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DIVIDEND TAXES, CORPORATE INVESTMENT, AND "Q"

James M. Poterba

Lawrence H. Summers

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Cambridge MA 02138

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ABSTRACT

Taxes on corporate distributions have traditionally been regarded as a "double tax" on corporate income. This view implies that while the total effective tax rate on corporate source income affects real economic decisions, the distribution of this tax burden between the shareholders and the corporation is irrelevant. Recent research has suggested an alternative to this traditional view. One explanation of why firms in the U.S. pay dividends in spite of the heavy tax liabilities associated with this form of distribution is that the stock market capitalizes the tax payments associated with corporate distributions. This capitalization leaves investors indifferent at the margin between corporations paying our dividends and retaining earnings. This alternative view holds that while changes in the dividend tax rate will affect shareholder wealth, they will have no impact on corporate investment decisions.

This paper develops econometric tests which distinguish between these two views of dividend taxation. By extending Tobin's "q" theory of investment to incorporate taxes at both the corporate and personal levels, the implications of each view for corporate investment decisions can be derived. The competing views may be tested by comparing the performance of investment equations estimates under each theory's predictions. British time series data are particularly appropriate for testing hypotheses about dividend taxes because of the substantial postwar variation in effective tax rates on corporate distributions. The econometric results suggest that dividend taxes have important effects on investment decisions.

James M. Poterba
Department of Economics
Nuffield College
Oxford OX1 1NF
England

Lawrence H. Summers
National Bureau of Economic Research
1050 Massachusetts Avenue
Cambridge, Massachusetts 02138

(617) 868-3909

The influence of taxation on corporate investment decisions has been the subject of numerous economic investigations. For the most part, these studies have focused only on the effect of taxes levied at the corporate level, examining the impact of changes in the corporate tax rate and depreciation rules. The effects of reform in the taxation of corporate distributions have received far less attention. This omission is significant since in Britain during the last three decades the effective tax rate on corporate distributions has ranged between zero and thirty percent.

Taxes on corporate distributions have traditionally been regarded as a "double tax" on corporate income. This view implies that while the total effective tax rate on corporate source income affects real economic decisions, the distribution of this tax burden between the shareholders and the corporation is irrelevant. Recent research has suggested an alternative to this traditional view. One explanation of why firms in the U.S. pay dividends in spite of the heavy tax liabilities associated with this form of distribution is that the stock market capitalizes the tax payments associated with corporate distributions. This capitalization leaves investors indifferent at the margin between corporations paying out dividends and retaining earnings. This alternative view holds that while changes in the dividend tax rate will affect shareholder wealth, they will have no impact on corporate investment decisions.

This paper develops econometric tests which distinguish between these two views of dividend taxation. By extending Tobin's "q" theory of investment to incorporate taxes at both the corporate and personal levels, the implications of each view for corporate investment decisions are derived. The competing views are tested by comparing the performance of investment equations estimated under each theory's predictions. British time series data are particularly appropriate for testing hypotheses about dividend taxes because of the substantial postwar variation in effective tax rates on corporate distributions. The econometric results suggest that dividend taxes have important effects on investment decisions.

The paper is divided into five sections. The first describes the competing views of dividend taxes in more detail. The implications of each view for stock market valuation and the investment decisions of the firm are explored. The second section presents a version of the "q" investment theory based on the decisions of value-maximizing firms with stochastic adjustment costs. Alternative investment equations based on the two views of dividend taxes are derived. The third section details the construction of the time series data which underlie our tests. It contributes an improved estimate of a tax-adjusted "q" variable for the entire postwar period in Britain. Econometric results, and their implications for the role of dividend taxation in affecting investment decisions, are discussed in the fourth section. A concluding section summarizes the findings and proposes several directions for future research.

I. Dividend Taxes and Corporate Distributions: Two Views

Analysis of the tax incentives for corporate distributions requires a consistent framework for treating changes in both tax rates and tax systems. We follow King (1977) in defining τ as the rate of tax on undistributed corporate profits, m as the marginal personal tax rate on dividend income, and θ as the shareholder's dividend receipts if the firm distributes one pound of retained earnings.[1] Therefore, if the firm distributes one pound the shareholder receives $(1-m)\theta$ pounds in after tax dividends. The effective rate of capital gains taxation is denoted by z. It depends on both the tax rate applicable to realized capital gains and the length of time between accrual and realization of gains.

A corporation affects its shareholders' tax liabilities by choosing whether to retain or to distribute corporate profits. The traditional view implies that investors should not be indifferent to the firm's financial policy. Since a pound retained yields $(1-z)$ to the investor and a pound distributed yields $(1-m)\theta$, only in the exceptional case when $(1-z) = (1-m)\theta$ will investors receive the same after tax return from retentions and distributions.[2] For Britain, $(1-z) > (1-m)\theta$ for the period 1947-58 and 1966-72. Between 1959 and 1965, the two tax burdens were approximately equal. Since 1972, investors should have preferred dividends to capital gains since under the current imputation system $(1-z) < (1-m)\theta$. Despite these tax changes, British firms have continued simultaneously retaining earnings

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[1] King's (1977) definition of $\hat{\theta}$ corresponds to our θ. Under the classical system of company taxation, $\theta = 1$. Under the imputation system currently used in Britain, $\theta = (1 - s)^{-1}$ where s is the imputation rate.

[2] This assumes that a pound of retentions increases the firm's value by a pound. This is consistent with the "traditional" view but counter to the spirit of the "new" view discussed below.

and paying some of their profits as dividends (see Bank of England (1981)). The payout ratio has not moved in the dramatic way which the simple tax rule calculations would suggest.

The firms' apparent failure to optimize their financial policies with respect to tax liabilities raises a difficult problem for investment theory. A profit-maximizing firm should invest until the marginal return from additional investment equals the cost of capital. When the effective cost of funds from different sources is unequal, the cost of capital becomes an elusive concept. A firm's investment policy will depend upon its marginal source of investment funds. The firm cannot be simultaneously indifferent between investing a pound and reducing dividends, and between investing a pound and issuing new equity. This is because the two financial actions have different tax costs associated with them.

Different assumptions about the firm's marginal source of investment finance have different implications for the investment consequences of dividend taxes. The first approach, corresponding to the "traditional view", argues that for some poorly understood reason firms act as if they are required to distribute a substantial fraction of their real profits in dividends. Subject to this constraint, the firm chooses an optimal investment plan and, when necessary, finances investment expenditures by issuing new equity. In an all-equity economy, the firm's cost of capital is

$$(1.1) \qquad c = \frac{\rho + \Psi(\gamma)}{[(1 - m)\theta\gamma + (1 - z)(1 - \gamma)](1 - \tau)} \qquad \Psi' < 0$$

where γ is the dividend-payout ratio, and ρ is the post-tax rate of return demanded by investors.[3] The $\Psi(\gamma)$ function captures the cost to the firm of retaining earnings. It may be thought of as arising from considerations of market signalling, or investor liquidity. Since lower payout ratios induce investors to demand higher returns, Ψ' is negative. The firm chooses its payout ratio to minimize the effective cost of capital. This means that $\left.\frac{dc}{d\gamma}\right|_{\gamma^*} = 0$, where γ^* is the optimal payout ratio. The firm's optimal investment policy should consist of equating the pretax return on capital and the cost of capital. Since c depends on the tax rates, changes in either the personal dividend tax rate (m) or the relative tax prices of dividends and retentions (θ) will affect investment policy.

This "traditional" model has several implications for the effects of a change in the dividend tax rate.[4] First, as dividend taxes increase the dividend payout ratio should decline. The firm is equating the marginal benefit from dividend payments, captured in the Ψ function, with the marginal cost of those payments. Since an increase in the dividend tax rate will raise the marginal cost of these unmeasured benefits, the optimal payout ratio should decline.[5] A second implication of this model is that when the dividend tax rate rises, equilibrium capital intensity will decline. Since in equilibrium $f'(k) = c$ we can solve for the change in the capital stock

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[3] Extension of the cost of capital expression to include the case of partial debt finance is straightforward. If b is the ratio of the market value of outstanding debt to the replacement value of the capital stock, then $c' = b(1-\tau)i + (1-b)c$, where c is taken from (1.1) and i is the nominal interest rate. Debt finance is treated in more detail in Section II.

[4] We consider "dividend tax" to mean the total (personal and corporate) tax liabilities associated with the distribution of one pound of retained earnings. This is $(1-m)\theta$.

[5] Feldstein (1970, 1972) and King (1971, 1972) tested the hypothesis that the payout ratio responded to changes in the effective dividend tax rate and concluded that taxes did seem to affect firms' choice of dividend policy. Their studies, however, did not focus primarily on the personal taxes imposed on dividends.

from

$$f''(k)\,\frac{dk}{d\beta} = \frac{\partial c}{\partial \beta} + \frac{\partial c}{\partial \gamma} \cdot \frac{d\gamma}{d\beta} \tag{1.2}$$

where $\beta = (1-m)\theta$. If the firm has chosen γ^* optimally, then $\left.\frac{\partial c}{\partial \gamma}\right|_{\gamma^*} = 0$ and the envelope theorem allows us to ignore the second term in (1.2). At the initial optimum, changes in the dividend payout ratio do not change the cost of capital. Therefore the effects of taxes on capital intensity which come from changes in the payout ratio may be ignored. This means

$$\frac{dk}{d\beta} = \frac{\partial c/\partial \beta}{f''(k)} = \frac{-\,\gamma(\rho + \Psi(\gamma)}{[\beta\gamma + (1-\gamma)(1-z)]^2(1-\tau)f''(k)} > 0 \tag{1.3}$$

The effective dividend tax rate is $t_D = 1 - \beta$. This means $\frac{dk}{dt_D} < 0$.

The capital stock's response to changes in the dividend tax was calculated assuming that changes in the tax rate did not affect the pretax return required by investors. An alternative extreme assumption is that capital is supplied inelastically. The only effect of a dividend tax increase is a reduction in the equilibrium rate of return, ρ. If capital was supplied with some positive elasticity, then an increase in the dividend tax rate would decrease both capital intensity and the rate of return.

There are two difficulties with this view of dividend taxes. First, the theory provides no explanation for why firms pay dividends. Equivalently stated there is no motivation for the $\Psi(\gamma)$ function. Edwards (1981) and and Stiglitz (1980) have discussed some of the leading explanations, such as market signalling (Ross (1977) and Bhattacharya (1979)) and investor clienteles (Feldstein and Green (1981)), and concluded that in almost every case, there would exist a mechanism with a lower tax cost for transmitting information or income from the firm to the shareholder. The payment of dividends remains a puzzle in the "traditional" view. Second, the theory implies that the marginal source of funds for new investment is either new equity issues or reduced share repurchases. Since the latter are illegal under Section 66 of the 1948 Companies Act, and most firms do not issue new shares, the theory's premise seems unlikely.

The "new" view of dividend taxes, based on the notion of tax capitalization, was developed as a response to the problem of explaining why firms pay dividends.[6] The new view may be understood in terms of the above discussion as a different assumption about the firm's financial margin. The dividend payout ratio is no longer fixed; dividends each period are determined as residual after desired new investment has been financed out of retentions. If q represents the market's valuation of a pound of earnings inside the firm, then the return to distributing earnings as dividends is $(1-m)\theta$ and that from retentions is $q(1-z)$. Firms will continue to invest until investors are indifferent between paying out earnings and retaining them. This means that q must equal

$$(1.4) \qquad q^* = \frac{(1-m)}{(1-z)}\,\theta.$$

Indeed in any model in which it is rational for firms to pay dividends, this condition must hold. It implies that the marginal value to shareholders of retentions equals that of dividends.

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[6] The tax capitalization hypothesis which underlies the new view was suggested implicitly in the work of King (1977), and explicitly by Auerback (1979a, 1979b) and Bradford (1981).

For the United States throughout the postwar era and Britain until 1973, $q^* < 1$. The new view was developed to explain firm behavior when q^* is less than one. Values of $q^* > 1$, as have prevailed in Britain since 1973, raise some theoretical difficulties. Since dividends are tax favored, new share issues are the preferred form of finance. A change in the dividend tax therefore affects on investment in the way we outlined for the traditional $q^* = 1$ view.

The cost of equity capital in the "$q^* \neq 1$" world is independent of either the dividend payout ratio or the personal tax rate on dividends. Regardless of the firm's financial policy, the cost of capital is $c = \rho/(1-z)$. It is easy to verify that if the firm earns this return on its investments, shareholders will receive their desired rate of return. Consider first a firm which distributes all its earnings in the form of dividends. If the firm earns $\rho/(1-z)$, it effectively pays $\theta\rho/(1-z)$ in net dividends, on which the shareholders are liable to taxes of $m\theta\rho/(1-z)$. Therefore the after tax return is $(1-m)\theta\rho/(1-z)$. But since the price of a share is q^*, the rate of return is $(1-m)\rho\theta/(1-z)q^* = \rho$. So by earning $\rho/(1-z)$ the all-dividends firm manages to provide its investors with their required rate of return. Now consider the case of a firm which retains all its earnings. If it earns $\rho/(1-z)$ and retains this amount, then the value of a share rises by $(\rho/(1-z))q^*$. Investors pay capital gains tax on the value of this increase, so they receive ρq^* after tax. The rate of return on this investment is just $\rho q^*/q^* = \rho$, so once again the investors are earning their required rate of return. The dividend payout ratio is irrelevant to the firm's cost of capital, and consequently to its investment plan.

Several other aspects of the $q^* \neq 1$ view deserve comment. First, provided $q^* < 1$, firms never issue new shares. Firms are assumed to have sufficient cash flow to pay for current investment and still pay some dividends. Second, a change in dividend taxes leads to a recapitalization of the value of corporate capital: this will reduce the value of stock market equity, but will not affect the rate of return earned on shares. If the desired wealth to income ratio is fixed, then an increase in the dividend tax will actually increase equilibrium capital intensity by reducing the market value of each physical unit of capital. Finally, permanent changes in the dividend tax rate will have no effect on dividend policy. This is because the firm's capital stock and investment, hence cash flow, are unaffected by the dividend tax. Since dividend payments are the difference between income and investment expenditure, they must also be unaffected by the dividend tax.[7]

There are two principal difficulties with the capitalization model of corporate investment. First, when $q^*<1$, it predicts that firms should always prefer acquiring new capital by taking over another company to purchasing an equivalent amount of new capital. This is because the purchase price of a new capital good is unity, but capital goods held by corporations are valued at only $(1-m)\theta/(1-z)$. Without limitations on takeovers, or other devices for passing money to corporate shareholders without incurring dividend tax liability, no equilibrium with $q < 1$ is sustainable. The second problem with the capitalization theory is that it predicts volatile dividend payments which will fall sharply when new opportunities make investment particularly

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[7] Summers (1981) has observed that permanent changes in dividend tax rates will have no effect, but temporary changes may have real consequences. Timing of dividend payment is also considered by King (1974). Bradford (1981) has generalized the dividend tax neutrality result and shown that in a model with debt and equity finance, the debt-equity ratio is unaffected by changes in the dividend tax rate.

desirable. There seems to be little evidence that firms actually <u>cut</u> dividends, and most research seems to support the notion of a rather stable dividend payout ratio which managers set as a "target".[8]

Before discussing the two theories' implications for investment behavior, an important caveat is in order. There need not be a <u>single</u> marginal source of finance for the entire economy. Different firms may find it optimal to be on different margins[9] and even within a single firm, different forms of finance may be used on different projects. Therefore, in the aggregate investment expenditures are likely to be financed partly from new issues and partly from dividend cuts. Our empirical work attempts to estimate the marginal funding shares which can be attributed to each source.

These two views of dividend taxation have different implications for the structure of investment relations based on Tobin's "q" theory. In a taxless world with homogeneous capital goods, Tobin (1969), following Keynes (1936), explained that firms invest as long as each pound spent in acquiring new capital goods raises the market value of the firm by at least a

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[8] Anderson (1980) has conducted time series tests on the Lintner (1956) "target payout ratio" hypothesis for Britain, and concluded that it explains the observed behavior of firms since 1963. For a general discussion of the difficulty of cutting dividends, see Brealey and Myers (1980, Chapter 16).

[9] Some firms may expect to experience negative profits in future years. If this is true, many of the tax calculations which we perform are irrelevant: without taxable profits, the different rates of tax on different sources of finance (to the firm) do not matter. This is just one explanation of why different firms might be observed to behave differently.

pound. A number of empirical investigators[10] have assumed that a good approximation to the market value of an additional unit of capital is the average market value of the existing capital stock. This amounts to assuming that "average q", the ratio of the market value of the capital stock to its replacement cost, is a good proxy for "marginal q".

Within this framework, it is natural to assume that the rate of investment is an increasing function of "q". Given adjustment costs and lags in decision making within the firm, one should not expect that all investment opportunities which will increase market value by more than their cost will be undertaken immediately. In fact, in the presence of adjustment costs, firms will always choose to spread investment projects over time.[11]

In the traditional view of dividend taxes, the marginal pound which is used to finance new investment comes from new equity issues, so the firm will invest only if the ratio V/pK, where V is stock market value and pK is the replacement value of the firm's existing capital stock, is greater than unity. This means that the investment function takes the form

$$I = g\left(\frac{V}{pK} - 1\right) \qquad \begin{array}{l} g' > 0. \\ g(0) = 0 \end{array} \tag{1.5a}$$

Note that when the capital stock is in equilibrium, no investment is occurring q=1.

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[10] Examples of U.S. investment studies based on the "q" model include von Furstenberg (1977), Ciccolo (1975), Engle and Foley (1975), and Summers (1981). Studies using British data include Jenkinson (1981) and Oulton (1978, 1979).

[11] This assumes, implicitly, that a convex adjustment cost function applies to investment activities. For a discussion of the plausibility of this assumption and some alternatives, see Rothschild (1971).

In the $q^* \neq 1$ model, however, the marginal financial resources are obtained by reducing dividend payments and the firm will therefore invest up to the point at which the market value of an additional unit of capital, $(1-m)\theta/(1-z)$, equals the price of capital goods. This gives rise to an investment equation of the form

$$I = g\left(\frac{V}{pK} - \frac{(1-m)\theta}{(1-z)}\right) \qquad \begin{array}{l} g' < 0. \\ g(0)=0. \end{array} \tag{1.5b}$$

implying that the equilibrium value of q is $\frac{(1-m)\theta}{1-z}$. The distinction between (1.5a) and (1.5b) provides the basis for our tests for the competing dividend tax hypotheses.

The various implications of the two views of taxes on corporate distributions discussed in this section are summarized below in Table 1.

Table 1

Alternative Views of Dividend Taxation

	Cost of Capital	$\frac{dI}{d(1-m)\theta}$	$\frac{d\gamma}{d(1-m)\theta}$	Equilibrium "q"
Traditional View:	$\frac{\rho + \psi(\gamma)}{(1-m)\theta\gamma+(1-z)(1-\gamma)\;\;(1-\;)}$	(-)	(-)	1
Capitalization Hypothesis	$\frac{\rho}{1-z}$	0	0	$\frac{(1-m)\theta}{1-z}$

This heuristic discussion of the Tobin's q investment function ignores numerous important aspects of the economic environment which affect investment decisions. Debt finance, depreciation, investment allowances, and an explicit model of the movement to equilibrium have all been omitted. The next section, provides a more rigorous justification for the q theory formulation and derives a model which can be estimated using time series data.

II. The Investment Function

In this section we develop a theory of the investment behavior of a value-maximizing firm in an environment with stochastic adjustment costs. The model is based on Summers' (1981) extension of Tobin's "q" investment theory to incorporate personal taxes. This formulation is one of several ways in which a q investment equation can be motivated on the basis of optimizing behavior of firms. Derivations based on lags in delivery or recognition imply relations very similar to those estimated here. The validity of tests comparing models of dividend behavior does not depend upon literal acceptance of the assumptions underlying the derivation presented below. The model developed here does constitute a denial of Sargent's (1976) claim that correlations between investment and q have no structural significance. We begin by considering the investment decisions of a firm which behaves according to the capitalization hypothesis and constrast the results with those obtained under the double tax view of dividend taxation.

Under the assumptions of the capitalization hypothesis, firms choose to issue no new equity and are barred from repurchasing existing shares so that prices are proportional to the outstanding value of a firm's equity. We assume that equity holders require a fixed real after tax return ρ to induce them to hold the outstanding equity. The sum of the expected net of tax capital gains and dividend return on equity must equal ρ,[12] so that

$$\rho V(t) = E\{(1 - m)\theta D_g(t) + (1 - z)\dot{V}(t)\} \tag{2.1}$$

where $D_g(t)$ defines gross dividend payments by the firm and $V(t)$ is the market value of the firm's equity. Future dividends are uncertain because of tech-

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[12] The value of ρ is the risk adjusted discount rate which investors apply to their expected equity returns. If expectations are exactly satisfied this is the return they will receive. Note that in a risk free environment ρ would correspond to the after-tax return on alternative assets.

nological shocks to the production and adjustment cost functions. Factor price and tax uncertainty could be treated easily. The expectation in (2.1) is taken over the random variables which generate these uncertainties. To solve the differential equation (2.1) for V(t), a transversality condition must be imposed on the path of V. Excluding the possibility that the value of the firm becomes infinite in finite time by requiring $\lim_{s\to\infty} E_t \{V(s)\, e^{-\rho(1-z)^{-1}(s-t)}\} = 0$ enables us to solve the differential equation (2.1) and find that:

$$V(t) = E \int_t^{\infty} \frac{(1 - m)\theta}{(1 - z)} D_g(s) \exp\left(- \left\{ \int_t^{s} \frac{\rho(r)\, dr}{(1- z)} \right\}\right) ds. \tag{2.2}$$

Note that the expectation in (2.2) is over the entire future path of random variables which affect dividends.

The firm seeks to maximize (2.2) subject to constraints on its initial capital stock and its investment program. We will assume that credit market constraints do not permit the firm to finance more than a fraction b of its investment through debt finance. This can be thought of as a measure of the firm's debt capacity. In the model presented below, the firm will always choose to borrow as much as possible, so b percent of all new investment finance comes from debt issues and (1-b) from retained earnings.

Any theory of investment, as opposed to a theory of the optimal capital stock, must explain why the firm does not instantaneously adjust its capital stock. We assume that there are internal adjustment costs.[13] The cost in terms of managerial time and resources of installing new capital is assumed to rise with the rate of capital accumulation. We assume that the adjustment cost function, $\phi(\frac{I}{K},\varepsilon_1)$ is convex, homogeneous in investment and capital, subject to random shocks ε_1 and that $\phi(0,\varepsilon_1) \equiv 0$. Under these conditions dividends may be derived as after tax profits less investment expenses.

$$D_g = (1 - \tau)\{pF(K,L,\varepsilon_2) - wL - pibK\} - \{1 - u - b + (1-\tau)\phi(\frac{I}{K},\varepsilon_1)\}pI + \tau D \tag{2.3}$$

Where K and L refer to factor inputs, p is the overall price level, $F(K,L,\varepsilon_2)$ is the production function which is subject to random shocks ε_2, w the wage rate, i the nominal interest rate, τ the effective corporate tax rate on undistributed profits, u, rate of first year write-offs on investment, and D, the value of writing down allowances on past investment. Adjustment costs are assumed to be expensed and hence ineligible for investment incentive treatment.[14] We have assumed that firms have positive profits at all times and are able to deduct depreciation allowances from corporate taxes. This may be an unreasonable assumption for the last decade, and we discuss modifications in Section IV.

Equations (2.2) and (2.3) imply that

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[13] The operative distinction here is between internal adjustment costs, which are resource costs to the firm induced by the decision to invest, and external adjustment costs which correspond to an increase in the price of investment goods as all firms attempt to invest more quickly. See Mussa (1977) for some discussion of these issues.

[14] An alternative assumption corresponding to external adjustment costs would increase the price of investment goods to $\{p+ (\frac{I}{K})\}$ and then allow the adjustment costs to be eligible for investment grants and depreciation allowances. This approach, used by Hayashi (1981), generates a slightly different formulation of the equilibrium q relationship and the investment function. When we used this approach and tested the competing theories of dividend taxes, the results were the same as those obtained using the internal adjustment cost formulation.

$$(2.4) \qquad V(t) = E_{\{\varepsilon_1, \varepsilon_2\}} \int_t^{\infty} \{\frac{(1 - m)\theta}{(1 - z)}\}\{(pF(K,L,\varepsilon_2) - wL - pibK\ (1 - \tau) - (1 - u - b + \{1 - \tau\}\phi\{\frac{I}{K},\varepsilon_1\})pI\}e^{\frac{-\rho(s-t)}{1 - z}}ds + B(t)$$

where B(t) is the present value of all remaining depreciation allowances which can be collected on the capital stock in place at time t and u_s is the present value taken to time s of depreciation allowances and investment incentives or L1 of investment at time s. This is discussed in greater detail in Section III. Notice that in (2.4) the firm's value depends on expectations of $\{\varepsilon_1(s), \varepsilon_2(s)\}_{s=t}^{\infty}$, the realization of a bivariate continuous time stochastic process.

The firm seeks to maximize (2.4), its current market value, subject to the capital accumulation constraint

$$(2.5) \qquad \dot{K}(t) = I(t) - \delta K(t)$$

I is gross investment and δ is the true depreciation rate on capital. The firm ignores B(t) in its maximization, since it is independent of any future decisions. The maximization problem can be solved using Pontryagin's maximum principle. The first order condition for investment at time t is:

$$(2.6) \qquad \{1 - u - b + (\phi\{ \frac{I}{K}, \varepsilon_1\}) (1 - \tau\})p = \frac{\lambda(1 - z)}{\theta(1 - m)} - (1 - \tau)(\frac{I}{K}) \quad \phi_1(\frac{I}{K},\varepsilon_1)p$$

Equation (2.6) implicitly determines the firm's investment behavior, since it defines a function linking investment to the real shadow price of capital, $\frac{\lambda}{p}$ and the tax parameters. The condition for zero gross investment is

$$(2.7) \qquad \frac{\lambda}{p} = \frac{(1 - m)\theta}{(1 - z)} (1 - u - b)$$

This result has an easy intuitive interpretation. The shadow price of an additional unit of capital is equated to its marginal cost, in after tax pounds. One implication of (2.7) is that there will be investment even if the shadow price of capital goods is less than unity, because the tax system reduces the effective price of new capital goods.

Equation (2.7) is of no operational significance as a theory of investment unless an observable counterpart to the shadow price λ can be developed. Hayashi (1981) has shown in a less complicated model how the shadow price and the market valuation of existing capital are related. Our result extends his by considering the case of uncertain future dividend streams, and the role of taxes levied at the personal level.

The link between λ and market value can be demonstrated as follows. Note that $V(t) - B(t)$ given in (2.4) is homogeneous in $K(t)$; a doubling of $K(t)$, together with the optimal doubling of investment and labor in every subsequent period, will double $V(t)-B(t)$. This follows from the assumption of constant returns to scale in the production function and homogeneity of the adjustment cost function. It follows that $(V^*(t)-B(t)) = \mu pK(t)$ where $V^*(t)$ is the value of the stock market at time t when the optimal investment plan is followed. The maximized value of the firm at time t, minus the value of depreciation allowances on existing capital, is proportional to the value of the initial capital stock. The maximum principle implies that $dV^*(t)/dK(t) = \lambda(t)$; this is just what is meant by the assertion that $\lambda(t)$ is the shadow price of new investment, or "marginal q." This result, along with the homogeneity condition, implies that

$$\lambda(t) = \frac{V(t) - B(t)}{pK(t)} \tag{2.8}$$

This expression provides an observable counterpart for the shadow price of new investment, under the assumption that the firm maximizes value so that $V(t) = V^*(t)$. Substituting (2.8) into (2.6) yields an implicit relation for investment at time t.

$$(\phi + \frac{I}{K}\phi_1) = Q \tag{2.9}$$

where the tax adjusted value of Tobin's q, Q, is defined by

$$Q = \frac{\{\frac{(1 - m)}{1 - z}\frac{\theta(V - B)}{pK} - 1 + u + b\}}{(1 - \tau)} \tag{2.10}$$

For simplicity, we assume that adjustment costs rise linearly with investment above some varying threshold.

$$A = \begin{cases} \frac{\beta}{2}(\frac{I}{K} - \eta - \varepsilon_1)^2 K & \frac{I}{K} > \eta + \varepsilon_1 \\ 0 & \frac{I}{K} < \eta + \varepsilon_1 \end{cases} \tag{2.11}$$

implying that the ϕ function, which describes adjustment costs per unit of investment, over the relevant range where $\frac{I}{K} \geq \eta + \varepsilon_1$

$$\phi(\frac{I}{K}) = \frac{\beta}{2}(\frac{I}{K} - \eta - \varepsilon_1)^2(\frac{I}{K})^{-1} . \tag{2.12}$$

This ϕ function is homogeneous in I and K as required. We assume that firms always operate in the positive adjustment cost range. These assumptions were chosen to yield the simple relation between investment and Q.

$$\frac{I}{K} = \eta + \frac{1}{\beta}Q + \varepsilon_1 . \tag{2.13}$$

This is the linear investment relationship which we estimate in section IV. Econometric issues, such as the independence of ε_1 and Q, are discussed at that point.

Before discussing the investment function under the alternative "q=1" or "double-tax" hypotheses, several features of the investment function in (2.13) deserve comment. First, the specification incorporates future expectations. Robert Lucas (1976) has argued that econometric investment equations which do not incorporate rational adaptation to policy changes cannot be used to predict the effects of such changes. The approach developed here is not subject to this objection because the parameters which are estimated, β and η, are technological. Since policy actions are assumed to have no effect on the adjustment cost function the investment equation will be unaffected by changes in policy expectations. The q model impounds expectations of future tax policy changes in the V/pK term. While the market's valuation of existing capital will be affected by the investor's expectations about the future, only the current values of the tax parameters and the current value of the stock market enter the estimated investment function. Second, other approaches to estimating the investment impact of personal taxes require us to specify the firm's cost of capital; the "q" formulation does not. Since the investors' discount rate ρ enters the cost of capital and is unobservable, efforts to define the cost of capital are prone to error. The "q" approach avoids this difficulty.

The superiority of the "q" approach can be illustrated by comparing our strategy for estimating the effects of investment incentives with those based on the flexible accelerator approach pioneered by Hall and

Jorgenson (1967). Presumably, one important channel by which tax incentives influence investment is by reducing capital costs leading firms to raise their desired supply of output. In the q model, expectations of higher output and profits are immediately incorporated in the market's valuation of corporate capital. By comparison, this expected output effect is constrained to be zero in the neoclassical investment formulation where investment is modelled holding desired output constant. Moreover, expected future output is modelled as a distributed lag forecast based on past output, so changes in the firm's expectations about future output are not allowed to depend on tax policy.

The model which was developed above assumed that the firm was choosing between paying dividends and investing. This is the margin which underlies the capitalization hypothesis. Now, we consider the model of the firm which supports the double tax view of dividend taxation and investment. The firm is assumed to pay out a fixed fraction, γ, of its real profits in every period. In the notation of (2.4), the firm is distributing

$$D_g = \gamma(1 - \tau)(pF\{K, L, \varepsilon_2\} - wL - pibK - p\delta K). \tag{2.14}$$

The firm chooses an optimal investment plan, hence an optimal capital stock through time, and finances investment with new share issues whenever necessary. If S is the value of new shares issued, then the equality of sources and uses of financial capital implies

$$D_g + \{1 - u_1 - b + (1 - \tau)\phi(\tfrac{I}{K}, \varepsilon_1)\} pI = (1 - \tau)\{pF(K, L, \varepsilon_2) - wL - pibK\} + S + \tau D \tag{2.15}$$

When firms issue new shares S(t), investors are indifferent to marginal changes in their equity portfolio if

$$(2.16) \qquad pV(t) = E\left[(1 - m)\,\theta\, D_g(t) + (1 - c)(\dot{V}(t) - S(t))\right] .$$

Notice that the capital gain component which current shareholders value is not the total increase in the market value of the firm, but only that part which is not attributable to new share issues.

By solving (2.16) for the value of the firm, we find that the "traditional" firm will maximize

$$(2.17) \qquad V(t) = E_{\varepsilon_1,\varepsilon_2} \int_t^{\infty} \frac{(1 - m)\theta}{(1 - z)}\{D_g(s) - S(s)\}e^{-\rho(1 - z)^{-1}(s - t)}ds$$

subject to $\dot{K} = I - \delta K$ and (2.15).

Expression (2.17) just shows that as the firm issues more future equity, the current shareholders' claim on the firm's total dividends is diluted. The traditional firm's first order condition for investment is

$$(2.18) \qquad \frac{\lambda}{p} = (1 - u - b + (1 - \tau)\; E_{\varepsilon_1}(\phi + \phi_1 \frac{I}{K}))$$

This is identical to (2.6) except for the $\frac{(1-m)\theta}{(1-z)}$ term which premultiplied λ in the old expression. This implies that the argument of the investment function is now

$$(2.19) \qquad \hat{Q} = \frac{(\frac{V - B}{pK}) - 1 + u + b}{(1 - \tau)} .$$

The assumptions about the adjustment cost function described above imply that

$$(2.20) \qquad \frac{I}{K} = \eta + \frac{1}{\beta}\hat{Q} + \varepsilon_1 .$$

Our tests of the two hypotheses about the financial margin at which firms operate are based on comparisons between investment equations (2.13) and (2.20).

Because all firms may not be on the same margin, the aggregate investment function might be a weighted average of the "capitalization" and the "double tax" investment functions. In order to allow for this possibility,
we specified an investment equation with a weight of α on (2.20) and $(1-\alpha)$ on (2.13). If $Z = (1-m)\,\theta/(1-z)$, then this weighted average investment equation takes the form

$$(2.21) \qquad \frac{I}{K} = \beta_0 + \beta_1 \frac{\{\alpha + (1-\alpha)Z\}\frac{V-B}{pK} + b + u - 1}{(1-\tau)} + \varepsilon_1 .$$

The traditional view of the dividend tax is supported by estimates of α near unity. If, however, $\hat{\alpha}$ is close to zero, then tax capitalization would appear to be the more appropriate model. We estimate (2.21) and perform this test in the fourth section of the paper.

III. Data

The principal data requirement for the estimation of the model developed in the preceding section is the construction of time series for tax adjusted Q, and the gross investment rate. This section describes the construction of an annual time series for these variables - British Industrial and Commercial companies covering the period 1950 - 1980.

A. Tax Adjusted Q

The values of the replacement cost of the capital stock, pk, the market value of equity v_1 and the debt capital ratio b, are drawn from the Bank of England (1980) for the post-1963 period. Earlier data, on an annual basis, were sometimes available from CSO. In other cases we extrapolated backwards as described in an appendix. Information on the marginal rates of individual income tax or dividends and capital gains (m and z) and the tax disincentive to dividend payment Θ, was obtained from King (1977) and King, Neldrett and Poterba (1981).

The principal complexities came in the calculations of terms reflecting the effects of depreciation allowances and investment inventives on old capital, B, and new capital u. Estimates of u, using procedures similar to ours have been presented by Meliss and Richardson for the post-1963 period. The only previous attempt to calculate B was made by Oulton (1979) who assumed the economy was in steady state through the period. Consistent estimates of B and u can be derived for the entire post-war period from information on tax depreciation rules.

British tax law identifies three distinct types of investment: 1) buildings, 2) plant, machinery and most types of vehicles, and 3) automobiles. The last two are treated in essentially identical fashion except for minor differences in the rates of writing down allowances. For each type of investment, we calculated the present value of depreciation allowances which the firm could expect to accrue over the lifetime of the investment. For each year after the investment and until the capital goods were completely written down for tax purposes, we determined the present value of the remaining future depreciation allowances.[15] By aggregating the value of the remaining allowances over vintages of capital, we computed the total value of the remaining depreciation allowances on the existing capital stock.

The treatment of investment incentives on buildings will be described first. Building investment, denoted $I_b(t)$, is eligible for a tax free investment grant (z_b^g) and taxable initial (z_b^i) allowances and investment allowances (z_b^a) in the year of construction. In subsequent years, buildings are depreciated on a straight line, historic cost schedule at the rate of writing down allowances (z_b^d). The present value of the investment incentives on a one pound investment is

$$(3.1) \qquad u_b = \frac{z_b^g + \tau(z_b^a + z_b^i + z_b^d)}{(1+r)} + \sum_{s=1}^{s=T_b} \frac{\tau z_b^d}{(1+r)^{s+1}}$$

$$= \frac{z_b^g + \tau(z_b^a + z_b^i + z_b^d)}{(1+r)} + \frac{\tau z_b^d}{r \cdot (1+r)^{T_b - 1}} \left[(1+r)^{T_b} - 1\right]$$

where $T_b = (1 - z_b^g - z_b^i)/z_b^d$. This expression follows Oulton (1979) in assuming that firms pay taxes about one year in arrears. The discount rate used is $r = (1-\tau)i$

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[15] We have ignored the rather complex issues associated with the resale of capital goods and the recapture provisions of the depreciation laws.

where i is the nominal interest rate on British government consols. We chose this rate becuase we are discounting a nominal stream of after-tax payments which is essentially risk-free.

The expression for u_b describes the present value of the subsidies which a firm can expect to receive when it considers investing in a new building. A related concept is the present value, at time t, of the remaining depreciation allowances (the "value of the depreciation bond") on investment put in place at time $s<t$. This consists of the present value of the writing down allowances for the $T_b(s)-(t-s)$ years remaining in the taxable life of the building. The value of these remaining allowances, $R_b(s,t)$, is just

$$(3.2) \qquad R_b(s,t) = I_b(s)* \sum_{k=0}^{T_b} \frac{z_b^d(s) \cdot \tau(t)}{(1 + r_t)^{k+1}}$$

$$= \frac{I_b(s) z_b^d(s) \tau(t)}{r_t(1 + r_t)^{T_b(s,t) + 1}} [(1 + r_t)^{T_b(s,t)+1} - 1]$$

where $T_b(s,t) = T_b(s) - (t - s)$. Both u_b and R_b are computed under the assumptions that 1) the firm will always have positive profits, against which to deduct the investment allowances and 2) firms anticipate that the current corporate tax rate will never change.

The tax treatment of plant, machinery, cars and other vehicle differs from that for buildings in that the writing down allowances are granted on a declining balance basis. The value of the plant which may be depreciated is the initial cost of the plant minus the investment grant and the initial allowance. In the above notation with subscript "p" for plant and machinery,

$$(3.3)\qquad u_p = \frac{z_p^g + \tau(z_p^a + z_p^i + z_p^d)}{(1 + r)} + \frac{\tau(1 - z_p^g)(1 - z_p^a - z_p^d)}{(1 + r)} \sum_{k=1}^{\infty} \frac{(1 - z_p^d)^{k-1}}{(1 + r)^k}$$

and

$$(3.4)\qquad R_p(s,t) = I_p(s) * \tau(t) \cdot C_p(s,t) \sum_{k=1}^{\infty} \left[\frac{1-z_p^d(s)}{1+r(t)}\right]^k$$

where $C_p(s,t) = [(1-z_p^g(s))(1-z_p^a(s) \; -z_p^d(s))(1-z_p^d(s))]$

The expressions for cars, u_c and $R_c(s,t)$, are exactly the same with z_c replacing z_p. Following the Bank of England (1980), we truncated the infinite series in (3.3) and (3.4) at a 33 year lifetime for plant and a 10 year lifetime for autos. Since 1972 the tax law has permitted the full expensing of investment in plant and machinery. This corresponds to z_p^a=1.0, and all of the investment incentives are collected in the year when the plant is installed.

The computed values of u_p, u_b, and u_c enabled us to compute the effective investment incentive which applied in each year since 1948. We did this by weighting the three investment credit series by the share of each type of gross investment.[16] The resulting series, u, measures the reduction in the cost of new investment goods which firms received because of investment incentives on a typical pound of investment. The series peaked in 1977, when investment incentives allowed firms to recoup 52.8 percent of investment costs. The full time series is reported in Column I of Table One.

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[16] While the tax treatment of autos differs from that for other types of vehicles, the available data on investment is typically divided into buildings, plant/ machinery, and all vehicles. To obtain the present value of investment credits on vehicles, we again followed the Bank of England (1980) and formed a weighted average of u_c and u_p with weighys .24 and .76, respectively. These weights approximately correspond to the share of autos in vehicle investment. Some sensitivity tests showed that our results are very insensitive to this weighting.

Our computations on $R(s,t)$ for the three types of investment expenditures allow us to determine the remaining value of the depreciation bond for all capital installed after 1947. However, for the early post-war years, it is important to know about investment before 1947. Unfortunately, information on the vintage composition of the capital stock which was standing at the end of World War II is tenuous at best.[17] We approximated the depreciation bond by assuming that the net capital stock in 1948, K^N_{1948}, would depreciate at a constant exponential rate and that companies would be permitted to deduct true economic depreciation on that capital stock forever. The exponential decay rate was calculated to be .04 per year using capital consumption and net capital stock data. Therefore, we computed

$$(3.5) \qquad R_{war}(s) = \tau(1-d)^{s-1948}K^N_{1948} \cdot \sum_{k=1}^{\infty} \frac{d(1-d)^k}{(1+r)^k} = \frac{\tau d(1-d)^{s-1948}K^N_{1948}}{d+r} .$$

To determine the total value of the depreciation bond outstanding in any year, we sum the value of the remaining allowances on all the vintages of each type of capital good which are still eligible for credit. If T^*_b is the date of installation of the oldest buildings which are still eligible for writing down allowances, then $B_b(t) = \sum_{s=T^*_b}^{s=t} R_b(s,t)$. Repeating this exercise for the other categories of investment yields $B_p(t)$ and $B_c(t)$, which may then be added to $B_{war}(t)$ to produce

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[17] Two of the best studies of capital formation before and immediately after the war are Redfern (1955) and Dean (1964). Neither conveys much information on the vintage distribution of the capital stock remaining after the war.

$$(3.6) \qquad B(t) = B_p(t) + B_b(t) + B_c(t) + B_{war}(t).$$

The actual values of this series are displayed in Column Two of Table One, and there is quite a substantial amount of variation in the data. This suggests that a computation based on steady states (i.e., Oulton (1979)) might be substantially misleading. For 1980, a year when the total market valuation of equity and preference shares was 81.94 billion pounds, the value of remaining depreciation claims was 7.04 billion, or 8.6 percent of the market's valuation. Alternatively, this may be thought of as 2.7 percent of the replacement value of the net capital stock.

A practical problem in the construction of Q measures is the treatment of inventories and work in progress. The definition of Q's denominator, the replacement value of the capital stock, is complicated by the presence of inventories and work in progress. Two approaches to the treatment of inventories were pursued. The first is to add together the replacement value of inventories and the physical capital stock and consider this as a measure of the total replacement value of the firm's physical assets. This approach, which we used, requires computing $\frac{V-B}{pK+INV}$. The alternative approach is to treat inventories as liquid assets and to subtract their value from the numerator of Q and compute $\frac{V - B - INV}{pK}$. This method of adjustment was also tried, and it yielded investment equation results very similar to those obtained with the first procedure. We report the series for $\frac{V-B}{pK+INV}$ in Table One, Column 3. This series has ranged from .11 to 1.00 during the last 30 years.

Table One: Tax Adjusted "Q" Variables and Company Investment Data

Year	Present Value of Investment Allowances, New Investment	Present Value of Outstanding Future Investment Allowances	Valuation Ratio	"Capitalization Hypothesis" Q	"Double Tax" Hypothesis Q	Gross Investment Rate
1948	0.455	2.862				6.73
1949	0.458	2.862	0.629	0.744	0.543	6.45
1950	0.479	2.975	0.407	0.243	0.069	6.55
1951	0.455	2.973	0.420	0.420	0.065	5.75
1952	0.415	2.824	0.359	0.099	-0.174	5.04
1953	0.442	2.922	0.295	-0.044	-0.266	5.19
1954	0.411	2.568	0.331	0.002	-0.213	5.53
1955	0.425	2.535	0.506	0.493	0.160	6.11
1956	0.403	2.557	0.465	0.432	0.039	6.48
1957	0.365	2.551	0.368	0.115	-0.203	6.80
1958	0.393	2.824	0.356	-0.110	-0.181	7.23
1959	0.444	3.029	0.370	-0.062	-0.063	7.19
1960	0.483	3.224	0.626	0.574	0.574	7.32
1961	0.492	3.452	0.717	0.854	0.853	7.48
1962	0.521	3.921	0.662	0.809	0.808	7.61
1963	0.585	4.153	0.559	0.780	0.779	8.08
1964	0.579	4.408	0.910	1.616	1.617	9.87
1965	0.453	3.639	0.738	0.802	0.802	9.73
1966	0.408	3.419	0.773	1.292	0.764	8.92
1967	0.434	3.524	0.429	0.599	0.306	8.45
1968	0.441	3.776	0.671	1.256	0.770	8.84
1969	0.423	4.125	1.002	2.143	1.352	9.10
1970	0.431	4.339	0.732	1.384	0.837	9.02
1971	0.368	4.162	0.503	0.613	0.286	8.12
1972	0.463	4.928	0.636	0.765	0.654	7.94
1973	0.496	4.961	0.483	0.481	0.481	8.24
1974	0.475	4.400	0.266	0.082	0.082	8.00
1975	0.510	4.840	0.110	-0.223	-0.223	7.44
1976	0.509	5.069	0.332	0.190	0.190	7.37
1977	0.528	6.116	0.265	0.055	0.055	7.59
1978	0.514	6.126	0.373	0.241	0.241	7.89
1979	0.516	6.645	0.431	0.336	0.336	7.32
1980	0.516	7.041	0.458	0.364	0.364	6.96

Sources: See Data Appendix and description in text.

Our estimates Q and $\hat{Q}$ are shown in Columns Four and Five of Table One. Q is computed under the capitalization hypothesis and $\hat{Q}$ under the double taxation view. The variance of Q under the capitalization hypothesis is 1.35 times that of $\hat{Q}$.

C. The Gross Investment Rate

The dependent variable in our specifications is the ratio of gross investment to the net capital stock. Data on gross investment by ICCs is available for the period since 1963. Before that, we extrapolated using data from the *Annual Abstract of Statistics* on investment by quoted companies and all non-nationalized companies. The net capital stock was computed in a similar fashion, using data from the Bank of England (1980) for the period since 1960 and Blue Book estimates of the net company sector capital stock and net investment for the pre-1960 period. Our series for the investment rate is shown in Column Six of Table One. The gross investment rate averages 7.5 for our sample period and peaks at 9.87 percent in 1964.

IV. Results

This section describes our empirical tests of the double tax and capitalization models. The two theories of dividend taxation give rise to the alternative empirical models of corporate investment behavior presented in (2.13) and (2.20). These equations are reproduced below; (4.1a) corresponds to the capitalization view and (4.1b) is derived under the assumptions of the traditional model.

(4.1a) $$\frac{I}{K} = \beta_0 + \beta_1 Q + \varepsilon_1$$

(4.1b) $$\frac{I}{K} = \beta_0 + \beta_1 \hat{Q} + \varepsilon_1$$

The difference between Q and $\hat{Q}$ is that Q adjusts the market value of the firm's equity to take account of future tax liabilities on the firm's dividends, while $\hat{Q}$ ignores this adjustment.

Before turning to the empirical results, it is necessary to discuss several issues connected with the estimation. The exogeneity of Q in (4.1a) is a delicate issue. There is no reason to believe that Q and ε_1 are uncorrelated. Shocks to the adjustment cost function may affect market valuation V, and therefore Q. This endogeneity is not likely to be severe since the vast majority of the variance in Q arises from other sources. The left out variable error formula implies that the bias in the OLS estimate of β is given by:

$$\hat{\beta} = \beta - \frac{\text{cov } \varepsilon \cdot Q}{\text{var } Q}$$

This implies that the bias is bounded by the variance of $\frac{\sigma_\varepsilon}{\sigma_Q}$, which as indicated below is negligible relative to the estimates of β. As a further precaution and in order to treat errors in measurement V and K, many of the equations were estimated using instrumental variables. The instruments were lagged values of the tax rates which went into the construction of Q. There is no reason to expect these variables to be correlated with technological shocks to the adjustment cost function.

Preliminary experimentation revealed that lagged values of Q and $\hat{Q}$ entered (4) with a very significant coefficient. While the theory developed in the preceding section implies that lagged Q should have no impact on investment given contemporaneous Q, lagged Q is included in all the estimated equations. Its presence is justified by delivery and decision lags and by the possibility of difficulties in data alignment. Inclusion of additional lagged values of Q or lagged values of the dependent variable did not improve the predictive power of the equations after making autocorrelation corrections.

The residuals in (4.1) displayed substantial autocorrelation. The equations were therefore re-estimated using a maximum likelihood procedure to correct the second order serial correlation in the residuals. Examination of the correllogram of the estimated residuals suggested that this was sufficient to achieve efficiency. The instrumental variable estimates were corrected for autocorrelation by applying the non-linear two stage least squares procedure of Amemiya (1974) to the quasi-differenced form of (4).

We present results for three sample periods in Table 2: (1) 1950-80, which is the full period for which our data were available; (2) 1963-80, the period for which Bank of England data were available and during which it was not necessary to make extrapolations and interpolations; and (3) 1950-72. There are two reasons for terminating the sample in 1972; both relate to the tax reform which took effect in 1973. First, 1972 is the last year when $q^*<1$ and the pure capitalization hypothesis should apply. Since 1973, $q^* > 1$ and we have assumed that firms treat this as $q^*=1$. The second reason for excluding the last eight years is that since 1973, many firms have paid no corporate profits taxes. Therefore, it becomes necessary to re-examine some of the calculations in Section II: in particular, firms will face values of $\tau=0$ which implies $u=0$ and $B=0$. If the firm pays no taxes, depreciation allowances which can be written off against taxes are of little value.[18]

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[18] We have estimated equations for the whole sample in which we constrain $\tau=u=B=0$ for the whole post-1972 period. This turns out to reduce the explanatory power of the equations and does not alter any of the basic results which are reported here.

Table Two: Investment Equations under the Competing Hypotheses

Eq.	Interval &	Estimation Method	Tax Hypothesis	β_0	$\beta_1(x10^{-2})$	$\beta_2(x10^{-2})$	ρ_1	ρ_2	S.S.R. $(x10^{-4})$	D.W.	R^2
1a	1950-80	OLS	TCH	6.56 (.23)	1.08 (.38)	.69 (.38)	-	-	2126	.37	.50
1b			DTH	6.68 (.17)	1.33 (.38)	1.00 (.37)	-	-	1434	.46	.66
2a	1950-80	AR2	TCH	6.92 (.41)	.64 (.18)	.39 (.18)	1.25 (.18)	-.45 (.18)	474	1.69	.88
2b			DTH	6.94 (.31)	.94 (.19	.54 (.19)	1.28 (.17)	-.50 (.17)	359	1.70	.91
3a	1950-80	IV	TCH	6.56 (.24)	1.19 (.42)	.72 (.41)	-	-	2274	.41	-
3b			DTH	6.70 (.17)	1.30 (.41)	1.13 (.40)	-	-	1258	.53	-
4a	1950-80	AR2-IV	TCH	6.58 (.42)	.97 (.25)	.98 (.29)	1.15 (.20)	-.43 (.20)	575	2.00	-
4b			DTH	6.80 (.30)	1.16 (.24)	1.04 (.27)	1.06 (.20)	-.37 (.20)	398	1.83	-
5a	1950-72	AR2	TCH	6.86 (.52)	.66 (.21)	.37 (.21)	1.27 (.20)	-.46 (.20)	386	1.68	.89
5b			DTH	6;86 (.36)	1.02 (.20)	.53 (.21)	1.33 (.20)	-.55 (.19)	259	1.65	.93
6a	1963-80	AR2	TCH	7.38 (.22)	.71 (.17)	.47 (.17)	.78 (.26)	-.59 (.25)	228	1.98	.74
6b			DTH	7.28 (.20)	1.10 (.22)	.69 (.20)	.63 (.33)	-.51 (.31)	190	1.83	.79

TCH = Tax Capitalization Hypothesis
DTH = Double Tax Hypothesis

The results demonstrate the superiority of the Q specification based on the "traditional view" of dividend taxation. It outperforms the equations based on the capitalization hypothesis for all sample periods. The standard error of estimate in the OLS equation is only 75 percent of that for the alternative hypothesis. The "traditional view" specifications also provide much better fits in the generalized least squares regressions, and the instrumental variable estimations.

A more formal comparison of the two hypotheses is possible. We begin by reporting the likelihood ratios for the pairs of equations in Table 2. These ratios represent the posterior odds ratio implied by Bayes' theorem starting with a diffuse prior or the two hypotheses. That is, if one started out assigning equal prior likelihoods to the estimated equations for two hypotheses, and then used these equations together with standard rules of inference, they represent the posterior odds ratio we would assign to the two hypotheses.[19] In all cases, the likelihood of the "double tax" hypothesis far exceeds that of the capitalization hypothesis. The worst case for the traditional view suggests that it is almost six times more likely than the new view.

Regression Pair	Posterior Odds Ratio
50-80 sample, OLS	64.60 to 1
50-80 sample, AR2	367.49 to 1
63-80 sample, AR2	5.63 to 1
50-72 sample, AR2	80.57 to 1

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[19] The posterior odds ratio is defined as

$$\lambda = \frac{\max\limits_{\theta} L(\theta|H_1)}{\max\limits_{\theta} L(\theta|H_2)} .$$

For the special case when ε_1 is assumed normally distributed and the

An alternative and perhaps more informative way of comparing the two hypotheses is through a specification test. Pesaran (1974) has shown that the Cox specification test takes a particularly simple form in the case of two non-vested linear models. The test requires that one of the hypotheses be chosen as the null. The Cox test statistic, μ, is then asymptotically distributed as N90.1) under the null. It is essentially a measure of the superiority of the relative performance of the null. The criterion for rejecting the null yields a one-sided test. If μ is a large negative number, the null is rejected in favor of the alternative hypothesis.

Cox Statistics

Null Hypothesis	Alternative Hypothesis	Error Specification[20]	μ
Capitalization (Q)	Double Tax ($\hat{Q}$)	IID	-16.07
Double Tax ($\hat{Q}$)	Capitalization (Q)	IID	3.80
Capitalization (Q)	Double Tax ($\hat{Q}$)	AR(2)	-16.70
Double Tax ($\hat{Q}$)	Capitalization (Q)	AR(2)	11.68

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model is linear, this statistic reduces to

$$\lambda = \frac{\hat{\hat{\sigma}}^2}{\hat{\sigma}^2}^{T/2}$$

where $\hat{\sigma}^2 = \Sigma(y-x\hat{\beta})^2$ under H_1 and $\hat{\hat{\sigma}}^2 = \Sigma(y-x\hat{\hat{\beta}})^2$ under H_2. The notion of using posterior odds ratios to compare alternative model specifications has a long history in statistics and econometrics. Zellner (1979) discusses the merits of this approach.

[20] The test in the AR2 case was performed by quasidifferencing the data using the average of the ρ_1 and ρ_2 values implied by equations 2a and 2b and then using OLS. This is only legitimate because of the near equality of the values of ρ_1 and ρ_2 in the two equations.

While the results show that the double tax view is never rejected in favor of capitalization, the capitalization model is rejected with a high degree of confidence in favor of double tax.[21]

While our research focuses on the use of investment equations to test hypotheses about the financial behavior, the equations reported in Table 2 may be analyzed as investment equations in their own right. They support earlier findings by Jenkinson (1981) and Oulton (1979) that the q theory model can be quite powerful in explaining the observed investment behavior of British industry. Our results suggest that an increase of 10 percent in the stock market would raise the investment rate G, about 15 percent. The coefficients on Q in the reported investment equations are larger than those in earlier studies despite the division of our Q measure by $(1-\tau)$. This is probably due to our use of annual as opposed to quarterly data series, the extension of the sample period and the improved estimates of tax effects.[22] Our equations also fit somewhat better than earlier efforts.

The equations also provide information about the dynamics of investment behavior. The year-lagged value of Q always enters significantly and with a coefficient that is about two thirds of the value of the current Q. Our results indicate that about 60% of the total investment response to Q occurs within a year of the change in the valuation ratio.

Part of the explanation for our larger coefficient is that annual data on Q is less contaminated by short-term fluctuations in market value than quarterly Q, so our equations are more successful at capturing the underlying

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[21] We also tested the competing hypotheses by including both Q and $\hat{Q}$ in the equation. In this case, $\hat{Q}$ and $\hat{Q}_{-1}$ always entered with significant positive coefficients and Q, Q_{-1} had <u>negative</u> coefficients which were sometimes significant. This simple test also suggests that $\hat{Q}$ is more appropriate than Q.

[22] Both Jenkinson (1981) and Oulton (1979) employ quarterly data compiled by the Bank of England for the period 1963-80 in their studies of investment.

long-term relationship between Q and investment. Most of the noise and measurement should be concentrated at relatively high frequencies while day to day changes in the market's value and in equity prices may be the result of new information or speculation; the longer term movements in the market probably reflect something about investors' underlying view of the returns to capital investment. This argument also explains why the correction for autocorrelation reduces the coefficients of Q. Quasi differencing the data increases the weight placed on high frequencies.

Engle and Foley (1975) have invoked this argument and then estimated an investment function for the United States using the band spectral regression technique.[23] This approach involves decomposition of the observed data series into frequency components and then filtering of data to eliminate high frequency variations. In applying this approach to British investment data, we alternately chose to eliminate those components of the variance in Q which occurred at periodicities below three and five years. The results, reported below, show that in fact the low frequency relationship between the investment rate and the valuation ratio is stronger than the relationship which is observed using the raw data on Q and investment. The effect of an increase in Q which is caused by a permanent change in the corporate environment, for example a new tax policy, is larger than one caused by a momentary increase in stock market values. The superiority of the $\hat{Q}$ to Q equations also remains evident at low frequencies.

All of the tests of the two dividend tax hypotheses which we have reported so far involve comparison of two alternative hypotheses. In Section II, however, we argued that there was no single margin for the whole economy

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[23] Band spectrum regression is described in greater detail in Engle (1974).

Table 3

Band Spectrum Regression Results

Window	β_0	β_1	R^2	SSR
1 year, TCH	6.70 (.23)	1.54 (.30)	.47	23.845
1 year, DTH	6.80 (.18)	2.01 (.30)	.79	18.03
3 years, TCH	6.64 (.29)	1.64 (.40)	.50	22.451
3 years, DTH.	6.76 (.22)	2.11 (.39)	.62	16.89
5 years, TCH	6.56 (.39)	1.78 (.54)	.53	20.09
5 years, DTH	6.68 (.29)	2.31 (.52)	.67	14.15

Note: Calculations were performed using the Troll Program.

and that in practice the aggregate investment equation would reflect a weighted average of the two finance sources. Defining $Z = (1-m)\theta/(1-z)$, we claimed that the aggregate investment function could be written

$$\frac{I}{K} = \beta_0 + \beta_1[(\alpha + (1 - \alpha)Z)\frac{V-B}{pK} + u + b - 1] + \varepsilon_1 \tag{4.4}$$

where α represents the fraction of investment financed at the margin by new equity issues, and $(1-\alpha)$ the share financed out of retentions. The double taxation hypothesis implies $\alpha = 1.0$ while the capitalization view predicts $\alpha = 0$.

The results of estimating equation (4.4) using non-linear least squares are reported in Table 4. They tell a consistent story. The estimates of α range from .76 to 2.16. In all but one case the hypothesis that $\alpha = 0$ can be rejected at the 5 percent level. The hypothesis is that $\alpha = 1$ cannot be rejected except for the 1963-80 period when $\hat{\alpha} = 2.16$. These results suggest that the capitalization hypothesis does not describe the behavior of the firms who undertake any empirically significant fraction of investment.

The results in this section universally support the traditional view of dividend taxation. The tax factor in Q implied by the capitalization view clearly detracts from the explanatory power of the investment equations. These results contrast with Summers (1981) who found that tax adjustments added to the explanatory power of Q investment equations for the U.S. The difference may arise because the earlier study tested the contribution of all the tax effects jointly rather than just the effect of the adjustment for distributions. Alternatively, it may reflect differences between countries in corporate behavior.

Table Four: Nonlinear Investment Equation Estimates

Equation	Interval	Estimation Method	α	$\beta_0(\times 10^{-2})$	$\beta_1(\times 10^{-2})$	$\beta_2(\times 10^{-2})$	ρ_1	ρ_2	$SSR(\times 10^{-3})$	D.W.
1.	1953-80	NLLS	1.19 (.29)	6.83 (.20)	1.20 (.89)	1.09 (.39)	-	-	.1221	.49
2.	1953-80	NLLS,AR2	1.83 (.47)	7.28 (.32)	1.04 (.19)	.48 (.19)	1.36 (.17)	-.57 (.17)	.267	1.81
3.	1953-80	NL2SLS	1.10 (.27)	6.74 (.21)	1.28 (.42)	1.16 (.42)	-	-	.1240	.54
4.	1953-80	NL2SLS,AR2	.76 (.49)	6.71 (.37)	1.14 (.25)	1.07 (.29)	1.06 (.21)	-.37 (.20)	.440	1.88
5.	1953-72	NLLS,AR2	2.16 (.30)	7.25 (.33)	1.19 (.16)	.39 (.18)	1.61 (.17)	-.83 (.17)	.135	1.60
6.	1963-80	NLLS,AR2	1.01 (.51)	7.30 (.21)	1.05 (.28)	.68 (.23)	.79 (.26)	-.46 (.29)	.142	1.92

Source: For data descriptions and specifications, see text.

Conclusions

The results in this paper provide strong support for the traditional view that dividend taxes discourage corporate investment. The data decisively refute the hypothesis that by raising the cost of paying out funds to shareholders, dividend taxes encourage investment through retentions. Rather, it appears that in making investment decisions, corporations act as if marginal investment is financed through new share issues. This suggests that the capitalization hypothesis cannot account for dividend behavior in the UK.

These findings have important implications for both tax analysis and policy. They imply that even though only a negligible fraction of investment is financed through new share issues, dividend taxes nonetheless have potent effects on the cost of capital and investment. This implies that formulations which employ weighted average costs of capital and assign a large weight to retentions will badly understate the disincentive to investment caused by the tax system. More generally, these results strongly confirm the importance of considering taxes levied at both the corporate and personal levels in assessing the tax system's impact on capital formation. This suggests the importance of including variables reflecting personal taxes in standard investment specifications.

This research could usefully be extended in several directions. If the investment equations reported here were coupled with a model of stock market valuating it would be possible to obtain estimates of the effect of tax reforms on investment. A rational expectations approach to modelling market valuation is developed in Summers (1981), which shows how it can be used to estimate the effect of policy announcements and temporary policy changes as well as the types of reform usually considered. It might also be valuable to examine empirically the effects of various tax reforms on q. This would require modelling investors anticipations about future tax rules. The sources and uses of funds identity connects decisions regarding investment, leverage, and payout policy. It would be valuable to examine the effects of changes in q, and in tax policy on these variables in a model in which they were jointly determined.

Most importantly, the negative findings in this paper regarding the "capitalization" hypothesis underscore the importance of developing a satisfactory theory of dividend behavior. The "traditional" view supported here offers no convincing explanation for the payment of dividends. Until such an explanation is found, it will be difficult to model persuasively the effects of changes in tax policy regarding corporate distributions.

TABLE A-1: Data Used in Constructing "Q"

	THETAP	THETAHAT	CGTAX	TAXFACT	MVEQ*SHRDOM	MVPREF	NETCAP	BVSM
1948	0.450	1.581	0.000	1.150	6,402.078	3,208	7,734	2,991
1949	0.450	1.570	0.000	1.158	5,332.984	2,082	8,131	3,052
1950	0.463	1.550	0.000	1.201	5,726.118	2,193	8,696	3,082
1951	0.475	1.361	0.000	1.400	5,875.599	1,949	9,919	3,610
1952	0.463	1.356	0.000	1.373	5,433.972	1,826	11,351	3,687
1953	0.450	1.333	0.000	1.364	6,159.736	1,908	11,798	3,769
1954	0.438	1.311	0.000	1.357	8,596.500	2,083	12,009	4,010
1955	0.425	1.277	0.000	1.362	8,713.199	1,996	13,100	4,469
1956	0.425	1.190	0.000	1.461	7,818.160	1,770	14,200	4,892
1957	0.425	1.183	0.000	1.470	8,326.986	1,659	15,700	5,155
1958	0.406	1.521	0.000	1.107	9,123.146	1,648	16,400	5,069
1959	0.388	1.633	0.000	1.001	15,020.248	1,711	16,700	5,204
1960	0.388	1.633	0.000	1.001	18,695.935	1,703	18,000	5,957
1961	0.388	1.633	0.000	1.001	18,796.875	1,657	19,500	6,173
1962	0.388	1.633	0.000	1.001	17,378.815	1,709	20,900	6,245
1963	0.388	1.633	0.000	1.001	27,942.780	1,801	21,596	6,521
1964	0.400	1.667	0.000	1.000	24,891.100	1,904	23,180	7,161
1965	0.412	1.527	0.184	0.909	27,423.260	1,844	25,152	8,000
1966	0.412	1.000	0.171	1.410	17,088.870	1,711	27,167	8,706
1967	0.412	1.000	0.174	1.405	26,694.100	1,593	27,942	8,986
1968	0.412	1.000	0.167	1.417	41,662.320	1,266	29,595	9,469
1969	0.412	1.000	0.154	1.439	34,819.250	1,076	32,839	10,539
1970	0.400	1.000	0.151	1.415	28,203.790	738	37,255	11,701
1971	0.388	1.000	0.149	1.391	38,346.830	965	42,631	12,607
1972	0.386	1.257	0.147	1.105	34,292.400	840	48,992	13,598
1973	0.413	1.460	0.145	0.998	24,455.000	556	59,536	15,900
1974	0.432	1.515	0.143	0.996	14,497.000	517	75,560	21,297
1975	0.437	1.538	0.141	0.992	43,606.080	451	92,892	25,123
1976	0.428	1.527	0.139	0.986	41,163.020	547	110,110	28,259
1977	0.417	1.504	0.137	0.984	65,814.650	767	127,865	34,167
1978	0.392	1.460	0.136	0.973	86,484.580	736	149,392	38,698
1979	0.364	1.429	0.135	0.952	108,343.320	781	177,665	46,245
1980	0.360	1.429	0.134	0.947	81,125.800	815	208,321	53,665

<u>Data Definitions and Legend:</u>

THETAP = m, the marginal personal tax rate on dividends

THETAHAT = θ, the effective amount of dividends received by shareholders when the firm distributes one pound

CGTAX = z, the effective tax rate on capital gains

TAXFACT = $\frac{(1-z)}{(1-m)\theta}$, the inverse of the equilibrium value of q*.

MVEQ*SHRDOM = market value of ordinary shares which correspond to domestic earnings

MVPREF = market value of preference shares

NETCAP = pK, the net value of the capital stock at replacement cost

BVSM = book value of stocks and work in progress

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