THE EFFECTS OF DEBT INDEXATION ON THE VALUE OF THE FIRM

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Indexed long-term debt is treated as an alternative financing policy to nominally specified debt financing for the firm. The general context and motivation for debt indexation in an inflationary economy are discussed. The general effects of indexation on the demand for the firm's capital assets due to their contribution to the diversification of the market portfolio are discussed. However, primary emphasis is given to the supply effects of indexation.

It is hypothesized that some firms would be able to reduce the variability of their net earnings by issuing indexed debt. It is further hypothesized that this effect is firm and industry specific. The variability of a firm's net earnings is related to insolvency risk and it is argued that a reduction in variability would create an additional debt capacity for the firm.

A test statistic is developed for the hypothesized relationship between an index and a firm's earnings. Also, to derive the benefits of indexation, a model is developed to estimate the risk of a firm, as measured by the (growth corrected) variability of the annual net earnings, and to estimate the additional debt capacity generated by indexation consistent with the original level of insolvency risk. This model is applied to a sample of 44 firms from the Standard and Poor's 500 Composite Index. Two indices are applied to the actual firm data and estimates of the generated debt capacity are derived. The value of the generated debt capacity is estimated based on the tax deductibility of the interest payments.

Finally, the results of the indexation simulations are presented. Twenty-two of the 44 firms are found to have benefited from the indexation policy and the average value of the generated debt capacity is estimated at $22 million. The firm and industry specific nature of the results is noted and suggestions are made for further research.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL CONTEXT AND MOTIVATION FOR INDEXATION

Indexation is probably a less familiar term in the United States than it is in other countries such as England, Israel, Finland, and Brazil where it is (or has been) explicitly and extensively employed by the government and in public capital markets. Nevertheless, numerous examples of indexation exist in our economy. Escalator clauses in union wage contracts, utility fuel adjustment clauses and similar provisions in leases, royalty agreements, etc., are common examples of the practice of indexation. Even the occasional practice of lowering Federal income tax rates over the last thirty years has been cited as an unintended policy of indexation.[1]

The implications of a "public policy" of indexation have been a recent subject of discussion, largely due to the recent high rate of inflation. Inflation may distort the relative benefits for the parties to financial contracts written in nominal terms. Since indexed contracts denominate future payments in terms of some concurrent price

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[1] Kuhn, James W., "Indexing: Pro and Con", Proceedings of the Academy of Political Science, Vol. 31, No. 4, p. 146.

index or market interest rate, etc., they may avoid some of the income redistributing effects of inflation. Another reason for the resurgence of interest in indexation lies in the potential effect of high rates of inflation in increasing the money risk of parties to a nominal financial contract. This risk is associated with potential losses due to variance in the rate of inflation. This variance is probably higher in times of high inflation.[2] A practical consequence of the heightened money risk in contracts is a shrinking supply of long term fixed-rate credit.

Modigliani argues that indexation can perhaps alleviate the credit shortages that arise in the housing industry when the rate of inflation shrinks the supply of funds to lending institutions at their statutory maximum interest rate on deposits.[3] State-chartered Savings and Loan

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[2] For a discussion of this hypothesis see: Genberg, Hans and Swoboda, A.K., eds., "Protection Against Inflation and Exchange Risk: The Role of Indexation," <u>Proceedings of the Saltsjöbaden Conference, July 4-6, 1974</u>, International Center for Money and Banking Studies, Geneva, and Skandinaviska Enskilda Banken, Stockholm (1974), pp. 14-15.

Although this hypothesis was based on the observation that the proportion of indexed assets in Finland has tended to rise with the rate of inflation, an alternate explanation would attribute the increased indexation to a supply limitation on fixed-rate debt.

[3] Modigliani, Franco, "Some Economic Implications of the Indexing of Financial Assets With Special Reference to Mortgages," Sloan School Working Paper #736-74, Massachusetts Institute of Technology, Sept. 1974, p. 13.

Associations are free of most legal restraints against asset indexation. Recently, the two largest mortgage lenders in the United States, both state-chartered, announced plans to introduce variable rate, or indexed mortgages.[4]

1.2 CORPORATE DEBT INDEXATION

Another aspect of the current discussion on policies of indexation is the diversity of views, pro and con, concerning it. Furthermore, this is complicated by the numerous practical applications of indexation. Despite this apparent diversity in the applications of indexation, it will be convenient for our purposes to use a more narrow definition of the term than we have implied. Since we are concerned with the effects of debt indexation on the value of the firm, we will place our emphasis at the firm level where the necessary decision to implement indexation would be made. Thus we will assume that the firm's political and institutional environment is permissive. For example, we shall assume that the resulting indexed interest payments are tax deductible. In addition, in emphasizing the financial aspects of indexation for a firm, we will avoid consideration of any organizational or procedural issues and any non-interest costs involved in indexation.

By concerning ourselves with the effects on a firm, we

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[4] The Wall Street Journal, January 13, 1975, p. 24.

intend to consider the effects on a large corporation achieved by indexing its publicly held debt. Due to the historic upward trend in interest rates, many of these corporations have benefitted from nominally specified interest on their long-term debt. We maintain that the reverse was equally likely to occur, that is, on the average, lenders correctly anticipate inflation. Further, since our concern is not with the redistributional effects of inflation, we will not consider this effect, or the risk of it, in evaluating a policy of debt indexation.[5]

Since it is relevant to compare the current practice of nominal long-term debt capitalization against the alternative of indexed debt, we will make an explicit comparison of the financial effects of the two as alternative, mutually exclusive financing policies.[6]

An example, the successful public offering in 1974 of $200 million of indexed bonds by the Chase Manhattan Corp., will assist in being more specific: The interest indexing

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[5] This is not to say that equity or redistributional risk will not have an effect on the relative pricing of indexed and nominal assets, but rather to say that this effect is separate and distinct from other effects on the firm as the supplier of indexed bonds. See: Fischer, Stanley, "The Demand for Index Bonds," Department of Economics Working Paper #132, Massachusetts Institute of Technology, 1974.

[6] Thus, we will not concern ourselves with the effects of mixed strategies or indexation of only a portion of the total debt issued by a firm.

feature on these bonds became operative eleven months after issue and provided for a semi-annual interest payment at a rate 1% greater than an average coupon equivalent yield at issue on thirteen-week Treasury Bills taken from the seventh month preceding the date of the interest payment.[7] We propose a more general policy of relating the long-term debt interest rate to the index on a month by month basis.

1.3 DEFINITION OF DEBT INDEXATION

Thus, for our purposes we define indexed debt as debt on which the interest rate is related by some prescribed formula to a specified market rate either concurrently or lagged by some constant period. And we seek to find evidence of economic value in a policy of long term debt indexation as an alternative to the existing nominally specified interest obligations. In order to do this we will simulate the substitution of indexed debt for the existing nominally specified debt of a number for firms and develop economic measures of the resulting effects.

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[7] Preliminary prospectus dated July 9, 1974 of the Chase Manhattan Corp. for $200 million in floating rate notes due 1999.

CHAPTER 2

2. THE EFFECTS OF INDEXATION ON THE DEBT CAPACITY OF THE FIRM

2.1 STATEMENT OF PROBLEM

This thesis will be concerned with the effects on the debt capacity of a firm as a result of substituting indexed debt for the firm's existing fixed rate senior securities, i.e., debt and preferred stock. Of primary interest to us will be the correlation, if any, between the firm's earnings stream and the resulting indexed interest payments. Since interest is an expense, a negative correlation would tend to emphasize the variability of net earnings while a positive correlation would tend to reduce the variability of net earnings.

Assume that the interest index chosen by a firm was the Treasury Bill rate (and not, for example, the level of sun-spot activity). We hypothesize that economic time series, such as the Treasury Bill rate, have potentially valuable characteristics to the firm as a debt index in that they are likely to have systematic macroeconomic relationships with the firm's earnings. Speculation suggests that these relationships involve either (or both) the firm's sales or expenses, that they are complex relationships and that they would be firm or industry specific. Further, due to such systematic correlations, we hypothesize that some firms or industries will be able to reduce the variability of their net earnings by issuing index-linked debt.

While we believe that any index should not be influenced by the debt issuer, a direct approach might be taken in reducing the variability of net earnings by choosing as an index some component of the firm's earnings itself. Such an approach was tried in France where the state owned coal, electricity and railroad companies linked their debt to the prices of their goods and services.[1] Since the resulting debt would, in fact, take on some of the characteristics of equity, it seems unlikely that U.S. tax regulations would be modified to afford it the benefits of tax deductibility for the indexed interest payments. Accordingly, we shall confine our discussion to market rates. It would seem more likely that such indirect methods could achieve the benefit of reduced variability of earnings and still qualify for favorable tax treatment.

The choice of an index by a firm involves both the choice of a particular economic time series to which the interest payments are to be linked and the choice of a time lag between the observation of the index and the payment of the resulting interest. It is the combination of

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[1] Genberg, Hans and Swoboda, A.K., <u>op</u>. <u>cit</u>., p. 45.

a particular index and lag with the earnings stream over time that determines any reduction in the variability of net earnings.

Since the uncertainty of a firm's future earnings is associated with the magnitude of their dispersion, we will choose their observed variability over the simulation period to characterize the financial or investment risk of the firm. If the variability of the net earnings of a firm is lowered as a result of indexation, additional debt may be undertaken to the extent that the resulting risk is not greater than that existing with the original fixed-rate debt. Since certain tax benefits are available to the firm as a result of the interest payments on this additional debt, an increase in the value of the firm may result from indexation.

The purpose of this thesis, therefore, is to study the effects of several potential indices over a sample of 44 firms. Because of the complexity of the economic relationships between these indices and the firms' earnings, we will demonstrate the effects of indexation by performing simulations using historic data. If a reduction in the variability of any firm's net earnings is achieved, we will estimate the net present value of the additional debt capacity generated as if the firm had adopted a perpetual policy of indexation.

Before discussing further the relationship between any reduction in the variability of net earnings and the generated debt capacity, it will be expedient to discuss additional potential effects of indexation that we will, of necessity, exclude from consideration. A likely effect of indexation would be a change in mean net earnings due to a change in the mean interest rate on the firm's debt. With indexation, a debt with uncertain real and nominal interest has been substituted for debt of certain nominal and uncertain real interest. In principle, the mean interest payments after indexation could be either greater or less than before, depending on their contribution to the diversification of the market portfolio. Fischer, in an economy including the household sector, has shown that ". . . risk aversion is not sufficient to guarantee that index bonds would be held in the portfolio at lower expected nominal returns than the nominal interest rate; the premium (positive or negative) of index bonds depends positively on the risk aversion of the household's utility function and negatively on the covariance of the return on equity with the price level -- the extent to which equity is a hedge against inflation."[2]

Analogous to this demand effect on the yield of the

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[2] Fischer, *op. cit.*, p. 2.

firm's indexed debt is a change in the premium placed on the firm's net earnings (equity) stream. Although the effects of indexation on the premium for any particular firm's equity and debt would be in opposite directions, the effects, because of taxes, will not cancel. Since our emphasis is on measuring other effects of indexation, we will neglect these changes in the premium (positive or negative) paid for the firm's capital assets because of the diversification they contribute to the market portfolio. Thus, we will assume that the mean interest rate on the firm's debt is unchanged by indexation and we will neglect any change in the premium on the firm's equity.

2.2 RELATIONSHIP OF A FIRM'S DEBT CAPACITY TO ITS CAPITAL STRUCTURE

In order to discuss our procedure in more meaningful terms it will be necessary to explain more precisely what is meant by the variability of a firm's net earnings stream and the implications, for our purposes, of this for the capital structure of the firm. We will assume that capital rationing is not imposed on the firms in our sample. Further, we will also assume that each firm has optimized its capital structure. That is, we will assume that each firm has adjusted the quantities of funds it has obtained from debt and equity sources so that the marginal after-tax costs of money from all sources are equal, thus resulting in maximizing the value of the whole firm. This policy would result in the lowest weighted-average after-tax cost of capital for the firm.

There is no general agreement as to all of the relevant costs for determining the optimal capital structure of a firm. However, we will consider two effects on the firm's after-tax cost of capital, both of which relate to the degree of financial leverage. First, we will consider the lowering of the effective cost of debt financing due to the tax-deductibility of interest payments. Second, we will consider the increasing expectation of insolvency, ceteris paribus, for the firm with increasing leverage. Thus, the value of the firm is lowered by the expected value of the insolvency costs which increase with leverage. We will provisionally choose the coefficient of variation of the firm's net earnings stream, that is the standard deviation of net earnings divided by mean net earnings, as a measure of the risk of insolvency for each firm.

Thus, if indexation results in lowering the coefficient of variation of net earnings, ceteris paribus, the expected costs of insolvency are lowered, the marginal cost of debt relative to equity is lowered and the firm's capital structure is no longer at the optimum we originally assumed.

Since the marginal cost of debt financing is now lower than equity, the assumed optimal capital structure may be restored by increasing the firm's leverage and repurchasing the firm's stock with the funds obtained from the additional debt until the original condition of equal marginal costs of funds from all sources is reached. However, in the process of increasing the firm's leverage, the firm's weighted average after-tax cost of capital is lowered due to the tax savings on the interest payments. Since the riskiness of this stream of tax benefits is assumed equivalent to that of the debt itself, the capitalized value of the additional tax savings is equal to the tax rate multiplied by the additional debt undertaken[3] in restoring the condition of the original optimal capital structure.

2.3 GENERAL PROCEDURE

To recapitulate, we have confined our inquiry to the direct effects of indexation on the firm. That is, we have excluded consideration of demand effects that might cause a change in the premium paid for the firm's capital assets and we have similarly neglected consideration of any effects on the relative pricing of the firm's nominal and index-linked debt. For the remainder of this thesis

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[3] Modigliani, Franco, and Miller, Merton H., "Corporate Income Taxes and the Cost of Capital: A Correction," The American Economic Review, Vol. 53, No. 3, p. 436.

we will also assume that there is no capital rationing that might limit the firms' debt, that the capital structure of the firm is optimized, that there are no transactions costs involved in issuing new debt or retiring equity and that indexed interest payments are tax deductible and the average tax rate on earnings is equal to 50%.

The first part of Chapter 3 discusses the rationale and methodology for the indexation simulation. Following this a model employing 18-years of annual earnings data is established for purposes of estimating insolvency risk for the sample firms. For this purpose the coefficient of variation provisionally adopted earlier in this chapter is modified so as to exclude variation attributable to earnings growth observed within the 18-year period. The resultant measure of insolvency risk is thus intended to capture the year-to-year variation in earnings while excluding the long-term growth of earnings, which does not constitute risk in the usual sense.

The recalculation of the earnings stream net of indexed interest payments is discussed next. For this purpose we rely on our earlier assumption that there is no change in the market risk premium on the firm's debt so as to allow the mean indexed interest payments to equal the mean original interest payments.

Since debt indexation may alter our measure of insolvency risk of the adjusted net earnings stream relative to that of the original net earnings stream, we next derive an expression for the incremental debt that may be undertaken in restoring the original level of insolvency risk for the firm. We assume that the additional debt is also indexed.

Next, we derive an expression for the net present value of the tax benefits as a perpetuity. The incremental debt capacity as derived is expressed as a fraction of the original debt, and we express the incremental borrowings as this fraction times the mean level of debt over the simulation period.

Finally, since our estimate of benefits for the indexation policy would depend on an underlying macro- and microeconomic relationship between an index and the firm's earnings, exclusive of the effects of the firm's historic financial policy, we introduce an expression for the correlation coefficient of earnings before interest and tax and the index. The effects of a firm's historic financial policy are thus viewed as determining the extent of benefits of the indexation policy relative to the historic policy, while the relationship between the index and the firm's operating earnings is viewed as fundamental to the systematic existence of benefits. The correlation coefficient is then related to a measure of the extent of smoothing of the firm's before tax, after interest earnings stream due to indexation.

Chapter 4 discusses the results in the context of actual simulations. Two different time series are used as indices for each firm,and each index is applied to the original data three times in increasing lags up to six months. In determining the range of lags for each index for which a debt capacity is generated, we reject solutions for which our measure of insolvency risk increases upon indexation of debt. Furthermore, since our calculated debt capacity factor is a root of a quadratic equation, the sense of the parameters in our risk measure is lost, and we choose to reject additional classes of solutions.

The indexation results are presented by firm and by industry. Our method provides a point estimate of the benefits of indexation taken from an aggregation of a firm's earnings. The correlation coefficient provides a test statistic for the underlying relationship of operating earnings and the index. The estimate of smoothing, also based on the correlation of operating earnings and the index, provides a comparison for the estimate of additional debt capacity independent of the firm's historic financing and tax policies.

Finally, Chapter 4 summarizes our results and conclusions and provides suggestions for further research.

CHAPTER 3

MEASUREMENT PROCEDURE

3.1 SIMULATION METHODOLOGY

This thesis seeks to establish the existence of some degree of economic benefit to the corporate sector resulting from a policy of indexing long-term debt. It attemps to suggest some of the relationships between a firm and the securities market which are relevant to the consideration of such a policy choice as well as to develop a measure of the possible resultant economic value to the firm. Because of the complexity of the macro- and micro-economic interactions between money market rates and corporate business activity, we investigate the effects of indexed corporate debt by simulating the effects of issuing market-linked floating rate debt on the income flows of a number of firms in several different industries.

We do not intend that our sample of firms be either an exhaustive representation of all industries, or a random cross-section within any one industry. Rather, the firms are chosen to illustrate the range of magnitudes for our measures of debt indexation and are sizeable, widely owned and traded corporations within several economic industry sectors.

Our method, then, is to simulate the behavior of an individual corporation's net earnings over a period of 18 years, had money market-linked, floating rate debt been substituted for its outstanding fixed rate long-term debt.[1] The only indexation policy for the firm which we investigate is that of issuing long-term bonds whose interest rate is related by a prescribed formula to a particular money market interest rate, applied either concurrently or lagged by some constant period. The alternative indexation policy of revaluing the firm's fixed rate debt principal on the basis of changes in a price level index[2] was not investigated.

The simulation calculations for this thesis were performed with the aid of a digital computer. The FORTRAN language code of the calculation procedure was developed by the authors. The corporate data used in the simulations were obtained from the Standard and Poor's Compustat annual report database which contains on magnetic tape the financial accounting information of approximately 2600 corporations for the 19 years ending 1973. The data base contains 63 data items relating to the income state-

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[1] The limitations and assumptions we make regarding the interaction of the firm and the capital market are those discussed in Chapter 2 of this thesis.

[2] We use the term debt indexation to refer, generally, to either policy, although a more precise usage would be to distinguish the first as "variable", or "floating" rate debt, reserving the term "debt indexation" for the second.

ment and balance sheet for each firm, for each fiscal year of the period. For our study, we used the data of 44 corporations belonging to the Standard and Poor's 500 companies. The corporations belonged to seven industries, as classified by U.S. Department of Commerce Standard Industrial Classification (SIC) code.

Two money market rates were used in the simulation study: the monthly average of 91-day U.S. Treasury Bill rates at issue, as determined by auction,[3] and the monthly average of 4- to 6-month Commercial Paper rates as of the initial dealer offerings.[4] In our computational procedure, we calculate the corporate interest payments on a monthly basis using both sets of monthly market rate data. For this calculation, the monthly corporate debt amount is multiplied by the rates with time lags of 0 (i.e., concurrently) 3 and 6 months. Thus, the change in each corporation's net earnings level in response to floating rate interest was simulated a total of six times, i.e., three lag structures for each of the two market rates.

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[3] For our computations, we used the coupon equivalent of the published Treasury Bill discount rate.

[4] Market rate data was obtained from "Financial and Business Statistics," Federal Reserve Bulletin, U.S. Board of Governors of the Federal Reserve System, Washington, December issues for the years 1953 to 1974.

In the following sections, 3.2 and 3.3, we develop the mathematical framework of the simulation calculations as well as the various measures we chose to use to evaluate the effects of debt indexation. Chapter 4 represents a discussion of the simulation results for the 44 firms in our sample on the basis of their industry classification.

3.2 PROCEDURE

We seek to estimate the change in variability of a firm's income stream given that the firm had paid its long-term debt interest at a rate that was linked to a well-established market interest rate. Since both market rates and corporate earnings fluctuate over time, the overall net effect on earnings, assuming index-linked debt, would depend on any correlation between the two. As interest is an expense, a negative correlation would tend to emphasize the variability of earnings, while a positive correlation would tend to reduce it.

The procedure, in brief, consists of determining a statistical measure of variability in the historical net earnings flow over 18 years of available data and relating the variability to risk; computing an adjusted net earnings stream as a function of the original earnings, original interest payments, long-term debt levels, and the independent market index data for the period; and recalculating the variability measure for the index adjusted earnings stream. We then develop a measure of the additional debt capacity available to the firm due to any reduction in earnings variation. Finally, the net present value of the additional debt capacity is computed as the measure of the economic value to the firm accruing from its policy of debt indexation.

3.2.1 STATISTICAL ANALYSIS OF NET EARNINGS

We assume that the variation in net earnings level from year to year is due to two factors: growth (negative or positive), and the other macro- and micro-economic influences which we may regard as giving rise to the total risk of the income stream. We require a generally applicable procedure which will characterize the year to year variability of the streams, but will exclude that component of variation due to growth, since the latter is not of itself commonly perceived as adding to the firm's risk. We first estimate the contribution of growth to the total variability of net earnings. The technique of linear time series regression is therefore applied to the annual net earnings data of the firm in order to estimate any growth trend. The resulting relationship of the estimated net earnings with time is known as the regression equation and is the straight line of least squares fit to the actual data points. The technique is applied to the net earnings data of each of the 66 sample firms in our study. We thus make the assumption that a linear growth trend is a generally appropriate functional form with which to model the earnings stream of all the firms.

If NE_t is the historic level of annual net earnings of the firm in year t, the regression on the time variable yields the linear regression equation:

$$\hat{NE}_t = \overline{NE} + \beta_{NE} t \; . \tag{1}$$

$\hat{NE}_t$ is the estimated value of net earnings for the year t resulting from the regression analysis. The period over which the earnings are taken is that of the available data in the Compustat database, namely, the 18-year period from 1956 to 1973.[5] For computational convenience, the variable t is a year counter constructed such that its origin is at the mid-point of the period. Summation of the values of t over its range is, thus, equal to zero, or, equivalently, t has zero mean. By virtue of this method of year counting, the intercept term in Eq (1), $\overline{NE}$, is the arithmetic mean value of the net earnings stream. That is,

$$\overline{NE} = \frac{\sum_t NE_t}{n} \; , \tag{2}$$

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[5] The Compustat database includes data for the year 1955, but our method will require the linear interpolation of long-term debt between current and preceding year-end debt levels, Thus, data for the year 1955 is incomplete for our purposes and the analyses and simulations are performed for the 18-year period.

where n is the number of years in the simulation period (n is equal to 18 in all computations).

The slope of the net earnings trend-line, β_{NE}, is given by:

$$\beta_{NE} = \frac{\sum_t (NE_t - \overline{NE})t}{\sum_t t^2} , \qquad (3)$$

which is the expression for the slope of the line which minimizes the value of the sum of squared deviations.

Commonly used measures of variability and fit associated with the regression technique are computed by the following expressions:

the total sum of squares,

$$TSS_{NE} = \sum_t (NE_t - \overline{NE})^2 ; \qquad (4a)$$

the regression sum of squares,

$$RSS_{NE} = \sum_t (\hat{NE}_t - \overline{NE})^2 ; \qquad (4b)$$

and, the error sum of squares,

$$ESS_{NE} = \sum_t (NE_t - \hat{NE}_t)^2 ; \qquad (4c)$$

where the relationship between these measures can be shown to be:[6]

$$TSS_{NE} = RSS_{NE} + ESS_{NE} . \qquad (4d)$$

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[6] Huntsberger, D.V., Billingsley, P., and Croft, D.J., Statistical Inference For Management and Economics, Allyn and Bacon, Inc., Boston, 1975, pp. 284-285.

Of the above statistical parameters, the error sum of squares is a measure of the residual variation of the data unaccounted for by the estimated linear relationship. The error sum of squares will be the basis for our characterization and measure of the investment risk associated with the firm's earnings stream.

3.2.2 FORMULATION OF RISK MEASURE

Chapter 2 argues for the correspondence of financial or insolvency risk and the variability of net earnings normalized by the mean value of net earnings. We adopt a one-period model in order to characterize the firm by a single, long-term risk measure. The 18 years of net earnings are, thus, regarded as a sample, and we assume that the long-term financial risk of the firm can be estimated by the variability of the yearly earnings data around the time trend. The long-term model is consistent with the long-term nature of debt. The economic influences on the firm that take place on a year to year basis are those that we wish to capture in our risk measure. Other influences which are longer than a year are not considered.

On a procedural level, the above considerations lead to the choice of the error sum of squares rather than the total sum of squares as the measure of variation. Specifically, we define the root residual variation, RRV_{NE}, as the estimated standard deviation of the net earnings data about the regression line:[7]

$$RRV_{NE} = \sqrt{\frac{\sum_t (NE_t - \hat{NE}_t)^2}{(n-2)}} = \sqrt{\frac{ESS_{NE}}{(n-2)}} \quad . \qquad (5)$$

The normalization of RRV_{NE} by the mean earnings for the period, thus, corresponds to our conception of the (growth corrected) standard deviation of returns, and therefore, is employed as our measure of risk. Hence, we define F_{NE} as the risk measure of the firm's historical net earnings stream, where F_{NE} is given by the expression:

$$F_{NE} = \frac{RRV_{NE}}{\overline{NE}} = \sqrt{\frac{ESS_{NE}}{(n-2)\ \overline{NE}^2}} \quad . \qquad (6)$$

3.2.3 INDEXATION ADJUSTMENT OF NET EARNINGS

Having established the risk measure, F_{NE}, as the measure of the firm's historic long-term financial risk, we now wish to calculate the value of the measure had the firm's entire long-term debt over the 18-year period been market linked. Therefore, a new net earnings stream must be computed for the firm to simulate earnings resulting from annual interest payments different from the historic payments. The difference between the original annual interest payments and the annual index-linked payments represents the pre-tax effect of indexation. These differences are

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[7] This quantity is also called the standard error of the estimate. The square of the quantity is commonly known as the variance of the disturbance term.

multiplied by a factor equal to (1 - the marginal tax rate), where the marginal tax rate is assumed to equal 50%, and added to the after-tax net earnings for each year. The resulting earnings stream is referred to as the adjusted net earnings.

This computational procedure is applied to all firms in our sample. We thus assume that the 50% tax rate applies in each year regardless of the size of the firm's net earnings. We will note in Chapter 4 when discussing the simulation results all simulations for which this procedure might overestimate the tax savings associated with interest payments.

The index-linked interest payment calculation is performed on a monthly basis in order to accomodate computationally the various fiscal years encountered which are different from calendar years as well as handle changes in fiscal year on the part of a given firm. Monthly market rate data was collected, and we calculated the annual interest payments by summing monthly interest computations over the course of each fiscal year. This method also allowed us to lag, by any number of months, the market rate applied to the debt. The year-end debt levels for the preceding and current year is linearly interpolated for the calculation.[8] Thus, if $\alpha_{i,t}$ is the market interest

[8] The fact that fiscal year ending dates are on a monthly

rate established for the i^{th} month of the year t, and D_t is the year-end long-term debt level in year t, the annual index-linked interest payment for that year, K_t, is:

$$K_t = 1/12 \sum_{i=1}^{12} \alpha_{i,t} \left\{ D_{t-1} + (D_t - D_{t-1})\, i/12 \right\} . \qquad (7a)$$

The factor 1/12 is needed since $\alpha_{i,t}$ is a per annum rate. D is the debt level of the firm at the beginning of the simulation period. In the case of applying a rate lagged by a constant period, Eq (7a) is generalized to:

$$K_t = 1/12 \sum_{i=1}^{12} \alpha_{i-\ell,t} \left\{ D_{t-1} + (D_t - D_{t-1}) \right\} , \qquad (7b)$$

where ℓ is the number of months of the lag period.[9]

For the purpose of evaluating the effects of indexation on the firm's risk, while maintaining net earnings unchanged, we constrain the total index-linked interest payments over the simulation period to equal the total original payments. This is equivalent to assuming that the mean interest rate is unchanged by indexation. Accordingly, some scale factor or "risk premium adjustment," R must be applied to K_t, such that

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basis has influenced our decision to use monthly index rate data. There is an added benefit here in that the expected error of the simulation (given step changes in the firm's debt) is reduced by the smoothing of monthly computations.

[9] In order to keep the notation consistent in Eq (7b) $\alpha_{12+i-\ell,t-1}$ must be substituted for $\alpha_{i-\ell,t}$ when $i-\ell \leq 0$.

$$R \sum_t K_t = \sum_t I_t \ , \qquad (8a)$$

or equivalently,

$$R = \sum_t I_t \Big/ \sum_t K_t = \frac{\bar{I}}{\bar{K}} \ , \qquad (8b)$$

where I_t and $\bar{I}$ are the annual original interest payment in year t, and the mean value of the original interest payments, respectively. $\bar{K}$ is the mean value of the payments computed in Eq (7b). For the purposes of adjusting the net earnings stream, therefore, the annual indexed interest payments made by the firm is the stream:

$$I'_t = R K_t \ . \qquad (9a)$$

Taking the mean value of Eq (9a), and using Eq (8b), we have:

$$\bar{I'} = R\bar{K} = \bar{I} \ . \qquad (9b)$$

The adjusted net earnings, ANE_t, can now be computed by the expression:

$$ANE_t = NE_t + (1-.5)(I_t - I'_t) = NE_t + .5(I_t - I'_t) \ . \qquad (10)$$

The linear time series regression technique is applied to the adjusted net earnings data generated by Eq (10) to obtain the regression equation:

$$\hat{ANE}_t = \overline{ANE} + \beta_{ANE}\, t \ , \qquad (11a)$$

where β_{ANE} is the slope of the growth trend in the ANE_t data, and is given by an expression analogous to Eq (3). However, by virtue of Eq (9b), it is assured that the mean adjusted net earnings, $\overline{ANE}$, is equal to the mean original net earnings, $\overline{NE}$. The result of the time series regression, Eq (11a), may thus be rewritten:

$$\hat{ANE}_t = \overline{NE} + \beta_{ANE}\, t \ . \qquad (11b)$$

The total, regression, and error sum of squares, and the root residual variation associated with the data ANE_t are calculated, respectively by:

$$TSS_{ANE} = \sum_t (ANE_t - \overline{NE})^2 ; \qquad (12a)$$

$$RSS_{ANE} = \sum_t (\hat{ANE}_t - \overline{NE})^2 ; \qquad (12b)$$

$$ESS_{ANE} = \sum_t (ANE_t - \hat{ANE}_t)^2 ; \qquad (12c)$$

$$RRV_{ANE} = \sqrt{\frac{ESS_{ANE}}{(n-2)}} \ . \qquad (12d)$$

Finally, the risk measure associated with the index adjusted net earnings of the firm, F_{ANE}, is determined by:

$$F_{ANE} = \frac{RRV_{ANE}}{\overline{NE}} = \sqrt{\frac{ESS_{ANE}}{(n-2)\ \overline{NE}^2}} \ . \qquad (13)$$

3.2.4 ADDITIONAL DEBT CAPACITY

The index adjustment to net earnings will result in a change in the financial risk of the firm. For the case in which the adjustment of net earnings increases the financial risk of the firm, i.e., $F_{ANE} \geq F_{NE}$, we assume that no potential benefit to the firm is created. In the case that the adjustment results in $F_{ANE} < F_{NE}$, the benefit to the firm of the lower risk must be determined. Since the insolvency risk of the firm can be measured by the variability of the net earnings stream, additional debt may be undertaken to the extent that the resulting variability is not greater than that existing with the original fixed rate debt. That is, the additional debt capacity available to the firm as a result of indexation is taken as that amount which restores the original level of risk, F_{NE}.

It was assumed that the original capital structure of the firm was optimal; that is, the marginal after-tax costs of debt and equity were equal. To the extent that insolvency risk is reduced, the marginal after-tax cost of debt relative to equity is lowered, and the optimality of the capital structure of the firm is changed. The optimal capital structure may be restored by increasing the firm's leverage until a condition of equal marginal costs of debt and equity is attained. We assume that the additional borrowed funds are applied to repurchasing the firm's equity shares. We further assume that the indexation, issuance of additional debt and share repurchase are performed simultaneously so that the firm's capital structure remains optimal throughout. This is equivalent to saying that the additional borrowings are exactly sufficient to retire enough equity shares so that, aside from any effects of taxes, the value of the firm is unchanged.

We assume that the interest rate on the additional borrowings is also indexed. Since the yearly interest payments on the enhanced debt position are larger, and are subtracted (after the 50% tax shield) from the same yearly revenue amounts, the annual and mean net earnings over the simulation period will be decreased. However, given our assumption of optimal capital structure, the reduction in net earnings is proportional to the retirement of originally outstanding equity.

We formulate the firm's capacity for additional borrowing as a constant scale factor, $(1 + \delta)$, which is applied to the original debt amounts. The set of original debt levels, D_t, thus, is increased to the levels, $(1 + \delta)D_t$. By replacing D_t by $(1 + \delta)D_t$ in either of the expressions of Eqs (7), the annual indexed interest payments with the assumption of the additional debt, I", can be defined as:

$$I''_t = R(1+\delta)K_t = (1+\delta)RK_t \, . \tag{14a}$$

By using Eq (9a), we rewrite Eq (14a) as:

$$I''_t = (1+\delta)I'_t \, . \tag{14b}$$

Thus, a third annual net earnings stream, this one resulting from indexation and an enhanced debt position, is defined:

$$\begin{aligned} U_t &= NE_t + (1-.5)(I_t - I''_t) = NE_t + .5(I_t - I'_t - \delta I'_t) \\ &= ANE_t - .5\,\delta I'_t \, . \end{aligned} \tag{15}$$

Since the constant, δ, is not yet determined, we are not able to solve Eq (15) for the earnings stream, U_t, which restores the original value of risk to the firm. However, all statistical parameters, as well as the risk measure, F_U, for the stream U_t may be defined in formal manner. Specifically, we define the regression equation:

$$\hat{U}_t = \bar{U} + \beta_U t \, ; \tag{16a}$$

the total sum of squares,

$$TSS_U = \sum_t (U_t - \bar{U})^2 \, ; \tag{16b}$$

the regression sum of squares,

$$RSS_u = \sum_t (\hat{U}_t - \bar{U})^2 ; \tag{16c}$$

the error sum of squares,

$$ESS_u = \sum_t (U_t - \hat{U}_t)^2 ; \tag{16d}$$

the root residual variation,

$$RRV_u = \sqrt{\frac{ESS_u}{(n-2)}} ; \tag{16e}$$

and the risk measure,

$$F_u = \frac{RRV_u}{\bar{U}} = \sqrt{\frac{ESS_u}{(n-2)\,\bar{U}^2}} . \tag{16f}$$

We also note the relationship between the total, regression and error sum of squares:

$$TSS_u = RSS_u + ESS_u . \tag{16g}$$

By taking the mean value of both sides of Eq (15), the mean earnings under the additional debt service is

$$\bar{U} = \overline{ANE} - .5\,\delta\,\bar{I}' = \overline{NE} - .5\,\delta\,\bar{I}' . \tag{17}$$

We can now derive an expression for the debt capacity factor, δ , in terms of known or calculable quantities. Since it is required that the additional debt restore the risk of the "indexed" firm to the original value, the risk measure of the stream U_t must be equal to the firm's original risk measure. That is:

$$F_U = F_{NE} \cdot \qquad (18)$$

Using the condition of risk equality, Eq (18), the value δ can be determined. The procedure, briefly, will be to expand the left hand side of Eq (18) in terms of the quantites defined in Eqs (16a) through (16f). Eqs (15) and (17) are then used to express all functions of U_t and $\overline{U}$ in terms of functions of the known quantites ANE_t, $\overline{NE}$, I'_t and $\overline{I}'$, as well as δ. Since the right hand side of Eq (18) is known, the result is an expression which can be solved for δ in terms of known quantites only.

Substituting Eqs (6) and (16f) into Eq (18), and squaring the result, yields:

$$\frac{ESS_U}{(n-2)\,\overline{U}^2} = \frac{ESS_{NE}}{(n-2)\,\overline{NE}^2} \cdot \qquad (19)$$

Eq (19) may be rewritten:

$$ESS_U = \frac{\overline{U}^2 ESS_{NE}}{\overline{NE}^2} = ESS_{NE}\left(1 - .5\delta\frac{\overline{I}'}{\overline{NE}}\right)^2, \qquad (20)$$

where Eq (17) was used to express $\overline{U}$ in terms of $\overline{NE}$, and $\overline{I}'$.

From Eq (9b), $\overline{I}' = \overline{I}$. Making this substitution and expanding Eq (20):

$$ESS_U = ESS_{NE}\left\{1 + \frac{\delta^2}{4}\left(\frac{\overline{I}}{\overline{NE}}\right)^2 - \delta\left(\frac{\overline{I}}{\overline{NE}}\right)\right\} \cdot \qquad (21)$$

In order to be able to express the lefthand side of

Eq (21) in terms of known quantities for the formal definition of $\hat{U}_t$,

$$\hat{U}_t = \overline{U} + \beta_U t \qquad (16a)$$

must now be rewritten in terms of previously determined earnings and interest streams. To do this, consider the application of linear regression to the defining equation of U_t, Eq (15). The linearity of the regression technique implies that the regression equation of U_t is equal to the sum of the regression equations for the data ANE_t and $-.5\delta I'_t$. Thus,

$$\hat{U}_t = \widehat{ANE}_t - .5\,\delta\,\hat{I}'_t\,. \qquad (22)$$

The quantity $\hat{I}'_t$ is the estimate we obtain by regressing the indexed interest payments, I'_t, i.e.,

$$\hat{I}'_t = \overline{I'} + \beta_{I'} t\,, \qquad (23)$$

where $\beta_{I'}$ is the regression line slope.

Substituting Eqs (11b) and (23) into Eq (22) yields:

$$\begin{aligned}\hat{U}_t &= \overline{NE} + \beta_{ANE} t - .5\,\delta\,(\overline{I'} + \beta_{I'} t) \\ &= (\overline{NE} - .5\,\delta\,\overline{I'}) + (\beta_{ANE} - .5\,\delta\,\beta_{I'})t\,.\end{aligned} \qquad (24)$$

Comparing Eq (24) to Eq (16a), we make the identifications:

$$\beta_U = \beta_{ANE} - .5\,\delta\,\beta_{I'}\,; \qquad (25a)$$

$$\overline{U} = (\overline{NE} - .5\,\delta\,\overline{I'}), \qquad (25b)$$

and where the latter relationship was previously established in Eq (17).

Returning to Eq (21) we may now continue the derivation of δ. Using Eqs (16c) and (16g), we rewrite the lefthand side of Eq (21) as:

$$\begin{aligned} ESS_U &= TSS_U - RSS_U \\ &= TSS_U - \sum_t (\hat{U}_t - \bar{U})^2 . \end{aligned} \qquad (26)$$

We introduce the variance of U_t, $\sigma^2(U)$, which is related to the total sum of squares by the relationship:

$$\sigma^2(U) = \frac{TSS_U}{n-1} . \qquad (27)$$

Using Eq (27) in Eq (26), and expanding the summation term yields:

$$\begin{aligned} ESS_U &= (n-1)\sigma^2(U) - \sum_t \left\{ \hat{U}_t^2 - 2\hat{U}_t\bar{U} + \bar{U}^2 \right\} \\ &= (n-1)\sigma^2(U) - \sum_t \hat{U}_t^2 + 2\bar{U}\sum_t \hat{U}_t - \sum_t \bar{U}^2 . \end{aligned} \qquad (28)$$

Substituting Eq (16a) for $\hat{U}_t$, and expanding terms:

$$\begin{aligned} ESS_U &= (n-1)\sigma^2(U) - \sum_t (\bar{U} + \beta_U t)^2 - n\bar{U}^2 + 2\bar{U}\sum_t (\bar{U} + \beta_U t) \\ &= (n-1)\sigma^2(U) - \sum_t (\bar{U} + \beta_U t)^2 - n\bar{U}^2 + 2n\bar{U}^2 \\ &= (n-1)\sigma^2(U) - \sum_t (\bar{U} + \beta_U t)^2 + n\bar{U}^2 . \end{aligned} \qquad (29)$$

Substituting Eq (25a):

$$\begin{aligned} ESS_U &= (n-1)\sigma^2(U) - \sum_t \left\{ \bar{U} + (\beta_{ANE} - .5\delta\beta_{I'})t \right\}^2 + n\bar{U}^2 \\ &= (n-1)\sigma^2(U) - \beta_{ANE}^2 S_t - \delta^2(.5\beta_{I'})^2 S_t + \delta\beta_{ANE}\beta_{I'} S_t , \end{aligned} \qquad (30)$$

where use was made of the zero mean property of t, and S_t

is equal to $\sum_t t^2$.

The variance of U_t can be calculated using Eq (15):

$$\sigma^2(U) = \sigma^2(ANE) + 1/4\,\delta^2\sigma^2(I') - \delta\,\sigma(ANE, I'), \quad (31)$$

where $\sigma^2(ANE)$, $\sigma^2(I')$, and $\sigma(ANE, I')$ are, respectively, the variance of ANE_t, the variance of I'_t, and the covariance between ANE_t and I'_t, all of which are calculable. Indeed, for the variances, we can use the total sum of squares computed from the regressions performed on ANE_t and I'_t:

$$\sigma^2(ANE) = \frac{TSS_{ANE}}{n-1} \quad (32)$$

and

$$\sigma^2(I') = \frac{TSS_{I'}}{n-1} . \quad (33)$$

We can, at last, express ESS_U in terms of δ and calculated statistical parameters of ANE_t and I'_t. Substituting Eq (31) into Eq (30), and using Eqs (32) and (33) to express variances in terms of total sums of squares, we have:

$$ESS_U = TSS_{ANE} + 1/4\,\delta^2\,TSS_{I'} - \delta(n-1)\sigma(ANE, I') - \beta_{ANE}^2 S_t - \delta^2(.5\beta_{I'})^2 S_t + \delta\beta_{ANE}\beta_{I'} S_t . \quad (34)$$

By substitution of Eq (34) into Eq (21), we obtain a quadratic equation for δ, of the form:

$$A\delta^2 + B\delta + C = 0 \qquad (35a)$$

where

$$A = 1/4\, TSS_{I'} - 1/4\left(\frac{\bar{I}}{NE}\right)^2 ESS_{NE} - (.5\,\beta_{I'})^2 S_t\,, \qquad (35b)$$

$$B = \beta_{ANE}\,\beta_{I'}\,S_t + \left(\frac{\bar{I}}{NE}\right) ESS_{NE} - (n-1)\,\sigma(ANE, I')\,, \qquad (35c)$$

and

$$C = TSS_{ANE} - \beta^2_{ANE} S_t - ESS_{NE}\,. \qquad (35d)$$

The solution for the value of the additional debt capacity factor, δ , determines, from Eq (15), the net earnings stream, U_t, generated by the firm under the policy of debt indexation and the assumption of additional debt.

Eq (35) has as a solution two roots which, in general, occur as complex or real pairs. For the purposes of interpreting the solution as the additional debt capacity factor, we restrict our attention to real roots only. Of these, a positive root represents the assumption of additional debt by the firm, and a negative root corresponds to the firm reducing its debt position. A negative root of absolute value less than unity signifies the unleveraging of the firm's capital structure. Since the outstanding debt of the firm is $(1 + \delta)$ times the historic debt level, a root $\delta = -1$ would represent an all equity firm. A root less than -1 implies a lending policy for the firm. Since in either case a negative additional debt capacity implies no gain in tax advantages of borrowing for the firm, we choose to ignore this class of solutions. In considering the positive roots we will exclude from consideration those that would result in a loss of tax benefits to the firm. As can be seen from Eq (17), we must place an upper bound on the additional debt capacity, $\delta = \delta_c$, such that the mean net earnings will not be negative. Thus,

$$\delta_c = \frac{2\,\overline{NE}}{\overline{I'}} \qquad (36)$$

δ_c is the upper limit of additional debt capacity factors we will consider. To summarize, we will consider positive real roots up to δ_c in evaluating the benefits of debt indexation for the firm.

As can be seen by Eqs (35b,c,d), the magnitude of δ is a result of a complex relationship among statistical parameters of the streams NE_t, ANE_t, and I'_t. Basically, in order to have achieved a reduction in risk by indexation, the indexed interest payments must have been more positively correlated with the firm's earnings than the actual interest payments. By raising the debt amount, the effects of the correlation will be enhanced, but the variation in the payment stream is also increased. The factor δ scales the interest payments to that level which exactly restores the risk of the resultant earnings stream to the original value. The magnitude of δ is, thus, a matter of balance between the variance of the interest payments and the co-variance of the interest payments with earnings.

3.2.5 PRESENT VALUE OF ADDITIONAL DEBT CAPACITY

Thus far we have dealt with the effects of debt indexation upon the firm through the medium of the firm's annual net income flows. We have first reduced, let us assume, the variation in net earnings as reflected in the transformation of NE_t to ANE_t. In doing this we imposed the condition that the mean interest payments under indexation remained unchanged. Our measure of risk, thus, decreased proportionally to the decrease in earnings variation (net of growth). Next, by virtue of the decrease in risk, the debt capacity factor, δ , which is the amount of additional debt capacity generated by indexation, expressed as a scale factor of the original debt amount, was calculated. The additional debt was assumed to be indexed, and the increased interest payments (tax shielded) on the enhanced debt were reflected in the net earnings flows U_t.

From the perspective of our model of the firm, we have abstracted point estimates for the firm over the simulation period of financial risk and additional debt capacity resulting from indexation. The firm's risk associated with the simulated dual policy of debt indexation and increased leverage is the same as the firm's historic risk, and the optimality of its capital structure, preserved. The tax deductibility of the interest on the increased leverage can now be shown to have enhanced the value of the firm.

Consider the mean annual before-interest after-tax operating income over the simulation period, $\overline{X}_o$. The income is divided into flows to the firm's equity and debt. Thus:

$$\overline{X}_o = \overline{NE} + \overline{I} \quad , \tag{37}$$

where $\overline{NE}$ is the mean net earnings and is the mean annual flow to equity. $\overline{I}$ is the mean historic interest payments, i.e., the mean annual flow to holders of the firm's debt. The historic risk of the firm is F_{NE}[10], and we associate with this risk an after-tax cost of capital for the firm, ρ_{NE}. Hence, assuming no growth, we may express the value of the firm as the value of an annuity of annual payments $\overline{X}_o$, discounted at the rate ρ_{NE}. That is:

$$V_o = \frac{\overline{X}_o}{\rho_{NE}} = \frac{\overline{NE} + \overline{I}}{\rho_{NE}} \; . \tag{38}$$

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[10] We do not specify nor need to calculate the after-tax cost of capital, ρ_{NE}. It is sufficient for our argument to assume only that there exists a unique mapping between risk, F_{NE}, and the after-tax cost of capital, ρ_{NE}.

The simulation of the policy of indexation and additional debt for the firm assumed that each dollar of additional borrowing was used to retire a dollar of equity shares. In this case, the total capitalization is the same as that of the historic firm. We may then write the average after-tax operating income, $\bar{X}_\delta$, for the firm having indexed its debt and borrowed an additional debt amount $\delta \bar{D}$, as:

$$\bar{X}_\delta = \bar{U} + \bar{I}'' = \bar{U} + (1+\delta)\bar{I}' \;. \tag{39}$$

The debt level, $\bar{D}$, is the average debt level of the firm over the simulation period, i.e.,

$$\bar{D} = \sum_t D_t / n \;. \tag{40}$$

Moreover, it was assumed in the simulation procedure that the mean indexed interest payments, $\bar{I}'$, equals the mean historic interest payments, $\bar{I}$, as shown by Eq (9b). This further implies that the average cost of debt capital over the simulation period is the same for the original fixed rate and the indexed rate debt. We can, thus, express the average, or effective interest rate, i, on the firm's debt, over the period as,

$$i = \frac{\bar{I}}{\bar{D}} = \frac{\bar{I}'}{\bar{D}} \;. \tag{41a}$$

In Eq (14) it was also assumed that the additional borrowing, which was expressed as a scale factor $(1+\delta)$ times the original debt, committed the firm to additional interest payments scaled by $(1+\delta)$. Thus, the additional debt was assumed obtained at the same effective rate, i. So,

$$i = \frac{\delta \overline{I'}}{\delta \overline{D}} \quad . \qquad (41b)$$

Returning to Eq (39), and substituting for $\overline{U}$ from Eq (17):

$$\overline{X}_{\delta} = \overline{NE} - .5\delta\overline{I'} + (1+\delta)\overline{I'}$$

$$= \overline{NE} + \overline{I'} + .5\delta\overline{I'} \cdot \qquad (42)$$

Using Eq (41b), we rewrite the last term on the right-hand side of Eq (42) as: $.5\,\delta\, i\overline{D}$. That is,

$$\overline{X}_{\delta} = \overline{NE} + \overline{I} + .5\delta i\overline{D} \ , \qquad (43)$$

where Eq (9b) was used.

The first two terms on the right hand side of Eq (43) represent the flows to equity and debt in the same annual amounts as the historic firm, as given by Eq (37). Since the risk, F_U, of the firm under the policy of debt indexation and additional borrowing is equal to the historic risk, F_{NE}, the flows are discounted at the original after-tax cost of capital, ρ_{NE}. Because of equivalent risks, the additional flow, $.5\delta i\overline{D}$, is appropriately capitalized at the effective average interest rate on the firm's outstanding debt, i. Hence, within the perpetuity approximation, assuming the temporal stability of the estimate of i and δ, the value of the firm under the policy of debt indexation and enhanced borrowing, V_δ, is:

$$V_\delta = \frac{\overline{NE} + \overline{I}}{\rho_{NE}} + \frac{.5\delta i\overline{D}}{i}$$

$$= \frac{\overline{X}_o}{\rho_{NE}} + .5\delta\overline{D}$$

$$V_\delta = V_o + .5\delta\overline{D}. \qquad (44)$$

Eq (44) shows that the incremental present value to the firm of the additional debt capacity resulting from the policy of debt indexation is the tax rate times the additional debt capacity. This implication is consistent with Modigliani and Miller's[11] view that, aside from its tax advantage, debt financing does not affect the value of the firm. The product of the tax rate, .5, and the additional debt capacity, $\delta\ \overline{D}$, where $\overline{D}$ is computed from Eq (40) and is our measure of the economic value to the firm of a policy of debt indexation.

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11 Modigliani and Miller, *op. cit.*, p. 439.

3.3 AUXILLARY MEASURES

Since our estimate of the additional debt capacity δ, was based upon the substitution of an indexed interest stream for the historic interest stream, it represents the benefits of indexation as an alternative financing policy. The benefits so derived are estimated on the basis of the relative effects of the indexed and historic interest payments on the variability of the net earnings stream. Our measure of insolvency risk thus implicitly considers the de facto smoothing (or unsmoothing) of the net earnings stream due to the historic tax accounting and financing policy of the firm. For example, an historic policy of issuing Commercial Paper or reliance on short-term financing by the firm could have smoothed its net earnings. The benefits of long-term debt indexation are thus estimated net of any smoothing effects of the historic financing policy.

Since we estimate the benefits to the firm of the long term debt indexation policy relative to the historic financing policy, the relationship evaluated in our measure of benefits incorporates the effects of the historic financing policy with those of the indexation policy and does not estimate the latter, per se. For example, suppose that the historic interest payments were negatively correlated with the firm's operating earnings, or earnings before interest and taxes (EBIT). If the indexed interest payments were less negatively correlated with the firm's earnings before interest and tax than the negatively correlated historic interest payments, the firm would benefit from the simulated indexation policy. Thus, in order to text the hypothesis of systematic macro- and micro-economic relationships between market rates and the firm's earnings, we seek to exclude any effects of the firm's historic financing policy. To recapitulate, the benefits of the long-term debt indexation policy will be estimated relative to those of the historic financing policy, and we also seek an estimate of the relationship between the market interest rates and the firm's earnings independently of the firm's historic financing policy.

To estimate the relationship between the index rate and the firm's earnings independent of historic financing policies we choose the partial correlation coefficient of the firm's operating income stream before interest and tax, $EBIT_t$, with the market index rate, α_t.[1] Both the earnings before interest and tax and the interest rate data are corrected for trend by considering only the variation around their regression estimated trend line. Thus, we compute the partial (i.e., trend corrected) coefficient of correlation,

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[1] Since the market interest rate, $\alpha_{i,t}$, is established for each month i of year t, we compute α_t as the arithmetic average of the monthly rates for each year t.

$r_{EBIT,\alpha/t}$, by the relation:

$$r_{EBIT,\alpha/t} = \frac{\sum(\alpha_t - \hat{\alpha}_t)(EBIT_t - \widehat{EBIT}_t)}{\sqrt{\sum(\alpha_t - \hat{\alpha}_t)^2 \cdot \sum(EBIT_t - \widehat{EBIT}_t)^2}} , \quad (45a)$$

where $\hat{\alpha}_t$ and $\widehat{EBIT}_t$ are the estimates by regression on time of the market index rate and the firm's earnings before interest and taxes, respectively.

Defining the quantities

$$ESS_{\alpha} = \sum(\alpha_t - \hat{\alpha}_t)^2 \quad (46a)$$

and

$$ESS_{EBIT} = \sum(EBIT_t - \widehat{EBIT}_t)^2 , \quad (46b)$$

Eq (45a) may be rewritten as:

$$r_{EBIT,\alpha/t} = \frac{\sum(\alpha_t - \hat{\alpha}_t)(EBIT_t - \widehat{EBIT}_t)}{\sqrt{ESS_{\alpha} \cdot ESS_{EBIT}}} . \quad (45b)$$

The partial coefficient of correlation may now be related to a measure of the smoothing of the firm's before tax, after interest earnings stream due to indexation. The firm's historic before tax, after interest stream is given by

$$EBIT_t - I_t ,$$

where $EBIT_t$ is the before interest and tax earnings and I_t is the historic interest payment. Under the policy of indexation, the stream is given by

$$EBIT_t - I_t' ,$$

where I'_t is the indexed interest payments.

We choose as the criterion for smoothing of the before tax, after interest earnings, the relation:

$$\begin{aligned} & ESS_{EBIT-I'} - ESS_{EBIT-I} \leq 0 \\ & = ESS_{EBIT} + ESS_{I'} - 2r_{EBIT,I'/t}\sqrt{ESS_{EBIT}\,ESS_{I'}} \\ & \quad - ESS_{EBIT} - ESS_{I} + 2r_{EBIT,I/t}\sqrt{ESS_{EBIT}\,ESS_{I}}\ . \end{aligned} \tag{47}$$

Since our criterion of smoothing is based on the difference of the error sums of squares of the two streams, the effect of trend is eliminated from our measure.

We wish to exclude from consideration the historic financing policies of the firm. We make the assumption that the historic interest payments, I_t, are constant, thus we may neglect their effect on the measure of variation. Eq (47) therefore reduces to:

$$ESS_{I'} - 2r_{EBIT,I'/t}\sqrt{ESS_{EBIT}}\sqrt{ESS_{I'}} \leq 0\ . \tag{48}$$

In order to eliminate the effects of the variability of the firm's historic debt on our measure, we make the further assumption that the firm's debt level is constant. That is,

$$I'_t = \alpha_t \bar{D}\ , \tag{49}$$

where $\bar{D}$ is the mean debt level of the firm.

Eq (48) may now be written as:

$$\bar{D}^2 \cdot ESS_\alpha - 2\bar{D}\, r_{EBIT,\alpha/t} \sqrt{ESS_{EBIT}} \sqrt{ESS_\alpha} \leq 0. \quad (50)$$

Dividing both sides of Eq (50) by $\bar{D} \cdot \overline{EBIT} \cdot ESS_\alpha$, a strictly positive quantity, yields

$$\frac{\bar{D}}{\overline{EBIT}} - \frac{2 r_{EBIT,\alpha/t} \sqrt{ESS_{EBIT}}}{\sqrt{ESS_\alpha}\ \overline{EBIT}} \leq 0, \quad (51a)$$

where $\overline{EBIT}$ is the mean value of the firm's before interest and tax earnings. For ease of expression, we change both the signs and the sense of the inequality in Eq (51a) and define our measure of smoothing, γ, as:

$$\gamma \equiv \frac{2 r_{EBIT,\alpha/t} \sqrt{ESS_{EBIT}}}{\sqrt{ESS_\alpha}\ \overline{EBIT}} - \frac{\bar{D}}{\overline{EBIT}} \geq 0. \quad (51b)$$

It can be seen from Eq (51b) that a necessary though not sufficient condition for smoothing is that γ, and hence, $r_{EBIT,\alpha/t}$ be positive. Whether smoothing of the before-tax, after-interest stream occurs depends on the relative magnitudes of $\frac{\bar{D}}{\overline{EBIT}}$ and $\frac{r_{EBIT,\alpha/t} \sqrt{ESS_{EBIT}}}{\sqrt{ESS_\alpha}\ \overline{EBIT}}$ as well as the non-negativity of $r_{EBIT,\alpha/t}$.

γ provides a measure of the potential smoothing of the firm's before-tax, after-interest earnings stream by indexation per se, independent of the firm's historic financing of taxes. To the extent that financing and taxes do not affect the variability of a firm's net earnings, a positive gamma provides support for our estimate of generated debt capacity, δ .

CHAPTER 4

RESULTS OF SIMULATIONS

4.1 PRESENTATION OF RESULTS

Our hypothesis concerning the effects of debt indexation on the value of the firm was tested on a sample of 44 firms classified within 7 industry sectors as identified by various classification levels of the U.S. Department of Commerce Standard Industrial Classification (SIC) code. All firms within a chosen industry sector included in the Standard and Poor's 500 Composite Index and for which complete data existed are included in our results. The firm data were obtained from the Compustat annual data base.

Our simulation procedure generated a point estimate of additional debt capacity for each application of a lagged index to the firm's debt. Since our measure of the value of the additional debt capacity is equal to the product of the tax rate, the average debt level and our estimate of the incremental debt capacity factor, we chose to compare the benefits estimated by different simulations on a given firm in terms of the incremental debt capacity factor alone. In addition, we will estimate the value of a policy of debt indexation for the index rate and lag that yielded the maximum incremental debt capacity.

The debt capacity factor is determined from a quadratic equation which has as solutions two roots. In order to limit our discussion to estimates of incremental debt capacity consistent with an increase in the value of the firm, we have included in our results only real, non-negative roots less than δ_c, as defined in Eq (36), at which incremental debt level the mean incremental after-tax interest payments become greater than the firm's mean original net earnings.

Since any systematic benefits of indexation would depend on an underlying systematic relationship between the index and the firm's earnings, partial correlation coefficients of earnings and the index, $r_{EBIT,\alpha/t}$, are included in the results for each of the simulations. The partial correlation coefficients provide a test statistic for the underlying relationship upon which the existence of benefits from indexation would depend. Since interest is an expense, we seek assurance, based on our sample estimate $r_{EBIT,\alpha/t}$, that the true correlation of earnings and the index is positive. Given the 18 years data in our simulations, attainment of a 5% level of significance implies that the estimated partial correlation coefficient must be greater than 0.48[1].

The following sections present the simulation results by firm within each industry. For each firm we estimate an incremental debt capacity factor for each of two rate indices

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[1] Snedecor, G.W., and Cochran, W.G., Statistical Methods, Iowa State University Press, Ames, Iowa, 1967, p. 557.

lagged zero (concurrent), three and six months. The indices used were 91-day Treasury Bill rates and 4- to 6-month Commercial Paper rates. In assessing the benefits to the firms of a policy of debt indexation, we have assumed the tax deductibility of interest payments on the additional debt. Thus we will identify firms which generated net losses in any year of the indexation simulations.

4.1.1 PACKAGED FOODS INDUSTRY

Six corporations within the packaged foods industry (SIC code 2000) were included in our simulations. Of these, General Foods Corporation showed potential benefit from a policy of debt indexation.

As seen in Table 4.1, General Foods attained positive incremental debt capacity factors for indexation with both Treasury Bill and Commercial Paper rates for all lags. The maximum debt capacity factor, .426, was generated by the Commercial Paper rate applied at a six month lag.

The firm had no net losses in any year of the simulation period. The other firms in our sample of the packaged foods industry did not achieve benefit from indexation with either index rate. Unfortunately, none of the partial correlation coefficients for General Foods are significant at the 5% level and we cannot conclude that our estimate of benefits is accompanied by a systematic positive correlation of the index with the firm's operating earnings. However, the

TABLE 4.1

SIMULATION RESULTS FOR PACKAGED FOODS INDUSTRY

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
General Foods Corp.									
Treasury Bill	.083	.275	.415	.289	.399	.454	1.97	3.13	3.99
Commercial Paper	.106	.290	.426	.294	.401	.452	2.03	3.23	4.03
Gerber Products Co.									
Treasury Bill	No additional			-.275	-.051	.192	-7.99	-1.40	4.21
Commercial Paper	debt capacity			-.291	-.066	.196	-7.68	-1.78	4.25
General Mills									
Treasury Bill		"		.263	.186	.119	13.2	8.07	4.48
Commercial Paper				.310	.242	.162	15.9	11.5	7.37
Kellogg Co.									
Treasury Bill		"		.227	.163	.087	2.52	1.90	0.94
Commercial Paper				.269	.190	.126	3.13	2.31	1.44
Quaker Oats									
Treasury Bill		"		.077	-.016	-.094	2.75	-1.07	-4.21
Commercial Paper				.123	.042	-.035	4.58	1.20	-1.89
Standard Brands									
Treasury Bill		"		.204	.190	.154	2.62	2.58	1.79
Commercial Paper				.282	.260	.232	4.45	4.24	3.52

Table 4.1. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market rate index ($r_{EBIT,\alpha/t}$), and estimates of smoothing (γ) for sample corporations in the packaged foods industry for 0, 3, and 6 month lags of two market rate indices.

estimate of smoothing based on operating earnings and the index, γ, shows a correspondence with the estimate of benefits, δ, for the various index rates and lags simulated.

It is noted that positive γ's were estimated for the firms which did not benefit from the simulated indexation policy. However, these were not based on statistically significant correlations between the firms' before interest and tax earnings and the index rate.

Table 4.8 summarizes the maximum benefits to all firms in the simulation study for which benefits were indicated. The estimate of value is the product of the marginal tax rate, the maximum debt capacity factor and the mean original debt capitalization of the firm. As seen from Table 4.8, the largest debt capacity factor for General Foods represents a net present value to that firm of $35.2 million. However, the correlation coefficient of .452 associated with the maximum debt capacity factor is not significant at the 5% level. The present value is based on the assumption of a perpetual continuation of the simulated indexation policy and the temporal stability of our estimate for δ and the mean interest rate.

4.1.2 TEXTILE PRODUCTS INDUSTRY

Five firms were included in our sample of the textile products industry (SIC code 2200). Incremental debt capacities were generated for all firms for each index rate and at least one lag. As shown by Table 4.2, the partial correlation coefficients for two of the firms were significant

TABLE 4.2

SIMULATION RESULTS FOR TEXTILE PRODUCTS INDUSTRY

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Burlington Industries									
Treasury Bill	.421	.199	.017	.578	.326	.056	26.1	13.7	-.004
Commercial Paper	.316	.110		.454	.179	-.068	20.3	6.30	-5.68
Cone Mills Corp.									
Treasury Bill	.078	.051	.030	.090	-.004	-.097	1.25	-3.40	-8.58
Commercial Paper	.064	.035	.013	.027	-.007	-.178	-1.85	-7.45	-12.8
M. Lowenstein & Sons									
Treasury Bill	.275	.171		.589	.527	.378	21.4	19.9	12.7
Commercial Paper	.272	.116		.624	.526	.367	23.8	20.3	12.1
Reeves Bros., Inc.									
Treasury Bill	.488	.379	.298	.412	.232	.038	15.9	7.51	-0.65
Commercial Paper	.434	.350	.284	.327	.162	-.013	12.1	4.64	-2.85
J.P. Stevens & Co.									
Treasury Bill	.069			.203	-.074	-.334	12.0	-8.60	-26.7
Commercial Paper	.017			.072	-.236	-.469	2.44	-20.8	-36.4

Table 4.2. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market rate index ($r_{EBIT,\alpha/t}$), and estimates of smoothing (γ) for sample corporations in the textile products industry for 0, 3, and 6 month lags of two market rate indices.

at the 5% level. The largest additional debt capacities for all firms in this industry were achieved by indexing interest payments to the Treasury Bill rate on a concurrent basis. Reeves Bros., Inc. generated the largest additional debt capacity factor of approximately 49% of its original debt level. Reeves Bros., Inc. also was one of the two firms in our sample of this industry for which incremental debt capacities were generated for all rate and lag combinations simulated.

It is noted that additional debt capacities were generated for several firms in cases where both the partial correlation coefficient and estimate of smoothing were negative. For example, Cone Mills Corp. had the largest negative partial correlation coefficient of -.178 for the Commercial Paper index lagged six months. In all cases, however, the negative correlation coefficient was not statistically significant.

The value of a policy of debt indexation and additional borrowings, given the lagged index that yielded the maximum incremental debt capacity, is shown in Table 4.8 for each firm. Because the estimate of value depends on a firm's original debt capitalization as well as the incremental factor, the increase in value for Burlington Industries, Inc. of $60.6 million was larger than that for Reeves Brothers, Inc. Since our estimate of value is based on the tax deductibility of the additional interest payments, the figure given for J.P. Stevens & Co., Inc. may be overstated. This firm had net losses in 1971 both originally and after undertaking the additional indexed debt (for both indices). These losses increased with the simulated debt policy.

4.1.3 FOREST PRODUCTS INDUSTRY

Five firms in the Standard and Poor's 500 companies are included in our simulation of the forest products industry (SIC code 2400). Table 4.3 shows that Champion International Company and Georgia Pacific Corporation benefit from indexation using both Treasury Bill and Commercial Paper rates applied at zero lag. In neither case was the relationship between the index and the firm's operating earnings demonstrated to be statistically significant at the 5% level. The maximum benefits accrued to both companies from indexation based on the Treasury Bill rates. Table 4.8 shows that the net present values of a policy of indexation for Champion International and Georgia Pacific are $67.9 million and $40.9 million, respectively.

4.1.4 PAPER PRODUCTS INDUSTRY

Eight firms in the paper products industry (SIC code 2600) were included in our simulations. Six of these firms generated an additional debt capacity for the simulation of some index and lag combination(s). For two of these six firms, Mead Corp. and Scott Paper Co., statistically significant correlations were obtained for the index rate and

TABLE 4.3

SIMULATION RESULTS FOR FOREST PRODUCTS INDUSTRY

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Champion Int. Co.									
Treasury Bill	.418			.325	.088	-.151	23.6	3.08	-19.8
Commercial Paper	.297			.306	.038	-.204	22.6	-1.56	-24.7
Georgia Pacific Corp.									
Treasury Bill	.167			.284	.060	-.173	18.3	0.04	-20.6
Commercial Paper	.125			.288	.032	-.187	19.1	-2.05	-21.6
Brown Co.									
Treasury Bill	No additional			.196	.002	-.119	14.3	-8.75	-23.8
Commercial Paper	debt capacity			.221	.009	-.123	17.9	-7.90	-24.3
Evans Products Co.									
Treasury Bill		"		.127	-.038	-.175	7.18	-8.84	-23.5
Commercial Paper				.157	-.032	-.172	10.3	-8.24	-22.8
Potlatch Corp.									
Treasury Bill		"		.234	-.029	-.282	25.5	-6.77	-38.9
Commercial Paper				.206	-.092	-.323	22.5	-14.9	-43.2

Table 4.3. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market rate index ($r_{EBIT,\alpha/t}$), and estimate of smoothing (γ) for sample corporations in the forest products industry for 0, 3, and 6 month lags of two market rate indices.

TABLE 4.4

SIMULATION RESULTS FOR PAPER PRODUCTS INDUSTRY

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Crown Zellerbach									
Treasury Bill	.753	.137		.351	.073	-.256	15.0	1.58	-15.9
Commercial Paper	.583	.025		.321	.005	-.305	13.9	-2.04	-19.2
International Paper									
Treasury Bill	1.043	.097		.434	.167	-.131	15.3	5.51	-6.77
Commercial Paper	.846			.414	.103	-.202	14.9	2.94	-9.65
Kimberly-Clark									
Treasury Bill	.102			.085	-.184	-.430	1.71	-8.89	-19.3
Commercial Paper	.043			.076	-.215	-.461	1.43	-10.2	-20.4
Mead Corporation									
Treasury Bill	.058			.525	.261	-.043	21.2	9.72	-5.41
Commercial Paper				.495	.181	-.119	20.5	5.85	-9.15
St. Regis Paper Co.									
Treasury Bill	.222			.384	.137	-.146	15.8	3.90	-11.4
Commercial Paper	.118			.376	.094	-.189	15.9	1.66	-13.6
Scott Paper Co.									
Treasury Bill	1.008	.730	.458	.608	.518	.345	21.4	19.6	12.7
Commercial Paper	.919	.638	.363	.573	.456	.243	20.8	17.4	8.37

TABLE 4.4 CONTINUED

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Union Camp Co.									
Treasury Bill	No additional debt capacity			.228	-.007	-.250	15.9	-2.41	-23.0
Commercial Paper				.240	-.025	-.253	17.3	-3.05	-23.0
Westvaco Corp.									
Treasury Bill		"		.248	-.065	-.320	26.7	-11.5	-39.9
Commercial Paper				.177	-.148	-.387	18.5	-11.6	-47.9

Table 4.4. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market index rate ($r_{EBIT,\alpha/t}$), and estimates of smoothing (γ) for sample corporations in the paper products industry for 0, 3, and 6 month lags of two market rate indices.

the firm's operating earnings. Of those for which additional debt capacities were generated, the maximum incremental debt capacities were achieved by concurrent indexation with the 91-day Treasury Bill rate. For this index and (lack of) lag, the additional debt capacities ranged from about 6% for Mead Corporation to 104% for the International Paper Company (see Table 4.4). Mead Corp. generated a relatively small additional debt capacity for the simulated concurrent Treasury Bill indexation and no additional debt capacity for concurrent Commercial Paper indexation. In each case the partial correlation coefficient of earnings before interest and taxes and the index rate was statistically significant. Since our estimate of benefits for the indexation policy is relative to the historic financing policy, the apparently reduced or non-existent benefits attributed to the indexation policy could be explained in terms of a favorable historical financial policy for this firm.

The estimated net present values of these additional debt capacities are shown in Table 4.8. None of the firms in our sample of the paper products industry generated net losses as a result of our indexation simulations.

4.1.5 ETHICAL DRUGS INDUSTRY

Our simulation includes five corporations in the ethical drugs industry (SIC code 2835). Table 4.5 shows that three of the five firms, Abbott Laboratories, American Home Products, Corp., and Pfizer, Inc., benefited in the

TABLE 4.5

SIMULATION RESULTS FOR ETHICAL DRUGS INDUSTRY

FIRM/INDEX	δ			$r_{EBIT,\alpha/t}$			γ		
	0	3	6	0	3	6	0	3	6
Abbott Laboratories									
Treasury Bill	2.114	2.016	1.420	.729	.668	.497	25.1	24.4	18.1
Commercial Paper	2.106	1.974	1.196	.710	.631	.411	25.0	23.3	14.6
Amer. Home Products									
Treasury Bill	.019	.004	.001	.165	.051	-.056	5.65	1.62	-2.62
Commercial Paper	.035	.017	.017	.218	.088	-.005	7.81	3.12	-0.59
Pfizer Inc.									
Treasury Bill	4.770	5.745		.214	.046	-.083	3.34	0.02	-2.59
Commercial Paper	4.895	5.922		.226	.050	-.064	3.67	0.12	-2.18
Eli Lilly & Co.									
Treasury Bill	No additional debt capacity			.239	.090	-.062	9.98	3.80	-2.99
Commercial Paper				.267	.101	-.036	11.4	4.27	-1.83
Merck & Co.									
Treasury Bill	"			.294	.233	.146	11.0	9.03	5.27
Commercial Paper				.349	.262	.177	13.7	10.4	6.54

Table 4.5. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market rate index ($r_{EBIT,\alpha/t}$), and estimates of smoothing (γ) for sample corporations in the ethical drugs industry for 0, 3, and 6 month lags of two market rate indices.

simulation of debt indexation. We note that Abbott Laboratories and Pfizer Corp. attained substantial maximum incremental debt capacity factors, the former for Treasury Bill rates at zero lag and the latter for Commercial Paper rates lagged three months. However, only the correlation coefficients for Abbott Laboratories were significant. American Home Products is characterized by relatively smaller factors occuring for all lags and rates. Table 4.8 displays the estimated value of the indexation policy and the associated correlation coefficients for the three firms.

4.1.6 AIR TRANSPORT INDUSTRY

Seven firms from the air transport industry (SIC code 4511) and the Standard & Poor's 500 were included in our simulations. As shown in Table 4.6, three of these companies, Delta Air Lines, Inc., Eastern Air Lines and National Airlines, Inc., generated additional debt capacities. The largest incremental debt capacities were generated with the Treasury Bill rate as an index. For Delta and National the largest increase in debt capacity occured without any lag, while for Eastern Air Lines this occured when the index was lagged by 3 months. It is noted in Table 4.6 that the estimate of benefits, δ , and the estimate of smoothing, γ , vary with lag in the same way: for Delta Airlines, both decreasing with increasing lags; for Eastern Airlines, both increasing with increasing lags.

TABLE 4.6

SIMULATION RESULTS FOR AIR TRANSPORT INDUSTRY

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Delta Air Lines									
Treasury Bill	1.149	.677	.291	.526	.310	.058	36.2	19.2	1.91
Commercial Paper	1.012	.591	.232	.487	.272	.009	33.0	16.8	-1.48
Eastern Air Lines									
Treasury Bill		.001	.003	.017	.176	.358	-16.3	36.1	97.7
Commercial Paper		.001	.003	.043	.220	.356	-8.04	51.5	94.6
National Airlines									
Treasury Bill	.028			.020	-.237	-.459	-1.53	-29.1	-53.1
Commercial Paper				-.095	-.328	-.538	-14.4	-39.0	-62.6
American Airlines									
Treasury Bill	No additional			-.108	-.104	-.060	-31.7	-32.5	-22.9
Commercial Paper	debt capacity			-.187	-.186	-.175	-48.6	-50.6	-47.8
Pan American									
Treasury Bill	"			-.088	-.138	-.200	-29.0	-40.8	-54.8
Commercial Paper				-.184	-.230	-.287	-49.4	-61.4	-73.1

TABLE 4.6 CONTINUED

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Trans World Airlines									
Treasury Bill	No additional debt capacity			-.295	-.470	-.561	-80.3	-128	-148
Commercial Paper				-.389	-.577	-.672	-103	-154	-173
UAL, Incorporated									
Treasury Bill	"			.123	-.080	-.245	6.39	-18.9	-40.3
Commercial Paper				.057	-.178	-.360	-1.58	-31.7	-54.4

Table 4.6. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market index rate ($r_{EBIT,\alpha/t}$), and estimates of smoothing (γ) for sample corporations in the air transport industry for 0, 3, and 6 month lags of two market rate indices.

The only debt capacity factors associated with statistically significant correlation coefficients occured for Delta Airlines at zero lag and both market rate indices. Table 4.8 gives the estimated net present values for the largest incremental debt capacity factors generated and the associated correlation coefficients for each firm. Both Eastern Air Lines and National Airlines had actual net losses during the simulation period. Losses also occured for these firms following the simulated indexation policy. (While the average of the losses in the simulated data for Eastern was greater in absolute terms than the actual figure, it was less for National.) Due to these losses, our estimate of value for the simulated policy of indexation and additional borrowing for these two firms is possibly overstated.

4.1.7 RETAIL DEPARTMENT STORE INDUSTRY

Eight firms comprise our sample of the retail department store industry (SIC code 5311). Table 4.7 shows that Carter Hawley Hale Stores generated positive debt capacity factors for both Treasury Bill and Commercial Paper rates for all lags. The other firm in the industry that benefited from the simulated indexation policy, Mercantile Stores Co., Inc., achieved positive factors with Commercial Paper rate indexation for zero and 3-month lags and with concurrent Treasury Bill rate indexation only. None of the

TABLE 4.7
SIMULATION RESULTS FOR RETAIL DEPARTMENT STORE INDUSTRY

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
Carter Hawley Hale									
Treasury Bill	1.142	1.017	.820	.168	.107	.019	6.64	3.53	-1.58
Commercial Paper	1.155	1.040	.825	.232	.161	.078	10.5	6.90	1.98
Mercantile Stores Co.									
Treasury Bill	.587			.161	.095	.039	1.90	0.76	-0.31
Commercial Paper	.853	.047		.220	.152	.090	3.07	1.88	0.72
Allied Stores									
Treasury Bill		No additional		.212	.014	-.185	2.09	-4.72	-12.2
Commercial Paper		debt capacity		.171	-.039	-.246	0.77	-6.71	-14.4
Assorted Dry Goods									
Treasury Bill		"		.231	.085	-.066	5.37	0.89	-4.23
Commercial Paper				.231	.071	-.089	5.51	0.46	-4.97
Federated Dept. Strs.									
Treasury Bill		"		.183	.013	-.174	1.62	-0.39	-2.89
Commercial Paper				.153	-.040	-.237	1.30	-1.07	-3.72
Gamble-Skogmo									
Treasury Bill		"		.681	.694	.642	15.8	18.0	17.7
Commercial Paper				.693	.694	.582	16.6	18.4	15.1

TABLE 4.7 CONTINUED

FIRM/INDEX	δ 0	δ 3	δ 6	$r_{EBIT,\alpha/t}$ 0	$r_{EBIT,\alpha/t}$ 3	$r_{EBIT,\alpha/t}$ 6	γ 0	γ 3	γ 6
R.H. Macy & Co.									
Treasury Bill	No additional debt capacity			.305	.171	.041	0.02	-1.35	-2.63
Commercial Paper				.279	.146	.029	-0.27	-1.60	-2.74
May Department Stores									
Treasury Bill		"		-.266	-.423	-.572	-9.26	-13.8	-18.4
Commercial Paper				-.343	-.497	-.625	-11.3	-16.1	-19.8

Table 4.7. Additional debt capacity factors (δ), partial correlation coefficients of EBIT and market rate index ($r_{EBIT,\alpha/t}$), and estimates of smoothing (γ) for sample corporations in the retail department store industry for 0, 3, and 6 month lags of two market rate indices.

TABLE 4.8

SUMMARY RESULTS BY FIRMS

INDUSTRY/FIRM	INDEX	LAG	DEBT FACTOR	PRESENT VALUE	CORRELATION COEFFICIENT
PACKAGED FOODS					
General Foods	Com. P	6	.426	$ 33.3	.452
TEXTILE PRODUCTS					
Burlington Indust.	T-Bill	0	.421	60.6	.578
Cone Mills Corp.	T-Bill	0	.078	1.7	.090
M. Lowenstein	T-Bill	0	.275	11.7	.589
Reeves Bros., Inc.	T-Bill	0	.488	4.3	.412
J.P. Stevens	T-Bill	0	.069	4.1	.203
FOREST PRODUCTS					
Champion Int.	T-Bill	0	.418	67.9	.325
Georgia-Pacific	T-Bill	0	.167	40.9	.284
PAPER PRODUCTS					
Crown-Zellerbach	T-Bill	0	.753	75.9	.351
International Paper	T-Bill	0	1.043	115.7	.434
Kimberly-Clark	T-Bill	0	.102	6.2	.085
Mead Corporation	T-Bill	0	.058	4.2	.525
St. Regis Paper	T-Bill	0	.222	22.1	.384
Scott Paper Co.	T-Bill	0	1.008	63.5	.608
ETHICAL DRUGS					
Abbott Laboratories	T-Bill	0	2.114	53.5	.729
Amer. Home Products	Com. P	0	.035	1.3	.218
Pfizer Corporation	Com. P	3	5.922	272.6	.050
AIR TRANSPORT					
Delta Air Lines	T-Bill	0	1.149	67.7	.526
Eastern Airlines	T-Bill	6	.003	0.6	.358
National Airlines	T-Bill	0	.028	1.2	.020
RETAIL DEPT. STORES					
Carter Hawley Hale	Com. P	0	1.155	51.4	.168
Mercantile Stores	Com. P	0	.853	9.5	.161

Table 4.8. Presentation of rate index, index lag (in months), present value ($-millions), and partial correlation coefficient ($r_{EBIT,\alpha/t}$) associated with the maximum additional debt capacity factor for sample firms by industry.

debt capacity factors generated are associated with statistically significant correlations of EBIT and market rate index. It is noted that the partial correlation coefficients associated with each rate and lag for Gamble-Skogmo Co. are significant, but no additional debt capacities are generated.

Table 4.8 shows that the maximum debt capacity factors correspond to net present values of $51.4 million and $9.5 million for Carter Hawley Hale Stores and Mercantile Stores Co., respectively.

4.2 DISCUSSION OF RESULTS

Of the forty-four firms included in our simulation study, twenty-two showed potential benefits from a policy of debt indexation. Of the seven industries sampled, at least one firm in each displayed a potential benefit. For six of these twenty-two firms, the additional debt capacities were associated with correlation coefficients that were significant at the 5% level. The six firms generating additional debt capacities associated with statistically significant correlation coefficients were distributed among four of the seven sample industries: textiles (two firms), paper (two firms), drugs (one firm), and airlines (one firm). Although statistically significant negative correlations were observed, in no cases were they associated with additional debt capacities.

As might be expected, there appears to be a comparability for a given firm between the magnitudes of the generated debt capacity factors for each of the indices investigated. For example, Table 4.5 shows for Abbott Laboratories a comparability of debt capacity factors for both indices which is maintained over the three lag structures simulated. Furthermore, seven firms evidenced statistically significant correlation coefficients with the Treasury Bill rate, and six of these did so with respect to the Commercial Paper rate. Thus, both index rates appear to have similar relationships with the earnings streams of the firms in this study. This effect can be attributed to the close correspondence between the two indices.

In terms of benefits from the indexation policy, more divergent results were obtained for the two index rates. As shown by Table 4.8, seventeen of the twenty-two firms benefiting from the simulated indexation policy achieved their maximum incremental debt capacities with the Treasury Bill index. Furthermore, in all cases where the maximum incremental debt capacity for a firm was associated with a statistically significant correlation coefficient, the index was the Treasury Bill rate. Given the similarity of the correlations of both indices with the sample firms' earnings, the larger debt capacities generated by the Treasury Bill index could be explained in terms of the greater variability (and hence contribution to risk reduction) of the Treasury Bill rate.

As was seen in Table 4.8, firms in four of the seven sample industries showed maximum benefits accruing from indexation on a concurrent basis exclusively. Two other industries achieved maximum benefits predominantly when indexed with zero lag, while the only firm in the remaining industry which attained an incremental debt capacity did so when indexed with a six-month lag. Independently of the significance of the associated correlation coefficients, there appears to be a pattern within industries for the index rate and lag generating the maximum benefits. For example, all sample firms in the textile products industry achieve their maximum additional debt capacities with the Treasury Bill index on a concurrent basis. Likewise, of the firms in the retail department stores industry which achieved benefits through indexation, all generated maximum debt factors for the Commercial Paper index lagged zero months.

When the industry data are aggregated, the pattern of maximum benefits achieved with indexation on a concurrent basis also predominates. Eighteen of the twenty-two firms benefiting from the simulated indexation policy achieved their maximum benefits when indexed on a concurrent basis. Also, all firms which achieved benefits and had statistically significant correlations also had their most significant correlations when indexed with zero lag.

All values of additional debt capacity factors generated by the sample firms in our simulation study of indexation are shown in Figures 4.1A, B, and C. Figure 4.1A shows the distribution of debt capacity factors, by intervals 0.10 in magnitude, over the total range of generated values. The factors are the results of simulating indexation using both Treasury Bill and Commercial Paper rates applied with zero lag. Figures 4.1B and 4.1C present similar results for the indices lagged three and six months, respectively. The first interval cell in each of the figures represents the number of occurances of non-positive additional debt capacity factors generated.

As can be seen from Figure 4.1A, of the total of 88 simulations corresponding to the two market rate indices and the 44 sample firms, there were 40 occurences of positive debt capacity factors for the zero lag case. For three- and six-month lags, Figures 4.1B and 4.1C show positive debt capacity factors occuring in 28 and 19 simulations, respectively. Hence, the zero lag case appears to be the most favorable lag period from the standpoint of generating the largest number of positive factors. Additionally, zero lag produces a wider distribution of positive factor values than the other lag periods simulated. A comparison of Figures 4.1A, B, and C shows that the

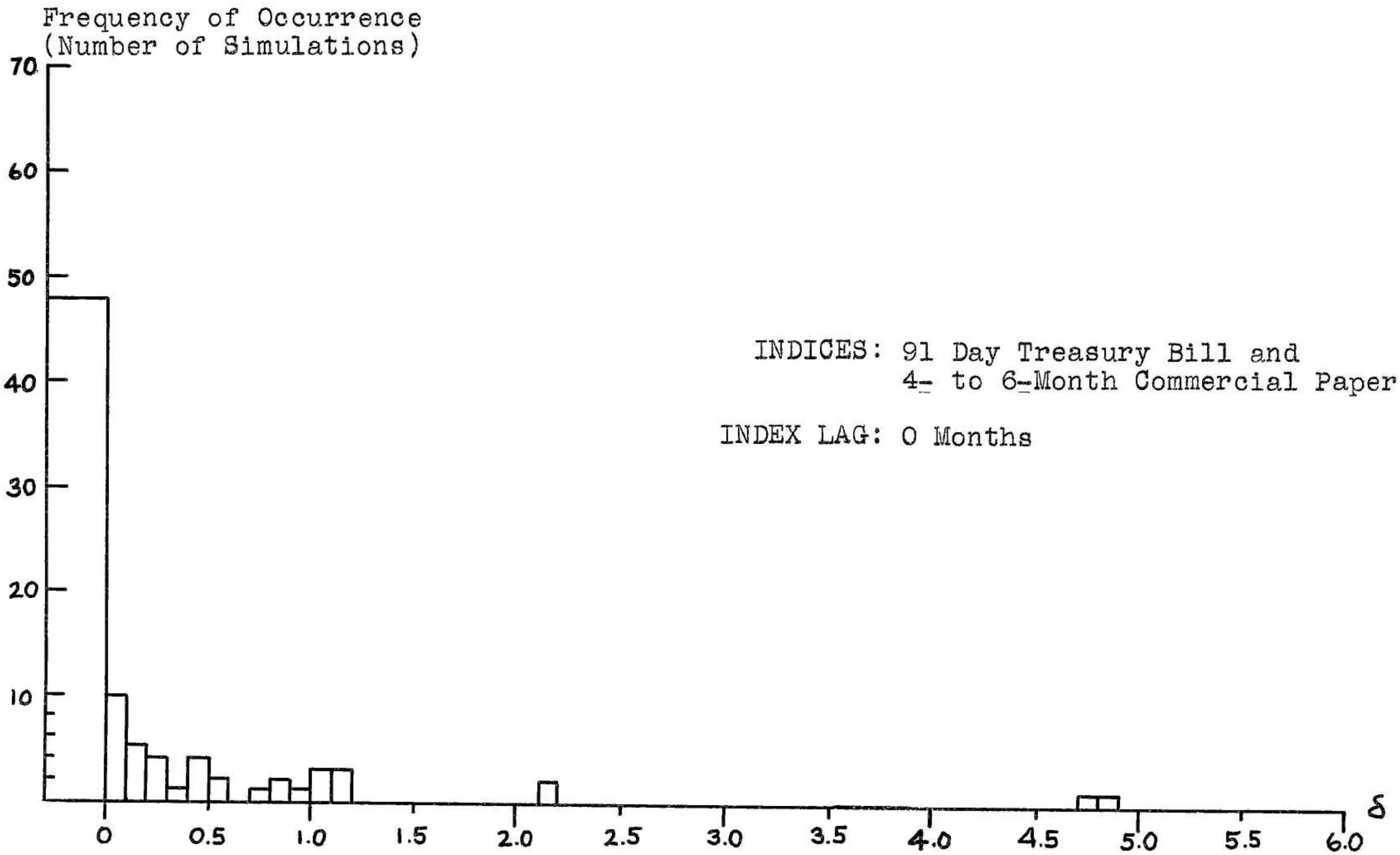

Figure 4.1A. Histogram of occurrence of additional debt capacity factor values generated for all firms in the simulation sample and both market rate indices applied at a lag of 0 months. The first cell represents the number of occurrences of non-positive debt capacity factors.

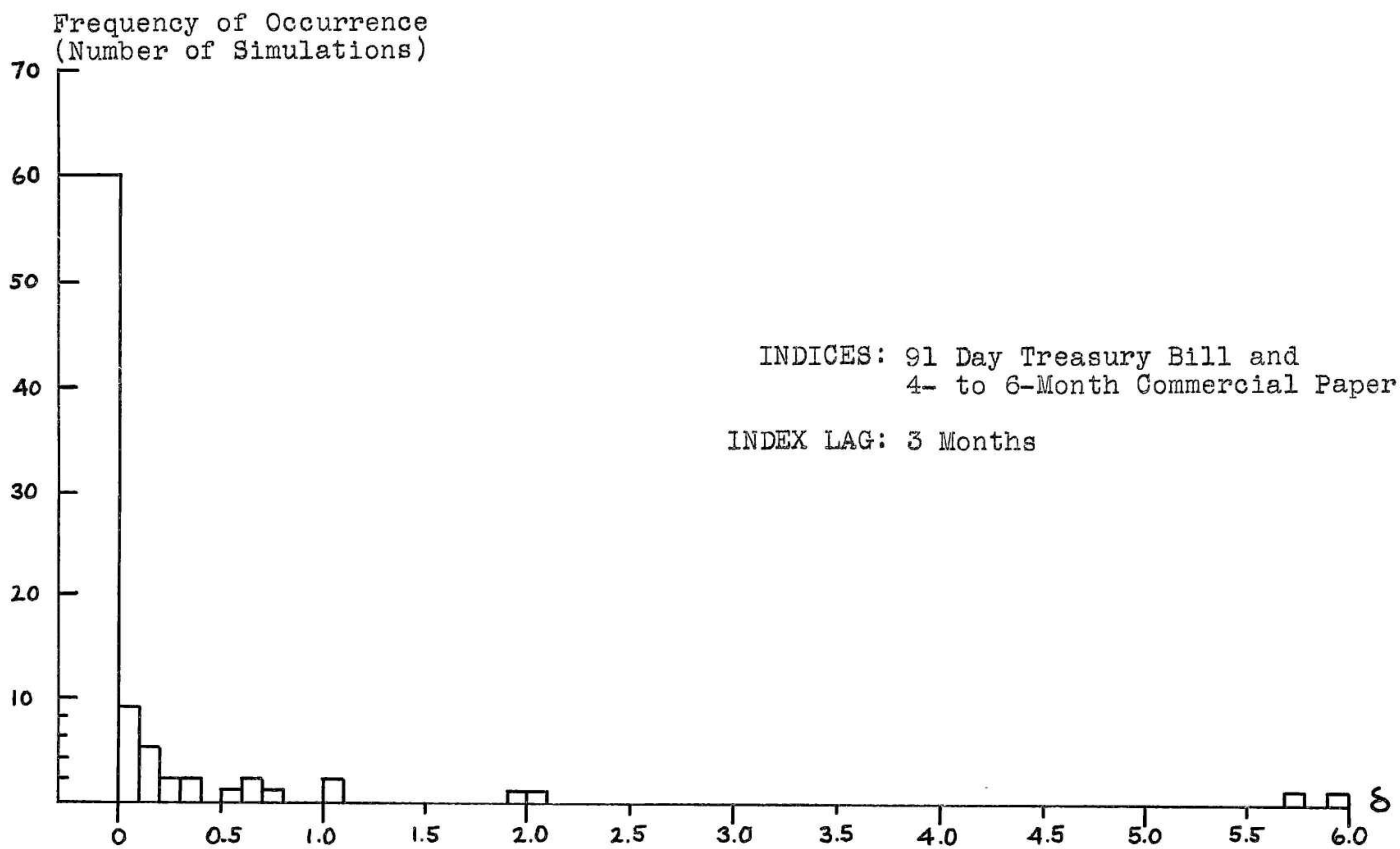

Figure 4.1B. Histogram of occurrence of additional debt capacity factor values generated for all firms in the simulation sample and both market rate indices applied at a lag of 3 months. The first cell represents the number of occurrences of non-positive debt capacity factors.

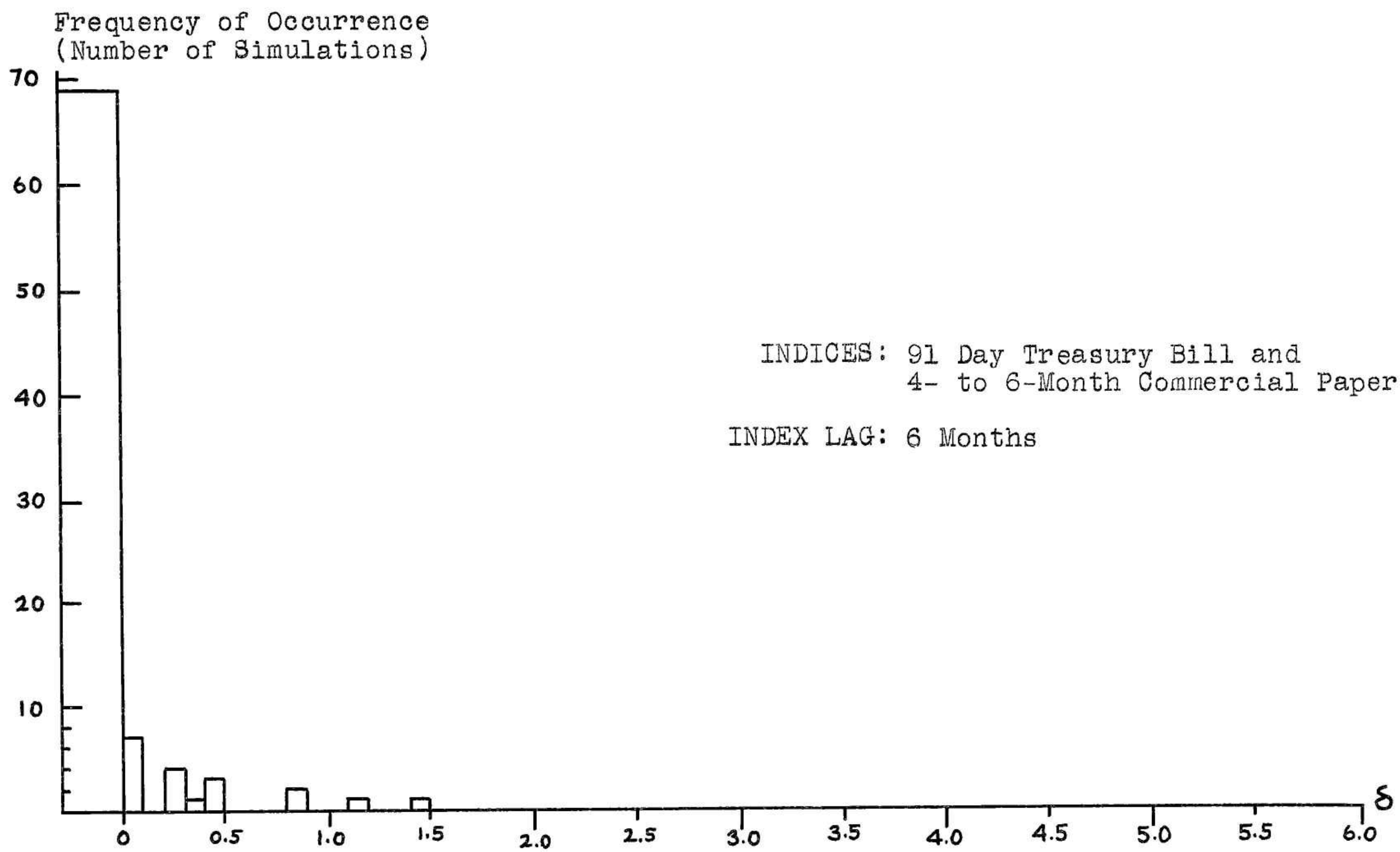

Figure 4.1C. Histogram of occurrence of additional debt capacity factor values generated for all firms in the simulation sample and both market rate indices applied at a lag of 6 months. The first cell represents the number of occurrences of non-positive debt capacity factors.

distribution of debt capacity factors decays more rapidly with increasing lag.

Table 4.9 shows by industry the number of firms included in our industry sample, the number of those generating positive debt capacity factors, the number achieving statistically significant correlation coefficients, and the number generating positive debt capacity factors as well as achieving a significant correlation for the same rate and lag. As indicated by the table there is an uneven distribution of firms evidencing statistically significant correlations of operating earnings and market rate index over the industry sectors of our sample. For example, no firm in our sample of 6 for the packaged foods industry achieved a statistically significant correlation while 2 of our 5 sample firms in the textile products industry did show significant correlations.

While our sample of firms is not large enough to establish a clear relationship, the data of Table 4.9 indicate that there is an uneven industry distribution of firms generating positive debt capacity and is similar to that achieving significant correlations. In the packaged foods group, for example, one firm of the 6 showed benefits, while all 5 firms in the textile products industry generated debt capacity factors. Moreover, with the exception of one firm in the retail department store industry, all firms

TABLE 4.9

SUMMARY RESULTS BY INDUSTRY

INDUSTRY	Sample Firms	Firms with Positive δ	Firms with Significant $r_{EBIT,a/t}$	Firms with both Significant $r_{EBIT,a/t}$ and Positive δ
Packaged Foods	6	1	0	0
Textile Products	5	5	2	2
Forest Products	5	2	0	0
Paper Products	8	6	2	2
Ethical Drugs	5	3	1	1
Air Transport	7	3	1	1
Retail Dept. Stores	8	2	1	0

Table 4.9. Presentation, by industry, of number of firms included in sample, number generating positive debt capacity factors, number achieving statistically significant correlation coefficients of EBIT and market rate indices, and number both generating positive debt capacity factors and achieving significant correlation.

which achieved a significant correlation coefficient of EBIT and market rate index also generated positive debt capacity. Thus, the simulation results suggest that the benefits of indexation are firm and industry specific. These results may imply that there are systematic macro- and micro-economic relationships between the sample firms' earnings and the indices used in our simulations.

A comparison of the estimates of smoothing, γ , with the generated debt capacities, δ , for firms in this study reveals generally consistent results. The most frequent divergence is the evidence of smoothing provided by a positive γ accompanied by no additional debt capacity. For example, consider the simulation results for Mead Corp. shown in Table 4.4. The correlation coefficients for the Treasury Bill and Commercial Paper rates at zero lag were both statistically significant. Values of γ were 21.2 and 20.5, respectively. An additional debt capacity was generated for the Treasury Bill index only, however, and the incremental debt was only approximately 6% of the originally outstanding debt. Another example is Gamble-Skogmo (Table 4.7), the only firm with significant correlations that did not benefit from the simulated indexation policy. Since the measure of benefit from indexation, δ , is determined relative to the smoothing effects of historic financial and tax policy, a lower threshold is established for each firm by the historic policies which indexation must surpass in order to generate an additional debt capacity. This effect would explain cases of a positive α not accompanied by an increase in debt capacity for the sample firms.

It has been our purpose to assess the potential magnitude and extent of the benefits accruing to firms as a result of a policy of long-term debt indexation. As was noted previously, at least one firm in each industry benefited from a simulated policy of indexation. Further, of the 44 sample firms 22 generated an additional debt capacity. The average incremental value resulting from the increased leverage for all firms in the study was $22 million.

4.3 CONCLUSION

With the presentation of our simulation results, the main purpose of demonstrating the potential effects of debt indexation on the value of the firm is complete. The average benefit of $22 million would seem to indicate that the policy merits serious consideration for reasons other than obtaining debt capital in times when a high rate of inflation has restricted the supply of fixed-rate debt.

However, the limitations of our "one period" model must be kept in mind. We did not set out to (nor did we) assess the causal nature of the economic linkages between various indices and a firm's earnings pattern or their stability over time. Further, by virtue of the simulation methodology employed, the effects of policy "choices" have been demonstrated ex post, yet the results per se do not imply they will be repeated in the future. These issues should be considered by any firm undertaking an indexation policy.

Of further interest is the equilibrium yield differential between nominal and index-linked debt. Since there is now a handful of firms, for the most part bank holding companies, with Treasury Bill-linked debt outstanding, an empirical approach might be taken here. The industry- and firm-specific nature of our results would seem to suggest that further research attempting to choose an index for a given firm should be carried out at those levels.

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