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Q and the tax bias theory

The role of depreciation tax shields

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A growing body of literature analyzes the variation in *Q*, the ratio of financial market value to asset current replacement cost, and makes inferences about attributes such as monopoly power, profitability, managerial performance, etc. These studies ignore potential biases embedded in *Q* that result from non-neutral tax policies. This study examines the association between *Q* and tax biases and establishes that differences in accumulated depreciation tax shields explain significant variation in *Q*. The implication that *Q* should be adjusted for tax biases before use in empirical research is examined further. Adjusting *Q* for tax biases, at least with the factors herein, leads only to minor changes in econometric analyses.

1. Introduction

On a balance sheet there is an identity between the value of total liabilities (including stockholders' equity) and the value of total assets. In the capital markets, on the other hand, asset and liability values are not equated so easily. For example, price indexes from the Bureau of Economic Analysis (1987) indicate that the current cost of a unit of new corporate fixed asset in 1970 was 78.4. At the same time, Standard and Poor's Composite Price Index of Common Stocks stood at 91.1. By 1980 a doubling of price levels had pushed the current cost of fixed assets to 169.5. The S&P Stock Price Index, far from doubling and keeping pace with asset values, had increased to only 107.8. The apparent doubling of asset values and near constancy of liability values between 1970 and 1980 is a thorny reminder of an unanswered yet elementary question: Is there a stable relationship between the financial market value of corporate liabilities and the current replacement cost of corporate assets?

Brainard and Tobin (1968) argue that the ratio of market value to current

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replacement cost, hereafter referred to as the Q ratio, is generally unity and that its divergence from unity results only when disequilibrating forces exist. When corporate assets are cheap relative to corporate liabilities, i.e. when Q is greater than one, incentives exist for investment in capital assets from suppliers in the capital good markets. Conversely, when the market value of financial liabilities is less than the value of corporate assets, meaning Q is less than one, investment in financial liabilities is economically sensible. The argument is that values of assets and liabilities should be driven to equality.

There has been the development of a substantial body of literature that relies on the 'Q should tend to unity' maxim. These studies generally link deviations in Q with attributes such as investment opportunity, profitability, or resource utilization. In the early 1980s several studies examined conditions under which tax factors might cause equilibrium Q to diverge from unity. Although there are two variants to this 'tax bias theory', the gist in either case is that because of differential taxation the equilibrium value of Q is not one, but rather it is a number dependent on tax policy variables. If this is true, then it is not legitimate to link the variation in Q exclusively with the variation in ex ante variables. Regardless of differences among firms of future investment opportunities, monopoly rents, or profitability, Q may vary solely because of tax biases.

The important contention that differential tax effects cause variations in Q is tested in the current study. Evidence is presented that cross-sectionally and across time there is substantial variation in the relative size of corporate tax shields and, further, the variation is significantly correlated with variation in Q. The findings suggest that tax policies with differential tax treatment of new and existing assets cause deviations in Q. The deviation occurs because current replacement cost, the denominator of Q, assigns identical value to assets having equivalent productive capacities even though there may be differences in their after-tax profitabilities.

These results suggest that research based on analysis of deviations in unadjusted Q ratios may be affected by the differential tax bias. To test this conjecture, adjustments to Q are made by employing depreciation tax shield variables constructed herein. Several analyses examine the importance of substituting tax-adjusted for unadjusted Q ratios. For the most part, it is found that even though significant variation in Q is caused by the tax bias, the inferences from studies employing unadjusted Q ratios are likely robust to the differential tax bias.

The study proceeds as follows. Section 2 presents an overview of the existing literature that examines the association between Q and tax policy. Section 3 specifies the theoretical relationship between Q and depreciation tax shields. Section 4 presents empirical evidence for the nonfinancial corporate sector, 1968–1985 annually, and for ten U.S. manufacturing industries that time series and cross-sectional variation in industry Q ratios is partially explained by differences in depreciation tax shields. Evidence also is presented on whether inferences based on tax-adjusted Q ratios are different from inferences based on unadjusted Q ratios. A brief summary closes the study.

2. Q and tax policy in the existing literature

The seminal studies of Brainard and Tobin (1968) and Tobin (1969) introduce Q as a link between the financial and real sectors of the economy. In their models the economy contains two assets, money and real capital. The substitution of money for capital in large part depends on Q, the major determinant of new investment. 'Indeed, this is the sole linkage in the model through which financial events, including monetary policies, affect the real economy' [Brainard and Tobin (1968, p. 103)]. Von Furstenberg (1977) examines whether Q contains incremental information about the investment process relative to other readily available measures such as output and capacity utilization. Von Furstenberg concludes that 'It is not entirely obvious at this stage that Q can bring a significant amount of new information to bear on capital goods orders and investment.... The use of Q in equations for capital goods orders and investment is optional' (p. 380).[1]

For the purposes of the current study, the most significant feature of the von Furstenberg work is that it makes an adjustment to Q so that it reflects the impact of differential tax benefits. Von Furstenberg argues that the market value of discounted profits on marginal investment exceeds the cost of the investment by the amount of the investment tax credit (ITC). This verbal argument is used to point out that in equilibrium the marginal value of Q should tend to $(1-ITC)$. Therefore, the Q employed in all his empirical work is the measured Q divided by $(1-ITC)$. This yields a tax-adjusted Q that arguably tends to unity.

Q ratios are used without acknowledgement of potential tax biases in numerous studies. Lindenberg and Ross (1981) generate estimates of Q for 246 firms and link the ratios to monopoly power and industry concentration. Hirschey and Wichern (1984) obtain the ratios from Lindenberg and Ross and conclude through factor analysis that Q and alternative accounting profit measures are reflecting different underlying profitability characteristics.[2] Smirlock, Gilligan and Marshall (1984) construct their own Q ratios and use them as profitability measures, concluding that high profitability stems from efficient cost structure rather than market power. Morck,

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[1] Other studies linking Q to gross fixed investment include Bischoff (1971), Bosworth (1975), Clark (1979), Brainard and Tobin (1977), Malkiel, von Furstenberg and Watson (1979), Yoshikawa (1980), Chappel and Cheng (1982), and Hayashi and Inoue (1989).

[2] Several studies have employed the Q ratios from Lindenberg and Ross, including Salinger (1984), Hirschey (1985), Bernier (1987), Nguyen and Bernier (1988), and Montgomery and Wernerfelt (1988a, b).

Schleifer and Vishny (1988) also presume that Q measures economic profitability and they link variations in Q with variations in the proportion of equity owned by the Board of Directors. A significant but nonlinear association is found between Q and insider ownership. In these and many other studies the potential biasing influence of differential tax policies on Q is ignored.[3]

A handful of studies formally model the association between Q and tax policy parameters. Auerbach (1979) argues that because of the differential taxation of dividends and capital gains, the value of marginal Q can fall below unity, irrespective of the future opportunities or monopoly rents available to the firm. The gist of this tax bias argument is that a firm receiving \$1 of capital income has two choices about making the distribution to the shareholder. The firm can payout \$1, thereby providing the shareholder with $(1-\tau^{\mathrm{div}})$ dollars after personal taxes. Alternatively, the firm can reinvest the dollar thereby providing the shareholder with a capital gain after personal taxes of $(1-\tau^{\mathrm{cg}})$ dollars. Efficient management equates the marginal returns from these alternatives and therefore Q should tend to $(1-\tau^{\mathrm{div}})/(1-\tau^{\mathrm{cg}})$. As pointed out by Gordon and Malkiel (1981), the Auerbach argument requires a constraint on the repurchase of equity and it also implies that efficient management willingly spends a dollar to buy capital that is worth less than one dollar.

Summers (1981) incorporates tax policy parameters in a framework that shows Q depends on the depreciation tax shield attributable to prior investments. He argues that before Q is used in empirical analyses it must be adjusted to reflect tax policies. Although Summers finds that investment equations using a tax-adjusted Q as an explanatory variable are shown to have somewhat more explanatory power than equations that rely on the Q variable that is customarily used' (p. 69), there is no test that deviations in Q are caused by differential tax policies. Summers does conjecture, though, that perhaps the decline in depreciation tax shields on existing assets is partially responsible for the fall in average Q ratios observed throughout the 1970s.

Abel (1982) introduces adjustment costs in the Q framework in order to analyze the responsiveness of investment behavior to tax policy changes. He finds that the depreciation tax savings on existing assets are an important determinant of Q. Yet this term is dropped in the development of the investment model because it is 'irrelevant for investment decisions from time t_0 onwards and hence will be ignored' (p. 356).

Hayashi (1982) is widely cited because of his finding that average Q is a reliable measure of marginal Q to the extent that the firm is a price-taker with constant returns to scale in both production and installation. Another

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[3] Two recent studies employing tax-adjusted Q ratios in their analysis are Bernanke, Bohn and Reiss (1988) and McMillin and Parker (1990). Neither study presents results based on analysis of unadjusted Q so the empirical significance of the tax adjustment is not clear.

important result in his study, though, is that Q depends on the present value of tax depreciation deductions attributable to past investments and that the Q used in empirical work must be adjusted to reflect this biasing influence. Hayashi presents casual empirical evidence that the discounted depreciation tax shield declined throughout the 1970s, and suggests that it may explain a significant portion of the decline in Q.

The findings by Summers, Abel, and Hayashi suggest that Q varies among firms or between years because of the differences in depreciation tax shields promised by historical investments. Casual empirical evidence about macroeconomic movement in aggregate Q and depreciation tax shields is provided by Summers and Hayashi. Thus far, though, the important contention put forth by these authors that the variation in Q is attributable to differences in discounted depreciation tax shields has not been tested. If Q is biased by tax policies, it implies that inferences based upon unadjusted Q ratios might be invalid. Evidence on the significance of Q and tax biases is needed.

3. Representing the association between Q and tax shields

Roughly half of all assets in the nonfinancial corporate sector are fixed assets. These assets are valued by current replacement cost methodologies and the estimate is added to the denominator of Q. The assets promise, to some extent, depreciation tax shields. The tax shields generate after-tax cash flow that is capitalized by investors in setting the market value of financial claims on the assets. The market value estimate is added to the numerator of Q. This section specifies the association between discounted depreciation tax shields and current replacement cost, and hence the dependence of Q on the association is shown. Attention is focused first on describing the current replacement cost measure of the fixed net asset stock. Attention then is turned to specifying the fixed net asset stock's expected after-tax cash flow stream. The final subsection examines the source of differences between current replacement cost and discounted after-tax cash flows.

3.1. Current replacement cost: CC

The current replacement cost of the firm's assets is the cost of replacing existing assets with new ones while leaving current productive capacity unchanged. Measuring current replacement cost requires a modeling of the firm's history of capital accumulation. As a starting point, let q_tI_t denote the gross investment (capital expenditure) in new capital assets at time t. This term is comprised of a price or nominal component, q_t, representing the acquisition price at time t of a unit of new asset. Also, there is a quantity or real component, I_t, which represents the number of units of productive capacity acquired at time t. The actual investment cost is therefore comprised of a price times a quantity.

Valuation methodologies link capital expenditures with a maintained pattern of capacity depreciation.[4] Specification of the capacity depreciation schedule predetermines how much the asset incrementally contributes to *potential* production at every point in the useful service life. Typically, the capacity depreciation schedule is assumed exogenous and independent of utilization rates or maintenance expenditures.[5] Let d_j denote the proportional decline in an asset's productive capacity occurring at the end of the jth year of use. For example, with straight-line capacity depreciation over a five-year service life $d_j = 1/5$ for $j = 1, \ldots, 5$ and $d_j = 0$ otherwise. Accumulated capacity depreciation for an asset entering its tth year of service equals $\sum_{j=1}^{t} d_{j-1}$.

Current replacement cost (CC) estimates partition the time $s-t$ capital expenditure into its two components, q_{s-t} and I_{s-t}. The real component, I_{s-t}, is depreciated according to the capacity depreciation schedule. The historical price component, q_{s-t}, is dropped and instead attention is focused on valuing the remaining productive capacity of the asset by referencing the current price level of capital goods, q_S. More precisely, the CC estimate of asset value is obtained by multiplying current productive capacity and the current price of new investments. Thus, the CC at time s for the fixed net asset stock is

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\begin{aligned}
CC_s &= q_s \left\{ \sum_{t=1}^{\infty} I_{s-t+1} \left[1 - \sum_{j=1}^{t} d_{j-1} \right] \right\}, \\
&= q_s K_s. \qquad (1)
\end{aligned}
$$

K, the term in curly brackets in eq. (1) denotes the quantity of real capital in the fixed net asset stock. The dependence of CC on the current price level of capital goods is evident because each unit of real capital is multiplied by q_s.

An implication of eq. (1) is that a particular net asset stock is valued the same as any other net asset stock as long as the two have the same current productive capacities, i.e. investment histories and future cash flows are

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[4] The depreciation and capital stock definitions employed herein follow the standard notation as most recently stated by Kim and Moore (1988, p. 111): 'We should distinguish between economic (physical) depreciation and economic (value) depreciation. The first refers to the loss in productive capacity of a physical asset, while the second refers to the asset's loss in monetary value.' Herein, we follow the terminology of the Bureau of Labor Statistics (1979) and Bureau of Economic Analysis (1987) and refer to the first type as 'capacity depreciation'.

[5] The 'neoclassical theory of the firm' [e.g. Jorgenson (1967)] assumes that capacity depreciation is exogenous. Two of the few models that assume depreciation is endogenous and that it depends upon utilization rates and maintenance expenditures as choice variables are Epstein and Denny (1980) and Kim and Moore (1988).

irrelevant. With CC a unit of capital is assigned a value that is based upon its pre-tax productivity rather than its after-tax profitability. Market value, to the contrary, is based upon discounted after-tax cash flows.

3.2. Discounted after-tax cash flows and tax-adjusted fundamental value: FV

Showing the relationship between Q and tax shields requires a complete modeling of the after-tax cash flow stream expected from net fixed assets. The discounted value of the after-tax cash flow stream is referred to herein as the 'tax-adjusted fundamental value', denoted FV. Within most equilibrium models, assumptions are made about the existence of competitive markets and the absence of liquidity constraints. With these assumptions in place, rational behavior implies that entrepreneurs invest in assets as long as discounted after-tax cash flows exceed investment costs. The attainment of economic equilibria is the assurance that marginal investments have zero net present values. For marginal investments, FV equals CC.

The equivalence between FV and CC that is applicable to new investments provides the rationale for the false maxim that Q must tend to unity. As mentioned previously, Hayashi (1982) shows that even though CC for net fixed assets is systematically linked to discounted after-tax cash flows when the firm is a price-taker with constant returns to scale in both production and installation, CC does *not* equal FV. To the contrary, it is likely that CC overstates FV. This result arises because differences exist in the tax benefits available to new and existing assets. Two assets bundles may be productively equivalent and have identical current replacement costs yet they may yield different after-tax cash flows. In other words, productively equivalent net asset stocks may have different tax-adjusted fundamental values.

Tax-adjusted fundamental value is formulated within the following framework: (i) the stream of expected tax depreciation deductions is constructed by depreciating historical capital expenditures with tax practices in effect at times of installation; (ii) the stream of expected pre-tax cash flow is constructed by combining the rental price with the expected real capital service stream; and (iii) after-tax cash flow equals the tax savings from depreciation deductions, plus pre-tax cash flow net of proportional taxes, and the discounted sum of after-tax cash flows is the tax-adjusted fundamental value.[6] The discussion below describes how the above methodology is operationalized. Focus is directed first toward the depreciation tax shield and second to the pre-tax cash flow stream.

Computation of the depreciation tax shield is somewhat mechanical

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[6] The model for estimating FV is also used by Downs and Hendershott (1987), Downs and Tehranian (1988) and Downs and Demirgures (1991) for estimating the effects of tax reform on stock prices. The relationship between FV estimates and fundamental stock analysis is discussed by Downs (1991).

because assets are depreciated for tax purposes by the practices in effect at the time of investment. Let $z_{s,j}$ equal the proportion of the investment expenditure made at time s that can be deducted for tax purposes at time $s+j$. At time s, then, the remaining depreciation deductions on the time $s-t$ fixed investment equal $q_{s-t}I_{s-t}[1-\sum_{j=1}^{t} z_{s-t,j}]$. Valuing the deductions remaining beyond time s requires that all prior investments for the fixed net asset stock be allocated into the future and subsequently discounted. That procedure shows the present value at time s of the depreciation deductions promised per dollar of the fixed net asset stock, denoted Y_S, is

$$Y_S = \sum_{t=1}^{\infty} (1+r)^{-t} \sum_{j=0}^{\infty} q_{s-j}I_{s-j}z_{s-j,j+t}/q_sK_s, \tag{2}$$

where r is the weighted average financing rate. The tax savings offered by the depreciation tax shield for the above asset equal τY_s, where τ denotes the statutory corporate tax rate.

Jorgenson (1967) established that important information about pre-tax cash flow is contained in the zero net present value investment equilibrium between the price of a new asset and the discounted value of its expected after-tax cash flow stream. The rental price is the pre-tax cash flow expected per unit of real asset, denoted c, and it may be extracted from the investment equilibrium as

$$c_s = \frac{q_s[r-\pi][1-v-\tau Z_s]}{[1-D_s][1-\tau]}, \tag{3}$$

where v denotes the investment tax credit (if any), π denotes the expected inflation rate, Z_s is the present value of tax depreciation deductions per dollar of marginal investment,

$$Z_s = \sum_{j=1}^{\infty} (1+r)^{-j} z_{s,j}, \tag{4}$$

and D is from the capacity depreciation schedule,

$$D_S = \sum_{j=1}^{\infty} (1+r-\pi)^{-j} d_j. \tag{5}$$

For assets that retain original capacity perpetually, D is zero and it approaches unity as capacity depreciation accelerates.

The pre-tax cash flow generated per unit of asset at time s equals c_s. When all prices are expected to change at the same rate π, the pre-tax cash flow per unit of capital service expected at time $s+t$ is $c_s(1+\pi)^t$. The pre-tax cash flow expected from all asset equals $c_s(1+\pi)^t K_{s,t}$, where $K_{s,t}$ denotes the capital services contributed at time $s+t$ by the assets in-place at s,[7]

$$K_{s,t} = \sum_{u=0}^{\infty} I_{s-u}\left[1 - \sum_{j=1}^{t+u} d_{j-1}\right]. \tag{6}$$

The tax-adjusted fundamental value is

$$FV_s = \sum_{t=1}^{\infty} (1+r-\pi)^{-t}(1-\tau)c_s K_{s,t} + \tau Y_s q_s K_s. \tag{7}$$

Eq. (7) is an empirically operational model computing FV for the fixed net asset stock as the sum of discounted pre-tax cash flow net of proportional taxes plus discounted tax savings provided by the depreciation tax shield.

3.3. *Wedges between current replacement cost and discounted after-tax cash flows*

The model for tax-adjusted fundamental value in eq. (7) may be simplified in order to generalize the association between CC and FV. Let $h_{s,t}$ denote the proportional decline at time $s+t$ of the net fixed assets in place at time s. That is,

$$h_{s,t} = [K_{s,t} - K_{s,t+1}]/K_s. \tag{8}$$

Notice that the $h_{s,j}$ series is the mortality distribution for the time s net fixed asset stock. The series is determined exclusively by the interaction between the capital accumulation pattern and the capacity depreciation schedule. Substitution of eqs. (3) and (8) into (7) yields, after rearrangement,

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[7] This assumes a constant real marginal physical product of capital beyond time s. In other words, the relative contribution to production of K with respect to the other factor inputs remains the same as it is at time s. This imposes restrictions on cost and revenue functions of continuity, constant returns to scale, and simultaneous successive expansion [Thomas (1969, esp. pp. 41–47)].

$$FV_s=[(1-\upsilon-\tau Z_s)(1-H_s)/(1-D_s)]q_sK_s+\tau Y_sq_sK_s,$$

$$=CC_s[(1-\upsilon-\tau Z_s)(1-H_s)/(1-D_s)+\tau Y_s], \tag{9}$$

where H_s is obtained as

$$H_s=\sum_{t=1}^{\infty}(1+r-\pi)^{-t}h_{s,t}. \tag{10}$$

To the extent that financial market value follows tax-adjusted fundamental value, Q should track the ratio FV/CC. This 'intrinsic Q ratio' is found by rearranging eq. (9) as

$$FV_s/CC_s=(1-\upsilon-\tau Z_S)(1-H_s)/(1-D_s)+\tau Y_s. \tag{11}$$

Intrinsic Q equals the sum of the two right-hand-side terms in eq. (11). Under some conditions the sum equals 1.0, FV and CC are conceptually equivalent, and intrinsic Q is unity. There are two reasons why intrinsic Q may differ from unity. The first pertains to capital accumulation and capacity depreciation patterns. The second pertains to tax biases.

For the moment, suppose there are no taxes (υ and τ equal zero), in which case intrinsic Q equals $(1-H)/(1-D)$. D depends solely on the capacity depreciation schedule of new assets, whereas H depends on the mortality distribution of the aggregate capital stock. The dependence of intrinsic Q on the interaction of capital accumulation and capacity depreciation paths is easily illustrated when assets depreciate along one-hoss-shay patterns. For example, suppose capital stock A is comprised exclusively of 1,000 new lightbulbs and capital stock B is comprised exclusively of 1,000 lightbulbs that are near the end of their service lives.[8] The current replacement cost of capital stocks A and B are identical because they each possess the same quantity of current productive capacity; they contribute equal amounts of current real capital services to production. The future productive capacity of stock A is much higher than for stock B, thus the discounted value of after-tax cash flows for A is much higher than for B, and its Q ratio is higher too. For capital stock A, the H and D terms are equal and intrinsic Q is unity

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[8] This illustration has benefited from insightful discussions with Kenneth Rogers and John Musgrave at the U.S. Department of Commerce (Office of Business Economics and Bureau of Economic Analysis, respectively) and Charles Hulten at the University of Maryland. The illustration is not restricted to the one-hoss-shay pattern. For example, say assets depreciate by straight-line over a ten-year service life. One unit of K comprised of fractional assets entering the ninth year of use has identical current replacement cost as one unit of new K because the two bundles have identical *current* capacity. Conversely, there are differences in their *future* capacities, discounted after-tax cash flows, and intrinsic Q ratios.

because the marginal capacity depreciation schedule is the same as the aggregate mortality distribution. However, for capital stock B, the H term is near unity, D is relatively small, and the intrinsic Q ratio, $(1-H)/(1-D)$, approaches zero.

In the absence of taxes and with constant returns to scale, the intrinsic Q ratio differs from unity if marginal assets and aggregate net asset stock depreciate along different paths.[9] This occurs because the price of new assets capitalizes the real service stream promised by new assets. The price of new assets is used in the current replacement cost methodology as a benchmark for valuing existing assets and adjustments are made for differences in *current* productive capacities. However, if the *future* productive capacities for new and existing assets differ, the current supply price is not a good benchmark for the discounted value of after-tax cash flows from existing assets. The Q ratio will not equal unity because CC, the denominator, is a biased estimate of tax-adjusted fundamental value.

The only capacity depreciation schedule for which intrinsic Q possibly equals unity is geometric depreciation. Hall and Jorgenson (1967) assume exogenous geometric depreciation, and Hulten and Wykoff (1981) provide supporting evidence. The geometric assumption has been challenged by Eisner (1972) and Feldstein and Rothschild (1974). Nonetheless, even with geometric depreciation, intrinsic Q may differ from unity due to tax biases.

Consider the case when the corporate income tax rate is τ, the rate of investment tax credit is v, the tax depreciation schedule for time s is summarized in the series of weights $z_{s,t}$, and capacity depreciation occurs at the geometric rate δ; i.e. $d_t=\delta(1-\delta)^{t-1}$ and $h_{s,t}=\delta(1-\delta)^{t-1}$. Simplifying eq. (11) shows that the intrinsic Q ratio is

$$FV_s/CC_s=1-v-\tau(Z_s-Y_S). \qquad (12)$$

This expression is unity when there are no taxes or when new investments and existing assets face the same tax treatment.[10] However, to the extent that new assets receive an investment tax credit (v or ITC), or to the extent that depreciation tax savings per dollar of new investment (τZ) exceed the savings per dollar of existing capital (τY), the discounted value of after-tax

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[9] Wildasin (1984) presents a conceptually analogous argument in a different context. He argues that there are for one firm many capital goods, meaning many marginal Q, and that under most conditions there is not a stable relationship between tax-adjusted Q and investment. The argument herein is that capital embodies time, assets from different vintages possess varying embodiments of time, and a capital stock that is heterogeneous with respect to embodied time, even though homogeneous with respect to production, does not have a stable intrinsic Q ratio.

[10] An interesting tax policy under which Y tends to Z is when (i) the depreciable basis is indexed to inflation, and (ii) the tax depreciation rate equals the economic depreciation rate δ. This policy was proposed with the U.S. Treasury Tax Reform Proposal of November 1984 but never enacted. Under these conditions $c=q[r+(1-\tau)\delta-\pi]/(1-\tau)$ and FV equals qK.

cash flows is less than the current replacement cost of the assets. Even with geometric capacity depreciation and constant returns to scale, intrinsic Q depends on the depreciation tax shields acquired through historical capital expenditures. These tax shields are independent of the firm's current or future decisions and they may cause variation in Q.

Most research employing Q ignores the tax bias introduced by differential tax policies. They rely on unadjusted Q ratios for making inferences about monopoly power, investment opportunities, economic performance, etc. If a substantial portion of the variation in unadjusted Q is explained by the movement in historical discounted depreciation tax shields, the reliability of their inferences is called into question.

4. The empirical significance of the tax bias in Q

Unadjusted Q is the ratio of market value to current replacement cost and it is hypothesized to track intrinsic Q, where the latter equals one minus the differential tax benefits between new and existing assets. This section presents empirical estimates of unadjusted and intrinsic Q ratios annually, 1968–1985, for the U.S. nonfinancial corporate sector (NFC) and for ten two-digit SIC U.S. manufacturing industries.[11] A discussion on constructing the tax shields is followed by a discussion on the existence of tax biases in unadjusted Q, followed by analyses that assess the econometric importance of adjusting Q for tax biases.

4.1. Construction and characteristics of the depreciation tax shields

The tax shields are constructed by depreciating historical capital expenditures in order to compute the stream of expected depreciation deductions. These streams are reconstructed for each year in the sample set. For example, the first year for which tax shields are constructed is 1968. In that year capital expenditures from all earlier years are depreciated to arrive at the tax book value as of 1968, e.g. investments from 1948 are depreciated to 1968 by using the tax practices in effect in 1948. The expenditures from all earlier years are subsequently depreciated beyond 1968, thereby resulting in the stream of expected tax depreciation deductions promised by the 1968 fixed net asset stock. The present value of the stream per dollar of existing capital is Y_{1968}, as specified in eq. (2). In 1969 (or any subsequent year) the

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[11] The adjustment reflects only tax effects. Deviations in Q attributable to differences in D and H are ignored. The sample selection is driven by data availability. The database by Hall, Cummins, Laderman and Mundy (1988) has annual data on Q only through 1985 and only for manufacturing firms. The ten industries selected encompass 73 percent of the net fixed assets in the manufacturing sector and they were analyzed by von Furstenberg, Malkiel and Watson (1980).

process is repeated; all investment expenditures preceding the reference year are depreciated for tax purposes up to the reference year and then remaining deductions are allocated into the future and discounted.

Capital expenditures data are available for each industry from the Bureau of Economic Analysis (1987) for two asset types, structures and equipment. The depreciation deductions for these two assets are computed separately and are then added together to arrive at the stream of total deductions promised to that particular industry. The tax depreciation schedules used to depreciate capital expenditures are reflected in the series of weights $z_{s,j}$ ($1,\dots,L$, where L is the asset tax life). This series sums to unity and it is recomputed annually for each asset, industry, and year ($s=1968-L,\dots,$ 1981), according to the procedures outlined by Downs and Hendershott (1987). The discount rate is a weighted average of (after-corporate-tax) debt and equity financing rates and it is recomputed for each industry and year according to the procedures outlined by Downs and Tehranian (1988). Intrinsic Q depends on the difference, $Z-Y$, and therefore it is fairly robust to the measurement of r because errors tend to cancel.

The stream of tax depreciation deductions is discounted with the weighted average financing rate. Some of the results from that process are listed in table 1. New NFC equipment in 1970 promises discounted tax depreciation deductions totaling $0.6752 per dollar of investment. The tax savings from the deductions are capitalized in the price of new investments, and that price is subsequently employed in order to establish the current replacement cost of existing assets. As listed in table 1, though, existing assets offered substantially fewer tax shields. A bundle of existing assets entering the seventh year of use but having equivalent current productive capacity as a new investment promises discounted depreciation deductions totaling $0.2690. The productive capacity of the new investment and the bundle of existing assets are equivalent, so therefore the two have identical current replacement costs, yet there are substantial differences in their discounted tax shields and after-tax cash flows.

Table 1 also reveals the acceleration between 1970 and 1981 in the tax depreciation schedules. Discounted depreciation tax savings on new investments increase because deductions become more front-loaded, but as new assets age they of course shed their tax shields relatively quickly. In 1970, equipment entering the seventh year of use has discounted tax savings that are 40 percent as large as the tax savings promised by new investments. In 1981, that proportion is 20 percent, signifying that the extent of the bias inherent with differential tax benefits is increased.

The lower part of table 1 lists the discounted tax depreciation deductions per dollar of existing net fixed assets. These entries correspond to Y from eq. (2) and are presented by type of asset (structures and equipment) as well as the combined asset average ('P&E') The entry in 1970 of $0.6220 is a

Table 1
Summary of discounted tax depreciation deductions per dollar of NFC equipment.

Per $ of assets entering this year of use	Discounted tax depreciation deductions in 1970	Discounted tax depreciation deductions in 1981
1	$0.6752	$0.7877
2	0.6422	0.5853
3	0.5331	0.4513
4	0.4418	0.3481
5	0.3702	0.2697
6	0.3123	0.2096
7	0.2690	0.1605
8	0.2332	0.1111
9	0.1970	0.0805
10	0.1611	0.0608
11	0.1262	0.0440
12	0.0885	0.0466
13	0.0513	0.0334
Y, the average for the net asset stock		
Equipment	0.6220	0.5010
Structures	0.3703	0.2414
Combined P&E	0.4909	0.3704

Notes: Each entry in the table is the present value of tax depreciation deductions remaining on a productively equivalent bundle of assets entering the tth year of use.

New assets are depreciated one-half year in their first year of use.

weighted average across all equipment vintages listed in the upper part of the table. Its closeness to the entry for two-year-old assets indicates that the bulk of discounted cash flows are generated by relatively new assets, e.g. the stock of seven-year-old equipment generates few depreciation tax savings relative to the amount generated by one- and two-year-old assets.

Table 2 lists the values of Z, Y, and intrinsic Q for NFC P&E in each year, 1968–1985. These intrinsic Q ratios assume geometric capacity depreciation and are computed according to eq. (12). Settings for the ITC are from the SSRC, as are the estimates of τ. Throughout the eighteen-year sample period Y begins at 53 cents and falls to as low as 37 cents. Conversely, Z rises from as low as 55 cents to as high as 67 cents. The gap, $Z-Y$, opens more than eight-fold from 3.55 cents in 1968 to 29.27 cents in 1981, and then it falls back to 21.18 cents by 1985. A tremendous overstatement bias in CC is exerted because the preferential tax benefits extended to new investments are being capitalized in new asset prices. The tax benefits from aging assets, to

Table 2
Components and estimates of intrinsic Q ratios, 1968–1985, nonfinancial corporate structures and equipment.

Year	Z	Y	Intrinsic Q
1968	0.5637	0.5282	0.9519
1969	0.5593	0.5159	0.9709
1970	0.5457	0.4909	0.9715
1971	0.5714	0.4841	0.9408
1972	0.5729	0.4800	0.9275
1973	0.5874	0.4879	0.9229
1974	0.5949	0.4657	0.9062
1975	0.5761	0.4174	0.8659
1976	0.5789	0.4119	0.8611
1977	0.5933	0.4206	0.8580
1978	0.5902	0.4157	0.8567
1979	0.5719	0.4018	0.8595
1980	0.5249	0.3702	0.8842
1981	0.6631	0.3704	0.7956
1982	0.6574	0.3747	0.7975
1983	0.6742	0.4100	0.8073
1984	0.6660	0.4224	0.8275
1985	0.6412	0.4294	0.8426

Notes: Z is the present value of tax depreciation deductions per dollar of new investment.

Y is the present value of tax depreciation deductions per dollar of existing net fixed assets.

Intrinsic Q is computed from eq. (12) as $1-v-\tau(Z-Y)$, where v is the investment tax credit and τ is the corporate tax rate, and it represents the theoretical ratio of tax-adjusted fundamental value to current replacement cost.

the contrary, are lessened because their tax shields are being exhausted during the early years of the service life.[12]

The overstatement bias in current replacement cost estimates is reflected through the decline in intrinsic Q, listed in the third column of table 2. Its movement reflects an opening in the gap $Z-Y$ as well as a slight increase in the *ITC*. In 1970 intrinsic Q for NFC P&E is 0.9715. Its closeness to unity implies only a slight divergence between *CC* and *FV*; discounted deductions per dollar of new and existing assets are almost equal. Intrinsic Q steadily

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[12] If assets could be churned costlessly, then the wedge introduced by the *ITC* or by accelerated depreciation could not persist. Auerbach and Kotlikoff (1983) estimate the benefits of churning pre-1981 investments so that tax depreciation schedules are reset to ACRS guidelines. They find that no equipment, but a substantial fraction of structures, could gain by transferring ownership and being brought under ACRS. The presence of transactions costs makes it difficult to know how much of this churning would take place. The current study proceeds as if no churning occurs.

Table 3
Intrinsic Q ratios in different industries, 1968–1985.

	SIC industry code									
Year	20	22	26	28	29	30	32	33	35	36
1968	0.9429	0.9291	0.9326	0.9199	0.9779	0.9286	0.9481	0.9452	0.9390	0.9576
1969	0.9711	0.9511	0.9622	0.9469	0.9819	0.9621	0.9732	0.9681	0.9642	0.9817
1970	0.9750	0.9534	0.9642	0.9494	0.9793	0.9672	0.9749	0.9677	0.9675	0.9827
1971	0.9454	0.9124	0.9126	0.9058	0.9521	0.9208	0.9459	0.9316	0.9324	0.9453
1972	0.9304	0.8906	0.8917	0.8838	0.9379	0.9031	0.9286	0.9106	0.9109	0.9305
1973	0.9287	0.8845	0.8926	0.8791	0.9316	0.8993	0.9229	0.9068	0.9265	0.9265
1974	0.9063	0.8517	0.8760	0.8613	0.9115	0.8782	0.8967	0.8884	0.9054	0.9062
1975	0.8695	0.8108	0.8233	0.8151	0.8783	0.8291	0.8593	0.8452	0.8772	0.8722
1976	0.8563	0.8089	0.8333	0.8193	0.8724	0.8324	0.8548	0.8526	0.8842	0.8688
1977	0.8613	0.8109	0.8209	0.8202	0.8834	0.8242	0.8468	0.8408	0.8844	0.8618
1978	0.8587	0.8083	0.8314	0.8201	0.8625	0.8156	0.8535	0.8440	0.8830	0.8712
1979	0.8586	0.8052	0.8358	0.8209	0.8644	0.8162	0.8638	0.8580	0.8878	0.8757
1980	0.8741	0.8354	0.8555	0.8395	0.8944	0.8448	0.8864	0.8799	0.9067	0.9013
1981	0.7976	0.7580	0.7656	0.7652	0.8130	0.7747	0.7906	0.7824	0.8316	0.8342
1982	0.7986	0.7637	0.7642	0.7653	0.8147	0.7737	0.8016	0.7773	0.8338	0.8397
1983	0.8020	0.7654	0.7575	0.7629	0.8200	0.7741	0.7992	0.7773	0.8406	0.8519
1984	0.8190	0.7877	0.7915	0.7809	0.8340	0.7948	0.8215	0.7923	0.8575	0.8672
1985	0.8202	0.7761	0.7830	0.7868	0.8295	0.8116	0.8425	0.7975	0.8736	0.8780
Sample maximum minus minimum										
	0.1774	0.1954	0.2067	0.1865	0.1689	0.1935	0.1843	0.1904	0.1359	0.1430

Notes: Intrinsic Q is computed from eq. (12) as $1-v-\tau(Z-Y)$ and it represents the theoretical ratio of tax-adjusted fundamental value to current replacement cost.

Industries are identified by their SIC codes in table 4.

declines throughout the 1970s, it reaches its low point of 0.7956 in 1981, and it rebounds to 0.8426 by 1985. This movement is due exclusively to changes in discounted depreciation tax shields and is evidence that the biasing influence of U.S. tax policies on Q may be substantial.

The intrinsic Q for the ten manufacturing industries listed in table 3 are qualitatively similar to those for the NFC. There is a substantial decline in all industries; sample maximums occur in either 1969 or 1970 and minimums occur in either 1981, 1982, or 1983. The extent of the declines in intrinsic Q differ among industries. The smallest decline of 13.59 percentage points occurs in Nonelectrical Machinery (SIC 35). The largest decline of 20.67 points occurs in Paper Products (SIC 26). If the movement in these relative depreciation tax shields drive Q, as hypothesized in this study, then the depressant effect on Q is substantially greater in Paper Products than in Nonelectrical Machinery.

4.2. *Evidence on the existence of the tax bias in Q*

To test the conjecture that Q is driven by relative movements in discounted depreciation tax shields, estimates of unadjusted Q ratios are constructed from the *R&D MasterFile* [(Hall, Cummins, Laderman and Mundy (1988)]. The source data for the *MasterFile* is primarily balance sheet and income statement information from *Compustat*, but Hall et al. augment and adjust the data so that they reflect the current replacement cost of all assets (the *MasterFile* variable *NETCAP*) and the market value of all debt and equity (the variable *VAL*). Unadjusted Q ratios are constructed by sorting firms according to two-digit SIC codes and computing the industry ratio of total *VAL* to total *NETCAP*.

The industry data for the eighteen years (1968–1985) are stacked and the unadjusted Q ratios are regressed on the intrinsic Q ratios using the seemingly unrelated regression technique. The SUR technique is appropriate for this situation because there is likely contemporaneous residual correlation across industry equations. The resulting system of ten equations is

$$\boldsymbol{Q}^{20}=\alpha^{20}\boldsymbol{U}+\beta^{20}\boldsymbol{F}^{20}+\boldsymbol{E}^{20},$$

$$\boldsymbol{Q}^{22}=\alpha^{22}\boldsymbol{U}+\beta^{22}\boldsymbol{F}^{22}+\boldsymbol{E}^{22},$$

$$\ldots$$

$$\boldsymbol{Q}^{36}=\alpha^{36}\boldsymbol{U}+\beta^{36}\boldsymbol{F}^{36}+\boldsymbol{E}^{36},$$

$\boldsymbol{Q}^{\mathrm{sic}}$ represents the vector of 18 unadjusted Q ratios in industry 'SIC' (the two-digit SIC code), $\boldsymbol{U}$ is a unit vector, $\boldsymbol{F}^{\mathrm{sic}}$ is a vector containing the 18 intrinsic Q ratios computed as $1-v-\tau(Z-Y)$ and listed in table 3, and $\boldsymbol{E}^{\mathrm{sic}}$ is the vector of residual errors. The estimated intercept and slope coefficients for industry SIC are α^{sic} and β^{sic}, respectively.

This regression model does not constitute a complete specification for Q because deviations likely result from differences in monopoly power, profitability, etc. Nevertheless, the slope coefficient is expected to be positive and statistically significant and the R^2 indicates the proportion of variation in unadjusted Q that is explained by movement in relative depreciation tax shields.

Results from the time-series regressions are shown in table 4. In all ten industries the slope coefficient has the expected sign and is significant at the 1 percent level. The hypothesis that the ten slope coefficients jointly equal zero is rejected at the 0.001 percent significance level. Additionally, the explanatory power of the equations is fairly high, as evidenced by R^2 values in the 50 percent range. The generally high significance level for the Ljung–Box statistic suggests residual autocorrelation is not a problem. These results indicate that the relative movement in the discounted depreciation tax shields

Table 4

Time series regression results, 1968–1985, annual observations.

Unadjusted $Q_t = \alpha + \beta$ (intrinsic Q)$_t$

Industry group	α	β	R^2	Ljung–Box significance level
Food products, SIC 20	-1.52 $(-4.30)^b$	2.83 $(7.09)^b$	0.55	0.08
Textile products, SIC 22	-1.46 $(-5.75)^b$	2.50 $(8.32)^b$	0.62	0.48
Paper products, SIC 26	-0.87 $(-3.25)^b$	1.84 $(5.85)^b$	0.49	0.26
Chemical products, SIC 28	-1.01 $(-2.85)^a$	2.36 $(5.62)^b$	0.56	0.97
Petroleum products, SIC 29	-1.80 $(-5.90)^b$	2.79 $(8.19)^b$	0.75	0.29
Rubber and plastics, SIC 30	-1.94 $(-5.77)^b$	3.05 $(7.82)^b$	0.59	0.43
Stone, clay, and glass, SIC 32	-1.76 $(-5.32)^b$	2.77 $(7.40)^b$	0.57	0.56
Primary metals, SIC 33	-0.56 $(-2.99)^a$	1.19 $(5.56)^b$	0.50	0.83
Non-electrical machinery, SIC 35	-3.08 $(-3.79)^b$	4.66 $(5.14)^b$	0.55	0.44
Electrical machinery, SIC 36	-2.00 $(-2.68)^a$	3.43 $(4.13)^b$	0.37	0.02

[a] Significant at the 5 percent level.

[b] Significant at the 1 percent level.

Notes: Unadjusted Q equals the ratio of industry market value to current replacement cost and is taken from the R&D MasterFile [Hall et al. (1988)].

Intrinsic Q is computed from eq. (12) as $1-v-\tau(Z-Y)$ and it represents the theoretical ratio of tax-adjusted fundamental value to current replacement cost.

Coefficients are estimated in a pooled regression with the seemingly unrelated regression technique.

T-statistics are shown in parentheses.

The Ljung–Box statistic tests for residual autocorrelation.

on new and existing assets explains the year-to-year variation in unadjusted Q ratios.[13]

The existence of a uniform relationship between unadjusted Q and the tax shields variable is tested by estimating the equation system with an equality constraint on the slope coefficient. The slope coefficient in the restricted equation equals 2.57 and its t-statistic is 12.19, indicating a high degree of

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[13] Q is regressed on the variable $Z-Y$ in order to verify that movement in relative tax shields rather than the investment tax credit drives Q. The results are qualitatively similar to those in table 4. Also, $\log(Q)$ is regressed on $\log(F)$. The slope coefficients from the log-equation are qualitatively similar in magnitude and significance, and the constants are around zero.

Table 5

Cross-sectional regression results, 10 industries.

	Unadjusted $Q_t = \alpha + \beta$ (intrinsic Q)$_t$				
Year	α	(t-stat)	β	(t-stat)	R^2
1968	1.80	(0.30)	−0.42	(−0.06)	0.00
1969	−2.31	(−0.31)	3.54	(0.45)	0.02
1970	−2.24	(−0.31)	3.37	(0.46)	0.03
1971	−2.07	(−0.38)	3.35	(0.58)	0.04
1972	−1.33	(−0.28)	2.58	(0.50)	0.03
1973	−0.96	(−0.27)	1.94	(0.50)	0.03
1974	−1.68	(−0.50)	2.59	(0.69)	0.06
1975	−1.53	(−0.58)	2.62	(0.85)	0.08
1976	−1.48	(−0.68)	2.61	(1.01)	0.11
1977	−3.64	(−1.62)	5.10	(1.92)[a]	0.31
1978	−4.05	(−1.75)	5.54	(2.02)[a]	0.34
1979	−3.16	(−1.57)	4.43	(1.87)[a]	0.30
1980	−4.22	(−1.82)	5.56	(2.10)[a]	0.35
1981	−3.15	(−2.39)[b]	4.71	(2.83)[b]	0.50
1982	−1.91	(−1.11)	3.23	(1.49)	0.22
1983	−2.14	(−1.21)	3.60	(1.63)	0.25
1984	−2.74	(−1.49)	4.16	(1.85)[a]	0.30
1985	−1.74	(−0.92)	3.01	(1.31)	0.18

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

Notes: Unadjusted Q equals the ratios of industry market value to current replacement cost and is taken from the R&D MasterFile [Hall et al. (1988)].

Intrinsic Q is computed from eq. (12) as $1 - v - \tau(Z - Y)$ and it represents the theoretical ratio of tax-adjusted fundamental value to current replacement cost.

T-statistics are shown in parentheses.

statistical significance. A standard F-statistic is computed from the sum-of-squared residuals in the unrestricted and restricted estimations. That statistic, with 9 and 160 degrees of freedom in the numerator and denominator, respectively, equals 1.63 and is less than the 5 percent critical value of 1.94. The stability across industries of the time-series relationship between unadjusted Q and discounted depreciation tax shields lends support to the theoretical specification.

The tax bias theory also predicts that within any given year Q varies between industries because of differences in tax shields. This hypothesis is investigated through examination of cross-sectional regressions of unadjusted Q on intrinsic Q. These regressions are estimated independently by year and the results are listed in table 5. During the first half of the sample period there is little explanatory power in differential tax shields; R^2 values are less than 5 percent. During the latter half of the 1970s, though, the significance level of the tax shield variable increases. In the years from 1977 to 1985, the coefficients are statistically different from zero at the 10 percent significance level or better for six years.

The data from 1977 to 1985 are isolated in order to investigate further the cross-sectional significance of the association between unadjusted Q and depreciation tax shields. The 90 unadjusted Q ratios (9 years, 10 industries) are regressed on intrinsic Q, and intercept dummy variables are added for each year.[14] The slope coefficient on intrinsic Q equals 4.19 with a t-statistic of 5.63. This indicates that for the nine years jointly the discounted depreciation tax shields are significant determinants of cross-sectional variation in unadjusted Q ratios.

The cross-sectional results are consistent with the following interpretation. Tax policies prior to the mid-1970s had not caused significant biases in current replacement cost estimates and little of the variation in unadjusted Q was attributable to differential tax effects. As the decade progressed, the incentive tax policies extending preferential tax treatment to new investments became increasingly important and they had a dual impact. First, they increased the value of tax benefits capitalized in new asset prices. This exerted immediate downward pressure on unadjusted Q. Second, as new assets aged their tax depreciation deductions were rapidly exhausted and there was a decline in the tax shield for existing assets. This depressant effect revealed itself only with the passage of time and differences between tax benefits on new and existing assets increased. Since 1977, significant variations in unadjusted Q ratios have been caused by differential tax policies.

4.3. *Evidence on the importance of using tax-adjusted rather than unadjusted Q*

Q is biased by differential tax effects and it is uncertain whether inferences from studies utilizing unadjusted Q ratios are robust to the tax bias. The importance of making the tax adjustment is gleaned in this subsection through two analyses. First, the correlation between unadjusted and tax-adjusted Q ratios for alternative samplings is examined. If the correlation between the two series were perfect, the tax-adjustment would not alter summary statistics or significance levels and inferences would be robust. In the second analysis, results in an econometric study are obtained by substituting the tax-adjusted for the unadjusted Q. The qualitative difference in results for this application provides information about whether ignoring the tax bias is warranted.

Among the studies employing tax-adjusted Q ratios, two different pro-

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[14] Estimation of the equation without annual intercept dummy variables yields a slope coefficient on intrinsic Q equal to 2.00 with a t-statistic of 3.49. However, the increase in sum-of-squared residuals allows rejection at the 1 percent significance level of the hypothesis that the dummies jointly equal zero.

cedures have been used for making the adjustment. Von Furstenberg (1977) constucts a tax-adjusted Q by dividing the measured Q by $1-ITC$. Even though this adjustment ignores disproportionate depreciation tax shields, the procedure is tantamount to division of unadjusted Q by intrinsic Q. Summers (1981), Hayashi (1982), and Hayashi and Inoue (1989) use a procedure tantamount to the subtraction of intrinsic Q from unadjusted Q. Herein, both procedues are used and there are no qualitative differences in results. In the discussion below the unadjusted Q ratio is the one obtained from the *MasterFile*. The tax-adjusted Q equals unadjusted Q minus intrinsic Q.

Among the ten industries and eighteen years the correlation between the 180 pairs of unadjusted and tax-adjusted Q ratios is 0.98. The high correlation also is found when the pairs are partitioned by industry or time subperiods.[15] The finding is checked further by repeatedly drawing random pairs from the two 180-length vectors and computing correlation coefficients. Regardless of whether the sampling size is small or large, the high correlation persists. This is preliminary evidence that the results from studies relying on unadjusted Q ratios are likely to be unaffected by adjustment with the intrinsic Q ratios presented in table 3.

The high correlation between unadjusted and tax-adjusted Q occurs for two reasons. First, there is significant correlation between intrinsic Q and unadjusted Q. With repeated random samplings, the average correlation between these two series exceeds 0.60. Subtracting intrinsic Q from unadjusted Q yields a tax-adjusted series with empirical characteristics that are similar to the unadjusted series. Second, the intrinsic Q among the different industries is correlated highly because the tax schedules used to construct the depreciation tax shields, while not identical across industries, are very similar and likely do not reflect as much variation as actually occurs. The high interindustry correlation among the intrinsic Q means that the tax-adjusted series is not as dissimilar from the unadjusted series as it might otherwise be.

The importance of using tax-adjusted rather than unadjusted Q is assessed further by substituting one series for the other in an econometric analysis. The analysis is based on the test by Salamon (1985) of the Fisher–McGowan (1983) hypothesis that the accounting rate of return (ARR) contains systematic biases about the true economic profit rate (EPR). Salamon tests the hypothesis for 197 firms over the 1974–1978 sample period by focusing on the positive significant relationship between the ARR and firm size ($SIZE$). He uses a three-step procedure. First, the ARR is regressed on $SIZE$ and the existence of a positive and significant relationship is established. Second, the ARR is regressed on a proxy for the EPR. This

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[15] The high correlation between tax-adjusted and unadjusted Q ratios in the 1970s is also evident in Summers (1981). His data show that the correlation coefficient between these series for the NFC, 1970–1978, is 0.85. For his complete time series, 1931–1978, the correlation coefficient is substantially less, 0.45.

second step partitions the *ARR* into two components: economic profit and residual error (*RES*). Third, the two components are regressed (independently) on *SIZE* in order to see whether the significant association between *ARR* and *SIZE* is due to *EPR* or *RES*. Salamon finds that *RES* is significantly related to *SIZE*, whereas *EPR* is not. He concludes that the significant positive association between *ARR* and *SIZE* occurs from the systematic bias in the *ARR* rather than from information about economic profitability.

The analysis herein conducts the three-step analysis for the cross-sectional sample of ten industries in 1979 with *ARR* and *SIZE* variables obtained from the *MasterFile*.[16] Regression of *ARR* on *SIZE* shows a significant positive relationship (*t*-statistics in parentheses),

$$\underset{(16.10)}{ARR=0.0696}+\underset{(3.11)}{1.3501}\ SIZE,\quad R^2=0.55.$$

As argued by Fisher and McGowan, though, the significant relationship may be due to a systematic bias in the *ARR* rather than its information content about economic profitability. Therefore, the *ARR* is partitioned by regressing it on unadjusted *Q*, since *Q* is used widely as a measure of the economic profit rate (*EPR*). That regression shows

$$ARR=\underset{(3.99)}{0.0554}+\underset{(1.66)}{0.0362}\ (\text{unadjusted } Q),\quad R^2=0.26.$$

The vector of residuals (*RES*) from the preceding equation is regressed on *SIZE*, as is unadjusted *Q*:

$$RES=\underset{(-2.36)}{-0.0073}+\underset{(4.17)}{1.3024}\ SIZE,\quad R^2=0.68,$$

$$\text{unadjusted } Q=\underset{(6.63)}{0.5962}+\underset{(0.15)}{1.3180}\ SIZE,\quad R^2=0.01.$$

SIZE is significantly related to *RES* but not to unadjusted *Q*. Therefore, the significant positive association between the *ARR* and *SIZE* is due to the bias in the *ARR*, rather than information about economic profitability. These findings are analogous to the ones obtained by Salamon.

The robustness of the preceding findings to the tax bias in unadjusted *Q* is

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[16] The *ARR* is proxied by the *MasterFile* variable *GRATE*, and *SIZE* is proxied as *BKPLANT* plus *CURRASST*. The invariance of the econometric substitution of unadjusted and tax-adjusted *Q* holds true for each year in the 1968–1985 sample period. However, only in 1979 are the qualitative findings analogous to the ones in Salamon (1985).

deduced by utilizing tax-adjusted Q in the analysis. Estimation of the equations with the tax-adjusted series shows

$$\underset{(11.51)}{ARR = 0.0860} + \underset{(1.50)}{0.3566}\ (\text{tax-adjusted } Q), \quad R^2 = 0.22,$$

$$RES = \underset{(-2.31)}{-0.0075} + \underset{(4.09)}{1.3263}\ SIZE, \quad R^2 = 0.68,$$

$$\text{tax-adjusted } Q = \underset{(-2.95)}{-0.2487} + \underset{(0.08)}{0.6669}\ SIZE, \quad R^2 = 0.01.$$

The residual rather than the economic profit component of the ARR is responsible for its significant positive association with $SIZE$. The conclusion is unchanged by the substitution, implying that tax adjustment is unnecessary, even though earlier results have shown that movement in relative tax shields explain significant cross-sectional variations in unadjusted Q.[17]

5. Summary

This study establishes that variation in Q occurs as a result of phenomena that are unrelated to the future decisions or performance of the firm. A tax bias in Q occurs because the current replacement cost of assets, the denominator of Q, is a valid measure of economic value when assets with equivalent productive capacities yield identical after-tax cash flows. In fact, though, new investments are extended preferential tax treatment in the form of accelerated depreciation schedules or, at times, investment tax credits. Those tax benefits are capitalized in the price of new investments. Valuing existing assets by relying on that price, such as is done in the current replacement cost methodology, results in an overstatement of the after-tax cash flows expected from the existing net asset stock. Current replacement cost overstates the discounted value of after-tax cash flows and Q is biased downward.

The tax bias does not depend solely on the size of the depreciation tax shield retained by the net asset stock. Rather, the important consideration is the size of the tax shield per dollar of new investment relative to the tax shield per dollar of existing capital. As the tax savings on new investments exceed the tax savings on existing assets, the tax bias increases and downward pressure is exerted on Q irrespective of changes in future growth

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[17] It is interesting to note that the same inferences are obtained when the intrinsic Q series, $1-v-\tau(Z-Y)$, is substituted into the analysis. The Q ratio can be proxied effectively through measurement of the differential tax benefits between new and existing assets.

opportunities or monopoly power. The existence of time-series and cross-sectional variations in depreciation tax shields on existing assets suggests that significant variations in Q may by induced by the tax bias.

Empirical estimates of depreciation tax shields for new and existing assets are constructed for the U.S. nonfinancial corporate sector (NFC) and for ten industries annually, 1968–1985. The results indicate an opening of eight-fold in the differential tax benefits between new and existing assets. This opening exerts a depressant effect on Q and it occurs because incentive tax policies of the recent past have a doubled effect. First, acceleration of tax depreciation schedules causes an immediate increase in the tax savings offered by new assets. Second, as time passes the new assets quickly shed their depreciation tax shields and there is a downward drift in the tax benefits available from existing assets. The estimates also indicate that from 1982 to 1985 the differential tax benefits diminished somewhat and the tax bias in Q is reduced.

The empirical evidence indicates that half of the time-series variation in Q between 1968 and 1985 is due to the tax bias inherent with current replacement cost estimates. The opening of the gap between tax savings on new and existing assets accounts for a fifteen to twenty point drop in Q. Likewise, from 1977 to 1985 significant cross-sectional variations in Q are due to differences in industry tax shields. In 1981, half of the cross-sectional variations in Q are explained by differential tax benefits.

A substantial body of empirical research is predicated on the assumption that, among alternative firms or time periods, Q must tend to unity and deviations in Q must be due to differences in ex ante factors such as investment opportunities, monopoly rents, or performance and profitability. To the contrary, the evidence in this study indicates that significant variations in Q are due to movements in the depreciation tax shield on existing assets relative to those on new investments. Consequently, variations in Q are not due exclusively to differences in investment opportunities, etc. Ex post factors also drive Q.

Several analyses are conducted in order to deduce the importance of using tax-adjusted rather than unadjusted Q. The evidence indicates that, at least for the adjustment factors constructed herein, econometric analyses are invariant to the tax adjustment. Even though Q is affected significantly by the tax bias, the bias is not strong enough to invalidate inferences based upon unadjusted Q.

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