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The Cost of Capital and U.S. Capital Investment: A Test of Alternative Concepts

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I. Introduction

IN THE RECENT LITERATURE on corporation finance, the role of the cost of capital in financial structure decisions has come under debate. Charles W. Haley and Lawrence D. Schall [19] argue that the concept can be misleading when applied to decisions on capital structure. Other difficulties with the concept applied to capital structure problems have been pointed out by Stewart Myers [25] and clarified by D. J. Ashton and D. R. Atkins [3], while a defense of its use in this context is presented by Timothy Nantell and C. R. Carlson [26].

The more widespread use of the cost of capital as a hurdle rate for investment has also spurred recent debate by Fred Arditti [2], James Ang [1], as well as by Haley and Schall. Objections raised regarding the use of the cost of capital in this context are less severe than for capital structure decisions, and are at least partially matters of semantics. A defense of the cost of capital used in this context is contained in Nantell and Carlson as well as in a recent paper by William Beranek [5]. Haley and Schall summarize the difficulties with the weighted average cost of capital as being concerned with two points, (a) there may be a different cost of capital for different risk levels and for different time periods, (b) internal and external financial investments can have differing rates of return under certain conditions.

Although technical problems such as those now cited remain with the concept of the cost of capital used as a hurdle rate, they appear to be of a refined and relatively minor nature when compared to the unresolved empirical questions associated with the cost of capital. The cost of equity alone accounts for much of the difficulty. It has been variously represented in the literature as a dividend yield, an earnings yield, an ex-post return on stock, and as the return on the general class of real assets. In addition, at least four substantively different groups of ideas have emerged over the past several decades as to how we may best represent fluctuations in the overall cost of capital through time. This produces a dilemma for those interested in empirical research into capital and investment theory. For, even if we agree upon the theoretical role of the cost of capital, which measure should be used to represent this role and why? Virtually no empirical results exist at present to support either the choice of one cost of capital measure over another or to support the decision that we may remain indifferent among the alternatives that have been presented.

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Moreover, there has not been much of a consensus on the empirical significance of theory's role for the cost of capital in investment spending. Dale Jorgenson's work [21, 22] uses one specific representation of the cost of capital embedded in a rental price of capital term. This produces the result that capital investment is highly inelastic relative to the cost of capital. Other econometric investment models oriented towards prediction such as those of Michael Evans [13] or Robert Resek [28] add an interest rate representation of the cost of capital as a term in a linear regression model having investment as the dependent variable. These terms are found to be of statistical significance. However, translating this into a test of the significance of the theoretical role of the cost of capital in investment has not been done in the regression models.

This paper seeks to examine empirically and at the aggregate level the influence of the marginal cost of capital upon investment. It does this by formulating an investment model structure that reflects explicitly and uncompromisingly the theoretical role of the cost of capital in investment. This model is used to compare and evaluate the usefulness of alternative measures of the marginal cost of capital in explaining investment. Two types of results are produced. First, we produce findings about the influence of the cost of capital on investment that are largely independent of how we represent the cost of capital. These results are important in establishing the extent to which the evidence affirms the theoretical role of the cost of capital regardless of how we measure that variable. Second, our tests produce results on differences in the relative performance of various cost of capital measures, which help establish the extent to which one measure of the cost of capital is preferable to another.

We proceed by first defining four measures of the marginal cost of capital that reflect major concepts proposed to date. We use each of these measures in an investment model structure that is based on the conventional premise of maximizing net present value of the firm.

Our tests find a clearly significant cost of capital effect upon investment regardless of the measure we use. We also find that the restrictions upon model parameters implied by the underlying theory are met by all the cost of capital measures used.

We find some substantive differences in the relative performance of the cost of capital measures examined. However, the alternatives are in general more alike than different, and do not allow a clear choice of one cost of capital measure.

II. The Cost of Capital Measures

The cost of capital measures and the marginal return on investment are measured in nominal terms following the usual pattern in the literature. Taking explicit account of inflationary expectations could lead to their alternate formulation in real terms. While this is conceptually more pleasing, there is little reason to believe it would affect the comparisons among cost of capital measures that are our main concern.

The first cost of capital measure is a debt interest rate. It is common in the empirical literature on capital investment to represent the cost of capital by a rate of interest on corporate bonds.[1] Macroeconomic theorists also almost uniformly follow this same pattern, employing a debt interest rate in aggregate demand functions to represent cost of capital effects in investment spending as well as interest rate effects on consumption spending.[2] With a stable term structure, fluctuations in a debt rate of interest should presumably approximate fluctuations in the costs of all types of capital.

Thus, movements in a debt rate conceivably can be a simple and observable indicator of movements in broader and more complex cost of capital measures. Along these lines, Joseph Stiglitz [30] has developed a model that shows that under conditions of certainty and under certain market efficiency restrictions, a pre-tax debt rate of interest is the theoretically correct representation of the marginal cost of capital. Without going this far, we make the less restrictive hypothesis that the marginal cost of capital, denoted as C_t is proportional to a bond rate of interest, i_t:

$$C_t = \gamma \cdot i_t \qquad \gamma > 0 \tag{1}$$

Operational definitions and sources of i_t and all other variables and data used in the present analysis are given in Appendix A.

The second and third measures of C_t we examine define the marginal cost of capital in the context of corporate business. This approach treats C_t as a weighted average of the marginal costs of debt, equity, and retained earnings, where the weights are the optimal proportions of each type of capital in the firm's financing mix. This way of measuring the cost of capital has been developed in the literature on corporation finance and capital budgeting.[3] An earnings rate on new investment of equal risk to that of the firm's accumulated assets that yields a return equal to the weighted cost of capital is just sufficient to pay all suppliers of capital their required returns. Thus, the weighted cost of capital is the combined opportunity cost of funds available for new investment projects of homogeneous risk. Before tax adjustment, the weighted marginal cost of capital, $W_{b,t}$ is

$$W_{b,t} = \rho_{i,t} i_t + \rho_{e,t} \cdot e_t + \rho_{r,t} \cdot r_t \tag{2}$$

where ρ_i, ρ_e, and ρ_r are the optimal proportions of debt, equity, and retained earnings respectively, and e_t and r_t are the marginal costs of equity capital and retained earnings respectively. Disregarding taxes, $r_t = e_t$ since both new equity and retained earnings are funds belonging to residual owners. Taxes alter expression (2) in two ways. First, corporate income taxes reduce the effective cost of debt below its nominal cost. Second, dividend taxes must be taken into account. Specifically with marginal dividend tax rates equal to $t_{d,t}$, $r_t = e_t(1 - t_{d,t})$. The resulting tax-adjusted weighted cost of funds, $W_{a,t}$, is:

$$W_{a,t} = \rho_{i,t} \cdot i_t(1 - t_{p,t}) + \rho_{e,t} \cdot e_t + \rho_{r,t} \cdot e_t \cdot (1 - t_{d,t}) \tag{3}$$

[1] As examples of this, see the widely differing studies by Robert Resek [28], Michael Evans [13] and Hershall Grossman [17].

[2] For diverse examples, see Don Patinkin [27], Thomas Sargent [29], Karl Brunner and Alan Meltzer [6] or virtually any text on macroeconomics.

[3] See a text such as James VanHorne [31] and the references cited there. James Duesenberry's classic book on business cycles [9] also discusses this general view, as does Michael Evans [14].

where $t_{p,t}$ is the marginal tax rate on corporate profits.

The two alternative weighted average measures of C_t we examine differ according to how each measures the cost of equity funds. The first alternative assumes the aggregate cost of equity to be equal to the earnings price ratio for all corporations. Denoting the aggregate earnings-price ratio by $(E/P)_t$, this gives;

$$C_t = \rho_{i,t} i_t (1 - t_{p,t}) + \rho_{e,t} \cdot (E/P)_t + \rho_{r,t} \cdot (E/P)_t \cdot (1 - t_{d,t}) \tag{4}$$

The earnings-price ratio as a measure of the cost of equity is an idea suggested in the accounting literature and in parts of the literature on capital investment. In this view, new equity funds that cannot produce added profits in proportion to (E/P) will not meet investor expectations and will presumably lead to a lower share price. Proponents of the use of (E/P) recommend its use to measure the cost of equity because it is simple to calculate and is fully observable. Critics of the earnings/price ratio point out that (*a*) it is distorted by the use of after-tax earnings whereas most capital budgeting is designed to identify cash flow rates of return on new investment, and (*b*) it uses actual rather than expected earnings which usually differ substantively.

The literature on capital investment theory stresses that the cost of equity is the expected return to shareholders on funds invested in the firm. However, there is little if any past work that formulates empirical measures of the cost of equity treated explicitly as a measure of expectations.[4]

Fundamentally, the cost of equity is a long-run perception by investors of the dividend and capital gains income they expect on this component of financial wealth, expressed as a rate of return. Interestingly, there has now accumulated growing experience with measuring long-run expected income from total household stocks of financial and other wealth. This work is in connection with the permanent income theory of consumption, and has produced highly satisfactory empirical results.[5] The techniques developed in the permanent income literature can be directly applied to measuring the long-run expected income from equity investment. Following this approach, permanent non-human or financial income is defined as the expected long-run return on financial wealth. The stock of equity capital is a component of the stock of total financial wealth. Accordingly, the income expected from equity wealth can be approximated in the same way that the income expected from total wealth is approximated in the permanent income literature. Michael Darby's [8] version of this procedure involves isolating a "permanent" component of the observable income from wealth.

This measure of permanent income views the typical investor as forming an

[4] Of the approaches that have been taken, Myron Gordon's [15] model appears to be one frequently discussed way of operationalizing the definition of the cost of equity. However, his approach only translates the empirical problem from one of measuring the expected return of shareholders to one of measuring the expected growth rate of dividends, and to do this requires a number of further assumptions including (a) investors expect dividends to grow at a constant rate indefinitely and (b) the future reinvestment rate equals the current long-run expected return. These conditions limit the actual usefulness of the Gordon model empirically. A reconsideration of the Gordon model and its offshoots can be found in a recent paper by Myron Gordon and Lawrence Gould [16].

[5] For recent work on the problems associated with measuring permanent income, see Michael Darby [8, 7] and the references cited there.

expectation of future long-run equity earnings partly on the basis of the past pattern of actual accrued earnings and partially on the basis of current earnings and prices. Statistically, permanent income is essentially a trend component of measured income modified by successive realizations of the actual income series. For equity, the observable income Y_e, is the flow of dividends plus changes in capital value. To quantify permanent equity income, we follow Darby's use of a difference equation that relates permanent income to observable income and past values of permanent income. This equation applied to income from equity is:

$$Y_{p,t} = \beta \cdot Y_{e,t} + (1 - \beta)(1 + g) \cdot Y_{p,t-1} \tag{5}$$

where β is the weight of current observable income upon permanent income and g is the long-run growth rate of permanent income.[6] The value of $Y_{p,t}$ calculated from (5) measures the expected or permanent income from equity. It has the advantage of following from a fairly well-known procedure that has proved successful in estimates of aggregated permanent income from total wealth. The cost of equity that follows from its use is $Y_{p,t}/P_{t-1}$. This permanent income measure of the cost of equity gives a third measure of C_t:

$$C_t = \rho_{i,t} \cdot i_t(1 - t_{p,t}) + \rho_{e,t} \cdot Y_{p,t}/P_{t-1} + \rho_{r,t} \cdot Y_{p,t}/P_{t-1} \cdot (1 - t_{d,t}) \tag{6}$$

The fourth cost of capital measure we examine is that of Franco Modigliani and Merton Miller [24, 23], in conjunction with their provocative analyses of the relationship between capital structure, the cost of capital and the market value of the firm. Basically, the Modigliani-Miller work shows that for certain well specified capital market conditions the only impact of debt financing upon the cost of capital arises from the tax deductability of interest payments. Accordingly, the weighted cost of capital is not appropriate for the Modigliani-Miller formulation. The Modigliani-Miller cost of capital measure we examine is taken from

[6] Following Darby's procedure, values of $y_{p,0}$ and g are found by estimating the following equation over the sample period:

$$\ln(y_{e,t}) = a_0 + a_1 t$$

From this equation, $a_1 = g$ and $\mathrm{EXP}(a_0) = y_{p,0}$. B is assumed to be .025, the same as that found to be the best in a series of experiments by Darby and by Elliott [11] for total wealth over a similar period. In evaluating permanent equity income in this way, the best results were produced by dividing y_p into dividend and capital gains income, and estimating trend equations for permanent dividend and permanent capital value. Then, permanent capital gains are extracted as the change in the latter. The estimated equations over 1947.1 to 1978.4 for permanent dividend income, $y_{div,t}$ and permanent capital value, $C_{p,t}$, are:

$$y_{div,t} = .025 \times D_t + (.975)(1.01519)y_{div,t-1}$$

and

$$C_{p,t} = .025 \times P_t + (.975)(1.01478)C_{p,t-1}$$

with $y_{div} = 0.194$ and $C_p = 19.47$ at the initial quarter of 1947.1, where D_t is quarterly dividend payments on he S & P 500 stocks and P_t is the S & P 500 stock index. The calculated values of these two equations are combined as follows to produce the permanent income from stock prices:

$$y_{p,t} = y_{div,t} + C_{p,t}$$

their application of their theory to measuring cost of capital effects in the utility industry [23]. At the aggregate level, the Modigliani-Miller measure is given as follows:[7]

$$C_t = \frac{E_t + (1 - t_{p,t}) \cdot F_t}{V_t - t_{p,t} \cdot D_t - G_t} (1 - t_{p,t} \cdot \rho_{i,t}) \tag{7}$$

where E_t is after-tax corporate profits, F_t is total corporate interest payments, V_t is the market value of all corporations as reflected by the market value of outstanding stocks and bonds, D_t is the total stock of corporate debt, G_t is the market's valuation of expected growth in V_t, and as before $t_{p,t}$ and $\rho_{i,t}$ are the marginal profits tax rate and the optimal debt proportion respectively.

The Investment Model Structure

The investment model used to evaluate these cost of capital measures is based upon the capital investment theory that has emerged over the past two decades in the literature in capital budgeting and finance. This theory follows from a shareholder wealth maximizing criterion. Each time period, the state of the world produces an array of new or revised investment opportunities. These opportunities include additions to or replacement of homogeneous capital, investment in new production technology, investment required to enter new product areas, or almost any other purchase of business assets. The net present value of each opportunity is based on each firm's expected future profit flow from the investment and upon its marginal cost of capital. Spending on new investment projects proceeds to the point where marginal projects earn zero net present value. This investment policy maximizes the present value of shareholder wealth for temporally independent sets of investment opportunities. At the aggregate level of our analysis, we may abstract from the types of conditions set forth by Varouj Awazian and Jeffrey Callen [4] where investment may stop short of or proceed beyond the usual point of zero net present value.

To represent this theory, we begin with the following statement of the cumulative net present value, N, of any volume of investment, I:

$$N = E^* \left[\frac{1}{(1 + C)} + \frac{1}{(1 + C)^2} + \cdots + \frac{1}{(1 + C)^n} \right] + \frac{S}{(1 + C)^{n+1}} - I \tag{8}$$

where E^* is the annual earnings over an n-period planning horizon expected from new investment of I funds, S is the scrap value of I which we assume is realized during the period following the last income producing period of the asset, i.e., at $n + 1$, C is as before the cost of capital, and where t subscripts have been dropped from N, E^*, C, S, and I for convenience.

To formulate an investment model from (8), we first take the expected scrap

[7] This is a slight rearrangement of the expression appearing on p. 340 of Modigliani-Miller [23]. The earnings term in their expression is after-tax profits plus interest payments, i.e. M & M's $E'_t = E_t + F_t$. When this is inserted into expression (7), the numerator becomes $E'_t - t_{p,t} \cdot F_t$ which is as it is shown in the M & M article. We state it with E_t instead because that term has been previously used to refer to after-tax corporate profits.

value to be approximately equal to one year's expected earnings.[8] We can then rewrite (8) as:

$$N = E^* \left[\frac{(1 + C)^{n+1} - 1}{C(1 + C)^{n+1}} \right] - I \tag{9}$$

or by letting $\dfrac{(1 + C)^{n+1} - 1}{C(1 + C)^{n+1}} = F(C)$

as

$$N = E^* \cdot F(C) - I \tag{9a}$$

We follow the approach in the finance literature of interpreting C as a hurdle rate that has an exogenous influence upon investment. Accordingly, $F(C)$ is assumed to influence N and therefore I without feedback effects. This interpretation of C is somewhat questionable for at least some of our alternative representations of C. When the adjustment mechanism is defined below, the possibility of feedback effects is explicitly addressed. According to the theory, the value of E^* should rise with I at a falling rate. E^* should also reflect the impact that the state of the world has upon investment opportunities of firms. With little theoretical guidance as to how to structure these effects upon E^*, we take them to be related in a simple log linear fashion:

$$E^* = a \cdot I^b \cdot Z^d \qquad 0 < b < 1 \qquad d > 0 \tag{10}$$

where a, b, and d are parameters and Z is a measure of profit expectations regarding I that reflects the way the state of the world impacts upon E^*. Combining (9a) and (10) gives:

$$N = aI^bZ^dF(C) - I \tag{11}$$

Maximum cumulative net present value from current investment occurs where $\dfrac{dN}{dI} = 0$ and $\dfrac{d^2N}{dI^2} < 0$, or where:

$$I^* = [abZ^dF(C)]^{\frac{1}{1-b}} \tag{12}$$

where I^* denotes the wealth maximizing or desired volume of investment.

Denoting $x^* = \log I^*$, $z = \log Z$, and $f(c) = \log F(C)$, and restoring the t subscripts, we can rewrite (12) as:

$$x_t^* = \gamma_0 + \gamma_1 z_t + \gamma_2 f(c)_t \tag{13}$$

where $\gamma_0 = \log(a \cdot b)/(1 - b)$, $\gamma_1 = d/(1 - b)$, and $\gamma_2 = 1/(1 - b)$. Expression (13)

[8] Studies of depreciation rates in capital assets (see Dale Jorgenson and James Stephenson [22] or J. Walter Elliott [10]) often find annual rates of depreciation in the 7% to 10% range, which implies useful asset lives in the 10–15 year range. For n equal to the midpoint of this range and c in the 5–8% range that our calculations suggest, if true depreciation is straight line, then in equilibrium S is approximately equal to one year's annual earnings.

can be converted into a model of investment behavior by specifying the mechanism by which changes in the actual level of investment respond to changes in the desired level. Using the generalized Koyck adjustment process developed by Jorgenson [21], we can write:

$$x_t - x_{t-1} = \sum_{i=0}^{m} w_i[x^*_{t-1} - x^*_{t-i-1}] \tag{14}$$

where we constrain $\sum_{i=0}^{m}$ to unity. Combining (14) and (13) gives:

$$x_t - x_{t-1} = \gamma_1 \sum_{i=0}^{m} w_i \Delta z_{t-i} + \gamma_2 \sum_{i=0}^{m} w_i \Delta f(c)_{t-i} \tag{15}$$

To approximate the nonobserved profit expectations variable Z, it is appealing to follow Yehda Grunfeld [18] in supposing that changes in security market values sensitively reflect perceived changes in the way the state of the world impacts upon investors' profit expectations. Given that securities markets are in equilibrium where expected returns are at required levels, the value of stocks and bonds, V_t, can be related to earnings expectations as:

$$V_t = \frac{A^*_t}{C_t} \tag{16}$$

where A^* is the market expectation of the annual flow of returns from amassed business assets and C_t is, as before, the cost of capital. We assume that state-of-the-world impacts on profit expectations regarding new investment are closely related to the same impacts on profit expectations regarding amassed business assets. Accordingly, we write:

$$Z_t = f\cdot(A^*_t) = f\cdot(C_t\cdot V_t) \qquad f > 0 \tag{17}$$

where f is a constant value. Taking logs of (17) to obtain z_t gives $z_t = \log f + \log (C\cdot V)_t$. Differencing and inserting this into (15) completes the investment model:

$$x_t - x_{t-1} = \gamma_1 \sum_{i=1}^{m} w_i \Delta \log(C\cdot V)_{t-i} + \gamma_2 \sum_{i=1}^{m} w'_i \, \Delta f(c)_{t-i} \tag{18}$$

where also the first term in each of the distributed lags has been constrained to zero to avoid problems of simultaneity in statistical estimation, especially due to $F(c)$.[9] Constraining $w_0 = 0$ is consistent with a body of studies on the lags in the capital investment process.[10] We also constrain the distributed lag weights w_i for both terms to lie along a polynomial of the same degree and length, but not necessarily the same curvature. We write the weights as w_i and w'_i in (18) to reflect this generalization.

[9] Note that in the final form of this model, C_t enters as a part of the profits expectations term as well as in the cost of capital term. The empirical tests were approached with apprehension due to the possibility of multicollinearity. However, severe multicollinearity was not in fact present. Oddly enough, if $(C\cdot V)_t$ is replaced by V_t in (18), multicollinearity then becomes severe.

[10] For a comparison of lags measured in the context of different models, see Michael Evans [14].

Empirical Analysis

For our purposes, the most direct and meaningful empirical results are produced by successively estimating equation (18) with each of the cost of capital measures. This gives information on both the common and unique features of each measure. To do this, quarterly data are taken for all variables sufficient to enable regressions to be run over the period 1955.1 to 1978.3.[11]

Each of the cost of capital measures is inserted into expression (18). The length of the distributed lag is fit separately for each cost of capital measure by adding terms to the lag as long as the standard error is reduced. Both lags begin at $t-1$ and multicollinearity is not a significant characteristic of the data. Accordingly, no special estimating procedures are required. The results below are obtained using OLS.

The dependent variable, investment spending, is defined in two ways. First, the GNP series, Fixed Non-Residential Investment, is used. Second, the narrower BEA New Plant and Equipment series is used.[12] Table I presents the results for each cost of capital measure using the GNP investment expenditure series. The F-statistic for the cost of capital term in Table I tests the null hypothesis that the coefficients in the cost of capital lag distribution, $\sum_{w_i}$, are zero.[13] We can reject this hypothesis in all four cases in favor of the alternative that a significantly non-zero cost of capital effect occurs. We may conclude that a cost of capital effect upon investment that is significant beyond the 1% level occurs regardless of which of the four cost of capital measures we use. This is positive empirical affirmation of the role expression (18) prescribes for the cost of capital in investment spending, regardless of how we measure the cost of capital.

Comparing the standard errors and R^2 values, we find a noticeable difference between the best fitting weighted average-permanent income equation (#3) and the worst fitting Modigliani-Miller equation (#4). The standard error is increased by almost 17 per cent by using the Modigliani-Miller measure instead of the weighted average measure, while the R^2 falls from .567 to .413. The data thus tends to support the weighted average concept of the cost of capital distinctly more strongly than it supports the Modigliani-Miller concept.

The other two cost of capital measures show less pronounced differences. The

[11] For our purposes, data problems associated with the wage-price controls of the early 1970s or other possibly contaminated data are minimized by our predominant interest in producing a comparison of relative explanatory significance of the cost of capital measures.

[12] The GNP series is reported in the *Survey of Current Business* while the plant and equipment series is reported in *Business Capital Expenditures*.

[13] The F-statistic in this case is the ratio of the increase in residual variance occurring when the cost of capital coefficients are constrained to zero to the residual variance when these coefficients are unconstrained, i.e.

$$F(K, N-K) = \frac{(RSS_H - RSS_A)/K}{RSS_A/N-K}$$

where RSS_H and RSS_A are the residual sum of squares for the hypothesis of $\sum_{w_i} = 0$ and for the alternate $\sum_{w_i} \neq 0$ respectively. K is the number of variables constrained to zero by the null hypothesis, and N is the degrees of freedom attributable to regression for the null hypothesis.

Table I

Statistics for GNP Investment Equations

$$x_t - x_{t-1} = \gamma_0 + \gamma_1 \sum_{i=1}^{m} w_i \Delta \log(C \cdot V)_{t-i} + \gamma_2 \sum_{i=1}^{m} w_i' \Delta f(C)_{t-i}$$

Cost of Capital Definition	γ_0	γ_1	γ_2	R^2 (Std. Error)	Regression F-Statistics	F-Statistic for Cost of Capital Term	Calculated b: D.W.	Calculated b: d	Calculated b: m
1. Interest Rate	.0030 (0.80)	0.472 (4.50)	2.229 (7.41)	.544 (.0178)	12.85[b]	14.95[a]	1.69	.551 .212	7
2. Weighted Average: Earnings/Price Version	−.0035 (1.15)	0.658 (6.45)	1.671 (7.43)	.505 (.0185)	10.97[b]	14.80[a]	1.63	.402 .393	5
3. Weighted Average: Permanent Income Version	−.0073 (2.51)	0.924 (7.90)	4.216 (4.12)	.567 (.0173)	14.09[b]	4.40[a]	1.73	.763 .219	9
4. Modigliani-Miller	−.0005 (0.20)	0.424 (6.24)	2.842 (5.08)	.413 .0202	7.55[b]	8.08[a]	1.31	.648 .149	7

Note: Numbers in parentheses are absolute values of t-statistics.

[a] Significant beyond 1% level (4, 86) d.f.

[b] Significant beyond 1% level (8, 86) d.f.

results using the interest rate measure (#1) are quite close to those using the weighted average-permanent income measure. And, while the weighted average earnings/price measure (#2) explains investment less sensitively than either the interest rate of permanent income measure, the difference is not large.

The estimated coefficient values show that both distributed lag sequences have significantly large t statistics in all four equations. Regression F-statistics show each of the equations provides a statistically significant explanation of fluctuations in investment. Indeed, both the F-statistics and the R^2 values in Table I support the model structure of equation (18) solidly given that the dependent variable in our regressions is a per cent change in investment.

The estimated coefficients enable calculations of the structural parameters b and d in expression (10). These are shown in the next to last column in Table I. The coefficient b shows the net present value impact of changes in investment, and can be interpreted as the long-run elasticity of expected net present value relative to investment. The value of b is between zero and one for all four cost of capital measures, consistent with the expectation of a declining marginal net present value product of investment. The estimated b values thus uniformly support the theory regardless of our choice of cost of capital measures.

The coefficient d shows the net present value impact of shifts in expectations. The estimated d values are all greater than zero, also corresponding to the expectation of our theory in every case.

The values of b and d also show that cost of capital effects on expected net present value are quantitatively greater than profit-expectations effects for all four measures, with the difference being quite pronounced in all cases except the weighted average-earnings/price model (#2). For the best-fitting weighted average-permanent income model (#3), the cost of capital elasticity is about 3½ times as large as the profit expectations elasticity. These results suggest that cost of capital influences on investment are relatively important compared to profit expectations influences.

Table II gives results for the same estimations using the narrower BEA Plant and Equipment series rather than the GNP investment series. The statistics in Table II are largely the same as Table I. The best-fitting model is again the weighted average-permanent income version (#3) while the worst fitting is the Modigliani-Miller model (#4), with the standard error in the latter case 16% higher than in the former case. Again, these data support the weighted average concept more strongly than the Modigliani-Miller concept.

F-statistics for the cost of capital term are significant beyond the 1% level for the first three cost of capital terms, and significant at about the 2% level for the Modigliani-Miller term. As earlier, the evidence suggests a statistically significant cost of capital effect upon investment regardless of how we define the cost of capital.

Furthermore, T-Statistics for the γ_2 coefficient are significant beyond the 1% level for all four measures. Computed b values all lie between 0 and 1, thus conforming to the expectation of theory. Values of d are all greater than zero, also in conformance with theory. And, as before, cost of capital influences upon net present value are several times larger than profit expectations influences in

Table II

Statistics for Plant and Equipment Equations

$$x_t - x_{t-1} + \gamma_0 + \gamma_1 \sum_{i=1}^{m} w_i \Delta \log(C \cdot V)_{t-i} + \gamma_2 \sum_{i=1}^{m} w_i' \Delta f(c)_{t-i}$$

Cost of Capital Definition	γ_0	γ_1	γ_2	R^2 (Std. Error)	Regression *F*-Statistics	*F*-Statistics for Cost of Capital Term	D.W.	Calculated *b*: *d*	Calculated *b*: *m*
1. Interest Rate	.0017	0.586	2.244	.430	8.11[b]	8.80[c]	1.71	.554	8
	(0.32)	(3.78)	(5.29)	(.0227)				.261	
2. Weighted Average: Earnings/Price Version	−.0076	0.781	1.831	.439	8.41[b]	9.27[c]	1.70	.454	6
	(1.96)	(5.62)	(6.00)	(.0225)				.426	
3. Weighted Average: Permanent Income Version	−.0102	1.060	6.179	.485	10.13[b]	5.75[c]	1.88	.838	11
	(2.64)	(6.50)	(4.61)	(.0216)				.172	
4. Modigliani-Miller	−.0004	0.376	2.246	.301	4.64[b]	3.53[a]	1.52	.555	7
	(0.11)	(4.42)	(3.24)	(.0251)				.167	

Note: Numbers in parentheses are absolute values of t-statistics.

[a] Significant at the 5% level with (4, 86) d.f.

[b] Significant beyond 1% level with (8, 86) d.f.

[c] Significant beyond 1% level with (4, 86) d.f.

all cases except the weighted average-earnings/price model (#2). In summary, Table II suggests that our conclusions on the influence of the cost of capital are largely independent of whether we define investment by the GNP series or by the Plant and Equipment series.

The Elasticity of Investment Relative to the Cost of Capital

As a result of the form of $F(c)$, the elasticity of investment relative to the cost of capital depends on the level of investment and the value of the cost of capital. In addition, the cost of capital influences investment in (18) with a distributed lag. These attributes suggest a dynamic simulation is a useful way to measure the elasticity in this case. To do this, a non-turbulent time period, 1964–1967 was chosen, and baseline results obtained for all four models using the GNP definition of investment. Then, a 10% one-time increase in the cost of capital was made in 1964.1. Table III gives elasticities calculated from the resulting deviations of investment from the baseline. All four cost- of capital measures show small initial elasticities, ranging from −.04 to −.14 one quarter after the change. By five quarters after the change, the elasticities range more widely, from −.35 to −.87. The long-run or steady state values show an even wider range, from −.35 to −1.47.

The weighted average-permanent income measure of the cost of capital produces a long-run elasticity that is more than twice as large as the next highest measure. This measure shows a relatively elastic response of investment to changes in the cost of capital for a response period of seven quarters or longer. Since this weighted average-permanent income measure gave the lowest standard error in explaining investment, the reader may wish to place somewhat more emphasis on the elasticity calculated from it than upon elasticities calculated for the other alternatives. The weighted average measure in particular gives elasticities considerably higher than elasticities measured elsewhere.

Table III

Elasticity of Investment Relative to the Cost of Capital

	Elasticities			
Quarters After Change	Interest Rate	Weighted Average: Earnings/ Price	Weighted Average: Permanent Income	Modigliani-Miller
1	−.07	−.07	−.14	−.04
3	−.31	−.23	−.50	−.29
5	−.48	−.35	−.87	−.46
7	−.67	−.35	−1.17	−.56
9	−.67	−.35	−1.39	−.56
long-run	−.67	−.35	−1.47	−.56

Note: Values shown are elasticities for the cumulative investment response to a 10% one-time change in the cost of capital introduced in 1964.1.

Conclusions and Implications

We have found that none of the four alternative concepts of the cost of capital examined can be rejected as being inconsistent with data on U.S. investment. All make a statistically significant contribution to explaining fluctuations in investment, and all have structural coefficient values that conform to the restrictions implied by underlying theory. This result is of particular interest, since the explanatory role we have found for the cost of capital in investment spending is independent of how we define the cost of capital.

The largest difference in the goodness of fit due to the cost of capital measures is between the weighted average concept of the cost of capital and the Modigliani-Miller concept. The weighted average-permanent income measure lowers the standard error by 17% compared to the Modigliani-Miller measure. This difference is large enough to support the conclusion that the weighted average cost of capital measure leads to a better explanation of fluctuations in investment than the Modigliani-Miller measure. Similar comparisons among other alternative cost of capital measures are not as clear. Indeed, other important differences in explanatory significance are not present.

The elasticity of investment relative to the cost of capital varies more widely among the alternative cost of capital measures than do any other statistical results associated with these measures. Using the best-fitting weighted average (permanent income) concept of the cost of capital, we find a long-run elasticity of investment of nearly 1.5, indicating a much greater level of sensitivity of investment to cost of capital fluctuations than has heretofore been found in empirical investment studies.[14] However, elasticities for the other cost of capital measures are smaller and more in line with prior results.

The weighted average cost of capital measure ranks highest among the alternatives examined using goodness of fit criteria. Accepting this as the most appropriate representation of the cost of capital has some interesting implications regarding the channel through which monetary policy may impact upon real markets. If we examine representative weights for debt vs. equity costs over the period of our study, we find that roughly 75% of the fluctuation in the cost of capital is due to fluctuations in tax-adjusted equity costs while only 25% is due to fluctuations in debt costs. Costs of debt and of equity may not always move closely together. In cases where they do not, monetary policy efforts to influence investment by changing the cost of capital will have a much greater impact if they succeed in influencing equity costs than if they are primarily confined to debt markets influences. Indeed, in these times activist monetary policy may have a more important concern with stock market conditions than with bond market conditions.

[14] See Michael Evans [14] for a survey of the interest rate elasticities of several different investment functions, all of which are well below 1.0.

Appendix A

Data Definitions and Sources

(1) i_t: Moody's average yield on corporate bonds as reported in *Moody's Bond Survey*.

(2) ρ_i, ρ_e, ρ_r: proportions of debt, equity, and retained earnings in the optimal financing mix. These proportions are approximated by calculating the sums of actual new capital raised in each category over the past eight quarters and reducing them to fractions of 1. This assumes that actual capital raised approximates optimal proportions over periods as long as two years. Net new debt and net new equity capital are found in the *Federal Reserve* Bulletin while retained earnings are taken from the GNP-related series as reported in the *Survey of Current Business.*

(3) $t_{p,t}$: marginal corporate profits tax rate, approximated by the average corporate profits tax rate found by dividing corporate taxes by corporate pre-tax profits are reported in the *Survey of Current Business.*

(4) $t_{d,t}$: marginal dividend tax rate, estimated by combining the spot estimates of this rate made in the studies of Vincent Jolivet [20] and Edwin J. Elton and Martin J. Gruber [12] with findings presented by the NYSE that the pattern of share ownership by U.S. citizens has closely followed the growth rate in disposable personal income. Since *ceteris paribus* more widely dispersed patterns of share ownership lead to falling marginal dividend tax rates while higher per capita personal incomes lead to higher rates, the net effect of these influences on marginal dividend tax rates should be closely related to movements in total disposable personal income through time. Following this approach, marginal dividend tax rates have been estimated by fitting an exponential equation through the Jolivet and Elton-Gruber spot estimates linking these rates to personal income levels and interpolating and extrapolating to obtain the complete time series. The specific equation used is:

$$\log(mt_t) = -.79077 - .0005854(Y_{DP})_t + 24.5859(1/Y_{DP})_t R^2$$

$$= .966 \text{ S.E.E.} = .0164 \text{ D.W.} = 2.32$$

where Y_{DP} is the level of disposable personal income in current dollars. As an alternative to this structure, a quadratic fit was made and found to exhibit severe multicollinearity. Estimates of mt_t formed from this model had a high variance and were considered unreliable. The exponential form used can accommodate rising, falling, humped, or dished patterns over time, depending on the characteristics of the data. The pattern observed was monotonically decreasing at a falling rate, which seems generally consistent with an increasing dominant role of income over share distribution effects, leading to a flattening of the marginal tax rate.

(5) $(E/P)_t$: earnings-price ratio, Standard & Poor's 500 stocks, as reported in *Trade and Securities Statistics*

(6) P_t: composite price index, Standard & Poor's 500 stocks, as reported in *The Outlook*.

(7) E_t: after-tax corporate profits, as reported in conjunction with the GNP statistics in the *Survey of Current Business*.

(8) F_t: net interest payments of corporations, as reported in conjunction with the GNP statistics in the *Survey of Current Business*

(9) V_t: the market value of corporations assets is approximated by the sum of the market value of corporations bonds and stocks. This measure does not include net short-term assets or non-public fixed assets and thus is useful as an index of approximate fluctuations in total asset value rather than an enumeration of dollar asset value. The market value of corporate bonds is found as the product of book value and the ratio of market to book value for these bonds. The ratio of market to book value is found by using the formula for market price, P_b, of an n-period bond yielding i and having a book/redemption value of R:

$$C\left[\frac{(1+i)^n-1}{i(1+i)^n}\right]+\frac{R}{(1+i)^n}=P_b \tag{A-1}$$

Dividing this expression by R gives

$$\frac{C}{R}\left[\frac{(1+i)^n-1}{i(1+i)^n}\right]+\frac{1}{(1+r)^n}=\frac{P_b}{R} \tag{A-2}$$

from which the ratio of market to book value, $\frac{P_b}{R}$, can be calculated given total coupon payments, book value, market yields, and average maturities of corporate debt. $\frac{C}{R}$ for corporations is found by dividing total non-financial business interest payments (assuming bank bonds are a negligible portion of total outstanding bonds) by the sum of outstanding business and commercial loans plus the outstanding book value of publicly-issued corporate bonds and notes. Values of C are as reported in the *Survey of Current Business*. Until 1969 the value of R is obtained from the U.S. Department of Census *Bicentennial Statistical Supplement*. Thereafter, the series is completed by adding the net new issues of corporate bonds and notes from FRB *Federal Reserve Bulletin*. It is converted from an annual to a quarterly series by the use of a spline function. r is estimated as the average yield on corporate bonds from Moody's Corporation *Moody's Bond Survey*. n is the midpoint of the maturity structure of the bonds in Moody's sample, assuming them to represent all corporate bonds.

The value of $\frac{P_b}{R}$ calculated from (A-2) is then multiplied by the estimated value of R to obtain P_b. The market value of stocks is approximated as the product of corporate after-tax earnings (see (7) above) and the reciprocal of the earnings-price ratio on the Standard & Poor's 500 stocks (see (5) above).

(10) D_t: total corporate debt as given in the *Economic Report of the President*, 1978, converted to a quarterly series by the use of a spline function.

(11) G_t: the market's expected growth in V_t (see (5) above) is approximated by treating it as the expected long-run or "permanent" change in V over time. Michael Darby's [8, 7] version of the method frequently used to extract permanent income is employed to estimate this value. The permanent value of V, denoted as V_p, is defined as follows:

$$V_{p,t} = \gamma \cdot V_t + (1 - \gamma)(1 + p) V_{p,t-1} \tag{A-3}$$

where γ is the weight of current asset value in permanent asset value and p is the long-run growth rate in permanent asset value. We use Darby's estimates of $\gamma = .025$ which he found best related current to permanent income and suppose these will adequately characterize the relationship between permanent and current corporate asset value as well. A study by J. Walter Elliott [11] verifies that $\gamma = .025$ is the best of a group of alternatives for use in the consumption function when total non-human and human wealth is used instead of current income. Thus, setting $\gamma = .025$ follows from both these studies. The values of p and $V_{p,0}$ in (A-3) are found from the following expression:

$$\log V_t = a_0 + a_1 t \tag{A-4}$$

where t is an index of time, $V_{p,0} = \mathrm{EXP}(a_0)$ and $p = a_1$. This equation is estimated over the sample period with $t = 0$ in the initial quarter. The resulting estimates of equation (A-3) are

$$V_{p,t} = .025\ V_t + (.975)(1.0182)\,V_{p,t-1} \tag{A-5}$$

with $V_p = 385.77$ billion for 1951.4. From the calculated values of $V_{p,t}$ from (A-5) we obtain $G_t = \Delta V_{p,t}$.

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