

# Investment, Accounting, and the Salience of the Corporate Income Tax

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## Abstract

This paper develops the argument that accounting rules make the corporate income tax less salient and less distortionary by obscuring the timing of tax payments. I develop and estimate a model of investment where firms maximize a discounted weighted average of after-tax cash flows and accounting profits. The cost of capital, the tax wedge on the return on capital, and the impact of tax incentives for investment depend on the weight placed on accounting profits. I estimate this weight by comparing the effectiveness of tax incentives that do and do not affect accounting profits. Investment tax credits, which do affect accounting profits, have more impact on investment than accelerated depreciation, which does not. I argue that the difference in estimated impact is not driven by discounting, cash flow effects, or measurement error. The difference is larger among firms with higher measures of earnings management. Results thus suggest that the tax burden on corporate capital is lower than we would otherwise estimate, and accelerated depreciation provisions are less effective than they otherwise would be.

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# 1 Introduction

The effects of taxation on capital formation have inspired a great deal of economic research and frequent tax policy changes. Striking results from Chamley [1986] and Judd [1985] indicate that the socially optimal tax system involves no distortion to capital investment decisions. Hall and Jorgenson [1967] and, more recently, Abel [2007], have stressed that the size of any distortion from capital income taxation does not depend solely on the statutory tax rate. It depends also on the timing of deductions from taxable income that firms may take to account for depreciation. When deductions are permitted at a faster rate than economic depreciation, depreciation is said to be accelerated. When depreciation is fully accelerated, such that all investment spending is fully deductible in the year of purchase (a treatment known as “expensing”), then investment decisions are not distorted at all.<sup>1</sup>

The federal government has used accelerated depreciation provisions to encourage capital formation for more than 50 years. In 1954, depreciation rules were liberalized explicitly “to maintain the present high level of investment in plant and equipment,”<sup>2</sup> Legislation changed the depreciation rules several times since then, but the intention to encourage investment through accelerated depreciation has persisted. So-called “bonus depreciation”—a large, temporary acceleration of depreciation deductions—was among the major policy responses to the recessions of 2001 and 2008, and these incentives remain in place at the time of this writing.

This paper studies how the accounting system may affect the perception of the timing of these depreciation deductions and may thus affect the effective tax burden on capital. A recent strand of public finance literature has emphasized the importance of the salience of taxation in understanding its effects on behavior. This literature develops the insight—perhaps obvious to non-economists—that less noticeable taxes may have smaller effects on the behavior of boundedly-rational agents. Chetty, Looney, and Kroft [2007] find that sales

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<sup>1</sup>In fact, if interest payments are deductible from taxable income, then investment may effectively be subsidized under accelerated depreciation or expensing.

<sup>2</sup>Senate Finance Committee, quoted in [Brazell, Dworin, and Walsh, 1989].

taxes have larger effects on consumer purchases when these taxes are more salient, and Chetty and Saez [2009] find that providing detailed information on the structure of the earned income tax credit increases its effects on labor supply. This paper argues that salience may also be important for understanding the impact of taxation on business investment decisions.

Evidence suggests that managers and shareholders of publicly-traded firms focus a great deal of attention on one particular measure of firm performance among the vast amount of data available on public firms. This measure is the bottom line of a firm's income statement when prepared under Generally Accepted Accounting Principals (GAAP), the set of rules that govern financial reporting in the United States.<sup>3</sup> This measure is commonly referred to as "net income," or "earnings," and I will hereafter refer to it as "book earnings."

Equity analysts and the business press devote a great deal of attention to book earnings. Commonly reported and forecasted metrics like earnings growth, earnings per share, and the price to earnings ratio are all based on this measure. The literature on the "accrual anomaly" further supports the notion that investors focus attention on earnings. Sloan [1996] writes that "stock prices are found to act as if investors 'fixate' on earnings, failing to reflect fully information contained in the accrual and cash-flow components of current earnings." This "fixation" is consistent with boundedly-rational investors attempting to make decisions based on only a subset of the information potentially available to them.

When investors fixate on book earnings, managers may rationally devote their energy to improving them. In their survey of corporate Chief Financial Officers, Graham, Harvey, and Rajgopal [2005] find evidence supporting this story, writing, "CFOs believe that earnings, not cash flows, are the key metric considered by outsiders." Accounting researchers have documented myriad examples where managers sacrifice actual cash flows in order to improve book earnings. Shackelford, Slemrod, and Sallee [2007] survey this literature and call for more research into its implications for tax policy. This paper was inspired by that call.

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<sup>3</sup>In fact, some may focus on Earnings Before Interest and Taxes (EBIT) or Earnings Before Interest Taxes and Depreciation and Amortization (EBITDA). As these measures completely ignore tax payments, any focus on them would strengthen the points made in this paper.

This paper develops the argument that GAAP accounting rules make the timing of tax payments less salient in such a way that distortions to investment decisions are mitigated. A key tenet of GAAP is the “matching principle,” or the notion that revenues and expenses associated with the same activity should be reported at the same time. For example, expenses associated with future repairs to goods sold under warranty are recorded when the goods are sold, even though the repairs have not yet been made. Application of the matching principle to depreciation of investment goods requires that tax savings from depreciation deductions be recognized at the same time that depreciation is recognized. Although the timing of cash tax payments is affected by accelerated depreciation, the income tax expense reported under GAAP is not. Discrepancies like this one are known as “book-tax differences.”<sup>4</sup>

The effects of this matching on investment distortions can be understood by comparison to expensing.<sup>5</sup> The key feature of expensing that makes it nondistortionary is the matching of expenditure on investment and the tax deductions associated with that investment. Under expensing, firms would not be required to make immediate expenditures on investment and recoup their associated tax deductions only in the future—instead they would realize the tax savings immediately as well. It is this feature of expensing that makes it nondistortionary. This matching of expenditures and tax savings is, of course, shared with the book earnings numbers reported under GAAP. The cost of investment—the depreciation expense—occurs at the same time as the associated tax savings. When managers focus more heavily on book earnings, their decisions will more closely resemble the undistorted decisions they would make under expensing. As a result, the long-run effective tax burden on corporate capital is lower than it otherwise would be, and, in the short run, accelerated depreciation provisions are less effective than they otherwise would be.

This paper develops a model of a firm that chooses its investment policy in order to maximize a weighted average of book earnings and cash flows. I show how the cost of capital, the tax wedge on the return on capital, and the impact of tax incentives for investment

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<sup>4</sup>See Hanlon and Shevlin [2005] or Desai [2003] for more on book-tax differences and their recent behavior.

<sup>5</sup>Again, expensing is the immediate deductibility of investment expenditure from taxable income.

depend on the weight placed on accounting profits. I also show that, in principle, this weight can be estimated by comparing the impact of accelerated depreciation—which does not affect book earnings—and the investment tax credit—which does—on firm investment decisions. I estimate this weight using data from the Compustat panel of firms and historical changes in the depreciation and ITC rules. There is some variation across specifications, but baseline estimates suggest that accelerated depreciation is less than half as effective as the ITC in influencing firm investment decisions.

There are reasons to be concerned, however, that accelerated depreciation may be less effective than the ITC for reasons other than its accounting treatment. First, measuring the present value of future depreciation deductions requires assumptions about appropriate discount rates. If these discount rates are improperly measured, estimates of the effect of accelerated depreciation could be improperly biased or attenuated. Second, if changes in accelerated depreciation rules take the form of shifting tax deductions from a distant future year to a less distant future year, then these changes have no impact on firm cash flows in the year of investment. The ITC, of course, does affect firm cash flows in the year of investment. If cash flows affect investment decisions, we might expect the ITC to have more impact on investment through this cash flow channel alone.

Fortunately, it is possible to isolate the depreciation deductions that are available to the firm in the year of investment. These deductions need not be discounted and have the same cash flow implications as the ITC. I find little evidence that these first-year depreciation deductions have any more impact than discounted future depreciation deductions, so results are not driven by these discounting or cash flow channels.

Another reason accelerated depreciation might be less effective than the ITC is simply that accelerated depreciation rules are more complex and less transparent than was the ITC. Although such a story is consistent with a role for bounded rationality in investment decisions, it is distinct from the accounting channel on which I focus. It may be impossible to distinguish completely between these channels, but I provide further evidence suggesting

a role for accounting. I allow the estimate of the weight placed on accounting profits to vary with firms' tendencies to manage earnings (that is, to use discretionary accruals or even fraud to improve the appearance of firm performance), as measured by several metrics from the accounting literature. Results from this exercise are somewhat mixed, but are overall supportive of a role for accounting. Estimates from some specifications suggest that observed variation in the earnings management measures is enough to produce large differences across firms in the estimated weight placed on accounting profits.

In the next section of the paper, I model a firm that chooses its investment policy to maximize a weighted average of cash flows and book earnings. I derive expressions for the user cost of capital, the tax wedge, and tax-adjusted Q, and I discuss how they depend on the weight placed on book earnings. In section III, I discuss the data used to estimate this weight. Section IV presents results, and Section V concludes.

## 2 A Model of the Firm

### 2.1 Terminology and Setup

Firms will maximize a discounted weighted average of their streams of after-tax cash flows ( $CF_t$ ) and their book earnings ( $BE_t$ ). Define after-tax cash flows as,

$$CF_t = (1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t] + B_t + \tau\delta^T K_t^T - pI_t(1 - ITC),$$

where  $\tau$  is the corporate tax rate and  $p$  is the unit price of capital.  $K_t$  is the capital stock, and  $I_t$  is investment.  $K_t$  evolves according to,

$$\dot{K}_t = I_t - \delta K_t$$

for depreciation  $\delta$ .  $D_t$  is the stock of debt outstanding, and  $B_t$  is new borrowing.  $D_t$  evolves according to,

$$\dot{D}_t = B_t.$$

$F$  is a net operating income function, which could incorporate maximization over variable factors. The function  $\psi$  represents costs of adjustment from production slowdowns or worker retraining associated with the installation of new capital. Investment  $I_t$  requires a cash payment of  $pI_t$  and entitles the firm to investment tax credit savings of  $pI_tITC$ .

The depreciation deductions permitted for tax purposes are determined by the stock of the firm's past capital expenditures that have not yet been used as a deduction from taxable income. I denote this quantity by  $K_t^T$ , and I will hereafter refer to it as "tax capital." Deductions are allowed in the amount  $\delta^T K_t^T$ , so that tax capital evolves according to:

$$\dot{K}_t^T = pI_t - \delta^T K_t^T.$$

The tax savings afforded by these deductions are in the amount  $\tau\delta^T K_t^T$ , and this term appears in  $CF_t$  above. The policy parameter  $\delta^T$  determines the extent to which depreciation is accelerated for tax purposes. Here I assume that the firm's taxable income is always large enough for the firm to fully utilize its depreciation deductions and tax credits. See Edgerton [2009] for a detailed treatment of the effects of investment incentives on loss-making firms.

Next define the firm's accounting profits, or book earnings, as,

$$BE_t = (1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t - \delta^B K_t^B] + pI_tITC.$$

Note that revenues  $F(K_t)$ , adjustment costs  $p\psi(I_t, K_t)$ , interest payments  $rD_t$ , and investment tax credits  $pI_tITC$  enter into both after-tax cash flows and book earnings.<sup>6</sup> In lieu of

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<sup>6</sup>I have assumed here that firms use the "flow-through method" of accounting for the investment tax credit, meaning that the credit is recognized as a reduction in income tax expense in the year of the investment. Under Accounting Principles Board Opinion No. 4, in effect from 1964 through the repeal of the investment tax credit in 1986, firms had the option to use either the flow-through method or the "deferral method,"

the capital expenditure  $pI_t$  and cash tax savings  $\tau\delta^T K_t^T$  that appear in cash flows, there appears in book earnings a book measure of depreciation deductions  $\delta^B K_t^B$  and their associated tax savings  $\tau\delta^B K_t^B$ . Much like tax capital, book capital evolves according to,

$$\dot{K}_t^B = pI_t - \delta^B K_t^B.$$

The difference between after-tax cash flows and book earnings is,

$$CF_t - BE_t = \delta^B K_t^B + \tau(\delta^T K_t^T - \delta^B K_t^B) - pI_t + B_t.$$

These terms should be familiar to anyone acquainted with the reconciliation of earnings and cash flows that appears in firms' Statement of Cash Flows under GAAP. Beginning with book earnings, one adds back the noncash charges for depreciation ( $\delta^B K_t^B$ ) and deferred taxes ( $\tau(\delta^T K_t^T - \delta^B K_t^B)$ ) to reach Cash Flow from Operating Activities. To Cash Flow from Operating Activities, we add Cash Flow from Investing Activities ( $-pI_t$ ), and Cash Flow from Financing Activities ( $B_t$ ), to reach total Net Cash Flow.

Deferred taxes represent the difference between taxes paid to the IRS and the provision for taxes that appears on the firm's income statement. The difference in depreciation rules for tax and book purposes results in a temporary difference in taxable income and book income. The total amount of depreciation deductions available for book and tax purposes is the same, but the time at which deductions are taken differs. Tax depreciation exceeds book depreciation in the year an investment is made, but, at some point in the future, book depreciation for the investment will exceed tax depreciation. Eventually the difference will be reversed. Deferred taxes represent the amount that will have to be "paid back" before

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under which the credit is recognized gradually over the course of the life of the investment. Choosing the flow-through method maximizes the present value of the tax savings from the credit, while choosing the deferral method would smooth the savings over time. Consistent with the model developed in this paper, anecdotal evidence suggests that most firms chose the flow-through method. For example, in their "Intermediate Accounting" textbook, Davidson, Hanouille, Stickney, and Weill [1985] state that "the flow-through method of accounting for the investment credit is far more commonly used in practice."

this reversal is complete. Tables 1 and 2 present the income and cash flow statements that would appear in SEC filings or annual reports presented under US GAAP for the firm in the model.

Table 1: The Income Statement

EBITDA	(1)	$F(K_t) - p\psi(I_t, K_t)$
– Depreciation	(2)	$\delta^B K_t^B$
= EBIT	(3)	$F(K_t) - p\psi(I_t, K_t) - \delta^B K_t^B$
– Interest Expense	(4)	$rD_t$
= Pretax Income	(5)	$F(K_t) - p\psi(I_t, K_t) - \delta^B K_t^B - rD_t$
– Income Taxes	(6)	$\tau[F(K_t) - p\psi(I_t, K_t) - rD_t - \delta_t^T K_t^T] + pI_t ITC$
– Deferred Taxes	(7)	$\tau[\delta_t^T K_t^T - \delta^B K_t^B]$
= Net Income	(8)	$(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t - \delta^B K_t^B] + pI_t ITC$

Table 2: The Cash Flow Statement

Net Income	(1)	$(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - \delta^B K_t^B - rD_t] + pI_t ITC$
+ Depreciation	(2)	$\delta^B K_t^B$
+ Deferred Taxes	(3)	$\tau[\delta_t^T K_t^T - \delta^B K_t^B]$
= Operating Cash Flow	(4)	$(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t] + \tau\delta_t^T K_t^T + pI_t ITC$
+ Investing Cash Flow	(5)	$- pI_t$
+ Financing Cash Flow	(6)	$B_t$
= Net Cash Flow	(7)	$(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t] + \tau\delta_t^T K_t^T - pI_t(1 - ITC) + B_t$

Table 3 presents a simple numerical example to illustrate these accounting concepts. It depicts a firm that buys a machine for \$200 in year 1. The machine produces net sales of \$200 in each of years 1 and 2, and it depreciates by \$100 in each of years 1 and 2. The firm is taxed on its profits at a rate  $\tau = 0.5$ , and it makes no interest payments.

The “Normal” columns depict the firm’s income and cash flows when book and tax depreciation are both equal to economic depreciation of \$100 per year. The firm’s earnings in both years for both book and tax purposes are Sales (\$200) - Depreciation (\$100) - Current Taxes (\$50) = \$50. In year 1, the firm’s cash flows are Sales (\$200) - Current Taxes (\$50)

Table 3: Numerical Example

	Normal		Expensing	
	Year 1	Year 2	Year 1	Year 2
(1) Sales	200	200	200	200
(2) Book Depreciation	100	100	100	100
(3) Tax Depreciation	100	100	200	0
(4) Pretax Income = (1)-(2)	100	100	100	100
(5) Income Tax Expense = (4) $\times\tau$	50	50	50	50
(6) Current Taxes = ((1)-(3)) $\times\tau$	50	50	0	100
(7) Deferred Taxes = (5)-(6)	0	0	50	-50
(8) Cash Flow = (1)-(6) (-\$200 in Yr1)	-50	150	0	100
(9) Earnings = (4)-(5)	50	50	50	50

- Capital Expenditure (\$200) = -\$50. In year 2, cash flows are just Sales (\$200) - Current Taxes (\$50) = \$150.

The “Expensing” columns depict the same firm making the same investment when it may expense the investment for tax purposes—that is, when it may deduct the entire purchase price of the machine in the year it is purchased. We see that this treatment shifts the \$50 that the firm paid in taxes in year 1 into year 2, and thus that \$50 of cash flow is shifted forward from year 2 to year 1. Note, however, that *the timing of earnings is unchanged*. Because the firm will still record \$100 of book depreciation in both year 1 and year 2, the matching principal dictates that it still book \$50 of tax savings from depreciation deductions in each year. Expensing has saved the firm \$50 in cash in year 1, which it will instead pay in year 2. GAAP treats this saving as “Deferred Taxes,” which will need to be “paid back” in year 2, and thus still deducts the \$50 from earnings in year 1.

The key point, of course, is that expensing affects only the cash flow line and not the earnings line. If a firm considers the cash flow line when evaluating whether to undertake the investment, then expensing makes the net present value of making the investment appear larger. The more focus that the firm places on the earnings line when evaluating the project, however, the smaller the benefits of expensing will appear.

## 2.2 Investment Policy

Returning to the model, I assume that the firm places a weight  $\alpha$  on book earnings and a weight  $(1 - \alpha)$  on after-tax cash flows when choosing its investment. The firm solves,

$$\max_{\{I_t, B_t\}} \int_0^{\infty} e^{-rt} [\alpha BE_t + (1 - \alpha) CF_t] dt$$

subject to,

$$\dot{K}_t = I_t - \delta K_t$$

$$\dot{K}_t^B = pI_t - \delta^B K_t^B$$

$$\dot{K}_t^T = pI_t - \delta^T K_t^T$$

$$\dot{D}_t = B_t$$

$$D_t \leq \bar{D}.$$

The final constraint crudely prevents the firm from choosing to be fully debt financed, which would otherwise be optimal.<sup>7</sup> This problem resembles that standard investment problem, with two important differences. First, it is traditionally assumed that  $\alpha = 0$  and the firm considers only its cash flows. Second, there are now three types of capital stocks that the firm must track. The stock of physical capital,  $K_t$ , is familiar from traditional models, but I have now introduced accounting measures of this stock for both book and tax purposes,  $K_t^B$  and  $K_t^T$ .

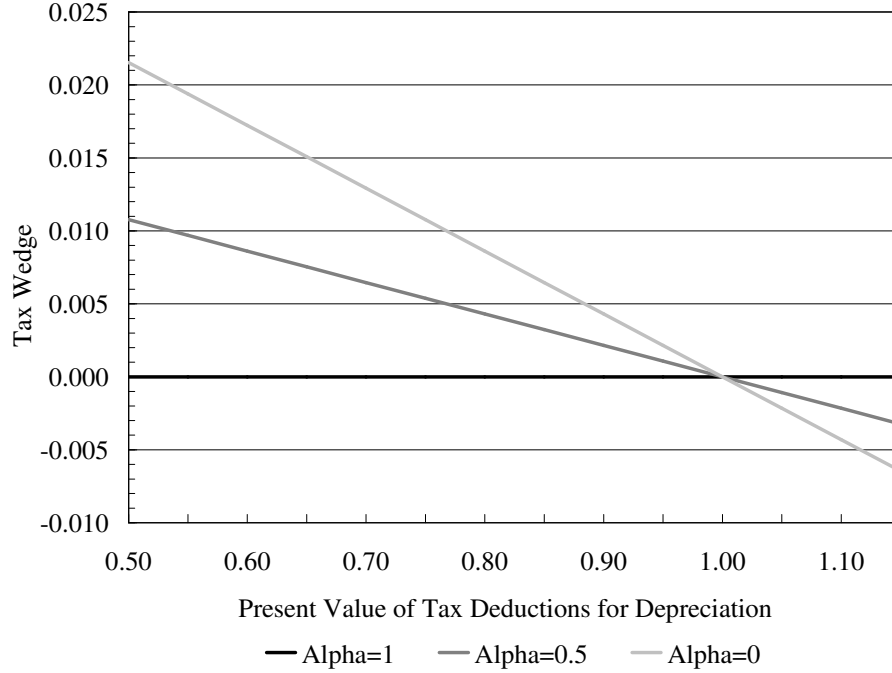
From this model, with no adjustment costs ( $\psi = 0$ ), I derive the user cost of capital,

$$F'(K_t) = \frac{(r + \delta)p}{1 - \tau} (1 - \alpha + \alpha z^B - \tau[(1 - \alpha)z^T + \alpha z^B] - ITC), \quad (1)$$

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<sup>7</sup>The specification of this constraint can matter for the effective tax burden on capital when the limit on borrowing or debt depends on the amount of investment or the size of the capital stock. It does not, however, affect the relative impact of accelerated depreciation and the ITC, so I abstract from these complications here.

Figure 1: Tax Wedge as Function of  $z^T$  for Different Values of  $\alpha$



where  $z^T$  and  $z^B$  are the present values of depreciation deductions for tax and book purposes, respectively.<sup>8</sup> Derivations appear in an appendix. When  $\alpha = 0$ , the user cost expression found in (1) simplifies to the one in Hall and Jorgenson [1967],

$$F'(K_t) = \frac{(r + \delta)p}{1 - \tau} (1 - \tau z^T - ITC).$$

Define the *tax wedge* as the distortion to the return on a marginal dollar of investment that is induced by the tax system:

$$F'(\tilde{K}_{SS})/p - F'(K_{SS})/p = [(1 - \alpha)\tau(1 - z^T) - ITC] \frac{r + \delta}{1 - \tau},$$

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<sup>8</sup>That is,

$$z^T = \int_0^\infty e^{-rs} \delta^T e^{-\delta^T s} ds = \frac{\delta^T}{r + \delta^T}$$

$$z^B = \int_0^\infty e^{-rs} \delta^B e^{-\delta^B s} ds = \frac{\delta^B}{r + \delta^B}.$$

where  $K_{SS}$  is the capital stock *without* tax distortion, and  $\tilde{K}_{SS}$  is the capital stock *with* tax distortion. Figure 1 plots the tax wedge as a function of  $z^T$  for  $\alpha = 0$ ,  $\alpha = 0.5$ , and  $\alpha = 1$ , with  $r = 0.05$ ,  $\tau = 0.35$  and  $ITC = 0$ . I set  $\delta = 0.03$ , roughly the rate of depreciation on nonresidential structures.<sup>9</sup> First, note that the tax wedge is still zero under full expensing ( $z^T = 1$ ), no matter the value of  $\alpha$ . Second, note that the tax wedge is zero if  $\alpha = 1$ , regardless of the tax parameters. As I've argued above, the book treatment of depreciation resembles expensing, in that deductions for depreciation and their associated tax savings appear contemporaneously. If firms focus entirely on book earnings, then there is no distortion imposed by the tax system.<sup>10</sup>

As  $z^T$  falls below 1, the tax wedge rises less quickly when  $\alpha > 0$  than when  $\alpha = 0$ . The departure from expensing induces less distortion when  $\alpha > 0$  because it affects only cash flows and not book earnings. These results suggest that the distortion to the capital stock created by the corporate income tax is smaller than we would calculate if we assumed that firms did not include book earnings in their objective function. Likewise, a policy change that moves towards expensing would have smaller effects than we might otherwise anticipate. For example, under current law, most business investments in structures are depreciated over 39 years. The present discounted value of the depreciation deductions associated with \$1 of investment in business structures is not far from \$0.55. If  $\alpha = 0$ , then Figure 1 suggests that the tax wedge on equity-financed business structures is about 2 percentage points (on

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<sup>9</sup>See, for example, Gravelle [1994].

<sup>10</sup>Tax distortions are often described using *effective tax rates* (ETRs), where the tax wedge above is expressed as a percentage of the pre-tax, tax-distorted rate of return. This exercise is complicated a bit in this setting by the fact that a focus on book earnings already distorts, in a sense, the firm's investment choice relative to its choice if it focused entirely on cash flows. In fact, it would distort investment upwards, since the "cost" of investment is reduced from  $p$  to  $pz^B$ , the present value of future book depreciation deductions. Since changes in  $\alpha$  shift the denominator of the ETR as well as the numerator, the ETR calculated in this way can either increase or decrease with  $\alpha$ , depending on the value of  $z^B$  relative to economic depreciation. I judge that the tax wedge discussed in the text is thus the best way of summarizing the effects of the tax system on incentives for investment when  $\alpha$  may vary.

Regarding the potential for a focus on book earnings to distort investment upwards, it is important to remember that other features of the separation of ownership and control, namely investors' uncertainty that managers will pay out the returns to their investments, would tend to distort aggregate investment downwards. Most commentators seem to think that aggregate savings and investment rates are "too low" in some sense, so I find it most natural to think about taxation exacerbating this downward distortion rather than correcting an upward distortion.

a base around 5%, for a rate of 40%). A switch to expensing would drastically reduce the tax wedge from 2% to zero. If, however,  $\alpha = 0.5$ , then the tax wedge on structures is only 1 percentage point, and a switch to expensing would produce only half as large a reduction in the tax burden.

### 2.3 Estimating $\alpha$

With adjustment costs nonzero, I solve for the derivative of the adjustment cost function,

$$\psi_I = \frac{\frac{\lambda_0}{p_0} - (1 - \alpha + \alpha z^B - \tau[(1 - \alpha)z^T + \alpha z^B] - ITC)}{1 - \tau}, \quad (2)$$

where  $\lambda_0/p$  is the shadow value to the firm of a marginal dollar of capital, or  $Q$ . With  $\alpha = 0$ , this simplifies to an expression like one in Summers [1981],

$$\psi_I = \frac{\frac{\lambda_0}{p} - (1 - \tau z^T - ITC)}{1 - \tau},$$

known as “tax-adjusted  $Q$ .” With  $\alpha > 0$ , we find new implications for the effects of the tax policy variables. First, note that changes to the investment tax credit,  $ITC$ , are no longer equivalent to changes to depreciation allowances,  $\tau z^T$ . That is,

$$\frac{\partial \psi_I}{\partial ITC} = \frac{1}{1 - \tau} > \frac{1 - \alpha}{1 - \tau} = \frac{1}{\tau} \frac{\partial \psi_I}{\partial z^T}.$$

Again, the effects of depreciation allowances are mitigated because they do not affect book earnings.

In principle,  $\alpha$  can be estimated quite easily. Under the familiar assumption of quadratic adjustment costs,

$$\psi(I_t, K_t) = \frac{1}{2c} \left[ \frac{I_t}{K_t} - a \right]^2 K_t,$$

we reach a linear expression for the investment ratio,

$$\frac{I_0}{K_0} = a + c \frac{\frac{\lambda_0}{p_0} - (1 - \alpha + \alpha z^B - \tau[(1 - \alpha)z^T + \alpha z^B]) - ITC}{1 - \tau} \quad (3)$$

$$= a + c \frac{\frac{\lambda_0}{p_0} - 1}{1 - \tau} + c\alpha \frac{1 - (1 - \tau)z^B}{1 - \tau} + c(1 - \alpha) \frac{\tau z^T}{1 - \tau} + c \frac{ITC}{1 - \tau}, \quad (4)$$

If I were to run the linear regression,

$$\frac{I_0}{K_0} = \beta_0 + \beta_1 \frac{\frac{\lambda_0}{p_0} - 1}{1 - \tau} + \beta_2 \frac{\tau z^T}{1 - \tau} + \beta_3 \frac{ITC}{1 - \tau}, \quad (5)$$

then the ratio  $\beta_2/\beta_3$  identifies  $(1 - \alpha)$ . That is, the difference in effectiveness between investment tax credits and accelerated depreciation can tell us about the relative weights that firms place on cash flows and book earnings.<sup>11</sup>

### 3 Data

I use firm-level data from Compustat to construct measures of investment, Q, cash flows, and earnings management indicators. I present results from the sample period 1962 to 1990. 1962 marks the first year for which variables used in the construction of Q are available in Compustat, although the necessity of excluding prior years is unfortunate because the investment tax credit was first introduced in 1962. I choose 1990 as the end year for two reasons. First, the investment tax credit was repealed in 1986, so it is sensible to compare the effects of the ITC and accelerated depreciation over a period when both were changing. Second, I find in Edgerton [2009] that the effects of investment incentives may be mitigated in firms that lose money or have low cash flows. As losses have been high and cash flows low during the bonus depreciation episodes of the 2000s, I exclude these years from the

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<sup>11</sup>Note that  $z^B$ , the present value of depreciation deductions for book purposes, also enters (3). Firms have considerable discretion over their choice of depreciation method for book purposes, and a small literature examines this choice, for example, Keating and Zimmerman [1999]. The interaction of this choice with firm investment decisions is a bit beyond the scope of this paper, but would be an interesting topic for future research.

estimation to deflect concerns that these episodes would improperly depress the coefficients on accelerated depreciation. In any case, results are not particularly sensitive to the choice of end year.

I follow Cummins, Hassett, and Hubbard [1994] and Desai and Goolsbee [2004] in constructing measures of the depreciation allowances and investment tax credits available to each Compustat firm. The depreciation allowances and investment tax credits allowed on corporate investment vary over time and across industries and asset types. See Cummins, Hassett, and Hubbard [1994] for more discussion of this variation. I thank Dale Jorgenson for providing data on the depreciation allowances and investment tax credits available in each year for each asset type. I collected additional information on the depreciation deduction available in the year of investment from old IRS publications.

These variables are matched to the 1997 Capital Flows table from the Bureau of Economic Analysis, which records the amount of investment made by each industry in each asset category.<sup>12</sup> I construct depreciation schedules and investment tax credit rates at the industry level by taking a weighted average across the assets purchased by each industry, with the weights equal to the percentage of the industry’s spending accounted for by each asset. These tax variables are then merged by industry into the Compustat sample of firms. Table 7 in the appendix provides descriptive statistics for the sample.

## 4 Results

Columns 1 and 2 of Table 4 present regressions of the form,

$$\frac{I_{it}}{K_{i,t-1}} = \beta_0 + \beta_1 \frac{\tau_t z_{it}^T + ITC_{it}}{1 - \tau_t} + \beta_2 \frac{\frac{\lambda_{it}}{p_{it}} - 1}{1 - \tau_t} + \beta_3 \frac{\text{CashFlow}_{it}}{K_{i,t-1}}.$$

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<sup>12</sup>There are 28 equipment categories, with examples including Computers and Peripheral Equipment, Metalworking Machinery, and Autos. There are 23 structures categories, with examples including Industrial Buildings, Railroads, and Petroleum Pipelines. There are 123 industries, which are roughly at the three-digit NAICS level. Examples include Coal Mining, Plastic and Rubber Products Manufacturing, and Air Transportation.

All specifications presented in the paper include firm fixed effects. Column 1 does not include year fixed effects; Column 2 does include them. Thus we might expect the tax coefficients in the Column 1 to be biased downward by policy endogeneity if accelerated depreciation and the ITC are used as counter-cyclical policy tools. The results in the table are consistent with this story.

The results in Column 2 are quite similar to those of Desai and Goolsbee [2004]. The coefficient on the “Tax Term”,  $(\tau z^T + ITC)/(1 - \tau)$ , is economically important and statistically significant.<sup>13</sup> In Columns 3 through 8 of Table 4, the terms on the right-hand side are rearranged as in Equation 5 above. The equipment tax term is split into two parts—one for the present value of depreciation deductions  $\tau z^T$ , and the other for the ITC. The even-numbered columns include year fixed effects; the odd-numbered columns do not. The distribution of investment is highly skewed towards the largest firms, so it is important to test that results hold in samples consisting of large firms only. The sample in Columns 3 and 4 include all Compustat firms, Columns 5 and 6 include only the largest 3000 firms when ranked by assets in the previous year, and Columns 7 and 8 include only the largest 500 firms each year.

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<sup>13</sup>Following most papers in the literature, including Desai and Goolsbee [2004], I present standard errors clustered by firm. Standard errors rise when clustered by broader groups like industry, consistent with positive correlation of error terms within these groups.

Table 4: Regressions of investment to capital stock ratio on tax variables and controls

	All Firms (1)	All Firms (2)	All Firms (3)	All Firms (4)	Largest 3000 (5)	Largest 3000 (6)	Largest 500 (7)	Largest 500 (8)
Equipment Tax Term: $\frac{ITC+\tau z^T}{1-\tau}$	.459 (.025)***	.891 (.345)***						
Equipment $\frac{ITC}{1-\tau}$			.504 (.032)***	1.509 (.445)***	.503 (.032)***	.952 (.426)**	.168 (.036)***	.450 (.649)
Equipment $\frac{\tau z^T}{1-\tau}$			.399 (.034)***	.691 (.357)*	.314 (.033)***	.285 (.338)	.109 (.043)**	.258 (.376)
Structures Tax Term	-.249 (.028)***	.078 (.063)	-.221 (.030)***	.030 (.069)	-.219 (.030)***	.007 (.065)	-.071 (.035)**	-.082 (.078)
$\frac{Q-1}{1-\tau}$	.038 (.002)***	.038 (.002)***	.038 (.002)***	.037 (.002)***	.045 (.003)***	.045 (.003)***	.016 (.004)***	.016 (.004)***
Cash flow / K	.013 (.004)***	.012 (.004)***	.013 (.004)***	.012 (.004)***	.068 (.009)***	.067 (.009)***	.171 (.053)***	.157 (.051)***
Year Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
Alpha			.208	.542	.375	.701	.355	.426
P-Value			.015	.031	3.46e-06	.060	.207	.754
Firms	6502	6502	6502	6502	5293	5293	991	991
Observations	60316	60316	60316	60316	53236	53236	12954	12954
$R^2$	.352	.358	.352	.359	.392	.399	.401	.425

Columns 1 and 2 present regressions of the form,

$$\frac{I_{it}}{K_{i,t-1}} = \beta_0 + \beta_1 \frac{ITC_{it} + \tau_t z_{it}^T}{1 - \tau_t} + \beta_2 \frac{\frac{\lambda_{it}}{p_{it}} - 1}{1 - \tau_t} + \beta_3 \frac{\text{CashFlow}_{it}}{K_{i,t-1}}.$$

Columns 3 through 8 present regressions of the form,

$$\frac{I_{it}}{K_{i,t-1}} = \beta_0 + \beta_1 \frac{ITC_{it}}{1 - \tau_t} + \beta_2 \frac{\tau_t z_{it}^T}{1 - \tau_t} + \beta_3 \frac{\frac{\lambda_{it}}{p_{it}} - 1}{1 - \tau_t} + \beta_4 \frac{\text{CashFlow}_{it}}{K_{i,t-1}}.$$

The Alpha row reports the value of  $(1 - \hat{\beta}_2 / \hat{\beta}_1)$ , the measure of the weight that firms place on book earnings when making investment decisions. The P-Value row reports the p-value from the linear hypothesis test that  $\beta_1 = \beta_2$ . Columns 1 through 4 include all non-missing Compustat firm-year observations from 1962 to 1990. Columns 5 and 6 restrict the sample to the largest 3000 firms by prior-year total assets in years when there are more than 3000 firms in the sample. Columns 7 and 8 restrict the sample to the largest 500 firms. All specifications include firm fixed effects. Standard errors in parentheses are clustered at the firm level.

\*\*\* indicates statistical significance at the 1% level, \*\* at 5%, and \* at 10%.

Results show clearly that the effect of the Tax Term in Columns 1 and 2 is driven more strongly by the investment tax credit than by accelerated depreciation. The bottom row of estimates presents the value of  $(1 - \hat{\beta}_2/\hat{\beta}_3)$ , the estimate of  $\alpha$ . The next row presents the p-value from the linear hypothesis test that the coefficients on the ITC and  $\tau z^T$  are equal, which would imply  $\alpha = 0$ .

Estimates of  $\alpha$  range from .208 in Column 3 to 0.701 in Column 6, with estimates centered around 0.4. The equality of the  $\tau z^T$  and ITC coefficients can be rejected in all columns except those using only the 500 largest firms, for which the sample is considerably smaller. Thus baseline estimates suggest that firms place a weight of around 0.4 on book earnings when making investment decisions.

Table 5 presents results to address the concern that  $\tau z^T$  may mismeasure the value of depreciation deductions relative to investment tax credits. As calculated,  $z^T$  reflects assumptions about the discount rate applied to future depreciation deductions. If these assumptions are incorrect, estimated coefficients could be attenuated by classical measurement error or otherwise biased. Further, the investment tax credit may provide additional cash flows in the year of investment, making it more effective than accelerating depreciation deductions from one future year to another. Table 5 addresses these concerns by estimating a separate coefficient for depreciation deductions available in the year an investment is made. These deductions need not be discounted and have the same cash flow benefits as the ITC.

There is little evidence that the observed lack of responsiveness to accelerated depreciation is driven by discounting or cash flows. The estimates of  $\alpha$  coming from a comparison of the coefficient on the ITC and on the first-year depreciation deduction are a bit lower than those in Table 4 in the even-numbered specifications which include year dummies, but are actually higher in the specifications without year dummies. The lowest estimate of  $\alpha$  in the table is still 0.285 in the specification with year dummies and the 500 largest firms in each year, although it is not precisely estimated.

Some might worry that an exercise comparing two coefficients like this one is easily con-

Table 5: Regressions of investment to capital stock ratio on tax variables and controls, with detail on depreciation allowances

	All Firms	All Firms	Largest 3000	Largest 3000	Largest 500	Largest 500
	(1)	(2)	(3)	(4)	(5)	(6)
Equipment $\frac{ITC}{1-\tau}$	.529 (.035)***	1.478 (.445)***	.532 (.035)***	.925 (.426)**	.231 (.040)***	.443 (.650)
Equipment $\frac{\tau z^T}{1-\tau}$ , First Year Only	.244 (.095)**	.767 (.362)**	.142 (.089)	.353 (.342)	-.197 (.100)**	.317 (.376)
Equipment $\frac{\tau z^T}{1-\tau}$ , Future Years	.453 (.044)***	.547 (.368)	.373 (.043)***	.153 (.351)	.200 (.051)***	.140 (.387)
Structures Tax Term	-.246 (.033)***	.038 (.069)	-.247 (.032)***	.015 (.066)	-.122 (.037)***	-.073 (.079)
$\frac{Q-1}{1-\tau}$	.038 (.002)***	.038 (.002)***	.045 (.003)***	.045 (.003)***	.016 (.003)***	.016 (.004)***
Cash flow / K	.013 (.004)***	.012 (.004)***	.068 (.009)***	.067 (.009)***	.169 (.053)***	.157 (.051)***
Year Fixed Effects	No	Yes	No	Yes	No	Yes
Alpha	.539	.481	.734	.618	1.854	.285
P-Value	.011	.067	.0002	.116	.0003	.839
Firms	6502	6502	5293	5293	991	991
Observations	60316	60316	53236	53236	12954	12954
$R^2$	.352	.359	.392	.399	.402	.425

All specifications include firm fixed effects. Standard errors in parentheses are clustered at the firm level. \*\*\* indicates statistical significance at the 1% level, \*\* at 5%, and \* at 10%.

founded by measurement error. One could worry here that depreciation depreciations are measured less accurately than the investment tax credit, falsely producing lower coefficients on depreciation deductions than on the ITC. In fact, it is true, in a sense, that the statutory maximum depreciation deduction available in the first year that I include in Table 5 mismeasures the depreciation deductions that firms used. This results from the fact that *firms often did not claim the most accelerated depreciation schedule that was available to them*. Congress explicitly authorized the use of double declining balance depreciation in 1954 (Brazell, Dworin, and Walsh [1989]), but Jorgenson and Sullivan [1981] find that a substantial fraction of investment was still depreciated using straight line methods up until the mandatory adoption of the Accelerated Cost Recovery System in 1981. A similar lack of take-up has been reported for recent bonus depreciation incentives by Knittel [2007]. I would not consider this discrepancy between statutory maximum deductions and the deductions actually taken by firms to be measurement error—rather, I would consider it a reflection of the phenomenon under study. Firms do not appear to value accelerated depreciation as much as economists think they should.

Still, it is possible that this undervaluation of accelerated depreciation results not from the accounting channel which I study in this paper, but from other facets of accelerated depreciation. A prime candidate would be the complexity of the depreciation rules. Firms may have simply preferred to stick with straight line depreciation after double declining balance was available because the calculations were simpler. Firms may opt to continue claiming depreciation under the Modified Accelerated Cost Recovery System rather than claiming bonus depreciation because their accounting systems are already set up to use the MACRS rules.

Table 6 presents results which may assist in distinguishing the effect of the accounting channel on which I focus from other factors that could produce the results in Tables 4 and 5. The table presents regressions similar to those presented before, where now  $\tau z^T$  is interacted with measures of the intensity with which firms attempt to manage their earnings. The

accounting literature contains a vast number of papers concerned with “earnings management,” or firms’ attempts to improve the appearance of their accounting numbers through discretionary accruals or even outright fraud. I adapt from Leuz, Nanda, and Wysocki [2003], a widely cited paper in this literature, five statistics that accounting researchers have used as measures of earnings management. I can then test whether my estimates of  $\alpha$  are larger for firms that have been identified as likely earnings managers using these other metrics.

Table 6: Regressions of investment to capital stock ratio on tax variables and controls, with variation by earnings management metrics

	All Firms	All Firms	All Firms	All Firms	All Firms	All Firms	All Firms	All Firms	All Firms	All Firms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Equipment $\frac{ITC}{1-\tau}$	.507 (.032)***	1.549 (.448)***	.507 (.032)***	1.459 (.449)***	.506 (.032)***	1.547 (.447)***	.517 (.032)***	1.466 (.448)***	.433 (.051)***	.533 (.716)
Equipment $\frac{\tau z^T}{1-\tau}$	.395 (.034)***	.623 (.357)*	.405 (.034)***	.589 (.357)*	.424 (.035)***	.660 (.359)*	.279 (.041)***	.563 (.355)	.332 (.051)***	.336 (.545)
Equipment $\frac{\tau z^T}{1-\tau} \times \text{EM1}$	-.120 (.097)	-.118 (.089)								
Equipment $\frac{\tau z^T}{1-\tau} \times \text{EM2}$			-.073 (.023)***	-.069 (.023)***						
Equipment $\frac{\tau z^T}{1-\tau} \times \text{EM3}$					.165 (.030)***	.179 (.031)***				
Equipment $\frac{\tau z^T}{1-\tau} \times \text{EM4}$							-.093 (.019)***	-.157 (.029)***		
Equipment $\frac{\tau z^T}{1-\tau} \times \text{EM5}$									-.009 (.034)	-.012 (.034)
Structures Tax Term	-.221 (.030)***	.029 (.069)	-.228 (.030)***	.015 (.069)	-.233 (.030)***	.036 (.069)	-.169 (.030)***	.052 (.069)	-.186 (.046)***	-.083 (.105)
$\frac{Q-1}{1-\tau}$	.038 (.002)***	.037 (.002)***	.038 (.002)***	.037 (.002)***	.038 (.002)***	.037 (.002)***	.037 (.002)***	.037 (.002)***	.045 (.004)***	.044 (.005)***
Cash flow / K	.013 (.004)***	.012 (.004)***	.013 (.004)***	.012 (.004)***	.012 (.004)***	.012 (.004)***	.012 (.004)***	.012 (.004)***	.023 (.010)**	.022 (.010)**
Year Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	59585	59585	59199	59199	59632	59632	59632	59632	19219	19219
$R^2$	.348	.355	.34	.347	.351	.357	.351	.357	.296	.302

All specifications include firm fixed effects. Standard errors in parentheses are clustered at the firm level.

The EM measures of earnings management are demeaned, scaled by their standard deviations, and signed so that they rise as earnings management increases. Thus, negative coefficients on the EM interaction terms indicate that accounting weights are higher in firms with more observed earnings management. EM1 is -1 times the ratio of the standard deviation of operating earnings to the standard deviation of cash flow from operations. EM2 is -1 times the correlation between accounting accruals and operating cash flows. EM3 is the median of the absolute value of the residuals in a full-sample regression of accruals on prior-year assets, sales growth, and plant, property, and equipment. EM4 is the residual in a regression of EM3 on the log of PPI-deflated prior-year assets. EM5 is the ratio of small profits to small losses among firms that have realized at least one loss, where “small” is defined as less than 1% of prior-year assets.

\*\*\* indicates statistical significance at the 1% level, \*\* at 5%, and \* at 10%.

The first measure is the ratio of the standard deviation of operating earnings to the standard deviation of cash flow from operations. When earnings are less variable than cash flows, it suggests that firms may be attempting to smooth them from year to year. The second measure is the correlation between accounting accruals and operating cash flows. This correlation is generally negative, but the more negative it is, the more likely it is thought to be that a firm is using accruals to manage its earnings. The third measure is the median of the absolute value of the residuals in a regression of accruals on prior-year assets, sales growth, and plant, property, and equipment, as in Bergstresser and Philippon [2006]. The fourth is the residual in a regression of this third measure on the log of PPI-deflated prior-year assets. When accruals are large in absolute value, it again suggests that firms may be using them to manipulate earnings. The fifth is the ratio of small profits to small losses among firms that have realized at least one loss, where “small” is defined as less than 1% of prior-year assets. When firms have many small profits but few small losses, it may be a sign that they are manipulating earnings to avoid reporting a loss. I transform all of these measures into standard deviations from their mean, and I change their sign so that they rise when earnings management is more intense.

Table 6 presents regressions where these measures are interacted with  $\tau z^T$ , the present value of depreciation deductions. Negative coefficients on the interaction terms indicate that  $\alpha$  is larger when the measures indicate that firms do more earnings management, as we would expect if accounting matters for the effectiveness of tax incentives. For example, Column 1 indicates that the coefficient on  $\tau z^T$  is 0.395 for a firm with the mean value of the first earnings management measure, but 0.275 for a firm one standard deviation above the mean.

Results are generally supportive of the conclusion that accounting drives the difference in the depreciation and ITC coefficients, but somewhat mixed. Four of the five measures have negative coefficients, but these are statistically different from zero for only two. The fifth measure—the absolute magnitude of accruals, with no correction for firm size—shows statistically significant coefficients of the wrong sign. It seems perfectly appropriate to adjust

for firm size when constructing the accruals measure as smaller firms have systematically larger accruals, but this discrepancy demonstrates the fragility of results nonetheless. For measures 1, 2, and 4, where coefficients have the expected sign, magnitudes are such that variation in the earnings management measures would induce large changes in estimated  $\alpha$ . For example, in Column 8, estimates suggest that a two standard deviation increase in the earnings management measure would cut the impact of accelerated depreciation by more than half.

## 5 Conclusions

I have estimated that accelerated depreciation has been less effective in stimulating business investment than the investment tax credit, and that this relative ineffectiveness is larger in firms that are more likely to manage their earnings according to several metrics developed in the accounting literature. I have shown that these results can be interpreted as a measure of the weight placed on accounting profits in a model where firms choose investment to maximize a weighted average of accounting profits and cash flows. At face value, these results suggest that the corporate income tax imposes smaller distortions to investment decisions than we would otherwise estimate, but that accelerated depreciation is less effective in stimulating investment than it otherwise would be. In truth, it may still be difficult to be confident that results on the relative ineffectiveness of accelerated depreciation are driven by this accounting effect and not by other features of accelerated depreciation. More research attempting to disentangle these effects would be welcome.

Even if results correctly characterize the role of accounting, there may still be reasons to favor a further acceleration of depreciation provisions as a means of lowering the tax burden on capital. First, the estimates presented here describe the behavior of large, publicly-traded firms in the Compustat sample. If information asymmetries between owners and managers are less important in smaller, private firms, then managers of these firms may

be less focused on book earnings and more responsive to depreciation provisions. Second, accelerated depreciation may reduce accounting costs, particularly for small firms. MACRS, with its limited number of asset classes and fixed depreciation schedules, is less complex than a system requiring that depreciation deductions equal economic depreciation for each asset in each year. A switch to expensing would further reduce complexity.

A potential strike against a further acceleration of depreciation provisions as a preferred means of reducing the tax burden on corporate capital is the argument that statutory and average tax rates may be just as important as marginal effective rates when firms are choosing where to locate their capital in an increasingly global economy. The role of the accounting treatment of taxes in this decision would be a fruitful topic for future research.

## 6 Appendix 1: Descriptive statistics

Table 7: Descriptive Statistics

Variable	Median	Mean	Std. Dev.
Equipment Tax Term: $\frac{ITC+\tau z^I}{1-\tau}$	0.871	0.777	0.181
Equipment $\frac{ITC}{1-\tau}$	0.120	0.098	0.077
Equipment $\frac{\tau z^I}{1-\tau}$	0.721	0.679	0.126
Equipment $\frac{\tau z^I}{1-\tau}$ , First year only	0.129	0.128	0.029
Equipment $\frac{\tau z^I}{1-\tau}$ , Future years	0.584	0.551	0.108
Structures Tax Term	0.564	0.516	0.181
$\frac{Q-1}{1-\tau}$	0.309	1.136	2.720
Cash flow / K	0.289	0.178	1.793
EM1	0.840	0.907	4.673
EM2	-0.852	-0.775	0.255
EM3	0.047	0.060	0.054
EM4	-0.009	-0.000	0.051
EM5	1.000	1.178	1.331

This table contains descriptive statistics for the full sample of 60,316 observations on 6,502 unique firms that is used in regressions presented in the text. The values of the earnings management measures EM1-EM5 in this table are prior to their transformation to mean=0, sd=1 variables, signed such that they increase with earnings management. It is the transformed variables that are used in the regressions in Table 6 in the text. These EM variables are missing for some firms. The number of nonmissing observations is visible in Table 6.

## 7 Appendix 2: Model derivation

Here I derive the user cost and tax-adjusted Q expressions that appear in the text. The firm solves,

$$\max_{\{I_t\}} \int_0^{\infty} e^{-rt} [\alpha BE_t + (1 - \alpha) CF_t] dt$$

subject to,

$$\dot{K}_t = I_t - \delta K_t$$

$$\dot{K}_t^B = pI_t - \delta^B K_t^B$$

$$\dot{K}_t^T = pI_t - \delta^T K_t^T$$

$$\dot{D}_t = B_t$$

$$D_t \leq \bar{D}.$$

Form the Lagrangian,

$$\begin{aligned} \mathcal{L} = & \int_0^{\infty} e^{-rt} [\alpha [(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - \delta^B K_t^B - rD_t] + pI_t ITC] \\ & + (1 - \alpha) [(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t] + \tau\delta^T K_t^T - pI_t(1 - ITC)]] dt \\ & - \int_0^{\infty} \lambda_t (\dot{K}_t - I_t + \delta K_t) dt \\ & - \int_0^{\infty} \lambda_t^B (\dot{K}_t^B - pI_t + \delta^B K_t^B) dt \\ & - \int_0^{\infty} \lambda_t^T (\dot{K}_t^T - pI_t + \delta^T K_t^T) dt. \end{aligned}$$

Note that,

$$\begin{aligned}
\int_0^\infty \lambda_t \dot{K}_t dt &= \int_0^\infty \lambda_t \frac{dK_t}{dt} dt \\
&= \int_0^\infty \frac{d(\lambda_t K_t)}{dt} - K_t \frac{d\lambda_t}{dt} dt \\
&= \lim_{t \rightarrow \infty} \lambda_t K_t - \lambda_0 K_0 - \int_0^\infty K_t \frac{d\lambda_t}{dt} dt \\
&= -\lambda_0 K_0 - \int_0^\infty K_t \dot{\lambda}_t dt,
\end{aligned}$$

where the second line follows from integration by parts and the last line from the transversality assumption,  $\lim_{t \rightarrow \infty} \lambda_t K_t = 0$ . Applying the same steps to  $\int_0^\infty \lambda_t^B \dot{K}_t^B dt$  and  $\int_0^\infty \lambda_t^T \dot{K}_t^T dt$ , and ignoring the constants,  $\lambda_0 K_0$ ,  $\lambda_0^B K_0^B$ , and  $\lambda_0^T K_0^T$ , we can rewrite the Lagrangian,

$$\begin{aligned}
\mathcal{L} &= \int_0^\infty e^{-rt} [ \alpha [(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - \delta^B K_t^B - rD_t] + pI_t ITC] \\
&\quad + (1 - \alpha) [(1 - \tau)[F(K_t) - p\psi(I_t, K_t) - rD_t] + \tau\delta^T K_t^T - pI_t(1 - ITC)] ] dt \\
&\quad + \int_0^\infty K_t \dot{\lambda}_t + \lambda_t(I_t - \delta K_t) dt \\
&\quad + \int_0^\infty K_t^B \dot{\lambda}_t^B + \lambda_t^B(pI_t - \delta^B K_t^B) dt \\
&\quad + \int_0^\infty K_t^T \dot{\lambda}_t^T + \lambda_t^T(pI_t - \delta^T K_t^T) dt.
\end{aligned}$$

The first-order conditions are,

$$0 = \frac{\partial \mathcal{L}}{\partial I_t} = e^{-rt} pITC - e^{-rt}(1 - \alpha)p - e^{-rt}(1 - \tau)p\psi_I(I_t, K_t) + \lambda_t + p\lambda_t^B + p\lambda_t^T, \quad (6)$$

$$0 = \frac{\partial \mathcal{L}}{\partial K_t} = e^{-rt}(1 - \tau)[F'(K_t) - p\psi_K(I_t, K_t)] + \dot{\lambda}_t - \lambda_t\delta, \quad (7)$$

$$0 = \frac{\partial \mathcal{L}}{\partial K_t^B} = e^{-rt}\alpha(\tau - 1)\delta^B + \dot{\lambda}_t^B - \lambda_t^B\delta^B, \quad (8)$$

$$0 = \frac{\partial \mathcal{L}}{\partial K_t^T} = e^{-rt}(1 - \alpha)\tau\delta^T + \dot{\lambda}_t^T - \lambda_t^T\delta^T. \quad (9)$$

Define  $z_T$  and  $z_B$  as the present values of future depreciation allowances for tax and book purposes, respectively,

$$z^T \equiv \int_0^\infty e^{-rs} \delta^T e^{-\delta^T s} ds = \frac{\delta^T}{r + \delta^T}$$

$$z^B \equiv \int_0^\infty e^{-rs} \delta^B e^{-\delta^B s} ds = \frac{\delta^B}{r + \delta^B}.$$

Note that

$$\lambda_t^B = \alpha(\tau - 1)e^{-rt} z^B$$

$$\lambda_t^T = (1 - \alpha)\tau e^{-rt} z^T \tag{10}$$

are solutions to the ordinary differential equations in (8) and (9).

First consider the case with no adjustment costs, that is, where  $\psi = 0$ . Equations (10) and (6) together imply that  $\lambda_t = e^{-rt} k$  for some constant  $k$ . Equation (7) then implies  $K_t$  constant, and,

$$\lambda_t = e^{-rt} (1 - \tau) \frac{F'(K_t)}{r + \delta} \tag{11}$$

is a solution to (7). Plugging (11) and (10) into (6) produces the user cost equation (1) in the text. When  $\psi$  is nonzero, the first order condition (6) can be rearranged to reach the tax-adjusted Q equation (2) in the text.

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