Do Financial Frictions Amplify Fiscal Policy? Evidence from Business Investment Stimulus*

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Abstract

We estimate the causal effect of temporary tax incentives on equipment investment using a difference-in-differences design and policy shifts in accelerated depreciation. Analyzing data for over 120,000 US firms from 1993 to 2010, we present three findings. First, bonus depreciation raised investment by 18.5 percent on average between 2001 and 2004 and 31.2 percent between 2008 and 2010. Second, financially constrained firms respond more than unconstrained firms. And third, firms respond strongly when the policy generates immediate cash flows, but do not respond at all when the policy only benefits them in the future. The results provide an estimate of the discount rate firms apply to future cash flows: constrained firms act as if $1 next year is worth 38 cents today. The estimated discount rate is too high to match the predictions of a frictionless model, nor can it be explained entirely by costly external finance, unless firms also neglect financial constraints binding in the future.

JOB MARKET PAPER

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1 Introduction

Going back to Hall and Jorgenson (1967), public and macroeconomists have asked how taxes affect investment. The answer is central to the design of countercyclical fiscal policy, since policymakers often use tax-based investment incentives to spur growth in times of economic weakness. Such policies typically coincide with disruptions in capital markets, so it is natural to ask how taxes affect investment in the presence of financial frictions. However, the standard theoretical and empirical treatments assume perfect capital markets.[1] This paper uses recent episodes of investment stimulus to study whether the effect of taxes on investment accords with the standard, frictionless model. We find that, in ignoring financial frictions, the standard analysis overlooks a crucial driver of firm responses to tax policy.

The policy we study, "bonus" depreciation, accelerates the schedule for when firms can deduct from taxable income the cost of investment purchases. Bonus alters the timing of deductions but not their amount, so the economic incentive created by bonus works because future deductions are worth less than current deductions. That is, bonus works because of discounting: firms judge the benefits of bonus by the present discounted value of deductions over time.[2] Speeding up the timing of deductions reduces short term taxes, but at the expense of higher taxes in the future. With a reasonable risk-adjusted discount rate, bonus depreciation generates a modest subsidy, so the frictionless model predicts a small effect of bonus on investment.[3] But in the presence of financial frictions, firms sharply discount future deductions. Thus financial frictions make bonus more appealing, since the difference in today's tax benefits dwarfs the present value comparison that matters in theory.

We study two episodes of bonus depreciation using a standard difference-in-differences methodology to estimate the effect of these policies. We present three empirical findings. First,

[1] Key theoretical studies include Hall and Jorgenson (1967), Tobin (1969), Hayashi (1982), Abel and Eberly (1994), and Caballero and Engel (1999). Abel (1990) presents a unifying synthesis of the early theoretical literature. Key empirical work includes Summers (1981), Auerbach and Hassett (1992), Cummins, Hassett and Hubbard (1994), Chirinko, Fazzari and Meyer (1999), Desai and Goolsbee (2004), Cooper and Haltiwanger (2006), and House and Shapiro (2008). Edgerton (2010) relaxes the frictionless assumption but, in contrast to our study, finds mixed results.

[2] Summers (1987) states this most clearly: "It is *only* because of discounting that depreciation schedules affect investment decisions. . . "

[3] Consider a firm making a $100 investment in computer equipment, which the IRS assigns a depreciation life of five years. Under the normal schedule, a firm can only deduct from taxable income $20 in the year of the purchase and must spread the remaining $80 over the next five years. Assuming a seven percent risk-adjusted discount rate, the difference in present values for even full expensing—i.e., 100 percent bonus, which lets the firm deduct $100 in the purchase year—implies a subsidy of less than four percent.

bonus depreciation has a substantial effect on investment, much larger than past estimates and much stronger than the conventional wisdom predicts. Estimates of how tax changes affect investment vary, but the consensus prediction is that bonus depreciation has a small positive effect.[4] In contrast, we find that bonus depreciation raised eligible investment by 18.5 percent on average between 2001 and 2004 and 31.2 percent between 2008 and 2010. We estimate a user cost elasticity of approximately 1.6, outside the range of estimates of 0.5 to 1 surveyed by Hassett and Hubbard (2002) and more than double the consensus point estimate.[5]

The first part of the paper details this finding and a litany of robustness tests. The research design compares firms at the same point in time whose benefits from bonus differ. Our strategy exploits technological differences between firms in narrowly defined industries. Firms in industries with most of their investment in short duration categories act as the "control group" because bonus only modestly alters their depreciation schedule. This natural experiment separates the effect of bonus from other economic shocks happening at the same time. If the parallel trends assumption holds—if investment growth for short and long duration industries would have been similar absent the policy—then the experimental design is valid.

The key threat to this design is that time-varying industry shocks may coincide with bonus. This risk is limited for four reasons. First, graphical inspection of parallel trends indicates smooth pretrends and a clear, steady break for short and long duration firms during both the 2001 to 2004 and 2008 to 2010 bonus periods. The effects are the same size in both periods, though different industries suffered in each recession. Second, the estimates are stable across many specifications and after including firm-level cash flow controls, industry Q, and flexible industry trends. Allowing industry-level co-movement with the macroeconomy actually increases our estimates. Third, the estimates pass a placebo test: the effect of bonus on ineligible investment is indistinguishable from zero. Last, for firms making eligible investments, bonus take-up rates (i.e., do firms fill in the bonus box on the tax form?) are indeed higher in long duration industries. For these reasons, spurious factors are unlikely to explain the large

[4] Cummins, Hassett and Hubbard (1994) study many corporate tax reforms and public company investment data and conclude that tax policy has a strong effect on investment. Using similar data and a different empirical methodology, Chirinko, Fazzari and Meyer (1999) argue that tax policy has a small effect on investment and that Cummins, Hassett and Hubbard (1994) misinterpret their results. Hassett and Hubbard (2002) survey empirical work and conclude that the range of estimates for the user cost elasticity has narrowed to between -0.5 and -1. Surveying this and more recent work, Bond and Van Reenen (2007) decide "it is perhaps a little too early to agree with Hassett and Hubbard (2002) that there is a new 'consensus' on the size and robustness of this effect."

[5] In Section 5, we collect estimates from past studies of tax reforms. The average user cost elasticity across these studies is 0.69.

effect of bonus.

Firms respond to bonus depreciation as if they apply implausibly high discount rates to investment decisions. This finding is inconsistent with a frictionless model of firm behavior. In the second part of the paper, we explore alternative models that generate high effective discount rates by adding financial frictions.[6] One alternative is costly external finance, which raises the total discount rate firms apply to evaluate projects. Another alternative is managerial myopia, which raises effective discount rates by sharply discounting the future relative to the present. Both models prove useful in explaining our findings.

Our second empirical finding is that, consistent with the costly external finance story, financial constraints *amplify* the effects of investment stimulus. Nearly all prior empirical tests of financial constraints use public firm data, which is problematic because public firms have the best collateral, the strongest banking relationships and broad access to equity and bond markets.[7] In contrast, we work with an analysis sample of more than 120,000 public and private companies drawn from two million corporate tax returns. Half the firms in our sample are smaller than the smallest firms in Compustat.[8] Our baseline estimate therefore averages over substantial heterogeneity in firm type, including many firms likely to face financial constraints.

The largest firms in our sample, those most like the firms in past studies, yield estimates in line with the Hassett and Hubbard (2002) range. In contrast, small and medium-sized firms, previously unstudied, show much stronger responses. Building on the differential response by firm size, we perform a split sample analysis using several markers of ex ante financial constraints. In addition to small firms, non-dividend payers and firms with low cash holdings are 1.5 to 2.6 times more responsive than their unconstrained counterparts. Moreover, we find that firms respond by borrowing and cutting dividends. These facts do not match the frictionless model of investment behavior, in which firms divided by financial constraint markers do not respond differently to bonus.

Firms with tax losses must wait to realize the benefits of tax breaks. Because many firms

[6]We use the term *financial frictions* as an umbrella term over a class of models that generate high effective discount rates. Some of these—such as managerial myopia and agency theory—are not about external finance per se, but refer instead to organizational frictions. These theories have not crossed from the finance literature into standard public and macroeconomics treatments.

[7]Kaplan and Zingales (1997) find that very few of Fazzari, Hubbard and Petersen's (1988*a*) most constrained firms appear constrained by other measures.

[8]When aggregated, these small firms account for a large amount of economic activity. According to Census tabulations in 2007 (`http://www.census.gov/econ/susb/data/susb2007.html`), firms with less than $100 million in receipts (around the 80th percentile in our data) account for more than half of total employment and one third of total receipts.

in our sample are in a tax loss position when a policy shock occurs, we can ask whether firms value *future* cash windfalls, namely, the larger deductions bonus depreciation provides them in later years. Our third empirical finding is that, consistent with the managerial myopia story, firms *only* respond to investment incentives when the policy immediately generates cash flows. This finding holds even though firms can carry forward unused deductions to offset future taxes, and it cannot be explained by differences in growth opportunities. Furthermore, this fact contradicts a simple model of costly external finance, because firms neglect how the policy affects borrowing in the future.

To confirm the myopia story, we study a second component of the depreciation schedule. Firms making small investment outlays face a permanent kink in the tax schedule, which creates a discontinuous change in marginal investment incentives. This sharp change in incentives induces substantial investment bunching, with many firms electing amounts within just a few hundred dollars of the kink. And when legislation raises the kink, the bunching pattern follows. Consistent with myopia, bunching strongly depends on a firm's current tax status: firms just in positive tax position are far more likely to bunch than firms on the other side of the discontinuity. For a different group of firms and a different depreciation policy, we again find that firms ignore future tax benefits.

These facts do not match the predictions of a frictionless model, which cannot account for the large baseline response, the differential response for constrained firms or the nonresponse for nontaxable firms. The facts point instead toward models in which costly finance matters and current benefits outweigh future benefits. We use an investment model to clarify these findings. The model incorporates costly external finance and managerial myopia into a general model in which the frictionless model of Hayashi (1982) is a special case. These alternative theories make predictions about the discount rate firms apply to future cash flows. The model shows how to combine reduced form estimates to distinguish the frictionless benchmark from costly external finance and managerial myopia.

The general model yields a set of theoretical moments—one comparing constrained and unconstrained firms and one comparing taxable and nontaxable firms—which we can combine with our empirical findings to measure financial frictions. With these comparisons we can estimate the shadow cost of external funds and an implied present versus future discount factor. We estimate the shadow cost of external funds to be between \$0.63 and \$1.61 per dollar and an implied discount factor of 0.84. Combining these results, financially constrained firms act as if $1 next year is worth just 38 cents today, yielding a total discount rate of 97 percent. Thus accounting for the effect of bonus depreciation on investment requires a major role for financial frictions.

The logic of the general model is simple. The optimal investment decision trades off the after-tax future benefits of the marginal dollar of investment against its price and the marginal external finance cost, less the marginal benefit due to depreciation deductions. Deductions reduce the marginal cost of investment both through their net present value and through relaxing the external finance constraint. By returning more cash in earlier years, bonus depreciation makes investment a better tax shield; by raising the value of cash back, financial constraints amplify this effect. There are two differences between taxable and nontaxable firms. First, if a firm owes no taxes in period zero, depreciation deductions only relax future financial constraints. Second, because the deductions must wait, the effect of bonus on current investment operates exclusively through discounted expectations of future benefits. If future benefits don't matter, neither does bonus.

Our paper sits at the intersection of several strands in the economics and finance literatures. Most directly, the paper relates to studies of the effect of taxes on business investment.[9] The paper also relates to the literature on financial constraints.[10] Our findings imply that incorporating financial frictions adds much explanatory power to neoclassical investment theory.[11] In the literature on salience and taxation, our study offers an example of a strong tax policy effect on economic behavior.[12]

The outline of the paper is as follows. Section 2 describes the paper's methodological approach and how it relates to past studies. Section 3 formalizes intuition about how bonus works and develops a set of testable hypotheses, which guide the empirical analysis. Section 4 describes the corporate tax data, variable construction and sample selection process. Section

[9]The modern empirical literature begins with Hall and Jorgenson (1967). Recent studies include Desai and Goolsbee (2004), Edgerton (2010) and Yagan (2013).

[10]Fazzari, Hubbard and Petersen (1988*a*) argue that, if firms more likely to be financially constrained respond more strongly to cash flow shocks, then financial constraints are responsible. Subsequent studies make this argument while identifying quasi-experimental variation in cash flows or credit supply (Lamont, 1997; Rauh, 2006; Chaney, Sraer and Thesmar, 2012). We apply this insight to the case of bonus depreciation, which creates a shock to the amount of cash firms need to perform their desired investment.

[11]Hayashi (1982) derives the workhorse neoclassical model. Stein (2003) surveys models in which financial frictions influence investment decisions.

[12]Our evidence is consistent with the strong behavioral response to and salience of the Earned Income Tax Credit (Chetty, Friedman and Saez, 2013). It stands, for instance, in contrast to evidence that individuals react incompletely to obscure taxes (Chetty, Looney and Kroft, 2009) and that business investment does not react to changes in the dividend tax (Yagan, 2013).

5 describes the main empirical strategy for studying bonus depreciation, the identification assumptions and presents results. Section 6 uses split sample tests by markers of financial constraints and by tax position to show financial frictions can account for the large baseline effect of bonus. Section 7 develops a set of theoretical moments and combines the empirical results to test between models and estimate implied discount rates. Section 8 studies substitution margins and external finance responses to bonus. There, we use our heterogeneous size results to estimate the aggregate investment effect. Section 9 discusses policy implications and avenues for future research.

2 Conceptual Framework and Related Literature

Consider a firm buying $1 million worth of computers. The firm owes corporate taxes on income net of business expenses. For expenses on nondurable items such as wages and advertising, the firm can immediately deduct the full cost of these items on its tax return. Thus, an extra dollar of spending on wages reduces the firm's taxable income by a dollar and reduces the firm's tax bill by the tax rate.[13] But for investment expenses the rules differ.

Usually, the firm follows the regular depreciation schedule in the top panel of Table 1. The first year deduction is $200 thousand, which provides an after-tax benefit of $70 thousand. Over the next five years, the firm deducts the remaining $800 thousand. The total undiscounted deduction is the $1 million spent and the total undiscounted tax benefit is $350 thousand. With bonus depreciation the situation changes. Assume fifty percent bonus. The firm can now deduct a $500 thousand bonus before following the normal schedule for the remaining amount, so the total first year deduction rises to $600 thousand. Each subsequent deduction falls by half.

The total amount deducted over time does not change. However, the accelerated schedule does raise the present value of these deductions. Applying a seven percent discount rate yields $311 thousand for the present value of cash back in normal times. Bonus raises this present value by $20 thousand, just two percent of the original purchase price. This small present

[13]The exact benefit depends on the marginal tax rate, which in turn depends on tax rate progressivity and the level of other expenses relative to taxable income. See, e.g., Graham (1996, 2000) for a method tracing out the marginal tax benefit curve. The policies we study will increase the use of investment as a tax shield regardless of where the firm is on this marginal benefit curve. Except when current and all future taxes are zero, bonus increases the marginal tax benefit of investment.

Table 1: Regular and Bonus Depreciation Schedules for Five Year Items

Normal Depreciation							
Year	0	1	2	3	4	5	Total
Deductions (000s)	200	320	192	115	115	58	1000
Tax Benefit ($\tau = 35\%$)	70	112	67.2	40.3	40.3	20.2	350
Bonus Depreciation (50%)							
Year	0	1	2	3	4	5	Total
Deductions (000s)	600	160	96	57.5	57.5	29	1000
Tax Benefit ($\tau = 35\%$)	210	56	33.6	20.2	20.2	10	350

Notes: This table displays year-by-year deductions and tax benefits for a $1 million investment in computers, a five year item, depreciable according to the Modified Accelerated Cost Recovery System (MACRS). The top schedule applies during normal times. It reflects a half-year convention for the purchase year and a 200 percent declining balance method (2X straight line until straight line is greater). The bottom schedule applies when 50 percent bonus depreciation is available. See IRS publication 946 for the recovery periods and schedules applying to other class lives.

value payoff is why some authors conclude that bonus provides little stimulus for short-lived items (Desai and Goolsbee, 2004).[14]

In a frictionless model, a firm will judge the benefits of bonus by comparing these present value payoffs.[15] Note however the large difference in the initial deduction, which translates into $140 thousand of savings in the investment year. Such a difference will matter if firms must borrow to meet current expenses and external finance is costly. Or it will matter if managers display myopia. The same high discount rate that causes myopic managers to underinvest in long-term, low-visibility activities will cause them to overinvest in short term, cash flow generating activities. One such short term activity might be using bonus to reduce current taxes at the expense of higher future taxes. Below, we find that bonus caused a large increase in eligible investment and financial frictions—whether due to costly external finance or to managerial myopia—offer the best explanation.

[14] See also Steuerle (2008), Knittel (2007) and House and Shapiro (2008). In his comment on Desai and Goolsbee (2004), Kevin Hassett argues that the temporary nature of these policies increases the stimulus through intertemporal shifting, and that the authors' results are consistent with a large response; see also Cohen, Hansen and Hassett (2002). The intertemporal shifting story cannot explain our heterogeneity results and predicts aggregate patterns which we do not observe.

[15] This is true whether the policy is temporary or permanent. If temporary, the firm will also take account of future present value payoffs, as in Auerbach and Hassett (1992). In their setup, expected future tax increases (e.g., expiration of temporary stimulus) reduce the current user cost and generate larger current stimulus. Still, the full discounted stream of deductions determines the effect size.

To show the effect of bonus depreciation on investment, we adopt the same methodological approach as Cummins, Hassett and Hubbard (1994), in which technology differences between firms imply that investment tax breaks benefit some more than others.[16] Like Cummins, Hassett and Hubbard (1994) and Edgerton (2010), we proxy for the firm-level benefit of bonus depreciation with an industry measure of policy benefits. Unlike these studies, our measure derives directly from tax data, reducing measurement error. From tax returns filed between 1993 and 2000, we compute average industry shares of eligible investment in each of the 3-, 5-, 7-, 10-, 15- and 20-year class lives. Applying these shares to a class-specific measure of the present discounted value of deductions yields an industry-level value of deductions per investment dollar. Bonus depreciation causes this present value to increase for all firms, but the size of the benefit varies across industries. This allows a continuous treatment, difference-in-differences experimental design.[17]

Our data improve on past studies by including two periods of bonus depreciation; a granular breakdown of eligible investment; a large sample of small, private firms; and better tax variables. Except for House and Shapiro (2008), earlier studies pool the effects of different tax reforms, which include depreciation changes, tax rate changes and rule changes regarding corporate form. We focus on one specific policy, bonus depreciation, and carefully dissect how firms respond. As a result, we can provide a new estimate of how much taxes affect investment that also tells us which models match the results.

House and Shapiro (2008) study the first episode of bonus depreciation using aggregate investment data. Their design compares residuals from a prediction model for investment in short duration (e.g., computers) and long duration (e.g., blast furnaces) categories. One risk here is that a misspecified prediction model will lead to measurement error in their residuals. Firm level data enable a cleaner research design. We compare firm investment growth rates, so that our first difference does not depend on an estimated model. Their design also suffers from the problem that only a few industries account for most long duration eligible investment. Thus, the design assigns a few industries to the "treatment group" and a larger number of dissimilar industries to the "control group." More, the long duration categories

[16] See also Cummins, Hassett and Hubbard (1996), Desai and Goolsbee (2004), House and Shapiro (2008) and Edgerton (2010).

[17] It is possible to apply the same strategy at the firm level. This approach does not alter our findings. We present results for the industry level design to make our results as comparable to these other studies as possible. In addition, cross-firm variation in investment composition is low within four-digit NAICS industries, so the industry level design captures most of the quasi-experimental variation.

account for a small share of total eligible investment, so that their approach can only yield an aggregate predicted effect under strong extrapolation assumptions across investment categories. Despite the same long duration/short duration logic, our experiment produces a more balanced division of firms that relies less on outlying industries.

With this natural experiment, we show that investment responds strongly to bonus depreciation. We then run a series of split sample tests by ex ante indicators for financial constraints, applying a standard methodology for documenting financial constraints going back to Eisner (1978) and Fazzari, Hubbard and Petersen (1988*a*). Suppose firms differ in how easily they can finance new investments. After sorting firms along this dimension, if constrained firms respond more to cash flow shocks, then we should reject the perfect capital markets model in favor of a model with financial constraints. Fazzari, Hubbard and Petersen (1988*a*) make and test this argument and find that financial constraints matter.

Subsequent studies ask if Fazzari, Hubbard and Petersen (1988*a*)'s outcome measure, the investment-cash flow sensitivity, offers a reliable test. In a static model with a general cost function, this measure does not increase monotonically with external finance costs (Kaplan and Zingales, 1997). In more general models, even when financing constraints are absent, investment responds to cash flow (Gomes, 2001; Alti, 2003) and small, growing firms can display higher sensitivities than big, stable firms (Abel and Eberly, 2011). This motivates taking the split sample approach to settings with plausibly exogenous shocks to cash flows (Lamont, 1997; Rauh, 2006). or credit supply (Chaney, Sraer and Thesmar, 2012).[18] We follow these latter studies and use depreciation changes as a plausibly exogenous financial constraint shock.[19] Unlike past studies, our instrument also changes the relative price of investment. We use this feature and an investment model to estimate the shadow price of internal funds from the difference between constrained and unconstrained firm elasticities.[20]

The tax code allows us to ask a related question about financial frictions: what do firms do with *future* cash windfalls? Cummins, Hassett and Hubbard (1995) and Edgerton (2010) note that tax losses will reduce the incentive of firms to respond to tax changes. The former study uses a sample of sixty loss firms to conclude that losses reduce the effect of tax breaks on investment. The latter maps financial accounting data to a tax account and finds mixed

[18]Others study cash management policies directly (Almeida, Campello and Weisbach, 2004).

[19]See the conclusion of Fazzari, Hubbard and Petersen (1988*a*) and Fazzari, Hubbard and Petersen (1988*b*) for a discussion of how taxes might affect investment in the presence of financial constraints. They focus on average tax rates more generally and do not perform an empirical analysis along these lines.

[20]This is a similar exercise to Koijen and Yogo's (2012) study of insurance companies.

evidence that losses matter.[21] With our data, we can precisely measure whether a firm's current tax position means that the next dollar of investment affects this year's tax bill. For tax loss firms, the effect of bonus operates only through expected future payoffs. Our sample of loss firms includes almost two hundred thousand loss year observations.

Our first split sample analysis compares financially constrained firms to unconstrained firms, revealing that constrained firms respond more strongly to bonus. Our second split sample analysis shows that currently taxable firms respond strongly while nontaxable firms do not respond at all. These findings reveal how much the data depart from a frictionless benchmark model. The next section introduces the theoretical framework we use to make this point.

3 Hypothesis Development

To direct our empirical analysis, we develop a simple model of investment in the presence of depreciation incentives, financial constraints and heterogeneous tax positions. We modify the neoclassical investment model with adjustment costs (Abel, 1982; Hayashi, 1982) by introducing an external finance wedge and managerial myopia. The model yields a formal hypothesis corresponding to our baseline investment design: investment increases due to bonus depreciation and increases more for industries doing longer lived investment. We develop two further hypotheses corresponding to split sample tests. First, investment responds more when firms face an external finance wedge. Second, investment responds less when firms are in tax loss positions. Here, we focus on the intuition of the model and the mapping from theory to empirical objects and tests. We use a simple one shot static investment model with a reduced form credit wedge, in the spirit of Stein (2003).[22] Appendix A derives the hypotheses in an infinite horizon setting with adjustment costs and a dynamic leverage constraint.

[21] Recent work documents large differences between "book" and tax accounts, which introduces the risk of measurement error into such a mapping (see, e.g., Mills, Newberry and Trautman (2002). Edgerton (2010) is very careful with this procedure, but acknowledges that "[one] cannot rule out, however, the possibility that difficulties in measuring firms' taxable status drive the relative unimportance of taxable status observed in the Compustat data."

[22] This wedge is a reduced form model of a set of capital market frictions, which might reflect, e.g., costly monitoring problems or adverse selection (Stein, 2003).

3.1 Model Setup

Consider a firm making a one shot investment decision. The firm begins with initial profits π_0 and chooses a level of investment I to determine the capital stock and hence future profits.[23] Future profits are given by $\pi(I)$, taxed at the proportional corporate tax rate τ. The firm discounts future flows at risk-adjusted rate r.

The tax code permits the firm to write off the cost of investment over time. The value of these deductions depends on the tax rate and how the schedule interacts with the firm's discount rate. We collapse the stream of future depreciation deductions owed for investment:

$$z^0(\beta) = D_0 + \beta \sum_{t=1}^{T} \frac{1}{(1+r)^t} D_t, \tag{3.1}$$

where D_t is the allowable deduction per dollar of investment in period t (e.g., $D_1 = .32$ in the normal schedule in Table 1) and T is the class life of investment (e.g., $T = 5$ in Table 1). $z^0(\beta)$ measures the present discounted value of one dollar of investment deductions before tax. If the firm can immediately deduct the full dollar, then z^0 equals one. Because of discounting, z^0 is lower for longer lived items (i.e., items with greater T), which forms the core of our identification strategy.

In general, the stream of future deductions depends on future tax rates and discount rates. Our empirical analysis assumes the effective tax rate does not change over time, except when the firm is nontaxable.[24] For discount rates, we begin by assuming a risk-adjusted rate of seven percent to compute z^0 in the data, which enables comparison to past work. We then relax this assumption in Section 7 when we estimate an implied discount rate. β is an additional discount term between zero and one, which reflects the possibility of myopia.[25] We use our heterogeneity analysis to identify this term separately.[26]

[23]Normalize the price of investment to one.

[24]We use the top statutory tax rate in the set of specifications requiring a tax rate. This is an upper bound on the more realistic effective marginal tax rate. In reality bonus would thus cause a smaller change in the tax term than we impute, tending to bias our estimates downward.

[25]The myopia model is closer to Akerlof (1991) and Laibson (1997) than it is to the model of managerial myopia in Stein (1989). Stein's (1989) model of managerial myopia specifically refers to the incentive to boost current earnings as a way of signaling high quality to the stock market. We use the term to reflect any motive to boost current earnings and neglect projects with long term payoffs and short term costs.

[26]There may at first appear an inconsistency in this setup, because we do not apply β to future profits. This is merely for notational convenience. In our analysis, we assume that β explicitly applies to depreciation deductions, which have both a present and future component. In the case of profits, which only arrive in the future, we assume π incorporates β implicitly. Our analysis does not rely on measures of future profitability, which we

Bonus depreciation, the policy we study in our empirical analysis, allows the firm to deduct a per dollar bonus, θ, at the time of the investment and then depreciate the remaining $1-\theta$ according to the normal schedule:

$$z(\beta) = \theta + (1-\theta)z^0(\beta) \tag{3.2}$$

At different points in time, Congress has set θ equal to 0, 0.3, 0.5 or 1. We use these policy shocks to identify the effect of bonus depreciation on investment. Industries differ by average z^0 prior to bonus, providing the basis for identification in a difference-in-differences setup with continuous treatment.

We further generalize z by incorporating a nontaxable state. When the next dollar of investment does not affect this year's tax bill, then the firm must carry forward the deductions to future years.[27] Our general z reflects this case:

$$z(\beta,\gamma) = \gamma z(\beta) + (1-\gamma)\beta\phi z(1), \tag{3.3}$$

where $\gamma \in \{0,1\}$ is an indicator for current tax state and ϕ is a discounter that reflects both the expected arrival time of the taxable state and the discount rate applied to the future and subsequent periods when the firm switches. Note that for the nontaxable firm, β applies to all future deductions. Even when β equals one, ϕ is less than one, so the value of these deductions are lower when the firm is nontaxable. We measure ϕ in the data and apply our split sample results to determine whether we can justify these findings in a model without myopia.

External finance matters for all investment exceeding current cash flow. During the investment period, the firm faces an external finance wedge that is linear in expenses net of cash flows, that is,

$$c(I) = \lambda\left[(1-\tau z)I - (1-\tau)\pi_0\right], \tag{3.4}$$

where λ can be thought of as the shadow price on a borrowing constraint that may or may not bind now or in the future. Thus, a dollar of cash inside the firm is worth $1+\lambda$.[28] We include

assume bonus does not affect in the infinite horizon.

[27]This assumes that "carrybacks"—in which firms apply unused deductions this year against past tax bills—have been exhausted or ignored. Carryback take-up rates are surprisingly low.

[28]Note that because we have assumed a linear external finance function, there will be no direct effect of cash flows on investment, that is, the investment-cash flow sensitivity is zero. This is not true in the general

z in the net expense term and not just the first year deduction, to capture the influence of depreciation deductions on future taxes and thus future borrowing.[29] While bonus depreciation relaxes the current constraint through reducing this year's tax bill, it does so at the expense of higher future taxes. The net effect is to reduce the present discounted borrowing costs for the firm. However, if myopia plays a role (that is, for low β), then only the current year change will matter. The two models thus yield different predictions for constrained, nontaxable firms: constrained, myopic firms respond much less to bonus when nontaxable than do constrained, farsighted firms. This is the feature we use to distinguish costly external finance from myopia models, which are otherwise observationally equivalent.

3.2 Optimal Investment

We derive a condition for optimal investment. Though the problem occurs over time, we can write it as a static one shot investment problem by discounting future flows to the present. Discarding elements not involving investment, the firm's objective is

$$\max_I \left\{ \frac{(1-\tau)\pi(I)}{1+r} - (1-\tau z)I - \lambda(1-\tau z)I \right\} \tag{3.5}$$

Here, we assume π is weakly concave, which ensures that the problem yields a unique interior solution.

The first order condition for optimal investment is

$$(1-\tau)\pi'(I^*) = (1+r)(1+\lambda)(1-\tau z). \tag{3.6}$$

Intuitively, the investment decision trades off the after-tax future benefits of the marginal dollar of investment against its price (normalized to one) and the marginal external finance cost, less the marginal benefit due to depreciation deductions. Deductions lower the hurdle rate for investment both through their net present value and through relaxing the external

model, because the dynamic constraint makes the effective external finance function convex. Nevertheless, this simplifying assumption is not worrisome. Because each dollar of investment can only generate at most 35 cents of cash back, these policies cannot operate mainly through a direct cash windfall channel.

[29] As modeled the constraint is closer to a long run credit constraint than it is to a liquidity constraint, which would depend on current cash balances only. Recovering a β close to zero might imply that this distinction is important. Note also that we do not include future profits in the external finance function. This is merely for notational convenience and to fit the simple model more closely into the adjustment cost framework in the full model.

finance constraint. With costly external finance, optimal investment is strictly lower than in the frictionless case or when inside cash can cover all investment expenses (i.e., when $\lambda = 0$).

3.3 Testable Hypotheses

We derive three testable hypotheses from the model. The first concerns the average effect of bonus depreciation on investment, while the latter two concern heterogeneous effects by the presence of costly external finance and by tax position. Bonus depreciation increases the present value of deductions, reducing the price of investment. Thus bonus depreciation should increase investment. Each hypothesis builds on the comparative static with respect to the bonus parameter θ. In the appendix, we show that investment is increasing in θ.

Hypothesis 1. *Investment responds more strongly to bonus depreciation for industries with more investment in longer lived eligible items. That is,* $\partial^2 I/\partial\theta\partial z^0 < 0$.

Bonus depreciation works through increasing θ. Hypothesis one concerns the basic effect of this policy on investment. The more delayed the normal depreciation schedule is, the more generous bonus will be. Longer lived items like telephone lines and heavy manufacturing equipment have a more delayed baseline schedule than short lived items like computers (i.e., $z^0_{\text{Long}} < z^0_{\text{Short}}$). Thus, industries that buy more long lived equipment see a larger relative price cut when bonus happens.

Our second hypothesis concerns how the investment response varies with costly external finance.

Hypothesis 2. *Investment responds more strongly to bonus depreciation for financially constrained firms. That is,* $\partial^2 I/\partial\theta\partial\lambda > 0$.

For financially constrained firms, bonus depreciation both reduces the price of investment and reduces how much they have to borrow. The effective price change is thus larger for constrained firms. We use several proxies for ex ante financial constraints—firm size, dividend payment activity and liquid asset positions—to test for a difference in elasticities between constrained and unconstrained firms. If financial constraints are unimportant, then we should not find a consistent, systematic difference in elasticities for groups of firms based on these proxies. We can use the difference in coefficients between constrained and unconstrained firms to ask what the implied external finance spread. We formalize and implement this intuition in Section 7.

Our third hypothesis concerns how the investment response varies with the firm's current tax position.

Hypothesis 3. *Investment responds more strongly to bonus depreciation for firms with current-year taxable income. That is,* $\partial I/\partial\theta|_{\gamma=1} - \partial I/\partial\theta|_{\gamma=0} > 0$.

Hypothesis three emerges in any model with some positive discounting, since future benefits are worth less than immediate benefits. The main value of the comparison between taxable and nontaxable groups derives from the calibration it offers. We can calibrate the expected arrival of the taxable state for nontaxable firms and ask whether the difference between elasticities for taxable and nontaxable firms requires some myopia (i.e., $\beta < 1$).

4 Business Tax Data

The analysis in this paper uses the most complete dataset yet applied to study business investment incentives.[30] The data include detailed information on equipment and structures investment, offering a finer breakdown than previously available for a broad class of industries. The sample includes many small, private firms and all of the largest US firms, which enables the heterogeneity analysis we use to document financial constraints. Because the data come from corporate tax returns, we can separate firms based on whether the next dollar of investment affects this year's taxes. This allows a split sample analysis that can distinguish the myopia model from a simple model of costly external finance. In this section, we describe where these data come from and the analysis sample, as well as how we map the theory into empirical objects.

4.1 Sampling Process

Each year, the Statistics of Income (SOI) division of the IRS Research, Analysis and Statistics unit produces a stratified sample of approximately 100,000 unaudited corporate tax returns.[31]

[30] Yagan (2013) uses these data to study the 2003 dividend tax cut. Kitchen and Knittel (2011) use these data to describe general patterns in bonus and Section 179 take-up.

[31] Details come from `http://www.irs.gov/pub/irs-soi/08cosec3ccr.pdf`.

Stratification occurs by form type,[32] total assets, and proceeds. Each sample year includes returns with accounting periods ending between July of that year and the following June. When necessary, we recode the tax year to align with the implementation of the policies studied in this paper. In 2008, the sample represented about 1.8 percent of the total population of 6.4 million C and S corporation returns.

SOI uses these samples to generate annual publications documenting income characteristics. The BEA uses them to finalize national income statistics. In addition, the Treasury's Office of Tax Analysis (OTA) uses the sample to perform policy analysis and revenue estimation. To enable these aggregate statistics, SOI carefully reports sampling weights which reflect each observation's sampling frequency. Our aggregate estimates incorporate these weights. Any corporation selected into the sample in a given year will be selected again the next year, providing it continues to fall in a stratum with the same or higher sampling rate. Shrinking firms are resampled at a lower rate, which introduces sampling attrition. We address this attrition in several ways, including a nonparametric reweighting procedure for figures and through assessing the robustness of our results in a balanced panel.

4.2 Analysis Samples, Variable Definitions and Summary Statistics

We create a panel by linking the cross sectional SOI study files using firm identifiers.[33] The raw dataset has 1.84 million rows covering the years from 1993 to 2010. There are 355 thousand distinct firms in this dataset, 19,711 firms with returns in each year of the sample and 62,478 firms with at least 10 years of returns. Beginning with the sample of firms with valid data for each of the main data items analyzed, we keep firm-years satisfying the following criteria: (a) having non-zero total deductions or non-zero total income[34] and (b) having an attached investment form.[35] In addition, we exclude partial year returns, which occur when a firm

[32]For example, C corporations file form 1120 and S corporations file form 1120S. Other form types include real estate investment trusts, regulated investment companies, foreign corporations, life insurance companies, and property and casualty insurance companies. Sampling frequencies reflect the distribution of these types in the population. We focus on 1120 and 1120S, which cover the bulk of business activity in industries making equipment investments.

[33]We thank OTA staff for providing the data crosswalk.

[34]Knittel et al. (2011) use a similar "de minimus" test to select business entities that engage in "substantial" business activity.

[35]Form 4562 is the tax form that corporations attach to their return to claim depreciation deductions on new and past investments. An entity that claims no depreciation deductions need not attach form 4562. It is likely that these firms do not engage in investment activity, and so their exclusion should not affect the interpretation of results.

closes or changes its fiscal year. To analyze bonus depreciation, we exclude firms potentially affected by Section 179, a small firm investment incentive which we analyze separately. Our main bonus analysis sample consists of all firms with average eligible investment greater than $100,000 during years of positive investment.[36] This sample consists of 820,769 observations for 128,151 distinct firms.

This section describes the economic concepts underlying the variables we study. **Eligible investment**, our main variable of interest, includes expenditures for all equipment investment put in place during the current year for which bonus and Section 179 incentives apply.[37] We conduct separate analyses for intensive and extensive margin responses. The intensive margin variable is the logarithm of eligible investment. The extensive margin variable is an indicator for positive eligible investment. We aggregate this indicator at the industry level and transform it into a log odds ratio[38] for our empirical analyses. In some specifications, we use an alternative measure of investment, which is eligible investment divided by lagged **capital stock**. Capital stock is the reported book value of all tangible, depreciable assets. **Sales** equals operating revenue and **assets** equals total book assets. **Total debt** equals the sum of non-equity liabilities excluding trade credit. **Liquid assets** equals cash and other liquid securities. **Payroll** equals non-officer wage compensation. **Rents** equals lease and rental expenses. **Interest** equals interest payments.

Our main policy variable of interest, $\mathbf{z_{N,t}}$, is the present discounted value of one dollar of deductions for eligible investment. In each non-bonus year, we compute the share of eligible investment a firm reports in each category.[39] We use these shares and the present value of one dollar of eligible investment for each category to construct a weighted average, firm-level z. Category z's come from applying a seven percent discount rate to the pertinent deduction

[36] The relevant threshold for Section 179 was $25,000 until 2003, when it increased to $100,000. In 2008, it increased to $250,000 and then to $500,000 in 2010. Using alternative thresholds in the range from $50,000 to $500,000 does not alter the results.

[37] Section 179 and bonus rules differ slightly, in that Section 179 also applies to used equipment purchases, while bonus only applies to new equipment. The form does not require firms to list used purchases separately.

[38] I.e., we use $\log(\frac{p}{1-p})$ as our measure of the extensive margin.

[39] Specifically, 3-, 5-, 7-, 10-, 15-, and 20-year Modified Accelerated Cost Recovery System (MACRS) property and listed property.

schedule, while assuming a six-month convention for the purchase year.[40][41] We compute z_N at the four-digit NAICS industry level as the simple average of the firm-level z's across non-bonus years prior to 2001. In bonus years, we adjust z by the size of the bonus. If θ is the additional expense allowed per dollar of investment (e.g., $\theta = .3$ for 2001), then $z_{N,t|\theta_t} = \theta_t + (1 - \theta_t) \times z_N$. The interaction between the time series variation in θ and the cross sectional variation in z_N delivers the identifying variation we use to test our three hypotheses.

Table 3 collects summary statistics for the sample in our bonus depreciation analysis. The average observation has \$6.8 million in eligible investment, \$180 million in sales and \$27 million in payroll. The size distribution of corporations is skewed, with median eligible investment of just \$370 thousand and median revenues of \$26 million. The average net present value of depreciation allowances, $z_{N,t}$, is 0.88 in non-bonus years, implying that eligible investment deductions for a dollar of investment are worth eighty-eight cents to the average firm. $z_{N,t}$ increases to an average of 0.94 during bonus years. Cross sectional differences in $z_{N,t}$ are similar in magnitude to the change induced by bonus, with $z_{N,t}$ varying from 0.87 at the tenth percentile to 0.94 at the ninetieth. The first year deduction, $\theta_{N,t}$, increases from an average of 0.18 in non-bonus years to 0.58 in bonus years.

The difference in z's over time of just six cents per dollar before tax translates into a benefit of just over two cents after tax, which is why some authors claim the effect of bonus on investment should be small. However, if the discount rate firms apply to future deductions includes a large external finance wedge or myopia, then this two cent difference can increase to as much as the forty cent difference in average θ's.

It is helpful to give a sense of the groups being compared, because our identification will be based on assuming that industry-by-year shocks are not confounding the trends between industry groups. The ten most common three-digit industries (NAICS code) in the bottom three z_N deciles are: motor vehicle and parts dealers (441), food manufacturing (311), real estate (531), telecommunications (517), fabricated metal product manufacturing (332), food services and drinking places (722), transportation equipment manufacturing (336), oil and gas extraction (211), nondurable goods wholesalers (424), and primary metal manufacturing

[40] The category deduction schedules are available in IRS publication 946. We use a seven percent rate as a frictionless benchmark that is likely larger than the rate firms should be using, which will tend to bias our results downward. Summers (1987) argues that firms should apply a discount rate close to the risk-free rate for depreciation deductions. Seven percent is the largest discount rate House and Shapiro (2008) apply when computing the value of bonus depreciation.

[41] The six-month convention is applied because on average the property is in place for only half of the first year.

(331). In the top three deciles are: professional, scientific and technical services (541), specialty trade contractors (238), computer and electronic product manufacturing (334), durable goods wholesalers (423), construction of buildings (236), heavy and civil engineering construction and land subdivision (237), truck transportation (484), rental and leasing services (532), nondepository credit intermediation (522), and administrative and support service (561). Neither group of industries appears to be skewed toward a spurious relative boom in the low z group. The telecommunications industry suffered unusually during the early bonus period as did real estate in the later period. Both industries are in the group for which we observe a larger investment response due to bonus.

5 The Effect of Bonus Depreciation on Investment

We begin with a test of Hypothesis 1, which predicts that investment responds more strongly to bonus depreciation for industries with more investment in longer lived eligible items.

Because bonus depreciation encourages investment by shifting later deductions forward in time, industries that invest more heavily in longer lived eligible items receive a more generous subsidy (Cummins, Hassett and Hubbard, 1994; House and Shapiro, 2008). Industries investing mainly in short-lived items provide a control group. This cross sectional variation in policy intensity allows us to identify the causal effect of bonus depreciation on investment.

In both bonus periods we study, we estimate large responses to bonus depreciation, which imply a significant effect on aggregate equipment investment. The estimates are similar in both periods. We assess the key risk of this design—that time-varying industry shocks confound our estimates—using a variety of specifications, a placebo test and differences in policy salience across space.

5.1 Policy Background

House and Shapiro (2008) provide a detailed discussion of the baseline depreciation schedule[42] and legislative history of the first round of bonus depreciation. Kitchen and Knittel (2011) provide a brief legislative history of the second round.[43] Appendix B summarizes the relevant legislation.

[42] Known as the Modified Accelerated Cost Recovery System, or MACRS.

[43] See also the Treasury's "Report to The Congress on Depreciation Recovery Periods and Methods" (2000).

In 2001, firms buying qualified investments[44] were allowed to immediately write off 30 percent of the cost of these investments. The bonus increased to 50 percent in 2003 and expired at the end of 2004. In 2008, 50 percent bonus depreciation was reinstated. In subsequent years it was extended to 100 percent bonus for tax years ending between September 2010 and December 2011.[45] The policies applied to equipment investment and excluded most structures.[46]

The policies were intended as economic stimulus. In the words of Congress, "increasing and extending the additional first-year depreciation will accelerate purchases of equipment, promote capital investment, modernization, and growth, and will help to spur an economic recovery" (Committee on Ways & Means, 2003, p. 23). To avoid encouraging firms to delay investment until the policy came online, legislators announced that the policy would apply retroactively to include the time when the policy was under debate. Although the first bonus legislation passed in early 2002, firms anticipating policy passage would have begun responding in the fourth quarter of 2001. We therefore include firm-years with the tax year ending within the legislated window in our treatment window.

Whether firms perceived the policy as temporary or permanent is a subject of debate. The initial bill branded the policy as temporary stimulus, slating it to expire at the end of 2004, which it did. For this reason, House and Shapiro (2008) assume firms treat the policy as temporary. In contrast, Desai and Goolsbee (2004) cite survey evidence indicating that many firms expected the provisions to continue, and our empirical analysis in Section 8 offers little evidence of intertemporal shifting.[47] Expecting the policy to be temporary is critical to House and Shapiro (2008), because their exercise relies upon how policies approximated as instantaneous interact with the duration of investment goods approximated as infinitely lived. Our design relies much less on this assumption. In our model, credit constraints and myopia amplify the effects of both temporary and permanent policies. And our cross sectional

[44]Depreciable tangible personal property with class life of twenty years or less, purchased for use in the active conduct of a trade or business. Used equipment was excluded.

[45]In the first bonus period, property had to be put in place after September 10, 2001 and before January 1, 2005. The start date for the second bonus period was December 31, 2007 and the end date was December 31, 2011.

[46]These provisions coincided with an increase in the Section 179 allowance for small investments from $24,000 to $100,000 in 2003, from $125,000 to $250,000 in 2008, and from $250,000 to $500,000 in 2010. In our main sample, we exclude firms with mean eligible investment greater than $100,000. Altering this threshold does not change our results.

[47]Note that when production functions exhibit constant returns to scale, the effect of temporary and permanent policies on investment will be the same (Abel, 1982).

identification relies much less on the response of the longest lived investment goods.

5.2 Empirical Setup

Bonus depreciation provides a temporary reduction in the price and a temporary increase in the first year deduction for eligible investment goods. Eligible items are classified for deduction profiles over time based on their useful life. Identification builds upon the idea that some industries benefited more from these cuts by virtue of having longer duration investment patterns, that is, by having more investment in longer class life categories. This cross-sectional variation permits a within-year comparison of investment growth for firms in different industries. The policy variation is at the industry-by-year level, so the key identifying assumption is that the policies are independent of other industry-by-year shocks. Several robustness tests validate this assumption.

The regression framework implements the standard difference-in-differences (DD) specification given by

$$f(I_{it}, K_{i,t-1}) = \alpha_i + \beta g(z_{N,t}) + \gamma X_{it} + \delta_t + \varepsilon_{it} \tag{5.1}$$

where $z_{N,t}$ is measured at the four-digit NAICS industry level and increases temporarily during the bonus years. The specific additive form we adopt in (5.1) for the unobserved firm-level components, α_i, can only be valid for a particular class of investment functions. For example, if valid in levels, the design cannot be valid in logs. The investment data summarized in Table 3 is highly skewed with a mean of $6.8 million and a median of just $368 thousand. Thus, a multiplicative unobserved effect (that is, $I_i = A_i I^*(z)$) is the most likely empirical model for investment levels. This delivers an additive model in logarithms, which is the approach we pursue below. Because approximately eight percent of our observations for eligible investment are equal to zero, we supplement the intensive margin logs approach with a log odds model for the extensive margin. We measure the log odds ratio as $\log(P[I > 0]/(1 - P[I > 0]))$ at the four-digit industry level.[48]

Studies often use an alternative empirical specification for $f(I, K)$, where investment is scaled by lagged assets or lagged capital stock. We prefer log investment for four reasons. First, small firms are not always required to disclose balance sheet information, so requiring

[48] An alternative specification, with the odds ratio replaced by $P[I > 0]$, works as well. However, the logs odds ratio has better statistical properties (e.g., a more symmetric distribution).

reported assets would reduce our sample frame. Second, and related to the first reason, requiring two consecutive years of data for a firm-year reduces our sample by fifteen percent. Third, there is some concern that balance sheet data on tax accounts are not reported correctly for consolidated companies due to failure to net out subsidiary elements.[49] Measurement error in the scaling variable introduces non-additive measurement error into the dependent variable. Last, with multiple types of capital, the scaling variable might not remove the unobserved firm effect from the model. This is especially a concern because we cannot measure a firm's stock of eligible capital and because firms vary in the share of total investments made in eligible categories.[50] While we prefer the log investment model for these reasons, we also report results using investment scaled by lagged capital stock, which allows comparison to past studies.

5.3 Graphical Evidence

Figure 1 presents a visual implementation of this research design. To allow a comparison that matches a regression analysis with fixed effects and firm-level covariates, we construct residuals from a two-step regression procedure. First, we nonparametrically reweight (i.e., Dinardo, Fortin and Lemieux (1996) reweight) the group-by-year distribution within ten size bins based on assets crossed with ten size bins based on sales.[51] This procedure addresses sampling frame changes over time, which cause instability in the aggregate distribution.[52] In the second step, we run cross sectional regressions each year of the outcome variable on an indicator for treatment group—either long duration or short duration—and a rich set of controls, including ten-piece splines in assets, sales, profit margin and age. We plot the residual group means from these regressions.[53]

We compare mean investment in calendar time for the top and bottom three deciles of the investment duration distribution.[54] Long duration industries show growth well above that of the short duration industries, with this difference only appearing in the bonus years. The

[49]Mills, Newberry and Trautman (2002) analyze balance sheet accounting in tax data and document difficulties in reconciling these accounts with book accounts.

[50]Abel (1990) notes that this issue and other violations of linear homogeneity can lead to spurious conclusions (e.g., a reversed investment-Q relationship.

[51]The bins are set based on the size distribution in 2000.

[52]During the period we study, the size of the sample frame changed twice due to budgetary constraints.

[53]To align the first year of each series and ease comparison of trends, we subtract from each dot the group mean in the first year and add back the pooled mean from the first year. All means are count weighted.

[54]Deciles are computed at the industry level.

difference between the slopes of these two lines in any year gives the difference-in-differences estimate between these groups in that year. The other years provide placebo tests of the natural experiment and indicate no false positives.

Figure 2 provides another way of visualizing this relationship. For each firm, we compute the difference in average eligible investment between when bonus was in place—treatment years—and an equal length period prior to bonus—control years.[55] We group these observations into equally sized bins based on $z_{N,t}$ in non-bonus years, our proxy for treatment intensity. The average level of investment growth is negative in both periods, which is not surprising because the motivation for these policies is prevailing economic weakness. Despite this weakness, temporary investment incentives clearly influence equipment investment. Firms doing more eligible investment in short duration equipment categories receive the smallest benefit from bonus depreciation and display the largest contraction in investment when these policies are active. The upward sloping relationship is clear and present in both samples.

5.4 Statistical Results and Economic Magnitudes

Table 4 presents regressions of the form in (5.1), where $f(I_{it}, K_{i,t-1})$ equals $\log(I_{it})$ in the intensive margin model, $\log(P_N[I_{it} > 0]/(1-P_N[I_{it} > 0]))$ in the extensive margin model, and $I_{it}/K_{i,t-1}$ in the user cost model; and $g(z_{N,t})$ equals $z_{N,t}$ in the intensive and extensive margin models and $(1-\tau z_{N,t})/(1-\tau)$ in the user cost model.[56] The baseline specification includes year and firm fixed effects. Standard errors are clustered at the firm level in the intensive margin and user cost models.[57] Because log odds ratios are computed at the industry level, standard errors in the extensive margin model are clustered at the industry level.

The first column reports an intensive margin semi-elasticity of investment with respect to z of 3.7, an extensive margin semi-elasticity of 3.8 and a user cost elasticity of -1.6. The average change in $z_{N,t}$ was 4.7 cents during the early bonus period and 8 cents during the later

[55]Unless otherwise specified, investment is measured by $\log(I_e)$ where I_e denotes eligible investment expense. This allows convenient interpretation of differences as approximate percent changes. We study the extensive margin in separate specifications.

[56]τ is set to 35 percent, the top statutory tax rate for all firms.

[57]This is consistent with recent work (e.g., Desai and Goolsbee (2004), Edgerton (2010), Yagan (2013)) and enables us to compare our confidence bands to past estimates. The implicit assumption that errors within industries are independent is strong, for the same reason that Bertrand, Duflo and Mullainathan (2004) criticize papers that cluster at the individual level when studying state policy changes. Our results in this section are robust to industry clustering, as are the tax splits in the next section. In the financial constraint splits regressions, we discuss which inferences are robust to this more conservative structure. We are not aware of other studies that restrict inference in this way and still show that taxes affect investment.

period, implying average investment increases of $18.5(= 3.79 \times 4.7)$ and $31.4(= 3.79 \times 8)$ log points, respectively. These predictions should not be confused with the aggregate effect of the policy, because they are based on equal-weighted regressions which include many small firms. They only provide an informative aggregate prediction under the strong assumption that the semi-elasticity is independent of firm size. We relax this assumption to produce an aggregate estimate in section 8.

In the second column, including a control for contemporaneous cash flow scaled by lagged capital does not alter the estimates. Columns three and four show a similar semi-elasticity for both the early and late episodes. Column five controls for fourth order polynomials in each of assets, sales, profit margin and firm age, as well as industry average Q measured from Compustat at the four-digit level. Column six adds quadratic time trends interacted with two-digit NAICS industry dummies, which causes the estimated semi-elasticity to increase.[58] These alternative control sets do not challenge our main finding: the investment response to bonus depreciation is robust across many specifications.

Appendix Table A.2 collects from other studies estimates that we can compare to our user cost model. Like our study, each one uses tax reforms crossed with industry characteristics to estimate the effect of taxes on investment. The average user cost elasticity across these studies is 0.69, which falls within Hassett and Hubbard (2002)'s consensus range of 0.5 to 1, but is less than half our estimate of 1.60.

In an investment model, the elasticity of investment with respect to the net of tax rate, $1 - \tau z$, equals the price elasticity and interest rate elasticity.[59] Our empirical model delivers an elasticity of 7.2. We are not aware of easily comparable estimates for prices or interest rates.

Thus by several accounts, bonus depreciation has a substantial effect on investment, much larger than past estimates and much stronger than the conventional wisdom predicts. We further investigate the robustness of this fact and then turn to potential explanations in Section 6.

[58] We can replace the quadratic time trends with increasingly nonlinear trends or two digit industry-by-time fixed effects. We can also replace the time trends with two-digit industry interacted with log GDP or GDP growth. In each case, the estimates increase. This suggests that omitted industry-level factors bias our estimates downward. Consistent with this story, Dew-Becker (2012) shows that long duration investment falls more during recessions than short duration investment.

[59] Appendix A provides a derivation.

5.5 Additional Robustness and Policy Salience

The calendar time plot in Figure 1 provides several visual placebo tests through inspection of the parallel trends assumption in non-bonus years. Because bonus depreciation excludes very long lived items (i.e., structures), we can use ineligible investment as an alternative intratemporal placebo test.[60] The first two columns of Table 5 present two specifications of the intensive margin model, which replace eligible investment with structures investment. The first specification is the baseline model, and the second includes two-digit industry dummies interacted with quadratic time trends. We cannot distinguish the structures investment response from zero. Thus, the results pass this placebo test.

Another concern with our results is that they may merely reflect a reporting response, with much less actual investment taking place. The third and fourth columns of Table 5 provide a reality check. We replace our measure of investment derived from Form 4562 with net investment, which is the difference in logarithms of the capital stock between year t and year $t-1$. Both the baseline and industry trend regressions confirm our gross investment results with net investment responding strongly as well.

Columns five and six of Table 5 offer a sanity check of our findings. Here, the dependent variable is an indicator for whether the firm reports depreciation expense in the specific form item applicable to bonus. Effectively, this is a test for bonus depreciation take-up. The table indicates that the probability of taking up bonus is strongly increasing in the strength of the incentive.

We present direct evidence that firms take the tax code into account when making investment decisions. With respect to equipment investment, they pay special attention to the depreciation schedule and the nonlinear incentives it creates. These nonlinear budget sets should induce *bunching* of firms at rate kinks. Consistent with this logic, we find sharp bunching at depreciation kink points. This evidence supports our claim that temporary bonus depreciation incentives were also salient.

To show policy salience, we study a component of the depreciation schedule, Section 179, which applies mainly to smaller firms. Under Section 179, taxpayers may elect to expense

[60] This placebo test is valid if structures are neither complements nor substitutes for equipment, an assumption that is unlikely to hold. Still, the structures test is useful, since observing a structures response equal in magnitude or larger than the equipment response would be a cause for concern that time-varying industry shocks drive our results.

qualifying investment up to a specified limit. With the exception of used equipment,[61] all investment eligible for Section 179 expensing is eligible for bonus depreciation. Focusing on Section 179 thus serves as an out of sample test of policy salience that remains closely linked to the bonus incentives at the core of the paper.

For a given tax year, there is a maximum deduction and a threshold over which Section 179 expensing is phased out dollar for dollar. Thus, Section 179 resembles bonus depreciation with a one hundred percent first year deduction. Appendix Table A.1 summarizes the changes in Section 179 depreciation rules over the past twenty years. The kink and phase-out regions have increased incrementally since 1993, with larger jumps in 2003 (from $24,000 to $100,000), 2008 (from $125,000 to $250,000) and 2010 (from $250,000 to $500,000).

We exploit the kink induced by the Section 179 schedule at the maximum deduction level of investment. When the tax schedule contains kinks and the underlying distribution of types is relatively smooth, the empirical distribution should display excess mass at these kinks (Hausman, 1981; Saez, 2010). Figure 4 shows how dramatic the bunching behavior of eligible investment is in our setting. These figures plot frequencies of observations in our dataset for eligible investment grouped in $250 bins. Each plot represents a year or group of years with the same maximum deduction, demarcated here by a vertical line. The bunching within $250 of the kink tracks the policy shifts in the schedule exactly and reflects a density five to fifteen times larger than the counterfactual distribution nearby.[62]

In general, evidence of bunching at kink points reflects a mix of reporting and real responses.[63] The bunching evidence is informative in either case because these are both behavioral responses, which show whether firms understand and respond to the schedule. In the next section, we study managerial myopia by comparing bunching activity across different groups of firms. This test does not depend on whether the response is real or reported.

We can interact the bunching evidence with the basic regression model identifying the re-

[61] Used equipment accounts for approximately six percent of equipment investment (Kitchen and Knittel, 2011).

[62] Excess mass ratios are computed using the algorithm and code in Chetty et al. (2011).

[63] See Saez (2010) for a discussion of this point. The bonus difference-in-differences (DD) design is less vulnerable to misreporting. In that design, we can confirm the response by looking at other outcomes. In addition, the DD estimator is much less sensitive to misreporting by a small fraction of total investment. Moreover, the sample contains many firms who use external auditors, for whom misreporting investment entails substantial risk and little benefit. Last, our conversations with tax preparers and corporate tax officers suggest that misreporting investment is an inferior way to avoid taxes. This is because investment purchases are typically easily verifiable, require receipts when audited, and usually reduce current taxable income by just a fraction of each dollar claimed as spent. In the case of investment expenses depreciated over multiple years, the audit risk of misreporting is also extended over the entire depreciation schedule.

sponse to bonus. The design of the test generates control and treatment groups from the notion that firms differ in their tax code knowhow.[64] We compute geographic proxies of investment schedule sophistication through measuring the local propensity to bunch at the Section 179 kink point. We use the low information areas as cross-sectional counterfactuals for the high information areas. We then separately estimate the baseline model for each group, effectively providing a difference-in-difference-in-differences estimate of the bonus response.

We group firms by two-digit ZIP code, which is the lowest level of aggregation that permits a reliable measure of bunching. For each ZIP-2, we pool all years and compute the fraction of firms within $10,000 of the kink who bunch within $250 of it. This provides the sorting variable. In this design, more bunching in a region indicates more awareness of the tax code for that region. So, we should expect the growth in investment during bonus periods to be increasing in the level of bunching. Columns seven and eight of Table 5 show that indeed the high bunching areas display a stronger response to bonus than do the low bunching areas.[65]

To recapitulate, bonus depreciation has a large effect on investment, and spurious time-varying industry factors cannot explain this fact. Such factors would cause parallel trends to fail in the years prior to bonus. They would lead to different estimates in recessions marked by weakness in different industries. They would lead ineligible investment to expand. They would attenuate the estimated effect when regressions include flexible industry-by-time controls. And they would lead to a similar response across geographies where firms pay more and less attention to the depreciation schedule. The facts do not match these predictions. Section 6, which presents heterogeneous effects by firm size, further contradicts the omitted industry factor story.

These investment responses directly correspond to take-up of depreciation incentives—bonus take-up rates rise with the policy's generosity and many firms sharply bunch around the Section 179 kink point—in contrast to recent work on partial salience of sales taxes (Chetty, Looney and Kroft, 2009) and the nonresponse of investment to dividend tax changes (Yagan, 2013). Net investment responds to bonus depreciation as well, even though the reported balance sheet items do not affect taxable income. Section 8 shows that debt issuance increases because of bonus depreciation and that payroll and dividend payments—which are double

[64] This test follows the design of Chetty, Friedman and Saez (2013), who use geographic differences in individual bunching at a kink in the Earned Income Tax Credit schedule to study the labor supply response to taxes.

[65] Specifically, we compare the top and bottom three deciles of local bunching.

reported—respond as well. Thus the observed response is a policy response that does not reflect a mere reporting response, but rather reflects real economic actions.

6 Explaining the Large Response with Financial Frictions

The large response of investment to bonus depreciation is not consistent with a frictionless model of firm behavior: the magnitudes imply implausibly high discount rates. In this section, we explore alternative models that generate high effective discount rates.

One alternative is costly external finance, which raises the total discount rate firms apply to evaluate projects. Our rich data environment enables us to study how the investment response to tax incentives interacts with costly external finance. We perform a series of split sample tests, using several common markers of ex ante financial constraints.[66] Consistent with this story, firms more likely to depend on costly external finance—small firms, non-dividend payers and firms with low levels of cash—respond more strongly to bonus. Split sample analysis by size also leads to a more accurate prediction for the aggregate policy response.

Another alternative model is managerial myopia, which raises effective discount rates by sharply discounting the future relative to the present. Consistent with this story, firms only respond to investment incentives when the policy immediately generates after-tax cash flows. For firms with positive taxable income before depreciation, expanding investment reduces this year's tax bill and brings extra cash into firm coffers today. Firms without this immediate incentive can still carry forward the deductions incurred but must wait to receive the tax benefits.[67] We present evidence that, for both Section 179 and bonus depreciation, this latter incentive is weak, and differences in growth opportunities cannot explain this fact.

6.1 Heterogeneous Responses by Ex Ante Credit Constraints

We divide the sample along several markers of ex ante credit constraints used elsewhere in the literature. Even for private unlisted firms, we can still measure size, payout frequency

[66] See Fazzari, Hubbard and Petersen (1988*a*) for an early application of this methodology and Almeida, Campello and Weisbach (2004) and Chaney, Sraer and Thesmar (2012) for recent examples.

[67] In the code, current loss firms have the option to "carry back" losses against past taxable income. The IRS then credits the firm with a tax refund. Our logic assumes that firms have limited loss carryback opportunities because, in the data, we find low take-up rates of carrybacks. Furthermore, carrybacks create a bias against our finding a difference between taxable and nontaxable firms, because carrybacks create immediate incentives for the nontaxable group.

and proxies for balance sheet strength. Figure 3 plots elasticities and confidence bands from regressions run for each of ten deciles based on average sales.[68] We plot both the intensive margin elasticities and the user cost elasticities. The smallest firms in the sample show the largest response to bonus, regardless of the specification. The user cost estimates help us reconcile our findings with those in past studies. Larger firms show user cost elasticities in line with the findings surveyed in Hassett and Hubbard (2002). It is only the smaller firms, for whom data were previously unavailable, that yield estimates outside the consensus range.

Table 6 presents a statistical test of the difference in elasticities across three markers of ex ante constraints. For the sales regressions, we split the sample into deciles based on average sales and compare the bottom three to the top three deciles.[69] The average semi-elasticity for small firms is twice that for large firms and statistically significantly different with a p-value of 0.03.[70] The second two columns present separate estimates for firms who paid a dividend in any of the three years prior to the first round of bonus depreciation.[71] Here, the non-paying firms are significantly more responsive.

Our third sample split is based on whether firms enter the bonus period with relatively low levels of liquid assets. We run a regression of liquid assets on a ten-piece linear spline in total assets plus fixed effects for four-digit industry, time, and corporate form. We sort firm-year observations based on the residuals from this regression lagged by one year, and then report in the last two columns of Table 6 separate estimates for the top and bottom three deciles. These are reported in the last two columns of Table 6. The results using this marker of liquidity parallel those in the size and dividend tests, with the low liquidity firms yielding an estimate of 7.2 as compared to 2.8 for the high liquidity firms.

These constraint markers are imperfect.[72] First, they do not directly measure the external finance cost faced by new firms. This concern would tend to bias any differences existing between groups toward zero, and thus against the results we present. A second concern with sample splitting is that the splitting criteria are correlated with the investment error term and

[68]Specifically, we use average sales from the three years before each bonus period. We use as many of these six years as are available for each firm.

[69]When we measure size with total assets or payroll, the size results are unchanged.

[70]Cross equation tests are based on seemingly unrelated regressions with a variance-covariance matrix clustered at the firm level.

[71]We only use the first round of bonus for the dividend split. The dividend tax cut of 2003, which had a strong effect on corporate payouts (Yagan, 2013), may have influenced the stability of this marker for the later period.

[72]Criticism of split sample markers dates back to Poterba's comments in Fazzari, Hubbard and Petersen (1988*a*). See Farre-Mensa and Ljungqvist (2013) for a more recent assessment of their value in samples of public and private companies.

so may bias the estimated coefficient of interest (Bond and Van Reenen, 2007). This issue is important for investment-cash flow sensitivity tests because cash flow is likely correlated with other components of the investment error term. Because our setting features plausibly exogenous policy variation at the industry level, this concern is less important here. The key assumption we make is that interacting our splitting criterion, measured prior to the policy change, with the policy variable and the year effects enables a valid difference-in-differences design for each group.

6.2 Heterogeneous Responses by Tax Position

The Section 179 bunching environment presents an elegant setting to document the immediacy of investment responses to tax policy. The simple idea is to separate firms based on whether their investment decisions will fully offset current year taxable income, or whether deductions will have to be carried forward to future years. We choose net income before depreciation expense as our sorting variable. Firms for which this variable is positive have an immediate incentive to invest and reduce their current tax bill. If firms for which this variable is negative show an attenuated investment response and these groups are sufficiently similar, we can infer that the immediate benefit accounts for this difference.

The panels of Figure 5 starkly confirm our intuition. In panel (a), we pool all years in the sample, recenter eligible investment around the year's respective kink, and split the sample according to a firm's taxable status. Firms in the left graph have positive net income before depreciation and firms in the right graph have negative net income before depreciation. For firms below the kink on the left, a dollar of Section 179 spending reduces taxable income by a dollar in the current year. Retiming investment from the beginning of next fiscal year to the end of the current fiscal year can have a large and immediate effect on the firm's tax liability. For firms below the kink on the right, the incentive is weaker because the deduction only adds to current year losses, deferring recognition of this deduction until future profitable years. As the figure demonstrates, firms with the immediate incentive to bunch do so dramatically, while firms with the weaker, forward-looking incentive do not bunch at all.

One objection to the taxable versus nontaxable split is that nontaxable firms have poor growth opportunities and so are not comparable to taxable firms. We address this objection in two ways. First, we restrict the sample to firms very near the zero net income before depreciation threshold to see whether the difference persists when we exclude firms with large losses. Panel (a) of Figure 6 plots bunch ratios for taxable and nontaxable firms, estimated within a narrow bandwidth of the tax status threshold. The difference in bunching appears almost immediately away from zero, with the confidence bands separating after we include firms within $50 thousand dollars of the threshold. For loss firms, the observed pattern cannot be distinguished from a smooth distribution, even for firms very close to positive tax position. The bunching difference for nontaxable firms is not driven by firms making very large losses.

Table 7 replicates the tax status split idea in the context of bonus depreciation. We modify the intensive margin model from Table 4 by interacting all variables with a taxable indicator based on whether net income before depreciation is positive or negative.[73] According to these regressions and consistent with bunching results, the positive effect of bonus depreciation on investment is concentrated exclusively among taxable firms. The semi-elasticity is statistically indistinguishable from zero for nontaxable firms, while it is 3.8 for taxable firms. In panel (b) of Figure 6, we repeat the narrow bandwidth test for bonus depreciation. The figure plots the coefficients on the interaction of taxable and nontaxable status with the policy variable. The difference in coefficients in Table 7 emerges within $50 thousand of the tax status threshold, and these coefficients are statistically distinguishable within $100 thousand of the threshold. Here as well, the results are not driven by differences for firms far from positive tax positions.

To address the concern about nontaxable firms, Panel (b) of Figure 5 uses differences within the group of taxable firms. This plot shows again that bunching is due to tax planning with regard to the immediate potential benefit. Here, we divide profitable firms by their stock of loss carryforwards in the previous year. Each dot in this plot represents a bunching histogram where the y-axis measures the degree of bunching using the excess mass estimator in Chetty et al. (2011). The groups are sorted according to the ratio of lagged loss carryforward stock to current year net income before depreciation, which proxies for the availability of alternative tax shields. The scatter clearly indicates a negative relationship between the presence of this alternative tax shield and the extent of eligible investment manipulation.

We confirm this pattern in the bonus setting. Column (7) of Table 7 focuses on the group of taxable firms with non-zero stocks of lagged loss carryforwards. We split this group into three subgroups based on the size of their carryforward stock. Firms with large stocks of loss

[73] That is, we interact z, any controls, and the time fixed effects with the taxable indicator. We do not interact the firm effects with the taxable indicator.

carryforwards display a semi-elasticity with respect to z of 2 compared to a semi-elasticity of 5.7 for firms with low loss carryforward stocks.

The finding for nontaxable firms contradicts a simple model of costly external finance, because firms neglect how the policy affects borrowing in the future. On the other hand, firms cannot be too myopic because the investment decision itself only pays off in the future. Thus for myopia to be the explanation, firms must use different accounts to think about investment decisions and the tax implications. Moreover, the myopia story needs complexity to explain the finding for financially constrained firms—are small firms, non-dividend payers and firms with low levels of cash more myopic? While plausible, there is no evidence of this.

The facts presented in this section—the stronger response for financially constrained firms and the nonresponse for nontaxable firms—do not match the predictions of a frictionless model. The facts point instead toward models in which costly external finance matters and current benefits outweigh future benefits, with neither alternative being obviously redundant.

In the next section, we use an investment model and the estimates to calibrate a parameter for each alternative model.

7 Discount Rates and the Shadow Cost of Funds

Taken together, our empirical findings emphasize a financial frictions channel for how investment incentives work. In this section, we use a standard investment model to quantify the importance of this channel. Specifically, we ask what is the marginal value of cash, λ, implied by our financial constraint split sample analysis, and what is the discount term, β, implied by our tax status split sample analysis. The answers combine to tell us what discount rates firms apply when making investment decisions.

In Appendix A, we derive the comparative static for investment with respect to the bonus depreciation term θ:

$$I \cdot \varepsilon_{I,\theta} \equiv \frac{\partial I}{\partial \theta} = \frac{(1+\lambda)p_I}{\psi_{II}} \frac{\partial z}{\partial \theta} > 0, \tag{7.1}$$

where $\varepsilon_{I,\theta}$ is the semi-elasticity of investment with respect to θ, p_I is the price of investment, ψ_{II} is the second derivative of the adjustment cost function, and z is defined as in (3.3). In the Appendix, we state assumptions under which $I \cdot \psi_{II}$ will be equal across groups.[74] Under

[74] That is, we assume linear homogeneity of the marginal adjustment cost function. Nearly all studies in the literature make this assumption, which is necessary for example for marginal q to equal average Q.

these assumptions, we can derive two empirical moments that combine our estimates for constrained and unconstrained firms and for taxable and nontaxable firms and yield simple formulas for λ and β.

The first empirical moment we use compares the estimated response with respect to bonus for constrained and unconstrained firms. Assuming constrained firms face shadow price λ_C and unconstrained firms face shadow price λ_U, we take the ratio of comparative statics:

$$\frac{\varepsilon^C_{I,z}}{\varepsilon^U_{I,z}} \equiv m_1 = \frac{\partial I/\partial\theta|_{\lambda_C}}{\partial I/\partial\theta|_{\lambda_U}} = \frac{1+\lambda_C}{1+\lambda_U} = 1 + \frac{\Delta\lambda}{1+\lambda_U}, \tag{7.2}$$

which reveals an implied credit spread between constrained and unconstrained firms. Table 2 presents m_1 for each pair of estimates in Table 6. λ is the shadow price of relaxing the firm's

Table 2: Calibrated Moments

Shadow Cost of Funds Calibration				
	Mean Sales	Dividend Payers	Lagged Cash	Average
m_1	1.95	1.63	2.61	2.06
$\lambda_C\|_{\lambda_U=0}$	0.95	0.63	1.61	1.06
Discount Factor Calibration				
	p	ϕ	r	β
High ϕ	.5	.88	.07	0.84
Low ϕ	.1	.59	.07	0.92

Notes: This table computes empirical estimates for m_1 and m_2, as defined in the text. m_1 reveals an implied credit spread between constrained and unconstrained firms. m_2 reveals the discount factor firms apply to all future cash flows relative to current flows.

borrowing constraint. An alternative interpretation is that every after-tax dollar inside the firm is worth $1+\lambda$ dollars outside the firm. Our estimates reveal that, for financially constrained firms, a dollar inside the firm is worth \$2.06 on average outside the firm.

Is this estimate reasonable? There are not many existing benchmarks. Faulkender and Wang (2006) attempt a calculation with a very different methodology, but that ultimately arrives at a similar conclusion. They estimate the value of changes in cash in excess return regressions, while attempting to control for a host of omitted factors. They find that for low payout firms and for small firms the value of a dollar of after-tax cash is worth \$1.67 and \$1.62, respectively. For these firms' unconstrained counterparts, a dollar is only worth \$1.07

and \$1.12. The spreads in their study are comparable to ours, especially considering their exercise operates within a group of firms we consider to be relatively unconstrained.[75]

We define a second empirical moment that compares taxable and nontaxable firms:

$$\frac{\varepsilon_{I,z}^{\gamma=0}}{\varepsilon_{I,z}^{\gamma=1}} \equiv m_2 = \frac{\partial I/\partial \theta|_{\gamma=0}}{\partial I/\partial \theta|_{\gamma=1}} = \beta \phi \frac{1 - z_t^0(1)}{1 - z_t^0(\beta)}, \tag{7.3}$$

where ϕ is a discounter that reflects the average arrival of the taxable status event for nontaxable firms. We proxy for ϕ by assuming a fixed transition probability p for nontaxable firms and an infinite horizon for carryforward realization.[76] This implies $\phi = p/(p + r)$.[77] We calibrate the transition probability using the probability that an actually nontaxable firm transitions into tax status in the next period. In our data, this probability is approximately 0.5.[78] The sample we compare restricts the nontaxable group to include only firms that are nearly taxable, so this p offers a conservative estimate of ϕ. We compute the implied β for this p and for an extreme p equal to 0.1.

Note the external finance wedge falls out of this expression. This is true as long as average shadow costs are the same across taxable and nontaxable groups. To maintain this assumption, we use our loss carryforward group estimates to calibrate m_2. That is, we estimate semi-elasticities within the group of taxable firms sorted according to their past stocks of alternative tax shields. For firms with large loss carryforward stocks relative to current income, the marginal dollar of investment is unlikely to affect this year's tax bill. At the same time, we have less reason to believe these firms face substantially worse growth opportunities or tighter financial constraints. This biases our estimates of β toward the neoclassical benchmark of β equal to one.

Applying the estimates from the last column of Table 7 yields a value for m_2 of $0.35 (= (5.68 - 3.7)/5.68)$. For $p = 0.5$, this maps to an implied discount factor (β) of 0.84. Ignoring for the moment the other discount terms, β equal to 0.84 implies a discount rate of approxi-

[75]Similarly, Koijen and Yogo (2012) find that a relaxed borrowing constraint for life insurers is worth \$2.32 per dollar of inside capital.

[76]The actual expiration period for carryforwards is twenty years.

[77]That is, the expected arrival is $p/(1+r) + (1-p)p(1+r)^{-2} + (1-p)^2 p(1+r)^{-3} + \cdots = p/(1+r) \cdot [1/(1 - (1-p)/(1+r))] = p/(p+r)$.

[78]Auerbach and Poterba (1987) note more persistence of nontaxable positions than we do. Our measure is based on net income before depreciation, in order to capture the state of having the next dollar of investment affect this year's tax bill. Their measure is based on whether firms exhaust their carryforward stocks. Below, we assess the robustness of our results to varying ϕ.

mately 17 percent. We are not aware of studies that attempt to measure discount factors such as this for firms. Prior studies on individual decision making have found similar magnitudes for short term discount rates in both lab and field experiments.[79]

The discounting implied by β says that one dollar next year is worth 84 cents, before taking into account risk or the shadow cost of funds. If we then apply the assumed risk adjusted rate of 7 percent and the estimated shadow cost of funds of 1.06, we find that a dollar next year is worth approximately 38 cents today for the credit constrained firms in our sample. This substantial discount is not surprising, given the starkness of the reduced form empirical results: nontaxable firms seem to ignore the future benefits and small, financially constrained firms seem to value highly the immediate cash back due to bonus depreciation. In the model, we use costly external finance and myopia to describe the deviations from a rational benchmark we observe, but the exercise performed here provides just one of several plausible calibrations of this basic fact. In general, models of firm behavior that do not generate high discount rates are unlikely to fit the data for most firms.

8 Substitution Margins, External Finance and Aggregation

We ask whether increased investment involves substitution away from payroll or equipment rentals, how firms finance their additional investment, and whether the increased investment reflects intertemporal substitution or new investment. Studying external finance responses helps us understand how firms paid for new investments. Understanding substitution margins is critical for assessing the macroeconomic impact of these policies. We then apply the findings from our heterogeneity analysis to estimate the predicted aggregate investment effect of bonus.

8.1 Substitution and External Finance

We find little evidence of substitution away from leasing or payroll. In contrast, these policies coincide with within-firm payroll growth, suggesting a new margin—complementarity between capital and labor—through which investment incentives affect employment. Regard-

[79]Laibson D. Repetto and Tobacman (2007) estimate short term discount rates of 40 percent in the context of individual saving decisions. In a more general model, they estimate a short run discount rate of 15 percent and a long run rate of 3 percent.

ing external finance, firms appear to fund new investments through a mix of debt issuance, despite tightened credit conditions, and reduced payouts. We also document limited intertemporal shifting, as high past incentives only weakly predict low future investment. The payroll and finance effects offer more evidence that the investment effects do not reflect misreporting, but rather reflect a real response.

Table 8 presents estimates of the intratemporal and intertemporal substitution margins. These regressions follow the baseline specification in equation 5.1, with a different left hand side variable. For rents, payroll and debt, we focus on flows[80] as outcomes that match investment (i.e., capital stock flows) most closely. For payouts, we study the logarithm of dividend payments and an indicator for whether dividends are non-zero, which separates the intensive and extensive margins.

How flexible is the rent-versus-own margin for equipment investment? This is a crucial question for assessing the real effect of these stimulus policies. If firms simply shift away from leasing to take advantage of the tax benefits of buying, then the aggregate impact of these policies will be minimal. In their tax returns, firms separately report rental payments for computing net income. Unfortunately, this item does not permit decomposition into equipment and structures leasing. Given this limitation, we can still ask what effect bonus depreciation had on changes in rental payments. The first column of Table 8 shows that growth in rental payments did not slow due to bonus, but rather increased somewhat. Thus, we do not find evidence of substitution away from equipment leasing. The second column of Table 8 reports the effect of bonus on growth in non-officer payrolls. Again, we find no evidence of substitution, but rather coincident growth of payroll. Finding limited substitution in both leasing and employment makes it more likely that bonus incentives caused more output.

While increased depreciation deductions do allow firms to reduce their tax bills and keep more cash inside the firm, they must still raise adequate financing to make the purchases in the first place. This point is especially critical if, as the data suggest, firms thought to be in tight financial positions respond more. Here, we test whether bonus incentives affect net issuance of debt and payout policy. Columns three through five of Table 8 provide some insight. Increased equipment investment appears to coincide with significantly expanded borrowing and reduced payouts both on the extensive and intensive margins.

We assess the extent of intertemporal substitution using a model that includes both con-

[80] Namely, differences in logs.

temporaneous z and lagged z. Our data often do not include the fiscal year month, so it is possible that we are marking some years as t when they should be $t-1$ or $t+1$. For most of our tests, this issue introduces an attenuation but no systematic bias. However, when testing for intertemporal substitution, we want to be sure that lagged z measures past policy changes. Thus, column (6) of Table 8 includes regressions with twice lagged z added to the baseline bonus model. The coefficient on lagged z is negative but not distinguishable from zero and including lagged z does not alter the coefficient on contemporaneous z. This implies limited intertemporal shifting of investment.[81]

8.2 Estimating the Aggregate Response to Bonus

We can use these cross sectional designs to produce aggregate estimates of the effect of bonus depreciation on equipment investment. While not the central question of this study, the answer to this question is of interest to policymakers. Two caveats should be noted. First, the cross sectional variation in the policy variable of interest (z) is smaller than the its time series variation. Aggregate predictions will therefore depend on an extrapolation of the estimating equations outside the support of the data we use to identify the policy semi-elasticity. Caution should be taken in relying upon these estimates.

A second concern is that our preferred empirical specification, which estimates the effect of bonus in percentage changes, does not permit a direct prediction in levels. We address this through supplementing our baseline specification with a conditional fixed effects Poisson estimation of the policy semi-elasticity. The Poisson model allows us to preserve the assumption of multiplicative firm-level unobserved effects, while modeling directly the level of investment. Gross investment is bounded below by zero and exhibits considerable skewness, so permits a natural analogy to count probability models such as the Poisson.

We run our baseline regression and generate both a predicted log investment and a predicted counterfactual log investment under the assumption that bonus does not occur. We

[81] The argument in House and Shapiro (2008) still holds even if intertemporal shifting is limited, because it remains true that investment would be higher during bonus periods. These results only imply that the temporarily high investment does not significantly alter the investment decision (through, e.g., affecting future marginal products). See Abel (1982) for an analysis of temporary incentives and discussion of when intertemporal shifting should occur.

compute the counterfactual level of investment using the formula,

$$I_{CF} = I \times \exp(\widehat{\log(I_{CF})} - \widehat{\log(I)}), \tag{8.1}$$

and then aggregate these counterfactuals using the SOI sample weights. For the stimulus period from 2008 to 2010, aggregate eligible investment averaged \$378 billion per year. This method yields an average difference relative to the counterfactual level of \$108 billion per year.

This prediction relies on the assumption that the policy response is the same across all firms. We can relax this assumption and estimate separate elasticities for each of three size groups based on average sales. To give a sense of how these groups compare in the aggregate, in 2005, the bottom, middle and top third have mean investment of \$216 thousand, \$699 thousand and \$12.1 million, respectively. The bottom, middle and top third have aggregate investment of \$53.1 billion, \$33.4 billion and \$244 billion, respectively. In 2004, the bottom third declared \$12 billion in bonus deductions, the middle third declared \$10.8 billion and the top third declared \$86.3 billion. Estimating separate coefficients for each group reduces the average aggregate response to \$95 billion. On average, the smallest, middle and largest third respectively account for 12 percent, 9 percent and 79 percent of this response.

To incorporate both the intensive and extensive margins into one model, while preserving the multiplicative identification assumption, we use a Poisson model with conditional fixed effects. The model enables direct estimation of the policy effect in levels, affording a more accurate aggregate prediction in levels. The Poisson model yields an aggregate prediction that because of bonus investment increased \$55 billion on average between 2008 and 2010.

9 Conclusion

This paper combines methods from public and applied economics with insights from finance to answer a first order macroeconomic question: how do taxes affect investment behavior in the presence of financial frictions? We find that firms respond strongly to incentives that directly target investment decisions. Our heterogeneity results—that the investment response is larger for financially constrained firms, but only when the benefit is immediate—show that financial frictions are critical for understanding investment behavior.

The results point toward a set of models in which costly external finance matters and firms place more weight on current benefits than they would in a frictionless model. Whether the high implied discount rate reflects an external finance wedge, managerial myopia, agency considerations or a mix of these is an important question for future research. Further study of the external finance mechanism would be valuable. A deeper study of the employment effects of these policies is of direct interest to macroeconomic modelers.

A related question for future research concerns the effects of tax planning. How do tax preparers affect the decision to take up these policies? More generally, do firms focus on minimizing current taxes at the possible expense of future payoffs? The answer to these questions might shed light on the role of agency problems and firm learning about optimal management practices.

The empirical results imply that policies which target investment directly and yield immediate payoffs are most likely to influence investment activity. Policies that target financial constraints, such as direct loans, might have a similar effect if conditional on the investment decision. In comparison to studies of consumer durable goods, we find less evidence of intertemporal shifting, but more work on this question is needed. Data from the period following the recent stimulus, once available, will be very useful.

A Investment with Adjustment Costs and a Borrowing Constraint

We develop an infinite horizon, non-stochastic investment model, deriving the testable hypotheses in Section 3 and the empirical moments for calibration in Section 7. The model nests the standard neoclassical investment model with adjustment costs (Hayashi, 1982), a model with credit constraints and a model with managerial myopia.

A.1 General Setup

We begin with a discrete time version of Hayashi (1982). Firm value, V_0, is given by an infinite series of discounted net receipts, R_t. The discount rate, r_t, is risk-adjusted and possibly time varying. The expression for firm value is

$$V_0 = \sum_{t=0}^{\infty} \frac{1}{\Pi_{s=0}^{t}(1+r_s)} R_t. \tag{A.1}$$

Net receipts in each period reflect net revenues after taxes, investment costs, adjustment costs and depreciation deductions for current and past investments:

$$R_t = \left[1-\tau_t\right]\pi_t - \left[1-k_t\right]p_{I,t}I_t - \psi_t(I_t, K_t) + \tau_t \sum_{x=0}^{\infty} D_{t-x}(x) p_{I,t-x} I_{t-x}, \tag{A.2}$$

where τ_t is the corporate tax rate, π_t is pretax profits, $p_{I,t}$ is the price of investment goods, k_t is the investment tax credit, I_t is investment, ψ_t is adjustment costs and $D_{t-x}(x)$ is the depreciation deduction for capital of age x, based on the schedule from time $t-x$. Pretax profits are π_t, which equals gross revenues, $p_t F_t(K_t, N_t)$, with capital, K_t, and labor, N_t, inputs, less the cost of labor inputs. Net revenues are thus given by

$$\pi_t = p_t F_t(K_t, N_t) - w_t N_t. \tag{A.3}$$

Firms are price takers so output prices, p_t, and wages, w_t, are exogenous. F_t is weakly concave. The firm maximizes (A.1) subject to a capital accumulation law of motion:

$$K_{t+1} = K_t - \delta K_t + I_t, \tag{A.4}$$

where δ is the rate of economic depreciation. The adjustment cost function is convex and reflects after-tax resource losses due to production disruptions and installation.[82]

It is useful to have an expression for the stream of future depreciation deductions owed for investment in time t:

$$z_t^0(\beta) = \tau_t D_0 + \beta \sum_{x=1}^{\infty} \frac{1}{\Pi_{s=1}^{x}(1 + r_{t+s})} \tau_{t+x} D_t(x). \tag{A.5}$$

$z_t^0(\beta)$ reflects the present discounted value of one dollar of investment deductions after tax.[83] If the firm can immediately deduct the full dollar, then z_t^0 equals τ_t. In general, the stream of future deductions will depend on future tax rates and interest rates. β is an additional discount term between zero and one, which reflects the possibility of myopia. We use our heterogeneity analysis to identify this term separately.

Bonus depreciation, the policy we study in our empirical analysis, allows the firm to deduct a per dollar bonus, θ_t, at the time of the investment and then depreciate the remaining $1 - \theta_t$ according to the normal schedule:

$$z_t(\beta) = \tau_t \theta_t + (1 - \theta_t) z_t^0(\beta) \tag{A.6}$$

At different points in time, Congress set θ_t equal to 0.3, 0.5 or 1. We use these policy shocks to identify the effect of bonus depreciation on investment.

We further generalize z_t by incorporating a nontaxable state. When the next dollar of investment does not affect this year's tax bill, then the firm must carry forward the deductions to future years. Our general z_t reflects this case:

$$z_t(\beta, \gamma) = \gamma z_t(\beta) + (1 - \gamma)\beta \phi z_t(1), \tag{A.7}$$

where $\gamma \in \{0, 1\}$ is an indicator for current tax state and ϕ is a discounter that reflects both

[82]Hayashi (1982) models adjustment costs through influencing the law of motion in (A.4), rather than as a net receipts flow. Abel (1982) models adjustment costs through augmenting pretax profits in (A.3). There is no strong a priori argument for one versus the other. We adopt this notation to simplify the borrowing constraint in our calibration exercise. Intuitively, it means adjustment costs are not verifiable and thus the firm cannot borrow to offset them. It makes sense to further assume that such costs would not be deductable as well. The hypotheses we derive do not depend on the assumption.

[83]In the main text, we define z without incorporating the tax rates, in order to isolate the direct effect of bonus. Here, we define z with tax rates because it matches Hayashi (1982)'s notation and highlights the general dependence of the term on future tax rates.

the expected arrival time and the discount rate, r_T, applied to the future period when the firm switches. Note that for the nontaxable firm, β will apply to all future deductions.[84]

Hayashi (1982) considers the case with β and γ equal to one. We consider this case first. Define $z_t \equiv z_t(1,1)$. We can rewrite the objective in (A.1) as

$$V_0 = \sum_{t=0}^{\infty} \frac{1}{\Pi_{s=0}^{t}(1+r_s)} \left[(1-\tau_t)\pi_t - \psi_t(I_t, K_t) - (1-k_t-z_t)p_{I,t}I_t\right] + A_0, \tag{A.8}$$

where A_0 is the present value of depreciation deductions on past investments.[85] We assume r is fixed over time and that k equals zero, since the investment tax credit is not active during our sample frame. We isolate the terms where period t investment enters and rewrite the relevant part of the problem:

$$\max_I \left\{-\psi(I,K) - (1-z)p_I I + \frac{q_{t+1}I}{1+r}\right\}, \tag{A.9}$$

where q_{t+1} is the multiplier on the law of motion for capital.

We write the first order condition for investment as

$$q_{t+1} = (1+r)\left[\psi_I + (1-z)p_I\right], \tag{A.10}$$

which emphasizes that optimal investment equates the marginal product of capital, q_{t+1}, with the hurdle rate $(1+r)$ applied to the marginal costs of investment. These costs include adjustment costs and the price of investment less the value of investment as a tax shield. q_{t+1} is the marginal value of a unit of capital, which accumulates over many future periods. We can apply the envelope condition and differentiate $V_0(K_t) = \max_I V_0(K_t, I)$ to show that

$$q_t = \sum_{s=t}^{\infty} \frac{1}{\Pi_{v=t}^{s}(1+r_v+\delta)} \left[(1-\tau_s)\pi_{K,s} - \psi_{K,s}\right], \tag{A.11}$$

which says that q_t includes the present discounted value of future after-tax marginal products

[84] This formula is not exactly correct because additional periods will lead to additional accumulated losses for subsequent deductions. The firm will deduct these at an accelerated rate relative to the schedule in $z_t(1)$. This formulation simplifies the algebra and biases our empirical findings toward the neoclassical benchmark.

[85] The A_0 term is important for Hayashi (1982) because it influences the average value of the firm and one purpose of his study is to show when average Q and marginal q are equal. A_0 does not affect the investment decision problem.

for capital, accounting for the rate of economic depreciation.[86] In a two period model without adjustment costs, we could rewrite (A.10) as

$$r = \left(\frac{1-\tau}{1-z}\right)\frac{\pi_{K,t+1}}{p_I} - 1, \tag{A.12}$$

which shows that the general condition is just a dynamic statement of the simple idea that optimal investment should equate returns and the risk-adjusted discount rate.[87]

We augment the problem to introduce the possibility of imperfect capital markets, which leads to a generalized version of (A.10). Firms face a credit limit on gross borrowing, B_t, which accumulates according to

$$B_{t+1} = B_t + (1-\tau_t)\pi_t - (1-z_t)p_{I,t}I_t. \tag{A.13}$$

Firms must borrow to cover tax obligations and investment outlays, to the extent these exceed current cash flows. Note that z_t and not just $\tau\theta_t$ enters here. This is because future borrowing constraints also matter.

From Summers (1981) to Edgerton (2010), modern empirical studies of investment apply a parameterized version of (A.10), typically under the conditions shown in Hayashi (1982) to yield marginal q equal to average Q.[88] The financial constraint augmented first order condition is

$$q_{t+1} = (1+r)\left[\psi_I + (1+\lambda)(1-z)p_I\right], \tag{A.14}$$

where $\lambda \geq 0$ is the shadow price associated with the borrowing constraint (A.13).[89] The shadow price on the borrowing constraint works in this model much like a discount rate. To see this, note that without adjustment costs and in the one shot model we can rewrite (A.12) as

$$r + \lambda = \left(\frac{1-\tau}{1-z}\right)\frac{\pi_{K,t+1}}{p_I} - 1, \tag{A.15}$$

where we have assumed for illustration that $r\lambda$ is small. The hurdle rate for an investment

[86] Note that capital also has an effect on future adjustment costs.

[87] Also, note that with immediate expensing, $z = \tau$ and so taxes do not affect investment. This also holds in certain versions of the more general model. See Abel (1982).

[88] These assumptions include making firms price takers in all markets and linear homogeneity for production (i.e., constant returns to scale) and adjustment costs.

[89] The general version of (A.9) is $\max_I \left\{-\psi(I,K) - (1-z)p_I I + \frac{q_{t+1}I}{1+r} - \lambda(1-z)p_I I\right\}$.

project reflects both the discount rate and the borrowing spread. In our empirical analysis, we assume that firms use the same r but may differ in λ, in order to back out an implied λ spread between constrained and unconstrained firms.[90]

A.2 Testable Hypotheses

We can derive the three testable hypotheses outlined in Section 3. Each hypothesis results from defining optimal investment in (A.14) as a function of an exogenous parameter, a, and then implicitly differentiating. The general condition is

$$\psi_{II}\frac{\partial I}{\partial a}+\frac{\partial q}{\partial a}=(1+\lambda)p_I\frac{\partial z}{\partial a}, \tag{A.16}$$

where z includes nontaxable states and possibly myopia, as in (A.7) and q now satisfies the general version of (A.11):

$$q_t=\sum_{s=t}^{\infty}\frac{1}{\Pi_{v=t}^{s}(1+r_v+\delta)}\left[(1+\lambda_s)(1-\tau_s)\pi_{K,s}-\psi_{K,s}\right]. \tag{A.17}$$

The only difference between (A.11) and (A.17) is that increasing capital leads to higher future after-tax profits, which relax future credit constraints.

We consider comparative statics with respect to θ, z_t^0, λ, and γ. Except for λ, none of these terms directly affect q. They only affect q through investment's effect on future capital. We assume this latter effect is negligible. While nontrivial, this assumption is justified for two reasons. First, while the policies we study have a substantial temporary effect on investment, the change in investment is small relative to the existing capital stock. Thus, the long run marginal product of capital, which q measures, is likely unaffected.[91] The second reason is that nearly all empirical studies of investment incentives assume that production exhibits constant returns to scale and linear homogeneity in adjustment costs, which leads to constant q as a function of capital.[92]

[90] When thinking about the discount rates firms apply to depreciation tax shields, this assumption feels appropriate. In general, our estimated λ spread will also include discount rate differences.

[91] This is the assumption House and Shapiro (2008) make to replace short run approximations to capital and q with their steady state values. (See p. 740.)

[92] Bond and Van Reenen (2007) survey the investment literature and argue that "conclusive evidence that linear homogeneity should be abandoned in the investment literature has not yet been presented." This is because the assumption has both theoretical appeal and fits with evidence that changes in firm size are hard to predict (implying that firms do not have a sharp, optimal firm size).

Given the assumption that $\partial q/\partial\theta = 0$, our testable hypotheses build on the comparative static with respect to the bonus parameter θ:

$$\frac{\partial I}{\partial\theta} = \frac{(1+\lambda)p_I\left[\gamma(\tau - z_t^0(\beta)) + (1-\gamma)\beta\phi(\tau - z_t^0(1))\right]}{\psi_{II}} > 0. \tag{A.18}$$

Bonus depreciation increases the present value of deductions, reducing the price of investment. Thus bonus depreciation should increase investment. Alternatively, we could study the effect of a general increase in z. The comparative static here is

$$\frac{\partial I}{\partial z} = \frac{(1+\lambda)p_I}{\psi_{II}} > 0, \tag{A.19}$$

which yields a useful equivalence between the depreciation elasticity, the price elasticity and the interest rate elasticity. In particular, $\varepsilon_{I,1-z} = \varepsilon_{I,p_I} \leq \varepsilon_{I,1+\lambda}$, where $\varepsilon_{I,x} = (\partial I/\partial x)(x/I)$ and the last inequality reflects the fact that $\partial q/\partial\lambda \geq 0$. We begin our empirical analysis by estimating different versions of (A.19), enabling easier comparisons to past work.

Hypothesis one concerns the differential effect of bonus depreciation on long and short duration industries. Long duration industries will have more delayed baseline deduction schedules and hence lower z_t^0. The hypothesis thus derives from the cross partial of (A.18) with respect to z_t^0:

$$\frac{\partial^2 I}{\partial\theta\partial z_t^0} = -\frac{(1+\lambda)p_I\left[\gamma + (1-\gamma)\beta\phi\right]}{\psi_{II}} < 0. \tag{A.20}$$

Bonus results in relatively more acceleration for long lived items and so the investment response should be greater for these items. Note this is *not* a statement about the relative price elasticities for goods of different durations, which depend on the curvature of production and adjustment cost functions. Rather, it is a statement that bonus mechanically leads to larger price reductions for long duration items, even holding underlying technologies constant.

Hypothesis two concerns the differential effect of bonus depreciation for constrained and unconstrained firms. This depends on the cross partial of (A.18) with respect to λ:

$$\frac{\partial^2 I}{\partial\theta\partial\lambda} = \frac{\gamma(\tau - z_t^0(\beta)) + (1-\gamma)\beta\phi(\tau - z_t^0(1))}{\psi_{II}}p_I > 0. \tag{A.21}$$

For constrained firms (i.e., when $\lambda > 0$), bonus both reduces the price of investment goods and relaxes the borrowing constraint.This is true even if the investment-cash flow sensitivity is zero, that is, if cash flow does not affect the marginal external finance cost, λ. The logic is similar to the foregoing logic about long versus short duration goods. The effective price cut due to bonus is larger for constrained firms, even if the cost of borrowing does not change. Under fairly general conditions therefore, credit constraints tend to amplify the effects of bonus.

Hypothesis three concerns the differential effect of bonus by taxable status. We can compare the elasticities for γ equal to zero and γ equal to one:

$$\left.\frac{\partial I}{\partial \theta}\right|_{\gamma=1} - \left.\frac{\partial I}{\partial \theta}\right|_{\gamma=0} = (1+\lambda)p_I \frac{(\tau - z_t^0(\beta)) - \beta\phi(\tau - z_t^0(1))}{\psi_{II}} > 0 \tag{A.22}$$

Because nontaxable firms must wait to take bonus deductions, bonus is less valuable to them. This might be due to neoclassical reasons. Namely, taking into account a possibly long delay and applying a reasonable discount rate might lead the response for nontaxable firms to be quite low, even without myopia (i.e., with $\beta = 1$). We use the empirical distribution of loss transition probabilities to calibrate ϕ in the model and ask whether the results still require $\beta < 1$.

A.3 Empirical Moments for Calibration

We perform a calibration exercise to distinguish between models, based on their predictions about the external finance wedge, λ, and the discount rate applied to future flows, β. This exercise requires comparing estimates across subgroups. For this comparison to be useful, we need to make certain homogeneity assumptions about technologies across these groups. In particular, we want the curvature of adjustment costs to be equal across groups.

One way to satisfy this requirement is to make second derivatives effectively constant across groups. We make a weaker assumption, based on the common quadratic form used elsewhere in the literature. One feature of relying on this assumption is that nearly all other empirical studies of investment do so as well. Specifically, we write the adjustment cost function as

$$\psi(I,K) = \frac{\alpha}{2}\left[\log(I) - \log(\delta K)\right]^2 p_I I, \tag{A.23}$$

so that adjustment costs are increasing quadratically as investment deviates from the replacement rate. As long as α is constant and average investment equals δK across groups, then the following results will hold.[93]

The first empirical moment we use compares the estimated response with respect to bonus for constrained and unconstrained firms. Define the semi-elasticity of investment with respect to θ as $\varepsilon_{I,\theta} \equiv (\partial I/\partial\theta)(1/I)$, where $\partial I/\partial\theta$ is defined in (A.18). Assuming constrained firms face shadow price λ_C and unconstrained firms face shadow price λ_U, we take the ratio of semi-elasticities:

$$\frac{\varepsilon^C_{I,\theta}}{\varepsilon^U_{I,\theta}} \equiv m_1 = \frac{1+\lambda_C}{1+\lambda_U} = 1 + \frac{\Delta\lambda}{1+\lambda_U}. \tag{A.24}$$

We estimate m_1 and solve (A.24) for $\Delta\lambda/(1+\lambda_U)$, which can be viewed as an implied credit spread. Our empirical analysis estimates the semi-elasticity with respect to z, rather than θ. Because z is linear in θ (see (A.6)), the ratio of z semi-elasticities equals the ratio of θ semi-elasticities.

We define a second empirical moment analogously by comparing taxable and nontaxable firms:

$$\frac{\varepsilon^{\gamma=0}_{I,\theta}}{\varepsilon^{\gamma=1}_{I,\theta}} \equiv m_2 = \beta\phi\frac{\tau - z^0_t(1)}{\tau - z^0_t(\beta)} \tag{A.25}$$

Note the external finance wedge falls out of this expression. This is true as long as average shadow costs are the same across taxable and nontaxable groups.[94] Under a constant τ assumption, we can drop tax rates from this formula, which we do in Section 7. We estimate m_2 and calibrate ϕ in order to estimate β.

B Legislative Background

This appendix describes legislation affecting the bonus and Section 179 depreciation provisions studied in this paper.

Economic Recovery Tax Act of 1981

The act set the Section 179 allowance at $5,000 and established a timetable for gradually increasing the allowance to $10,000 by 1986. Few firms took advantage of the allowance

[93] With our functional form for adjustment costs, we have $I\psi_{II} = \alpha p_I(1+\log(I/\delta K))$, which is equal across groups under these assumptions.

[94] We can relax this assumption, since we expect nontaxable firms to be more constrained on average. Alternatively, we can narrow our taxable/nontaxable comparison to groups that differ only by how likely it is for the next dollar of investment to affect this year's taxes. We pursue this latter approach and use the stock of alternative tax shields to sort firms.

initially. Some attributed the low response to limitations on the use of the investment tax credit. A business taxpayer could claim the credit only for the portion of an eligible asset's cost that was not expensed; so the full credit could be used only if the company claimed no expensing allowance. For many firms, the tax savings from the credit alone outweighed the tax savings from combining the credit with the allowance.[95]

Depreciation Policies Affected – Section 179

Date Signed – August 13, 1981

Bill Number – H.R. 4242

Deficit Reduction Act of 1984

The act postponed from 1986 to 1990 the scheduled increase in the Section 179 allowance to $10,000. Use of the allowance rose markedly following the repeal of the investment tax credit by the Tax Reform Act of 1986.

Depreciation Policies Affected – Section 179

Date Signed – July 18, 1984

Bill Number – H.R. 4170

Omnibus Budget Reconciliation Act of 1993

The act increased the Section 179 allowance from $10,000 to $17,500, as of January 1, 1993.

Depreciation Policies Affected – Section 179

Date Introduced – May 25, 1993

Date of First Passage Vote – May 27, 1993

Date Signed – August 10, 1993

Bill Number – H.R. 2264

Small Business Job Protection Act of 1996

The act increased the Section 179 allowance and established scheduled annual (with one exception) increases over six years. Specifically, the act raised the maximum allowance to $18,000 in 1997, $18,500 in 1998, $19,000 in 1999, $20,000 in 2000, $24,000 in 2001 and 2002, and $25,000 in 2003 and thereafter.

Depreciation Policies Affected – Section 179

[95] Source: http://www.section179.org/stimulus_acts.html

Date Introduced – May 14, 1996

Date of First Passage Vote – May 22, 1996

Date Signed – August 20, 1996

Bill Number – H.R. 3448

Job Creation and Worker Assistance Act of 2002

The act created the first bonus depreciation allowance, equal to 30 percent of the adjusted basis of new qualified property acquired after September 11, 2001, and placed in service no later than December 31, 2004. A one-year extension of the placed-in-service deadline was available for certain property with a MACRS recovery period of 10 or more years and for transportation equipment.

Depreciation Policies Affected – Bonus Depreciation

Date Introduced – October 11, 2001

Date of First Passage Vote – October 24, 2001

Date Signed – March 9, 2002

Bill Number – H.R. 3090

Jobs and Growth Tax Relief Reconciliation Act of 2003

The act (JGTRRA) raised the bonus allowance to 50 percent for qualified property acquired after May 5, 2003, and placed in service before January 1, 2005. The act raised the Section 179 allowance to $100,000 (as of May 6, 2003), set it to stay at that amount in 2004 and 2005, and then reset in 2006 and beyond at its level before JGTRRA ($25,000). JGTRRA also raised the phase out threshold to $400,000 from May 2003 to the end of 2005, indexed the regular allowance and the threshold for inflation in 2004 and 2005, and added off-the-shelf software for business use to the list of depreciable assets eligible for expensing in the same period.

The American Jobs Creation Act of 2004 extended the Section 179 changes made by JGTRRA through the end of 2007. The Tax Increase Prevention and Reconciliation Act of 2005 extended the changes in the allowance under JGTRRA through 2009.

Depreciation Policies Affected – Bonus Depreciation and Section 179

Date Introduced – February 27, 2003

Date of First Passage Vote – May 9, 2003

Date Signed – May 28, 2003

Bill Number – H.R. 2

U.S. Troop Readiness, Veterans' Care, Katrina Recovery, and Iraq Appropriations Act of 2007

Congress extended the changes in the allowance made by JGTRRA through 2010, raised the maximum allowance to $125,000 and the phaseout threshold to $500,000 for 2007 to 2010, and indexed both amounts for inflation in that period.

Depreciation Policies Affected – Section 179

Date Introduced – May 8, 2007

Date of First Passage Vote – May 10, 2007

Date Signed – May 25, 2007

Bill Number – H.R. 2206

Economic Stimulus Act of 2008

The act provided for 50 percent bonus depreciation. To claim the allowance, a taxpayer had to acquire qualified property after December 31, 2007 and place it in service before January 1, 2009. The previous $125,000 limit on the Section 179 allowance was increased to $250,000, and the $500,000 limit on the total amount of equipment purchased became $800,000.

Depreciation Policies Affected – Bonus Depreciation and Section 179

Date Introduced – January 28, 2008

Date of First Passage Vote – January 29, 2008

Date Signed – February 13, 2008

Bill Number – H.R. 5140

American Recovery and Reinvestment Act of 2009

The act extended the deadlines by one year, to the end of 2009, for the 50 percent bonus depreciation allowance.

Depreciation Policies Affected – Bonus Depreciation

Date Introduced – January 26, 2009

Date of First Passage Vote – January 28, 2009

Date Signed – February 17, 2009

Bill Number – H.R. 1

Small Business Jobs Act of 2010

The act extended the 50 percent bonus depreciation to qualifying property purchased and placed in service during the 2010 tax year. The act increased the amount a business could expense under Section 179 from $250,000 to $500,000 of qualified capital expenditures. These deductions were subject to a phase-out for expenditures exceeding $2,000,000. The provision covered tax years for 2010 and 2011.

Depreciation Policies Affected – Bonus Depreciation and Section 179

Date Introduced – May 13, 2010

Date of First Passage Vote – June 17, 2010

Date Signed – September 27, 2010

Bill Number – H.R. 5297

Tax Relief, Unemployment Compensation Reauthorization, and Job Creation Act of 2010

The bonus depreciation allowance increased to 100 percent for qualified property acquired after September 8, 2010, and placed in service before January 1, 2012. The act also established a 50 percent allowance for property acquired and placed in service in 2012.

Depreciation Policies Affected – Bonus Depreciation

Date Introduced – March 16, 2010

Date Signed – September 27, 2010

Bill Number – H.R. 5297

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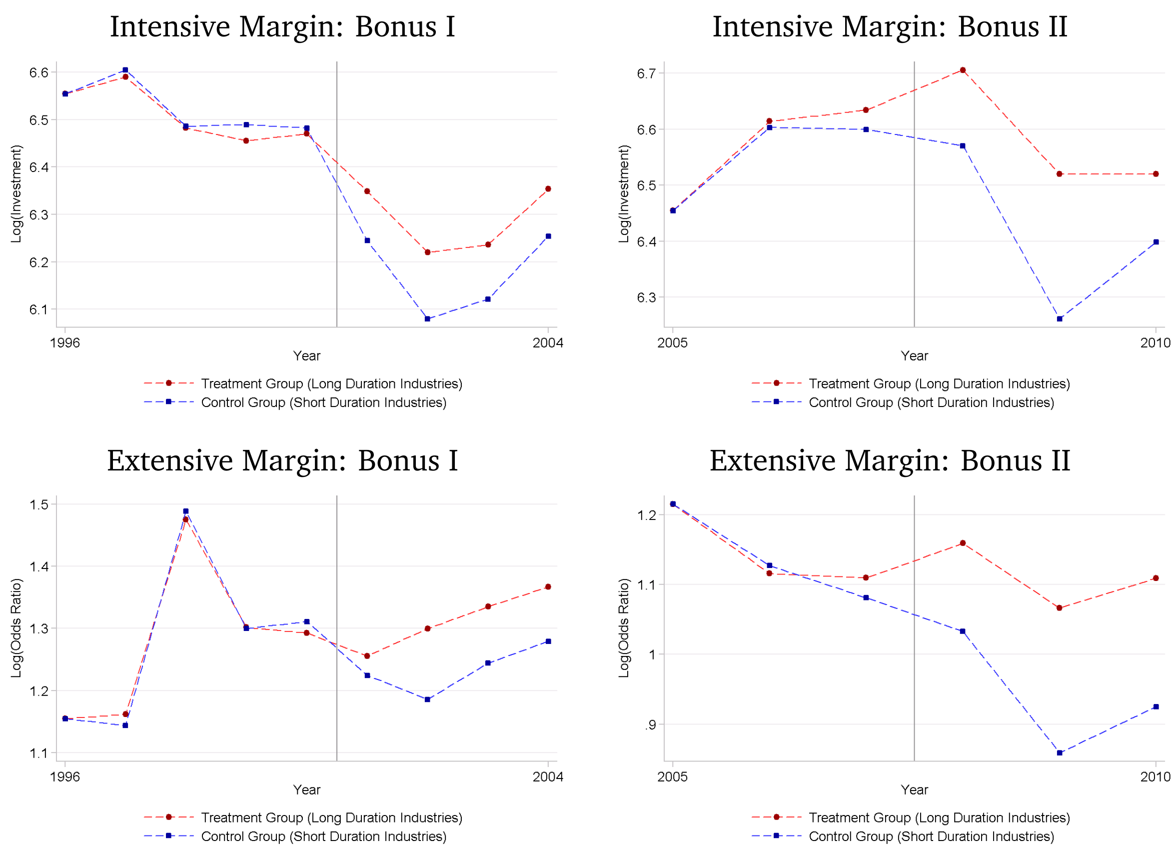
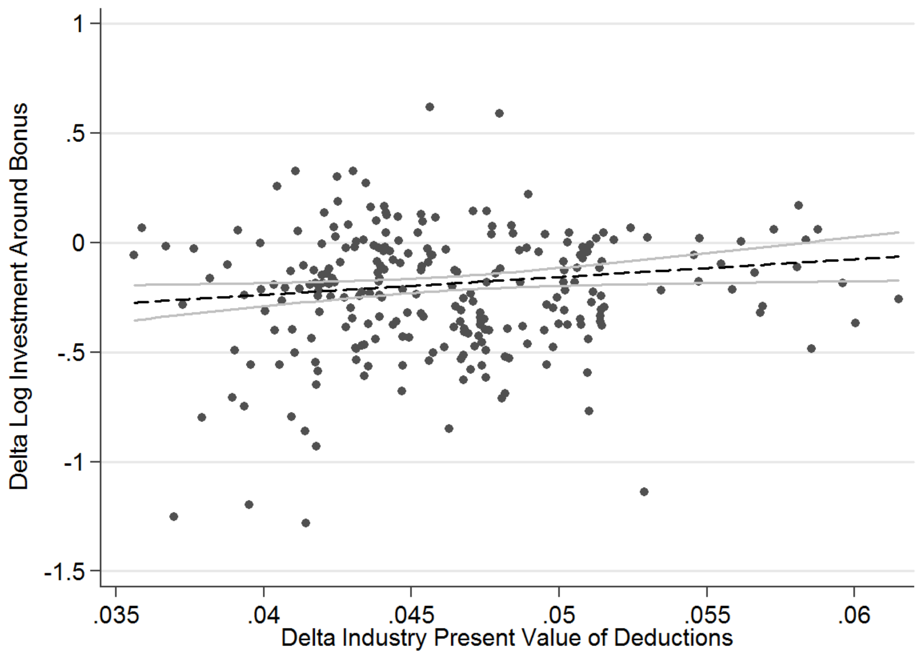
Figure 1: Calendar Difference-in-Differences



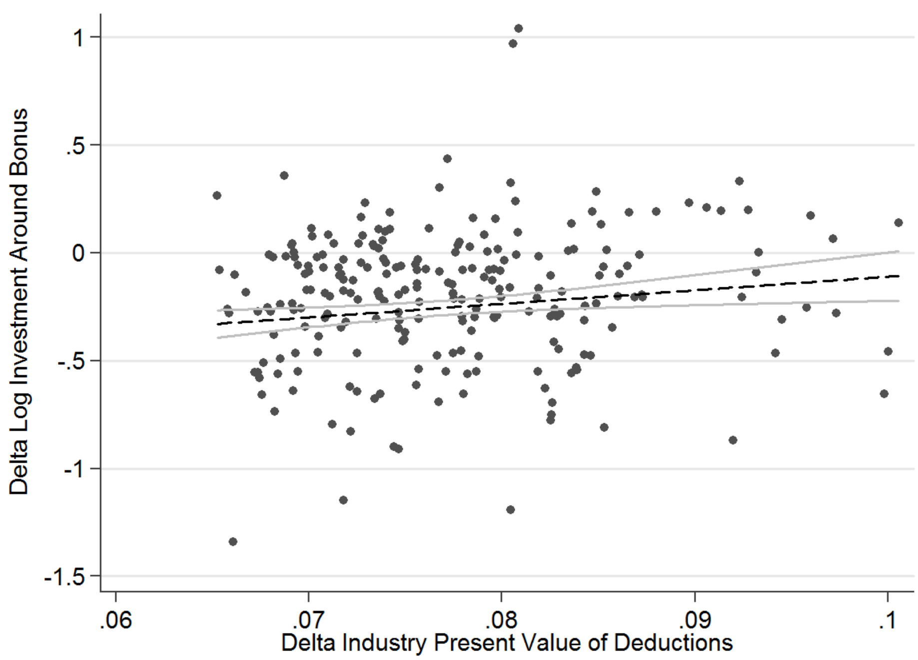
Notes: Panel (a) plots the average logarithm of eligible investment over time for groups sorted according to their industry-based treatment intensity. Treatment intensity depends on the average duration of investment, with long duration industries (treatment groups) seeing a larger average price cut due to bonus than short duration industries (control groups). Panel (b) plots the industry-level log odds ratio for the probability of positive eligible investment, thus offering a measure of the extensive margin response. The treatment years for Bonus I are 2001 through 2004 and 2008 through 2010 for Bonus II. In these years, the difference between changes in the red and the blue lines provides a difference-in-differences estimator for the effect of bonus in that year for those groups. The earlier years provide placebo tests and a demonstration of parallel trends. The averages plotted here result from a two-step regression procedure. First, we nonparametrically reweight the group-by-year distribution (i.e., Dinardo, Fortin, and Lemieux (1996) reweight) within ten size bins based on assets crossed with ten size bins based on sales to address sampling frame changes over time. Second, we run cross sectional regressions each year of the outcome variable on an indicator for treatment group and a rich set of controls, including ten-piece splines in assets, sales, profit margin and age. We plot the residual group means from these regressions. To align the first year of each series and ease comparison of trends, we subtract from each dot the group mean in the first year and add back the pooled mean from the first year. All means are count weighted.

Figure 2: Grouped Difference-in-Differences

(a) Bonus I: 2001-2004 vs. 1997-2000

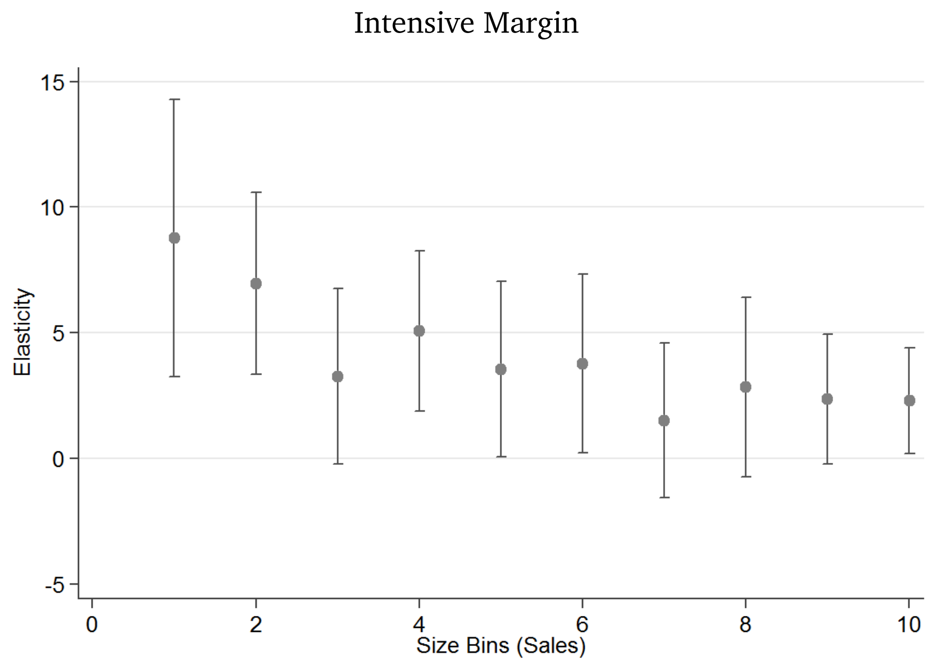


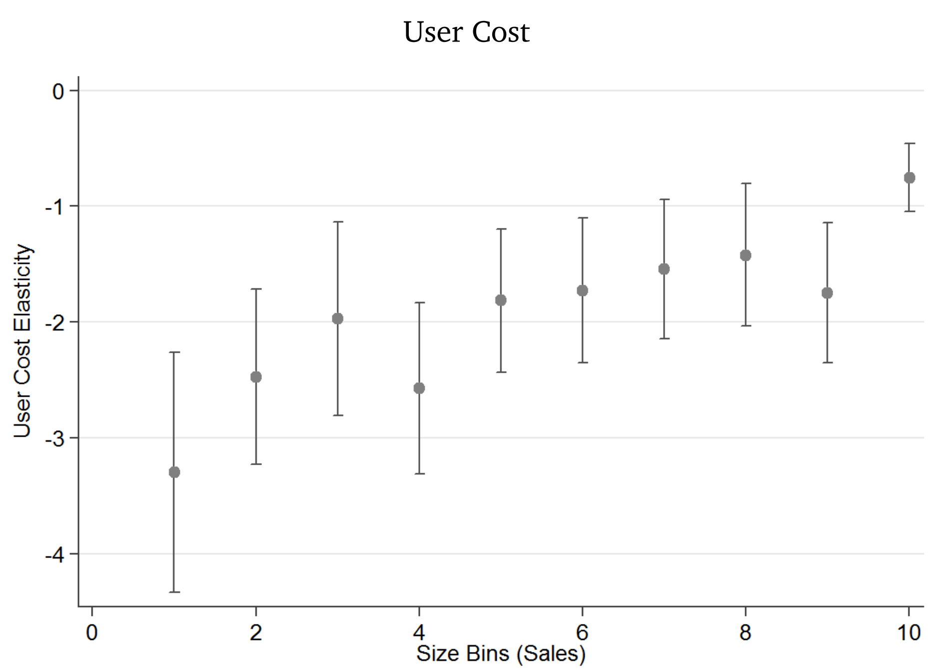
(b) Bonus II: 2008-2010 vs. 2005-2007



Notes: These figures display the effect of bonus depreciation on industry-level investment for two episodes of bonus. For each four digit NAICS industry, we plot mean growth rates in eligible investment between bonus years and pre-bonus years. The x-axis matches these growth rates to average predicted changes due to bonus in the present value of depreciation deductions (Δz) at the industry level. The slope of these lines yields the average reduced form effect of bonus on eligible investment.

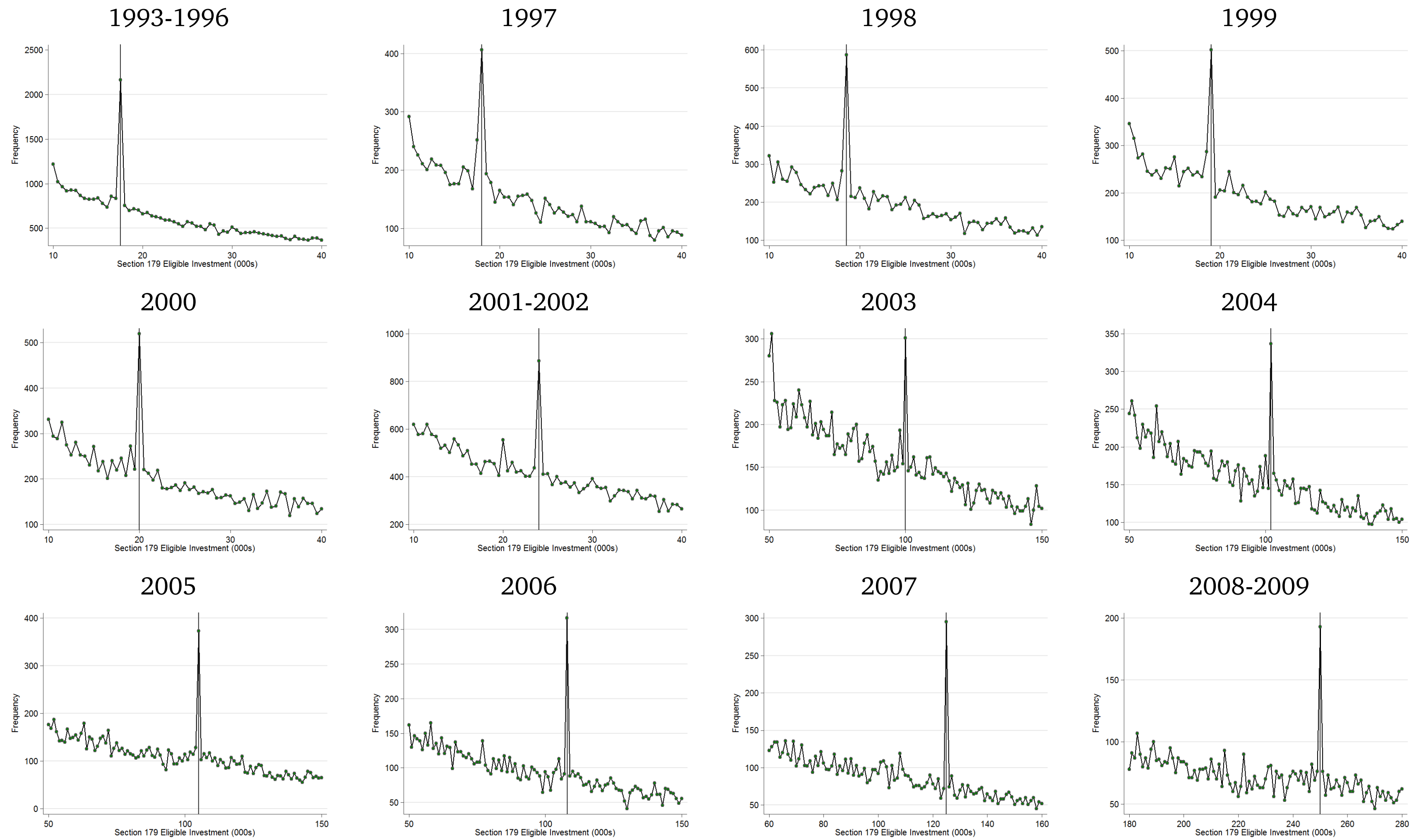
Figure 3: Heterogeneous Effects by Firm Size





Notes: These figures plot coefficients and confidence bands from the baseline intensive margin and user cost specifications presented in table 4. We split the sample into deciles based on mean pre-policy sales. The average firm in Compustat during this time period falls in the tenth size bin (with sales equal to $1.8B), which coincides with the Hassett and Hubbard (2002) survey range of user cost elasticity estimates (-0.5 to -1).

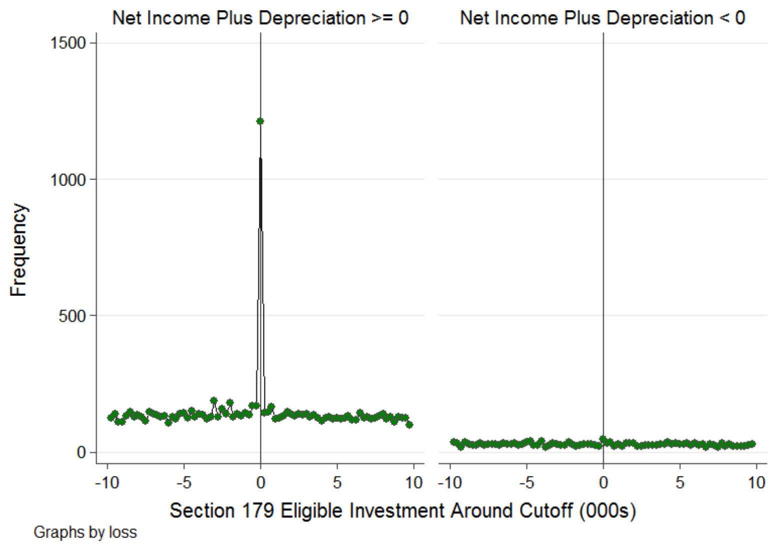
Figure 4: Depreciation Schedule Salience



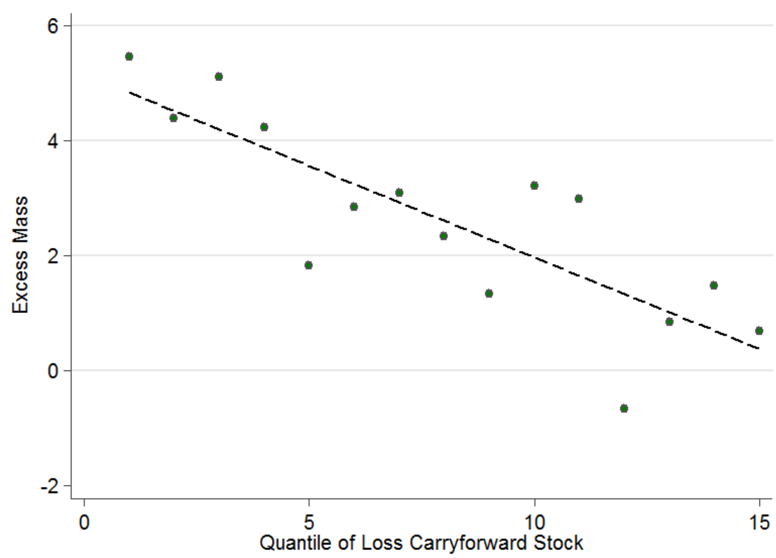
Notes: These figures illustrate the salience of complex nonlinearities in the depreciation schedule. They show sharp bunching of Section 179 eligible investment around the depreciation schedule kink from 1993 through 2009. Each plot is a histogram of eligible investment in our sample in the region of the maximum deduction for a year or group of years. Each dot represents the number of firms in a $250-bin. The vertical lines correspond to the kink point for that year or group of years. Bunching behavior by geography serves as a proxy for tax code sophistication.

Figure 5: Bunching Behavior and Tax Incentives

(a) By Current Year Tax Status



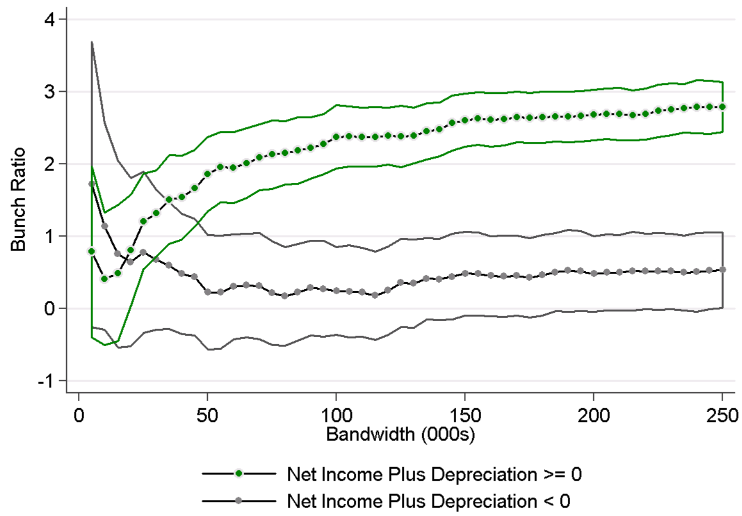
(b) By Lagged Loss Carryforward Stock



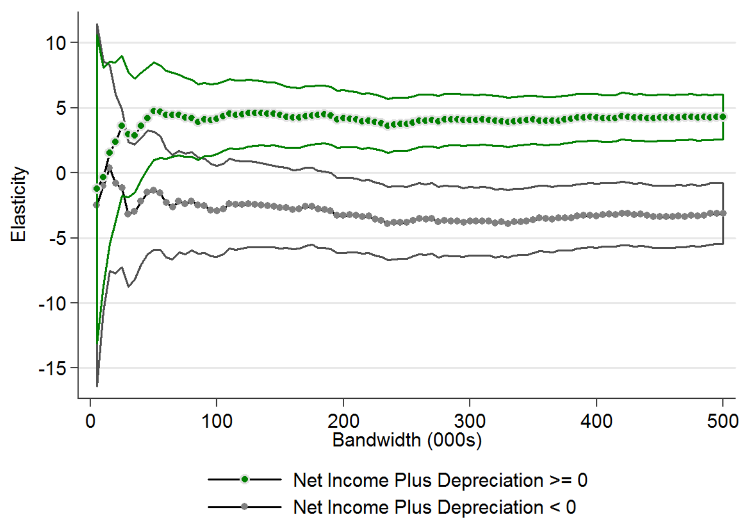
Notes: These figures illustrate how bunching behavior responds to tax incentives. Firms bunch less when eligible investment provides less cash back now. Panel (a) splits the sample based on whether firm net income before depreciation is greater than or less than zero. Firms with net income before depreciation less than zero can carry back or forward deductions from eligible investment but have no more current taxable income to shield. Panel (b) groups firms with current year taxable income based on the size of their prior loss carryforward stocks. The x-axis measures increasing loss carryforward stocks relative to current year income. The y-axis measures the excess mass at the kink point for that group. Firms with more alternative tax shields find investment a less useful tax shield and therefore bunch less.

Figure 6: Investment Behavior and Tax Incentives: Narrow Bandwidth

(a) Bunching with Narrow Bandwidth



(b) Bonus with Narrow Bandwidth



Notes: These figures replicate the taxable position splits in the bunch and bonus settings, while restricting the sample to within a narrow bandwidth of the tax status threshold. Panel (a) replicates the analysis in panel (a) of Figure 5, which compares bunching behavior for taxable and nontaxable firms. Panel (b) replicates the regression in column (1) of table 7, which estimates separate coefficients with respect to bonus incentives for taxable and nontaxable firms.

Table 3: Statistics: Bonus Analyses

	Mean	P10	Median	P90	Count
Investment Variables					
Investment (000s)	6,786.87	0.81	367.59	5,900.17	818,576
log(Investment)	6.27	4.10	6.14	8.81	735,341
Investment/Lagged Capital Stock	0.10	0.00	0.05	0.27	637,243
Δ log(Capital Stock)	0.08	-0.05	0.05	0.33	637,278
log(Odds Ratio$_N$)	1.28	0.54	1.34	2.05	818,107
Other Outcome Variables					
Δ log(Debt)	0.04	-0.37	0.03	0.56	642,546
Δ log(Rent)	0.08	-0.38	0.04	0.66	574,305
Δ log(Wage Compensation)	0.06	-0.21	0.05	0.40	624,918
log(Structures Investment)	5.02	2.13	4.98	8.10	389,232
Policy Variables					
$z_{N,t}$	0.90	0.87	0.89	0.94	818,576
Characteristics					
Assets (000s)	403,597.2	3,267.96	24,274.82	327,301.6	818,576
Sales (000s)	180,423.8	834.65	25,920.92	234,076.1	818,576
Capital Stock (000s)	89,977.09	932.00	7,214.53	80,122.69	818,576
Net Income Before Depreciation (000s)	15,392.59	-2,397.92	1,474.65	17,174.55	818,576
Profit Margin	0.17	-0.07	0.05	0.68	777,968
Wage Compensation (000s)	26,826.36	372.09	4,199.88	38,526.46	818,576
Cash Flow/Lagged Capital Stock	0.05	-0.09	0.03	0.26	647,617

Notes: This table presents summary statistics for analysis of bonus depreciation. To preserve taxpayer anonymity, "percentiles" are presented as means of all observations in the $(P-1, P+1)$th percentiles. Investment is bonus eligible equipment investment. $z_{N,t}$ is the weighted present value for a dollar of eligible investment expense at the four-digit NAICS level, with weights computed using shares of investment in each eligible category. The odds ratio is defined at the four-digit NAICS level as the fraction of firms with positive investment divided by the fraction with zero investment. Cash flow is net income before depreciation after taxes paid. Ratios are censored at the one percent level.

Table 4: Investment Response to Bonus Depreciation

	Intensive Margin: LHS Variable is log(Investment)					
	(1)	(2)	(3)	(4)	(5)	(6)
$z_{N,t}$	3.69***	3.78***	3.07***	3.02***	3.73***	4.69***
	(0.53)	(0.57)	(0.69)	(0.81)	(0.70)	(0.62)
$CF_{it}/K_{i,t-1}$		0.44***				
		(0.016)				
Observations	735341	580422	514035	221306	585914	722262
Clusters (Firms)	128001	100883	109678	63699	107985	124962
R^2	0.71	0.74	0.73	0.80	0.72	0.71
	Extensive Margin: LHS Variable is log(P(Investment > 0))					
	(1)	(2)	(3)	(4)	(5)	(6)
$z_{N,t}$	3.79**	3.87**	3.12	3.59**	3.99*	4.00***
	(1.24)	(1.21)	(2.00)	(1.14)	(1.69)	(1.13)
$CF_{it}/K_{i,t-1}$		0.029**				
		(0.0100)				
Observations	803659	641173	556011	247648	643913	803659
Clusters (Industries)	314	314	314	274	277	314
R^2	0.87	0.88	0.88	0.93	0.90	0.90
	User Cost: LHS Variable is Investment/Lagged Capital					
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{1-t_c z}{1-t_c}$	-1.60***	-1.53***	-2.00***	-1.42***	-2.27***	-1.50***
	(0.096)	(0.095)	(0.16)	(0.13)	(0.14)	(0.10)
$CF_{it}/K_{i,t-1}$		0.043***				
		(0.0023)				
Observations	637243	633598	426214	211029	510653	631295
Clusters (Firms)	103890	103220	87939	57343	90145	103565
R^2	0.43	0.43	0.48	0.54	0.45	0.44
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	No
Industry Trends	No	No	No	No	No	Yes

Notes: This table estimates regressions of the form

$$f(I_{it}, K_{i,t-1}) = \alpha_i + \beta g(z_{N,t}) + \gamma X_{it} + \delta_t + \varepsilon_{it}$$

where I_{it} is eligible investment expense and $z_{N,t}$ is the present value of a dollar of eligible investment computed at the four-digit NAICS industry level, taking into account periods of bonus depreciation. Regression (2) augments the baseline specification with current period cash flow scaled by lagged capital. Column (3) focuses on the early bonus period and column (4) focuses on the later period. Column (5) controls for four-digit industry average Q for public companies and quartics in assets, revenues, profit margin and firm age. Column (6) includes quadratic time trends interacted with two-digit NAICS industry dummies. Ratios are censored at the one percent level. Standard errors clustered at the firm level are in parentheses.

Table 5: Investment Response to Bonus Depreciation: Robustness

	Structures		Net Investment		Has Bonus		Salience Split	
	Basic	Trends	Basic	Trends	Basic	Trends	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$z_{N,t}$	0.52	1.10	1.07***	0.78***	0.95***	1.15***	5.09***	1.56
	(0.78)	(0.98)	(0.23)	(0.22)	(0.13)	(0.16)	(0.87)	(0.94)
Observations	389232	381921	637278	631680	818576	804128	211390	215205
Clusters (Firms)	92351	90166	103447	103147	128150	125534	29627	30836
R^2	0.59	0.60	0.27	0.27	0.61	0.61	0.70	0.70
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Trends	No	Yes	No	Yes	No	Yes	No	No

Notes: This table estimates regressions of the form

$$Y_{it} = \alpha_i + \beta z_{N,t} + \delta_t + \varepsilon_{it}$$

where Y_{it} is either the logarithm of structures investment (columns (1) and (2)), log growth in capital stock (columns (3) and (4)), an indicator for take-up of bonus depreciation ((5) and (6)), or the logarithm of eligible investment ((7) and (8)). $z_{N,t}$ is the present value of a dollar of eligible investment computed at the four-digit NAICS industry level, taking into account periods of bonus depreciation. Columns (1), (3), (5), (7) and (8) implement the baseline specification in table 4. Columns (2), (4) and (6) include quadratic time trends interacted with two-digit NAICS industry dummies. Columns (7) and (8) split the sample into the top and bottom three deciles according to local geographic salience of the depreciation schedule. We proxy for local salience using frequency of bunching by small firms at the Section 179 kink point in the depreciation schedule. Standard errors clustered at the firm level are in parentheses.

Table 6: Heterogeneity by Ex Ante Constraints

	Sales		Div Payer?		Lagged Cash	
	Small	Big	No	Yes	Low	High
$z_{N,t}$	6.29***	3.22***	5.98***	3.67***	7.21***	2.76**
	(1.21)	(0.76)	(0.88)	(0.97)	(1.38)	(0.88)
Equality Test	$P = .030$		$P = .079$		$P = .000$	
Observations	177620	255266	274809	127523	176893	180933
Clusters (Firms)	29618	29637	39195	12543	45824	48936
R^2	0.44	0.76	0.69	0.80	0.81	0.76
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table estimates regressions from the baseline intensive margin specification presented in Table 4. Here, we split the sample based on pre-policy markers of financial constraints. For the size splits, we divide the sample into deciles based on the mean value of revenues, with the mean taken over years 1998 through 2000.Small firms fall into the bottom three deciles and big firms fall into the top three deciles. For the dividend payer split, we divide the sample based on whether the firm paid a dividend in any of the three years from 1998 through 2000. The dividend split only includes C corporations. The lagged cash split is based on lagged residuals from a regression of liquid assets on a ten piece spline in total assets and fixed effects for four-digit industry, year and corporate form. The comparison is between the top three and bottom three deciles of these lagged residuals. Standard errors clustered at the firm level are in parentheses.

Table 7: Heterogeneity by Tax Position

	LHS Variable is Log(Investment)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Taxable $\times z_{N,t}$	3.83***	3.08***	1.95*	6.43***	4.32***	4.15***	
	(0.79)	(0.93)	(0.92)	(1.46)	(0.96)	(0.82)	
$z_{N,t}$	-0.15	0.60	0.38	-3.03*	-0.69	0.88	5.68***
	(0.90)	(1.05)	(1.06)	(1.55)	(1.15)	(0.94)	(1.70)
Medium LCF $\times z_{N,t}$							-2.56
							(1.46)
High LCF $\times z_{N,t}$							-3.70*
							(1.55)
$CF_{it}/K_{i,t-1}$		0.14***					
		(0.028)					
Taxable $\times CF_{it}/K_{i,t-1}$		0.27***					
		(0.035)					
Observations	735341	580422	514035	221306	585914	722262	119628
Clusters (Firms)	128001	100883	109678	63699	107985	124962	40282
R^2	0.71	0.74	0.74	0.80	0.73	0.72	0.84
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	No	No
Industry Trends	No	No	No	No	No	Yes	No

Notes: This table estimates regressions from each intensive margin in columns (1) through (6) specification presented in Table 4. For each firm year, we generate an indicator based on whether a firm is in taxable position prior to depreciation expense. We fully interact this indicator with all controls and the time effects. Column (7) splits taxable firms into three groups based on the size of their lagged loss carryforward stocks relative to net income before depreciation. We interact these group indicators with $z_{N,t}$ and the time effects. Only firms with nonzero stocks of lagged loss carryforwards are included. Standard errors clustered at the firm level are in parentheses.

Table 8: Substitution Margins and External Finance

	Dependent Variable					
	ΔRents	ΔPayroll	ΔDebt	Dividends	Payer?	Investment
	(1)	(2)	(3)	(4)	(5)	(6)
$z_{N,t}$	0.75**	1.49***	1.84***	-2.14***	-0.36***	4.22***
	(0.26)	(0.20)	(0.21)	(0.54)	(0.089)	(0.62)
$z_{N,t-2}$						-0.86
						(0.69)
Observations	574305	624918	642546	133161	818576	476734
Clusters (Firms)	98443	102043	103868	28891	128150	84777
R^2	0.18	0.23	0.20	0.90	0.68	0.76
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table estimates regressions of the form

$$X_{it} = \alpha_i + \beta z_{N,t} + X_{it} + \delta_t + \varepsilon_{it}$$

where X_{it} equals the difference in the logarithm of the dependent variable in columns (1) through (3). In columns (4) and (5), the dependent variable is the logarithm of dividends paid or an indicator for positive dividend payments. $z_{N,t}$ is the present value of a dollar of eligible investment computed at the four-digit NAICS industry level, taking into account periods of bonus depreciation. Column (6) includes contemporaneous and twice lagged $z_{N,t}$. Standard errors clustered at the firm level are in parentheses.

Table A.1: Section 179 and Bonus Depreciation Policy Changes

Year	S179 Max Value	S179 Phase-out Region	Bonus
1993-96	$17,500	$200,000-$217,500	
1997	$18,000	$200,000-$218,000	
1998	$18,500	$200,000-$218,500	
1999	$19,000	$200,000-$219,000	
2000	$20,000	$200,000-$220,000	
2001-02	$24,000	$200,000-$224,000	30% Tax years ending after 9/10/01
2003	$100,000	$400,000-$500,000	50% Tax years ending after 5/3/03
2004	$102,000	$410,000-$512,000	50%
2005	$105,000	$420,000-$525,000	
2006	$108,000	$430,000-$538,000	
2007	$125,000	$500,000-$625,000	
2008-09	$250,000	$800,000-$1,050,000	50% Tax years ending after 12/31/07
2010-11	$500,000	$2,000,000-$2,500,000	100% Tax years ending after 9/8/10

a. 2008 was retroactive.

Table A.2: Past User Cost Estimates

paper	equation	β_1(SE)	estimation details	data	table / page cite
Cummins, Hassett, and Hubbard (1994)	$\frac{I}{K} = \beta_0 + \beta_1 Q$	0.083(0.006)	first-differences; firm and year FEs; robust SE; all-years	US public firm panel (Compustat), 1953-88	Table 4 (OLS, all years) / p. 28
		0.554(0.165)	first-differences; robust SE; 1962 (major tax reform)	US public firm panel (Compustat), 1953-88	Table 4 (OLS, 1962) / p. 28
		0.198(0.067)	first-differences; robust SE; 1972 (major tax reform)	US public firm panel (Compustat), 1953-88	Table 4 (OLS, 1972) / p. 28
		0.299(0.091)	first-differences; robust SE; 1981 (major tax reform)	US public firm panel (Compustat), 1953-88	Table 4 (OLS, 1981) / p. 28
		0.178(0.083)	first-differences; robust SE; 1986 (major tax reform)	US public firm panel (Compustat), 1953-88	Table 4 (OLS, 1986) / p. 28
Cummins, Hasset, and Hubbard (1996)	$\frac{I}{K} = \beta_0 + \beta_1 Q$	0.647(0.238)	difference observed and forecasted variables; forecasting based on lagged $\frac{I}{K}$, lagged $\frac{CF}{K}$, time-trend, and firm FE; robust SE; AUS 1988	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (AUS 1988, top) / p. 254
		1.626(0.520)	same as above; BEL 1990	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (BEL 1990, top) / p. 254
		0.810(0.216)	same as above; CAN 1988	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (CAN 1988, top) / p. 254
		0.867(0.458)	same as above; DNK 1988	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (DNK 1990, top) / p. 254
		0.756(0.286)	same as above; FRA 1990	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (FRA 1990, top) / p. 254

		0.938(0.242)	same as above; GER 1990	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (GER 1990, top) / p. 254
		0.663(0.237)	same as above; ITA 1992	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (ITA 1992, top) / p. 254
		0.893(0.219)	same as above; JPN 1989	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (JPN 1989, top) / p. 254
		0.423(0.340)	same as above; NLD 1989	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (NLD 1989, top) / p. 254
		1.373(0.528)	same as above; NOR 1992	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (NOR 1992, top) / p. 254
		1.485(1.378)	same as above; SPN 1989	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (SPN 1989, top) / p. 254
		0.641(0.241)	same as above; SWE 1990	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (SWE 1990, top) / p. 254
		0.644(0.198)	same as above; UK 1991	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (UK 1991, top) / p. 254
		0.603(0.086)	same as above; USA 1987	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (USA 1987, top) / p. 254
Desai and Goolsbee (2004)	$\frac{I}{K} = \beta_0 + \beta_1 \frac{1-\tau z-ITC}{1-\tau} + \beta_2 \frac{q}{1-\tau} + \beta_2 \frac{CF}{K}$	-0.8895(0.3173)	year and firm FEs; SE clustered at firm-level	U.S. public firm panel (Computstat), 1962-03	Table 8 (baseline) / p. 314
Edgerton (2010)	$\frac{I}{K} = \beta_0 + \beta_1 \frac{1-\tau z-ITC}{1-\tau} + \beta_2 \frac{q}{1-\tau}$	-0.846(0.323)	year and firm FEs; SE clustered at firm-level; includes dummy and interaction for non-taxable firms	US public firm panel (Computstat), 1967-05	Table 3 (2) / p. 945