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

Eric Zwick
University of Chicago
Booth School of Business
ezwick@chicagobooth.edu

James Mahon
Harvard University
jmahon@fas.harvard.edu

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Abstract

We estimate the effect of temporary tax incentives on equipment investment using shifts in accelerated depreciation. Analyzing data for over 120,000 firms, we present three findings. First, bonus depreciation raised investment 17.3 percent on average between 2001 and 2004 and 29.5 percent between 2008 and 2010. Second, financially constrained firms respond more than unconstrained firms. Third, firms respond strongly when the policy generates immediate cash flows but not when benefits only come in the future. Implied discount rates are too high to match a frictionless model and cannot be explained entirely by costly finance, unless firms neglect future financial constraints.

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Going back to Hall and Jorgenson (1967), economists 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 often 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, by 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. 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 difference-in-differences methodology to estimate the effect of this policy. We present three empirical findings. First, 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.[3] In contrast, we find that bonus depreciation raised eligible investment by 17.3 percent on av-

[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), Goolsbee (1998), 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] 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."

erage between 2001 and 2004 and 29.5 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.[4]

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. Controlling for 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 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.[5] 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

[4]In Appendix Table A.2, we collect estimates from past studies of tax reforms. The average user cost elasticity across these studies is -0.69.

[5]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.

the best collateral, the strongest banking relationships and broad access to equity and bond markets.[6] 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.[7] 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 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

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

[7] 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.

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 compute 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 0.82. 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.

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. 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. 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.[8] In the literature on salience and taxation, our study offers an example of a strong tax policy effect on economic behavior.[9]

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 evidence that losses matter.[10]

[8]House and Shapiro (2008) study the first episode of bonus depreciation using aggregate investment data.

[9]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).

[10]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."

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. Our sample of loss firms includes almost two hundred thousand loss year observations.

The paper also relates to the literature on financial constraints.[11] We use depreciation changes as a plausibly exogenous financial constraint shock.[12] Unlike past studies, our instrument also changes the relative price of investment. We use this feature and an investment model to compute the implied shadow price of internal funds. Our findings imply that incorporating financial frictions adds much explanatory power to neoclassical investment theory.

The outline of the paper is as follows. Section 1 formalizes intuition about how bonus works and develops a set of testable hypotheses, which guide the empirical analysis. Section 2 describes the corporate tax data, variable construction and sample selection process. Section 3 describes the main empirical strategy for studying bonus depreciation, the identification assumptions and presents results and robustness tests. Section 4 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. We then develop a set of theoretical moments and combine the empirical results to compute implied discount rates. Section 5 discusses policy implications and avenues for future research.

1 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. 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.[13] In Appendix A, we derive the hypotheses in an infinite horizon setting with adjustment costs and a dynamic leverage constraint.

Consider a firm making a one shot investment decision. The firm begins with initial profits

[11] 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. Stein (2003) surveys models in which financial frictions influence investment decisions.

[12] 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.

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

π_0 and chooses a level of investment I to determine the capital stock and hence future profits. 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:

$$z^0(\beta) = D_0 + \beta \sum_{t=1}^{T} \frac{1}{(1+r)^t} D_t, \tag{1.1}$$

where D_t is the allowable deduction per dollar of investment in period t and T is the class life of investment. $z^0(\beta)$ 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.[14] For discount rates, we apply a risk-adjusted rate of seven percent for r to compute z^0 in the data, which enables comparison to past work. In Section 4.3 we compute the implied additional discount firms apply to future deductions because of costly finance. β is an additional discount term between zero and one, which reflects the possibility of myopia.[15] We use our heterogeneity analysis to identify this term separately.

Bonus depreciation 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:

$$z(\beta) = \theta + (1-\theta) z^0(\beta) \tag{1.2}$$

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.

[14] 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, 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.

[15] 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.

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.[16] Our general z reflects this case:

$$z(\beta,\gamma) = \gamma z(\beta) + (1-\gamma)\beta\phi z(1), \tag{1.3}$$

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 our 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,

$$c(I) = \lambda\left[(1-\tau z)I - (1-\tau)\pi_0\right], \tag{1.4}$$

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 $1+\lambda$.[17] We include z in the net expense term rather than the first year deduction to capture the influence of depreciation deductions on future taxes and thus future borrowing. 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.

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,

[16]This assumes that "carrybacks"—in which firms apply unused deductions this year against past tax bills—have been exhausted or ignored. Relaxing this assumption complicates notation without altering the puzzle of a low response for nontaxable firms.

[17]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. 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.

the firm's objective is

$$\max_{I}\left\{\frac{(1-\tau)\pi(I)}{1+r}-(1-\tau z)I-\lambda(1-\tau z)I\right\} \tag{1.5}$$

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

The first order condition for optimal investment is

$$(1-\tau)\pi'(I^*)=(1+r)(1+\lambda)(1-\tau z). \tag{1.6}$$

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 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 $\lambda=0$).

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 also use the difference in coefficients between constrained and unconstrained firms to infer the implied external finance spread. We formalize and implement this intuition in Section 4.3.

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,* $\partial I/\partial\theta|_{\gamma=1} > \partial I/\partial\theta|_{\gamma=0}$.

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., $\beta < 1$).

2 Business Tax Data

The analysis in this paper uses the most complete dataset yet applied to study business investment incentives.[18] 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.

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.[19] Stratification occurs by form type,[20] total assets, and proceeds. SOI

[18]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.

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

[20]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,

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.

In 2008, the sample represented about 1.8 percent of the total population of 6.4 million C and S corporation returns. 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. 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.

Analysis Samples, Variable Definitions and Summary Statistics. We create a panel by linking the cross sectional SOI study files using firm identifiers.[21] 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[22] and (b) having an attached investment form.[23] In addition, we exclude partial year returns, which occur when a firm 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.[24] This sample consists of 820,769 observations for 128,151 distinct firms.

We describe 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.[25] We conduct

and property and casualty insurance companies. We focus on 1120 and 1120S, which cover the bulk of business activity in industries making equipment investments.

[21] We thank Jason Debacker and Rich Prisinzano for providing the data crosswalk.

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

[23] 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.

[24] 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.

[25] Section 179 and bonus rules differ slightly, in that Section 179 also applies to used equipment purchases,

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[26] 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.[27] 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 schedule, while assuming a six-month convention for the purchase year.[28][29] We compute z_N at the four-digit NAICS industry level as the simple average of firm-level z's across non-bonus years prior to 2001.[30] 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 1 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 sales 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. $z_{N,t}$

while bonus only applies to new equipment. The form does not require firms to list used purchases separately.

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

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

[28] 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.

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

[30] 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. It is possible to apply the same strategy at the firm level. This approach does not alter our findings.

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 fourteen cent difference in average after-tax θs.

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 five 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), and fabricated metal product manufacturing (332). 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), and construction of buildings (236). 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.

3 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. In both bonus periods we study, we estimate large responses to bonus depreciation. 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.

Policy Background. House and Shapiro (2008) provide a detailed discussion of the baseline depreciation schedule and legislative history of the first round of bonus depreciation. Kitchen and Knittel (2011) provide a brief legislative history of the second round.[31] Appendix B summarizes the relevant legislation for our sample frame.

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

Table 1: 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. Appendix Table A.3 presents more detailed investment statistics, allowing comparison of our sample to past work.

In 2001, firms buying qualified investments 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. It was later extended to 100 percent bonus for tax years ending between September 2010 and December 2011. The policies applied to equipment and excluded most structures.[32]

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. But for investment expenses the rules differ.

Table 2: 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.

Usually, the firm follows the regular depreciation schedule in the top panel of Table 2. 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 50 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.

[32] 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.

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 value payoff is why some authors conclude that bonus provides little stimulus for short-lived items (Desai and Goolsbee, 2004).[33]

In a frictionless model, a firm will judge the benefits of bonus by comparing these present value payoffs. 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 are myopic in the sense that they will aggressively use bonus to reduce current taxes even at the expense of higher future taxes. In short, when firms use higher effective discount rates to evaluate bonus, they will respond more than the frictionless model predicts.

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 3 offers little evidence of intertemporal shifting. Expecting the policy to be temporary is important for 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 less on this assumption. In our model, costly external finance and myopia amplify the effects of both temporary and permanent policies. And our cross sectional identification also relies less on the response of the longest lived investment goods.

[33] 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 patterns which we do not observe.

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.[34] 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 difference-in-differences (DD) specification,

$$f(I_{it}, K_{i,t-1}) = \alpha_i + \beta g(z_{N,t}) + \gamma X_{it} + \delta_t + \varepsilon_{it}, \tag{3.1}$$

where $z_{N,t}$ is measured at the four-digit NAICS industry level and increases temporarily during bonus years. The specific additive form we adopt in (3.1) 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 1 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.[35]

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 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.[36] 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

[34] This methodological approach was first applied in Cummins, Hassett and Hubbard (1994). See also Cummins, Hassett and Hubbard (1996), Desai and Goolsbee (2004), House and Shapiro (2008) and Edgerton (2010).

[35] 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).

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

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.[37] While we prefer the log investment model, we also report results using investment scaled by lagged capital stock, which allows comparison to past studies.

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.[38] This procedure addresses sampling frame changes over time, which cause instability in the aggregate distribution.[39] 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.[40]

We compare mean investment in calendar time for the top and bottom three deciles of the investment duration distribution.[41] Long duration industries show growth well above that of the short duration industries, with this difference only appearing in the bonus years. The 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.

Statistical Results and Economic Magnitudes. Table 3 presents regressions of the form in (3.1), 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.[42] 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.[43] Because log

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

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

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

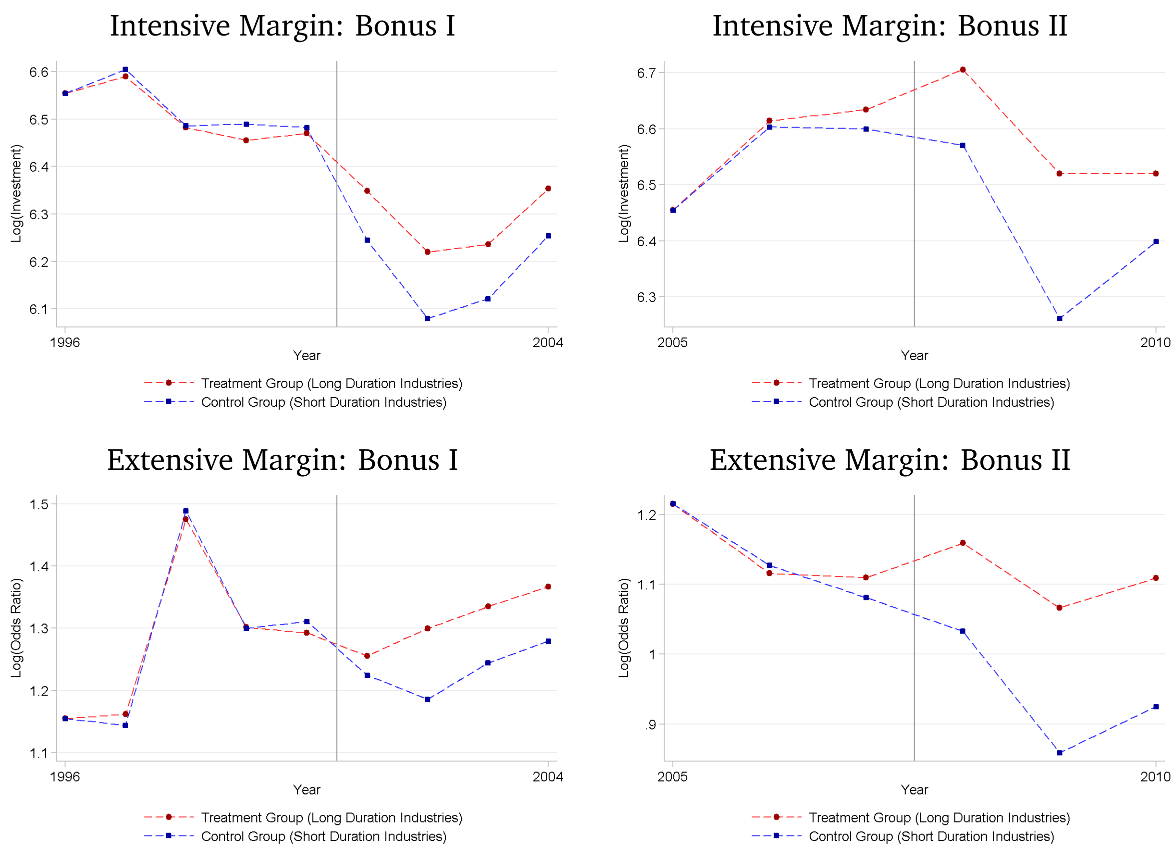
[40] To align the first year of each series and ease comparison of trends, we subtract from each dot the group mean in the first year and add back the pooled mean from the first year. All means are count weighted.

[41] Deciles are computed at the industry level.

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

[43] 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. We are not aware of other studies that

Figure 1: Calendar Difference-in-Differences



Notes: The top graphs plot 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). The bottom graphs plot 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.

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

restrict inference in this way and still show that taxes affect investment.

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 period, implying average investment increases of $17.3 (= 3.69 \times 4.7)$ and $29.5 (= 3.69 \times 8)$ 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.

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.[44] These alternative control sets do not challenge our main finding: the investment response to bonus depreciation is robust across many specifications.[45]

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. Panel (a) of Table 3 plots the estimates from these studies with confidence bands, highlights the consensus range, and compares them to our estimate. 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, derived in Appendix A. Our empirical model delivers a large elasticity of 7.2. 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.

Additional Robustness. 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. The first two columns of Table 4 present two

[44]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.

[45]We have confirmed these results in a balanced panel and for the sample of firms with enough observations to compute firm-level zs, which allows inclusion of four-digit industry-by-time fixed effects. Results for these additional specifications are available upon request.

Table 3: 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
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. Column (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, sales, 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. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses (industry level for the extensive margin models).

Table 4: 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
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 3. 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. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses.

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.[46]

Another concern with our results is that they may merely reflect a reporting response, with less real investment taking place. The third and fourth columns of Table 4 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 4 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

[46]This placebo test is valid if structures are neither complements nor substitutes for equipment. Without this assumption, the structures test remains useful because observing a structures response equal in magnitude or larger than the equipment response would indicate that time-varying industry shocks drive our results.

incentive.

Policy Salience. We now 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.

We study a component of the depreciation schedule, Section 179, which applies mainly to smaller firms. Under Section 179, taxpayers may elect to expense qualifying investment up to a specified limit. With the exception of used equipment,[47] 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.

Each tax year, there is a maximum deduction and a threshold over which Section 179 expensing is phased out dollar for dollar. The kink and phase-out regions have increased incrementally since 1993. 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 2 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.[48]

In general, evidence of bunching at kink points reflects a mix of reporting and real responses.[49] 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.

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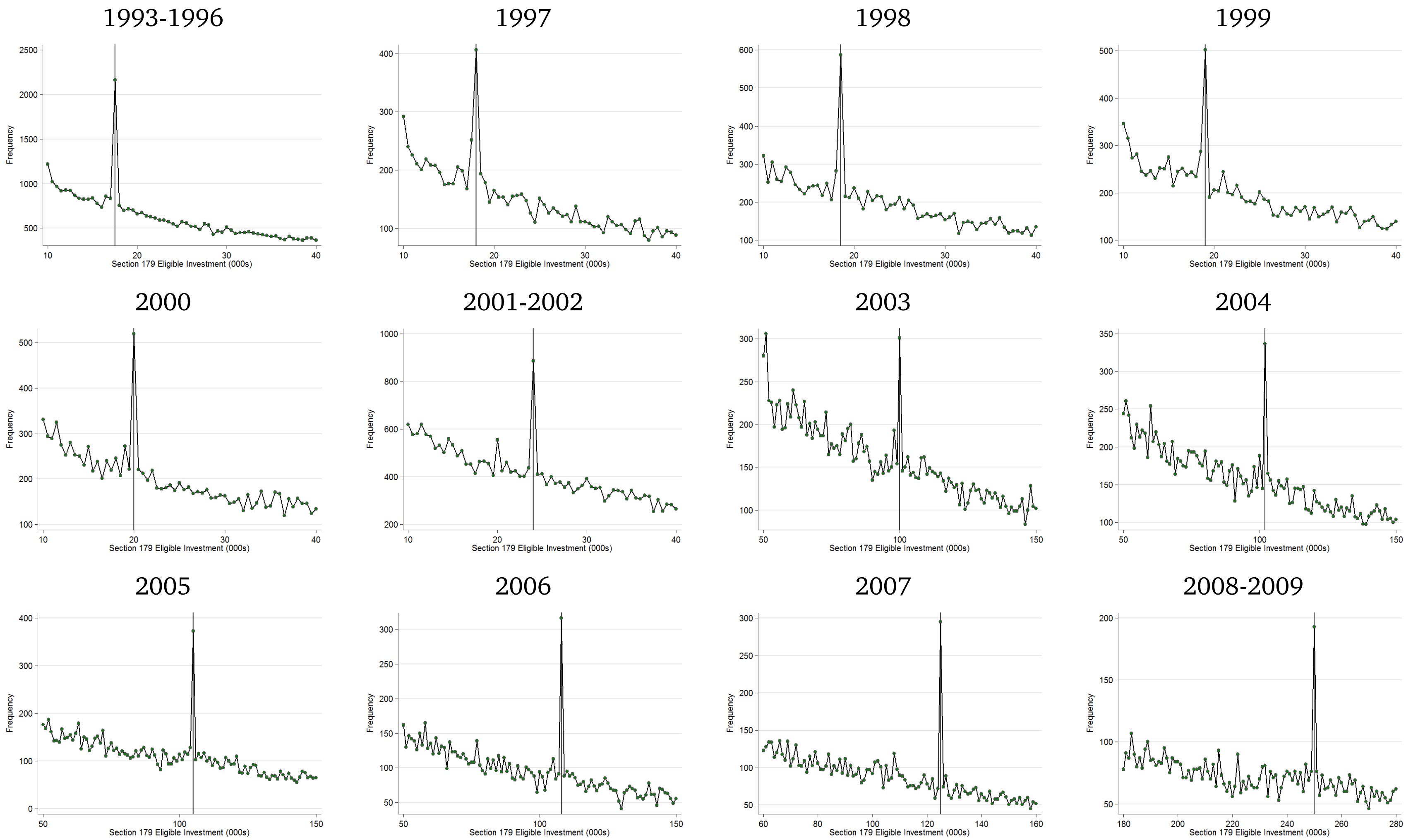
[47] Used equipment accounts for approximately six percent of equipment investment (Kitchen and Knittel, 2011).

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

[49] 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.

Figure 2: Depreciation Schedule Salience



Notes: These figures illustrate the salience of 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 or state conformity with federal depreciation rules.

We can interact the bunching evidence with the basic regression model identifying the response to bonus. The design of the test generates control and treatment groups from the notion that firms differ in their tax code knowhow.[50] 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 4 show that indeed the high bunching areas display a stronger response to bonus than do the low bunching areas.[51]

Substitution Margins and External Finance. 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. Understanding substitution margins is critical for assessing the macroeconomic impact of these policies and provides further indication of whether the observed response is real. Studying external finance responses helps us understand how firms paid for new investments.

Table 5 presents estimates of the intratemporal and intertemporal substitution margins. These regressions follow the baseline specification in equation 3.1, with a different left hand side variable. For rents, payroll and debt, we focus on flows (namely, differences in logs) as outcomes that match investment most closely. For payouts, we study an indicator for whether dividends are non-zero.

How flexible is the rent-versus-own margin for equipment investment? 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. Acknowledging this limitation, we ask what effect bonus depreciation had on changes in rental payments. The first column of Table 5 shows that growth in rental payments did not slow due to bonus, but rather increased somewhat. Thus we

[50]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. An alternative explanation for the differences we observe is state differences in conformity with federal bonus rules (Kitchen and Knittel, 2011).

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

do not find evidence of substitution away from equipment leasing. The second column of Table 5 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 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 (3) and (4) of Table 5 provide some insight. Increased equipment investment appears to coincide with significantly expanded borrowing and reduced payouts.

We assess the extent of intertemporal substitution using a model that includes both contemporaneous z and lagged z. In the case of temporary incentives, the shifting of investment from the high tax future to the low tax present offers a potential source of amplification (Abel, 1982; House and Shapiro, 2008). 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 5 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

Table 5: Substitution Margins and External Finance

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

Notes: This table estimates regressions of the form

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

where Y_{it} equals the difference in the logarithm of the dependent variable in columns (1) through (3). In column (4), the dependent variable is 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 (5) includes contemporaneous and twice lagged $z_{N,t}$. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses.

including lagged z does not alter the coefficient on contemporaneous z. This implies limited intertemporal shifting of investment, which further motivates our study of amplification through financial frictions.

Summary. 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 4, which presents heterogeneous effects by firm size and tax position, 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. Debt issuance increases because of bonus depreciation and payroll and dividend payments—which are double 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 behavior.

4 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 can generate high effective discount rates and thus reconcile our estimates with past work.

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.[52] 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.

[52]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.

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 returns extra cash to the firm today. Firms without this immediate incentive can still carry forward the deductions incurred but must wait to receive the tax benefits.[53] 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.

4.1 Heterogeneous Responses by Ex Ante Financial Constraints

We divide the sample along several markers of ex ante financial constraints used elsewhere in the literature. Even for private unlisted firms, we can still measure size, payout frequency and proxies for balance sheet strength. Panel (b) of Figure 3 plots elasticities and confidence bands from regressions run for each of ten deciles based on average sales.[54] The smallest firms in the sample show the largest response to bonus. These estimates help us reconcile our findings with 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.[55] The average semi-elasticity for small firms is twice that for large firms and statistically significantly different with a p-value of 0.03.[56] 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.[57] 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

[53] 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.

[54] 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.

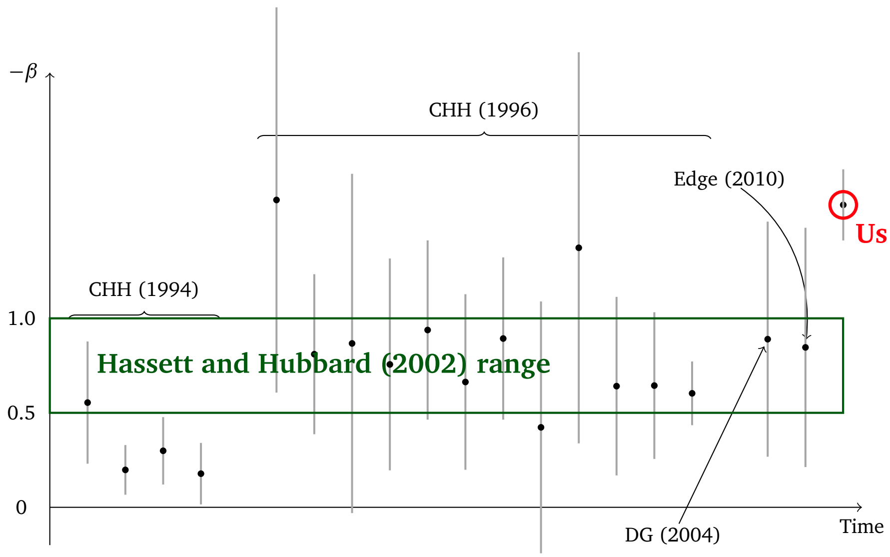
[55] When we measure size with total assets or payroll, the size results are unchanged.

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

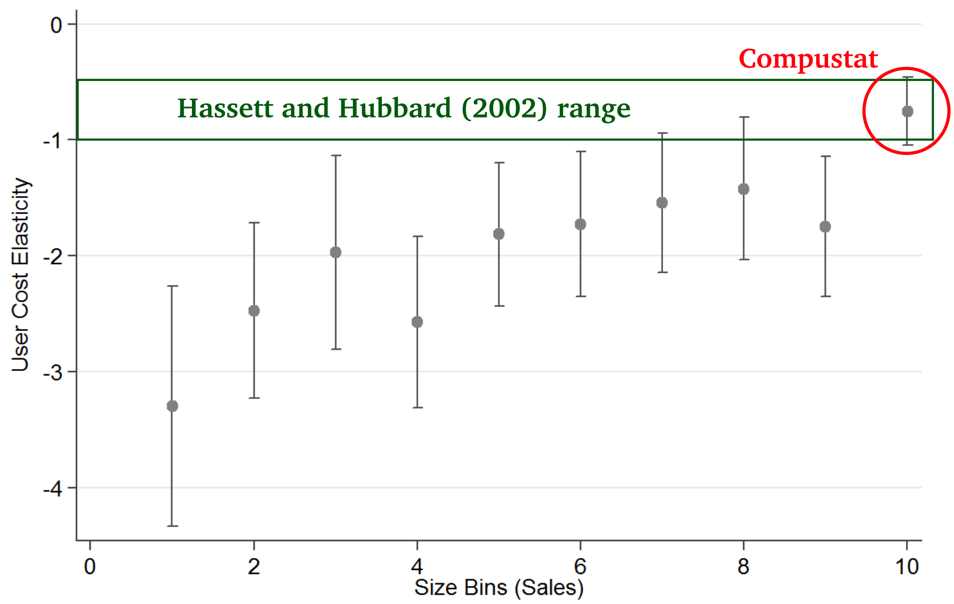
[57] We only use the first round of bonus for the dividend split. The dividend tax cut of 2003, which had a strong effect on corporate payouts (Yagan, 2013), may have influenced the stability of this marker for the later period.

Figure 3: Heterogeneous Effects by Firm Size

(a) Past Estimates



(b) Estimates by Firm Size, Bonus Sample



Notes: These figures plot coefficients and confidence bands from user cost specifications (see the third row of Table 3) for past studies of tax reforms and our sample. The sources for the coefficients in Panel (a) are in Appendix Table A.2. Panel (b) splits 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).

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. Note that this sort is uncorrelated with firm size by construction. The estimates 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.

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

Notes: This table estimates regressions from the baseline intensive margin specification presented in Table 3. 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 sales, 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. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses.

These constraint markers are imperfect.[58] 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 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.

[58] 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.

4.2 Heterogeneous Responses by Tax Position

The Section 179 bunching environment offers an ideal setting for documenting the immediacy of investment responses to depreciation incentives. 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 4 starkly confirm this 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.[59]

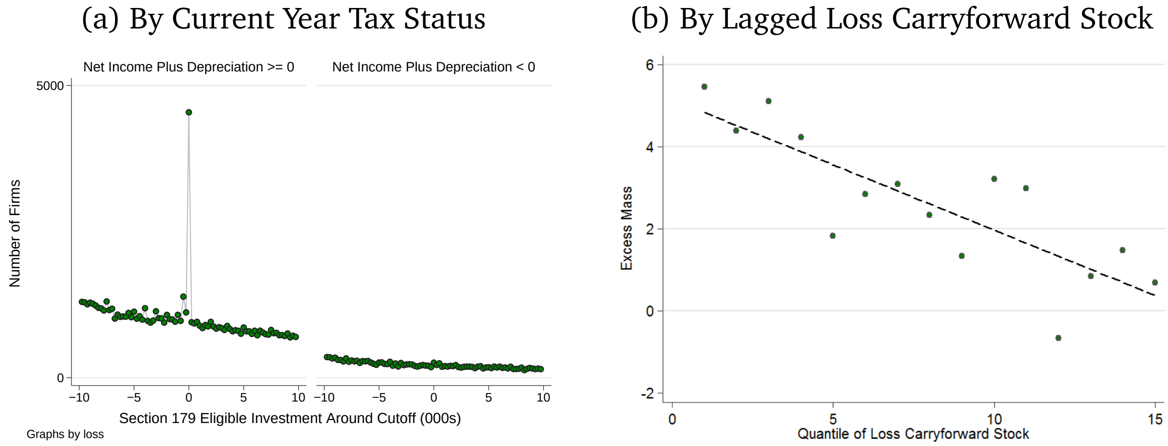
One objection to the taxable versus nontaxable split is that nontaxable firms have poor growth opportunities and so are not comparable to taxable firms. We address this objection in two ways. First, we restrict the sample to firms very near the zero net income before depreciation threshold to see whether the difference persists when we exclude firms with large losses. Panel (a) of Figure A.1 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 3 by interacting all variables with a taxable indicator based on whether net income before depreciation is positive or negative.[60] According to these

[59] On average, half of the nontaxable firms transition to taxable status in the next year. Thus this provides further evidence against amplification through intertemporal substitution, in which nontaxable firms expecting higher future taxes should also respond.

[60] 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.

Figure 4: Bunching Behavior and Tax Incentives



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.

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 A.1, 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 further address the concern about nontaxable firms, Panel (b) of Figure 4 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

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
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 3. 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. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses.

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 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 must also explain the finding for financially constrained firms—are small firms, non-dividend payers and firms with low levels of cash more myopic?

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.

4.3 Discount Rates and the Shadow Cost of Funds

Taken together, our empirical findings emphasize a financial frictions channel for how investment incentives work. 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 allow us to summarize our findings through an implied discount rate that firms seem to apply in evaluating investment incentives.

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

$$I \cdot \varepsilon_{I,\theta} \equiv \frac{\partial I}{\partial \theta} = \frac{(1+\lambda)p_I}{\psi_{II}} \frac{\partial z}{\partial \theta} > 0, \tag{4.1}$$

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 (1.3). In the Appendix, we state assumptions under which $I \cdot \psi_{II}$ will be equal across groups.[61] Under 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:

$$\frac{\varepsilon^C_{I,z}}{\varepsilon^U_{I,z}} \equiv m_1 = \frac{\partial I/\partial \theta|_{\lambda_C}}{\partial I/\partial \theta|_{\lambda_U}} = \frac{1+\lambda_C}{1+\lambda_U} = 1 + \frac{\Delta\lambda}{1+\lambda_U}, \tag{4.2}$$

which reveals an implied credit spread between constrained and unconstrained firms. Table 8 presents m_1 for each pair of estimates in Table 6. λ is the shadow price of relaxing the firm's 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

[61] 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.

Table 8: 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	0.51	0.88	0.07	0.82
Medium ϕ	0.31	0.82	0.07	0.84
Low ϕ	0.05	0.42	0.07	0.97

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.

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.[62]

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

$$\frac{\varepsilon_{I,z}^{\gamma=0}}{\varepsilon_{I,z}^{\gamma=1}} \equiv m_2 = \frac{\partial I/\partial\theta|_{\gamma=0}}{\partial I/\partial\theta|_{\gamma=1}} = \beta\phi\frac{1-z_t^0(1)}{1-z_t^0(\beta)}, \tag{4.3}$$

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 realizing carryforwards.[63] This implies $\phi = p/(p+r)$.[64] We calibrate p using tax status transitions in the data. Specifically, we measure the probability that a currently nontaxable firm has sufficient income in the next year for depreciation deductions to affect next year's tax bill. In our data, this probability is 0.51 if future loss carryforwards are not used and 0.31 if all future carryforwards are deducted prior to considering investment

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

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

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

incentives.[65] We also consider an extreme transition probability of 0.05.

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 $p = 0.51$, this maps to an implied discount factor (β) of 0.82.[66] The more conservative $p = 0.31$ hardly affects the calculation; only a counterfactual, extreme expectation of loss persistence can justify a β near the neoclassical benchmark. Ignoring for the moment the other discount terms, β equal to 0.82 implies a discount rate of approximately 20 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.[67]

The discounting implied by β says that one dollar next year is worth 82 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 financially 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 observed deviations from a rational benchmark, 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.

[65] Auerbach and Poterba (1987) note more persistence of nontaxable positions than we do. Our measure is based on net income before depreciation, 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.

[66] We evaluate $z_t^0(1)$ at the sample average of 0.88 and use the sample average first year deduction of 0.18 to set $z_t^0(\beta) = 0.18 + \beta \times 0.7$.

[67] 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.

5 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 macroeconomists and policymakers.

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.

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Internet Appendix

A Investment with Adjustment Costs and a Borrowing Constraint

We develop an infinite horizon, non-stochastic investment model, deriving the testable hypotheses in Section 1 and the empirical moments for calibration in Section 4.3. 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.[68]

[68] 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 deductible as well. The hypotheses

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.[69] 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 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.[70]

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.[71] We assume r is fixed over time and that k equals zero, since the investment tax credit is not active during

we derive do not depend on the assumption.

[69]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.

[70]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.

[71]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.

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 for capital, accounting for the rate of economic depreciation.[72] 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.[73]

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.[74] The financial constraint augmented first order condition

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

[73] 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).

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

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).[75] 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 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.[76]

A.2 Testable Hypotheses

We can derive the three testable hypotheses outlined in Section 1. 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 financial 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.[77] 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.[78]

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

[76] 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.

[77] 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.)

[78] Bond and Van Reenen (2007) survey the investment literature and argue that "conclusive evidence that linear

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, financial constraints tend to amplify the effects of bonus.

Hypothesis three concerns the differential effect of bonus by taxable status. We can com-

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).

pare the elasticities for γ equal to zero and γ equal to one:

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

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

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

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.[79]

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:

$$\frac{\varepsilon_{I,\theta}^C}{\varepsilon_{I,\theta}^U} \equiv m_1 = \frac{1+\lambda_C}{1+\lambda_U} = 1 + \frac{\Delta\lambda}{1+\lambda_U}. \qquad \text{(A.24)}$$

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

[79] 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.

firms:

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

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.[80] Under a constant τ assumption, we can drop tax rates from this formula, which we do in Section 4.3. 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 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.[81]

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

[80] 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.

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

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

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

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.

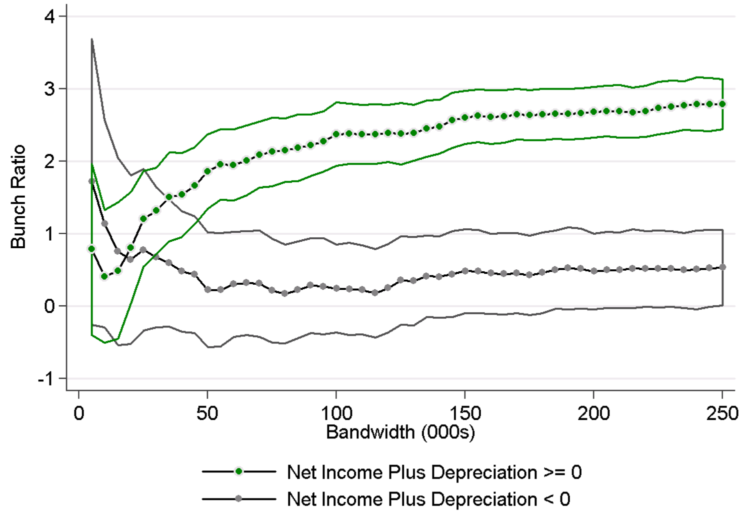
Table A.2: Past User Cost Estimates

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

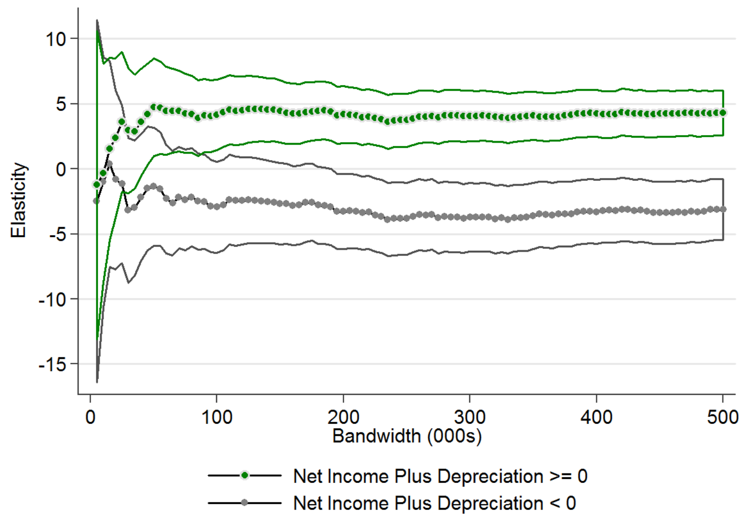
		0.938(0.242)	same as above; GER 1990	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (GER 1990, top) / p. 254
		0.663(0.237)	same as above; ITA 1992	Int'l public firm panel (Global Vantage), 1982-92	Table 6 (ITA 1992, top) / p. 254
		0.893(0.219)	same as above; JPN 1989	Int'l public firm panel (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

Figure A.1: Investment Behavior and Tax Incentives: Narrow Bandwidth

(a) Bunching with Narrow Bandwidth



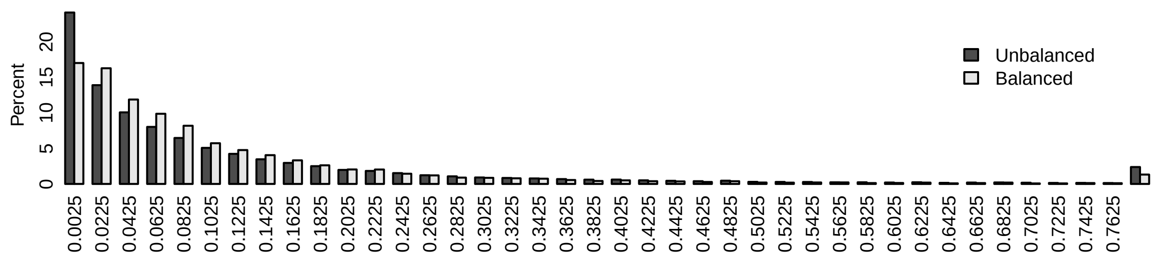
(b) Bonus with Narrow Bandwidth



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 4, 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 A.3: Detailed Investment Statistics (1998-2010)

(a) Investment Rate Distribution



(b) Summary Statistics

Variable	Unbalanced	Balanced
Average investment rate	11.9% (0.20, 3.23, 12.7)	10.4% (0.16, 3.60, 17.6)
Inaction rate	30.2%	23.7%
Spike rate	17.4%	14.4%
Serial correlation of investment rates	0.38	0.40
Aggregate investment rate	7.7%	6.9%
Spike share of aggregate investment	25.1%	24.4%

(c) Summary Statistics over Time and Correlation with Aggregate Investment (Unbalanced)

Variable	1998	1999	2000	2001	2002	2003	2004	2005
Average investment rate (%)	15.1	15.7	13.9	12.1	11.3	12.0	13.0	12.7
Std. dev. investment rate	0.221	0.234	0.213	0.195	0.189	0.205	0.209	0.209
Inaction rate (%)	22.9	21.9	25.7	28.5	28.7	29.3	26.2	27.4
Spike rate (%)	22.9	23.9	21.3	17.9	16.6	16.8	18.8	18.5
Aggregate investment rate (%)	11.7	8.7	8.8	7.5	7.0	6.4	7.2	7.0
	2006	2007	2008	2009	2010		σ	β_{Agg}
Average investment rate (%)	12.8	11.3	10.4	7.1	7.0		0.026	0.74
Std. dev. investment rate	0.208	0.189	0.180	0.140	0.129		0.030	0.64
Inaction rate (%)	28.7	31.2	34.0	41.5	40.5		0.059	-0.68
Spike rate (%)	19.2	15.5	15.5	9.0	9.2		0.045	0.76
Aggregate investment rate (%)	8.3	7.5	7.5	6.3	6.0		0.015	

(d) Investment Rates by Firm Characteristics (Unbalanced)

Sorting Variable	Investment	Inaction	Spike		Investment	Inaction	Spike
Size by Mean Sales Decile (Unweighted)							
$< 0.9M$	11.2% (0.23)	53.8%	16.5%	$[23.1M, 33.5M]$	11.4% (0.17)	17.3%	16.1%
$[0.9M, 3.7M]$	13.0% (0.21)	32.0%	20.2%	$[33.5M, 48.8M]$	10.6% (0.16)	17.4%	13.7%
$[3.7M, 8.7M]$	12.0% (0.19)	23.3%	17.2%	$[48.8M, 77.4M]$	10.5% (0.16)	16.3%	13.3%
$[8.7M, 15.4M]$	11.0% (0.16)	20.3%	15.6%	$[77.4M, 164M]$	10.7% (0.16)	14.8%	13.5%
$[15.4M, 23.1M]$	11.3% (0.18)	19.5%	15.7%	$> 164M$	10.0% (0.14)	14.3%	11.7%
Dividend Payer							
Yes	8.9% (0.14)	20.2%	10.3%				
No	12.0% (0.20)	30.6%	17.6%				

Notes to Table A.3: This exhibit provides detailed investment statistics to enable comparison to past work. The investment rate is bonus eligible investment divided by lagged depreciable assets. All statistics are weighted by sampling weights from SOI. The unbalanced sample includes all firms used in the bonus analysis. The balanced sample includes only those firms in the sample for the entire sample frame. Figure (a) plots investment rate densities with intervals labeled by right end points. Table (b) follows Table 1 of Cooper and Haltiwanger (2006). Inaction is defined by investment below 1%. Spikes are defined by investment above 20%. Aggregate investment is total eligible investment divided by total lagged capital. The spike share of aggregate investment is total eligible investment due to spikes divided by total eligible investment. Table (c) presents these statistics over time for the unbalanced panel. σ is the standard deviation of a statistic over time. β_{Agg} is the correlation of a statistic with the aggregate investment rate. Table (d) presents investment rate statistics for the unbalanced panel with firms sorted by firm characteristics. Standard deviations, skewness and kurtosis are in parentheses for investment rates. Standard deviations are in parentheses for all other statistics.