

DIVIDEND TAXES, CORPORATE INVESTMENT, AND 'Q'

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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 United States 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 a corporation's decision to pay out dividends or to retain 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 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 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 changes 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.

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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. On this view, the neglect of personal taxes in studies of investment is potentially very misleading. Recent research has suggested an alternative to this traditional view. One explanation of why firms in the United States 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 the first econometric tests distinguishing between these two views of dividend taxation. Each view's implications for corporate investment decisions are derived by extending Tobin's '*q*' theory of investment to include corporate taxes, personal taxes, and financing constraints. 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. Section 1 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. Section 2 presents a discrete time version of the '*q*' investment theory based on the decisions of value-maximizing firms facing stochastic adjustment costs. We show that the competing views of dividend taxes result from different assumptions about the firm's financial margin, and derive alternative investment equations based on each. Section 3 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 section 4. A concluding section summarizes the findings and proposes several directions for future research.

1. 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 earnings¹ 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 distributions² 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, many investors should have preferred dividends to capital gains since under the current imputation system $(1-z)<(1-m)\theta$ ³ Despite these tax changes, British firms have continued simultaneously retaining earnings 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

¹King'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

²This 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

³Basic rate taxpayers, for whom $(1-m)\theta=1$, will prefer dividends to capital gains Investors facing higher marginal tax rates may still prefer capital gains to dividends For institutions and some corporations, these two types of income may be taxed equally The average marginal tax rates calculated by King (1977), which we use below, suggest that on balance there has been a continued preference for capital gains in the post-1973 period

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

$$c = \frac{\rho + \Psi(\lambda)}{[(1-m)\theta\lambda + (1-z)(1-\lambda)](1-\tau)}, \quad \Psi' < 0, \quad (11)$$

where λ is the dividend-payout ratio, and ρ is the post-tax rate of return demanded by investors⁴ The $\Psi(\lambda)$ 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 $dc/d\lambda|_{\lambda^*} = 0$, where λ^* 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 tax rates, changes in either the personal dividend tax rate (m) or the relative tax price 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 rate⁵ First, as dividend taxes increase, the 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 decline⁶ 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 with respect to a change in dividend taxes as

$$\frac{dk}{d\beta} = \left(\frac{\partial c}{\partial \beta} + \frac{\partial c}{\partial \lambda} \frac{\partial \lambda}{\partial \beta} \right) / f''(k),$$

⁴Extension 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 $c' = b(1-\tau)\iota + (1-b)c$, where c is taken from (11) and ι is the nominal interest rate Debt finance is treated in more detail in section 2

⁵We consider 'dividend tax' to mean the total (personal and corporate) tax liabilities associated with the distribution of one pound of retained earnings This is $1 - (1-m)\theta$

⁶Feldstein (1970, 1972), King (1971, 1972), and Poterba (1983) test the hypothesis that the payout ratio responds to changes in the effective dividend tax rate and show that taxes seem to affect firms' choice of dividend policy

where $\beta = (1 - m)\theta$, the shareholders' after-tax income when the firm distributes one pound of retentions. If the firm has chosen λ^* optimally, then $\partial c / \partial \lambda|_{\lambda^*} = 0$ and the envelope theorem allows us to ignore the second term. This means

$$\frac{dk}{d\beta} = \frac{\partial c / \partial \beta}{f''(k)} = \frac{-\lambda(\rho + \Psi(\lambda))}{[\beta\lambda + (1 - \lambda)(1 - z)]^2(1 - \tau)f''(k)} > 0 \tag{12}$$

Since the effective dividend tax rate is $t_D = 1 - \beta$, $dk/dt_D < 0$

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.

The difficulty with this view of dividend taxes is that it provides no explanation for why firms pay dividends. Equivalently stated, there is no motivation for the $\Psi(\lambda)$ function. Stiglitz (1980) has discussed some of the leading explanations, such as market signalling [Ross (1977) and Bhattacharya (1979)] and investor clienteles [Feldstein and Green (1983)], 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. As we show below, the theory assumes that the marginal source of funds for new investment is either new equity issues or reduced share repurchases.

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.⁷ The new view may be understood as a different assumption about the firm's financial margin. Required dividend payments are 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 earnings paid out or retained, or when q equals

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

⁷The tax capitalization hypothesis which underlies the new view was suggested implicitly in the work of King (1977), and explicitly by Auerbach (1979a, 1979b) and Bradford (1981).

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

For the United States throughout the postwar era and Britain until 1973, $q^* < 1$. The new view was developed to explain firm behavior in this case. Values of $q^* > 1$, as have prevailed for some investors 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 investment as in 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 of its earnings in the form of dividends. If the firm earns $\rho/(1-z)$, shareholders receive $\theta\rho/(1-z)$ in net dividends and their after-tax return is $(1-m)\theta\rho/(1-z)$. But since the price of a share is q^* , the rate of return is $(1-m)\theta\rho/(1-z)q^* = \rho$. 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, receiving ρq^* after tax. The rate of return on this investment is just $\rho q^*/q^* = \rho$. The dividend payout ratio is therefore irrelevant to the firm's cost of capital, and consequently to its investment plan.

Several other aspects of the capitalization view deserve comment. First, provided $q^* < 1$, firms would never issue new shares while paying positive dividends. This prediction seems contradicted by the behavior of most firms in the United States and the United Kingdom. Second, changes in dividend taxes lead to a recapitalization of the value of corporate capital: this will alter the value of stock market equity, but will not affect the rate of return earned on a share. If the desired wealth-to-income ratio is fixed, then an increase in the dividend tax, which reduces each capital good's market value, will actually *increase* equilibrium capital intensity. Finally, permanent changes in the dividend tax rate will have no effect on dividend policy. Dividend payments are the difference between income and investment expenditure, both of which are independent of the tax rate. Dividends must therefore be unaffected by the dividend tax.⁸

There are two principal difficulties with the capitalization model of corporate investment. First, when $q^* < 1$, it predicts that firms should always prefer to acquire new capital by taking over other companies than by buying to order. This is because the purchase price of a new capital good

⁸Summers (1981) has observed that permanent changes in dividend tax rates will have no effect, but temporary changes may have real consequences.

is unity, but capital goods held by other corporations are valued at only $(1-m)\theta/(1-z)$. The second problem with the capitalization theory is that it predicts volatile dividend payments which will fall sharply when new opportunities make investment particularly desirable. There seems to be little evidence that firms actually *cut* dividends [Brealey and Myers (1981)] and most research seems to support the notion of a rather stable dividend payout ratio which managers set as a 'target'.

Before discussing the two theories' implications for investment behavior, an important caveat is in order. There need not be a *single* marginal source of finance for the entire economy. Different firms may face different financial margins. 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. The share of each type of financing cannot be discovered simply by looking at the 'sources of funds' table in the National Income Accounts. This is because many of a firm's internal financial choices which involve actions which are equivalent to share repurchase, for example takeovers, adding equity to pension fund reserves, or buying shares in other firms, are not recorded as 'new issues' by the Central Statistical Office.

2. The investment function

Some simplifications are necessary in modelling the corporation.^{8a} We assume that corporations maintain a constant debt-to-capital ratio.⁹ There is only one type of uncertainty: firms cannot ascertain *ex ante* the costs in terms of managerial time and lost production which will accompany the installation of new capital goods. Econometric specifications are simplified by working in discrete time.

We begin by considering the problem of one firm. For easy reference, notation is specified below:

V_t = value of the firm's equity,

G_t = gross dividend payments,

I_t = gross investment expenditures,

p_t = relative price of new investment goods (output is the numeraire),

V_t^* = value of new share issues,

^{8a}Our approach to modelling the two views of investment is based on recent work by Edwards and Keen (1982).

⁹Factors affecting a corporation's choice of a debt-equity ratio are a subject of some dispute. The Miller (1977) model suggests that for each firm, the choice of leverage is a matter of indifference. The 'bankruptcy versus taxes' theory, expounded by Gordon and Malkiel (1981) and others, argues that each firm chooses an optimal leverage position by balancing the marginal increase in expected bankruptcy costs against the tax savings from an additional dollar of debt. We assume that marginal investments are financed with (D/pK) 100 percent borrowing where D = market value of outstanding debt, and that the debt interest rate is insensitive to changes in the firm's borrowing demands.

w_t = wage rate,
 N_t = labor input,
 r_t = risk-adjusted nominal discount rate,
 τ = marginal corporation tax rate,
 i_t = nominal interest rate on corporate debt,
 A_t = value of writing down allowances on past investment,
 u_t = rate of first year investment write-offs

All tax rates are assumed to be constant through time. The debt–capital ratio is b .

Analysis of a corporation's demand for investment goods must begin with the asset market arbitrage conditions governing shareholders' portfolio decisions. If investors maximize the expected after-tax real return on their portfolios, they will hold shares if and only if the expected return on equity, composed of the dividend yield and capital appreciation, equals the return on comparably-risky assets.

$$r_t V_t = (1 - m)\theta G_t + (1 - z)(E_t[V_{t+1}] - (V_t + V_t^n)) \quad (2.1)$$

This arbitrage equation can be rewritten as a difference equation for V_t . Defining $\gamma = (1 - m)\theta/(1 - z)$, the 'effective tax price' of dividends, and

$$R_t = \left(1 + \frac{r_t}{1 - z}\right)^{-1},$$

the equilibrium condition in (2.1) becomes

$$V_t = R_t(\gamma G_t - V_t^n) + R_t E_t[V_{t+1}], \quad (2.2)$$

where $E_t[\]$ denotes the expectation at time t .

Solving this difference equation forward subject to a transversality condition which prevents the firm's value from becoming infinite in finite time yields an expression for the firm's time zero market value

$$V_0 = \sum_{t=0}^{\infty} \left[\prod_{j=0}^t \left(1 + \frac{r_j}{1 - z}\right)^{-1} \right] E_0(\gamma G_t - V_t^n) \quad (2.3)$$

The value of the firm's equity equals the present discounted value of expected dividends, minus the present discounted value of the amount which shareholders on record at time zero would have to spend to offset the diluting effects of future equity issues.

Firms attempt to maximize their market value¹⁰ There are four constraints on the firm's action, and these are essential to the development of a theory of investment The firm cannot pay negative dividends, and it cannot repurchase shares. The first constraint is definitional, and the second stems from provisions in the 1948 Companies Act¹¹

$$G_t \geq 0, \quad V_t^n \geq 0, \quad \forall t \tag{2.4}$$

The third constraint defines the firm's cash flow, linking together profits, dividends, and investment expenditures The corporation's income includes profits and the receipts from new share issues Outflows include dividends, factor payments, and investment expenditures net of investment tax credits The cash flow constraint is

$$\begin{aligned} (1-\tau)(F(K_t, N_t) - w_t N_t - \psi(I_t, K_t, \varepsilon_t)p_t - p_{t,t}bK_t) + V_t^n + \tau A_t \\ = G_t + (1-u-b)p_t I_t, \quad t=0, 1, \end{aligned} \tag{2.5}$$

This may be solved to define dividend payout

$$\begin{aligned} G_t = (1-\tau)(F(K_t, N_t) - w_t N_t - \psi(I_t, K_t, \varepsilon_t)p_t - p_{t,t}bK_t) \\ + V_t^n - (1-u-b)p_t I_t + \tau A_t, \end{aligned} \tag{2.6}$$

where $F(K, N)$ is the firm's production function, and $\psi(I_t, K_t, \varepsilon_t)$ is an adjustment cost function A random shock to adjustment costs is represented by ε_t We shall assume convex internal adjustment costs: higher rates of gross investment lead to increased dislocation within the firm, raising the effective cost of capital goods ($\psi_I > 0$) Larger firms can, however, undertake a given size investment project at lower cost ($\psi_K < 0$) For tax purposes, adjustment costs are treated just like wage costs To the extent that the true cost of installing capital is forgone labor productivity, this is a reasonable choice¹²

The firm's final constraint is the capital stock accounting identity

$$K_t = I_t + (1-\delta)K_{t-1}, \tag{2.7}$$

¹⁰There are difficult questions associated with whether shareholders will agree upon a value-maximizing strategy for the firm, and strong conditions such as spanning are required to generate value-maximization as a dominant strategy

¹¹Section 66 of the Companies Act restricts share repurchases

¹²An alternative modelling strategy assumes external adjustment costs which increase the market price of capital goods The real after-tax price of a new unit of capital becomes $(1-u-b)(p+\psi(I, K))$ Note that then the investment tax credit u applies to the total purchase price of the new capital and that this includes adjustment costs The two assumptions lead to very similar specifications of the investment function

where δ is the one-period depreciation rate on capital goods. When the capital stock is stationary ($K_t = K_{t-1}$), gross investment just offsets depreciation, so $I_t = \delta K_{t-1}$. We shall assume that there are no adjustment costs when only this 'replacement' investment is undertaken.

The managers' optimization problem is to maximize (2.3) subject to (2.4), (2.6) and (2.7). We proceed, even though the managers may not, by constructing the discrete time Hamiltonian function

$$H_t = (\gamma G_t - V_t^n) - \lambda_t^1 (K_t - I_t - (1 - \delta)K_{t-1}) - \lambda_t^2 V_t^n - \lambda_t^3 G_t \quad (2.8)$$

The shadow value of capital goods is λ_t^1 , λ_t^2 and λ_t^3 are the marginal values of being able to repurchase shares and pay negative dividends, respectively. Substituting the cash flow constraint into (2.8) and rewriting yields

$$H_t = (\gamma - \lambda_t^3) \{ (1 - \tau)(F(K_t, N_t) - w_t N_t - \psi(I_t, K_t, \varepsilon_t) p_t - p_t \varepsilon_t b K_t) - (1 - u - b) p_t I_t + \tau A_t \} - (1 + \lambda_t^2) V_t^n - \lambda_t^1 (K_t - I_t - (1 - \delta)K_{t-1}) \quad (2.9)$$

Maximizing the initial value of the firm, V_0 , is equivalent to maximizing an expected discounted sum of the Hamiltonian functions. That is,

$$V_0 \equiv \sum_{t=0}^{\infty} \beta_t E_0(H_t),$$

where

$$\beta_t = \prod_{j=0}^t \left(1 + \frac{r_j}{1 - z} \right)^{-1},$$

the discount factor which applies to income which will be received t years into the future.

The firm chooses strategies, or decision rules, which will at any moment determine investment, share issues, and labor input as a function of previously observed shocks. The first-order condition for investment at time t may be written

$$E_{t-1} \{ -(\gamma - \lambda_t^3) \{ (1 - \tau) \psi_I(I_t, K_t, \varepsilon_t) + 1 - u_t - b - n_t \} p_t + \lambda_t^1 \} = 0, \quad (2.10)$$

where n_t is the present value of the writing down allowances which will flow from the investment. Eq. (2.10) implicitly determines the firm's investment behavior, since it defines a function linking investment to the real shadow price of capital, λ^1/p , and the tax parameters. The condition for zero gross

investment is

$$\frac{\lambda_t^1}{p_t} = (\gamma - \lambda_t^3)(1 - u_t - b - n_t) \tag{2 11}$$

The first-order conditions for new share issues and dividend payments are

$$E_{t-1}\{\gamma - 1 - \lambda_t^3 - \lambda_t^2\} \geq 0, \quad V_t^n \geq 0, \tag{2 12}$$

$$(\gamma - 1 - \lambda_t^3 - \lambda_t^2) V_t^n = 0,$$

and

$$G_t \geq 0, \quad E_{t-1}(\lambda_t^3) \geq 0 \tag{2 13}$$

$$G_t, \lambda_t^3 = 0$$

These expressions include the complementary slackness conditions associated with non-negativity constraints

The shadow price of capital equipment, λ_t^1 , defines the marginal increase in firm value which would result from adding one unit of capital to the firm. The real market price of a new unit of capital is p_t . Tobin's 'q' theory of investment asserts that the corporation's investment decision depends upon the ratio of the marginal equity value of capital, λ_t^1 , to the price of capital goods, p_t . We shall define $q_t = \lambda_t^1/p_t$. Absent taxes, the capital goods market is in equilibrium if and only if $q = 1$. This need not be true, however, when taxes are introduced. The existence of investment grants, or dividend and capital gains taxes, may lead equilibrium q to diverge from unity. The size of this divergence depends critically upon the corporation's marginal source of financial capital.

The economic structure of the firm's financing problem simplifies the mathematical programming problem above. A reduction in dividend payments is equivalent to an increase in new equity issues from the firm's cash flow perspective. However, dividend retention and new equity issues have different tax consequences and therefore different effects on shareholders. In the presence of personal and corporate taxes on distributed earnings, if $\gamma \neq 1$ so that the relative tax price of dividends is not equal to unity, the firm will never simultaneously choose to issue new shares and to pay dividends. Therefore, either dividends (G_t) or new issues (V_t^n), or both, must be zero. At all times one, but not both, of λ_t^2 or λ_t^3 is equal to zero.

First, consider a firm which issues new shares to obtain marginal investment funds. Assuming $\gamma < 1$, the firm pays no dividends. In terms of the

shadow prices discussed above, $\lambda_t^2 = 0$ and $\lambda_t^3 \neq 0$. The inequality in the first half of (2.12) becomes an equality and $\lambda_t^3 = \gamma - 1$. This explicit result for the shadow value of negative dividend payments can be used to simplify the first-order conditions for investment, yielding

$$(1 - \tau)\psi_I(I_t, K_t, \varepsilon_t) = \frac{\lambda_t^1}{p_t} + u_t + b + n_t - 1 \quad (2.14)$$

Eq. (2.14) defines the firm's optimal investment plan, and gross investment I_t^* may be found by inverting

$$\psi_I(I_t^*, K_t, \varepsilon_t) = \frac{\lambda_t^1/p_t - 1 + u_t + b + n_t}{1 - \tau} = Q_N \quad (2.15)$$

Q_N is the summary statistic for the marginal investment incentives of a firm which uses new equity finance.

The steady-state value of Tobin's 'q' is achieved when net investment is zero. If this occurs when marginal adjustment costs are zero,¹³ then the equilibrium 'q' when firms are on the new-issue margin is $(\lambda^1/p)^e = q_N^e = (1 - u_t - b - n_t)$. If there were no tax credits and no debt, firms would invest until the marginal value of new capital equipment just equalled its market cost. The presence of tax grants changes the marginal cost of purchasing new capital.

Now consider a firm which finances new investment out of retained earnings. By the above argument on the mutual exclusivity of dividend payments and share issues, the use of retentions as a source of funds implies the existence of some positive dividend payments.¹⁴ Therefore, $\lambda_t^3 = 0$ and the first-order condition for investment becomes

$$\gamma\{(1 - \tau)\psi_I(I_t, K_t, \varepsilon_t)p_t + (1 - u_t - b - n_t)p_t\} = \lambda_t^1 \quad (2.16)$$

The optimal investment rule is defined implicitly by

$$\psi_I(I_t^*, K_t, \varepsilon_t) = \frac{(\lambda_t^1/\gamma p_t) - 1 + u_t + b + n_t}{(1 - \tau)} = Q_R \quad (2.17)$$

Q_R summarizes the marginal investment incentives of a retentions-financed firm. Repeating the analysis which led to equilibrium 'q' above shows that

¹³Since replacement investment can be carried out with no adjustment costs, $\psi(\delta K_t, K_t) = 0$. We follow the literature [for example, Summers (1981)] in assuming that marginal adjustment costs are also zero at the replacement only investment level $\psi_I(\delta K_t, K_t) = 0$.

¹⁴Some firms may use all of their retained earnings for investment but issue no new equity. These firms will behave as a hybrid between the retentions and new equity cases.

the steady-state value of q when retentions are the marginal finance source is just

$$\left(\frac{\lambda^1}{p}\right)^e = q_R^e = \gamma(1 - u_t - b - n_t) = \frac{(1 - m)\theta}{1 - z}(1 - u_t - b - n_t)$$

The equilibrium q_R^e depends upon corporate and personal dividend taxes, in addition to investment tax credits

The implications of these results for investment policy should be clear. In the traditional view of dividend taxes, the marginal financial pound comes from new equity issues, so the firm will invest only if the ratio λ^1/p is greater than unity. In the $q^* \neq 1$ model, however, the marginal financial resources are obtained by reducing dividend payments and the firm will therefore invest until the market value of an additional unit of capital, $(1 - m)\theta/(1 - z)$, equals the price of capital goods. Our tests of the competing dividend tax hypotheses attempt to distinguish between the resulting investment functions.

The preceding analysis yielded a precise rule for the firm's optimal investment decision, but it depended upon the unobservable shadow price of capital, λ_t^1/p_t . To make the theory useful for econometric work, some measure of λ_t^1/p_t must be constructed. Earlier investment studies have employed the ratio of the market value of corporate equity to the replacement cost of corporate capital as a proxy for capital's shadow value.¹⁵ The adequacy of this empirical approximation lies at the heart of the debate about 'average versus marginal q '.

Under assumptions made explicit by Hayashi (1982), the marginal value of capital equipment is equal to its average value, which may be measured using data on stock market valuation. Hayashi's conditions are (i) homogeneity of the production function, and (ii) homogeneity of the capital adjustment cost function. To understand the homogeneity argument, we must distinguish two sources of value in the firm. One is the return from operating the capital stock. If the production and adjustment cost functions are homogeneous, then the present value of these returns will be homogeneous of degree one in the size of the current capital stock. However, the second component of returns, the present value of writing down allowances on past investments, is independent of new investment activity. Therefore, if we let B denote the present value of these 'outstanding' writing down allowances, the quantity $V_t - B_t$ will be homogeneous in K_t . 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

¹⁵U.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).

implies that $d(V_t - B_t)/dK_t = \lambda_t^1$, this is just what is meant by the assertion that λ_t^1 is the shadow price of new investment, or 'marginal q '. This result, along with the homogeneity condition, implies that

$$\frac{\lambda_t^1}{p_t} = \frac{V_t - B_t}{p_t K_{t-1}(1-\delta)} \quad (2.18)$$

This expression provides an observable counterpart for the shadow price of new investment. The denominator involves $(1-\delta)K_{t-1}$ because this is the size of the firm's capital stock at the beginning of this period.¹⁶

We have emphasized the role of internal adjustment costs in the firm's investment decision. The functional form of the investment function is completely determined by inverting $\psi_I(I_t^*, K_t, \varepsilon_t)$. In general, the resulting specification will be highly nonlinear. However, a tractable adjustment cost function which yields a linear investment equation was introduced by Summers (1981). The firm faces convex adjustment costs which are proportional to the square of $(I/K - \alpha - \varepsilon)$, where $\alpha + \varepsilon$ represents the 'normal' investment level. Scaling these costs by the size of the firm yields

$$\psi(I, K, \varepsilon) = \frac{\phi}{2} \left(\frac{I}{K} - \alpha - \varepsilon \right)^2 K \quad (2.19)$$

Returning to the investment first-order condition, since $\psi_I(I, K, \varepsilon) = \phi(I/K - \alpha - \varepsilon)$ we can find an explicit investment function.¹⁷ We invert the equation

$$\psi_I(I_t, K_t, \varepsilon) = \phi \left(\frac{I}{K} - \alpha - \varepsilon \right) = Q_t, \quad i = R, N, \quad (2.20)$$

where Q_t , defined above, depends upon both tax rates and the marginal source of investment finance. The result is a linear investment equation

$$\frac{I_t}{K_t} = \alpha + \frac{1}{\phi} Q_t + \varepsilon, \quad (2.21)$$

in which the effect of Q on investment activity depends upon β , the parameter from the adjustment cost function. It is important to notice that ε , the innovation term in the adjustment cost function, has a direct effect on the

¹⁶A more detailed derivation is presented in Poterba (1982).

¹⁷A firm would never choose to invest less than $\alpha + \varepsilon$. The firm sets $\psi_I = Q$, and since adjustment costs are symmetric in (I/K) around $\alpha + \varepsilon$, there are two points at which this condition is satisfied. However, at the point where $\psi_I(I/K) = Q$ and $I/K < \alpha + \varepsilon$, marginal adjustment costs are falling so the firm should undertake further investment.

value of the firm because changes in the optimal level of investment today affect the total value of the discounted profit sum. The value of the firm affects Q , and it is therefore appropriate to treat Q as an endogenous variable when estimating the investment model.

Alternative assumptions about the firm's marginal source of financial capital relate investment to different functions of the market value-to-replacement-cost ratio. The investment function when firms use retentions is (2.21) with Q_R defined by

$$Q_{R,t} = \frac{\left(\frac{1-z}{(1-m)\theta} \right) \left(\frac{V_t - B_t}{p_t K_{t-1} (1-\delta)} - 1 + u_t + n_t + b \right)}{1-\tau} \quad (2.22)$$

The new equity finance case corresponds to

$$Q_{N,t} = \frac{\frac{V_t - B_t}{p_t K_{t-1} (1-\delta)} - 1 + u_t + n_t + b}{1-\tau} \quad (2.23)$$

In later sections of this paper we use econometric tests of 'non-nested' hypotheses to distinguish between these alternative investment specifications, implicitly testing which financial margin assumption is more appropriate.

It is important to realize that while we have tried to justify the 'q' approach in an adjustment cost framework, this is not the only, or perhaps even the best, derivation. Keynes (1936) and Tobin (1969) both suggested that the level of investment activity should be an increasing function of stock market value. Our study may be viewed as an extension of previous 'q' investment studies, in which we analyse the firm's financial constraints. Although criticisms may be levelled at the 'q' methodology, unless they affect one of (2.22) and (2.23) more than the other, they should not bias our results.

3. Data

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

3.1 Tax adjusted Q

The values of the replacement cost of the capital stock, pK , the market

value of equity, V , 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 the CSO. In other cases we extrapolated backwards.¹⁸ Information on the marginal rates of individual income tax on dividends and capital gains (m and z) and the tax disincentive to dividend payment, θ , was obtained from King (1977) and King, Naldrett and Poterba (1983).

The principal complexities came in the calculation of terms reflecting the effects of depreciation allowances and investment incentives on old capital, B , and new capital, u . Estimates of u and n , using procedures similar to ours, have been presented by Melliss 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 postwar 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.¹⁹ 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 allowances (z_b^i) 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

$$\begin{aligned}
 u_b &= \frac{z_b^g + \tau(z_b^a + z_b^i + z_b^d)}{(1+r)} + \sum_{s=1}^{s=T_b} \frac{\tau z_b^d}{(1+r)^{s+1}} \\
 &= \frac{z_b^g + \tau(z_b^a + z_b^i + z_b^d)}{(1+r)} + \frac{\tau z_b^d}{r(1+r)^{T_b-1}} [(1+r)^{T_b} - 1], \quad (3.1)
 \end{aligned}$$

¹⁸A data appendix is available from the authors on request.

¹⁹We have ignored the rather complex issues associated with the resale of capital goods and the recapture provisions of the depreciation laws.

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 $r = (1 - \tau) i$ where i is the nominal interest rate on British government consols. We chose this rate because 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

$$\begin{aligned}
 R_b(s, t) &= I_b(s) * \sum_{k=0}^{T_b} \frac{z_b^d(s) \tau(t)}{(1 + r_t)^{k+1}} \\
 &= \frac{I_b(s) z_b^d(s) \tau(t)}{r_t (1 + r_t)^{T_b(s, t) + 1}} [(1 + r_t)^{T_b(s, t) + 1} - 1], \tag{3.2}
 \end{aligned}$$

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 vehicles 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

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

and

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

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 in gross investment.²⁰ 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 1963, when investment incentives allowed firms to recoup 58.5 percent of investment costs. The full time series is reported in column 1 of table 1.

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 postwar 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.²¹ We approximated the depreciation bond by assuming that the net capital stock in 1948, K_{1948}^N , 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 0.04 per year using capital consumption and net capital stock data. Therefore, we computed

$$R_{\text{war}}(s) = \tau(1-d)^{s-1948} K_{1948}^N \sum_{k=1}^{\infty} \frac{d(1-d)^k}{(1+r)^k} = \frac{\tau d(1-d)^{s-1948} K_{1948}^N}{d+r} \quad (3.5)$$

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

$$B_b(t) = \sum_{s=T_b^*}^{s=t} R_b(s, t)$$

²⁰While 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 weights 0.24 and 0.76, 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.

²¹Two 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.

Table 1
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' \bar{Q}	'Double-tax hypothesis' \bar{Q}	Gross investment rate
1948	0.455	2.862	—	—	—	6.73
1949	0.458	2.862	0.629	0.805	0.596	6.45
1950	0.479	2.975	0.407	0.286	0.105	6.55
1951	0.455	2.973	0.420	0.471	0.102	5.75
1952	0.415	2.824	0.359	0.141	-0.143	5.04
1953	0.442	2.922	0.295	-0.010	-0.240	5.19
1954	0.411	2.568	0.331	0.036	-0.188	5.53
1955	0.425	2.535	0.506	0.545	0.198	6.11
1956	0.403	2.557	0.465	0.484	0.075	6.48
1957	0.365	2.551	0.368	0.156	-0.175	6.80
1958	0.393	2.824	0.356	-0.079	-0.153	7.23
1959	0.444	3.029	0.370	-0.032	-0.032	7.19
1960	0.483	3.224	0.626	0.627	0.626	7.32
1961	0.492	3.452	0.717	0.918	0.917	7.48
1962	0.521	3.921	0.662	0.868	0.867	7.61
1963	0.585	4.153	0.559	0.830	0.829	8.08
1964	0.579	4.408	0.910	1.698	1.699	9.87
1965	0.453	3.639	0.738	0.857	0.857	9.73
1966	0.408	3.419	0.773	1.368	0.818	8.92
1967	0.434	3.524	0.641	0.641	0.337	8.45
1968	0.441	3.776	0.671	1.325	0.819	8.84
1969	0.423	4.125	1.002	2.251	1.427	9.10
1970	0.431	4.339	0.732	1.461	0.892	9.02
1971	0.368	4.162	0.503	0.662	0.321	8.12
1972	0.463	4.928	0.636	0.814	0.698	7.94
1973	0.496	4.961	0.483	0.515	0.515	8.24
1974	0.475	4.400	0.266	0.105	0.105	8.00
1975	0.510	4.840	0.110	-0.213	-0.213	7.44
1976	0.509	5.069	0.332	0.219	0.219	7.37
1977	0.528	6.116	0.265	0.078	0.078	7.59
1978	0.514	6.126	0.373	0.273	0.273	7.89
1979	0.516	6.645	0.431	0.373	0.373	7.32
1980	0.516	7.041	0.458	0.404	0.404	6.96

Sources See appendix and description in text

Repeating this exercise for the other categories of investment yields $B_p(t)$ and $B_c(t)$, which may then be added to $B_{\text{war}}(t)$ to produce

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

The actual values of this series are displayed in column 2 of table 1, 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.

There is a practical problem in the construction of Q . 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 $(V-B)/(pK + INV)$. The alternative approach is to treat inventories as liquid assets and to subtract their value from the numerator of Q and compute $(V-B-INV)/pK$. 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 $(V-B)/(pK + INV)$ in table 1, column 3. This series has ranged from 0.11 to 1.00 during the last 30 years.

Our estimates of Q_N and Q_R are shown in columns 4 and 5 of tables 1. Q_R is computed under the capitalization hypothesis and Q_N under the double taxation view. The variance of Q_R under the capitalization hypothesis is 1.35 times that of Q_N .

3.2 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 6 of table 1. The gross investment rate averages 7.5 percent for our sample period and peaks at 9.87 percent in 1964.

4. 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, as presented above. These equations are reproduced below, (4.1a) corresponds to the capitalization view and (4.1b) is derived under the assumptions of the traditional model.

$$\frac{I}{K} = \beta_0 + \beta_1 Q_R + \varepsilon_1, \tag{4.1a}$$

$$\frac{I}{K} = \beta_0 + \beta_1 Q_N + \varepsilon_1 \tag{4.1b}$$

The difference between Q_R and Q_N is that Q_R adjusts the market value of the firm's equity to take account of future tax liabilities on the firm's dividends, while Q_N ignores this adjustment.

Before turning to the empirical results, it is necessary to discuss several issues connected with estimation. The exogeneity of Q in (4.1a, b) 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_1 is given by

$$\hat{\beta}_1 = \beta_1 - \frac{\text{cov } \varepsilon, Q}{\text{var } Q}$$

This implies that the bias is bounded by the ratio $\sigma_\varepsilon/\sigma_Q$, which, as indicated below, is negligible relative to the estimates of β_1 . As a further precaution and in order to treat errors in measurement of 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.

The investment model which was derived in section 2 related current investment expenditure to the current value of Q . Lagged Q should have no impact on investment, given contemporaneous Q , since all of the information which was used in agents' calculation of Q_{t-1} can also be used in the calculation of Q_t . However, a glance at the data in table 1 shows that investment activity is highly serially correlated. To guard against the prospect that residual autocorrelation would contaminate our inferences

about the competing investment theories, we estimated 'overfitting' models²² [see Box and Jenkins (1970) or Hendry and Mizon (1978)], and then attempted to impose zero restrictions or common factor restrictions²³ After eliminating parameters from the general specification, we were led to the 'parsimonious' model below²⁴

$$\left(\frac{I}{K}\right)_t = \beta_0 + \beta_1 Q_t + \beta_2 Q_{t-1} + u_t, \quad (4.2a)$$

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \varepsilon_t \quad (4.2b)$$

The presence of residual autocorrelation reflects serial correlation in the shocks to the adjustment cost function. The lagged values of Q in the investment function are more troubling. However, the annual investment series which we used to construct (I/K) doubtless includes some projects for which the decision to invest was taken in the year prior to recording the expenditure. These delivery and decision lags, or the possibility of data misalignment, may explain the presence of Q_{t-1} in the investment models.

After discovering second-order autocorrelation, our equations were estimated by a variant of Amemiya's (1974) nonlinear two-stage least squares procedure. We first defined the 'quasi-differenced' form of (4.2)

$$\begin{aligned} \left(\frac{I}{K}\right)_t &= \beta_0 + (\beta_1 + \beta_2 L)Q_t + (1 - \rho_1 L - \rho_2 L^2)^{-1} \varepsilon_t \\ &= \beta_0(1 - \rho_1 - \rho_2) + \rho_1 \left(\frac{I}{K}\right)_{t-1} + \rho_2 \left(\frac{I}{K}\right)_{t-2} + \beta_1 Q_t \\ &\quad + (\beta_2 - \beta_1 \rho_1)Q_{t-1} - (\beta_1 \rho_2 + \beta_2 \rho_1)Q_{t-2} - \beta_2 \rho_2 Q_{t-3} + \varepsilon_t \end{aligned} \quad (4.3)$$

We then applied nonlinear 2SLS to this specification.

²²Our most general overfitting models included five lagged values of (I/K) and Q . For example, for the investment model under the double-tax hypothesis, the estimated model is

$$\begin{aligned} \left(\frac{I}{K}\right)_t &= 0.025 + 1.23 L - 1.05 L^2 + 0.73 L^3 - 0.45 L^4 + 0.14 L^5 \left(\frac{I}{K}\right)_t \\ &\quad + (0.85 - 0.53 L + 0.47 L^2 - 0.17 L^3 + 0.46 L^4 - 0.19 L^5) Q_{N,t} + \varepsilon_t \\ &\quad (0.011) \quad (0.25) \quad (0.39) \quad (0.45) \quad (0.40) \quad (0.19) \quad (0.21) \quad (0.34) \quad (0.33) \quad (0.33) \quad (0.27) \quad (0.24) \end{aligned}$$

$$\bar{R}^2 = 90, \quad SSR = 1460, \quad DW = 2.05$$

²³While our theory admits the possibility of autocorrelated errors in the adjustment cost function, the presence of lagged values of (I/K) would raise some difficulties. The level of investment today would thereby influence the marginal cost of investment tomorrow. The solution to the firm's optimal control problem would therefore depend upon both the shadow price of capital today and its expected shadow value tomorrow, leading to an investment function which would be difficult to implement econometrically.

²⁴The common factor restriction implied by the autocorrelated error structure was not rejected by the data.

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 3 in particular, firms will face values of $\tau = 0$ which imply $u = 0$ and $B = 0$ If the firm pays no taxes, depreciation allowances which can be written off against taxes are of little value²⁵

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

While our research focuses on the use of investment equations to test hypotheses about 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 by 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 (both Jenkinson and Oulton use quarterly data), the extension of the sample period and the improved estimates of tax effects Our equations also fit somewhat better than earlier q investment models

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 percent 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 are less contaminated by short-term fluctuations in market value than are

²⁵We 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 2
Investment equations under the competing hypotheses

Eq	Interval	Estimation & method	Tax hypothesis	β_0	$\beta_1 (\times 10^{-2})$	$\beta_2 (\times 10^{-2})$	ρ_1	ρ_2	SSR ($\times 10^{-4}$)	DW	R^2
(1a)	1950-80	OLS	TCH	6.51 (0.23)	1.04 (0.38)	0.66 (0.38)	—	—	2167	0.37	0.49
(1b)			DTH	6.61 (0.17)	1.28 (0.38)	0.96 (0.37)	—	—	1470	0.46	0.65
(2a)	1950-80	AR2	TCH	6.89 (0.41)	0.61 (0.18)	0.37 (0.18)	1.25 (0.18)	-0.45 (0.18)	477	1.69	0.88
(2b)			DTH	6.90 (0.31)	0.90 (0.19)	0.51 (0.19)	1.28 (0.17)	-0.50 (0.17)	361	1.70	0.91
(3a)	1950-80	IV	TCH	6.20 (0.24)	1.63 (0.74)	0.62 (0.64)	—	—	2476	0.54	—
(3b)			DTH	6.46 (0.20)	1.41 (0.68)	1.20 (0.63)	—	—	1558	0.63	—
(4a)	1950-80	AR2-IV	TCH	6.58 (0.42)	0.97 (0.25)	0.98 (0.29)	1.15 (0.20)	-0.43 (0.20)	575	2.00	—
(4b)			DTH	6.80 (0.30)	1.16 (0.24)	1.04 (0.27)	1.06 (0.20)	-0.37 (0.20)	398	1.83	—
(5a)	1950-72	AR2	TCH	6.84 (0.52)	0.63 (0.21)	0.35 (0.21)	1.27 (0.20)	-0.46 (0.20)	388	1.68	0.89
(5b)			DTH	6.82 (0.36)	0.97 (0.20)	0.50 (0.21)	1.33 (0.20)	-0.55 (0.19)	261	1.65	0.93
(6a)	1963-80	AR2	TCH	7.35 (0.22)	0.68 (0.17)	0.46 (0.17)	0.78 (0.26)	-0.59 (0.25)	230	1.98	0.74
(6b)			DTH	7.24 (0.20)	1.06 (0.22)	0.66 (0.20)	0.64 (0.33)	-0.51 (0.31)	191	1.83	0.78

TCH = Tax capitalization hypothesis

DTH = Double-tax hypothesis

quarterly Q series, our equations are more successful at capturing the underlying long-term relationship between Q and investment. Most of the noise and measurement error 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 frequency variation.

Engle and Foley (1975) have invoked this argument and then estimated an investment function for the United States using the band spectral regression technique [see Engle (1974)]. This approach involves decomposing the observed data series into frequency components and then filtering the data to eliminate high frequency variations. In applying this approach to British investment data, we alternatively chose to eliminate those components of Q -variance which occurred at periodicities below three, and below five, years. The results show that the low frequency relationship between the investment rate and the valuation ratio is stronger than the relationship which is observed using the raw quarterly or annual data (table 3). 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 double-tax q to the capitalization equations also remains evident at low frequencies.

Table 3
Band spectrum regression results

Window	Tax hypothesis	α	β	R^2	SSR
1 year	TCH	6.70 (0.23)	1.54 (0.30)	0.47	23.845
1 year	DTH	6.80 (0.18)	2.01 (0.30)	0.79	18.03
3 years	TCH	6.64 (0.29)	1.64 (0.40)	0.50	22.451
3 years	DTH	6.76 (0.22)	2.11 (0.39)	0.62	16.89
5 years	TCH	6.56 (0.39)	1.78 (0.54)	0.53	20.09
5 years	DTH	6.68 (0.29)	2.31 (0.52)	0.67	14.15

Note: Calculations were performed using the TROLL Program. The equation estimated is $I/K = \alpha + \beta Q + \varepsilon$

The previous results showed that double-tax regression models estimated using Q_N , which corresponds to the double-tax hypothesis, fit better than those estimated using Q_R , which was derived from the tax capitalization hypothesis. A more formal comparison of the two hypotheses is possible. We take three different approaches in weighing the evidence: one involves Bayesian analysis of the two models, one is a classical statistical test, and the last estimates a weighted average of the two models.

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 on the two hypotheses. That is, if one started out assigning equal prior likelihoods to the estimated equations for the 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.²⁶ 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 more than five times more likely than the new view.

<i>Regression pair</i>	<i>Posterior odds ratio</i>
50-80 sample, AR2	59 to 1
50-80 sample, OLS	337 to 1
50-82 sample, AR2-IV	5 to 1
63-80 sample, AR2	78 to 1
50-72 sample, AR2	249 to 1

An alternative and perhaps more informative way of comparing the two hypotheses is through a specification test. The problem of testing non-nested hypotheses has been an active research area in econometrics during the last decade. Pesaran (1974) showed how the basic results of Cox (1961) could be applied to the problem of comparing two linear regression specifications. Research since then is summarized in Mizon and Richard (1982). That paper

²⁶The posterior odds ratio is defined as

$$\lambda = \frac{\max_{\theta} L(\theta | H_1)}{\max_{\theta} L(\theta | H_2)}$$

For the special case when ε_1 is assumed normally distributed and the model is linear, this statistic reduces to

$$\lambda = \left(\frac{\hat{\sigma}^2}{\hat{\sigma}^2} \right)^{T/2},$$

where $\hat{\sigma}^2 = \sum (y - x\hat{\beta})^2$ under H_1 and $\hat{\sigma}^2 = \sum (y - x\hat{\beta})^2$ 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. Feenstra and Weitzman (1981) describe empirical procedures for evaluating the distribution of λ . Our procedure amounts to assuming an equally-likely prior over the two points which constitute likelihood function maxima under the two hypotheses.

also develops Cox's original 'encompassing' principle in great detail In the Mizon-Richard terminology, our problem reduces to the following two hypotheses

$$H_1 \quad E\left(\left(\frac{I}{K}\right) \middle| Q_R, Q_N\right) = \alpha_0 + \alpha_1 Q_N + u$$

$$H_2 \quad E\left(\left(\frac{I}{K}\right) \middle| Q_R, Q_N\right) = \gamma_0 + \gamma_1 Q_R + v$$

H_1 corresponds to the new issues margin, since it proposes that conditional on the summary statistics Q_R and Q_N for investment activity, (I/K) depends only upon Q_N Similarly, H_2 corresponds to the retentions margin, or capitalization case

Cox's encompassing principle states that we can test H_1 by analyzing its ability to predict what we observe when estimating the misspecified (under H_1) model described by H_2 Mizon and Richard (1982) show that the Wald encompassing test of H_2 when H_1 is the null is the 'orthodox' F -test of $\delta_2 = 0$ in

$$\left(\frac{I}{K}\right) = \delta_0 + Q_N \delta_1 + Q_R \delta_2 + \tilde{\epsilon} \tag{4.4}$$

Encompassing tests are easy to compute in the models which I have reported Table 4 shows several such calculations, and their conclusions The tests are quite clear about which model is more data-compatible In all cases considered, the encompassing tests reject the null of the capitalization

Table 4
Encompassing tests of competing models

Null hypothesis	Alternative hypothesis	Estimation method	Test result/conclusion
Capitalization	Double tax	OLS	6.82/Reject null
Capitalization	Double tax	AR2	3.92/Reject null
Capitalization	Double tax	AR2-IV	13.91/Reject null
Double tax	Capitalization	OLS	0.37/Do not reject
Double tax	Capitalization	AR2	1.76/Do not reject
Double tax	Capitalization	AR2-IV	2.51/Do not reject

Notes The 95% value for $F(2,22)$ is 2.95 This is the appropriate test level for statistics reported in rows 3 and 6 The test statistics in the other rows are distributed $F(2,26)$ under the null their critical value is 3.07 The reported test statistics are Wald tests of the restriction that the coefficients on the alternative-hypothesis Q variables are zero

hypothesis when faced with the alternative of the 'traditional' view. In contrast, however, when the roles of the null and alternative are reversed, the traditional view cannot be rejected.

All of the tests of the two dividend tax hypotheses which we have reported so far involve comparison of two alternative hypotheses. In section 2, however, we argued that there was no single margin for the whole economy and that in practice the aggregate investment equation would reflect a weighted average of the two finance sources. Defining $Z = (1-z)/(1-m)\theta$, we claimed that the aggregate investment function could be written

$$\frac{I}{K} = \beta_0 + (\beta_1 + \beta_2 L) \left[(\omega + (1-\omega)Z) \frac{V-B}{pK} + u + b + n - 1 \right] + \varepsilon_1, \quad (4.5)$$

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

The results of estimating eq (4.5) using nonlinear least squares are reported in table 5. They tell a consistent story. The estimates of ω range from 0.76 to 2.16. In all but one case the hypothesis is that $\omega = 0$ can be rejected at the 5 percent level. The hypothesis is that $\omega = 1$ cannot be rejected except for the 1963-80 period when $\hat{\omega} = 2.16$. 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. Our preferred investment model is the one which would be derived if either the double-tax hypothesis were correct or if the stock market ignored taxes in valuing shares. The present tests have no power to distinguish between these explanations. However, a large body of empirical work has shown that the value of securities does reflect their after-tax yield. Therefore we prefer to interpret the findings as supporting the double-tax view.

Our results contrast with Summers (1981), who found the tax adjustments added to the explanatory power of Q investment equations for the United States. 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.

5. Conclusions

The results in this paper provide strong support for the traditional view

Table 5
Nonlinear investment equation estimates

Eq	Interval	Estimation method	ω	β_0	$\beta_1 (\times 10^{-2})$	$\beta_2 (\times 10^{-2})$	ρ_1	ρ_2	SSR ($\times 10^{-3}$)	DW
(1)	1953-80	NLLS	1.19 (0.29)	6.83 (0.20)	1.20 (0.89)	1.09 (0.39)	—	—	0.1221	0.49
(2)	1953-80	NLLS,AR2	1.83 (0.47)	7.28 (0.32)	1.04 (0.19)	0.48 (0.19)	1.36 (0.17)	-0.57 (0.17)	0.267	1.81
(3)	1953-80	NL2SLS	1.10 (0.27)	6.74 (0.21)	1.28 (0.42)	1.16 (0.42)	—	—	0.1240	0.54
(4)	1953-80	NL2SLS,AR2	0.76 (0.49)	6.71 (0.37)	1.14 (0.25)	1.07 (0.29)	1.06 (0.21)	-0.37 (0.20)	0.440	1.88
(5)	1953-72	NLLS,AR2	2.16 (0.30)	7.25 (0.33)	1.19 (0.16)	0.39 (0.18)	1.61 (0.17)	-0.83 (0.17)	0.135	1.60
(6)	1963-80	NLLS,AR2	1.01 (0.51)	7.30 (0.21)	1.05 (0.28)	0.68 (0.23)	0.79 (0.26)	-0.46 (0.29)	0.142	1.92

Source The basic equation estimated is

$$\frac{I}{K} = \beta_0 + (\beta_1 + \beta_2 L) \left[\frac{\omega + (1-\omega) \left(\frac{1-z}{(1-m)\theta} \right) \left(\frac{V-B}{PK(1-\delta)} \right) - 1 + n_t + b_t + u_t}{(1-\tau)} \right] + (1-\rho_1 L - \rho_2 L^2)^{-1} \varepsilon_t$$

See text for further description. Standard errors are shown in parentheses

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 United Kingdom.

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 valuation 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), who 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.

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.

Appendix: 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

Data definitions and legend

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 = $(1-z)/[(1-m)\theta]$, 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

References

- Amermiya, T, 1974, The nonlinear two-stage least squares estimator, *Journal of Econometrics* 2, 105–110
- Auerbach, A, 1979a, Share valuation and corporate equity policy, *Journal of Public Economics* 11, 291–305
- Auerbach, A, 1979b, Wealth maximization and the cost of capital, *Quarterly Journal of Economics* 93, 433–446
- Bank of England, 1980, Company sector data base, Economic Research Division, mimeo
- Bank of England, 1981, Dividend payments Some recent trends, *Bank of England Quarterly Bulletin*, 33–41
- Bhattacharya, S, 1979, Imperfect information, dividend policy, 'the bird in the hand' fallacy, *The Bell Journal of Economics* 10, 259–270
- Box, G E P and G Jenkins, 1970, *Time series analysis* (Holden Day, San Francisco)
- Bradford, D F, 1981, The incidence and allocation effects of a tax on corporate distributions, *Journal of Public Economics* 15, 1–22
- Brealey, R and S Myers, 1981, *Principles of corporate finance* (McGraw-Hill, New York)
- Ciccollo, J H, 1975, Four essays on monetary policy, Ph D thesis, Yale University, New Haven
- Cox, D R, 1961, Tests of separate families of hypotheses, *Proceedings of the Fourth Berkeley Symposium on Mathematical Statistical Probability*, vol 1 (University of California Press, Berkeley)
- Dean, G, 1964, The stock of fixed capital in the United Kingdom in 1961, *Journal of the Royal Statistical Society, Series A*, 127, part 3, 327–361
- Edwards, J S S and M Keen, 1982, Wealth maximization and the cost of capital A comment, mimeo
- Engle, R F, 1974, Band spectrum regression, *International Economic Review* XV, 1–11
- Engle, R and D Foley, 1975, An asset price model of aggregate investment, *International Economic Review* 16, 625–647
- Feenstra, D and M Weitzman, 1981, On the exact small sample distribution of a test of non-nested hypotheses, MIT working paper, Cambridge, Mass
- Feldstein, M S, 1970, Corporate taxation and dividend behaviour, *Review of Economic Studies* 37, 57–72
- Feldstein, M S, 1972, Corporate taxation and dividend behaviour Reply and further results, *Review of Economic Studies* 39, 235–240
- Feldstein, M S and J Green, 1983, Why do companies pay dividends? *American Economic Review* 73, 17–31
- Gordon, Roger and Burton Malkiel, 1981, Corporation finance, in J H Pechman and H J Aaron, eds, *How taxes affect economic behaviour* (Brookings Institution, Washington)
- Hayashi, F, 1982, Tobin's marginal q and average q A neoclassical interpretation, *Econometrica* 40, 213–225
- Hendry, D and G Mizon, 1978, Autocorrelation as a simplification and not a nuisance The transactions demand for money, *Economic Journal* 88, 549–563
- Jenkinson, N, 1981, Investment, profitability, and the valuation ratio, Bank of England discussion paper, unpublished
- Keynes, J M, 1936, *The general theory of employment, interest, and money* (Macmillan, London)
- King, M A, 1971, Corporate taxation and dividend behaviour — A comment, *Review of Economic Studies* 38, 377–380
- King, M A, 1972, Corporate taxation and dividend behaviour — A further comment, *Review of Economic Studies* 39, 231–234
- King, M A, 1977, *Public policy and the corporation* (Chapman and Hall, London)
- King, M A, M Naldrett and J Poterba, 1983, Country chapter UK, in M A King, ed, *The taxation income from capital An international comparative study* (University of Chicago Press, Chicago)
- Meliss, C L and P W Richardson, 1976, Value of investment incentives for manufacturing industry 1946 to 1974, in A Whiting, ed, *The economics of industrial subsidies* (HMSO, London)
- Miller, M, 1977, Debt and taxes, *Journal of Finance* 32, 261–273

- Mizon, G and J F Richard, 1982, The encompassing principle and its application to non-nested hypotheses, unpublished manuscript
- Mussa, M, 1974, Market value and the investment decision in an adjustment cost model of firm behavior (Department of Economics, University of Rochester, Discussion Paper 74-15)
- Oulton, N, 1978, Explaining aggregate investment in Britain The importance of Tobin's Q , *Economic Letters* 1
- Oulton, N, 1979, Aggregate investment and Tobin's Q Evidence from Britain, University of Lancaster discussion paper, no 5
- Pesaran, H, 1974, On the general problem of model selection, *Review of Economic Studies* 41, 153-171
- Poterba, James M, 1982, Dividend taxes, corporation finance, and investment An empirical investigation, M Phil thesis, Oxford University
- Poterba, James M 1983, Taxation, expectations, and corporate dividend policy, mimeo, Nuffield College, Oxford
- Redfern, P, 1955, Net investment in fixed assets in the United Kingdom, 1938-53, *Journal of the Royal Statistical Society, Series A*, 118, part 2
- Ross, S, 1977, The determination of financial structures The incentive signalling approach, *The Bell Journal of Economics* 8, 23-40
- Stiglitz, J E, 1980, The inefficiency of stock market equilibrium, unpublished
- Summers, L H, 1981, Taxation and corporate investment A q -theory approach, *Brookings Paper on Economic Activity* 1, 67-140
- Tobin, J, 1969, A general equilibrium approach to monetary theory, *Journal of Money, Credit, and Banking* 1, 15-29
- von Furstenberg, G, 1977, Corporate investment Does market valuation matter in the aggregate?, *Brookings Paper on Economic Activity* 6, 347-397
- Zellner, A, 1979, Posterior odds ratios for regression hypotheses General considerations and some specific results (Invited paper at the Econometric Society Meeting, 28-30 December, Atlanta, Georgia)