--G is the growth rate of each industry. It can be derived as follows:

$$G = \frac{\text{relative change in sales}}{\text{absolute change in time}}.$$

The β_1 of the following growth model measures the growth over time of the sales.

$$\ln \text{Sales} = \alpha_0 + \beta_1 \text{ Time} + e \qquad (3)$$

This is estimated using company sales data for ten years. In this study, a high growth-rate industry is defined as one with a sales growth rate greater than .15 standard deviations above the all-industry mean. A medium-growth industry has a growth rate between these two, i.e., the mean ± .15 standard deviations. A low-growth rate industry has a sales growth rate of less than .15 standard deviation below the all-industry mean.

Measuring stock risk.--Two measures of stock risk will be tested, CV price and Beta. CV price (the coefficient of variation of stock prices) can be calculated as follows:

$$\text{CV price} = \frac{\sigma(\text{price})}{E(\text{price})} = \frac{\text{standard deviation of stock price}}{\text{expected value of stock price}}$$

Betas were obtained from *Value Line*.

Measurements of DOL and DFL.--Since the degree of leverage is built on the concept of elasticity, like MR's paper, the following time-series regressions are used.

$$\ln \text{EBIT} = a_0 + a_1 \ln \text{sales} + e \qquad \text{(A)}$$

$$\ln \text{EAT} = b_0 + b_1 \ln \text{EBIT} + e \qquad \text{(B)}$$

The estimated regression coefficients, a_1 and b_1, represent the degrees of operating leverage (DOL) and financial leverage (DFL) respectively.

Data.--All data except BETAs between 1964 and 1981 were taken from COMPUSTAT data files. Model I, IV, and V which use CVPR as dependent variables are based on a sample of 758 firms during the period from 1964 to 1981. For Beta as dependent variable, Model I, IV, and V are based on a sample of 820 firms during the period from 1977 to 1981.

Those companies which have negative operating income or earnings in any year between 1964 and 1981 were dropped from these ten industries because loss-firms' stock prices usually drop sharply (investor's psychological effect) in a way which is unexplained by such factors as combined leverage. BETAs were obtained from Value Line.

The ten industries selected represent varying degrees of financial and operating leverage. They also have different industry growth rates.[15]

Summary

This study examines 1) the relationship between firms' combined leverage and volatility of stock prices (Model I), 2) the differences among different types of industries on the effect of combined leverage on stock prices (Model II), 3) whether industry growth rates are related to the impact of combined leverage on stock prices (Model III), 4) whether combined leverage is a better measure than DOL and DFL together (or DTL) (Model IV), and 5) whether there is a significant interaction between DOL and DFL.

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[15] Sources of data are described in detail in Appendix B.

CHAPTER IV

RESULTS

Models I, IV, and V which use CVPR as dependent variables are based on a sample of 758 firms during the period from 1964 to 1981. Models II and III which use CVPR as dependent variable and use industry or industry growth rate as interacting variables are based on a sample of 220 firms and 322 firms respectively during the period from 1964 to 1981. Although there are hundreds of industries on COMPUSTAT, only part of these could be chosen for Models II and III; many industries contain too few companies for this part of the study. Model III (industry growth rate interaction) uses more industries than Model II (industry interaction) because industries are classified into only three classifications--high, medium, and low growth rate.

For BETA as dependent variable, Model I, IV, and V are based on a sample of 820 firms during the period from 1977 to 1981, and Models II and III are based on a sample of 190 and 345 firms during the period from 1977 to 1981. For inclusion, these firms were required to have complete financial data on the Standard and Poor's Compustat Annual Data tape (1964-1981) for calculating CVPR and that BETA data be available on Value Line (1977-1981). Moody's Industrial Manuals (1964-1981) were used to verify some ambiguous or missing financial data.

Empirical Results

Mandelker and Rhee's model uses multiplicative form (log form) in both dependent variable (BETA) and independent variables (DOL and DFL). Since DOL and DFL measures are based on the concept of elasticity, it is easy to understand how many DOLs and DFLs might be negative. Therefore, without some forms of aggregation, it is impossible to take a natural log for all observations due to the negative DOLs and negative DFLs. That may be one reason MR combined companies into portfolios--to obtain positive DOLs and DFLs. It appears that MR's results may be biased (and incorrect) and they are, necessarily subjective. Regardless, this study reports two forms of results, one is additive form (without double log) and the other is multiplicative (with the double log transformation).

The first hypothesis which is tested with Model I is that the relative price variability (CV price and/or BETA) of a common stock is related to the degree of combined leverage of the firm. Equation (1), the empirical results of Model I (additive form), are as follows:

$$CVPR = \underset{(0.0001)}{11.15} + \underset{(0.0001)}{44.07}\ DOCL \tag{1a}$$

$$BETA = \underset{(0.0001)}{0.95} + \underset{(0.0001)}{0.05}\ DOCL \tag{1b}$$

The significant levels are in parentheses. The adjusted $R^2_{(1a)} = .2417$ and adjusted $R^2_{(1b)} = .0203$.

The t value of combined leverage (DOCL) variable for equation (1a) is 15.56 and for equation (1b) is 4.24, indicating DOCL is significant at 0.0001 in both models. The criterion of significance level for the above equation and the rest of the equations in this chapter is set at 10 percent. In the multiplicative form (with double log) of equation 1, the results are as follows:

$$\ln CVPR = \underset{(0.0001)}{3.90} + \underset{(0.0001)}{0.62}\ \ln DOCL \tag{1a$'$}$$

$$\ln BETA = \underset{(0.0058)}{-0.03} + \underset{(0.0001)}{0.06}\ \ln DOCL \tag{1b$'$}$$

The adjusted $R^2_{(1a')} = .2210$ and adjusted $R^2_{(1b')} = 0.0228$.

The t value of combined leverage (DOCL) variable for equation (1a$'$) is 14.69 and for equation (1b$'$) is 4.49, indicating DOCL is significant at 0.0001 and 0.0001 levels, respectively. Thus, from both additive form and multiplicative form, relatively large amounts of combined leverage tend to raise the coefficients of variation of stock prices and systematic risk.

In the second hypothesis types of industry were introduced as an interacting variable. The appropriate question asked is whether the effect of DOCL on CVPR tends to be stronger in certain types of industries. It is expected that the effect of DOCL on CVPR varies from industry to industry. Different industries have different sales and cost stabilities; DOCL might create different impacts on earning-per-share stability in different industries. The degree of sales instability varies from industry to industry and business cycle to business cycle. Thus the effect of combined leverage on the stability of stock prices depends on the type of industry in question. The empirical results of Model II (additive form) are presented in Table I.

From equation (2a) one can derive several individual regressions, three of which are as follows: The mean CVPR of utility industry, the base category (i.e., when all dummies take a value of zero) is

$$\begin{aligned} CVPR &= 0 + 40.09\ DOCL; \\ &= 40.09\ DOCL \end{aligned} \tag{2a$_1$}$$

(Note: the intercept is set to zero because it is not statistically significant; this convention is followed throughout this study, i.e., if a coefficient is nonsignificant, it is

TABLE I

REGRESSION COEFFICIENTS FOR MODEL II
(SIGNIFICANCE LEVEL PROBABILITY)

Industry Interaction (Additive Form)

$$
\begin{aligned}
CVPR = &\underset{(0.9181)}{-0.64} + \underset{(0.0001)}{40.09}\ DOCL + \underset{(0.1026)}{22.03}\ D_1 - \underset{(0.9079)}{1.41}\ D_2 \\
&- \underset{(0.3137)}{52.06}\ D_3 + \underset{(0.3570)}{42.91}\ D_4 + \underset{(0.1667)}{49.87}\ D_5 - \underset{(0.6219)}{19.94}\ D_6 \\
&- \underset{(0.9596)}{0.77}\ D_7 - \underset{(0.2143)}{72.69}\ D_8 + \underset{(0.0589)}{44.92}\ D_9 - \underset{(0.5766)}{8.37}\ D_1 \cdot DOCL \\
&+ \underset{(0.0132)}{32.70}\ D_2 \cdot DOCL + \underset{(0.0650)}{91.18}\ D_3 \cdot DOCL - \underset{(0.6907)}{16.84}\ D_4 \cdot DOCL \\
&- \underset{(0.4208)}{34.37}\ D_5 \cdot DOCL + \underset{(0.3178)}{44.94}\ D_6 \cdot DOCL + \underset{(0.0565)}{35.14}\ D_7 \cdot DOCL \\
&+ \underset{(0.0701)}{114.79}\ D_8 \cdot DOCL - \underset{(0.2558)}{31.85}\ D_9 \cdot DOCL
\end{aligned}
$$

$$R^2 = \underset{(0.0001)}{0.6152} \qquad (2a)^*$$

$^*D_1$ = steel industry	D_6 = retail drug stores
D_2 = machine industry	D_7 = petroleum refining
D_3 = electric measures and testing industry	D_8 = engineering and architect services
D_4 = computer	D_9 = publishing industry
D_5 = bottled-canned soft drinks	base industry = utility industry

TABLE I--Continued

Industry Interaction (Additive Form)

$$
\begin{aligned}
\text{BETA} = \ & \underset{(0.0001)}{0.66} + \underset{(0.4987)}{0.05}\ \text{DOCL} + \underset{(0.0012)}{0.46}\ D_1 + \underset{(0.0568)}{0.27}\ D_2 \\
& + \underset{(0.1848)}{0.29}\ D_3 + \underset{(0.0008)}{0.33}\ D_4 + \underset{(0.0001)}{0.66}\ D_5 + \underset{(0.0003)}{0.50}\ D_6 \\
& + \underset{(0.0095)}{0.55}\ D_7 + \underset{(0.0451)}{0.31}\ D_8 + \underset{(0.0720)}{0.28}\ D_9 - \underset{(0.4963)}{0.07}\ D_1 \cdot \text{DOCL} \\
& + \underset{(0.4963)}{0.08}\ D_2 \cdot \text{DOCL} - \underset{(0.8118)}{0.04}\ D_3 \cdot \text{DOCL} + \underset{(0.9386)}{0.01}\ D_4 \cdot \text{DOCL} \\
& - \underset{(0.8981)}{0.01}\ D_5 \cdot \text{DOCL} - \underset{(0.9553)}{0.01}\ D_6 \cdot \text{DOCL} - \underset{(0.1884)}{0.26}\ D_7 \cdot \text{DOCL} \\
& + \underset{(0.4700)}{0.13}\ D_8 \cdot \text{DOCL} - \underset{(0.9701)}{0.01}\ D_9 \cdot \text{DOCL} \\
& R^2 = \underset{(0.0001)}{0.5432} \qquad (2b)^{**}
\end{aligned}
$$

$^{**}D_1$ = chemical and allied products	D_6 = radio/TV transmitting equipment
D_2 = drug	D_7 = trucking
D_3 = steel	D_8 = chain restaurants
D_4 = machine	D_9 = retail drug stores
D_5 = computer	base industry = utility industry

treated as if it were zero.) The mean CVPR of machine industry (i.e., when dummy 2 is equal to 1) is

$$\text{CVPR} = 0 + (40.09 + 32.70)\ \text{DOCL};$$
$$= 72.79\ \text{DOCL}. \qquad (2a_2)$$

In equation ($2a_2$), 40.09 represents the base industry's slope coefficient and 32.70 is the differential slope coefficient (the difference between machine industry and utility industry). The mean CVPR of petroleum refining industry (i.e., when dummy 7 is equal to 1) is

$$\text{CVPR} = 0 + (40.09 + 35.14)\ \text{DOCL};$$
$$= 75.23\ \text{DOCL}. \qquad (2a_3)$$

From equation (2b) one can also derive several individual regressions, three of which are as follow: The mean BETA of utility industry (i.e., when all dummies take a value of zero) is

$$\text{BETA} = 0.66 + 0\ \text{DOCL};$$
$$= 0.66 \qquad (2b_1)$$

The mean BETA of chemical industry (i.e., when dummy 1 is equal to 1) is

$$\text{BETA} = 0.66 + 0.45 + 0\ \text{DOCL};$$
$$= 1.11. \qquad (2b_2)$$

The mean BETA of computer industry (i.e., when dummy 5 is equal to 1) is

$$\text{BETA} = 0.66 + 0.66 + 0\ \text{DOCL};$$
$$= 1.32 \qquad (2b_3)$$

In equation (2b), if none of the differential slope coefficients are statistically significant, it would mean that the slopes of all industries are the same. Since most differential intercept coefficients are statistically significant, one may accept the hypothesis that the regressions have different intercepts.

The results of Model II (multiplicative form) are presented in Table II. From equation (2a′) of Table II one can derive several individual regressions, three of which are as follows: The mean ln CVPR of utility industry (when all dummies are zero) is

$$\ln \text{CVPR} = 3.42 + 0.47 \ln \text{DOCL}. \qquad (2a_1')$$

The mean ln CVPR of computer industry (when dummy 4 is equal to 1) is

$$\begin{aligned} \ln \text{CVPR} &= (3.42 + 0.64) + 0.47 \ln \text{DOCL}; \\ &= 4.06 + 0.47 \ln \text{DOCL}. \qquad (2a_2') \end{aligned}$$

The mean ln CVPR of petroleum refining (when dummy 7 is equal to 1) is

$$\begin{aligned} \ln \text{CVPR} &= (3.42 + 0.85) + (0.47 + 0.59) \ln \text{DOCL}; \\ &= 4.27 + 1.06 \ln \text{DOCL}. \qquad (2a_3') \end{aligned}$$

TABLE II

REGRESSION COEFFICIENTS FOR MODEL II (LOG FORM)
(SIGNIFICANCE LEVEL PROBABILITY)

Industry Interaction (Multiplicative Form)

$$
\begin{aligned}
\ln CVPR = {} & \underset{(0.0001)}{3.42} + \underset{(0.0001)}{0.47} \ln DOCL + \underset{(0.0001)}{0.52}\, D_1 + \underset{(0.0001)}{0.75}\, D_2 \\
& + \underset{(0.0001)}{0.92}\, D_3 + \underset{(0.0001)}{0.63}\, D_4 + \underset{(0.0060)}{0.56}\, D_5 \\
& + \underset{(0.0001)}{0.73}\, D_6 + \underset{(0.0001)}{0.85}\, D_7 + \underset{(0.0020)}{0.94}\, D_8 \\
& + \underset{(0.0024)}{0.52}\, D_9 - \underset{(0.9082)}{0.02}\, D_1 \cdot \ln DOCL \\
& - \underset{(0.8734)}{0.02}\, D_2 \cdot \ln DOCL + \underset{(0.2816)}{1.17}\, D_3 \cdot \ln DOCL \\
& - \underset{(0.9292)}{0.09}\, D_4 \cdot \ln DOCL - \underset{(0.4703)}{0.42}\, D_5 \cdot \ln DOCL \\
& + \underset{(0.1554)}{0.97}\, D_6 \cdot \ln DOCL + \underset{(0.0276)}{0.59}\, D_7 \cdot \ln DOCL \\
& + \underset{(0.1354)}{1.75}\, D_8 \cdot \ln DOCL + \underset{(0.3232)}{0.39}\, D_9 \cdot \ln DOCL \\
& R^2 = \underset{(0.0001)}{0.6022} \qquad (2\acute{a})^{***}
\end{aligned}
$$

***Those industries chosen for this regression are the same as additive form for CVPR in Table I.

TABLE II--Continued

Industry Interaction (Multiplicative Form)

$$
\begin{aligned}
\ln \text{BETA} = {} & \underset{(0.0001)}{-0.37} + \underset{(0.4398)}{0.05} \ln \text{DOCL} + \underset{(0.0001)}{0.45}\, D_1 \\
& + \underset{(0.0001)}{0.43}\, D_2 + \underset{(0.0003)}{0.33}\, D_3 + \underset{(0.0001)}{0.42}\, D_4 + \underset{(0.0001)}{0.64}\, D_5 \\
& + \underset{(0.0001)}{0.54}\, D_6 + \underset{(0.0002)}{0.33}\, D_7 + \underset{(0.0001)}{0.52}\, D_8 + \underset{(0.0001)}{0.36}\, D_9 \\
& - \underset{(0.4973)}{0.08}\, D_1 \cdot \ln \text{DOCL} + \underset{(0.6308)}{0.06}\, D_2 \cdot \ln \text{DOCL} \\
& - \underset{(0.6979)}{0.08}\, D_3 \cdot \ln \text{DOCL} + \underset{(0.6859)}{0.03}\, D_4 \cdot \ln \text{DOCL} \\
& + \underset{(0.3768)}{0.09}\, D_5 \cdot \ln \text{DOCL} - \underset{(0.9089)}{0.02}\, D_6 \cdot \ln \text{DOCL} \\
& - \underset{(0.1340)}{0.20}\, D_7 \cdot \ln \text{DOCL} + \underset{(0.5372)}{0.07}\, D_8 \cdot \ln \text{DOCL} \\
& + \underset{(0.9202)}{0.01}\, D_9 \cdot \ln \text{DOCL} \qquad R^2 = \underset{(0.0001)}{0.5728} \qquad (2b')^{****}
\end{aligned}
$$

****Those industries chosen for this regression are the same as additive form for BETA in Table I.

Similarly, one can derive several individual regressions from equation (2b́) of Table II. Both additive form and multiplicative forms of equation 2 support the second hypothesis. That is, the impact of DOCL on risk is different across industries.

The third hypothesis is that industry growth rates affect the impact of combined leverage on stock price risk.

The empirical results of model III (additive form), are presented in Table III.

From equation (3a) one can derive three individual regressions. The mean CVPR of low-growth-rate industries (when all dummies take a value of zero) is

$$\begin{aligned} \text{CVPR} &= 0 + 39.48 \text{ DOCL;} \\ &= 39.48 \text{ DOCL.} \end{aligned} \tag{3a$_1$}$$

The mean CVPR of medium-growth-rate industries (when dummy G_2 equals 1) is

$$\begin{aligned} \text{CVPR} &= (0 + 0) + (39.48 + 0) \text{ DOCL;} \\ &= 39.48 \text{ DOCL.} \end{aligned} \tag{3a$_2$}$$

The mean CVPR of high-growth-rate industries (when dummy G_1 equals 1) is

$$\begin{aligned} \text{CVPR} &= (0 + 0) + (39.48 + 24.76) \text{ DOCL;} \\ &= 64.24 \text{ DOCL.} \end{aligned} \tag{3a$_3$}$$

One can also derive three individual regressions from equation (3b). The mean BETA of low-growth-rate industries (when all dummies take a value of zero) is

$$\text{BETA} = 0.78 + 0.09 \text{ DOCL.} \tag{3b$_1$}$$

The mean BETA of medium-growth-rate industries (when dummy G_2 equals 1) is

TABLE III

REGRESSION COEFFICIENTS FOR MODEL III
(SIGNIFICANCE LEVEL PROBABILITY)

Growth Interaction (Additive Form)

$$CVPR = \underset{(0.3548)}{4.42} + \underset{(0.0001)}{39.48}\ DOCL - \underset{(0.7638)}{3.01}\ G_1 - \underset{(0.2735)}{9.35}\ G_2$$

$$+ \underset{(0.0195)}{24.76}\ G_1 \cdot DOCL + \underset{(0.1785)}{14.02}\ G_2 \cdot DOCL$$

$$R^2 = \underset{(0.0001)}{0.4255} \qquad (3a)^*$$

$$BETA = \underset{(0.0001)}{0.78} + \underset{(0.0056)}{0.09}\ DOCL + \underset{(0.0001)}{0.24}\ G_1 + \underset{(0.0925)}{0.11}\ G_2$$

$$+ \underset{(0.9295)}{0.004}\ G_1 \cdot DOCL - \underset{(0.9057)}{0.01}\ G_2 \cdot DOCL$$

$$R^2 = \underset{(0.0001)}{0.1974} \qquad (3b)^*$$

*See Appendix C for explanation of the industry growth rate classification used in these regressions.

$$BETA = (0.78 + 0.11) + (0.09 + 0)\ DOCL;$$

$$= 0.89 + 0.09\ DOCL. \qquad (3b_2)$$

The mean BETA of high-growth-rate industries (when dummy G_1 equals 1) is

$$BETA = (0.78 + 0.24) + (0.09 + 0)\ DOCL;$$

$$= 1.02 + 0.09\ DOCL. \qquad (3b_3)$$

Table IV presents the results of model III (Eq. 3--multiplicative form).

TABLE IV

REGRESSION COEFFICIENTS FOR MODEL III (LOG FORM)
(SIGNIFICANCE LEVELS PROBABILITIES)

Growth Interaction (Multiplicative Form)

$$\ln CVPR = \underset{(0.0001)}{3.67} + \underset{(0.0001)}{0.56} \ln DOCL + \underset{(0.0001)}{0.42} G_1 - \underset{(0.7837)}{0.02} G_2$$

$$+ \underset{(0.0397)}{0.39} G_1 \cdot DOCL + \underset{(0.6175)}{0.07} G_2 \cdot DOCL$$

$$R^2 = \underset{(0.0001)}{0.3837} \qquad (3a')^*$$

*Those industries chosen for this regression are the same as Table III (additive form).

$$\ln BETA = \underset{(0.0001)}{-0.16} + \underset{(0.0182)}{0.09} \ln DOCL + \underset{(0.0001)}{0.25} G_1 + \underset{(0.0008)}{0.13} G_2$$

$$+ \underset{(0.7090)}{0.02} G_1 \cdot \ln DOCL + \underset{(0.3955)}{0.05} G_2 \cdot \ln DOCL$$

$$R^2 = \underset{(0.0001)}{0.2014} \qquad (3b')^{**}$$

**Those industries chosen for this regression are the same as Table III (additive form).

From equation (3a′) one can derive three individual regressions: The mean ln CVPR of low-growth-rate industries (when all dummies take a value of zero) is

$$\ln CVPR = 3.67 + 0.56 \ln DOCL. \qquad (3a'_1)$$

The mean ln CVPR of medium-growth-rate industries (when dummy G_2 equals 1) is

$$\ln CVPR = (3.67 + 0) + (0.56 + 0) \ln DOCL$$
$$= 3.67 + 0.56 \ln DOCL. \qquad (3a'_2)$$

The mean ln CVPR of high-growth-rate industries (when dummy G_1 equals 1) is

$$\ln CVPR = (3.67 + 0.42) + (0.56 + 0.40) \ln DOCL$$
$$= 4.09 + 0.60 \ln DOCL. \qquad (3a'_3)$$

The results of equation (3a') (multiplicative form) can be depicted graphically as shown in Figure 3.

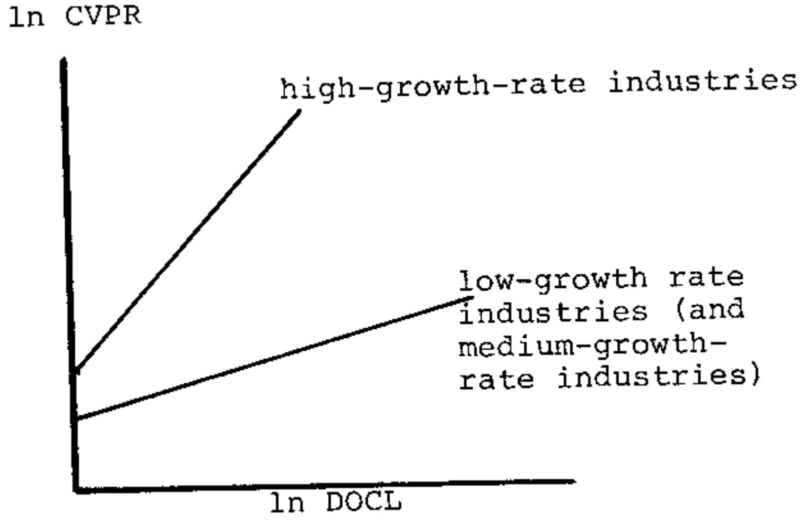

Fig. 4--Growth interaction (ln CVPR)

From equation (3b'), multiplicative form one can derive three individual regressions: The mean ln BETA of low-growth-rate industries (when all dummies take a value of zero) is

$$\ln BETA = -0.16 + 0.09 \ln DOCL. \qquad (3b'_1)$$

The mean ln BETA of medium-growth-rate industries (when dummy G_2 equals to 1) is

$$\ln \text{BETA} = (-0.16 + 0.13) + (0.09 + 0) \ln \text{DOCL};$$
$$= -.03 + 0.09 \ln \text{DOCL}. \qquad (3b'_2)$$

The mean ln BETA of high-growth-rate industries (when dummies G_1 equals to 1) is

$$\ln \text{BETA} = (-0.16 + 0.25) + (0.09 + 0) \ln \text{DOCL};$$
$$= 0.09 + 0.09 \ln \text{DOCL}. \qquad (3b'_3)$$

The results of equation (3b') (multiplicative form) can be depicted graphically as shown in Figure 4.

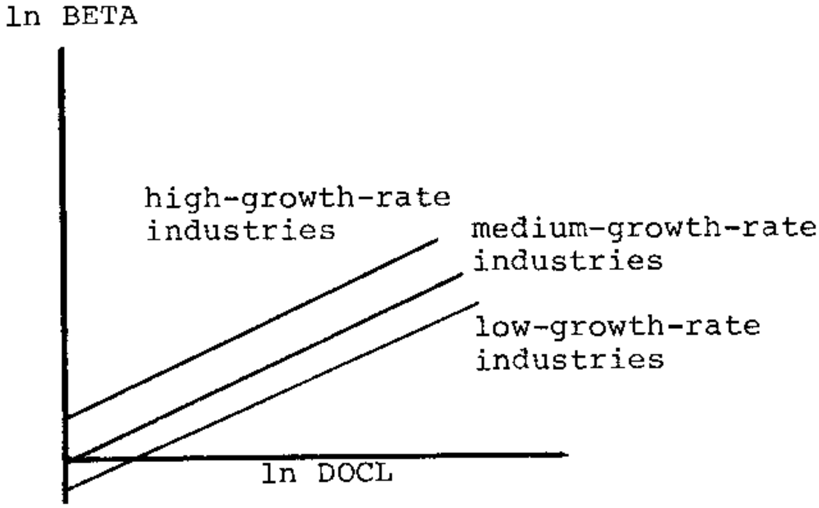

Fig. 5--Growth interaction (ln BETA)

In the industry growth rate interaction, DOCL has a very significant effect on CVPR in high-growth-rate industries and has a small but significant (positive) effect on

CVPR in medium-growth-rate industries. Thus the effect of DOCL on CVPR in different growth rates of industries is quite different.

Rapid growth industries' DOCL is often large because of the amount of debt financing undertaken to build up capacity. One characteristic of the growth stage is strong product demand. In this stage, competition is severe and management tries to expand their market by reducing costs and improving quality. Management introduces manufacturing efficiencies to reduce costs, improve productivity, and lower selling prices. This combination of lower prices and high DOCL makes profitability fluctuate severely. Therefore, the effect of DOCL on stock risk in high-growth industries tends to be stronger.

The fourth hypothesis is that the combined leverage (DOCL) is a better risk measure than the traditional total leverage (DTL) or DOL and DFL together. Equation (4), the empirical results of model IV (additive form), are as follows:

$$\begin{aligned} CVPR &= \underset{(0.0259)}{-13.78} + \underset{(0.0001)}{40.99}\ DOL + \underset{(0.0001)}{27.59}\ DFL && \text{(4a)} \\ BETA &= \underset{(0.0001)}{0.93} + \underset{(0.0001)}{0.06}\ DOL + \underset{(0.52)}{0.01}\ DFL && \text{(4b)} \end{aligned}$$

Significant levels are in parentheses, an adjusted $R^2_{(4a)} = 0.2274$ and $R^2_{(4b)} = 0.0163$. The F value for equation (4a) is 112.387 and equation (4b) is 7.772, indicating equation (4a) and (4b) to be significant at 0.0001 and 0.0005 levels, respectively. Both DOL and DFL are significant at equation (4a); in equation (4b) DOL is significant at the 0.0001 level, but DFL is not significant (0.52).

For the multiplicative form of equation 4 the results are as follow:

$$\underset{}{\ln CVPR} = \underset{(0.0001)}{3.89} + \underset{(0.0001)}{0.59 \ln DOL} + \underset{(0.0002)}{0.35 \ln DFL} \qquad (4a')$$

$$\ln BETA = \underset{(0.0475)}{-0.019355} + \underset{(0.0001)}{0.06 \ln DOL} + \underset{(0.0759)}{0.04 \ln DFL} \qquad (4b')$$

The adjusted $R^2_{(4a')}$ = .2201 and adjusted $R^2_{(4b')}$ = 0.0206. The F values are 107.80 and 9.592, respectively, indicating both equations are significant at the 0.0001 level. Both DOL and DFL are significant in both equations (4a') and (4b').

Model I and Model IV are used to compare the effectiveness of DOCL versus DTL (or DOL and DFL together) in both additive and multiplicative forms. In order to compare these two models (or measurements), Cp and PRESS statistics are utilized as a criteria for goodness of fit. Panel A of Table V presents a Cp statistics comparison between DOCL versus DOL and DFL when dependent variable is CVPR (additive form). Table V (Panel B) presents a Cp statistics comparison between DOCL versus DOL and DFL when the dependent variable is BETA (additive form).

TABLE V

DOCL VERSUS DTL

Number of Independent Variables	R^2 (Unadjusted)	Cp	Variable(s) in Model
	Panel A Dependent Variable CVPR		
1	0.2427	9.08	DOCL
2	0.2296	24.43	DOL DFL
	Panel B Dependent Variable BETA		
1	0.0215	4.56	DOCL
2	0.0187	8.92	DOL DFL

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. When using the Cp criterion, one seeks to identify the set of independent variables that leads to the smallest Cp value.[1]

Panel A of Table VI exhibits a Cp statistics comparison between ln DOCL versus ln DOL and ln DFL (multiplicative form) when dependent variable is ln CVPR. Table VI (Panel

[1]John Neter and William Wasserman, Applied Linear Statistical Models (Homewood, 1974), pp. 379-390.

TABLE VI

DOCL VERSUS DTL AS RISK PREDICTORS

Number of Independent Variables	R^2 (Unadjusted)	Cp	Variable in Model
	Panel A Dependent Variable ln CVPR		
1	0.2220	33.92	ln DOCL
2	0.2222	35.76	ln DOL ln DFL
	Panel B Dependent Variable ln BETA		
1	0.0240	3.51	ln DOCL
2	0.0229	6.40	ln DOL ln DFL

B) presents a Cp statistics comparison between ln DOCL and ln DOL and ln DFL together (multiplicative form) when dependent variable is ln BETA.

Table V and VI indicate that Cp value for the DOCL is less than the Cp value for a regression using DOL and DFL together. This is true in both the additive and multiplicative forms. These results indicate that DOCL is a better risk measure than DTL (DOL and DFL together).

PRESS statistics can also be used to compare DOCL versus DTL (DOL and DFL). PRESS stands for prediction error sum of squares. For any candidate model, the technique involves holding out one of the observations and fitting the model to the remaining n-1 observations. The next step is to look at its residual and see how well the regression equation predicts the withheld observation. This is done for each observation, in turn, for n possible regressions. By summing the n squared residuals thus obtained (the PRESS value) one sees how this particular model predicts on the whole set of data. The smaller the PRESS value is, the better the model is.[2]

Table VII shows the results of PRESS comparisons between DOCL and DTL (additive form). The results are the same as with the Cp. DOCL is a better risk measure than DTL.

Table VIII shows the results of PRESS value comparison for the multiplicative (double log) regressions. The results are similar to those in Table VII; the DOCL model is better.

Table VII and VIII indicate that PRESS statistics for DOCL are less than those for regressions using DOL and DFL together (for both additive and multiplicative form regressions). These results support the hypothesis four that DOCL is a better risk measure than DTL (DOL and DFL together).

The fifth hypothesis is that there is an interaction effect between DOL and DFL. Equation (5), the empirical

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[2]Mary Sue Younger, A Handbook for Linear Regression (North Scituate, Massachusetts, 1979), pp. 483-484.

TABLE VII

PRESS STATISTICS FOR MODEL I AND MODEL IV
(ADDITIVE FORM)

Dependent Variable	Independent Variable	PRESS Statistics
	Panel A Dependent Variable CVPR	
CVPR	DOCL (Model I)	447017.45
CVPR	DOL DFL (Model IV)	464070.12
	Panel B Dependent Variable BETA	
BETA	DOCL (Model I)	56.70
BETA	DOL DFL (Model IV)	57.07

results of model V (additive form), are as follows:

$$\underset{(0.0432)}{\text{CVPR} = 16.94} + \underset{(0.2447)}{7.93\ \text{DOL}} - 9.57\ \text{DFL} + \underset{(0.0001)}{40.13\ \text{DOL} \cdot \text{DFL}} \tag{5a}$$

$$\text{BETA} = \underset{(0.0001)}{1.01} - \underset{(0.1857)}{0.04\ \text{DOL}} - \underset{(0.0134)}{0.08\ \text{DFL}} + \underset{(0.0002)}{0.12\ \text{DOL} \cdot \text{DFL}} \tag{5b}$$

The adjusted $R^2_{(5a)} = 0.2544$ and adjusted $R^2_{(5b)} = 0.0319$. The F value for equation (5a) is 87.116 and equation (5b) is 9.987, indicating equations (5a) and (5b) are both significant at the 0.0001 levels.

TABLE VIII

PRESS STATISTICS FOR MODEL I AND MODEL IV
(MULTIPLICATIVE FORM)

Dependent Variable	Independent Variable	PRESS Statistics
	Panel A	
ln CVPR	ln DOCL (Model I)	164.02
ln CVPR	ln DOL ln DFL (Model IV)	166.66
	Panel B	
ln BETA	ln DOCL (Model I)	59.42
ln BETA	ln DOL ln DFL (Model IV)	59.66

In the multiplicative form of equation (5), the results are as follows:

$$\ln CVPR = \underset{(0.0001)}{3.91} + \underset{(0.0001)}{0.73 \ln DOL} + \underset{(0.0001)}{0.48 \ln DFL} + \underset{(0.0001)}{0.52 \ln DOL \cdot \ln DFL} \qquad (5a')$$

$$\ln BETA = \underset{(0.0667)}{-0.02} + \underset{(0.0001)}{0.06 \ln DOL} + \underset{(0.0301)}{0.05 \ln DFL} + \underset{(0.0789)}{0.05 \ln DOL \cdot \ln DFL} \qquad (5b')$$

The adjusted $R^2_{(5a')} = 0.2536$ and adjusted $R^2_{(5b')} = 0.0231$. The F value for equation (5a') is 86.751 and equation (5b') is 7.443, indicating equations (5a') and (5b') are both significant at the 0.0001 level.

Interaction variables indicate a positive DOCL influence on stock risk in both additive and multiplicative forms, indicating Mandelker and Rhee's[3] model is oversimplified. Equation 5 shows that interaction variables have consistently positive signs; these results support Huffman's theory. Huffman emphasized that for debt less than a critical level, the direct effect of debt on equity risk is only partially attenuated by the indirect effect of debt on equity risk (interaction effect) causing an overall increase in equity risk as debt increases. That is, for debt level less than a critical level, the capacity decision (DOL) is altered so as to offset the effect of the increase in oustanding debt. However, for debt level greater than a critical level, the capacity decision exacerbates, rather than attenuates, the effect of the increase in outstanding debt on equity risk. For this reason, one can see that the higher the DFL, the greater the equity risk because the interaction effect (or indirect effect of debt on equity risk) increases. The traditional total leverage used in Mandelker and Rhee's model is deficient in that it does not consider the endogenous nature of the capacity decision (DOL) and its relation to production.[4]

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[3]Mandelker and Rhee, op. cit., p. 51.

[4]Huffman, op. cit., p. 208.

Summary

The results of this study can be summarized very concisely. In every case the multiplicative and additive form results were consistent. These results were as follows:

1. The relationship between stock price risk (both CVPR and BETA) and DOCL was positive and statistically significant.

2. The influences of DOCL on stock price risk (both CVPR and BETA) varies for the majority of industries used in this study. That is, the effect of DOCL on stock risk varies in different environments (industries).

3. In the industry growth rate interaction, the influences of DOCL on stock price risk (both CVPR and BETA) shows statistically significant difference between high-growth-rate industries and low-growth-rate industries. However, the influence of DOCL on CVPR (but not on BETA) shows statistically significant difference between medium-growth-rate industries and low-growth-rate industries.

4. The results show that DOCL is a better risk measure than DTL (DOL and DFL together), using both CVPR and BETA.

5. Equation 5 for both CVPR and BETA shows that there are consistently positive interactions between DOL and DFL.

CHAPTER V

CONCLUSIONS

The purpose of this study has been to examine the relationship between firms' combined leverage and volatility of their stock prices. The study also examined industry and industry growth rates to see if the relationship is influenced by these factors. Further, it has focused upon the question whether DOCL is a better stock risk measure than DTL (or DOL and DFL together) and whether there is an interaction effect between DOL and DFL.

The inferences that can be drawn from these results are as follows.

1. The evidence presented supports the first hypothesis that stock risk (coefficient of variation of stock prices and BETA) is a function of combined leverage.

2. Industry influences the relationship between stock risk and DOCL to a significant degree.

3. High industry growth rates tend to increase the relationship between stock risk and DOCL. That is, the higher the industry growth rate, the greater the stock risk as DOCL increases.

4. Combined leverage is a better risk measure than traditional total leverage (DOL and DFL together). Further, the problem with the traditional total leverage measure is the omission of the interaction between DOL and DFL which was consistent with the theory developed by Huffman.

5. Mandelker and Rhee's model appears to be oversimplified. The evidence indicates that a DOL-DFL interaction should be included in their model.

This study does not pretend to solve all of the problems of defining stock risk. It does, however, correct some omissions with regard to that measurement. Further, it suggests that all current textbooks should update their leverage coverage to include a discussion of Huffman's theory.

APPENDIX A

GLOSSARY OF FREQUENTLY USED SYMBOLS

β_G	Systematic risk associated with return derived from growth opportunities
β_π	The systematic risk inherent in that portion of the common stockholder's return that derives from the firm's existing after-tax cash flow
CV(REV)	Coefficient of variation of stock prices
DOL	Degree of operating leverage
DFL	Degree of financial leverage
DTL	Degree of total leverage (traditional measurement)
DOCL	Degree of combined leverage
$D_n \cdot$ DOCL	Interaction variables between dummy variables and DOCL
$E(R_M)$	Expected return on the market portfolio
σ	Revenue risk
F	Fixed costs
$G_n \cdot$ DOCL	Interaction variables between growth and DOCL
$\sigma\ (R_M)$	Standard deviation of return on the market portfolio
G	Growth rate of sales
g*	Sustainable growth rate
K	Unit production cost
η	Percentage change in value of equity divided by percentage change in revenue (DOCL) (see Huffman)

ρ	Correlation coefficient
P	Price per unit sold
Q	Quantity of units sold
r	Return on equity
R_F	Risk free rate of return
S	Value of equity (Chapter II only)
S (X*)	Value of equity at optimum capacity level X*
X*	Optimal fixed capacity commitment made by the equity
λ'	$E(R_M) - R_F$
V	The present value of the next period's after-tax cash flow to the owners from existing assets
V_G	The portion of the value of the firm's equity which is attributable to potential opportunities to make future investments in real assets, or expected rates of return
V_π	The present value of the next period's after-tax cash flow to the owners from existing assets

APPENDIX B

SOURCES OF DATA

Industries.--All data between 1964 and 1981 are taken from COMPUSTAT data files. Ten industries (chemical and allied products, drugs, petroleum refining, steel, machinery, electronic computing equipment, automobiles, airlines, utility, retail-grocery stores) are examined. The machinery industry includes ten smaller component industries: engines and turbines, farm and garden machinery, materials handling machinery and equipment, construction machinery, oil field machinery, tractors and trailers, metalworking machinery, special industry machinery, pollution control machinery, general industrial machinery. The utility industry includes telephone communication and electric service companies.

Annual industrial data items.--COMPUSTAT data item number 12 (net sales), 13 (operating income before depreciation), 14 (depreciation and amortization), and 65 (amortization of intangibles), are used to compute the degree of operating leverage (DOL). Data items number 13 minus 14 plus 65 equals EBIT (earnings before interest and taxes). Earnings after tax and preferred dividend (EAT) are obtained by subtracting preferred dividend (data item number 19) from net income (data item number 18). EAT and net sales (data item 12) are used to compute DOCL (degree of combined leverage). EBIT and EAT are used to compute DFL (degree of financial leverage). Finally, market price, price per share (data item 24) times shares outstanding (data item 25), is used in CV price calculation.

APPENDIX C

Classification of Industry Growth Rate

In Table III (CVPR), high-growth-rate industries include crude petroleum natural gas industry, petroleum refining, oil field machinery and equipment, computer, trucking, telephone communication, building construction, newspaper, drug, grocery stores, semiconductors and related devices, and engineer lab and research equipment. Medium-growth-rate industries include plastic products, measuring and controlling instruments, miscellaneous chemical products, motor vehicle parts, and electric services. Low-growth-rate industries include food and kindred products, textile mill products, apparel and other finished products, chemical and allied products, steel, general industrial machine and equipment, radio-TV transmitting equipment, radio-TV broadcasters, and gas and electric services.

In Table III (BETA) high-growth-rate industries include crude petroleum and natural gas, oil field machinery and equipment, computer, trucking, telephone communication, food stores, semiconductors and related devices, retail drug stores, railroad-line haul operating, building construction, newspaper, meat products, oil and gas field services, and natural gas transmission. Medium-growth-rate industries include drug, miscellaneous chemical products, plastic products, motor vehicle parts, measuring and controlling instruments, construction handling machines, construction machines, special industry machinery, cigarettes, natural gas distribution, paper products, electric lighting-wiring, and electronic components. Low-growth-rate industries include food and kindred products, apparel and other finished products, chemical and allied products, soap and other detergents, steel, general industrial machinery, radio-TV transmitting equipment, gas and electric services, photographic equipment and supplies, and hardware.

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