The Impact of Depreciation Savings on Investment: Evidence from the Corporate Alternative Minimum Tax

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Abstract

Over the past decade, the United States has offered investment incentives in the form of larger depreciation savings, namely, bonus depreciation. The neoclassical investment model implies that investment responds to changes in depreciation savings, but there have been few direct attempts to investigate this implication. This paper examines investment patterns surrounding the 1999 shortening of the Alternative Minimum Tax (AMT) depreciation recovery periods, finding strong evidence that firms subject to the AMT increase investment in response to the AMT reform. The empirical results show that firms subject to the AMT increase their investment, measured as the ratio of capital expenditures to capital stock, by around 0.036 to 0.065, compared to firms subject to the regular tax. Given their average annual investment rate of approximately 0.26 during this period, the results imply a relative increase in investment of 14%-25%. By contrast, I find that the 2002 introduction of bonus depreciation, available both for firms subject to the regular tax and for firms subject to the AMT, affects both groups of firms similarly. The estimation uses an empirical specification developed from the Summers (1981) tax-adjusted q model, and the results imply that the responsiveness of investment to the tax term is somewhat larger than previously estimated.

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1 Introduction

Investment has long been recognized by both economists and policymakers as an important factor in short-run aggregate demand fluctuations as well as long-run capital accumulation. Indeed, the United States government has frequently changed the three main tax instruments – corporate tax rates, investment tax credits, and depreciation allowances – because the neoclassical investment model implies that investment responds to changes in these instruments. However, empirical evidence was not very supportive until recently when the focus of empirical studies shifted to cross-sectional variations based on firm- or asset-level data, as in Auerbach and Hassett (1991), Cummins, Hassett and Hubbard (1994), and Desai and Goolsbee (2004).

These studies use as the source of identification several tax reforms, enacted over the course of more than 30 years, that typically result in simultaneous changes to at least two of these tax instruments. One concern that arises is the possibility that these tax instruments may play asymmetric roles in describing investment incentives. As Summers (1987) points out, the interest rates used by firms to discount future depreciation deduction streams in calculating the present value of depreciation allowances may be much higher than economists' likely assumptions. On the other hand, the effects of corporate tax rates and investment tax credits on tax liability are calculated in a straightforward manner by researchers, and perhaps by firms as well. Moreover, from the perspective of firms, recognition of investment tax credits would be more immediate and salient than that of generous depreciation allowances. Thus, in the presence of agency problems with short-tenured managers, generous depreciation allowances may not be as appreciated as investment tax credits, as it takes more time to recognize their benefits. In addition, Neubig (2006) argues that firms prefer lower corporate tax rates to higher depreciation allowances for other accounting and practical reasons.[1]

Nevertheless, of the three major tax instruments, depreciation allowances have changed most frequently in the United States. Especially over the past decade, in hopes of stimulating the economy, investment incentives have been provided in the form of depreciation allowances, namely, bonus depreciation.[2] So far, mixed results have been reported regarding responses to the bonus depreciation policy. Edgerton (2009) finds no evidence for effects of the policy, whereas other researchers have found that firms exploit bonus depreciation by temporarily weighting longer-lived assets more heavily (House and Shapiro, 2008) or by using more tax-favorable financing methods such as leasing (Park, 2012). It remains unclear, though, whether *levels* of total firm-level investment are responsive to the recent changes in depreciation allowances.

There have been, to my knowledge, few attempts to investigate the responsiveness of investment to depreciation allowances, independently of other tax instruments. In this paper, I

[1] Neubig (2006) argues, for example, that a generous depreciation system does not reduce the effective tax rate for accounting purposes, which matters to corporate tax directors and officers.

[2] Corporate tax rates and investment tax credits have seen almost no changes since 1986, the only exception being in 1993 when the corporate tax rate in the top bracket was increased from 34% to 35%.

investigate whether firm investment is responsive to changes in depreciation savings by exploiting the 1999 change in the corporate Alternative Minimum Tax (AMT) depreciation rule that converged the previously disadvantaged AMT recovery period to the favorable regular depreciation recovery period.

I first extend the standard investment model to consider the conditions under which investment incentives are characterized by the AMT system. Then, from SEC 10-K filing data, I identify two groups of firms in terms of whether their investment incentives are characterized by the AMT or regular tax system. Using a difference-in-difference approach, I find strong evidence that the AMT firms increase investment after 1999.[3] Specifically, my empirical results show that firms subject to the AMT respond to the reform by increasing investment, measured as the ratio of capital expenditures to capital stock, by around 0.036 to 0.065. Given their average annual investment rate of approximately 0.26 during this period, the results imply a relative increase in investment of 14%-25%. To test the validity of my identifying assumption, I examine the responses to the 2002 bonus depreciation available to both groups, and find similar results for both groups of firms. The estimation uses an empirical specification developed from the Summers (1981) tax-adjusted q model, and the results imply that the responsiveness of investment to the tax term is larger than previously estimated.

The rest of this paper is organized as follows. Section 2 provides a discussion of depreciation allowances and the corporate AMT. In Section 3, I formally introduce AMT to the firm maximization problem. The investment equation is derived in Section 4. My research design and data construction are explained in Section 5, and the main empirical results are presented in Section 6. In Section 7, I discuss the implications of the empirical results for estimation of the tax-adjusted q model. Section 8 concludes.

2 Background

Background 1. Depreciation Allowances

In calculating corporate taxable income, firms are permitted certain deductions from revenue for the taxable year. Capital expenditure is first capitalized, then depreciated and deducted over a certain amount of time (also known as the recovery period). Firms calculate the amount of annual depreciation using a balancing method that specifies the extent to which the depreciation allowance is front-loaded over a given period.

U.S. tax code assigns a recovery period and a balancing method according to the type of asset. For example, an asset used in the manufacture of aerospace products is depreciated over seven years using the 200% balancing method. The deduction stream allowed for this type of asset for a one-dollar purchase is illustrated in Table 1. The present value of depreciation allowances,

[3] Figure 5 summarizes the main results.

Table 1: Present value of depreciation allowances z

Example: Assets used in the manufacture of aerospace products

Year	1	2	3	4	5	6	7	8	z
Deduction Allowed	.1429	.2449	.1749	.1249	.0893	.0892	.0893	.0446	.845

Note: z is calculated using an interest rate of 5% and a 200% balancing method. (Source: IRS Publication 946, Table A1)

typically denoted as z in the literature, measures how much of the per-dollar capital expenditure is deducted from taxable income. Consequently, depreciation saving is generally calculated as z multiplied by the corporate tax rate, τ.

Depreciation rules have changed frequently over the years. Most recently,[4] the Tax Reform Act of 1986 created the modified accelerated cost recovery system (MACRS) under which two recovery periods are assigned to each type of property, one based on the general depreciation system (GDS), and the other based on the alternative depreciation system (ADS).[5] Although most assets placed in service are depreciated under GDS, as in the example in Table 1, ADS is used in special cases, such as property used predominantly outside the United States, tax-exempt use properties, and tax-exempt, bond-financed properties. Depreciation allowances for the Alternative Minimum Tax system also used the ADS recovery period until 1999 (see Appendix A for GDS and ADS recovery periods for selected properties; note that, for each type of asset, recovery periods are longer under the latter than under the former).

In 2002, the U.S. government attempted to stimulate aggregate demand through temporary increases in depreciation allowances, also known as bonus depreciation. The first bonus depreciation, signed into effect as part of the Job Creation and Worker Assistance Act (JCWAA), allowed 30% of new assets purchased after September 11, 2001 to be written off immediately, with the remaining portion to be depreciated under the regular MACRS schedule. In 2003, the first-year accelerated allowance was increased from 30% to 50%. The first bonus depreciation policy expired at the end of 2004; the second was enacted in 2008 and, in 2011, complete expensing (z=1) became temporarily available.

Since the introduction of bonus depreciation in 2002, researchers studying whether firms are taking advantage of the depreciation subsidy have reported mixed results. House and Shapiro (2008) documents a sharp response to the 2002 bonus depreciation in investment in assets with a very long tax life, relative to investment in assets with a short tax life. Edgerton (2009), however, provides evidence that the relative prices of new and used equipment did not respond to the bonus

[4] A change in the depreciation rules for the corporate Alternative Minimum Tax system in 1999 is described in the following section.

[5] See Section 168(g) of the Internal Revenue Code, as well as Revenue Procedure 87-56 and 87-57.

Table 2: Calculating an AMT bill

1.		Regular taxable income, before net operating losses
2.	+	Adjustments and preferences
3.	=	Taxable income before net operating losses
4.	−	AMT net operating losses (up to 90% of line 3)
5.	=	Alternative minimum taxable income
6.	−	Exemption amount
7.	=	Alternative minimum taxable income net of exemptions
8.	×	20%
9.	=	AMT before credits
10.	−	Allowable AMT foreign tax credits
11.	=	Tentative minimum tax
12.	−	Regular tax (before all credits except foreign tax credit and possessions tax credit)
13.	=	AMT (if greater than zero)

Source: Lyon (1997) Table 2.3.

depreciation, although the tax policy affects only new equipment. Also noteworthy is evidence provided by Knittel (2007) and Kitchen and Knittel (2011) that only about half of the eligible investment was claimed for bonus depreciation, probably due to the limited use of depreciation subsidy for firms in a loss status.

Background 2. Corporate Alternative Minimum Tax

In response to public criticism that large, profitable firms were paying too little income tax, the Tax Reform Act of 1986 established the corporate AMT in its current form, which requires that all firms calculate two tax bills each year, one using the regular tax rule, the other using the AMT rule. The firm must use whichever rule yields the larger tax liability.[6] Calculation of the AMT is illustrated in Table 2.

The AMT taxable income base is broadened in step 2, in which a firm adds "adjustments and preferences" to its regular taxable income to calculate its minimum taxable income. This is the step in which several types of deductions allowed under the regular tax system, but not under the AMT system, are added back in. Thus, the more adjustment and preference items a firm must add back in step 2, the more likely the AMT system will yield a larger tax liability. This also implies that, the greater the deductions, relative to revenue, claimed under the regular tax system, the more likely a firm will need to make additional tax payments. Multiplying the

[6] A firm is exempt from the AMT if it qualifies as "a small corporation" under Section 55(e) of the Internal Revenue Code. As these firms are not the focus of the paper, however, I assume here that all firms are required to calculate both tax bills.

alternative minimum taxable income by the 20% tax rate yields the tentative minimum tax bill, which is compared to the regular tax bill to determine if a positive AMT is due.[7]

Studies by Lyon (1997) and Carlson (2005a), based on actual tax return data, show that the two major upward adjustments from regular taxable income to alternative minimum taxable income are: (1) the depreciation adjustment, and (2) the adjusted current earnings (ACE) adjustment. Specifically, Carlson (2005a) reports that 63.2% of total adjustments and preferences comprised the depreciation adjustment in 1999. Given that the less generous AMT depreciation allowances during the pre-reform period are a key element of the empirical study in this paper, it is not surprising that most firms required to pay the AMT have a positive depreciation adjustment.[8] The second largest adjustment, the ACE adjustment, is calculated as 75% of the difference between pre-ACE AMT income and ACE. By adding back items excluded in taxable income but included in earnings and profits (E&P), such as tax-exempt interest income, and disallowing such deductions as dividends and drilling costs, the ACE adjustment renders AMT income closer to E&P.[9]

Although in the AMT calculation, positive AMT payments are carried forward indefinitely to reduce future regular tax liability, these credit carryforwards cannot reduce a firm's tax liability below the tentative minimum tax against which regular tax liability is compared to determine if a positive amount of AMT is due. When the AMT credit carryforwards are exhausted, a firm returns to the regular tax system. Unless a firm's tentative minimum tax tends to be systematically higher than its regular tax, the role of the AMT is thus to smooth out tax bills over time rather than to discretely increase a firm's tax liability. I nevertheless argue in this paper that AMT status plays an important role in determining investment incentives for firms affected by the AMT for extended periods.[10]

[7] Because both tax bills must be calculated each year, net operating loss (NOL) for both tax systems should also be calculated and maintained separately. For example, suppose in year 0, a firm has taxable income of negative $1M under both the regular and AMT tax systems. This firm's regular NOL and AMT NOL carryforwards will then both be $1M at the end of year 0. Suppose further that in year 1, this firm, with large gross revenue, has sufficient deductions allowed only under the regular tax system that its regular taxable income is $0, but the AMT taxable income (in step 3) is $1M. At the end of year 1, this firm's regular NOL carryforward is still $1M (unused), but its AMT NOL, because 90% is used in step 4, will be $0.1M. However, my empirical analysis ignores loss status, which Edgerton (2010) shows to have a small effect on investment.

[8] It may also imply that endogeneity concerns may arise from the interaction between investment and AMT status, but this concern is mitigated by the way AMT firms are selected in this study. See Section 5 for further discussion.

[9] The three main tax instruments – marginal tax rates, investment tax credits, and depreciation allowances – have not been altered through the ACE adjustment since 1993. Thus, I do not consider items of the ACE adjustment to have an impact on investment incentives. However, until the ACE depreciation system was repealed in 1993, firms had been required to calculate depreciation allowances for assets placed in service under a third method based on the ACE depreciation system. See Lyon (1997) for the detailed adjustment items.

[10] Bernheim (1989) argues that the AMT depreciation system provides more uniform investment incentives for different types of assets and, as a result, firms permanently affected by the AMT are less distorted by the tax system. Lyon (1990) numerically shows that the user costs of capital are generally higher for firms temporarily subject to the AMT than for firms permanently subject to the regular tax system. In each study, the research question revolves around whether being subject to the AMT discourages investment (or distorts investment decisions) relative to

Table 3: Changes in z before and after 1999

Example: Assets used in the manufacture of aerospace products

Tax System	Before 1999			After 1999		
	Recovery Period	Balancing Method	z	Recovery Period	Balancing Method	z
Regular	GDS (7-year)	200%	0.845	GDS (7-year)	200%	0.845
AMT	ADS (10-year)	150%	0.752	GDS (7-year)	150%	0.818

Note: z is calculated using an interest rate of 7%.

Whereas the AMT system used to be based on ADS, for which the recovery period is longer than for GDS, the Taxpayer Relief Act of 1997 changed the AMT recovery period for assets placed in service after 1999 from ADS to GDS. Consequently, depreciation allowances are made favorable only for the AMT system through shorter recovery periods, while the depreciation rule remains the same for the regular tax system.[11] Table 3 illustrates increases in z for the same asset as in Table 1.[12]

For the purposes of the present study, a number of advantages of the AMT reform are worth noting. First, because this tax reform directly affects depreciation allowances, it allows a transparent estimate of the role of depreciation allowances in firm investment. Second, firms under the regular tax system, for which the depreciation rule remained unchanged around the reform, can be used as a control group in a difference-in-difference study. Lastly, that the policy change was implemented just three years before the 2002 bonus depreciation granted generous depreciation allowances regardless of AMT status affords an opportunity to test the validity of the assumption I make for the difference-in-difference approach.

3 Model

3.1 Baseline Model

In this section, I present a baseline investment model that assumes a firm to be subject to the regular tax system. This firm maximizes its value at time t,

being subject to the regular tax system. By contrast, this study asks whether investment levels for firms subject to the AMT increase after 1999.

[11] Because of the requirement to calculate both tax bills every year, each firm in the study used ADS for the minimum tax bill, and GDS for the regular tax bill before 1999. In Section 4, I discuss the conditions under which a single depreciation system dominantly characterizes a firm's investment incentive.

[12] An asset used in the manufacture of aerospace products is chosen as an example because it resembles a representative type of capital good. That is, under MACRS, seven years is closest to the weighted average of GDS recovery periods across all types of assets. Also, assets with a 7-year GDS recovery period typically have a 10- or 12-year ADS recovery period. Thus, this type of asset, with 7-year GDS and 10-year ADS recovery periods, is representative.

$$V_t = \sum_{s=t}^{\infty} \rho^{s-t} CF_s^R, \tag{1}$$

where ρ is the discount factor and CF_s^R is the after-tax cash flow of the firm at time s under the regular tax system:[13]

$$CF_s^R = (1-\tau_s^R)F(K_s) - (1+(1-\eta\tau_s^R)\Psi)I_s + \tau_s^R \left[\sum_{u=-\infty}^{s} \left(D_u^R(s-u) \right) (1+(1-\eta)\Psi) I_u \right], \tag{2}$$

where $F(K_s)$ is the production function; τ_s^R is the regular tax rate; $\Psi(\cdot)$ is the convex adjustment costs, of which the fraction of η is expensed;[14] and $D_u^R(s-u)$ is the time s GDS depreciation deduction of investment made at time u ($< s$). Cash flow is rearranged as:

$$CF_s = F(K_s) - (1+\Psi)I_s - \underbrace{\tau_s^R \left[F(K_s) - \eta \cdot \Psi \cdot I_s - \sum_{u=-\infty}^{s} \left(D_u^R(s-u) \right) (1+(1-\eta)\Psi) I_u \right]}_{\text{Regular Tax Bill} \equiv TB_s^R}.$$

3.2 Introducing the AMT

With the AMT system, the firm is required to calculate both the regular tax bill and the minimum tax bill.[15] The minimum tax bill is calculated as:

$$TB_s^m = \tau_s^m \left[F(K_s) + G - \eta \cdot \Psi \cdot I_s - \sum_{u=-\infty}^{s} \left(D_u^m(s-u) \right) (1+(1-\eta)\Psi) I_u \right], \tag{3}$$

where G represents preferences and adjustments other than depreciation adjustments;[16] and $D_u^m(s-u)$ is time s' ADS depreciation deduction of investment made at time u. Note that, assuming the top tax bracket for the regular tax bill, $\tau^R = 0.35$ and $\tau^m = 0.2$. However, since the AMT tax base is broader, it is ambiguous as to which tax bill is higher.

[13]The relative price of investment to output is assumed to be unity for simplicity.

[14]When η is one, as in Summers (1981), the after-tax per-dollar adjustment cost is (1-τ_s^R); that is, adjustment costs are immediately deducted (or expensed). When η is zero, as in Auerbach (1989), the adjustment costs are deducted in the same way that acquisition costs are deducted. Most empirical studies follow Summer's assumption ($\eta = 1$), but this generalized setup clarifies the different sources of the net-of-tax rate that appear in empirical investment equations.

[15]Recall from Table 2 that, in fact, "tentative minimum tax" is compared to "regular tax" to determine whether a firm is required to pay a positive AMT. However, I use "regular tax bill" and "minimum tax bill" in this section, as they are in accord with the flow of the analysis without causing confusion.

[16]I assume G to be a firm- or industry-specific element not correlated with K_t or I_t. G includes, for example, interest and dividend income deductions allowed under the regular tax system, but disallowed under the AMT system.

The firm's cash flow in the presence of the AMT system is:

$$CF_s = F(K_s) - (1+\Psi)I_s - TB_s^R - \underbrace{\max\{TB_s^m - TB_s^R, 0\}}_{\text{AMT payment}} + \underbrace{\min\{M_{s-1}, \max\{TB_s^R - TB_s^m, 0\}\}}_{\text{limited use of AMT credit carryforwards}}, \quad (4)$$

where M_{s-1} represents for AMT credit carryforwards at the end of time s-1 (or at the start of time s). The evolution process of this term is:

$$M_s = max\{M_{s-1} + (TB_s^m - TB_s^R), 0\}, \quad (5)$$

with $M_0 = 0$. Note that since AMT credit carryforwards are non-refundable, they are bounded by zero; that is, at any time t, $M_t \geq 0$.

3.3 Defining the AMT Year

Before discussing the conditions under which investment incentives are characterized by the AMT system, I first define the AMT year, or the time during which a firm is subject to the AMT. A firm is considered to be subject to the AMT in a year when its AMT bill is the binding tax bill, so that

$$CF_s = F(K_s) - (1+\Psi(\cdot))I_s - TB_s^m.$$

Thus, in an AMT year, its current marginal tax rate is the AMT rate; and its asset recovery rule follows the AMT recovery rule.[17]

A firm's binding tax bill is its AMT bill in one of two cases: (Case 1) it currently makes a positive AMT payment, or (Case 2) it does not pay AMT, but its use of AMT credit carryforwards is limited by its minimum tax bill. In either case, it is straightforward to show that the firm's relevant tax bill is its minimum tax bill (TB_s^m) and its AMT credit carryforwards at the end of period (M_s) are strictly positive, an important key to the data collection procedure.[18]

Figure 1 illustrates the AMT years and evolution of AMT credit carryforwards for a hypothetical firm. The white bars represent the firm's annual regular tax bills, the black bars represent its annual minimum tax bills, and the gray bars represent its AMT credit carryforwards at the end of each year. The firm is assumed not to have been subject to the AMT before year t. For example,

[17]That a firm's current tax calculations are based on the AMT rules in an AMT year does not necessarily mean that the AMT system characterizes the firm's investment incentives in that year. Indeed, in Section 5, I argue that the AMT system characterizes investment incentives for only those firms that expect to be continuously subject to the AMT for an extended period. Nonetheless, defining an AMT year is a necessary step in the discussion.

[18]See Appendix B for a formal proof. Lyon (1997), Carlson (2005a), and Carlson (2005b) use these two criteria to construct aggregate measures of AMT. This section supports this insight in a formal way, and provides a bridge to the data collection procedure.

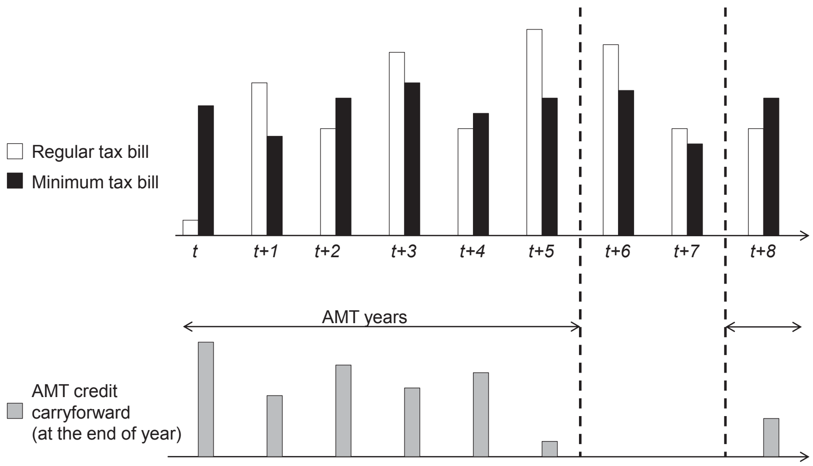


Figure 1: AMT years and the evolution of AMT credit carryforwards

suppose at time t, a firm's regular tax bill and minimum tax bill are \$10 and \$100, respectively. In this case, the positive AMT payment of \$90 becomes an asset (that is, it becomes AMT credit carryforwards) at the end of year t. The next year (year $t+1$), suppose further that the firm's regular and minimum tax bills are \$110 and \$70, respectively. Because its regular tax bill is now higher than the minimum tax bill, the AMT credit carryforwards can be used against its tax liability, but cannot reduce the tax liability below \$70. Thus, its AMT credit carryforwards at the end of year $t+1$ would be \$50 (=\$90 - (\$110 - \$70)).

In Figure 1, this firm makes positive AMT payments in years t, t+2, and t+4 (i.e., Case 1). Although in years t+1, t+3, and t+5, the firm's regular tax bill is greater than its minimum tax bill, its use of AMT credit carryforwards is limited (i.e., Case 2). Thus, from year t to t+5, the firm ends up making tax payments exactly as much as the black bars, which implies that the firm's binding tax bill is the minimum tax bill, and the relevant depreciation recovery period follows the AMT depreciation rule. Note that the AMT credit carryforwards at the end of a given year are always positive in the AMT years. In years t+6 and t+7, the firm returns to the regular tax system. Because AMT credit carryforwards are neither refundable nor carried backward, the firm has zero AMT credit carryforwards in these years.

4 Deriving the Investment Equation in the Presence of AMT

4.1 *Ex Ante* Expectation Regarding AMT Status

Depreciation saving is a forward-looking variable, as it is a function of a firm's future depreciation deduction schedules. Thus, a firm can derive its optimal investment based on a particular path that defines the timing and length of its future AMT years. Given uncertainty as to which path it will be on, a firm needs to assess the probability of being on each path and the corresponding optimum in order to fully derive its optimal investment behavior. An equivalent, but simpler, approach for a researcher is to assume that a firm, by evaluating all future possibilities of the two parallel tax bills, first derives its expected path, and then calculates its optimal investment based on that path.

Following this approach, I consider a firm subject to the AMT at time t that anticipates the following scenario: it will be subject to the AMT system continuously until it begins to be subject to the regular tax system at time $t + n^e$; and it remains permanently in the regular tax system afterwards.[19]

4.2 Investment Demand Function: Tax-Adjusted q Revisited

Recall that binding tax bills are minimum tax bills, TB^m, in AMT years and regular tax bills, TB^R, in regular tax years. Also recall that, at time $t+n^e$, any leftover AMT credit carryforwards are realized. For example, for the firm in Figure 1, small AMT credit carryforwards at the end of year $t+5$ are realized at time $t+6$ to reduce the firm's tax liability. This realization is measured as the sum of annual differences between the two tax bills:

$$L_{t+n^e} = \sum_{s=t}^{t+n^e-1} (TB_s^m - TB_s^R). \tag{6}$$

Thus, a firm maximizes

$$V_t = \sum_{s=t}^{\infty} \rho^{s-t} \left[F(K_s) - (1+\Psi)I_s\right] - \underbrace{\left[\sum_{s=t}^{t+n^e-1} \rho^{s-t} TB_s^m - \rho^{n^e} L_{t+n^e} + \sum_{s=t+n^e}^{\infty} \rho^{s-t} TB_s^R\right]}_{\text{Stream of tax bills}}, \tag{7}$$

subject to

$$K_{s+1} = (1-\delta)K_s + I_s.$$

The first order condition for I is:

$$\left[1 - \underbrace{[\eta \cdot \tau_t(n^e) + (1-\eta)\Gamma_t(n^e)]}_{\equiv [W_\eta(n^e)]_t}\right] \frac{\partial(\Psi(\cdot)I_t)}{\partial I_t} = \lambda_t \; - \left[1 - [\Gamma_t(n^e)]\right], \tag{8}$$

[19] In Figure 1, for example, $n^e = t+6$. This simple characterization is general enough to examine firm investment incentives in this study. Under my research design, for firms subject to one tax system for a sufficiently long time (i.e., $n^e = 10$ years), expecting to switch back and forth between the two tax systems more than n^e years from now would make little differences in terms of current investment incentives.

where $\tau_t(n^e)$, the expected marginal tax rate, is defined as

$$\tau^m + \rho^{n^e}(\tau^R - \tau^m)$$

and $\Gamma_t(n^e)$, the expected depreciation savings, is defined as[20]

$$\underbrace{\tau^m\left[z_t^m(0,n^e)\right] + \widetilde{\tau z}_t(0,n^e)}_{\substack{\text{depreciation savings} \\ \text{from year 0 to } n^e\text{-1}}} + \underbrace{\tau^R\left[z_t^R(n^e,\infty)\right]}_{\substack{\text{depreciation savings} \\ \text{from year } n^e \text{ to } \infty}} \quad . \tag{9}$$

A firm should invest up to the point at which the marginal after-tax *adjustment* cost (left hand side) is equal to the real shadow value of capital (λ, or marginal q), net of the after-tax *acquisition* cost of capital goods. Note that $W_\eta(n^e)$ measures the deductibility of adjustment costs, ranging from the expected marginal tax rate ($\tau(n^e)$) to the expected depreciation savings ($\Gamma(n^e)$), depending on η.

Following the investment literature, I assume the convex adjustment cost to take a quadratic form: $\Psi(I,K) = \frac{1}{2b}\frac{(I/K-a)^2}{I/K}$. Then the first order condition for investment provides a closed-form solution for investment demand:[21]

$$\begin{aligned} \frac{I}{K} &= a + b\left[\frac{1-\tau(n^e)}{1-W_\eta(n^e)}\right]\left[\frac{q}{1-\tau(n^e)} - \frac{1-\Gamma(n^e)}{1-\tau(n^e)}\right] \\ &= a + b\underbrace{\left[\frac{q}{1-W_\eta(n^e)} - \frac{1-\Gamma(n^e)}{1-W_\eta(n^e)}\right]}_{\text{tax-adjusted } q}. \end{aligned} \tag{10}$$

To avoid possible measurement error problems in q, I follow Desai and Goolsbee (2004) in separating the tax term of acquisition costs from q, so that

$$\begin{aligned} \frac{I}{K} &= a + b\left[\frac{q}{1-W_\eta(n^e)} - \frac{1-\Gamma(n^e)}{1-W_\eta(n^e)}\right] \\ &= a + b_1\left[\frac{q}{1-W_\eta(n^e)}\right] + b_2\left[\frac{1-\Gamma(n^e)}{1-W_\eta(n^e)}\right], \end{aligned} \tag{11}$$

where b_2 represents the responsiveness of investment to tax variables.[22]

Summers (1981) first assumes that adjustment costs are expensed (i.e., $\eta = 1$). Consequently,

[20] See Appendix C for the complete derivation and characterization of these variables.

[21] In deriving the investment equation in this section, the time subscript t is omitted for notational simplicity. All variables are measured at time t.

[22] In fact, b_2, which measures the price elasticity of investment, can also be interpreted as being inversely related to adjustment costs.

the investment demand equation takes the following simple form

$$\frac{I}{K} = a + b_1 \left[\frac{q}{1-\tau(n^e)}\right] + b_2 \left[\frac{1-\Gamma(n^e)}{1-\tau(n^e)}\right]. \tag{12}$$

Note that the assumption of fully expensed adjustment costs (i.e., $\eta = 1$) is adequate for some types of adjustment costs, such as forgone profits, but tax law dictates that even the indirect administrative costs of purchasing assets that are capitalized be capitalized as well (i.e., $\eta = 0$). Thus, η may be both an unobserved firm-specific and asset-specific measure. Furthermore, that grey areas exist in practice makes assumptions on η even more arbitrary. When we assume capitalized adjustment costs to be dominant, η approaches zero and the tax variable in equation (11) loses most of its variation. Indeed, a polar case of $\eta = 0$ yields the following investment equation:

$$\frac{I}{K} = a + b_1 \left[\frac{q}{1-\Gamma(n^e)}\right] + b_2 [1],$$

with the "tax term" always equal to one.

In words, one issue in studying variations in the tax treatment of acquisition costs is that these may be accompanied by variations in the tax treatment of *adjustment* costs that move in the opposite direction. Thus, I separate the tax treatment of acquisition costs of capital goods from that of adjustment costs, as the time period of interest is relatively short, using a Taylor approximation:

$$\begin{aligned}
\frac{I}{K} &= a + b\left[\frac{q}{1-W_\eta(n^e)} - \frac{1-\Gamma(n^e)}{1-W_\eta(n^e)}\right] \\
&\approx a + b\left[\frac{q}{1-W_\eta(n^e)} - \left[\overline{\left(\frac{1}{1-W_\eta(n^e)}\right)} \cdot (1-\Gamma(n^e)) + \frac{1}{1-W_\eta(n^e)} \cdot \overline{(1-\Gamma(n^e))}\right]\right] \\
&\approx a + b_1 \underbrace{\left[\frac{q-(1-\overline{\Gamma(n^e)})}{1-W_\eta(n^e)}\right]}_{\substack{\text{tax-adjusted } q \\ \text{holding depreciation} \\ \text{savings fixed}}} + b_2 \underbrace{\left[\frac{1-\Gamma(n^e)}{1-\overline{W_\eta(n^e)}}\right]}_{\text{main tax variable}},
\end{aligned} \tag{13}$$

where the overline indicates the within-firm average around which a Taylor approximation is applied (in the second line).[23] The first variable in the right hand side represents the tax-adjusted q, holding fixed depreciation savings from acquisition cost. The second variable, which is my main tax variable, measures the depreciation savings from capital goods acquisition, holding the tax treatment of adjustment cost fixed. I use equation (13) as the basis for my empirical analysis.

[23] Note that a Taylor approximation is valid for a small change around a point, so that this method is appropriate for a study with a short time span, like the one in this paper.

5 Research Design and Data

5.1 Treatment and Control Groups

This paper examines how firms, the investment incentives of which were characterized by the AMT depreciation schedule around 1999 (the treatment group), respond to the policy change in depreciation allowances compared to firms that followed the regular depreciation schedule (the control group). Specifically I compare the three-year pre-reform period (1996 to 1998) with the three-year post-reform period (1999 to 2001).[24] Firms in the treatment group must have investment incentives dominantly characterized by the AMT system during these periods. To explore this requirement, consider the expected depreciation savings formula in equation (9), repeated here:

$$\Gamma_t(n^e) = \tau^m \left[z_t^m(0, n^e\text{-}1)\right] + \widetilde{\tau z}_t(0, n^e\text{-}1) + \tau^R \left[z_t^R(n^e, \infty)\right]. \tag{9}$$

A sufficient condition for the depreciation savings to be characterized mainly by the AMT system is that a long n^e be chosen, so the first term in equation (9) dominates other terms. Then $\Gamma(n^e)$ becomes close to $\tau^m \left[z_t^m(0, \infty)\right]$. Hence, the treatment group in this analysis includes only firms that expect to be in AMT years for a sufficiently long period around the AMT reform. Likewise, the control group includes only firms that expect never to be subject to the AMT.[25]

I choose a 10-year window from 1996 to 2005 as the minimum period during which a firm must be subject to the AMT to be included in the treatment group. This means that, just before the reform takes effect (from 1996 to 1998), a firm in the treatment group is continuously subject to the AMT for at least eight more years. The treatment group firms stay in at least five more AMT years during the post-reform period.[26]

In modeling a firm's expectation about its own future AMT status, I consider as benchmarks two possibilities: perfect foresight and adaptive expectation. Under the perfect foresight assumption, firms' *ex ante* expectations regarding their AMT status correspond to the actual AMT status *ex post*. For example, under the perfect foresight assumption, a firm in the treatment group that returns to the regular tax system in 2007 has correctly anticipated doing so and behaved accordingly.

[24] It is natural to pick a three-year period because the first bonus depreciation, of which the period is also three years (from 2002 to 2004), was enacted three years after the AMT reform. To be precise, the first bonus depreciation was enacted retrospectively, so that assets placed in service after September 11, 2001 were also eligible for the benefits.

[25] Note that it is possible, although unlikely, that a firm's current marginal investment may extend its AMT duration from, say, eight to nine years. Selecting only firms subject to the AMT for long periods in the treatment group mitigates the concern that a firm's current investment may affect its future AMT duration on the margin. That is, whereas a long n^e is crucial for the AMT system to be able to characterize investment incentives, a marginal change around the *long* n^e would have little effect on investment incentives, due to the continuous nature of the AMT impact.

[26] As robustness checks, I run the regressions with other selection window lengths, one with 1996 to 2007 (i.e., minimum 12 years), another with 1996 to 2001 (i.e., minimum 6 years).

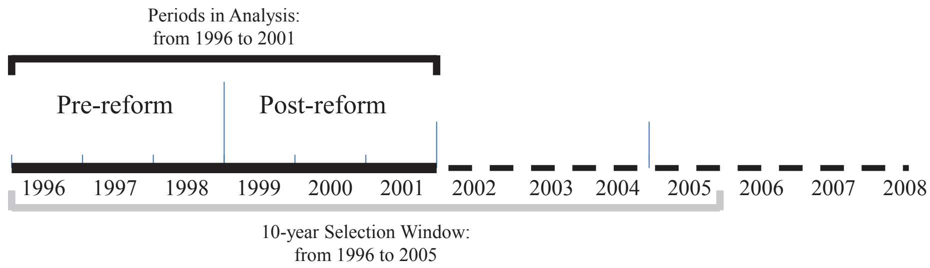


Figure 2: 10-year selection window for treatment and control groups

On the other hand, under the adaptive expectation assumption, the treatment group firms form their expectations based on their current status, and thus behave as if they are permanently subject to the AMT.[27] In other words, for the treatment group firms during the period in analysis (1996 to 2001), $n^e = \infty$ under the adaptive expectation assumption. This distinction between the two benchmarks has an important implication for the empirical analysis, which I discuss in the following subsection.

5.2 The Size of Treatment and Role of Expectation in Identification

In this section, I discuss the size of the treatment, that is, changes in the main tax variable around the AMT reform depending on the expectation assumptions, and how other periods can be used to identify the impact of the reform.

In measuring the main tax variable, two issues arise with depreciation savings, $\Gamma(n^e)$. First, it is possible that, in a perfect foresight world, source of changing expected depreciation savings, in addition to the AMT reform, occurs for the treatment group. To illustrate this point, let Γ_t^{ADS} be the depreciation savings at time t under the pre-reform AMT system (i.e., the ADS recovery period) and Γ_t^{GDS} be the depreciation savings under the post-reform AMT system (i.e., the GDS recovery period). Then, the relationship $\Gamma_t^{GDS} \geq \Gamma_t^{ADS}$ reflects an increase in depreciation savings caused by the AMT reforms at a given time t. However, the actual variation in depreciation savings around the AMT reform we observe, $\Gamma_{post}^{GDS} - \Gamma_{pre}^{ADS}$, is decomposed as:

$$\Gamma_{post}^{GDS} - \Gamma_{pre}^{ADS} = \underbrace{\Gamma_{post}^{GDS} - \Gamma_{post}^{ADS}}_{\text{reform-induced variations}} + \underbrace{\Gamma_{post}^{ADS} - \Gamma_{pre}^{ADS}}_{\text{expectation-induced variations}},$$

where the subscripts *post* and *pre* indicate the post- and pre-reform periods, respectively. The reform-induced variations, or the main variations of interest, are the differences between depreciation savings caused purely by the AMT reform, regardless of expectation assumptions. The

[27] This may also be a reasonable assumption because, by construction, my treatment group firms tend to generate large minimum tax bills systematically, compared to regular tax bills.

expectation-induced variations, on the other hand, are mechanical increases in depreciation savings that may arise from a firm's expectations of being one step closer to getting out of AMT, year by year.[28] For a firm that is, or behaves as if it is, permanently subject to the AMT (i.e., under the adaptive expectation assumption), this expectation-induced variation is zero, whereas for a firm that expects to be out of AMT at a certain time in the future (i.e., under the perfect foresight assumption), the size of expectation-induced increases may be non-negligible. I calculate these variations separately in Table 4.

Second, the asset-level z should be converted into firm-level measures. Because firm-level asset composition information is not available, I use industry-level measures for depreciation savings, following the procedures in Cummins, Hassett and Hubbard (1994), Desai and Goolsbee (2004), and Edgerton (2010). For each type of asset, I first calculate two depreciation allowance measures, one under the regular tax system, and the other under the AMT system.[29] I then match these measures to those in the 1997 BEA Capital Flows table to construct industry-level depreciation saving measures for the two tax systems.

Table 4 compares the size of variations for the main tax variable, $\frac{1-\Gamma(n^e)}{1-\tau(n^e)}$, between the treatment and control groups. I divide the sample years into three periods: pre-reform (1996 through 1998), post-reform (1999 through 2001), and bonus depreciation (2002 through 2004). The table assumes full expensing ($\eta = 1$) for the tax treatment of adjustment costs.[30]

Panel A of Table 4 measures the main tax variable under the adaptive expectation assumption in which the treatment group firms are assumed to behave as if they are permanently subject to the AMT. Thus, the expectation-induced variation is zero and the variation presented is entirely reform-induced. The variation observed in Panel B of Table 4, on the other hand, which follows the perfect foresight assumption, contains expectation-induced increases as well. In Panel B, each firm in the treatment group is assumed to anticipate that it eventually returns back to the regular tax system and behaves accordingly, so its depreciation saving becomes larger year after year even without the AMT reform. Intuitively, the values of the main tax variable for the treatment group in Panel A only use the AMT system, whereas those in Panel B reflect the weighted average of the AMT system and the regular system with the latter weighted more heavily year after year.

Comparing the pre- and post-reform periods, the AMT reform *per se* decreases the variable

[28] Depreciation savings are higher under the regular tax system than under the AMT system, because z and τ are both higher. Therefore, the closer a firm is to returning to the regular tax system, the higher depreciation savings the firm can receive from marginal investment.

[29] I use Moody's Baa rates as the discount rate when discounting depreciation savings. In my sample years, the rates are fairly stable at around 7%. There has been controversy around which interest rates to use to discount depreciation savings. Contrary to economists' belief that depreciation savings are a form of lending money to the government, and so should be considered riskless, Summers (1987) finds that firms may use much higher interest rates. In his survey, firms report an average discount rate in excess of 15%, which is approximately the Baa rate in the year in which the survey was conducted.

[30] Note that the same calculations with a full capitalizing (η=0) assumption, presented in Appendix D, are similar, which would not be too surprising since the main tax variable is constructed so as not to be sensitive to the expensing vs. capitalizing assumption. Therefore, for simplicity, I continue to use the full expensing assumption hereafter.

Table 4: Size of variation in the tax variable: $\frac{1-\Gamma(n^e)}{1-\overline{\tau(n^e)}}$

Panel A. Adaptive Expectation – *Permanently* subject to the AMT ($n^e = \infty$)

		Control		Treatment	
Periods	Years	Value	Δ	Value	Δ
Pre-Reform	1996-1998	1.069	-	1.056	-
Post-Reform	1999-2001	1.069	0.000	1.041	0.015
Bonus Depreciation	2002-2004	1.035	0.034	1.020	0.021

Panel B. Perfect Foresight – *Temporarily* subject to the AMT (n^e: actual year[1])

		Control		Treatment	
Periods	Years	Value	Δ	Value	Δ
Pre-Reform	1996-1998	1.069	-	1.095	-
Post-Reform	1999-2001	1.069	0.000	1.057	0.038
Bonus Depreciation	2002-2004	1.035	0.034	1.006	0.049

1. The actual year each firm in the treatment group returns back to the regular system is used for calculation.

by 0.015 (Panel A of Table 4). Therefore, the size of the expectation-induced variation is as small as 0 under adaptive expectation; and as large as 0.023 (= 0.038 - 0.015) under perfect foresight.[31] Because the control group firms do not experience any change in the tax variable, these two periods will be used for the difference-in-difference analysis in this study.

The 2002 bonus depreciation, which allowed accelerated depreciation deductions for firms regardless of AMT status, decreases the tax variable for both groups. During this period, the tax variable drops by 0.034 for the control group, and by 0.021 for the treatment group due to the tax reform; additionally, it drops by as much as 0.028 (= 0.049 - 0.021) for the treatment group under the perfect foresight assumption. Which group benefits more from bonus depreciation depends on the expectation assumption, but, on average, the measures are quite similar. Thus, this provides us with an opportunity to test for heterogeneity in the different groups' responsiveness to tax

[31] Note that the tax variable here is the after-tax acquisition cost ($1 - \Gamma(n^e)$), divided by the tax treatment of adjustment costs averaged within-firm ($1 - \overline{\tau(n^e)}$). Under perfect foresight, the after-tax adjustment cost (the denominator) for the treatment group firms also decreases year by year while they anticipate to get out of AMT status. As explained in Section 4.2, my specification attempts to hold this denominator fixed, by averaging the tax treatment of adjustment costs within-firm. Thus, values of the variable in Table 4, especially for the treatment group in Panel B, are compared only within-firm, not across-firm. For example, in Panel B of Table 4, the tax variables calculated as 1.006 for the treatment group firms, and as 1.035 for the control group firms, during the bonus depreciation period do not necessarily imply that the treatment group firms enjoyed greater depreciation savings than did the control group firms. Rather, 1.006 for the treatment group during the bonus depreciation period is interpreted as quite low, compared to 1.057 for the same group before the bonus depreciation was allowed. In other words, it is the within-firm changes (Δ) that matter. This interpretation issue, however, would not affect the empirical analysis in Section 6, since firm fixed effects are included in all specifications.

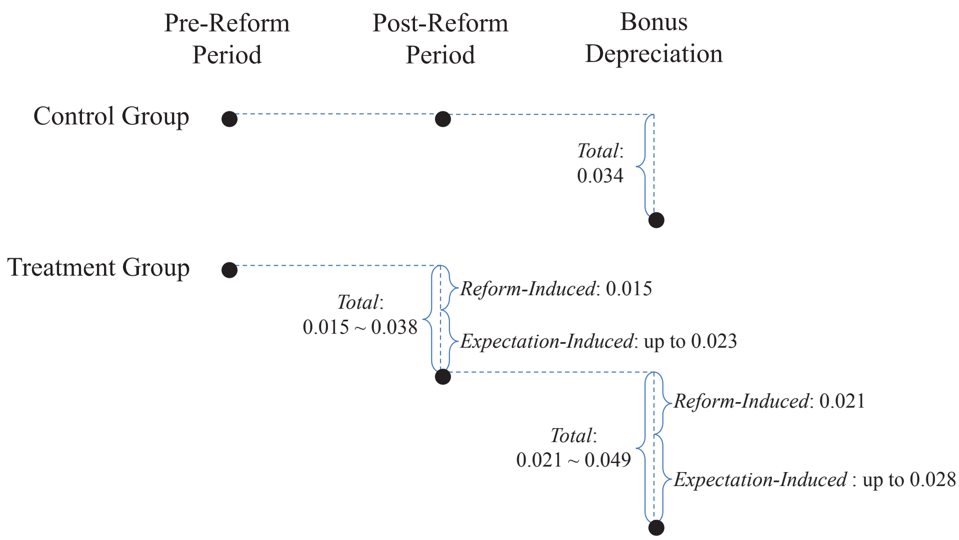


Figure 3: Decomposition of variations in the tax variable

policies. The decomposition of variation is illustrated in Figure 3.

The possible existence of expectation-induced variation raises concerns about whether it is possible (1) to observe the way a firm forms its expectation, and (2) to separate the effects of the tax reforms on investment from the effects of expectation-induced variation. I address these concerns by using the preceding period, from 1993 to 1995, to isolate the expectation-induced variation, as expectation-induced increases in depreciation savings, $\Gamma_{post}^{ADS} - \Gamma_{pre}^{ADS}$, arise regardless of periods. Intuitively, if firms behave according to the perfect foresight assumption, any expectation-induced increases must have affected their investments in any given period. That is, $\Gamma_{post}^{ADS} - \Gamma_{pre}^{ADS} = \Gamma_{t+3}^{ADS} - \Gamma_{t}^{ADS}$ for any t. The effects of expectations would then be captured by comparing the preceding period (1993-1995) with the pre-reform period (1996-1998) for the treatment and control groups. Figure 4 presents a conceptual sketch of the research design.

To summarize, the main difference-in-difference analysis is conducted with the sample years from three years before to three years after the AMT reform. Given the possibility of other sources of increases in depreciation savings, the preceding period is used to isolate the impact of the AMT reform from that of those sources. Finally, bonus depreciation policy is used to check for heterogeneity in the groups' inherent responsiveness to tax policies.

5.3 AMT Status Data

Firms report their AMT status (whether they are subject to the AMT and the amount of AMT credit carryforwards they possess for the year) in the tax footnote to their financial statements. This tax footnote information, which is contained in 10-K filings to the SEC, is collected from the Morningstar database. Morningstar provides a search engine for 10-K filings, which are required

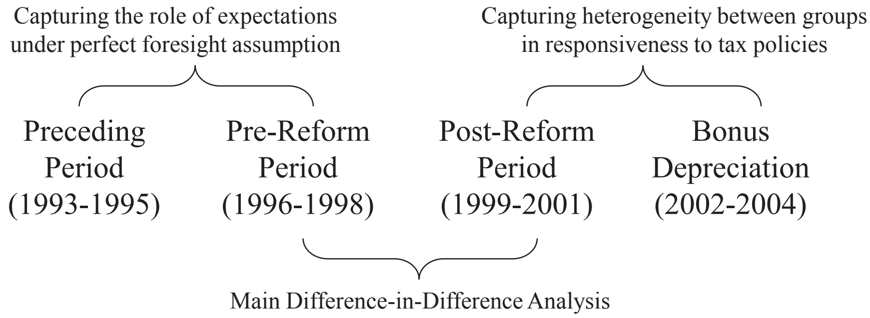


Figure 4: Research design

by the SEC for firms with more than $10 million in assets and equity securities held by more than 500 owners. As discussed in Section 3, I make use of the fact that AMT credit carryforwards are positive in, and only in, AMT years. Because firms use slightly different terms in their filings, I look first for 10-K information matched with the following keywords: AMT credit, AMT credits, AMT carryforwards, AMT carry forwards, minimum tax credit, minimum tax credits, minimum tax carryforwards, and so forth. I then select for the treatment group firms that have one of these keywords in their 10-K filings for every filing from 1996 to 2005.[32]

One possibility that may affect the results is that firms are not required to mention AMT status specifically. Rather, AMT credit carryforwards are part of the deferred tax assets firms are required to report collectively in the tax footnote, and it is left to individual firms whether to break this information out. However, I believe it is reasonable to assume that sample firms listed on major stock markets, such as the New York Stock Exchange, American Stock Exchange, or NASDAQ, have a strong incentive to provide shareholders and investors with detailed asset information in their tax footnotes. Nevertheless, I compare the aggregate AMT information from the 2002 10-K filings collected in the way described above with the aggregate information from the 2002 actual tax return data reported in Carlson (2005a) in Appendix E. Given that the universe of firms reporting to the SEC is a subset of the universe of firms filing tax returns, collecting data through SEC 10-K filings identifies AMT firms relatively well, especially the larger firms that

[32]Not all of these firms are necessarily subject to the AMT for the entire period. Firms typically report the previous year's accounting information, in their annual 10-K filings. For example, a firm may report accounting information for fiscal years 2003 and 2004 in its 2004 filing. This firm may, even if it returns to the regular tax system in 2004, *mention* AMT credit carryforwards in its 2004 filing. I therefore manually look up all annual 10-K filings for the treatment group firms and find 10 firms among my 84 baseline treatment group firms that end up being subject to the regular tax system for one year out of the 10-year window. As the manual filtering does not alter the empirical results quantitatively or qualitatively, I omit this manual filtering in the analysis to ensure comparability with other group selections for robustness checks performed in Section 6. In Appendix G, I list the treatment group firms and indicate the ten firms that have deviated for one year.

comprise the bulk of my treatment group firms.

5.4 Other Variables

I next match AMT status information with Compustat firm-level information including capital expenditures and capital stock. Following the firm-level investment literature, investment at time t, the dependent variable, is measured as the ratio of Capital Expenditure in the current year (t) to Property, Plant and Equipment (PPE) at the end of the previous year ($t-1$).

I briefly sketch how other financial measures are constructed in this section, and provide detailed descriptions in Appendix F. I construct the q variable as equity (market value) plus liability (book value) divided by total assets (book value), and truncate the sample at the highest and lowest 1% of investment and q. Following the corporate finance literature, which argues that cash flow has explanatory powers with respect to investment for financially-constrained firms, I include a cash flow measure, a financial constraint measure, and the interaction of the two. For the financial constraint measure, I use the Size-Age index (also known as the S-A index) developed by Hadlock and Pierce (2010), since this index is least likely to suffer from endogeneous financial decisions reflected in the variables used to construct such indices, such as cash holding and leverage.[33]

I include only firms that show up in Compustat before 1996 and survive until at least 2001, so that the panel is balanced at least from 1996 to 2001. In addition, I include only firms in manufacturing-related industries (Mining, Utilities, Construction, Manufacturing, Trade, and Transportation). Recall that the treatment group includes firms subject to the AMT from 1996 to 2005, and the control group includes firms subject to the regular tax during the same period. As mentioned above, the treatment group only includes firms that report a positive amount of AMT credit carryforwards, while listed on one of major stock exchanges, during that period (from 1996 to 2005). The baseline sample consists of 84 firms in the treatment group and 1,330 firms in the control group.

Summary statistics for the two groups are presented in Table 5. These statistics show that the treatment group firms tend to have a lower investment rate and lower q. They also have a higher capital intensity and lower sales ratio, as suggested in Section 2. By construction, the K-Z index and the S-A index are higher for financially-constrained firms. This much higher K-Z index suggests that the treatment group firms are more financially-constrained across all periods, but the similar S-A index between the two groups implies that the relationship reflected in the K-Z index may be spurious.

[33] For example, cash holding is usually entered as a negative in financial constraint measures, but Hadlock and Pierce (2010) find some financially-constrained firms have large cash holdings for precautionary reasons. Nonetheless, following the previous literature, I use the Kaplan-Zingales index as a robustness check; the results (not reported) do not change substantially.

Table 5: Summary statistics

		Control Group (1330 firms)			Treatment Group (84 firms)		
		1996-1998	1999-2001	2002-2004	1996-1998	1999-2001	2002-2004
Investment	(median)	.2497	.2006	.1552	.1993	.1695	.1215
	(mean)	.3984	.2982	.2306	.3004	.2630	.2005
	(std. dev.)	.5281	.3540	.3194	.3366	.3866	.2870
q	(median)	1.5865	1.3822	1.4387	1.2214	1.1288	1.1996
	(mean)	2.0771	2.0564	1.8082	1.5174	1.4892	1.5362
	(std. dev.)	1.5737	2.2230	1.2651	.9169	1.1959	.9133
Cash flow	(median)	.3563	.3039	.3078	.1584	.1405	.1591
	(mean)	-.0147	.1163	-.6803	.0571	.0730	.1046
	(std. dev.)	8.5230	5.4492	34.0193	2.0113	1.7905	2.8983
S-A index	(median)	-3.2538	-3.4293	-3.5805	-3.2781	-3.4316	-3.5779
	(mean)	-3.3140	-3.4922	-3.6311	-3.3328	-3.4788	-3.6431
	(std. dev.)	.7274	.6754	.6423	.6530	.6280	.5798
K-Z index	(median)	.1273	.3646	.2608	1.0376	1.2081	1.1112
	(mean)	-.0317	.2655	.1539	1.0056	.9860	1.1074
	(std. dev.)	2.3493	1.9594	1.6514	1.3168	4.9317	1.2385
Sales ratio	(median)	1.1960	1.0863	1.0158	.9775	.8916	.9285
	(mean)	1.3825	1.2554	1.1820	1.1031	1.0860	1.1200
	(std. dev.)	1.0323	.8927	.8366	1.0112	.8831	1.0457
Capital intensity	(median)	.2696	.2602	.2443	.4434	.4069	.3890
	(mean)	.3326	.3203	.3054	.4619	.4393	.4226
	(std. dev.)	.2353	.2316	.2264	.2612	.2662	.2755

Industries (SIC two-digit code)	**Number of Firms**	
Mining (10-14)	65 (4.9%)	13 (15.5%)
Construction (15-17)	20 (1.5%)	2 (2.4%)
Manufacturing (20-39)	885 (66.5%)	46 (54.7%)
Transportation (40-47)	35 (2.6%)	6 (7.2%)
Utility (48-49)	138 (10.4%)	9 (10.7%)
Trade (50-59)	187 (14.1%)	8 (9.5%)
All	1330 (100%)	84 (100%)

Note: The table presents summary statistics for the baseline control and treatment group firms. The baseline control group includes firms subject to the regular tax from 1996 to 2005, and the baseline treatment group includes firms subject to the AMT during the same period.

6 Empirical Results

In this section, I provide the results for the difference-in-difference analysis. First, the investment trends for both groups are illustrated graphically in Figure 5. Panel A and Panel B use the original investment measures, I/K. Panel A shows the annual investment trends, while Panel B shows the average investment for each period. Comparing the pre- and post-reform periods, the treatment group firms do not decrease investment as much as the control group firms do. The figures also show a somewhat close movement in investment after 1999 between treatment and control groups. Panel C and Panel D construct the residuals from the following equation to show the measures of investment to be explained solely by the tax reform:

$$\frac{I_t}{K_{t-1}} = \beta_0 + c_1 \cdot q_{it} + c_2 \cdot X_{it} + \alpha_i + \gamma_t + e_{it}, \tag{14}$$

where subscript i indicates firm i and t indicates year t. q_{it} is the average q, and X_{it} is the set of firm-year specific covariates, such as cash flow and the financial constraint index. α_i and γ_t are firm fixed effects and year fixed effects, respectively.[34] Controlling for firm fixed effects, year fixed effects, industry-year fixed effects,[35] and other covariates including q, it becomes clear in these two figures that treatment group firm investments increase after 1999 relative to control group firm investments, and that the two groups investment behaviors do not appear to be different entering the bonus depreciation period.

6.1 Baseline Regression Difference-in-Difference

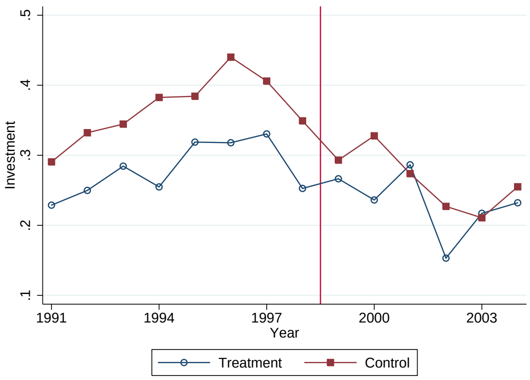
In this section, I examine the impact of the AMT reform on firm investment, based on equation (13), using a difference-in-difference approach. This analysis has three goals, (1) to investigate differences in investment between the two groups in a transparent way, (2) to use the bonus depreciation period to check the validity of my identifying assumption, namely, the same tax responsiveness of both groups, and (3) to use the preceding period to check the pre-treatment trends of the two groups. I hence consider the following specification:

$$\begin{aligned}\frac{I_t}{K_{t-1}} = \beta_0 \quad &+ \quad \beta_1(D_i^{treat} \cdot D_t^{a1999}) + \beta_2(D_i^{treat} \cdot D_t^{bonus}) + \beta_3(D_i^{treat} \cdot D_t^{a1996}) \\ &+ \quad c_1 \cdot q_{it} + c_2 \cdot X_{it} + \alpha_i + \gamma_t + e_{it}, \end{aligned} \tag{15}$$

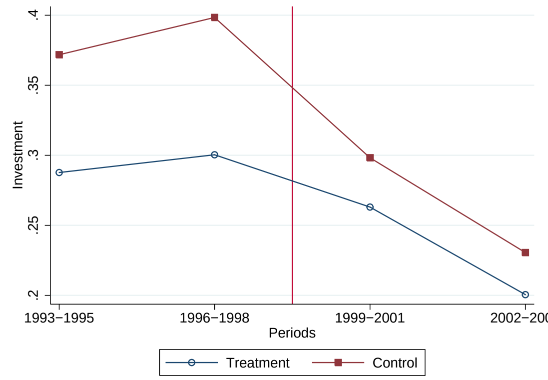
where D_i^{treat} is a dummy variable for the treatment group, D_t^{a1999} is a time dummy variable for the post-reform period (in or after year 1999), D_t^{bonus} is a time dummy variable for the bonus depreciation period (year 2002-2004), and D_t^{a1996} is a time dummy variable for the post-preceding period (in or after year 1996). The other variables are as described in equation (14). The main

[34] That is, the residuals are constructed as follows: $\widehat{e}_{it} = \frac{I_t}{K_{t-1}} - \widehat{c_1} \cdot q_{it} - \widehat{c_2} \cdot X_{it} - \widehat{\alpha_i} - \widehat{\gamma_t}$.

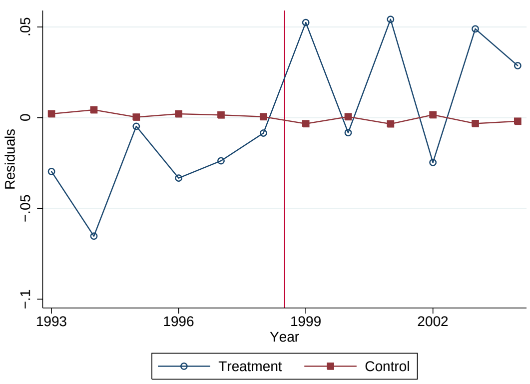
[35] Industry-year fixed effects are included to control for unobserved industry-specific shocks over time.



A. Annual Investment



B. Three-year-average Investment



C. Annual Investment (residual)

D. Three-year-average Investment (residual)

Figure 5: Investment trends.

The control group includes firms subject to the regular tax from 1996 to 2005, and the treatment group includes firms subject to the AMT during the same period. Panel A and Panel B present the trends of the original investment rate, $\frac{I_t}{K_{t-1}}$, in an annual base and in a 3-year period base, respectively. Panel C and Panel D present the trends of the investment residual in an annual base and in a 3-year period base, respectively. The residuals are constructed as $\widehat{e}_{it} = \frac{I_t}{K_{t-1}} - \widehat{c}_1 \cdot q_{it} - \widehat{c}_2 \cdot X_{it} - \widehat{\alpha}_i - \widehat{\gamma}_t$.

variable of interest is the interaction term, $D_i^{treat} \cdot D_t^{a1999}$.

The regression results are reported in Table 6. In column (1), which uses equation (15) from year 1996 through year 2001, the main coefficient of interest, β_1, is estimated as 0.0645. In column (2), I control for industry-year fixed effects to address potential concerns that the result in column (1) could be driven by an unobserved shock, such as unexpected increases in output prices, that benefits only those industries heavily comprised of AMT firms. However, controlling for such effects yields an almost identical estimate (0.0646), suggesting that any unobserved investment shock in the AMT-firm-heavy industries is not likely to drive the results.

Column (3) is extended to include the preceding period so that the regression runs from year 1993 to year 2001. The estimate for the interaction of the treatment group dummy with the time dummy for after-1996, β_3, is insignificant; thus I cannot reject the null that the two groups have the same trends before the treatment.[36]

Column (4) includes the bonus depreciation period, so that the regression uses the full sample years, 1993 to 2004. The estimate for the coefficient of $D_i^{treat} \cdot D_t^{bonus}$ is insignificant and fairly small, indicating that the two groups exhibit a similar response to bonus depreciation. Recall that the identification of this difference-in-difference comes from the assumption of similar investment responsiveness to tax changes across the two groups. On the one hand, if the main result is driven by a higher responsiveness in the treatment group, I would expect a relatively larger increase in investment in response to bonus depreciation by this group. On the other hand, if my identifying assumption is satisfied, the coefficient estimate for the interaction term $D_i^{treat} \cdot D_t^{bonus}$ would be insignificant. Thus, the results in column (4) suggest that the main result is not likely to be driven by unobserved heterogeneous responsiveness between the two groups.

Column (5) repeats the analysis with three-year average investments as the dependent variable in order to address possible serial correlation problems. As emphasized by Bertrand, Duflo and Mullainathan (2004), a study is likely to suffer from serial correlation problems when the dependent variable is highly serially correlated and the treatment indicator changes little over time. A simple method for addressing this concern is to collapse annual time series into pre and post periods. Consequently, column (5) collapses the sample years 1996 through 2001 into two three-year periods. The main estimate for β_1 is similar to those in the previous columns, suggesting that the main results of this table are not likely to result from a serial correrlation problem.

6.2 The Role of the Perfect Foresight Assumption

So far the analysis has been based on a 10-year tax window beginning in 1996; the main period in the analysis is the *first* 6-year period out of the 10-year window. However, as discussed in Section 5, the perfect foresight assumption generates year-by-year expectation-induced variation

[36]Nonetheless, one can interpret $\beta_1 - \beta_3$ as the pure impact of the AMT reform on investment, which is 0.0394 (= 0.0616 - 0.0222).

Table 6: Baseline regression of investment

	(1)	(2)	(3)	(4)	(5)
$D_i^{treat} \cdot D_t^{a1999}$	.0645**	.0646**	.0616*	.0611*	.0584*
	(.0320)	(.0324)	(.0322)	(.0324)	(.0321)
$D_i^{treat} \cdot D_t^{bonus}$				-.0168	
				(.0340)	
$D_i^{treat} \cdot D_t^{a1996}$			.0222	.0128	
			(.0281)	(.0277)	
q	.0276***	.0300***	.0317***	.0346***	.0688***
	(.0078)	(.0083)	(.0055)	(.0056)	(.0139)
Cash Flow	-.0234***	-.0243***	-.0174**	-.0118	-.0346***
	(.0051)	(.0055)	(.0072)	(.0081)	(.0071)
S-A Index	-.0827	-.1289	.0001	.0174	.1185
	(.1061)	(.1065)	(.0627)	(.0537)	(.1193)
Cash Flow	-.0077***	-.0082***	-.0002	-.0038	-.0141***
× S-A index	(.0026)	(.0029)	(.0665)	(.0030)	(.0035)
Years	1996 ∼ 2001	1996 ∼ 2001	1993 ∼ 2001	1993 ∼ 2004	1996 ∼ 2001
Periods "collapsed"	No	No	No	No	Yes
Firm Fixed	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes
Industry-Year Fixed	No	Yes	Yes	Yes	Yes
Observations	8484	8484	11896	15825	2828
# of Treatment Group	84	84	84	84	84
# of Control Group	1330	1330	1330	1330	1330

Note: The dependent variables in columns (1) through (4) are annual investment (capital expenditures to lagged capital stock); and three-year-averaged investment in column (5). For column (5), all the covariates are also averaged over each period. The main variable of interest is $D_i^{treat} \cdot D_t^{a1999}$, the interaction of the treatment group dummy with the post-reform time dummy. Variable descriptions are in Appendix F. All standard errors are clustered at the firm-level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

in depreciation savings, so the length of the *remaining* AMT spell would also be important in determining the role of the perfect foresight assumption in describing firm investment incentives.

Figure 6 illustrates the appropriate selection windows under the perfect foresight assumption. Note that the first selection window is the baseline for the analysis conducted so far. However, to explore the possibility and implications of the perfect foresight assumption using the 6-year period before the reform (i.e., 1993-1998), one would also need to construct treatment and control groups based on the 10-year window starting in the same year as the main period, namely, 1993. This way, the period to be analyzed (i.e., 1993-1998) is the *first* six years out of the 10-year selection window, so that it can be tested whether expectation-induced variation affects the investment behaviors of the treatment group firms during the first six years. Thus, to check the role of the perfect foresight assumption, I select firms subject to the AMT from 1993 to 2002 as the treatment group, and firms subject to the regular tax system during the same period as the control group, as illustrated

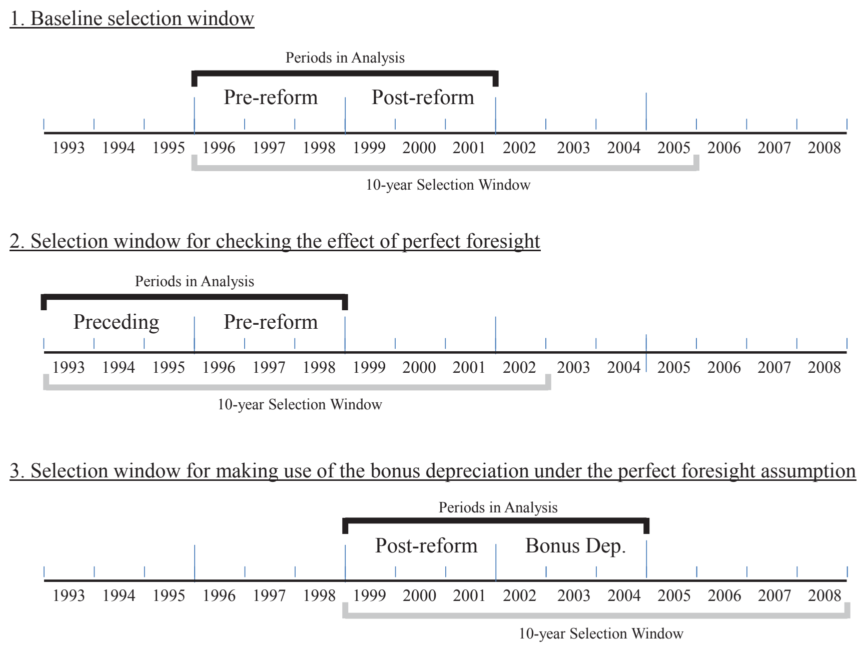


Figure 6: Various 10-year selection windows under perfect foresight assumption

in the second selection window in Figure 6. Likewise, to test the existence of heterogeneous responsiveness to the 2002 bonus depreciation under the perfect foresight assumption, I select the treatment and control groups based on the 10-year selection window starting from 1999, as in the third selection window in Figure 6.

Table 7 presents the regression results. Columns (1) and (2) use the 10-year selection window starting from 1993 to examine pre-treatment trends under the perfect foresight assumption. The sample years used for this specification are 1993-1998. In column (1), the variable of interest is the interaction term of the treatment group dummy with the *after-1996* time dummy, so one can also consider the after-1996 period as the placebo treatment. In column (2), I include group-specific time trends, so that the main variable of interest is the time trend of the treatment group. In both specifications, although the coefficients of interest are statistically insignificant, the sizes are non-negligible. In column (1), relative to the control group firms, the treatment group firms increase their investment by as much as 0.0283 before and after 1996. This result is also consistent with the results in column (2) which implies that treatment group firms increase their investment by as much as 0.0120 every year during the six-year period.

Thus, I conclude that perfect foresight appears to be too strong an assumption to describe expectations regarding future AMT status for firms subject to the AMT for at least 10 years. I nonetheless provide conservative estimates for the impact of AMT reform by subtracting the estimates of the impact of perfect foresight from the main results reported in column (2) of Table 6, yielding 0.0363 (=0.0646-0.0283).

Table 7: The role of the perfect foresight assumption and other robustness checks

Truncation Cutoffs:	1% (baseline)					0.5%
Selection Window:	1993 - 2002 (10 year)		1999 - 2008 (10 year)	1996 - 2007 (12 year)	1996 - 2001 (6 year)	1996 - 2005 (10 year)
	(1)	(2)	(3)	(4)	(5)	(6)
$D_i^{treat} \cdot D_t^{a1999}$				.0539*	.0384	.0629*
				(.0315)	(.0261)	(.0338)
$D_i^{treat} \cdot D_t^{bonus}$			.0267			
			(.0311)			
$D_i^{treat} \cdot D_t^{a1996}$	.0283					
	(.0286)					
Time Trend		-.0614*				
		(.0344)				
$D_i^{treat} \cdot$ Time Trend		.0120				
		(.0086)				
q	.0427***	.0427***	.0254***	.0266***	.0289***	.0293***
	(.0125)	(.0125)	(.0058)	(.0076)	(.0077)	(.0082)
Cash Flow	-.0271*	-.0271*	.0125***	-.0241***	-.0261***	-.0205***
	(.0139)	(.0139)	(.0218)	(.0058)	(.0074)	(.0061)
S-A index	-.0720	-.0731	-.5967***	-.1097	-.1054	-.1967
	(.0952)	(.0952)	(.1013)	(.1094)	(.0980)	(.1338)
Cash Flow × S-A index	-.0131*	-.0131*	.0049	-.0080***	-.0083***	-.0058*
	(.0069)	(.0069)	(.0079)	(.0029)	(.0032)	(.0031)
Years	1993 ∼ 1998	1993 ∼ 1998	1999 ∼ 2004	1996 ∼ 2001	1996 ∼ 2001	1996 ∼ 2001
Firm Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7662	7662	8295	8082	9612	8544
# of Treatment Group	36	36	81	59	148	84
# of Control Group	1384	1384	1357	1288	1454	1340

Note: The dependent variable is annual investment (capital expenditures to lagged capital stock). Variable descriptions are in Appendix F. All standard errors are clustered at the firm-level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Column (3) selects the treatment and control groups based on the 10-year selection window from 1999 to 2008. In this window, I select sample years from 1999 to 2004 to test whether both groups exhibit similar responses to the 2002 bonus depreciation under the perfect foresight assumption. The small, insignificant coefficient for the interaction term of the treatment group dummy with the dummy for year 2002-2004 suggests that it is indeed reasonable to attribute the main results in this study to firm responses to the AMT reform.

6.3 Robustness Checks

Recall that the treatment group includes 84 firms subject to the AMT for at least 10 years starting in 1996. Having shown that firms in the treatment group are more likely to behave as if they are permanently subject to the AMT, a natural question is whether the results are sensitive to the length of the selection window. Hence, I now examine whether the result that firms subject to the AMT for 10 years behave as if they are permanently subject to the AMT is robust to a longer selection window. To check this, I choose two other selection window lengths and repeat the main regression. The results are presented in Table 7.

In column (4), I use a 12-year selection window starting in 1996. This stricter selection rule reduces the size of the treatment group to 59 firms. The estimate for β_1 (0.0539) is in the same range as for the other specifications in the main table. In column (5), I choose the period from year 1996 to year 2001, so that firms continuously subject to the AMT for only six years are now also included in the analysis. That the main estimate (0.0384) loses its size and significance is consistent with the theory in Section 4, which suggests that with a small n^e the AMT system would not dominate a firm's investment incentives for the AMT reform to be appreciated. Hence, I conclude that a 10-year window is likely to be sufficiently long, but that a selection window as short as six years may not be long enough.

So far, to avoid dealing with extreme values reported in accounting measures in Compustat, I have followed the corporate finance literature in truncating investment at the highest and lowest 1% levels. To check whether my truncation level matters, I also use the 0.5% truncation level. Note that the number of treatment group firms (84) does not change, because only control group firms are being truncated due to extreme values. The main results in column (6) are largely close to the baseline results, qualitatively and quantitatively.

6.4 Other Explanations

With strong evidence that the 84 treatment group firms increase their investment in response to the AMT reform, I conduct additional analyses to determine if firm-specific investment fluctuation over the sample years might be driving the results. That is, AMT firms' cyclical increase in investment might have coincided with the post-reform period, in which case a treatment group firm with a smaller pre-reform investment level would have seemingly stronger responses to the tax reform than a firm with a larger pre-reform investment. Moreover, this effect would be larger for a smaller or less capital-intensive firm that is less able to smooth out its investment across periods. Thus, I check whether a treatment group firm with a smaller level of pre-reform investment responds to the reform more strongly; and whether a smaller (measured as total asset) or a less capital-intensive (measured as capital intensity) treatment group firm responds more strongly.

To do so, I divide the 84 treatment group firms into two categories based on their pre-reform levels of investment. That is, a treatment group firm is classified based on whether its pre-reform investment level falls into the lower half or the upper half of all the treatment group firms. I interact the post-reform time dummy with the dummy for treatment group firms with high pre-reform investment level (i.e., $D_i^{treat-highI} \cdot D_t^{a1999}$). Likewise, I divide the treatment group firms on the pre-reform levels of capital intensity and total asset, and create the interaction terms of the post-reform time dummy with the dummy for treatment group firms with high pre-reform level, $D_i^{treat-highK} \cdot D_t^{a1999}$ and $D_i^{treat-highA} \cdot D_t^{a1999}$, respectively.

See Table 8 for the regression results. The baseline estimation is repeated in column (1) for comparison. Results in columns (2), (3), and (4) show that the coefficients for the interaction dummies, $D_i^{treat-highI} \cdot D_t^{a1999}$, $D_i^{treat-highK} \cdot D_t^{a1999}$, and $D_i^{treat-highA} \cdot D_t^{a1999}$, are statistically indistinguishable from zero, suggesting that there is little evidence that AMT firms with a smaller pre-reform investment level, smaller capital intensity, or smaller total asset level increase investment more strongly during the post-reform period. Hence, it is unlikely that factors related to investment cycles derive the main results.

7 Discussion: Estimation of the Tax-adjusted *q* Model

Having run a difference-in-difference analysis to exploit a transparent identification, checked the identifying assumptions, and performed various robustness checks, I now discuss the estimation of the tax-adjusted q model. Recall that the baseline tax-adjusted q equation in this study is given by equation (13):

$$\frac{I}{K} = a + b_1 \underbrace{\left[\frac{q-(1-\overline{\Gamma(n^e)})}{1-W_\eta(n^e)}\right]}_{\substack{\text{tax-adjusted } q \\ \text{holding depreciation} \\ \text{savings fixed}}} + b_2 \underbrace{\left[\frac{1-\Gamma(n^e)}{1-\overline{W_\eta(n^e)}}\right]}_{\text{main tax variable}}. \tag{13}$$

As discussed in Section 5, the variation in the main tax variable $\left[\frac{1-\Gamma(n^e)}{1-\overline{W_\eta(n^e)}}\right]$, generated purely by the AMT reform, is -0.015 (assuming η=1) or -0.014 (assuming η=0) for the baseline treatment and control group firms. Furthermore, the empirical results reported in Section 6 imply that AMT firms increase investment by 0.036 to 0.065, depending on specifications. Therefore, b_2, the inverse of the adjustment cost parameter, is estimated to be from -2.4 to -4.3.[37]

[37]Note that b_2 is also interpreted as the price elasticity of investment. Intuitively, the larger adjustment costs, the less responsive investment is to its tax price.

Table 8: Testing observed heterogeneity

Heterogeneity in:		Investment (Pre-reform)	Capital Intensity (Pre-reform)	Total Asset (Pre-reform)
	(1)	(2)	(3)	(4)
$D_i^{treat} \cdot D_t^{a1999}$	.0646**	.1022***	.1004*	.0873
	(.0324)	(.0242)	(.0582)	(.0576)
$D_i^{treat-highI} \cdot D_t^{a1999}$		-.0756		
		(.0633)		
$D_i^{treat-highK} \cdot D_t^{a1999}$			-.0742	
			(.0728)	
$D_i^{treat-highA} \cdot D_t^{a1999}$				-.0462
				(.0664)
q	.0300***	.0300***	.0300***	.0300***
	(.0083)	(.0083)	(.0083)	(.0083)
Cash Flow	-.0243***	-.0243***	-.0243***	-.0243***
	(.0055)	(.0055)	(.0056)	(.0055)
S-A Index	-.1289	-.1303	-.1301	-.1280
	(.1065)	(.1068)	(.1066)	(.1067)
Cash Flow × S-A index	-.0082***	-.0082***	-.0082***	-.0082***
	(.0029)	(.0029)	(.0029)	(.0029)
Years	1996 $\sim$ 2001			
Firm Fixed	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes
Industry-Year Fixed	Yes	Yes	Yes	Yes
Observations	8284	8284	8284	8284
# of Treatment Group	84	84	84	84
# of Control Group	1330	1330	1330	1330

Note: The dependent variable is annual investment (capital expenditures to lagged capital stock). Variable descriptions are in Appendix F. All standard errors are clustered at the firm-level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

In the literature, efforts have been made to estimate the size of the adjustment cost parameter. Recently, Desai and Goolsbee (2004) and Edgerton (2010) report estimates slightly less than one (in absolute value). Although their estimates are within the 95%, or even 90%, confidence interval for $\widehat{b_2}$ estimated in Section 6, I discuss which factor is likely to explain the differences, first explaining possible causes for the discrepancy, then discussing tests, as needed, related to the respective causes

1. Different Tax Instruments Targeted by Tax Reforms. Whereas this paper uses changes in depreciation allowances around the AMT reform as a natural experiment, previous studies use tax reforms that typically change investment tax credits and depreciation allowances at the same time. For example, because TRA86 changes the two tax instruments (ITC and z) in the same direction, it is unclear whether ITC or z drives their main results. Nonetheless, as

ITC is likely to have a larger impact on investment incentives than depreciation allowances, this difference would not explain why their estimates are *smaller* than the estimates reported in this paper.

2. Different Sources of Identification. Previous studies, by including year fixed effects, have the common effects of tax reforms on investment incentives absorbed; thus, the remaining cross-sectional variations in their tax term occur across asset types. Roughly speaking, these studies test whether the type of asset that benefits most from a tax reform is purchased most after the tax reform. Hence, they implicitly assume that price elasticities (or adjustment cost parameters) are the same across asset types.[38] However, this assumption may be strong: that is, on asset levels, the size of adjustment costs and benefits from a tax reform may be positively related. For example, the type of asset that benefits least from a tax reform, such as computers, is likely to have the shortest recovery period, and also be expected to have smaller adjustment costs. This endogeneity would bias their estimates towards zero, implying that it could potentially explain at least some of the differences in the estimates for b_2.

3. Different Periods in Analysis. Moreover, whereas previous studies use more than 40 years as the sample period, I use only the six recent years from 1996 to 2001. One might suspect that firm responses to tax reforms may be larger these days, compared to 20 to 40 years ago, for reasons unrelated to the tax reforms.

To check this possibility, I run an additional regression of equation (13) using the 2002 bonus depreciation as the only treatment, with sample years from 1999 to 2004 (excluding the AMT reform in the sample period). The only source of variation in this additional regression comes from different tax treatments across different assets (and industries). This is identical to the source of variation in previous studies, but with the sample period similar to that of this study. This setting helps separate the effects of the two factors. Table 9 provides a comparison across studies. The first two rows summarize Desai and Goolsbee (2004) and Edgerton (2010), respectively. The third row describes the main empirical results of this paper, and the fourth row presents the results of the additional regression described above. Note that the additional regression, using a period of sample years similar to that used in the main empirical analysis, estimates the coefficient for the tax term to be around -1.2 (albeit insignificant), similar to the estimates in the two previous papers. Therefore, the different sample periods are not a likely explanation for the large gap between the two sets of estimates.

4. Different Specifications of Tax Terms. Another possible explanation is that the new tax term $\left[\frac{1-\Gamma}{1-W_\eta}\right]$ from the alternative specification developed in this paper measures investment incentives in a different way than the usual tax term $\left[\frac{1-\Gamma}{1-\tau}\right]$. However, recall that the main

[38] In addition, in converting the asset-level investment incentives reflected in *ITC* and z into industry-level information, another assumption implicitly made in their papers is the same price elasticity across different industries.

Table 9: Comparison of tax term coefficients

	Tax Term Coefficient	q Term Coefficient	Sample Years	Tax Reforms	Source of Variations
Desai and Goolsbee (2004)	-.889***	.023***	1962-2003	Various	Across industries
Edgerton (2010)	-.842***	.038***	1967-2005	Various	Across industries
Main analysis in this study	-2.4* ∼ -4.3*	.030***	1996-2001	AMT reform	Across tax systems
Additional "test"	-1.192	.020***	1999-2004	Bonus Depreciation	Across industries

point of the specification developed here is to provide a tax term, changes in which are robust to assumptions on η: that is, $\Delta\left[\frac{1-\Gamma}{1-\bar{\tau}}\right] \approx \Delta\left[\frac{1-\Gamma}{1-\bar{\Gamma}}\right]$. Furthermore, the main variations around the AMT reform are the changes in depreciation savings (Γ), so that it is straightforward to see $\Delta\left[\frac{1-\Gamma}{1-\bar{\tau}}\right] \approx \Delta\left[\frac{1-\Gamma}{1-\tau}\right]$ as well. That is, what the tax term in the specification developed here measures for investment incentives is similar to what the usual tax term (with the full-expensing assumption) would have measured around the AMT reform.[39] This implies that the new specification developed in Section 4 plays little role in explaining the large gap in the estimates.

5. Selection Issues Regarding AMT Firms. It may also be possible that AMT firms' (the treatment group) investment behavior differs from that of the regular tax firms due to selection bias. Three possible concerns include: (1) heterogeneous responsiveness to changes in depreciation savings between the two groups, (2) heterogeneous time trends in investment between the two groups, and (3) heterogeneous firm-specific short run investment cycles that are orthogonal to the AMT reform. Although all these three concerns have been addressed in Section 6, I briefly summarize the relevant discussion below.

First, recall that although the 2002 bonus depreciation is available to both groups of firms, the treatment group firms do not behave differently than the control group firms. Hence, heterogeneous responsiveness to changes in depreciation is unlikely to have biased my estimates. Second, there is evidence, albeit insignificant, that AMT status itself *might* contribute to increases in investment regardless of the AMT reform (see Section 6). However, this concern is reflected in the lower set of my estimates (0.0363), which still implies a large coefficient for b_2 (that is, 2.4 in absolute value). Thus, this possibility does not explain the observed differences. Lastly, it is

[39]Thus, in a sense, this alternative specification provides a justification for the widely-used full expensing assumption.

possible that AMT firms' cyclical increase in investment coincided with the AMT reform. Such short-run investment cycles would be better described as industry-level, than firm-level, but I do control for industry-level shocks in my specification. Furthermore, in section 6.4., I sort the AMT firms into two subgroups based on their pre-reform investment, total asset, or capital intensity, and conclude that their investment behaviors are indistinguishable. Thus, it is unlikely that unobserved heterogeneity between the two groups accounts for the large difference in the results.

6. Salience of Tax Policy. Finally, it is possible that the AMT reform was especially salient to my treatment group firms. Recall that, every year, the AMT firms in the treatment group calculate both tax bills and end up having *average* tax rates higher than otherwise, largely due to the depreciation structure under the AMT system, and that the AMT reform effectively decreases their current average tax rates (or current tax liabilities) by shortening the recovery periods. Consequently, AMT firms might have paid closer attention to the reform.[40]

In contrast, there is evidence that some eligible firms, especially those in a loss status, did not even try to claim their bonus depreciation allowances.[41] One interpretation of this evidence is that, although tax credits should be valuable in the future, even for a firm currently in a loss status, that they do not directly decrease a firm's current tax liability makes firms less likely to claim the credits. In addition, previous major U.S. tax reforms incorporate multiple changes, one change increasing, another decreasing, the tax term. Thus, it may be unclear even to individual firms how such tax reforms affect their investment decisions. In this regard, the high salience of the AMT reform relative to previous tax reforms may potentially explain some of the differences in estimating b_2.

8 Conclusion

This study investigates whether firms respond to changes in a particular tax instrument, namely, depreciation savings, by using the 1999 shortening of the Alternative Minimum Tax depreciation recovery periods. I first characterize a firm's investment incentives in the presence of AMT, and show that the AMT system affects investment incentives only for firms that expect to be subject to the AMT for a long period. Using data obtained from the tax footnotes to financial statements reported to the SEC, I then show empirically that firms, the investment incentives of which are characterized by the AMT system around the 1999 reform, increase investment significantly compared to firms never subject to the AMT. Given the observed and unobserved heterogeneity between the treatment and control groups, I use the bonus depreciation policy available to both groups, and find no significant differences in firm responses between the two groups. I also report

[40]Indeed, Joint Committee on Taxation (1997), in explaining the "reasons for change" (that is, the AMT reform), specifically states that the Congress believed that the pre-reform depreciation rule adversely affected firm investment incentives.

[41]See, for example, Knittel (2007) and Kitchen and Knittel (2011).

evidence that firms subject to one tax system for a long time are likely to form their expectations regarding future tax status following the adaptive expectation assumption rather than the perfect foresight assumption. That is, their investment behaviors are more closely described when they are assumed to behave as if they are permanently subject to the particular tax system.

This paper is, to my knowledge, one of the first attempts to directly investigate firm investment responses to changes in depreciation savings. In the analysis, I propose an alternative empirical specification of the tax-adjusted q model that is immune to changes in assumptions about the tax treatment of adjustment costs. I find the responsiveness coefficient estimated here to be around two to four times larger than the estimates in Desai and Goolsbee (2004) and Edgerton (2010). I discuss possible reasons for the differences in the estimates, and conclude that the new identification strategy and high salience of the AMT reform are likely the main factors that account for the differences.

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Appendix A. GDS and ADS Recovery Periods

Capital Goods	ADS recovery (Pre-reform)	GDS recovery (Post-reform)
Tractor Units for Over-the-road Use	4	3
Racehorses With Over 2 Years in Service	5	
Horses Over 12 Years Old	10	
Light Vehicles	5	5
Computers & Office Equipment	6	
Trucks	6	
Buses	9	
Office Furniture	10	7
Agricultural Equipment	10	
Single-purpose Agricultural Structures	15	10
Water Transportation Equipment	18	
Radio Towers	20	15
Engines and Turbines	20	
Land Improvements	20	
Pipelines	22	
Electricity Generation and Distribution Systems	22	
Cable Lines	24	
Farm Buildings (other than Single Purpose Structures), Railroad Structures, Telephone Communications, Electric utilities, Water Utilities Structures Including Dams, and Canals	25	20

Source: IRS Publication 946. Capital goods are selected based on House and Shapiro (2008), Table 2.

Appendix B. The Evolution of AMT Credit Carryforwards in an AMT year

To show that AMT credit carryforwards are positive in an AMT year, I consider the two cases discussed in Section 3.

Case 1: Positive AMT payment at time s.

In this case, $TB_s^m > TB_s^R$ at time s, thus from equation (4),

$$CF_s = F(K_s) - (1 + \Psi(\cdot))I_s - TB_s^m,$$

and the AMT payment $(TB_s^m - TB_s^R)$ is accumulated into the next year's AMT credit carryforwards, so that:

$$\underbrace{M_{s-1} + (TB_s^m - TB_s^R)}_{=M_s} > M_{s-1} \geq 0.$$

Case 2: No AMT payment, but the use of AMT credit carryforwards is limited.

In this case, $TB_s^R > TB_s^m$ at time s but this firm cannot use all of its AMT credit carryforwards against its current tax bill because the lower bound of the firm's annual tax bill is the minimum tax bill. That is, $M_{s-1} > TB_s^R - TB_s^m > 0$, then again

$$CF_s = F(K_s) - (1 + \Psi(\cdot))I_s - TB_s^m,$$

and the role of $(TB_s^R - TB_s^m)$ is to reduce the next year's AMT credit carryforwards, so that:

$$M_{s-1} > \underbrace{M_{s-1} + (TB_s^m - TB_s^R)}_{=M_s} > 0.$$

Appendix C. Derivation of Expected Depreciation Savings and Expected Marginal Tax Rates

I derive a generalized formula of a firm's expected depreciation savings and expected marginal tax rates in the presence of AMT, which, absent consideration of AMT, would have been simply τz and τ, respectively.

Let $\mathbb{E}\left[\Gamma_t(n^e)\right]$ be the total expected depreciation savings from capital goods purchased at time

t by an AMT firm expecting to return to the regular tax in year $t+n^e$. Then,

$$\mathbb{E}\left[\Gamma_t(n^e)\right] \equiv \underbrace{\tau^m\left[z_t^m(0,n^e)\right] + \widetilde{\tau z}_t(0,n^e)}_{\substack{\text{depreciation savings} \\ \text{from year 0 to } n^e\text{-1}}} + \underbrace{\tau^R\left[z_t^R(n^e,\infty)\right]}_{\substack{\text{depreciation savings} \\ \text{from year } n^e \text{ to } \infty}} \quad . \tag{9}$$

To discuss the formula, first note that $z_t^j(l_1, l_2)$ is the present value of the depreciation allowance stream of investment made at time t, from time $t+l_1$ to time $t+l_2$-1 under tax system j, where j is either m for the AMT system or R for the regular tax system. Thus, the term inside the first bracket in equation (9) measures the present value of the depreciation allowance stream during the first AMT period (i.e., from time t to $t+n^e$-1):

$$z_t^m(0,n^e) \equiv \sum_{s=t}^{t+n^e-1} \rho^s\left(D_t^m(s-t)\right). \tag{16}$$

Second, I define $\widetilde{\tau z}_t(l_1, l_2)$ as the sum of *reduced* depreciation savings generated by the AMT depreciation system from time $t+l_1$ and $t+l_2$-1, measured as depreciation savings under the AMT system, subtracted from the amount of depreciation savings the firm would have realized under the regular tax system. Therefore, in the baseline expected path, the firm's tax bill at time t is reduced by:

$$\widetilde{\tau z}_t(0,n^e) \equiv \rho^{t+n^e}\left[\sum_{s=t}^{t+n^e\text{-}1}\left(\tau^R(D_t^R(s-t)) - \tau^m(D_t^m(s-t))\right)\right]. \tag{17}$$

This term reflects the smoothing function of the AMT, or the fact that any discrepancy between the two tax bills caused in AMT years is eventually realized, in the form of AMT credit carry-forwards, in year $t+n^e$ when the firm returns to the regular tax system.[42] Therefore, a shorter n^e reduces the impact of the AMT on investment incentives. In the polar case, in which a firm expects to be permanently subject to the regular tax system, $\mathbb{E}\left[\Gamma_t(0)\right]$ would be $\tau^R\left[z^R(0,\infty)\right]$.[43] By contrast, for a firm permanently subject to the AMT, $n^e \to \infty$, so that $\widetilde{\tau z}(0,\infty) = 0$, which indicates that the reduced savings would not be realized. Hence, because only the first term

[42] Note that this is similar to the concept of investment incentives for a loss firm. Let's ignore AMT for now and suppose a firm is in loss status with a large stock of loss carryforwards such that it will continue to be in loss status for the next five years. The firm's tax bills during that period will be zero. Thus it might seem that the firm would not receive any depreciation savings from capital goods purchases. However the firm would eventually realize whatever depreciation savings a fully taxable firm would have received, in the form of an increased (or unused) loss carryforward. That is, the marginal depreciation savings are realized at time 6 (albeit discounted) when the firm exhausts its stock of loss carryforwards. Therefore, tracking the duration of tax status is important when calculating a firm's marginal investment incentives. See Graham (1996) for discussion of the marginal tax rates for a loss firm.

[43] Recall that $D_t^j(s-t)$ is the time s depreciation allowance, under tax system j, of capital goods purchased at time t. Thus, $z_t^R(0,\infty)$ represents the present value of depreciation allowances under the regular tax system, which is the usual depreciation allowance measure in the literature. Likewise, the relevant z for a firm permanently subject to the AMT is $z_t^m(0,\infty)$.

survives for a permanent AMT firm, the depreciation savings are given by $\tau^m\left[z^m(0,\infty)\right]$.

Similarly, I define the expected marginal tax rate for a firm subject to the AMT that expects to return to the regular tax n^e years from now as

$$\mathbb{E}\left[\tau_t(n^e)\right] \equiv \tau^m + \rho^{n^e}(\tau^R - \tau^m),$$

that is, a weighted average of τ^m and τ^R with the weights depending on the expected duration of the AMT period. As $n^e \to \infty$, $\mathbb{E}\left[\tau_t(n^e)\right] = \tau^m$ for a permanent AMT firm, whereas $n^e = 0$ implies $\mathbb{E}\left[\tau_t(n^e)\right] = \tau^R$ for a regular tax firm.

Finally, as superscript e indicates expectation, it is clear that $\tau_t(n^e)$ and $\Gamma_t(n^e)$, like $\mathbb{E}\left[\tau_t(n^e)\right]$ and $\mathbb{E}\left[\Gamma_t(n^e)\right]$, also measure marginal tax rates and depreciation savings in expectation, respectively. Thus, I drop the operator $\mathbb{E}$ whenever doing so does not cause confusion.

Appendix D. Replication of Table 4 – Assuming Full Capitalizing

Panel A. Adaptive Expectation – *Permanently* Subject to the AMT

		Control		Treatment	
Periods	Years	Value	Δ	Value	Δ
Pre-Reform	1996-1998	1.008	-	1.016	-
Post-Reform	1999-2001	1.008	0.000	1.002	0.014
Bonus Depreciation	2002-2004	0.976	0.032	0.982	0.020

Panel B. Perfect Foresight – *Temporarily* Subject to the AMT

		Control		Treatment	
Periods	Years	Value	Δ	Value	Δ
Pre-Reform	1996-1998	1.008	-	1.048	-
Post-Reform	1999-2001	1.008	0.000	1.011	0.037
Bonus Depreciation	2002-2004	0.976	0.032	0.963	0.048

Appendix E. Comparison of Aggregate AMT Information in 2002

	Panel A. Tax Return Data		Panel B. SEC 10-K Filing Data	
Assets Size	# of Firms Filing Tax Return	# of AMT Firms Filing Tax Return	# of Firms Filing 10-K	# of AMT Firms Filing 10-K
Over $10M	43761	3425 (7.8%)	3432	453 (13.2%)
Over $50M	17484	1715 (9.8%)	2948	417 (14.1%)
Over $1B	2577	415 (16.1%)	1442	250 (17.3%)

Note: Panel A shows how many firms were actually subject to the AMT in 2002, taken from Table 6 of Carlson (2005a), constructed based on tax return data. For Panel B, I count the number of firms that mention one of the "AMT credit" keywords in their 2002 SEC 10-K filing – that is, in the same way AMT status is collected in this study.

Appendix F. Variable Descriptions

- Investment is the ratio of the current year's capital expenditures (item 128) to the prior year's net property, plant, and equipment (item 8).
- q is the sum of the market value of equity (item 199 $\times$ item 25) and book liabilities minus deferred taxes (item 6 - item 60 - item 74), divided by book assets (item 6).
- Cash Flow is the ratio of the current year's operating income plus depreciation (item 18 + item 14) to the prior year's net property, plant, and equipment (item 8).
- S-A index is measured as -0.737 $\times$ Size plus 0.043 $\times$ Size^2 minus 0.040 $\times$ Age, where size is the log of inflation-adjusted book assets (item 6) and age is the number of years the firm is listed on Compustat. Size is capped at log($4.5 billion) and age is at thirty-seven years.
- K-Z index is calculated as 3.139 $\times$ current year's debt (item 142 + item 34) over the current year's total capital (item 142 + item 34 + item 144) minus 39.368 $\times$ current year's dividend (item 19 + item 21) over the prior year's book assets (item 6) minus 1.315 $\times$ current year's cash (item 1) over the prior year's book assets (item 6).[44]
- Capital Intensity is the ratio of the current year's net property, plant, and equipment (item 8) to the current year's book assets (item 6).
- Sales Ratio is the ratio of the current year's sales (item 12) to the prior year's book assets (item 6).

[44] As in Edgerton (2010), I exclude cash flow and q in calculating the index since these two variables are already included in all empirical equations.

Appendix G. List of Firms of the Baseline Treatment Group

Industry	Firm
Mining (sic 10-14)	Coeur D'Alene Mines Corp, Freeport-Mcmoran Cop & Gold, Burlington Resources Inc.*, Castle Energy Corp., Forest Oil Corp., Goodrich Petroleum Corp., KCS Energy Inc., Patterson-Uti Energy Inc., Primeenergy Corp.*, Range Resources Corp., Stone Energy Corp., Swift Energy Co., U S Lime & Minerals
Construction (sic 15-17)	Tutor Perini Corp., Goldfield Corp
Manufacturing (sic 20-39)	Craft Brewers Alliance Inc., Penford Corp., Hartmarx Corp., Pope & Talbot Inc., Smurfit-Stone Container Corp., Temple-Inland Inc., Cenveo Inc., Multi-Color Corp., Cyanotech Corp., E-Z-Em Inc.*, IGI Laboratories Inc., LSB Industries Inc., MGI Pharma Inc., Neurocrine Biosciences Inc., Neurogen Corp., Potash Corp Sask Inc., TOR Minerals Intl Inc., Valhi Inc., Hess Corp., American Biltrite Inc PW Eagle Inc.*, Owens-Illinois Inc., NS Group Inc., Oregon Steel Mills Inc., Phelps Dodge Corp., Titanium Metals Corp., 3D Systems Corp., Cummins Inc., Delphax Technologies Inc., Flow Intl Corp., Joy Global Inc., Network Equipment Tech Inc., Scientific Games Corp., Stratasys Inc.*, Wells-Gardner Electronics., WSI Industries Inc., Cobra Electronics Corp.*, Lamson & Sessions Co., Spire Corp., Symmetricom Inc., Westell Tech Inc., Fountain Powerboat Inds Inc., Itron Inc., Millipore Corp., Orbit International Corp., Possis Medical Inc.
Transportation (sic 40-47)	Railamerica Inc., P.A.M. Transportation Svcs*, AMR Corp., Mesa Air Group Inc., US Airways Group Inc.*, World Air Holdings Inc.,
Utility (sic 48-49)	Allied Waste Industries Inc., Aquila Inc., Blue Dolphin Energy Co., Delta Natural Gas Co Inc., Southern Union Co., Southwestern Energy Co., Western Gas Resources Inc., Williams Cos Inc., York Water Co.*
Trade (sic 50-59)	Newpark Resources, Officemax Inc., Gottschalks Inc., Checkers Drive-In Restaurant, Dennys Corp, Caremark RX Inc.*, Matria Healthcare Inc., Michaels Stores Inc

Note: * indicates that the firm's AMT credit carryforwards were positive only for 9 years during the 10-year selection window (from 1996 to 2005).