ON THE FIRM'S PRODUCTION, CAPITAL STRUCTURE AND DEMAND FOR DEBT

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I. Introduction

SOME economists have ignored corporate financing decisions on the assumption that they do not affect the investment and production decisions of firms. Yet even if this extreme position is accepted, firms must still make financing decisions which in turn have impacts on other sectors of the economy. Since interest payments on corporate debt are tax deductible, the reliance of firms on debt as opposed to equity financing directly affects the revenue the federal government collects through taxation of corporate profits. The corporate presence in bond markets and corporate borrowing from banks can be expected to affect both interest rates and the demand for money. Thus any large macro model must somehow account for the borrowing behavior of firms. Yet in assessing this portion of the 1965 Brookings Quarterly Econometric Model of the United States, de Leeuw (1965, p. 506) writes that the "regressions for business borrowing are the least successful of the model."

In this paper we derive an equation for the long-term debt ratio (capital structure) of a firm which can be estimated using available data. Unlike some recent qualitative studies[1] on the aggregate corporate debt ratio as related to inflation and taxation over time, our primary aim is to explain differences in the debt behavior among individual firms. Tobit estimation results, explicitly allowing for the fact that some firms have no long-term debt, are presented for both U.S. and Japanese firms. Our theoretical model implies that the long-term debt ratio which maximizes the present value of the existing stockholder's equity depends positively on the cost of equity and negatively on the cost of debt, capital productivity, and retained earnings. Our estimation results are generally in agreement with these expectations. In particular, we find that capital productivity, which has not been included as an explanatory variable in most previous studies,[2] and the cost of equity capital are both important determinants of the firm's capital structure. Our empirical results also support the view put forward by Komiya[3] that debt ratios for Japanese firms are higher than those for U.S. firms in part because the cost of equity has been historically higher in Japan than in the United States in relation to the cost of debt.

Other important attempts to explain the debt ratio as a behavioral function of the price of debt and other variables include the studies of de Leeuw (1965) and Goldfeld (1969).[4] Certain conceptual problems mar these studies, however. Short-term and long-term debt are not distinguished, despite the fact that long-term debt is usually used to finance capital spending while short-term debt is used to finance inventory and

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[1] See, for example, Feldstein (1980), Feldstein, Green and Sheshinski (1978, 1979), Friedman (1980) and Gordon (1980).

[2] Tambini (1969) considers the importance of taxation in relating the firm's financial variables to the marginal product of capital. The created variables included in his empirical specifications, however, make it difficult to interpret his results. Vickers (1968, 1970) and Turnovsky (1970) studied interesting static models where the costs of equity and debt capital are assumed to be related to business and financial risks. Hence these authors could look at the effects of business risk, for instance, on output, capital investment and the leverage of a firm. Dynamic elements such as inflation and depreciation are not considered, however, and these models are too complex in their original form to be estimated or tested using real data. In our paper we present an integrated dynamic model which allows us to investigate the relationship between a firm's financing decision and (real) capital stock, where the latter is treated as a factor of production in the spirit of the Jorgenson model (see Jorgenson (1971) for further references). Our formulation also allows us to derive an econometric specification which can be implemented empirically using existing micro data and econometric techniques.

[3] Komiya (1975, p. 202) has been arguing this point for many years. A similar view has also been expressed by Wallich and Wallich (1976, p. 269).

[4] Of course, there are many empirical studies where the econometric specifications are not derived from any general theory of the investment and financial behavior of the firm. See, for example, Ferri and Jones (1979), Flath and Knoeber (1980), and Taub (1975).

to meet short-term cash flow needs. Thus it is unlikely that one set of explanatory variables can explain the demand for both categories of debt. In the de Leeuw and Goldfeld studies the demand for debt is not clearly related to the capital investment and financing decisions of the firm, or to the maximization of the present value of the current stockholder's equity. Moreover the cost of equity capital, which represents the opportunity cost of the firm's stockholders, and the productivity of capital as related to the price of debt are ignored in their studies.[5] Nevertheless their empirical equations include variables such as the price of debt and capital spending which have been ignored in much of the literature on optimal capital structure.

Models in the tradition of Miller and Modigliani's (M-M's) work do not readily yield a demand equation for debt. In the usual M-M world, when there are no corporate taxes the value of a firm is unaffected by its capital structure.[6] When corporate taxes are introduced, but interest payments on debt are deductible for tax purposes as in both the United States and Japan, M-M find that the capital structure which will maximize the value of the firm is 100% debt. Thus in the M-M world it is not possible to consider the optimal degree of leverage for a firm as a function of the price of debt. Nor are the conclusions which M-M derive consistent with reality, since the capital structures of most firms in the United States and Japan are far from 100% debt.[7]

Some researchers have attempted to reconcile the discrepancy between M-M's theory and reality by introducing bankruptcy costs and equating the marginal expected costs of failure (bankruptcy) due to additional debt with the marginal tax advantage of additional debt financing.[8] It is difficult to test hypotheses of this sort, of course, since the expected costs of bankruptcy cannot usually be observed.[9] Also for a firm with a history of financial stability and with a debt ratio which is low, it seems intuitively clear that the change in the probability of bankruptcy, and hence the change in the expected cost of bankruptcy, associated with a modest increase in the existing debt ratio must be small compared wih the resulting tax advantage from the increase in debt. That is, many real firms do not appear to be equating the marginal costs of failure due to additional debt with the associated marginal tax advantage.[10] And, like the original theory of M-M, these theories of financial distress do not allow us to consider the optimal capital structure, or the demand for debt, as a function of the price of debt or of variables characterizing the productive nature of the firm.

II. Production, Debt Financing and Capital Structure

The value of equity in a neoclassical firm may be represented as the present value net of taxes of all dividends to be received by the stockholder and the capital gains which will be realized if, and when, the stockholder sells his equity. Letting $V(t)$ denote the equity net of taxes in a firm at time t, the present value of equity, $V(O)$, satisfies

$$V(O) = \int_0^T e^{-ks}(1-\theta)B\{(1-\tau)y + \dot{D} + CM\}ds + (1-\mu\theta)e^{-kT}[V(T) - V(O)], \tag{1}$$

where $y(s)$ is the net earnings before taxes of the firm at time s, τ is the corporate income tax rate, $\dot{D}$ $(= dD/ds)$ is the rate of change in the stock of debt $D(s)$, $CM(s)$ is the rate at which new equity is issued, B is the firm's dividend payout ratio,[11]

[5] These remarks also apply to Laffont and Garcia (1977) and Sealey (1979). Goldfeld has equity-related variables such as retained earnings and dividends in some of his equations, but these are not entered to capture the effects of the cost of equity capital. Taub (1975) finds a positive relationship between the difference in the costs of equity and debt and the probability that the desired debt-equity ratio will be nonzero.

[6] Yet there is historical evidence (Copeland and Weston, 1979, p. 308) that debt made up a fairly stable portion of total corporate capital in the United States before corporate taxation was introduced.

[7] Average debt-equity ratios have also been rising in both the United States and Japan. For instance, for the particular firms in our data base, the average debt-equity ratios for manufacturing and for non-manufacturing firms for 1961 are 0.40 and 0.68 for the United States and 0.91 and 1.36 for Japan, while the corresponding numbers for 1976 are 1.32 and 2.01 for the United States and 2.00 and 2.12 for Japan.

[8] See, for instance, Scott (1976) and Flath and Knoeber (1980).

[9] The only estimates of the cost of bankruptcy that we are aware of were made by Warner (1977) for railroad bankruptcies. Only direct costs such as fees for lawyers, accountants and for managerial time spent in administering the bankruptcy were estimated.

[10] Similar observations can be made with respect to the cost of financial distress theory (see, for instance, Brealey and Myers (1981)) which postulates that the amount of debt held by a firm is limited by the potential risk of financial distress resulting, for instance, from conflicts of interest between the debtholders and stockholders of the firm.

[11] Unlike the traditional payout ratio defined to be the

θ is the stockholder's personal income tax rate, $\mu\theta$ is the stockholder's tax rate on capital gains, k is the cost of equity which is used as a discount rate for the future cash flows from the firm, and T is the time at which the stockholder will sell his stock. The first term on the right-hand side of (1) represents the present value net of personal income tax of the dividends which will be paid out over the period (O,T), where the firm determines the amount of the total available cash flow $\{(1 - \tau)y + \dot{D} + CM\}$ that will be paid out in dividends by choosing the value of the payout ratio B $(0 \leq B < 1)$. Thus the possible sources of funds for dividends are the after-tax earnings $(1 - \tau)y$, new debt issued if $\dot{D}$ is positive, and new equity issued if CM is positive. The dividend payout ratio itself has been the subject of a great deal of research. John Lintner (1956) finds, for instance, "that dividends represent the primary . . . decision variable in most situations." Moreover, he reports that two-thirds of the companies included in his study had "a rather definite policy regarding the ideal or target ratio." The second term on the right-hand side of (1) represents the present value net of capital gains tax of the capital gains which will be realized when the stockholder sells his stock at time T. If $T = \infty$ then $V(O)$ is simply the present value of an infinite stream of future dividends.

Solving (1) for $V(O)$ we get

$$V(O) = (1/A) \int_o^T e^{-ks}(1 - \theta)B\{(1 - \tau)y + \dot{D} + CM\}ds + \{(A - 1)/A\}V(T), \quad (2)$$

where $A = 1 + (1 - \mu\theta)e^{-kT}$. Since $V(O)$ is the sum of the old (present) stockholder's equity $V^o(O)$ and the new stockholder's equity $V^n(O)$, where

$$V^n(O) = \int_o^\infty e^{-ks}CMds \quad (3)$$

$$= \int_o^T e^{-ks}CMds + e^{-kT}V^n(T),$$

we have $V^o(O) = V(O) - V^n(O)$, or

$$V^o(O) = (1/A) \int_o^T e^{-ks}(1 - \theta)B\{(1 - \tau)y + \dot{D}\}ds + (1/A)((1 - \theta)B - A) \int_o^T e^{-ks}CMds + G, \quad (4)$$

where

$$G = \{(A - 1)/A\}V(T) - e^{-kT}V^n(T).$$

Since we are interested in a firm which uses the residual cash flow after dividends are paid to increase capital stock, we introduce production, new capital investment and its financing as follows. Earnings before tax are given by

$$y = qF(K,L) - wL - \delta(pK) - k_dD, \quad (5)$$

where $F(K,L)$ is a neoclassical production function, K is capital stock with its unit price p, L is labor with wage rate w, q is the unit price of the product, δ is the economic depreciation rate of capital stock, and k_d is the cost of debt.[12] The parameters q, w, p, k_d and δ are all assumed to be functions of time and given to the firm.[13] It is also assumed that the depreciated portion of capital stock continues to be replaced and is tax-deductible (and hence a cost item).[14]

The net change in the dollar value of capital stock $K^* = pK$ is given by[15]

$$\dot{K}^*(= dK^*/ds) = pI + (\dot{p}/p)K^* - \delta K^*. \quad (6)$$

percentage of earnings that is paid out, B is defined to be the percentage of total cash flow that is paid out. Since current earnings constitute a substantial portion of the firm's cash flow, these two definitions are not expected to result in substantive differences empirically. This position appears to be supported by Brealey and Myers' (1981, p. 336) argument that financing dividends by issuing stock (and also debt) is self-defeating.

[12] Nakamura and Nakamura (1981a) use a model involving a production function to estimate the cost of equity capital for Japanese firms.

[13] It is implicitly assumed here that marginal changes in the firm's debt position ($\dot{D}$ and CM) do not affect k and k_d. This implies that financial markets determine k and k_d based on the firm's long-term debt position and that the firm is a price-taker in these markets. Vickers (1968) considers some theoretical models in which this assumption is relaxed, but these models are sufficiently complicated that they have not been implemented empirically.

[14] This assumption is commonly made. See, for example, Nickell (1978, p. 210).

[15] $$\dot{K}^* = p\dot{K} + \dot{p}K = p(I - \delta K) + (\dot{p}/p)(pK) = pI + (\dot{p}/p)K^* - \delta K^*,$$

where the property that $\dot{K} = I - \delta K$ is used.

New investment pI is financed by residual cash flow after dividends; i.e.,

$$pI = (1 - B)\{(1 - \tau)y + \dot{D} + CM\},$$

or

$$pI = (1 - B)(1 - \tau)y(1 + RD + RC), \quad (7)$$

where for notational convenience we define $RD = \dot{D}/((1 - \tau)y)$ and $RC = CM/((1 - \tau)y)$ and where $(1 - \tau)y$ is assumed to be strictly positive. The decision problem of the firm is to choose K^*, B and RC so as to maximize[16] the old stockholder's present value given by (4) subject to (6) and to $0 \leq B < 1$.

The Lagrangean for this calculus of variations problem is

$$\begin{aligned} f = {} & (1/A)e^{-ks}(1 - \theta)B(1 - \tau)y(1 + RD) \\ & + (1/A)((1 - \theta)B - A)e^{-ks}(1 - \tau)yRC \\ & - \lambda\{\dot{K}^* - (1 - B)(1 - \tau)y(1 \\ & + RD + RC) - (\dot{p}/p)K^* \\ & + \delta K^*\} + \gamma B, \end{aligned} \quad (8)$$

where λ and γ (≥ 0) are Lagrange multipliers and where (7) is substituted into (6). The quantity G in (4) does not appear in (8) because it does not depend on the firm's decision variables. The necessary conditions for optimality are[17]

$$\begin{aligned} & (1/A)e^{-ks}(1 - \theta)B(1 - \tau)((qF_K/p) - \delta)(1 \\ & \quad + RD) + (1/A)((1 - \theta)B - A)e^{-ks}(1 \\ & \quad - \tau)((qF_K/p) - \delta)RC + \lambda\{(1 - B)(1 \\ & \quad - \tau)(1 + RD + RC)((qF_K/p) - \delta) \\ & \quad + (\dot{p}/p) - \delta\} = -\dot{\lambda}, \end{aligned} \quad (9)$$

$$(1/A)((1 - \theta)B - A)e^{-ks}(1 - \tau)y = -\lambda(1 - B)(1 - \tau)y, \quad (10)$$

$$\begin{aligned} & (1/A)e^{-ks}(1 - \theta)(1 - \tau)y(1 + RD) \\ & \quad + ((1 - \theta)/A)e^{-ks}(1 - \tau)yRC \\ & \quad - \lambda(1 - \tau)y(1 + RD + RC) \\ & \quad + \gamma = 0, \end{aligned} \quad (11)$$

and

$$\gamma B = 0. \quad (12)$$

From (10) we get

$$\lambda = \{(A - (1 - \theta)B)/A(1 - B)\}e^{-ks}$$

and

$$\dot{\lambda} = -k\{(A - (1 - \theta)B)/A(1 - B)\}e^{-ks}, \quad (13)$$

and substituting (13) into (9) we get

$$\begin{aligned} & A(1 + RD)(1 - \tau)((qF_K/p) - \delta) = \\ & \quad (1/(1 - B))(A - (1 - \theta)B)(k - (\dot{p}/p) + \delta), \end{aligned} \quad (14)$$

or

$$\begin{aligned} & \{1 + (1 - \mu\theta)e^{-kT}\}(1 + RD)(1 - \tau)\ ((qF_K/p) \\ & \quad - \delta) = (1/(1 - B))(1 + (1 - \mu\theta)e^{-kT} \\ & \quad - (1 - \theta)B)(k - (\dot{p}/p) + \delta). \end{aligned} \quad (15)$$

Since $\{(qF_K/p) - \delta\}$ is the marginal product of capital (after depreciation), the left-hand side of (15) is the marginal product of capital adjusted for corporate tax, debt and capital gains. The right-hand side of (15) represents the cost of equity capital k adjusted for inflation and depreciation and weighted by income from capital gains minus dividends divided by retained earnings.

Finally from (11) and (13) we have

$$\{A - (1 - \theta)\}e^{-ks}(1 - \tau)y(1 + RD + RC) = \gamma A(1 - B). \quad (16)$$

An interesting proposition concerning the choice of the "target" dividend payout ratio B follows from equations (12) and (16). By (12) we see that $B > 0$ is equivalent to $\gamma = 0$, and hence by (12) and (16) we see that $B > 0$ implies that

$$\{A - (1 - \theta)\}e^{-ks}(1 - \tau)y(1 + RD + RC) = 0 \quad (17)$$

for any s ($0 \leq s \leq \infty$). Hence a positive value of the payout ratio B is optimal if and only if[18]

$$(A =)1 + (1 - \mu\theta)e^{-kT} = 1 - \theta. \quad (18)$$

Thus the firm pays out dividends if and only if there are no personal taxes ($\theta = \mu\theta = 0$) and the stockholder has no plans to sell his equity ($T = \infty$). In the real world this condition might be satisfied, for instance, if the dominant coalition of stockholders consists of institutions such as pension funds and non-profit organizations, which operate free of all taxes.[19] These condi-

[16] Note that once K^* (and hence pI), B and RC are determined, then RD is determined by (7).

[17] Equations (9), (10), (11) and (12) are derived from $df/dK^* - (\partial/\partial s)(df/d\dot{K}^*) = 0$, $df/d(RC) = 0$, $df/dB = 0$ and complimentary slackness, respectively.

[18] It is assumed here that the corporate tax rate τ satisfies $0 \leq \tau < 1$.

[19] See Brealey and Myers (1981, p. 338). Feldstein (1980, p. 312) states that: "These institutions own a significant and

tions may also be approximately satisfied for elderly investors living on modest incomes and who do not plan to sell their securities during their lifetimes.

From (15) we see therefore that the interrelationships between the debt behavior of the firm, as characterized by RD, and the other factors appearing in (15) may be represented by some function Z^* as

$$RD = Z^*\{\overset{-}{((qF_k/p) - \delta)}, \overset{+}{k}, \overset{-}{(1 - B)}\}, \quad (19)$$

where positive and negative relationships are indicated by the sign above each argument in (19) and where the parameters θ $(0 \leq \theta \leq 1)$, μ $(0 \leq \mu \leq 1)$, T (> 0), q (> 0) and $\dot{p}/p$ (≥ 0) are assumed given. Since $RD = \dot{D}/(1 - \tau)y$ by definition where y is given by (5), and since y is negatively related to k_d, we can rewrite (19) for some function Z as

$$\dot{D} = Z\{\overset{-}{((qF_k/p) - \delta)}, \overset{+}{k}, \overset{-}{k_d}, \overset{-}{(1 - B)}\}. \quad (20)$$

Thus $\dot{D}$ is seen to be positively related to the cost of equity capital k, and negatively related to the cost of debt capital k_d, the retention rate $(1 - B)$ and the marginal product of (real) capital after depreciation $\{(qF_k/p) - \delta\}$.

III. Econometric Specification

A number of problems must be resolved in order to arrive at an econometric specification for (20) which can be estimated using existing data. In order to evaluate F_k in (20) the production function is specified to be Cobb-Douglas,[20] i.e., $F = CK^{\alpha}L^{\beta}$ for some constants C, α, and $\beta > 0$ with $\alpha + \beta < 1$. Thus the marginal product of capital is $F_k = \alpha(F/K)$, and the capital productivity term (qF_k/p) in (20) is replaced by $\alpha(qF/pK)$ where qF is total sales. We assume that α is the same for all firms.

In order to estimate (20) within a partial equilibrium framework we assume that both new investment and dividend decisions are made prior to the financing decision. Hence $(qF_k/p) = \alpha(qF/pK)$, δ and $(1 - B)$ are treated as predetermined variables.[21] Since the cost of equity capital k includes the risk premium which depends on the debt position of the firm it is necessary to replace k in (20) by its predicted value $\hat{k}$ to avoid the simultaneous equations bias problem. The predicted values of k are obtained from the regression of k on ρ, the cost of equity capital to an unlevered firm which is identical in all other respects to the firm under consideration,[22] and other instruments.

growing fraction of corporate stock, especially of the major publicly traded corporations. Probably because of their exemption from capital gains taxes, these institutions account for a disproportionately large share of all transactions in equity shares."

[20] Evidence supporting our choice of this particular form for the production function is found, for example, in Griliches (1967), Zarembka (1970) and Jorgenson (1971).

[21] There are several areas of study where the theoretical models presented in the literature are often more fully simultaneous than the forms of these models which are estimated. For instance, in theoretical models of household labor supply a husband and wife are typically conceived of as deciding at the time of marriage how much labor each will supply in each time period for the remainder of their lives. Fertility may also be considered as endogenous. Some authors have even suggested that further insights might be gained by treating education and the marriage decision as endogenous as well. Yet empirical studies of the labor supply of married women often concentrate on a single time period such as a particular year; the labor supply of the husband is treated as a current (in contrast to lagged) predetermined variable; and education, marital status and child status are usually treated as lagged predetermined variables. (See, for instance, Heckman (1976, 1978); Nakamura, Nakamura and Cullen (1979); and Nakamura and Nakamura (1981).)

In empirical work we rarely have enough instruments available to estimate models in their fully simultaneous forms. On the other hand, in the real world of imperfect information, uncertainty and institutional considerations and constraints which are typically assumed away in qualitative theoretical work, there may be good reasons for adopting a partial equilibrium approach. For instance, support for the position that the dividend, and hence the retention rate, decision is predetermined comes from the Lintner study (1956) referred to earlier. Empirical implementation of our original theoretical model would also require estimation of a system of simultaneous equations involving several limited (and generally nonnegative) dependent variables. Statistical methods for estimating such a system are still under development (see Amemiya (1974) and Heckman (1978), for example).

One way of checking for possible simultaneous equations biases which may result from our partial equilibrium approach is to estimate the debt ratio equation for which results are presented in table 1 for subsamples of our original data base, where selection into each of the subsamples is based on the value of an included endogenous variable such as B. We have done this for subsamples of firms for which $B = 0$ and for which $B > 0$, and have not found any evidence of systematic differences in the coefficient estimates obtained for these two subsamples.

[22] The formula $\rho = (Div + CG + P\,Div + (1 - \tau)k_d D)/(V - D)_{-1}$, where Div, CG and $P\,Div$ are dividends, capital gains and preferred dividends, respectively, and where V denotes the market value of the levered firm, was proposed and successfully used by Hamada (1972). The other variables included in our equation for k are a constant, *Time*, C_1–C_5 and S, where these variables are defined as in (21). We also experimented with instruments other than ρ to predict k since the above expression for ρ is implied by the M-M proposition, but these changes seemed to have little impact on our final

Thus our econometric specification for (20) for the i^{th} observation is

$$\dot{D}_i = a_0 + a_1\hat{k}_i + a_2(k_d)_i + a_3(qF/pK)_i + a_4(Ret)_i + a_5(Time) + \sum_{j=1}^{5} a_{5+j}(C_j)_i + a_{11}S_i + a_{12}\delta_i + \epsilon_i, \quad (21)$$

where *Ret* denotes the total cash flow minus dividends, *Time* is a linear time trend, C_1–C_5 are industry dummies, and S represents the size of the firm measured in terms of total assets. The theoretical specification of (20) implies that in (21) the expected signs of a_1 and a_{12} are positive while the expected signs of a_2, a_3 and a_4 are negative. A time trend is included to control for the effects of variables such as τ and $\dot{p}/p$ which have varied over time, but which are assumed to be the same for all firms in any given time period. Finally, industry dummies and the size variables are included in (21) because there is some evidence[23] that borrowing behavior is systematically different for firms of different sizes and in different industries.

An important but previously ignored statistical problem associated with estimating a demand for debt equation like (21) is that we cannot observe the cost of debt k_d for firms which have no long-term debt (hence $D = 0$). The resulting sample selection bias problem,[24] if ordinary least squares is applied to (21) ignoring observations with missing data for k_d, may be avoided by viewing (21) as a Tobit model with a limited dependent variable[25] and deriving maximum likelihood estimates for a_0–a_{12}. The resulting estimates will be consistent and asymptotically efficient.

In this study we use data for individual firms which are pooled over a period of years. Our data for Japan consist of observations on financial and other variables for a sample of 478 firms collected over the period 1964–1974 by the Japan Development Bank (1978). There is no missing data problem for these Japanese data. Our data for the United States consist of observations on similar variables for 1,104 firms chosen from the Compustat tape for the period 1966–1970. Where values were missing for some variables in the U.S. data base, values from other sources when available or values interpolated over time were substituted in.[26] Although our theoretical model de-

empirical results. If more observations over time were available, it might also be desirable to replace k_d by $\hat{k}_d$ obtained by regressing k_d on some risk-free rate such as the Treasury bill rate and other instruments, thus eliminating the financial risk premium due to debt financing from this right-hand variable as well.

[23] Ferri and Jones (1979) found that the leverage class can be predicted more satisfactorily using SIC codes than with generic industry groupings. Our industry dummies are defined in terms of SIC codes. Taub, and Ferri and Jones found that the size of a firm measured, for instance, by total assets has a positive impact on the desired debt-equity ratio of the firm. We also experimented with introducing various measures of earnings risk or variability into the right-hand side of our debt-equity equation. Like Taub (1975), however, we encountered problems of multicollinearity and obtained inconsistent results for the coefficients of our risk variables.

[24] This problem has received considerable attention in the context of studies of the labor force behavior of married women, since the offered (or market) wage rate is observed only for those who work. See, for instance, Gronau (1974), Lewis (1974), Heckman (1976), Nakamura, Nakamura and Cullen (1979) and Nakamura and Nakamura (1981).

[25] We are implicitly assuming that ϵ in (21) is normally distributed. The likelihood function for Tobit analysis accounts first for the probability that the debt ratio will be positive, and hence that k_d will be observed, for each firm. For those firms with positive debt ratios, the Tobit likelihood function also accounts for the probability density of occurrence for the observed value of the debt ratio. Under appropriate conditions it is shown that maximizing the Tobit likelihood function results in consistent and efficient parameter estimates. (See Amemiya (1973), Heckman (1976) and Tobin (1958).)

[26] Further details of variable definitions are the following: The cost of long-term debt k_d is calculated as the difference between total and short-term interest expenses divided by the amount of long-term debt, where long-term debt is defined to be debt which will mature in more than a year. Where they are not given in our data sources, interest expenses on short-term debt are estimated to be the amount of short-term debt (averaged over the year) times the average prime lending rate. Sales figures are used for qF, while capital stock figures are used for pK. Both qF and pK are deflated by the appropriate price indices. In an exploratory phase of our analysis we used both undeflated and deflated values for (qF/pK), and found the results to be very similar.

As *Ret* we used retained earnings plus new equity minus depreciation all divided by the total assets. The current year's retained earnings are used for Japan, while cumulative retained earnings (divided by 10^5) are used for the United States. A linear time trend is used for the variable *TIME*, and the size of the firm S is measured as the total assets of the firm in millions of yen for Japan and in ten thousands of dollars for the United States. The industry dummies C_j ($j = 1, 2, \ldots, 5$) are defined to be 1 if the firm is in industry j, and to be 0 otherwise. The industries included for the United States are manufacturing I defined by SIC codes 20–29 including food, chemicals and allied products ($j = 1$); manufacturing II defined by SIC codes 30–39 including metals and machinery ($j = 2$); transportation, utilities and sanitary services ($j = 3$); wholesale and retail trades ($j = 4$); finance, insurance and real estate ($j = 5$); and services (omitted category). The industries included for Japan are food ($j = 1$); textiles, pulp and chemicals ($j = 2$); metals ($j = 3$); machinery ($j = 4$); electrical appliances and precision instruments ($j = 5$); and transportation (omitted category).

scribes the firm's behavior at the margin, marginal data for variables such as k and k_d are not generally available. We use the average cost of equity and the average cost of long-term debt for k and k_d, respectively. Hence estimation results are presented for the average debt ratio defined as $R = D/(D + E)$ where E is common equity.[27] The debt ratio R thus defined lies between 0 and 1, and is uniquely and monotonically related to the corresponding debt-equity ratio. For qF and pK we use, respectively, sales and capital stock adjusted using the appropriate price indices; and for δ we use the book rate of depreciation since data on the real economic rate of depreciation are not available. Since δ measured as the book rate of depreciation may well be a poor proxy for the rate of economic depreciation, estimation results are presented for our Tobit model with δ omitted and included in order to determine whether this possible errors in the variable problem may be causing us to obtain biased estimates of the coefficients of some of our other variables.[28]

[27] In our empirical implementation debt is measured in terms of book value while equity is measured in terms of market value. There is a continuing discussion about how to measure the debt variable. While the authors of recent standard texts (Copeland and Weston (1979) and Brealey and Myers (1981), for example) argue for the market value approach, empirical implementation of theory often utilizes a debt variable measured in terms of book value. (See Ferri and Jones (1979) and references cited there. Turnovsky (1970) and references cited there also seem to support the latter.) Among other things it should be noted that the book value of debt is the amount the firm must pay back, while the only relevant measure of the equity value is the market value.

[28] The original data are in terms of yen for Japan and dollars for the United States. Note, however, that the dependent variable for this study and the key explanatory variables k, k_d, (qF/pK) and Ret are all unit free. In fact, only the size variable is measured in (millions of) yen for Japan and (thousands of) dollars for the United States.

TABLE 1.—DETERMINANTS OF DEBT RATIOS FOR JAPAN AND UNITED STATES: TOBIT ANALYSIS

	Japan		United States	
$\hat{k}$	0.079[c] (24.2)	0.072[c] (22.7)	0.010[b] (1.65)	0.009[a] (1.47)
k_d	−0.020[c] (4.79)	−0.021[c] (5.23)	−0.003 (0.237)	−0.005 (0.385)
(qF/pK)	−0.019[c] (19.7)	−0.018[c] (18.9)	−0.005[c] (9.69)	−0.005[c] (9.72)
Ret	−3.40[c] (30.9)	−3.10[c] (28.4)	−2.09[c] (11.5)	−2.04[c] (10.4)
Time	0.004[c] (4.88)	0.004[c] (5.11)	0.012[c] (6.04)	0.011[c] (6.06)
C_1	−0.038[c] (5.91)	−0.016[c] (2.56)	−0.046[c] (4.83)	−0.046[c] (4.79)
C_2	−0.008 (0.978)	0.001 (0.110)	−0.033[c] (3.62)	−0.033[c] (3.64)
C_3	−0.086[c] (9.47)	−0.057[c] (6.28)	0.272[c] (25.9)	0.273[c] (25.7)
C_4	−0.079[c] (9.01)	−0.047[c] (5.34)	0.036[c] (2.88)	0.036[c] (2.91)
C_5	0.019[b] (1.98)	0.019[b] (2.05)	0.246[c] (12.6)	0.241[c] (11.6)
Size	0.221[c] (9.20)	0.234[c] (9.91)	−0.020 (0.321)	−0.020 (0.316)
δ		−0.696[c] (15.2)		0.201 (0.805)
Constant	.281	.367	.204	.202
R^2	.35	.38	.39	.39
Log-Likelihood	1643.1	1758.6	1078.2	1185.3
No. of Observations	5258		5520	
No. of Observations with $R = 0$	129		479	

Note: Numbers in parentheses are asymptotic t-statistics.
[a] 80% significance level.
[b] 90% significance level.
[c] 99% significance level.

IV. Empirical Findings

Maximum likelihood estimation results are presented in table 1 for both Japan and for the United States. In general, the coefficient estimates have the expected signs and are highly significant for both countries. In particular, looking at those coefficient estimates which are significant with at least an 80% level of confidence, we find that reliance on debt financing increases as the cost of equity k increases, but decreases as the cost of debt k_d increases. The significantly negative signs of the estimates for the coefficient of the capital productivity term are consistent also with the hypothesis that higher capital productivity allows a firm to rely more on equity funds, and hence reduces the firm's demand for debt capital. Similarly a higher retention rate, which is the same thing as a lower payout rate for dividends, is seen to lead to a lower level of reliance on debt capital. We find, as have others, that the size of the firm is positively related to the degree of dependence on debt for Japan, and that the industry dummies are generally significant.[29] The coefficients of the industry dummies are not comparable between Japan and the United States, since they are defined somewhat differently for the two countries.[30] What is clear, however, is that there are industry specific effects which cannot be explained by the systematic differences between firms in different industries in the values for our other explanatory variables. The coefficients of the time trend are found to be significantly positive. The positive signs of the coefficients of this variable support the assertion of some authors (Feldstein, Green and Sheshinski (1978) and Gordon (1980), for example) that inflation tends to increase corporate debt ratios. It is also in agreement with Friedman's view (1980) that the relative decline of the government debt to GNP ratio helped increase corporate debt ratios over this time period.[31] The estimates for the coefficient of the depreciation variable are positive as expected for the United States, but are significantly negative for Japan. This confirms other researchers' findings that the book rate of depreciation for Japan includes hidden profits which were generated during the 1950s and 1960s by special provisions for accelerated depreciation which particularly benefited some large firms.[32] Furthermore, as Komiya (1966, 1975) points out, Japanese banks were more willing to lend to the firms which benefited from these special provisions. For both countries the coefficient estimates for our explanatory variables change hardly at all depending on whether the depreciation variable is included in our estimating equation. Thus any errors in the variables problem related to the depreciation

[29] These findings are consistent with earlier findings by Taub (1975) and by Ferri and Jones (1979). We also note that the coefficient of *Size* is significantly positive for Japan but highly insignificant (and hence statistically not different from zero) for the United States. Thus the size of the firm has a positive impact on the debt ratio of Japanese companies as is often expected (Taub, 1975), but we failed to verify the same phenomenon for U.S. companies. This appears to support the finding for U.S. firms by Ferri and Jones (1979) that "... size can account for differences in financial structure. Nonetheless, the relationship is not straightforward."

[30] See footnote 26 for definitions of industry dummies.

[31] Our findings are cross-sectional in nature, and hence pertain to the long-term behavior of debt-equity ratios. Nevertheless it is relevant to ask whether changes over time in the variables which seem to account for much of the variability between firms in their debt-equity ratios may also account for some of the observed changes over time in average debt-equity ratios. To answer this question we expanded our data base to include the years 1963 through 1975 for the United States and the years 1962 through 1976 for Japan, and computed the mean value for each of the variables in our study including the dependent variable for each year and each country for manufacturing and for non-manufacturing firms with positive debt in that year. We also calculated the respective average predicted values for our dependent variable by substituting the appropriate means for the explanatory variables into the estimated equations given in table 1. We find that fluctuations in the mean values of both the cost of equity and the size variable "explain" a substantial portion of the observed variability in the dependent variable over time for Japan. However, the only variable partially accounting for the steep rise in the dependent variable after 1972 for both manufacturing and non-manufacturing firms in the United States is the time trend. These results suggest that the rise in the mean values of the debt-equity ratio over time for both the United States and Japan may be largely due to macro variables which have been ignored in virtually all the other studies of the capital structure of firms cited in this paper, and which we were not able to explicitly include in this study because we do not have enough years of data for either the United States or Japan (even in the expanded data bases used for computing the results cited in this footnote) to allow us to measure responses to variables which take on the same value for all firms in a given country in a given year. The variables included in the present study explain in part why some firms have more debt in a relative sense than others given the prevailing macro conditions, and hence given the average behavior of the firm sector as a whole. The response of this average debt holding behavior to macro economic conditions must be examined using other more appropriate data bases.

[32] See Komiya (1966, 1975) and Pechman and Kaizuka (1976) for details. Grabowski and Mueller (1975) also find evidence for some U.S. firms that depreciation contains a component of hidden profits.

variable does not appear to be causing biased estimates for the coefficients of these variables.

Debt ratios observed for Japanese firms during the 1960s and early 1970s are considerably higher than those observed for U.S. firms. Professor Komiya (1975, chapter 7, for example) argues that these higher debt ratios for Japanese firms were caused by the historically high cost of equity relative to the cost of debt in Japan.[33] The positive signs of our estimated coefficients for k, the cost of equity capital, and the negative signs of our estimated coefficients for k_d, the cost of debt, are consistent with Komiya's theory.

The predictive power of the debt ratio equations is quite high for both countries given the pooled cross-sectional nature of the data base (approximately 40% of the variability in the dependent variable is explained in each case). Also it is reassuring to note that the results are so similar for both Japanese and U.S. firms.

V. Conclusions

In this paper we find for both U.S. and Japanese firms that the long-term debt ratio depends positively on the cost of equity and negatively on the cost of debt, capital productivity and retained earnings. In particular, capital productivity, which was not included as an explanatory variable in most earlier studies, and the cost of capital are found to be important determinants of the firm's capital structure. We also find that the debt ratios for Japanese firms are higher than those for U.S. firms partly because of the historically higher cost of equity in Japan than in the United States in relation to the cost of debt.

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