Taxation, Financing, and Corporate Investment in Plant and Equipment: A Macro-Econometric Model of Corporate Real and Financial Decisions

Nadeau, Serge J. and Robert P. Strauss

Working Paper No. 333
October 1992

Taxation, Financing, and Corporate Investment in Plant and Equipment: A Macro-Econometric Model of Corporate Real and Financial Decisions

Serge J. Nadeau
and
Robert P. Strauss

Rochester Center for Economic Research
Working Paper No. 333

Taxation, Financing, and Corporate Investment in Plant and Equipment: A Macro-Econometric Model of Corporate Real and Financial Decisions

Serge J. Nadeau * and Robert P. Strauss†

October 14, 1992

Abstract

This paper develops a comprehensive model of a corporation's dividend, investment, and financing decisions. Under reasonable assumptions about the model, the model provides theoretical predictions which are in accord with the following stylized facts about observed corporate financing behavior:

- Firms are financed by debt and equity;
- Firms that are highly leveraged pay a higher cost of debt; and,
- Firms will both pay dividends and issue equity at the same time.

This model of the firm's real and financial decision process is then empirically tested with aggregate U.S. data, and implications of taxation are analyzed. The estimates suggest the following: the effects of dividend and capital gains taxation on investment are statistically significant but are cushioned substantially by financial policy; the current US income tax system upwardly biases investment in equipment; and the tax deductibility of debt significantly encourages debt financing over equity financing.

*Department of Economics, University of Victoria, Victoria, Canada, V8W 3P5

†Visiting Professor of Economics and Public Policy, University of Rochester, 1992-3; Professor of Economics and Public Policy, H. John Heinz III School of Public Policy, and Management, Carnegie-Mellon University, Pittsburgh, PA 15217. The authors wish to thank Miguel Gouveia and Mark Mazur for their helpful comments on an earlier version of this paper. Responsibility for remaining errors rests with the authors.

1 Introduction

The measurement of the macroeconomic impact of taxation on business investment expenditures often requires the use of models linking the real and financial decisions. Ignoring this link may yield puzzling results. For example, in an important paper, Summers (1981) found that dividend taxation does not influence real investment in the long run. As Bosworth commented, this surprising if not counter-intuitive result may be due to not modeling the financing side of investment (Bosworth, 1981). More generally, since firms can use financial policies in addition to investment policies to affect the wealth of their stockholders, macro-econometric models of investment behavior that ignore the link between the real and financial decisions will overestimate the impact of tax policies on real investment. Nevertheless, as noted by Feldstein (1982) and Chirinko (1986, 1987), most macro-econometric models of the impact of taxation on business investment expenditures assume that financial decisions are exogenous to the investment decisions.[1]

The few models which have been used to estimate empirically the joint impact of taxation on financing and investment fall in two categories. The models in the first category force financial flow of funds constraints into Jorgensonian formulations of investment behavior (see, for example, Brimmer and Sinai, 1976; and Graddy and Strauss, 1984). A limitation of these models is that, by relying heavily on accounting identities, they provide little insight into the economic determinants of the real and financial decisions of the firm. At best, they only indicate the presence of correlation between the real and financial variables. The models in the second category attempt to link the real and financial decisions in an internally consistent and empirically tractable manner. As far as we know, there are only two models in the literature which fall into this category. One of these models is the model in Chirinko (1987) which endogenizes, although with little empirical success, the firm's leverage decision into a Q model of investment behavior.[2] The other model in this category is the model in Nadeau (1988) and Nadeau and Strauss (1991a) which, unlike the model in Chirinko (1987), endogenizes with some empirical success both the dividend and the leverage decisions.

The purpose of this paper is to present an in-depth and self-contained analysis of the impact of taxation on corporate financing and corporate investment. To that end,

[1]Most of the models in the financial economics literature which relate dividends, debt financing and real investment, are designed primarily for testing the Modigliani-Miller separation theorem, and ignore the influence of taxation on these real and financial decisions (see, for examples, Dhrymes and Kurtz, 1967; McCabe, 1978; and Peterson and Benesh, 1983).

[2]Based on the empirical results of his study, Chirinko concludes that the "...Q theory is unlikely to provide the basis for a satisfactory investment model linking the real and financial sectors" (Chirinko, 1987: 86).

a macro-econometric model linking the real and financial decisions of the firm is theoretically developed, empirically tested, and its predictions in terms of "tax effects" are analyzed. Thus, unlike Nadeau (1988) and Nadeau and Strauss (1991a), we formally derive from first principles the model in this paper, and we provide a comprehensive analysis of the impact of taxation on financing and real investment.

Our work builds on earlier research on corporate investment, corporate finance and taxation, but provides a more general and empirically tractable model. Our model endogenizes the firm's financial policies in the context of a neoclassical framework of investment behavior. As is common in empirical models of sets of equations, we have to compromise in the specification of individual equations to keep the overall model tractable; nevertheless, we feel that our model has three advantages over the models previously cited. First, our model is complete in the sense that both the dividend decision and the debt financing decision are treated as endogenous; it thus allows the measurement of the impact of taxation on financing and investment in a unified framework. Second, our model is theoretically derived and empirically verified; hence it is causal and its assumptions are clearly spelled out. Third, the predictions of our model are in accord with the following stylized facts about corporate financing behavior:

1. Firms are financed both by debt and equity;
2. Firms that are highly leveraged pay a higher cost for debt;
3. It is common for firms to pay dividends and issue equity at the same time.

The paper is organized as follows. Section 2 gives an initial overview of the model to aid in subsequent exposition. Section 3 develops the theoretical model and examines its properties. Section 4 examines the theoretical predictions of the model in terms of the impact on financing and investment of small changes in dividend taxation, capital gains taxation and corporate income taxation. Section 5 presents the econometric model. Section 6 reports FIML estimates of the parameters of the model (based on U.S. aggregate annual data covering the period 1933 to 1986), compares the explanatory power of the equations of our model with the explanatory power of "representative" single equation specifications drawn from the literature, and reports estimates of tax elasticities along with their asymptotic standard errors. The statistical analysis supports the model and shows that, in particular, the effects of dividend and capital gains taxation on investment are statistically significant, but are cushioned substantially by the firm's financial policy;

the current US income tax system upwardly biases investment in equipment; and the tax deductibility of debt encourages significantly debt financing over equity financing. Section 7 concludes and suggests future avenues of research.

2 The Model: An Overview

The literature concerned with the relationship between the investment and financing decisions of the firm is substantial and complicated, and no attempt is made here to review it exhaustively.[3] Central to these discussions is the observation that the financial cost of capital is the discount rate that firms use in evaluating real investment projects. The financial cost of capital thus links the real and financial sectors of the economy. In particular, it is through this variable that the effects of taxation on financial policies may influence corporate investment.

The theory of the financial cost of capital is, to say the least, unsettled. In their seminal paper, Modigliani and Miller (1958) showed that in a world of perfect capital markets, without bankruptcy or taxes, financial policies are irrelevant and the appropriate financial cost of capital is then, undistinguishably, the cost of debt or the cost of equity. Thus, in such a world, the firm can make its investment decisions independently of its financing decisions. This is the so-called separation theorem.

By relaxing the assumption of no taxes, Modigliani and Miller (1963) then argued that the firm should finance marginally by debt and that the financial cost of capital should be a weighted average of the cost of debt and the cost of equity. They were, however, unclear as to the determination of the weights. On the other hand, Stiglitz (1974) argued that even in a world with taxes, provided there is no bankruptcy, the firm's financial policies do not matter and the appropriate cost of capital is the before-tax cost of debt. Thus, in such a world, the firm does not use financial policies to cushion the impact of taxation on investment. King (1974) found that under similar conditions the cost of capital depends on optimal financial policies but that, assuming historically reasonable values for tax parameters, firms will never issue new shares nor pay dividends.

[3] See Ravid (1988) for an extensive review of the financial economics literature on the link between the real and financial decisions. In our 1991a paper, we examined in detail the major macro-econometric models which have been proposed in the literature for analyzing the impact of tax changes on the real and financial decisions.

In another important study, Auerbach (1979) found that the firm should proceed in two steps to maximize the wealth of its shareholders: first, the firm should determine the financial policy that minimizes the cost of capital faced in each period; second, the firm should use the minimized cost of capital as its discount rate in determining the optimal investment strategy. Auerbach (1979) obtained, however, puzzling results concerning the firm's financial policies and financial cost of capital. In particular, he found that under the assumption of no bankruptcy, the firm should never pay dividends and issue equity at the same time. Furthermore, with the additional assumption of no new shares, Auerbach found that the firm's dividend policy is irrelevant and, as in King (1974) and Miller (1977), that the firm's debt-equity ratio depends on the shareholders tax attributes and is thus indeterminate. The key assumptions underlying Auerbach's results are that corporate earnings before interest and taxes (EBIT) are large enough to cover interest payments, that there is no bankcruptcy, and that dividends have no value beyond their cash value. Relaxing these assumptions yields very different results.

Dotan and Ravid (1985) and Dammon and Senbet (1988) showed that, if the assumption that EBIT are always large enough to cover interest payments deductions is relaxed, then the financing and investment decisions are simultaneous decisions: investment policy depends on debt policy through the financial cost of capital, and debt policy depends on investment policy through the volume of the non-debt-related tax shields (e.g. depreciation). The practical significance of this result appears to be, however, marginal: the dependence of debt policy on investment policy is only of second order and is greatly reduced by the loss carry-forward provisions in the tax code. Empirical evidence is also ambiguous.[4]

Relaxing the assumption of no bankruptcy also alters Auerbach's (1979) results. In fact, Feldstein, Green and Sheshinski (1979) show that replacing the assumption of no bankruptcy by the assumption that the price of debt rises as the debt-equity ratio rises (because of the risk of bankruptcy) yields an interior solution for corporate debt policy even when individual marginal tax rates for debt and equity income indicate a tax advantage to debt.

The key assumption underlying Auerbach's (1979) result that the firm's dividend payout rate is irrelevant is, however, that shareholders do not value dividends beyond their cash value. In fact, assuming instead, as in Poterba and Summers (1985), that

[4] In a micro-econometric study, Bradley, Jarrell and Kim (1984) found, contrary to the theory, a positive relationship between leverage and non-debt-related tax shields. In another micro-econometric study, MacKie-Mason (1988) found a negative relationship between debt issuance and the amount of available non-debt tax shields as the theory predicts. In a macro-econometric study, Pozdena (1987) found that debt issuance is not statistically related to non-debt tax shields.

dividends have some *intrinsic* value beyond their cash value,[5] leads to the result that the firm's cost of capital depends on its dividend payout rate.

Figure 1 displays schematically the model which will be developed rigorously below. Table 1 lists the endogenous and exogenous variables of the model. In Figure 1, the decision variables are represented with an asterisk and the arrows represent the direction of causality. The key assumptions of our model are:

1. The objective of the firm is the maximization of the present value of the net returns to its stockholders under the constraint of a constant-returns-to-scale-putty-clay production technology.
2. The firms always has sufficient EBIT to claim interest expenses.
3. The *intrinsic value of dividends* is a concave function of the dividend payout rate.
4. The supply price of debt increases exponentially with leverage.

Our macro-econometric model, which represents the process described in Figure 1, is composed of three equations: a dividend equation, a debt equation and an investment equation. The first two equations determine the financial cost of capital and the third equation uses the financial cost of capital as a determinant. Section 3 formally develops the theoretical model.

3 A Theoretical Model of the Real and Financial Decisions of the Firm

We begin our theoretical development, as have many others, by assuming that in formulating real and financial policies, the objective of the firm is the maximization of the present value of the net returns to its stockholders. If we let VE_t denote the present value at time t of the returns to stockholders and if we let S_t denote the present value of

[5]Poterba and Summers (1985) and Poterba (1987a) discusses the *intrinsic value of dividends*. In particular, it can be argued that shareholders value dividends as a signal of the firm's future prospect (John and Williams, 1985). Shareholders can also perceive cash dividends as a hedge against uncertain future income stream (Shefrin and Statman, 1984).

Figure 1: **The Real and Financial Decisions Process**

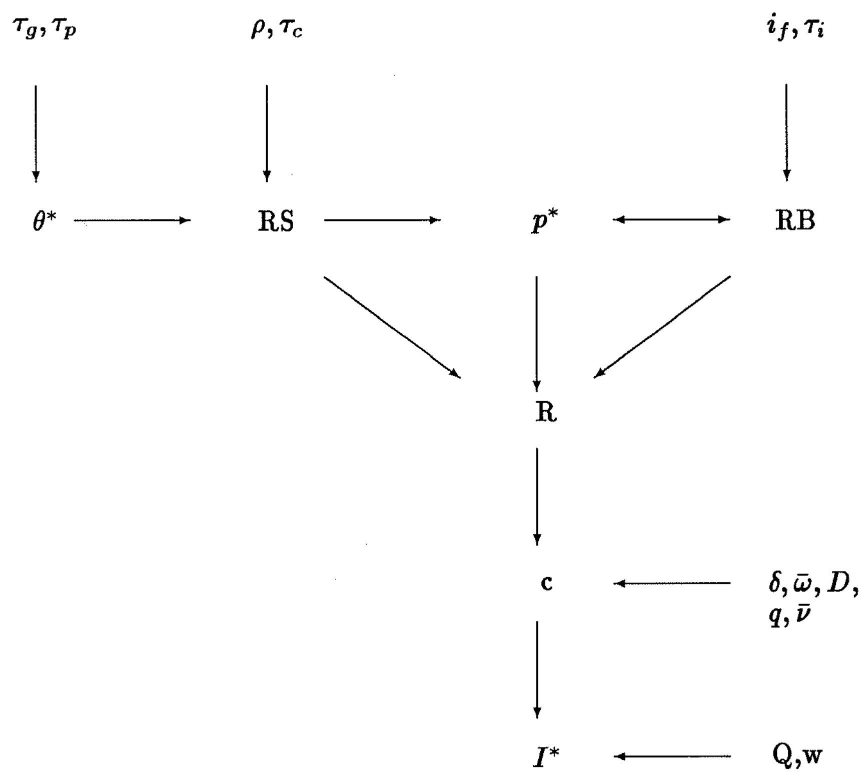

Table 1: **The Variables in the Model**

Exogenous Variables:

D :	depreciation schedule;
δ :	depreciation rate;
i_f :	riskless rate of interest;
$\bar{\omega}$:	long run expected inflation rate in the wage rate;
$\bar{\eta}$:	long run expected inflation rate in the price of output;
π :	price of output
q :	net of tax considerations purchase price of real capital;
Q :	expected output level;
ρ :	shareholders discount rate;
w :	wage rate;
$\bar{\nu}$:	long run expected inflation rate in the price of capital goods;
τ_c :	tax rate on corporate income;
τ_g :	accrual-equivalent tax rate on capital gains income;
τ_i :	tax rate on interest income;
τ_p :	tax rate on dividend income;

Endogenous Variables:

θ :	payout rate;
RS:	cost of equity;
p :	debt/asset ratio;
RB:	cost of debt;
R :	financial cost of capital;
c :	user cost of capital
I^* :	investment.

the current and future stockholders's contributions, then we may express the maximand as

$$\max[VE_t - S_t]. \tag{1}$$

Let ρ denote the after-tax rate of return required by investors to hold equity; let $\tilde{Y}$ denote the firm's cash flow; and let SB denote the shareholder's after-personal income tax benefit of a dollar of corporate cash flow. Thus, assuming arbitrarily that we look forward from time t, the present value of the stokholders returns is

$$VE_t = \int_t^{\infty} e^{-\rho_t(s-t)} \tilde{Y}_s SB_s ds. \tag{2}$$

In this study, ρ is determined as the net of tax opportunity cost of not investing funds in other assets of the same risk class as equity. We assume that ρ is invariant to the conduct of the firm's real investment or financial policies and that in a world of no uncertainty and no inflation, it arbitrages to the rate of time preference.[6]

We first formulate the firm's cash flow. We assume that the firm produces one output Q which is sold at price π. In addition, we assume that the production of Q depends on the use of only two factors: capital and labor. We relate output to capital and labor as follows. Let I_u denote investment at time u and let $L_{u,s}$ denote the amount of labor assigned to I_u at time s. We assume that there is a simple constant returns to scale neoclassical production function f that relates output to capital and labor; that the technology is putty-clay,[7] and that capital decays at a constant rate δ. Thus

$$Q_s = \int_{-\infty}^{s} e^{-\delta(s-u)} f(I_u, L_{u,u}) du. \tag{3}$$

and

$$L_s = \int_{-\infty}^{s} e^{-\delta(s-u)} L_{u,u} du. \tag{4}$$

[6] The assumption that ρ is independent of the firm's financing policies is a potentially important oversimplification. For example, Bhandari (1988) shows that expected common stock returns are positively related to the debt-equity ratio. Nevertheless, no attempt is made here to model the relationship between ρ and financing policies because it is not clear how a closed-form, testable solution of the maximization process could be derived. The empirical testing of the model will show if this assumption is too unreasonable.

[7] In other words, we assume that capital goods can be bought from a whole range of possibilities which require more or less labor to work with, but, after purchase, the quantity of labor to be used with a particular unit of capital is fixed.

To produce Q, the firm must hire labor and invest in real capital. Let w denote the wage rate. Let q denote the effective purchase price of real capital goods (*i.e.* the price of capital goods corrected for any investment tax credit).[8] The effective real capital investment expenditure at time u is thus $q_u I_u$. Let $D_u(s)$ denote the proportion of capital investment of vintage u that can be deducted for tax purposes at time s. Thus, the total depreciation allowed for tax purposes at time s is

$$DEP_s = \int_{-\infty}^{s} D_u(s) q_u I_u du \tag{5}$$

The firm can finance its investment expenditure with some combination of equity and debt. Let p denote the proportion of investment expenditure which is financed by debt. Thus, at time u, bonds will be issued in the amount $p_u q_u I_u$. We assume that the interest on the debt is tax deductible.[9] To take into account the fact that a high debt ratio induces bondholders to require a higher return because of an increasing risk of insolvency, we assume that the nominal rate of return required by bondholders, denoted RB, increases exponentially with leverage p, but that it is independent of the level of capital stock.[10] We also assume that RB is a linear increasing function of the riskless rate of interest i_f. Thus $RB \equiv RB(i_f, p)$ with the properties that $\partial RB/\partial i_f > 0$; $\partial^2 RB/\partial i_f^2 = 0$; $\partial RB/\partial p > 0$; $\partial^2 RB/\partial p^2 > 0$; and $\partial^2 RB/\partial p \partial i_f = 0$. We assume that the firm issues consols so that we do not have to make specific assumptions regarding the time path of the firm's debt repayment. Given these assumptions, total interest payment at time s is

$$B_s = \int_{-\infty}^{s} RB(i_{fu}, p_u) p_u q_u I_u du. \tag{6}$$

We can now specify the firm's cash flow. Let τ_c denote the corporate income tax rate. Since

[8] In this analysis, it is assumed that the supply of real capital goods, the supply of saving and the supply of labor are perfectly elastic.

[9] We thus assume, unlike Dotan and Ravid (1985) and Dammon and Senbet (1988), that the firm ignores the possibility of not having sufficient EBIT in the long run to claim interest expenses.

[10] Note that the assumptions of constant returns to scale and of a perfectly elastic supply of saving are sufficient for RB to be independent of the amount of real capital investment: (i) the assumption of a perfectly elastic supply of saving implies that for a constant risk of bankruptcy, RB is independent of the amount borrowed; (ii) the assumption of constant returns to scale implies that the probability of bankruptcy, hence the premium attached to the risk of bankruptcy, is independent of the amount of capital stock.

$$CashFlow = After\ Tax\ Profit + Value\ of\ the\ Depreciation\ Tax\ Shield,$$

we have at time s, using the notation already introduced,

$$\tilde{Y}_s = (\pi_s Q_s - w_s L_s - B_s)(1 - \tau_{cs}) + \tau_{cs} DEP_s. \tag{7}$$

Of the after-tax cash flow, a portion θ is distributed as dividends, while the remainder $(1-\theta)$ is kept as retained earnings. The decision to pay dividends is probably the least understood of all corporate financing decisions. Given the asymmetric way in which distributed as opposed to undistributed earnings are taxed, it is not clear why most firms pursue a policy of paying substantial dividends. Many arguments have been posited for this state of affairs.[11] Our purpose here is not to provide a new explanation for the existence of dividends, but to use the results of previous studies on the firm's dividend behavior to build a reasonable model of the real and financial decisions of the firm.

In the literature, it is often argued that shareholders value dividends beyond their cash value. It is often postulated that shareholders value dividends as a signal of the firm's future prospects. Closely related to this idea is the notion that paying dividends is a solution to an agency problem: paying dividends forces firms into capital markets regularly where they are scrutinized by investors. Another argument for the existence of dividends is that shareholders perceive cash dividends as a hedge against an uncertain future income. All these reasons for the firm to pay dividends, even if it involves a tax penalty, are reasonable and in reality all of them probably intervene in the firm's payout rate decision.[12] Poterba and Summers (1985) and Poterba (1987a) refer to these reasons for the firm to pay dividends, even if it involves a tax penalty, as the *intrinsic value of dividends.*

Given these considerations, we model SB in (2) as:

$$SB(\theta, \tau_p, \tau_g) = \Omega(\theta) + \{(1-\tau_g)(1-\theta) + (1-\tau_p)\theta\}, \tag{8}$$

where $\Omega(\theta)$ is an *umbrella* function that we use to capture the *intrinsic value of dividends,* τ_g is the accrual-equivalent tax rate on the shareholder's capital gains income and τ_p

[11] Zodrow (1991) synthesizes the theoretical and empirical arguments for and against the different views of dividend taxation.

[12] Abrutyn and Turner (1990) report the results of a survey of 550 of the biggest 1000 corporations in the United States to try to distinguish between the competing explanations for the existence of dividends. The results suggest that "no single theory consistently explains the behavior of all firms" (Abrutyn and Turner, 1990: 495).

is the tax rate on the shareholder's dividend income. Implicit in this expression is the assumption that the increase in the market value of the firm resulting from one dollar of retained earnings is one dollar.

The function $\Omega(\theta)$ in (8) is modeled explicity in Section 5. It is convenient, now, to make several assumptions about its properties. Since $\Omega(\theta)$ is introduced to account for uncertainty and imperfections in the capital markets, it seems reasonable to assume that in a world of no uncertainty and perfect capital markets, $\Omega(\theta) = 0$ (note, for later reference, that if there is also no personal income tax in such a world then $SB(\theta, \tau_p, \tau_g) = 1$). Another assumption about $\Omega(\theta)$ that seems reasonable is that it is concave in θ.[13] We thus basically assume that while taxation makes dividends unattractive, the *intrinsic value of dividends* increases with a higher payout rate, and therefore compensates for the tax penalty on dividend income. This approach to the modeling of dividend behavior is consistent with the so-called *old view* of dividend taxation.[14]

To complete the formulation of the firm's maximand defined in (1), we need to specify the present value of shareholders's future contributions S. Given that at each time period s, a proportion p_s of total investment expenditures $q_s I_s$ is financed by debt, it follows that a proportion $(1 - p_s)$ is financed by equity. Hence, the present value of the stockholders's future contributions is

$$S_t = \int_t^{\infty} e^{-\rho_t (s-t)} (1 - p_s) q_s I_s ds. \tag{9}$$

Given (1), (2), (7) and (9), the objective of the firm is the maximization of

[13]This assumption is consistent with the literature on the theory of the information content of dividends. In this literature (*e.g.* John and Williams, 1985), it is implicity stated that if dividends act as signals then the value of dividends as signals must be concave for an equilibrium to exist.

We should also note that $\Omega(\theta)$ is not precluded from being negative. If $\Omega(\theta)$ is negative then it implies, in conjunction with the assumption of concavity, that what we refer to as the *intrinsic value of dividends* must be reinterprated as the *intrinsic penalty* of not distributing dividends.

[14]A competing theory of dividend behavior is the so-called *new view* (see, among others, Auerbach, 1979; Bradford, 1981; and King 1977). This theory argues that dividend do not have any *intrinsic value*. A prediction of this theory is that taxes are capitalized in the price of shares, hence that dividend taxation is irrelevant and that any payout rate is consistent with equilibrium. There are two major difficulties with this theory. First, it ignores uncertainty. Second, the theory does not explain the well-known observed stability of the payout rate over time for individual companies and for the aggregate economy in the United States and Western Europe.

$$
\begin{aligned}
VE_t - S_t &= \int_t^\infty e^{-\rho_t(s-t)} \cdot \{(\pi_s Q_s - w_s L_s - B_s)(1-\tau_{cs}) + \tau_{cs} DEP_s\} \cdot \\
&\quad SB(\theta_s, \tau_{ps}, \tau_{gs}) ds - \int_t^\infty e^{-\rho_t(s-t)}(1-p_s) q_s I_s ds. \qquad (10)
\end{aligned}
$$

with respect to $\{\theta_s, p_s, I_s, L_{s,s}\}_{s \geq t}$, subject to the constraints defined by (3), (4), (5), (6) and (8).

As it stands, the maximization problem stated in (10) is still too general to yield closed-form testable solutions. We must introduce further restrictions. Assume that the firm acts as if tax variables and the riskless rate of interest i_f will remain constant over the future, and as if wages, the prices of output and of capital stock will increase at constant rates $\bar{\omega}_t$, $\bar{\eta}_t$ and $\bar{\nu}_t$ respectively.[15] Under these conditions, and using (3), (4), (5) and (6), the firm's maximand (10) becomes

$$
\begin{aligned}
VE_t - S_t &= \int_t^\infty e^{-\rho_t(s-t)} \Bigg[\Bigg[\Bigg(\pi_t e^{-(\delta-\bar{\eta}_t)(s-t)} \int_{-\infty}^s e^{\delta u} f(I_{u,u}, L_{u,u}) du - \\
&\quad w_t e^{-(\delta-\bar{\omega}_t)(s-t)} \int_{-\infty}^s e^{\delta u} L_{u,u} du - \int_{-\infty}^t RB(i_{fu}, p_u) p_u q_u I_u du - \\
&\quad \int_t^s RB(i_{ft}, p_u) p_u q_u I_u du \Bigg) \cdot (1-\tau_{ct}) + \\
&\quad \tau_{ct} \int_{-\infty}^s D_t(s-u) q_u I_u du \Bigg] \cdot SB(\theta_s, \tau_{pt}, \tau_{gt}) - \\
&\quad q_t e^{\bar{\nu}_t(s-t)}(1-p_s) I_s \Bigg] ds
\end{aligned}
$$

which can be simplified to

$$
\begin{aligned}
VE_t - S_t &= \int_t^\infty \Bigg[\Bigg[\Bigg[\left(\frac{\pi_t e^{-(\rho_t-\bar{\eta}_t)(s-t)}}{\rho_t + \delta - \bar{\eta}_t}\right) \cdot f(I_s, L_{s,s}) - \left(\frac{w_t e^{-(\rho_t-\bar{\omega}_t)(s-t)}}{\rho_t + \delta - \bar{\omega}_t}\right) \cdot L_{s,s} - \\
&\quad \left(\frac{q_t e^{-(\rho_t-\bar{\nu}_t)(s-t)}}{\rho_t}\right) \cdot RB(i_{ft}, p_s) p_s I_s \Bigg] \cdot (1-\tau_{ct}) + \\
&\quad \tau_{ct} \tilde{D}_t q_t e^{-(\rho_t-\bar{\nu}_t)(s-t)} I_s + Z(t, \tau_{ct}) \Bigg] \cdot SB(\theta_s, \tau_{pt}, \tau_{gt}) -
\end{aligned}
$$

[15] Auerbach and Hassett (1992) derive and estimate corporate investment models in which expectations are fully rational. On the other hand, their models ignore the link between the investment and financing decisions.

$$q_t e^{-(\rho_t - \bar{\nu}_t)(s-t)}(1-p_s)I_s\Bigg] ds \qquad (11)$$

where

$$\tilde{D}_t \equiv \int_0^\infty e^{-\rho_t u} D_t(t+u)du,$$

and where $Z(t, \tau_{ct})$ is a term that depends on τ_{ct} and on $\{\theta_s, p_s, I_s, L_{s,s}\}_{s<t}$ but not on the decision variables $\{\theta_s, p_s, I_s, L_{s,s}\}_{s\geq t}$. Note that $\tilde{D}_t$ is, in fact, the present value of the depreciation allowance of one dollar of capital stock according to the depreciation schedule applicable at time t.

Let us introduce additional notation to facilitate the analysis that follows below. Let $\mathcal{T}_t$ denote the vector of tax variables $[\tau_{pt}\tau_{gt}\tau_{ct}]$. Let

$$RS(\theta_s, \mathcal{T}_t, \rho_t) \equiv \frac{\rho_t}{SB(\theta_s, \tau_{pt}, \tau_{gt})(1-\tau_{ct})}, \qquad (12)$$

and let

$$R(p_s, \theta_s, \mathcal{T}_t, \rho_t, i_{ft}) \equiv p_s RB(i_{ft}, p_s) + (1-p_s) RS(\theta_s, \mathcal{T}_t, \rho_t). \qquad (13)$$

Note that $RS(\theta_s, \mathcal{T}_t, \rho_t)$ is the before-corporate tax rate of return that the firm must achieve on a dollar of real capital for the stockholders to obtain a rate of return equal to ρ_t if real capital is financed completely by equity. The variable $RS(\theta_s, \mathcal{T}_t, \rho_t)$ can thus be seen as the anticipated cost of raising equity at time s given time t.[16] So, since $RB(i_{ft}, p_s)$ is the anticipated cost of raising debt at time s given time t, it follows that $R(p_s, \theta_s, \mathcal{T}_t, \rho_t, i_{ft})$ can be seen as the anticipated financial cost of capital at time s given time t.

Given the information available at time t, maximizing (11) with respect to the decision variables $\{\theta_s, p_s, I_s, L_{s,s}\}_{s\geq t}$ yields the first order conditions

$$\Omega_\theta - (\tau_{ps} - \tau_{gs}) = 0 \qquad (14)$$

$$RB(i_{ft}, p_s) + p_s \frac{\partial RB(i_{ft}, p_s)}{\partial p_s} - RS(\theta_s, \mathcal{T}_t, \rho_t) = 0 \qquad (15)$$

[16]Note that this measure of the cost of equity is very similar to the form which Poterba and Summers (1985) attribute to the *old* view of dividend taxation. The only difference is that they assume that the *intrinsic value of dividends* affects the shareholder discount rate while we assume, instead, that it affects the value of dividends.

$$\pi_t e^{\bar{\eta}_t(s-t)} f_I = q_t e^{\bar{\nu}_t(s-t)} \left(\frac{\rho_t + \delta - \bar{\eta}_t}{\rho_t}\right) \left[R(p_s, \theta_s, \mathcal{T}_t, \rho_t, i_{ft}) - \frac{\tau_{ct} \tilde{D}_t \rho_t}{1 - \tau_{ct}}\right] \tag{16}$$

$$\pi_t e^{\bar{\eta}_t(s-t)} f_L = w_t e^{\bar{\omega}_t(s-t)} \left(\frac{\rho_t + \delta - \bar{\eta}_t}{\rho_t + \delta - \bar{\omega}_t}\right) \tag{17}$$

for all $s \geq t$. So, in particular, at the beginning of period t, the firm must choose $\{\theta_t, p_t, I_t, L_{t,t}\}$ so that the conditions

$$\Omega_\theta - (\tau_{pt} - \tau_{gt}) = 0 \tag{18}$$

$$RB(i_{ft}, p_t) + p_t \frac{\partial RB(i_{ft}, p_t)}{\partial p_t} - RS(\theta_t, \mathcal{T}_t, \rho_t) = 0 \tag{19}$$

$$\pi_t f_I = q_t \left(\frac{\rho_t + \delta - \bar{\eta}_t}{\rho_t}\right) \left[R(p_t, \theta_t, \mathcal{T}_t, \rho_t, i_{ft}) - \frac{\tau_{ct} \tilde{D}_t \rho_t}{1 - \tau_{ct}}\right] \tag{20}$$

$$\pi_t f_L = w_t \left(\frac{\rho_t + \delta - \bar{\eta}_t}{\rho_t + \delta - \bar{\omega}_t}\right) \tag{21}$$

are jointly satisfied. Equation (18) states that the firm should distribute dividends up to the point where the *intrinsic value of dividends* is equal to the tax induced cost of distributing dividends. This result is consistent with Poterba (1987a). Equation (19) states that the firm should finance by debt until the marginal cost of financing an additional unit of capital by debt is equal to the cost of equity. Equation (20) states that the firm should invest in real capital stock until the marginal revenue product of capital is equal to the marginal cost of capital or, if one prefers, the user cost of capital. For later reference, let c_t denote our measure of the user cost of capital i.e.

$$c_t \equiv q_t \left(\frac{\rho_t + \delta - \bar{\eta}_t}{\rho_t}\right) \left[R(p_t, \theta_t, \mathcal{T}_t, \rho_t, i_{ft}) - \frac{\tau_{ct} \tilde{D}_t \rho_t}{1 - \tau_{ct}}\right]. \tag{22}$$

Equation (21) states that the firm should hire labor until the marginal revenue product of labor is equal to the marginal cost of labor (observe that if $\bar{\eta}_t = \bar{\omega}_t$ in (21) then our measure of the marginal cost of labor reduces to the wage rate).

In Section 5, we present an econometric model that is consistent with the first order conditions (14) to (17). For the remainder of this Section, we interpret these first order conditions and discusss the theoretical properties of our model.

3.1 Properties of the Model

Two important observations can be made from the examination of the first order conditions. First, given (13) and (22), the optimal amount of real investment depends, in this model, on a weighted average of the nominal costs of the two financing sources: debt and equity. Second, observe that given (8), (12) and (13), the first order conditions (14) and (15) correspond to the first order conditions of the minimization problem:

$$\text{Min } R(p_s, \theta_s, \mathcal{T}_t, \rho_t, i_{ft}) \tag{23}$$

with respect to p_s and θ_s for all $s \geq t$. Thus, according to this model, the firm faces two separate problems: first, the problem stated in (23), which is the minimization of the financial cost of capital and which yields conditions (14) and (15); and, second, the determination of the optimal investment strategy given the minimized cost of capital which yields condition (16). The assumptions in our model which are central to this result are: 1] that the supply of saving is perfectly elastic; 2] the production function is homogeneous of degree one; 3] the shareholders discount rate is independent of the firm's real investment policies; and 4] EBIT are always large enough to cover interest payments deductions. While many authors have arrived at similar results, the process of minimizing the financial cost of capital remains somewhat unclear in their models.[17]

Our model, however, makes clear that the minimization of the financial cost of capital is also itself a two-step procedure. This can be seen as follows. According to our formulation, the minimization problem stated in (23) yields, in particular, $\partial RS(\theta_s, \mathcal{T}_t, \rho_t)/\partial\theta_s = 0$ which implies, given (8) and (12), the first order condition (14). Thus, according to our model, the firm should first minimize the cost of equity by choosing the dividend payout rate which maximizes the shareholders's after-tax benefit of one dollar of corporate cash flow. Then, given the minimum cost of equity, the firm should choose the external financing mix which minimizes the financial cost of capital. The sequential nature of the dividend and debt decisions is the consequence of the assumption that the shareholder's discount rate ρ is independent of the firm's financial policies.

Let us compare key variables and relationships in our model with those in other models that are frequently cited in the literature. Consider the case of perfect capital

[17] Among others, Auerbach (1979) and Poterba and Summers (1983) present models in which the shareholder's wealth maximization process is a two step procedure, but they do not examine the link between the dividend and debt decisions, and they do not model the financial cost of capital minimization process. In particular, when discussing the impact of personal taxes, Auerbach (1979) assumes that the firm does not issue new shares. Poterba and Summers (1983) assumes, on the other hand, that the firm does not issue bonds. Both methods of financing are accounted for in our model.

markets, no uncertainty and no income taxes. Under those circumstances, $\rho_t = i_{ft}$ from our definition of ρ_t; $RB(i_{ft}, p_t) = i_{ft}$ from our previous assumptions about $RB(i_{ft}, p_t)$; $SB(\theta_t, \tau_{pt}, \tau_{gt}) = 1$ from our previous assumptions about $SB(\theta_t, \tau_{pt}, \tau_{gt})$; and it follows that the firm's maximand (11) reduces to

$$\begin{aligned} VE_t - S_t \;=\; & \int_t^{\infty} \Bigg[\left(\frac{\pi_t e^{-(\rho_t - \bar{\eta}_t)(s-t)}}{\rho_t + \delta - \bar{\eta}_t} \right) \cdot f(I_s, L_{s,s}) - \left(\frac{w_t e^{-(\rho_t - \bar{\omega}_t)(s-t)}}{\rho_t + \delta - \bar{\omega}_t} \right) \cdot L_{s,s} + \\ & \tau_{ct} \tilde{D}_t q_t e^{-(\rho_t - \bar{\nu}_t)(s-t)} I_s + Z(t) - q_t e^{-(\rho_t - \bar{\nu}_t)(s-t)} I_s \Bigg] ds - \\ & \int_{-\infty}^{t} e^{-P(s)} (1 - p_s) q_s I_s ds \end{aligned}$$

which is not a function of p_s for $s \geq t$. This is consistent with the result of Modigliani and Miller (1958) which states that under these conditions, financing policy is irrelevant. On the other hand, if we re-introduce corporate income taxes, then

$$\begin{aligned} VE_t - S_t \;=\; & \int_t^{\infty} \Bigg[\Bigg[\left(\frac{\pi_t e^{-(\rho_t - \bar{\eta}_t)(s-t)}}{\rho_t + \delta - \bar{\eta}_t} \right) f(I_s, L_{s,s}) - \left(\frac{w_t e^{-(\rho_t - \bar{\omega}_t)(s-t)}}{\rho_t + \delta - \bar{\omega}_t} \right) L_{s,s} \Bigg] (1 - \tau_{ct}) - \\ & \tau_{ct} \tilde{D}_t q_t e^{-(\rho_t - \bar{\nu}_t)(s-t)} I_s + Z(t, \tau_{ct}) - q_t e^{-(\rho_t - \bar{\nu}_t)(s-t)} (1 - \tau_{ct}) p_s I_s \Bigg] ds \end{aligned}$$

and, for $s \geq t$,

$$\frac{\partial [VE_t - S_t]}{\partial p_s} = \tau_{ct} q_t e^{-(\rho_t - \bar{\nu}_t)(s-t)} I_s,$$

which is always greater than zero. Thus, according to our model, the firm should always finance by debt when there is no uncertainty, no personal income taxes and financial markets are perfect. This is another well known result. We now examine special cases of our measure of the user cost of capital.

Several special cases of our measure of the user cost of capital have been encountered in the literature. If there is no uncertainty, no personal income taxes and financial markets are perfect then $\rho = i_f$ and $RS = i_f/(1 - \tau_c)$. Hence, under these conditions, financing is by debt only, $R = i_f$, and (22) simplifies to (omitting subscript t)

$$c = q \left(\frac{\rho + \delta - \bar{\eta}}{1 - \tau_c} \right) \{1 - \tau_c(1 + \tilde{D})\}. \tag{24}$$

Consider again the case of no uncertainty, no personal income taxes and perfect financial markets, but suppose that the firm finances nevertheless solely by equity (or that interest payments are not tax deductible). Then $R = \rho/(1-\tau_c)$ and (22) simplifies to

$$c = q\left(\frac{\rho+\delta-\bar{\eta}}{1-\tau_c}\right)(1-\tau_c\tilde{D}) \tag{25}$$

which corresponds to the well known Hall and Jorgenson (1967) measure of the user cost of capital corrected for inflation.

In a later paper, Hall and Jorgenson (1971) proposed the following measure of the user cost of capital to account for the interest deductibility feature of the corporate income tax:

$$c = q\left(\frac{RB(1-\tau_c)+\delta}{1-\tau_c}\right)(1-\tau_c\tilde{D}).$$

We observe that this is a special case of (22) when we assume an all debt-economy (*i.e.* no uncertainty), no inflation, and that the debt holders are also the owners of the firm so that

$$RB = \rho/(1-\tau_c).$$

If the debt holders are not the owners of the firm and if there is inflation, then (24) is the appropriate measure.

Another interesting special case of our measure of the user cost of capital arises when we assume that the discount rate corresponds to the after-tax weighted average of the cost of debt and the cost of equity, that is

$$\rho_t \equiv (1-\tau_{ct})R_t.$$

Then (22) simplifies to

$$c = q\left(\frac{R(1-\tau_c)+\delta-\bar{\eta}}{1-\tau_c}\right)(1-\tau_c\tilde{D})$$

which is probably the measure of the user cost of capital most often used in applied work (see, for example, Feldstein (1982)).

A final observation about the properties of our model is with respect to its relationship with a Tobin$-Q$ type model of investment behavior.[18] We show elsewhere (see

[18]The Q model is theoretically appealing because it takes explicitly into account forward looking expectations. On the other hand, as noted in Chirinko (1986) and Sumner (1989), the empirical record of the Q model is poor. In addition, very little work on the effects of taxes on investment has been undertaken within the Q framework. Summers (1981) incorporates personal taxes and depreciation considerations into the model but ignores the role of financial policies. Chirinko (1987) endogenizes, with little empirical success, the firm's external financing mix policy in a Q model but ignores the role of dividend policy.

Nadeau and Strauss, 1991b) that the decision rule governing real investment decisions in our model is identical to that in the Q model: firms should invest in real capital stock as long as the ratio of the increase in the market value of the firm from acquiring an additional unit of real capital to its net-of-tax considerations purchase cost is greater than 1.

4 Taxation, Financing and Real Investment

There is an extensive literature on the impact of taxation on the financial decisions of the firm. There is also an extensive literature on the impact of taxation on investment.[19] On the other hand, there is very little in the literature which examines the impact of personal and corporate income taxation on financing and investment in a joint framework. The model derived in the preceding Section allows us to perform such a task. The advantages of our model over other models that examine the joint impact of taxation on financing and investment (*e.g.* Stiglitz, 1973) is that the predictions of our model are in accord with the following stylized facts about corporate financing behavior:

1. Firms are financed both by debt and equity;
2. Firms that are highly leveraged pay a higher cost of debt;
3. It is common for firms to pay dividends and issue equity at the same time.

Here, we use our model to examine the effects on financing and investment of small changes in dividend taxation, capital gains taxation and corporate income taxation. These effects are derived by differentiating totally the first order conditions (18) to (20); their signs are reported in Table 2. Most of these effects are straightforward to derive and do not contradict our intuition: dividend income taxation reduces the dividend payout rate, increases the cost of equity and leverage, and reduces investment; capital gains income taxation increases the dividend payout rate, increases the cost of equity and leverage and reduces investment.

The effects of corporate income taxation on investment are not, however, that clear and can be determined only empirically. Corporate income taxation increases the cost of

[19] See, for example, Nickell (1978), Auerbach (1983) and our (1991a) paper for exhaustive reviews of studies which focus on the impact of corporate taxation on the real and financial decisions.

Table 2: **Impact of Tax Changes on the Real and Financial Decision Variables**

Tax	Real and Financial Variables					
Variables	θ	RS	p	RB	R	I
τ_p	$-$	$+$	$+$	$+$	$+$	$-$
τ_g	$+$	$+$	$+$	$+$	$+$	$-$
τ_c	0	$+$	$+$	$+$	$+$	?

equity, leverage and the cost of debt but it also increases the after-tax value of depreciation allowances. Thus, contrary to conventional wisdom that corporate income taxation is a tax on entrepreneurship and reduces investment, the overall impact of corporate taxation on corporate real investment is ambiguous. The effect essentially depends on bondholders' aversion to risk, the taxation level of dividend and of capital gains income, and the generosity of capital consumption allowances. In fact, it is easily shown that

$$\frac{dI}{d\tau_c} = \left(\frac{1}{f_{II}}\right) \cdot \left(\frac{q}{\pi}\right) \cdot \left(\frac{\rho + \delta - \bar{\eta}}{(1-\tau_c)^2}\right) \cdot h \tag{26}$$

where

$$h = \left(\frac{1-p}{SB} - \tilde{D}\right). \tag{27}$$

The sign of h is ambiguous and can be settled only empirically. Note, however, that if dividend and capital gains are taxed heavily, then we should expect SB to be small hence, *ceteris paribus*, h to be positive and, since $f_{II} < 0$, $dI/d\tau_c$ to be negative.

Another case when we can expect an increase in corporate income taxes to have a negative impact on investment is when investors are strongly risk averse. Then, *ceteris paribus*, we should expect the debt-equity ratio to be small, hence h to be positive and $dI/d\tau_c$ to be negative.

Still another case when we can expect an increase in corporate income taxes to have a negative impact on investment is if the present value of the depreciation allowance for tax purpose, namely $\tilde{D}$, is small. This can occur not only if, of course, capital consumption allowances for tax purposes are small, but also if the discount rate ρ is large *and/or* if the tax-life of capital assets is long. This last observation suggests that corporate income taxation may affect different capital assets differently depending on their tax lives: an increase in corporate income taxation is likely to hurt more investment in assets with long tax lives than investment in assets with short tax lives.[20]

Our model also allows us to verify the following results regarding the impact of corporate taxation on investment. In particular, equations (26) and (27) indicate that in the absence of uncertainty, that is if $p = 1$, corporate income taxation increases investment. If, in addition, depreciation deductions are not allowed, then $h = 0$ and corporate income taxation is non-distortionary as shown by Stiglitz (1973).[21] Our model also verifies Stiglitz (1976) contention that in a world of no uncertainty, no personal income taxes, no interest deductibility but immediate write-off, capital income taxation does not distort investment. In fact, under these circumstances, $\tilde{D} = 1$ and, using (25),

$$c = q(\rho + \delta - \bar{\eta})$$

which is not a function of τ_c. In an uncertain world, however, our results indicate that no simple taxation rule can be devised to make corporate income taxation truly investment neutral.

There are two other important results concerning the effects of taxation on investment that are not apparent in Table 2, but that need to be discussed. One result is that if the financial decisions and the real investment decisions are separable, then, based on the envelope theorem, we can ignore the tax induced changes in financial policies when assessing the total impact of *small* changes tax changes on the financial cost of capital.[22] Such a practice is, however, probably unacceptable when assessing the impact of important tax changes such as those contained in Tax Reform Act of 1986. As an illustration, we examine the total impact of a change in dividend income taxation on the financial cost of capital. Given (13),

$$\frac{dR}{d\tau_p} = \frac{\partial R}{\partial p} \cdot \frac{dp}{d\tau_p} + \frac{\partial R}{\partial \theta} \cdot \frac{d\theta}{d\tau_p} + \frac{\partial R}{\partial \tau_p}.$$

The first component of this expression represents the indirect impact via a change in leverage, the second component represents the indirect impact via a change in the payout rate, and the third component represents the direct impact. Since, as derived earlier,

[20] For evidence on the endogeneity of depreciation and empirical evidence on the relation between corporate taxes and economic depreciation, see Hyun, Mazur and Strauss (1991).

[21] Boadway and Bruce (1979) examines in detail the conditions for the corporation income tax to be investment neutral in a world of no uncertainty.

[22] This is not entirely a new result. Poterba and Summers (1983) show that in an all-equity economy, if the dividend and investment decisions are separable, then the envelope theorem allows us to ignore the tax induced changes in the dividend payout rate when assessing the impact of small tax changes on investment. In another paper, Poterba (1987b) shows that if the leverage and investment decisions are separable then the envelope theorem allows us to ignore the tax induced changes in leverage policy.

p and θ are chosen so that R is at a minimum, it follows that $\partial R/\partial p = 0$ and that $\partial R/\partial \theta = 0$. Hence, from the envelope theorem,

$$\frac{dR}{d\tau_p} = \frac{\partial R}{\partial \tau_p}.$$

This shows that we can ignore the tax induced changes in financial policies when assessing the total impact of small changes in the dividend income tax on the financial cost of capital.

Another important result that is not apparent in Table 2 comes from the examination of the role of the variable p in equation (26) (via equation (27)), and in equations

$$\frac{dI}{d\tau_p} = \left(\frac{1}{f_{II}}\right) \cdot \left(\frac{q}{\pi}\right) \cdot \left(\frac{\rho + \delta - \bar{\eta}}{\rho}\right) \cdot \left[\frac{(1-p) \cdot \theta \cdot RS}{SB}\right]$$

and

$$\frac{dI}{d\tau_g} = \left(\frac{1}{f_{II}}\right) \cdot \left(\frac{q}{\pi}\right) \cdot \left(\frac{\rho + \delta - \bar{\eta}}{\rho}\right) \cdot \left[\frac{(1-p) \cdot (1-\theta) \cdot RS}{SB}\right].$$

We observe that $dI/d\tau_c$, $dI/d\tau_p$ and $dI/d\tau_p$ decrease (in magnitude) with p. This indicates that the firm's financing policy cushions the impact of taxation policies on investment.

5 The Econometric Model

Section 3 presented the general theory of a model of the real and financial decisions of the firm. Assumptions were made, and conditions necessary for an optimum were derived. The purpose of this Section is to derive an empirically tractable econometric model that is consistent with these assumptions and conditions. This econometric model will be used to test statistically the validity of these assumptions and to estimate empirically the impact of taxation on the corporate real and financial decisions. The econometric model is composed of three equations: a dividend equation, a debt equation and an investment equation.

5.1 The Dividend Equation

According to (18), the condition that must be satisfied for an optimal dividend payout rate is:

$$\Omega_\theta = \tau_p - \tau_g \tag{28}$$

where $\Omega(\theta)$ is assumed to be concave. For reasons of tractability, we assume that:

$$\Omega(\theta) = \beta\theta^\alpha \tag{29}$$

where β and α are constants satisfying one of these conditions:

$$\beta > 0, 0 < \alpha < 1; \text{or} \beta < 0, \alpha < 0;$$

either of which ensures the concavity of Ω. Given (28) and (29), we obtain

$$\theta^* = \left(\frac{\tau_p - \tau_g}{\alpha\beta}\right)^{\frac{1}{\alpha-1}}. \tag{30}$$

The optimal payout rate is thus an exponentially decreasing function of the tax penalty on dividends.

It is interesting to compare (30) with the form suggested in Poterba (1987a). Under assumptions similar to ours, Poterba postulates that the dividend target is a decreasing function of the ratio of after-tax capital gains income to after-tax dividend income, and a concave function of corporate earnings. Equation (30), however, states that the dividend target is an exponentially decreasing function of the tax penalty on dividends, and a linear function of corporate earnings. Equation (30) is thus closely related to the form suggested by Poterba, and is also based on an explicit objective function for the firm.

Assuming quadratic adjustment costs, the observed payout rate converges to the optimal payout rate according to a partial adjustment process. Thus, given (30), the observed payout rate is modeled as:

$$\theta_t = (1 - g_\theta) \cdot \theta_{t-1} + g_\theta \cdot \left(\frac{\tau_{pt} - \tau_{gt}}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} + \epsilon_{\theta t}, \tag{31}$$

where g_θ is the adjustment constant $0 < g_\theta < 1$, and $\epsilon_{\theta t}$ is a stochastic error term.

5.2 The Debt Equation

In Section 3, RB was assumed to be an increasing function of the riskless rate of interest i_f and of leverage p. Again, for reasons of tractability, we specify $RB(i_f, p)$ as

$$RB(i_f, p) = i_f + \lambda p^\gamma \tag{32}$$

where λ is a positive constant and γ is the elasticity of the risk premium with respect to leverage. The constant γ is expected to be greater than one.

Given (32) and the first order condition (19), the optimal financing mix takes the form:

$$p^* = \left(\frac{RS(\theta, \mathcal{T}, \rho) - i_f}{\lambda(\gamma + 1)} \right)^{1/\gamma}. \tag{33}$$

So, given the assumptions about λ and γ, the optimal external financing mix turns out to be a concave function of the differential between the cost of equity and the riskless rate of interest.

As in the case of the dividend payout rate, we aassume that adjustment costs are quadratic and, as a result, we link the optimal payout rate to the observed payout rate via a partial adjustment process. More specifically, the observed financing mix is approximated by the form:

$$p_t = (1 - g_p) \cdot p_{t-1} + g_p \cdot \left(\frac{RS(\theta, \mathcal{T}, \rho) - i_f}{\lambda(\gamma + 1)} \right)^{1/\gamma} + \epsilon_{pt} \tag{34}$$

where g_p is the response adjustment constant $(0 < g_p < 1)$, and ϵ_{pt} is a stochastic error term.

5.3 The Investment Equation

Completing a planned investment requires, in general, expenditures over a certain number of periods. We assume that firms are aware of these necessary lags, and that investment planners order equipment in advance to avoid shortages in the future. The extension of our model of the investment process to reflect this assumption necessitates that we first look at how firms anticipate future investment needs.

Assume the firm's expectations about future output demand at time $t + i$ given time $t - 1$, denoted $Q_{t+i|t-1}$, are *economically rational* in the sense of Feige and Pearce (1976), and that the production technology is Cobb-Douglas with an elasticity of output with respect to labor equal to some constant ζ. Let

$$w_{t+i|t} \equiv w_t(1 + \bar{\omega}_t)^i;$$

$$q_{t+i|t} \equiv q_t(1 + \bar{\nu}_t)^i;$$

and let

$$\tilde{c}_{t+i|t} \equiv q_{t+i|t} \left(\frac{\rho_t + \delta - \bar{\omega}_t}{\rho_t} \right) \left[R(p_{t+i}, \theta_{t+i}, \mathcal{T}_t, \rho_t, i_{ft}) - \frac{\tau_{ct} \tilde{D}_t \rho_t}{1 - \tau_{ct}} \right].$$

The variables $w_{t+i|t}$ and $q_{t+i|t}$ are discrete time approximations to $w_t e^{\bar{\omega}_t i}$ and $q_t e^{\bar{\nu}_t i}$ respectively, and the variable $\tilde{c}_{t+i|t}$ can be seen as a variant of the (usual) expected user cost of capital at time $t+i$ given time t where the expected inflation rate in the cost of labor is used instead of the expected inflation rate in the price of output. Hence, using (16) and (17), the additional increases in capital stock anticipated to be needed time at $t+i$, given time t, is

$$I_{t+i|t} = B \cdot \left[\frac{w_{t+i|t}}{\tilde{c}_{t+i|t}} \right]^{\zeta} \cdot \Delta Q_{t+i|t-1} \tag{35}$$

where B is a scaling constant and $\Delta Q_{t+i|t-1}$ denotes the expected gross increment in output at time $t+i$ given time $t-1$, *i.e.*

$$\Delta Q_{t+i|t-1} = Q_{t+i|t-1} - (1-\delta) Q_{t+i-1|t-1}.$$

Now, assuming that in each period $t-i$ in the planning interval $(t-h, t)$, the firm orders a portion of the discrepancy between the additional capital stock it anticipates it will need at time t and the previous orders it made to be delivered at t, yields the result that realized investment at time t takes the form of a distributed lag of additional capital stock anticipated to be needed in the previous time periods for time t. Hence, given (35), we can write investment expenditures at time t as

$$\bar{I}_t = \varphi + \sum_{i=0}^{h} \phi_i \cdot \left[\frac{w_{t|t-i}}{\tilde{c}_{t|t-i}} \right]^{\zeta} \cdot \Delta Q_{t|t-i-1} + \epsilon_{It} \tag{36}$$

where φ, ζ and the ϕ_i's are coefficients to be estimated, and ϵ_{It} is a stochastic error term.

6 Estimation Results

Equations (31), (34) and (36) form a system of three non-linear recursive equations. Its estimation is performed using US aggregate time-series data. The data covers the period 1933 to 1986. A short description of the data is contained in Appendix A. Appendix B explains how the dividend equation is modified to allow for the presence of the surtax on retained earnings in 1936 and 1937.

The estimation of the system is performed by the Full Information Maximum Likelihood method. To that end, the error terms in (31), (34), and (36) are assumed to be normally distributed with zero means and constant variances. Since the equations of the system are recursive, and since the error terms are theoretically uncorrelated across equations,[23] the use of a simultaneous equations estimation method is not appropriate.

The results of the estimation are reported in Table 3.[24] Table 4 reports the residuals' cross-correlation coefficients. We observe that all the estimated coefficients in Table 3 have the expected sign and, except for $\hat{\beta}$ and $\hat{\phi}_1$ which are statistically significant at only the 8 percent and 22 percent levels respectively, all the coefficients are statistically significantly different from zero at the 2.5 percent level (or better) in one-tail tests. The results in Table 4 suggest, however, that to relax the assumption that the cost of equity is independent of the firm's leverage (and hence that the dividend decision is independent of the leverage decision) could improve, albeit marginally, the specification of the model—the hypothesis that $\hat{\epsilon}_\lambda$ is uncorrelated with $\hat{\epsilon}_p$ is almost accepted at the 1 percent level.[25] On the other hand, the estimated correlation coefficients between $\hat{\epsilon}_\lambda$ and $\hat{\epsilon}_I$, and between $\hat{\epsilon}_p$ and $\hat{\epsilon}_I$ do not contradict our contention that the financial decisions are independent of the investment decisions. Thus, as a general diagnostic, we find that our model is reasonably consistent with the data.

6.1 The Dividend Payout Rate Equation

The results reported in Table 3 indicate that the tax penalty on dividends has a statistically significant and substantively important impact on dividend behavior. Our estimate of the equilibrium elasticity of the payout rate with respect to the tax penalty on dividends is

$$\frac{1}{1-\hat{\alpha}} = -0.375$$

[23]The error terms are theoretically uncorrelated across equations because, in our model, the payout rate decision does not depend on the leverage decision, and the payout rate and leverage decisions do not depend on the investment decision.

[24]The estimation of the investment equation is corrected for autocorrelation in the residuals. Note also that the hypothesis that the generating process of the error term in the investment equation contains a unit root is strongly rejected (the test is described in Engle and Granger, 1987), therefore indicating that the statistical strength of our results is not a case of "spurious regression."

[25]This test is based on the result that, in large samples, the contemporaneous correlation coefficient between two independent time series is normally distributed with mean 0 and standard error $1/\sqrt{n}$ (see Granger and Newbold, 1986). To the benefit of our model, however, it must be pointed out that since our sample is not very large, the "true" p-value associated with this test is larger than the value of 1 percent we obtain.

Table 3: **Estimation Results**

Dividend payout rate equation (31):

Coefficient	Estimate	Standard Error	
g_θ	0.238	0.047	
α	-1.664	0.435	
β	-0.006	0.004	$R^2 = 0.93$; $\hat{\rho}^\dagger = 0.10$

Debt Equation (34):

Coefficient	Estimate	Standard Error	
g_p	0.085	0.026	
λ	0.046	0.016	
γ	5.937	1.585	$R^2 = 0.98$; $\hat{\rho} = -0.12$.

Investment Equation (36):

Coefficient	Estimate	Standard Error	
φ	-11.953	5.222	
ϕ_0	0.059	0.024	
ϕ_1	0.017	0.022	
ϕ_2	0.195	0.080	
ζ	0.419	0.151	$R^2 = 0.98$; $\hat{\rho} = 0.67$

†For equations (31) and (34) $\hat{\rho}$ corresponds to the estimate of the first order autocorrelation in the residuals. For equation (36), $\hat{\rho}$ corresponds to the estimated coefficient associated with ϵ_{It-1} in the correction for the autocorrelation in the residuals.

Table 4: **Cross-correlation of the Residuals**

	$\hat{\epsilon}_\lambda$	$\hat{\epsilon}_p$	$\hat{\epsilon}_I$
$\hat{\epsilon}_\lambda$	1.00	-0.36	-0.12
$\hat{\epsilon}_p$		1.00	-0.06
$\hat{\epsilon}_I$			1.00

with an estimated asymptotic standard error of 0.061. Thus, as conjectured in Section 5, the dividend payout rate is an exponentially decreasing function of the tax penalty on dividends.[26] This result also provides, incidentally, additional empirical support for the *old view* of dividend taxation.[27]

Taxation affects, however, dividend payout in a gradual manner. From Table 3, the speed-of-adjustment constant is equal to 0.238. Hence, according to this model, the half-life of the adjustment process is slightly more than two years. This is more than twice as fast as the speed of adjustment estimated in Poterba (1987a) in the case of a permanent change in dividend taxation.

The results in Table 3 allow also the identification of the umbrella function $\Omega(\theta)$ introduced to capture the *intrinsic value of dividends.* According to Table 3 and (29),

$$\Omega(\theta) = -0.006\theta^{-1.66}. \tag{37}$$

This function is concave as conjectured, and, given the magnitude of the elasticity parameter, it appears that shareholders are highly sensitive to the *intrinsic value of dividends.* Another observation is that since $\Omega(\theta)$ is negative, this function should be referred to as, instead, the *intrinsic penalty* of <u>not</u> distributing dividends.

6.2 The Debt Equation

Given the estimation of the payout rate equation, the before-corporate tax cost of equity is calculated using (8), (12) and (37) as:

$$RS(\theta, \mathcal{T}, \rho) = \frac{\rho}{[-0.006\theta^{-1.66} + (1-\tau_g)(1-\theta) + (1-\tau_p)\theta] \cdot (1-\tau_c)}. \tag{38}$$

This variable links the debt equation to the payout rate equation.

[26] We cannot directly compare our estimate of the long-run effect of a reduction in the tax penalty on dividend income with the estimates calculated by Poterba (1987a), because, unlike our estimate, Poterba's estimates depend on the level of corporate income. On the other hand, using the values calculated at their means we can state loosely that our estimate is smaller (in magnitude) than Poterba's favored estimate: -0.375 vs -0.64. Note also that Poterba's estimate is not contained in a 99 percent confidence interval around our estimate.

[27] Empirical support for this view is also provided by Poterba and Summers (1985), Poterba (1987a) and Nadeau (1988).

Based on the results in Table 3, an estimate of the equilibrium elasticity of leverage with respect to the differential between the cost of equity and the riskless cost of debt is

$$1/\hat{\gamma} = 0.17$$

with an estimated asymptotic standard error of 0.04. Thus, as conjectured in Section 5, the differential between the cost of equity and the cost of debt affects the equilibrium leverage in a concave manner. For example, a differential of 1 percentage point yields an equilibrium leverage of 0.61; whereas a differential of 5 percentage point yields an equilibrium leverage of 0.77.

The most surprising result, however, is the very small magnitude of the adjustment constant, g_p. According to Table 3, it is equal to 0.085. Thus, following a permanent change in the differential between the cost of debt and the cost of equity, it would take about 8 years for half the adjustment to occur.

The estimation of the financial mix equation allows also the identification of the relationship between the cost of debt and leverage as specified by (32). According to Table 3,

$$RB(p) = i_f + 0.046p^{5.94}. \tag{39}$$

Thus, as conjectured, the cost of debt is an exponentially increasing function of leverage. For example, increasing leverage from 0.1 to 0.6 increases the cost of debt by only 0.2 percent. On the other hand, increasing leverage from 0.6 to 0.8 increases the cost of debt by 1 percent. Although perhaps on the low side, these results are not out of line with casual observation of the bond market.[28]

6.3 The Investment Equation

The financial cost of capital $R(p, \theta, \mathcal{T}, \rho, i_f)$ is the variable that links equation (36) to equations (31) and (34). A measure of this variable is obtained by using (13), (38) and (39). The results of the estimation of the investment equation using this construct are reported in Table 3. As indications of the general validity of the model, we find the coefficients to be of the expected sign and the fit to be very good. Converting the coefficients into elasticities at the means of the variables yields an elasticity of the

[28] Arguably more realistic estimates of the impact of leverage on the cost of debt can be obtained if they are based on boundaries of 95 percent confidence intervals for λ and γ. For example, if we use $\hat{\lambda} = 0.08$ and $\hat{\gamma} = 2.83$ instead, then increasing leverage from 0.1 to 0.6 increases the cost of debt by 1.9 percent, while increasing leverage from 0.6 to 0.8 increases the cost of debt by 2.4 percent.

demand for equipment with respect to the ratio of factor prices of 0.5. These results are not out of line with those previously reported in the literature. As an illustration, we can compare the prediction of our model of the impact of a doubling of the investment tax credit with the predictions of the 7 major econometric models which are reported in Chirinko and Eisner (1983). Our model predicts that a doubling of the investment tax credit in 1973 would have increased investment in equipment in 1977 by 7.9 percent. This figure is close to the median prediction value of 9.8 percent reported by Chirinko and Eisner.

6.4 Model Comparison

We now compare the explanatory power of the equations of our model with the explanatory power of representative single equation specifications drawn from the literature. The objective of this comparison is to see if the compromises imposed on the specification of the individual equations of our model—in order to keep the overall model theoretically consistent and empirically tractable—are costly from a statistical point of view. Table 5 reports the results of estimating three well known dividend specifications with our data: Lintner (1956), Brittain (1964) and Poterba (1987a) specifications. From an R^2 point of view, our specification performs significantly better than all three specifications: compare 0.93 vs 0.61, 0.62 and 0.57. In terms of statistical reliability, our specification yields an estimate of the effect of taxes on dividends much more reliable than Brittain's (1964) estimate and as reliable as the Poterba's (1987a) estimate.

Table 6 reports the results of estimating the equation which, as far as we know, is the only other empirically tractable leverage equation available in the literature: the equation in Rangazas and Abdullah (1987).[29] In terms of *goodness of fit*, our debt equation fits the data only slightly worse than Rangazas and Abdullah (1987) equation. In terms of statistical reliability, however, our equation does much better: very few of the independent variables in Table 6 have a statistically significant impact (in particular, the tax advantage of debt financing over equity financing does not seem to have any impact on leverage) while, with our specification, we find that the differential between the cost of debt and the cost of equity has a very statistically significant impact on leverage financing.

[29] In Rangazas and Abdullah (1987), the variable p is measured as the *market value* as opposed to the *book value* of the debt/asset ratio. This different definition of the dependent variable is not, however, the principal source of the difference between their estimates and the estimates in Table 6. The principal source of the difference is the different sample period used: the sample period they use is 1930-1979 while the sample period we use is 1933-1986. In fact, if we use the 1933-1979 sample period instead, then the results we obtain are qualitatively and quantatively quite similar to their results.

Table 5: **Other Dividend Specifications**

Lintner (1956):

$$\Delta DIV_t = -\underset{(659.9)}{621.13} + \underset{(0.02)}{0.075}\, Y_t - \underset{(0.06)}{0.134}\, DIV_{t-1}$$

$R^2 = 0.61;\ \hat{\rho} = -0.04$

Brittain (1964):

$$\Delta DIV_t = -\underset{(682.9)}{733.12} - \underset{(0.05)}{0.038}\, (\tau_{pt} - \tau_{gt}) \cdot Y_t + \underset{(0.02)}{0.066}\, Y_t - \underset{(0.07)}{0.106}\, DIV_{t-1}$$

$R^2 = 0.62;\ \hat{\rho} = -0.07$

Poterba (1987a):

$$\Delta ln(DIV_t) = -\underset{(0.14)}{0.220} + \underset{(0.05)}{0.326}\, \Delta ln(Y_t) + \underset{(0.24)}{0.820}\, \Delta ln(z_t) - \underset{(0.05)}{0.104}\, ln(DIV_{t-1}) +$$
$$\underset{(0.05)}{0.132}\, ln(Y_{t-1}) + \underset{(0.18)}{0.158}\, ln(z_{t-1})$$

$R^2 = 0.57;\ \hat{\rho} = 0.03$

where

DIV : dividends;

Y : corporate accounting earnings;

z : Poterba's measure of relative after-tax income from dividends vs retained earnings.

Table 6: **Other Debt/Asset Ratio Specification**

Rangazas and Abdullah (1987):

$$
\begin{array}{llllll}
p_t = & 0.054 \; + & 0.124 \; E_{t-1} - & 0.640 \; r^i_{t-1} + & 0.921 \; r^i_{t-2} - & 0.294 \; r^i_{t-3} - \\
& (0.02) & (0.23) & (0.51) & (0.69) & (0.42) \\
& 0.015 \; r^e_{t-1} - & 0.026 \; r^e_{t-2} - & 0.006 \; r^e_{t-3} + & 0.983 \; p_{t-1} + & 0.172 \; p_{t-2} - \; 0.226 \; p_{t-3} \\
& (0.01) & (0.01) & (0.01) & (0.16) & (0.24) \quad\quad (0.15)
\end{array}
$$

$R^2 = 0.99$; $\hat{\rho} = -0.07$

where

E: measure of the tax advantage of debt financing over equity financing;
r^i : the risk premium on corporate bonds (determined exogenously);
r^e: the risk premium on equity (determined exogenously).

What most differentiates our investment equation from the other neo-classical investment equations in the literature is our specification of the user cost of capital. Hence, instead of reporting the results of estimating other investment equations using our data, Table 7 reports the results of estimating *our* investment equation with three other measures of the user cost of capital: the measure used in Jorgenson (1967) (with the long-term government bond rate replaced by the the earnings/price ratio), the measure used in Hall and Jorgenson (1971), and a measure in which the financial cost of capital is an exogenously determined weighted average of the cost of debt and the cost of equity (*e.g.* Feldstein, 1982). Based on the figures in Table 7, our specification of the user cost of capital and the system estimation of our model does not reduce the explanatory power of our investment equation — the magnitude of the coefficients in Table 7 is very much comparable to the magnitude of the coefficients of the investment equation in Table 3, and the diagnostic checking statistics are also comparable.

What this model comparison indicates is that each equation of our model has, despite of being part of a system, at least as much explanatory power as any of the single equation specifications best representative of the literature. This suggests, in turn, that our model allows the analysis of the effects of taxation in a more complete framework without imposing over-restrictive assumptions.

Table 7: **Other Investment Specifications**

Jorgenson (1967): $c = q\left(\frac{e+\delta-\bar{\eta}}{1-\tau_c}\right)(1-\tau_c\tilde{D})$

Coefficient	Estimate	Standard Error	
φ	-3.526	4.520	
ϕ_0	0.038	0.017	
ϕ_1	0.070	0.012	
ϕ_2	0.084	0.049	
ζ	0.830	0.218	$R^2 = 0.99$; $\hat{\rho} = 0.47$

Hall and Jorgenson (1971): $c = q\left(\frac{i(1-\tau_c)+\delta-\bar{\eta}}{1-\tau_c}\right)(1-\tau_c\tilde{D})$

Coefficient	Estimate	Standard Error	
φ	-9.428	5.598	
ϕ_0	0.073	0.027	
ϕ_1	-0.064	0.057	
ϕ_2	0.370	0.938	
ζ	0.323	0.078	$R^2 = 0.98$; $\hat{\rho} = 0.71$

Feldstein (1982): $c = q\left(\frac{pi(1-\tau_c)+(1-p)e+\delta-\bar{\eta}}{1-\tau_c}\right)(1-\tau_c\tilde{D})^{\dagger}$

Coefficient	Estimate	Standard Error	
φ	-5.128	4.500	
ϕ_0	0.056	0.020	
ϕ_1	-0.016	0.031	
ϕ_2	0.179	0.077	
ζ	0.581	0.145	$R^2 = 0.99$; $\hat{\rho} = 0.63$

where e : S&P earnings/price ratio;
i : average yield on corporate bonds.

† p is determined exogenously.

Table 8: **Tax Elasticities**

Tax Variables	Real and Financial Variables						
	θ	RS	p	RB	R	c	I
$\tau_p^{\dagger}$	-0.433 (0.071)	0.090 (0.005)	0.033 (0.009)	0.021 (0.004)	0.036 (0.003)	0.059 (0.005)	-0.029 (0.009)
$\tilde{\tau}_g^{\ddagger}$	0.060 (0.010)	0.026 (0.001)	0.010 (0.003)	0.010 (0.001)	0.010 (0.001)	0.017 (0.001)	-0.008 (0.003)
τ_c	0	0.706 na	0.262 (0.070)	0.166 (0.034)	0.286 (0.017)	-0.616 (0.049)	0.305 (0.093)

†Asymptotic standard errors are in parentheses.
$^{\ddagger}\tilde{\tau}_g$ denotes the tax rate on realized (as opposed to accrued) capital gains income.

6.5 Estimated Elasticities

The most important feature of our model is that it allows the statistical measurement of the joint effects of personal and corporate income taxation on the real and financial decisions of the firm. Existing models of investment behavior allow only for the measurement of the direct effects of corporate income taxation on investment expenditures through the user cost of capital and, sometimes, cash flow. Our model goes one step further: it explicitly formulates the influence of both corporate and personal income taxes on the firm's financing decisions. It thus allows for a broader and a more accurate statistical analysis of the effects of taxation on business invesment expenditures than the models currently available. Our estimated model is used here to provide estimates of the tax elasticities.

The estimated equilibrium tax elasticities, along with their estimated asymptotic standard errors, are reported in Table 8. These elasticities are computed at the sample means of the exogenous variables. Note that these elasticities are asymptotically normally distributed and that the standard errors are computed using linear Taylor series approximations. Note also that the capital gains income tax elasticities refer to realized, as opposed to accrued, capital gains income.

The first observation that we make is that although the impact of dividend and capital gains taxation on investment is statistically very significant, it is cushioned substantially by financial policy. In fact, our model estimates that a 1 percent relative increase in the dividend income tax rate (approximately a 0.25 percentage point increase) decreases, as compared to baseline, the dividend payout rate by 0.433 percent, increases only marginally the cost of equity, the cost of debt and the financial cost of capital, and decreases investment in equipment by only 0.029 percent. Because capital gains are taxed only on accruals, the estimated impact of capital gain income taxation on financial variables and on investment is even more modest: our model estimates that a 1 percent increase in the tax rate on realized capital gains income decreases investment in equipment by only, although statistically significantly, 0.008 percent. On the other hand, because the impact of corporate income taxation cannot be cushioned by dividend policy, the impact of corporate income taxation on financing and investment is quantitatively much more important.

The most surprising result, however, is the qualitative nature of the estimated impact of corporate income taxation on investment in equipment. Our empirical analysis allows us to sign the impact of corporate income taxation on investment in equipment. We find that, contrary to conventional wisdom, corporate income taxation <u>increases</u> investment in equipment. In fact, although a one percentage point relative increase in corporate income tax increases statistically significantly the financial cost of capital—a 0.286 percent relative increase in R for each percentage point relative increase in τ_c—it increases even more the after tax value of depreciation allowances for equipment. The net effect of a 1 percent relative increase in corporate income taxation is thus a substantial decrease in the user cost of capital and a substantial increase in investment in equipment: a -0.616 percent relative decrease in c and a 0.305 percent relative increase in $\bar{I}$. The robustness of these estimates to sampling errors in the estimation of the coefficients of the relations can be examined using 95 percent confidence intervals: (-0.712, -0.520) for the elasticity of c with respect to τ_c, and (0.123, 0.487) for the elasticity of $\bar{I}$ with respect to τ_c. These statistics suggest strongly that corporate income taxation biases upward investment in equipment. We must be careful, however, not to extend this result to the case of investment in structures because the tax life of structures is much longer than the tax life of equipment, which implies that an increase in the corporate income tax rate influences much less the after-tax value of depreciation allowances for structures than the after-tax value of depreciation allowances for equipment.

Another interesting result is that, as conjectured theoretically,[30] the tax deductibility of debt encourages debt financing over equity financing: we find that the equilibrium elasticity of p with respect to τ_c is 0.262 (compared to an estimate of 0.055 obtained with the Rangazas and Abdullah (1987) specification). What surprises us the most,

[30] See, for example, Bernanke, Campbell and Whited (1990) for a study of the determinants of leverage.

however, is the statistical reliability of this estimate—the p-value associated with the test of the null hypothesis that τ_c does not affect p against the alternative hypothesis that τ_c increases p is approximately 0.01 percent.

7 Conclusions and Future Research Directions

Since financial policy can be used to cushion the impact of taxation on corporate investment, a comprehensive study of the effect of taxation on corporate investment necessitates the use of models linking the real and financial decisions. This paper develops theoretically and estimates empirically such a model. This model views the firm's financing-investment decision process as the following sequence of events:

1. Given the *intrinsic value of dividends*, and given the tax penalty on dividend income, the firm chooses the dividend payout rate minimizing the cost of new equity financing.
2. Given the minimized cost of new equity financing and the cost of debt (as a function of leverage), the firm chooses the mixture of debt and equity minimizing the financial cost of capital.
3. Given the minimized financial cost of capital, the cost of labor and expectations about future output demand, the firm decides on a level of investment. The realization of this investment is, however, influenced by considerations such as delivery lag.

Several measures of the user cost of capital encountered in the literature are derived as special cases of this model's measure. Comparing the explanatory power of the equations of our model with the explanatory power of representative single equation specifications drawn from the literature shows that this system modeling of the real and financial decision process does not impose over-restrictive assumptions.

Because several tax variables enter as determinants into this model, and because of its empirical support, this model is particularly well suited for an in-depth and self contained statistical analysis of the effects of taxation on the real and financial decisions of the firm. According to the statistical analysis, the effects of dividend and capital gains taxation on investment are significant but are cushioned substantially by financial policy. The statistical analysis also indicates that corporate income taxation hurts more investment in assets with long tax lives than investment in assets with short tax lives, and that the current US income tax system upwardly biases, in a statistically significant manner, investment in equipment. Another interesting finding is that the tax deductibility of debt encourages, statistically significantly, debt financing over equity financing.

Our study can be extended in a number of ways. An obvious extension is that this model should be tested on investment in nonresidential structures. Much more challenging extensions, however, are: 1] the modeling of the link between the shareholder's discount rate and financial policies; 2] the endogenization of the depreciation rate and the replacement rate (see, for example, Hyun, Mazur and Strauss, 1991); 3] the relaxation of the assumption that EBIT are always sufficient to cover interest payments deductions; and 4] the formulation of the real and financial decisions process in a New-classical framework (for example, by endogenizing the financial decisions in Auerbach and Hasset (1992) New-classical corporate investment model).[31]

A Data Estimates

Most of the data used for the empirical analysis in this paper is described, and given for the period 1934-1980, in Nadeau (1986) and is available upon request. This Appendix describes only key data and those that differ from Nadeau (1986).

The tax rate τ_p is measured as the effective tax rate on dividend income. The tax rate τ_c is measured as the effective tax rate on corporate income. The variable τ_g is constructed using Auerbach (1983), and the holding period for corporate equities is set equal to 40 years (see Bailey, 1969; Gravelle, 1989; and our 1991a paper). The variable p is set equal to the *book value* of the debt/asset ratio. The variable ρ is set equal to the post-tax rate of return on preferred stocks, and the variable i_f is measured as the yield on US government long term bonds. The payout rate θ is calculated as the ratio of cash dividend over cash flow. The variables Q and $\bar{I}$ are measured respectively as Business Gross Product and as Producer's Nonresidential Durable Equipment.

[31] Chirinko's (1988) results suggest, however, that the gain of formulating the real and financial decisions process in a New-classical framework may not be quantatively important.

B Allowing for the 1936-1937 Surtax on Retained Earnings

In order "to provide a fairer distribution of the tax load among all the beneficial owners of business profits whether derived from unincorporated businesses and whether distributed to the real owners as earned or witheld from them"[32] a surtax was imposed on retained earnings in 1936. The effective surtax rate was substantially reduced in 1938 and the surtax expired formally in December 1939. Thus, unlike in our theoretical development of Section 3, the tax rate on corporate income was a function of the dividend payout rate during that time period. We must modify our econometric model accordingly.

If we let τ_u denote the tax rate on undistributed earnings and τ_d denote the tax rate on distributed earnings, then the tax rate on corporate income was

$$\tau_c(\tau_u, \tau_d, \theta) = \frac{\theta\tau_d + (1-\theta)\tau_u}{1 + \theta(\tau_d - \tau_u)}. \tag{40}$$

during the period 1936-1937. As a result, the maximization of (11) with respect to $\{\theta_s\}_{s\geq t}$ does not yield a first order condition as simple as (14) for that time period and, given (8) and (29), we cannot solve for θ^*. This necessitates that we simplify the problem. We approximate (11) by the expression

$$\begin{aligned} VE_t - S_t \quad \approx \quad & \int_t^\infty \Bigg[\Bigg[\left(\frac{\pi_t e^{-(\rho_t - \bar{\eta}_t)(s-t)}}{\rho_t + \delta - \bar{\eta}_t}\right) \cdot f(I_s, L_{s,s}) - \left(\frac{w_t e^{-(\rho_t - \bar{\omega}_t)(s-t)}}{\rho_t + \delta - \bar{\omega}_t}\right) \cdot L_{s,s} - \\ & \left(\frac{q_t e^{-(\rho_t - \bar{\xi}_t)(s-t)}}{\rho_t}\right) \cdot RB(i_{ft}, p_s) p_s I_s + \\ & \left(\frac{\tau_c(\tau_{ut}, \tau_{dt}, .5)\tilde{D}_t q_t e^{-(\rho_t - \bar{\xi}_t)(s-t)}}{1 - \tau_c(\tau_{ut}, \tau_{dt}, .5)}\right) I_s + \\ & \left(\frac{Z\{t, \tau_c(\tau_{ut}, \tau_{dt}, .5)\}}{1 - \tau_c(\tau_{ut}, \tau_{dt}, .5)}\right)\Bigg] \cdot \{1 - \tau_c(\tau_{ut}, \tau_{dt}, \theta_t)\} SB(\theta_s, \tau_{pt}, \tau_{gt}) - \\ & t_t^{-(\rho_t - \bar{\xi}_t)(s-t)}(1 - p_s) I_s \Bigg] ds \end{aligned} \tag{41}$$

where

$$\tau_c(\tau_u, \tau_d, .5) = \frac{.5\tau_d + (1 - .5)\tau_u}{1 + .5(\tau_d - \tau_u)}$$

[32]U.S. President, "Additional Information Concerning the Budget for the Fiscal Year 1937," House Doc. No. 418, 74th Cong., 2nd Session.

can be seen as a "close" approximation of $\tau_c(\tau_{ut}, \tau_{dt}, \theta_t)$. Maximizing (41) with respect to $\{\theta_s\}_{s \geq t}$ yields the first order condition

$$\frac{\partial\{1 - \tau_c(\tau_{ut}, \tau_{dt}, \theta_s)\} SB(\theta_s, \tau_{pt}, \tau_{gt})}{\partial \theta_s} = 0. \tag{42}$$

The first order conditions corresponding to the maximization of (41) with respect to the other decision variables $\{p_s, I_s, L_{s,s}\}_{s \geq t}$ are identical to (15), (16) and (17). Thus, given our simplification, allowing for the 1936-1937 surtax affects only the dividend equation of our econometric model.

Given (8), (29), and (40), (42) yields that θ^* must be chosen to satisfy the equality

$$\beta \theta^{\alpha-1}\{\theta(\tau_u - \tau_d)(1-\alpha) + \alpha\} = (\tau_p - \tau_g) - (1 - \tau_g)(\tau_u - \tau_d). \tag{43}$$

So, when $\tau_u = \tau_d$,

$$\theta^* = \left(\frac{\tau_p - \tau_g}{\alpha\beta}\right)^{\frac{1}{\alpha-1}}.$$

as in (30). On the other hand, when $\tau_u \neq \tau_d$ we cannot solve (43) for θ since the term $\theta(\tau_u - \tau_d)(1-\alpha)$ is then different from zero. To solve the problem, we approximate the term $\theta(\tau_u - \tau_d)(1-\alpha)$ by $.5(\tau_u - \tau_d)(1-\alpha)$. Hence, for the period 1936-1937,

$$\theta^* \approx \left[\frac{(\tau_p - \tau_g) - (1 - \tau_g)(\tau_u - \tau_d)}{\beta\{.5(\tau_u - \tau_d)(1-\alpha) + \alpha\}}\right]^{\frac{1}{\alpha-1}}.$$

and

$$\theta_t = (1 - g_\theta) \cdot \theta_{t-1} + g_\theta \cdot \left[\frac{(\tau_{pt} - \tau_{gt}) - (1 - \tau_{gt})(\tau_{ut} - \tau_{dt})}{\beta\{.5(\tau_{ut} - \tau_{dt})(1-\alpha) + \alpha\}}\right]^{\frac{1}{\alpha-1}} + \epsilon_{\theta,t}.$$

as opposed to (31).

C REFERENCES

Abrutyn, Stephanie and Robert W. Turner, 1990, "Taxes and Firms' Dividend Policies: Survey Results," *National Tax Journal* 53, 491-496.

Auerbach, Alan J., 1979, "Wealth Maximization and the Cost of Capital," *Quarterly Journal of Economics* 93, 433-446.

Auerbach, Alan J., 1983, "Taxation, Corporate Financial Policy and the Cost of Capital," *Journal of Economic Literature* 21, 905-940.

Auerbach, Alan J. and Kevin Hassett, 1992, "Tax policy and business fixed investment in the United States," *Journal of Public Economics* 47, 141-170.

Bailey, Martin J, 1969, "Capital Gains and Income Taxation," in Arnold C. Harberger and Martin J. Bailey, eds, *The Taxation of Income from Capital*, (Brookings Institute, Washington, DC) 11-49.

Bernanke, Ben S., John Y. Campbell and Toni M. Whited, 1990, "U.S. Corporate Leverage: Developments in 1987 and 1988," *Brookings Papers on Economic Activity* 21, 255-278.

Bhandari, Laxmi Chand, 1988, "*Debt/Equity* Ratio and Expected Common Stock Returns: Empirical Evidence," *Journal of Finance* 43, 507-528.

Boadway, Robin and Neil Bruce, 1979, "Depreciation and Interest Deductions and the Effects of the Corporate Income Tax on Investment," *Journal of Public Economics* 13, 93-105.

Bosworth, Barry P., "Taxation and Corporate Investment: A q-Theory Approach — Comments and Discussion," *Brookings Papers on Economic Activity* 12, 128-130.

Bradford, David F., 1981, "The Incidence and Allocation Effects of a Tax on Corporate Distributions," *Journal of Public Economics* 15, 1-22.

Bradley, M., G. Jarrel, and E.H. Kim, 1984, "On the Existence of Optimal Capital Structure: Theory and Evidence," *Journal of Finance* 39, 857-878.

Brimmer, Andrew F., and Allen Sinai, 1976, "The Effects of Tax Policy on Capital Formation, Corporate Liquidity and the Availability of Investible Funds: A Simulation Study," *Journal of Finance* 31, 287-308.

Brittain, J.A., 1964, "The Tax Structure and Corporate Dividend Policy," *American Economic Review* 54, 272-287.

Chirinko, Robert S., 1986, "Business Investment and Tax Policy: A Perspective on Existing Models and Empirical Results," *National Tax Journal* 39, 137-156.

Chirinko, Robert S., 1987, "Tobin's Q and Financial Policy," *Journal of Monetary Economics* 19, 69-87.

Chirinko, Robert S., 1988, "Business Tax Policy, The Lucas Critique, and Lessons from the 1980's," *American Economics Association Papers and Proceedings*, 206-209.

Chirinko, Robert S., and Robert Eisner, 1983, "Tax Policy and Investment in Major U.S. Macroeconomic Econometric Models," *Journal of Public Economics* 20, 139-166.

Dammon, Robert M. and Lemma W. Senbet, 1988, "The Effects of Taxes and Depreciation on Corporate Investment and Financial Leverage," *Journal of Finance* 43, 357-373.

Dhrymes, P. J. and M. Kurz, 1987, "Investment, Dividends and External Finance Behavior of Firms," in R. Ferber, ed., *Determinants of Investment Behavior*, (Universities-National Conference Series, No. 18, New-York: Columbia University Press for NBER).

Dotan, Amihud, and S. Abraham Ravid, 1985, "On the Interaction of Real and Financial Decisions of the Firm Under Uncertainty," *Journal of Finance* 40, 501-527.

Engle, Robert F. and Clive W. J. Granger, 1987, "Co-Integration and Error Correction: Representation, Estimation, and Testing," *Econometrica* 55, 252-276.

Feige, E.L. and D.K. Pearce, 1976, "Economically Rational Expectations: are innovations in the rate of inflation independent of innovations in measures of monetary and fiscal policy?," *Journal of Political Economy* 84, 499-522.

Feldstein, Martin S, 1982, "Inflation, Tax rules and Investment: Some Econometric Evidence," *Econometrica* 50, 825-862.

Feldstein, Martin, Jerry Green and Eytan Sheshinski, 1979, "Corporate Financial Policy and Taxation in a Growing Economy," *Quarterly Journal of Economics* 93, 411-432.

Graddy, Elizabeth A., and Robert P. Strauss, 1984, "Corporate Integration and the Real and Financial Decisions of the Firm," Working Paper, School of Urban and Public Affairs, Carnegie-Mellon University.

Granger, Clive W. J., and Paul Newbold, 1986, *Forecasting Economic Time Series*, 2nd Edition, (Academic Press, New York).

Gravelle, Jane G., 1989, "Differential Taxation of Capital Income: Another Look at the 1986 Tax Reform Act," *National Tax Journal* 42, 441-464.

Hall, Robert E., and Dale W. Jorgenson, 1967, "Tax Policy and Investment Behavior," *American Economic Review* 57, 391-414.

Hall, Robert E., and Dale W. Jorgenson, 1971, "Application of the Theory of Optimal Capital Accumulation," in G. Fromm, ed., *Tax Incentives and Capital Spending*, (Brookings Institute, Washington, DC).

Hyun, Jin K., Mark J. Mazur and Robert P. Strauss, 1991, "The Interaction between Economic Depreciation and Taxes," Working Paper, School of Urban and Public Affairs, Carnegie-Mellon University.

John, Kose and Joseph Williams, 1985, "Dividends, Dilution, and Taxes: A Signalling Equilibrium," *Journal of Finance* 40, 1053-1070.

King, Mervyn A., 1974, "Taxation and the Cost of Capital," *Review of Economic Studies* 41, 21-35.

King, Mervyn A., 1977, *Public Policy and the Corporation*, (Chapman and Hall, London).

MacKie-Mason, Jeffrey K., 1988, "Do Taxes Affect Corporate Financing Decisions?," NBER Working Paper No. 2632.

McCabe, George M., 1978, "The Empirical Relationship between Investment and Financing: A New Look," *Journal of Financial and Quantitative Analysis* 14, 119-135.

Miller, Merton H., 1977, "Debt and Taxes," *Journal of Finance* 32, 261-275.

Modigliani, Franco and Merton H. Miller, 1958, "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review* 48, 261-297.

Modigliani, Franco and Merton H. Miller, 1963, "Taxes and the Cost of Capital – A Correction," *American Economic Review* 53, 433-443.

Nadeau, Serge, 1986, "A Theoretical and Empirical Model of the Real and Financial Decisions of the Firm: Effects of Tax Integration and other Tax Policies," *Ph. D. thesis*, School of Urban and Public Affairs, Carnegie-Mellon University.

Nadeau, Serge, 1988, "A Model to Measure the Effects of Taxes on the Real and Financial Decisions for the Firm," *National Tax Journal* 41, 467-482.

Nadeau, Serge and Robert P. Strauss, 1991a, "Tax Policies and the Real and Financial Decisions of the Firm: The Effects of the Tax Reform Act of 1986," *Public Finance Quarterly* 19, 252-292.

Nadeau, Serge and Robert P. Strauss, 1991b, "Taxation, Financing and Corporate Investment: A Model of the Real and Financial Decisions of the Firm," Working Paper, Department of Economics, University of Victoria.

Nickell, S.J., 1978, *The Investment Decisions of Firms*, (Cambridge University Press).

Peterson, Pamela P., and Gary A. Benesh, 1983, "A Reexamination of the Empirical Relationship between Investment and Financing Decisions," *Journal of Financial and Quantitative Analysis* 18, 439-453.

Poterba, James M. and Lawrence R. Summers, 1983, "Dividend Taxes, Corporate Investment, and "*Q*"," *Journal of Public Economics* 12, 125-167.

Poterba, James M. and Lawrence R. Summers, 1985, "The Economic Effects of Dividend Taxation," in E.I. Altman and M.G. Subramanyan, eds., *Recent Advances in Corporate Finance*, (Richard D. Irwin, Homewood, Illinois), 227-284.

Poterba, James M., 1987a, "Tax Policy and Corporate Saving," *Brookings Papers on Economic Activity* 18, 455-503.

Poterba, James M., 1987b, "Taxation & Financing of Business: Comments," in J.M. Mintz and D.C. Purvis, eds., *The Impact of Taxation on Business Activity*, (John Deutsch Institute for the Study of Economic Policy, Queens University, Kingston, Ontario), 267-274.

Pozdena, Randall Johnston, 1987, "Tax Policy and Corporate Capital Structure," Federal Reserve Bank of San Francisco Economic Review, 37-52.

Rangazas, Peter and Dewan Abdullah, 1987, "Taxes and the Corporate Sector Debt Ratio: Some Time Series Evidence," *Review of Economics and Statistics* 69, 357-362.

Ravid, S. Abraham, 1988, "On Interactions of Production and Financial Decisions," *Financial Management* 17, 87-99.

Shefrin, Hersh M. and Meir Statman, 1984, "Explaining Investor Preference for Cash Dividends," *Journal of Financial Economics* 13, 253-282.

Stiglitz, Joseph E., 1973, "Taxation, Corporate Financial Policy, and the Cost of Capital," *Journal of Public Economics* 2, 1-34.

Stiglitz, Joseph E., 1974, "On the Irrelevance of Corporate Financial Policy," *American Economic Review* 64, 852-866.

Stiglitz, Joseph E., 1976, "The Corporation Tax," *Journal of Public Economics* 5, 303-311.

Summers, Lawrence H., 1981, "Taxation and Corporate Investment: A q-Theory Approach," *Brookings Papers on Economic Activity* 12, 67-127.

Sumner, Michael, 1989, "Investment, Q, and Taxes," *Public Finance / Finances Publiques* 44, 285-294.

Zodrow, George R., 1991, "On the "Traditional" and "New" Views of Dividend Taxation," *National Tax Journal* 44, 497-510.