

Essays on Taxation and Investment

by

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Abstract

This thesis consists of three essays that examine the impact of tax policy on firms' decisions to invest in productive capital. The first chapter uses newly-collected data on transaction prices of used construction machinery to examine the impact and incidence of recent tax incentives for investment. Theory predicts that incentives applying only to new investment should drive a wedge equal to the value of the incentives between the prices of new machines and equally productive used machines. The estimated effect of recent "bonus depreciation" incentives on the size of this wedge is close to zero. The total supply of machines, however, is highly price elastic. Together, these results suggest that the effectiveness of tax incentives that succeeded in stimulating investment demand would not be blunted by inelastic supply, but that the most recent set of tax incentives did little to stimulate investment demand.

The second chapter documents the prevalence of losses among US corporations in recent years and examines their implications for the effectiveness of tax incentives for investment. Results suggest that asymmetries in the corporate tax code made recent bonus depreciation tax incentives about 5% less effective than they otherwise would have been. Recent declines in the ratio of cash flows to assets made bonus depreciation as much as 24% less effective than it otherwise would have been. Thus, recent losses can explain only part of the observed ineffectiveness of bonus depreciation.

The final chapter estimates the response of dividend payouts to a 2003 dividend tax cut using a new control group of unaffected firms. Dividend payouts by real estate investment trusts rose sharply following the tax cut, even though REIT dividends did not benefit from the cut. It appears that the surge in aggregate dividend payouts subsequent to the tax cut was driven primarily by an increase in corporate earnings. Evidence from the tax cut thus provides little support for the claim that dividend taxation creates large distortions to firm investment decisions or large efficiency costs.

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Introduction

Economists have focused a great deal of attention on the effects of tax policy on firms' decisions to invest in productive capital. In the long run, the taxation of income from capital presents a particularly stark version of the familiar tradeoff between equity and efficiency that often confronts tax policy makers. Because income from capital is earned disproportionately by high-income households, one might wish to tax this income heavily if one hopes to redistribute resources from those with high incomes to those with low incomes. On the other hand, seminal theoretical results like those in Chamley [1986] and Judd [1985] suggest that distortions from taxing capital income can be so large that efficiency concerns require a zero tax rate on capital income under an optimal tax system. The writing of this dissertation was motivated largely by my desire to assess the empirical relevance of these efficiency arguments, that is, to examine carefully whether taxes on income from capital indeed have important effects on capital accumulation.

The research contained herein focuses on responses to changes in taxation in the United States over relatively short horizons. In part, this choice is motivated by necessity, in that I am unable to observe long-run differences across nations that differ only in their approach to capital income taxation. These short-run responses, however, are also of interest in their own right. Spending on business investment is highly cyclical, and policy makers have repeatedly used tax policy in attempts to encourage investment during downturns. From 2002 to 2004 and again in 2008 and 2009, the United States offered special "bonus depreciation" tax incentives to firms purchasing eligible equipment. In 2003, the tax rate on dividend income was lowered, in part to encourage investment. Empirical estimates of the impacts of policies like

these can be used both to assess their effectiveness in achieving their stated short-run goals and to inform our understanding of the likely long-run effects of capital income taxation.

The existing literature already contains many empirical estimates of the effects of tax policy on investment and dividend behavior. I survey this literature in more detail in the following chapters, and it will suffice here to say that results are quite mixed. Many papers, sometimes using the same or similar data, have produced different answers regarding the effects of investment incentives and dividend taxes on firm behavior. The chapters that follow provide new estimates of these effects using new data and new attention to useful features of the tax code.

The first chapter uses newly-collected data on transaction prices of used construction machinery to examine the impact and incidence of bonus depreciation. Theory predicts that incentives applying only to new investment should drive a wedge equal to the value of the incentives between the prices of new machines and equally productive used machines. The estimated effect of recent bonus depreciation on the size of this wedge is close to zero, suggesting that bonus depreciation had negligible effects on demand. The elasticity of substitution between new and used machines is low, suggesting that tax changes favoring investment in new machines have relatively little welfare impact on owners of used machines. Finally, the total supply of machines is highly price elastic, with important responses coming from net exports of used machines. Together, these results suggest that the effectiveness of tax incentives that succeeded in stimulating investment demand would not be blunted by inelastic supply, and would not hurt owners of existing capital as much as previous literature would suggest. It appears, however, that the most recent set of tax incentives did little to stimulate investment demand.

The second chapter is motivated, in part, by the ineffectiveness of bonus depreciation in stimulating investment demand observed in the first chapter. In particular, it documents the prevalence of losses among US corporations in recent years and explores their implications for the effectiveness of tax incentives for investment. I develop a tax-adjusted Q model of corporate investment in a setting featuring carry-

backs and carryforwards of operating losses, as well as debt, tax credits, and financing constraints. I estimate investment responses to tax incentives using data from the Compustat panel of publicly-traded firms. Estimates suggests that firms currently facing the statutory rate on marginal income are about two-thirds more responsive to tax incentives for investment than currently nontaxable firms. A one standard deviation increase in the ratio of cash flows to assets makes a firm about one-half more responsive to tax incentives. Results suggest that asymmetries in the corporate tax code made recent bonus depreciation tax incentives about 5% less effective than they otherwise would have been. Recent declines in the ratio of cash flows to assets made bonus depreciation as much as 24% less effective than it otherwise would have been. Thus, recent increases in losses can explain only part of the observed ineffectiveness of bonus depreciation.

The final chapter estimates the response of dividend payouts to recent tax legislation using a new control group of unaffected firms. Several studies have observed a large increase in dividend payouts following the 2003 dividend tax cut and argued that the tax cut caused these increases. These results would imply that dividend taxation creates large efficiency costs. I document that dividend payouts by real estate investment trusts also rose sharply following the tax cut, even though REIT dividends did not benefit from the cut. With REITs as a control group, estimated effects of the tax cut on dividend payouts are far smaller. I also document a notable surge in corporate earnings whose beginning coincided with the tax cut. In fact, the ratio of dividend payouts to earnings did not increase after the tax cut. I thus argue that the increase in dividend payouts was driven primarily by the increase in earnings, with little or no role for the tax cut. Evidence from the tax cut provides little support for the claim that dividend taxation creates large efficiency costs.

In sum, the results presented here suggest that recent tax policy changes have had quite modest effects on firm behavior at the horizons that I observe. The extent to which these observations are informative for understanding the effects of tax policy at longer horizons remains debatable and an important subject for future research.

Chapter 1

Taxes and Used Equipment: Evidence from Construction Machinery

1.1 Introduction

The effect of taxation on business investment has long been a focus of research in economics. In the long run, the taxation of income from capital can provide the revenues needed to fund government, but may depress capital formation, output, and consumption. The optimal long-run level of capital income taxation remains the subject of vigorous debate in both the theoretical economics literature and in public political discourse. In the short run, policymakers frequently use tax policy in attempts stimulate business investment. Recent examples include the “bonus depreciation” provisions in place from 2002 to 2004 and again in 2008 and 2009.

Although the effects of taxation on investment have inspired a voluminous theoretical literature and frequent tax policy changes, empirical evidence on the size of such effects remains mixed. To briefly summarize a large literature, early results like Eisner [1969], Summers [1981], and Bernanke, Bohn, and Reiss [1988] implied extremely small effects of taxation on investment. A more recent literature, including

Auerbach and Hassett [1991], Cummins, Hassett, and Hubbard [1994], and Desai and Goolsbee [2004] has estimated larger effects.

The state of recent debate can be summarized by comparing two papers estimating the effects of the 2002 to 2004 bonus depreciation provisions. Cohen and Cummins [2006] compare investment in assets most affected and least affected by the provisions in a differences-in-differences framework. They find no evidence for significant effects of the policy. House and Shapiro [2008] begin with the same data, but follow a methodology like that of Auerbach and Hassett [1991] by extracting investment forecast errors from an atheoretical forecasting regression. They find significant effects of the policy in the forecast errors, after controlling for nondurables consumption. Thus it seems that the effects of tax policy found in the investment data are quite sensitive to the choice of estimation method.¹

This paper tests for effects of tax policy in the market for investment goods using new data and a new methodology. The bonus depreciation tax incentives in place at times over the last decade applied only to investment in new capital equipment. Theory suggests that these incentives should drive a wedge between the price of new equipment and equally productive used equipment. The observed size of this wedge measures the implied value of bonus depreciation to marginal investors. I examine this wedge using a large, newly-collected dataset of auction prices of used construction machines.

I also provide new evidence on two questions related to the incidence of tax incentives for investment, that is, to the distribution across agents of welfare gains or losses from incentives. The first question regards the effect of tax incentives on the owners of existing assets; the second regards the effects on suppliers of new assets. Since the influential work of Summers [1981], it has been widely understood that tax policy changes can affect owners of existing assets through their impact on asset prices. A large literature based on this “asset price approach to incidence” provides theoret-

¹Knittel [2007] provides additional reasons to doubt that the effect of bonus depreciation was large. He reports that bonus depreciation was claimed for only about 60% of eligible investment. That is, the firms responsible for 40% of the investment that qualified for bonus depreciation did not even make the minor changes to their tax forms that were necessary to claim the benefits. In light of these figures, the large effects estimated by House and Shapiro [2008] are surprising.

ical and simulation results on the welfare impacts of various proposed tax changes. See, for example, Poterba [1984], Auerbach and Hines [1987], Goulder and Summers [1989], Bradford [1996], Hall [1996], Gentry and Hubbard [1997], Altig, Auerbach, Kotlikoff, Smetters, and Walliser [2001], and Judd [2001]. All of these papers assume that,

“[s]ince equally productive units of new and old capital must sell for the same price, tax provisions favoring new capital imply a lower price for existing capital,”

as stated by Kotlikoff [1983].

There is surprisingly little empirical work examining this statement. In the absence of data on transaction prices of used assets, papers by Downs and Tehranian [1988] and Cutler [1988] tested for effects consistent with the asset price approach in stock market returns around the passage of tax legislation in 1981 and 1986. Downs and Tehranian [1988] claim to find “moderate support” for the implications of the asset price approach by comparing stock returns across three manufacturing industries. Cutler [1988] finds no evidence for effects at the industry level. At the firm level, he finds evidence supporting the asset price approach in only one of several subsets of his results. Noting the weakness of these results, Cutler concludes that the stock market may fail to price news about tax changes efficiently. His conclusion suggests that a more powerful test of the asset price approach might look for effects of tax changes directly in transaction prices of new and used assets, rather than in stock prices of firms that own them. To my knowledge, this is the first paper to attempt such a test.²

²There is, however, a related literature that looks for effects of property and other taxes in house prices. Results in this literature are mixed. Poterba [1990], Agell, Englund, and Sodersten [1996], and Boelhouwer, Haffner, Neuteboom, and Vries [2004] discuss the annual time series of housing prices surrounding changes in the income tax treatment of housing in the United States, Sweden, and several European countries, respectively. All three suggest that the time series are, at best, partially consistent with any affect of these tax changes on house prices. Another literature, dating at least to Oates [1969], attempts to measure the extent to which property taxes are capitalized into house prices, and finds a wide range of estimates. Neither literature makes use of the distinction between old and new capital, as the tax provisions under study typically apply to both old and new houses.

The second incidence question relates to suppliers of new capital goods. Goolsbee [1998] points out that if the supply of new capital is not perfectly price elastic, tax-induced demand shifts will be reflected in capital goods prices, as well as quantities. He estimates large pass-throughs of tax incentives into equipment prices and low price elasticities of supply. His estimates of tax pass-through in construction machinery prices are quite close to those estimated on the pooled sample of all assets, suggesting that construction machinery supply elasticities are typical of other equipment types.

I provide two new pieces of evidence on the elasticity of supply. First, I provide the first estimates of the price sensitivity of net exports of used machines by constructing international used machinery price indices from auction sales data. Second, I provide estimates of the price elasticity of the total supply of construction machines in recent data. Large swings in demand for machinery associated with the recent boom and bust in the US housing markets provide particularly stark evidence on the elasticity of supply.

To summarize results, the effect of recent bonus depreciation incentives for new machines on the relative price of used machines is close to zero, and I can reject many plausible values in the range predicted by a neoclassical investment model. These estimates suggest that bonus depreciation had less value to machinery buyers than the neoclassical model would predict. As a result, it did little to stimulate demand for investment.

I also find that new and used construction machines are far from perfect substitutes, in contrast to the assumptions underlying much of the literature based on the asset price approach to incidence. Papers in this literature assume that tax incentives favoring new capital hurt owners of existing capital when the proliferation of new capital drives down the marginal product of existing capital. This effect can be mitigated or even reversed when new and used capital are imperfect substitutes.

Finally, I find the supply of construction machinery to be highly price elastic. There were extremely large and rapid swings in the quantity of machinery supplied during the recent boom and bust in US housing markets, accompanied by small movements in prices. Further, I find that net exports of used machines are sensitive

to price differences between the United States and other countries, and that responses on this margin have become an important component of the overall supply response to price changes. In fact, the response of net exports of used machinery alone is as large as the total price elasticity of supply estimated by Goolsbee [1998]. My estimates of the price elasticity of total supply are an order of magnitude larger than Goolsbee's estimates.

Together, these results suggest that tax incentives which succeeded in stimulating investment demand would not be blunted by inelastic supply, and they would not hurt owners of existing capital as much as previous literature would suggest. It appears, however, that the most recent set of tax incentives did little to stimulate investment demand.

The following section of the paper provides background information on markets for used assets and construction machinery. Section 3 models the expected effects of bonus depreciation on the prices of new and used machinery, describes the data on new and used prices, and presents results related to the demand for construction machines. Section 4 describes data and presents results related to the supply of machines, including net exports of used machines. Section 5 concludes.

1.2 Background

1.2.1 Used Equipment Markets

Table 1.1 reports data from the American Capital Expenditure Survey, which asks firms about their annual expenditures on both new and used capital. For some industries, including various construction and transportation specialties, spending on used equipment can be as much as 30% of total equipment expenditure. Stated differently, the value of used equipment that changes hands each year can be as large as $3/7$, or 43%, of spending on new equipment. Across all industries, spending on used equipment accounts for about 5% of total equipment spending.³

³Eisfeldt and Rampini [2006] provide evidence on variation in used equipment sales and other forms of capital reallocation over the business cycle.

Table 1.1:
 Spending on Used Equipment for Selected Industries

Industry	Spending on Used Equipment, in \$Billions	Used as Percent of Total Equipment Spending
Water Transportation	0.66	29.8
Construction: Heavy and civil engineering	2.19	29.5
Couriers and messengers	0.80	27.3
Forestry, fishing, and agricultural services	0.43	25.1
Construction: Specialty trade contractors	2.13	22.6
Construction of buildings	0.99	21.5
Truck transportation	1.70	19.6
Mining	1.72	12.9
All industries	29.30	5.6
Manufacturing	4.17	5.0
Real estate and rental and leasing	1.39	2.7
Finance and insurance	0.59	0.4

Source: American Capital Expenditure Survey, 2003

Despite the size of markets for used equipment documented in Table 1.1 and the focus on asset prices in much of the literature on tax incidence, no papers of which I am aware have tested for effects of tax changes directly in used equipment prices. One reason may be that high-quality data on the prices of used assets have been scarce until relatively recently. The Bureau of Labor Statistics tracks the prices of thousands of goods in order to construct the Consumer Price Index (CPI), Producer Price Index (PPI), and Import/Export Price Index (MXP). However, the only prices for used goods available in these data are for used cars and other vehicles. Since the marginal buyer of most cars is likely a consumer, these data are not likely to provide information about the effects of taxes on business investment.

Some prior researchers have used data on used capital goods prices in efforts to measure depreciation patterns and changes in capital quality over time, with seminal examples being Hulten and Wykoff [1981] and Gordon [1990]. Both relied primarily on values from published price guides to used equipment. The source of price estimates in early price guides is unclear,⁴ and data are available at relatively low frequencies. More recent efforts in these literatures have attempted to use datasets of transaction prices. For example, Oliner [1996] uses 573 observations on sales of machine tools,

⁴Modern price guides rely on auction data like the ones I use.

and Wu and Perry [2004] use 10,785 observations on farm equipment auctions. As I describe below, I assemble a dataset of over a million sales observations from data that became available beginning in 1994. Mas [2008] uses a small subset of these data to study the effects of labor disputes on the quality of production.

1.2.2 Construction Machinery

According to the Bureau of Economic Analysis, investment in new construction machines totaled \$23 billion in 2007, bringing the net stock of construction machines to about \$150 billion. This value of the US stock of construction machinery is comparable to the value of the stock of heavy trucks and buses, farm machinery, metalworking machinery, or automobiles owned by businesses. It is about half the value of the stock of aircraft.

There is a particularly active market for used construction machines. The American Capital Expenditures Data indicate that at least \$5 billion of construction machinery changes hands each year in the United States. Many of these transactions take place at large public auctions. Every week at auction sites around the world, hundreds or thousands of machines are lined up on lots the size of several football fields. Each machine is driven in front of a grandstand seating hundreds or thousands of bidders. The machine is auctioned, typically in an open-outcry, ascending bid format, before being driven off and replaced by the next machine for sale.

It should be noted that features of construction machinery that make it attractive for study in this paper could also make it unusual relative to other kinds of capital goods. The construction machinery used by firms all over the world is apparently quite homogenous, and most construction machines are easily transported on flatbed trucks or “roll-on, roll-off” cargo ships. These features likely facilitate the existence of a liquid global resale market with relatively minor information asymmetries between knowledgeable buyers and sellers. Other forms of capital that may be more difficult to transport or more customized to their owners’ needs may not have such liquid resale markets. It is plausible, for example, that manufacturers of other forms of capital can restrict quantities and affect prices to a greater degree than construction machinery

manufacturers, who must compete with prices in the active market for used machines. As noted previously, however, the results of Goolsbee [1998] suggest that the supply elasticity of construction machinery is typical of other equipment types.⁵

1.3 Tax Incentives and the Demand for Machinery

This section of the paper will focus on the demand side of the market for construction machinery. Subsection 3.1 presents a first model of the demand for machinery, and subsection 3.2 discusses recent tax incentives for investment in the context of the model. Subsection 3.3 introduces the possibility that used machines are imperfect substitutes for new machines. Subsections 3.4 and 3.5 describe the data on new and used machine prices. Subsection 3.6 presents estimation results.

1.3.1 A Basic Model of Investment

I begin by introducing a neoclassical model of investment so that I may discuss recent tax legislation in the context of the model. A firm chooses its current investment in new machinery, I_t , and its stock of machinery, K_t , to maximize the present discounted value of after-tax cash flows. It solves,

$$\max \int_0^{\infty} e^{-rt} [(1 - \tau)(F(K_t) - rD_t) - (1 - \tau z)p_t I_t + B_t] dt, \quad (1.1)$$

⁵A final notable fact about the market for construction machines is the large fraction of machines owned by lessors, that is by firms that rent or lease machines to the firms that use them. Data from the Bureau of Economic Analysis suggest that about 16% of the stock of construction machines was purchased by firms in the rental and leasing industry. This figure only includes machines under short-term rental agreements or operating leases and excludes machines under long-term capital leases. On the other hand, it also fails to account for machines that were originally purchased by the leasing industry and subsequently sold to firms in other industries. Thus it is difficult to determine with certainty the importance of leased machines, and I will discuss implications for the effectiveness of tax incentives below.

subject to,

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

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

$$B_t \leq \phi p_t I_t.$$

Units of machinery can be purchased at price p_t and depreciate at a geometric rate of δ . Borrowing B_t increases the stock of debt D_t , which requires interest payments at the discount rate r . New borrowing is limited by the parameter ϕ , which is the debt capacity of machines, or the maximum fraction of their purchase price that can be borrowed. The tax rate is τ , and the present value of the depreciation deductions available on newly purchased machines is z . The solution to this problem requires that firms set,

$$F'(K_t) = p_t(r + \delta - \pi_t) \frac{1 - \tau(\phi + z)}{1 - \tau}, \quad (1.2)$$

where $\pi_t = (\partial \Gamma_t / \partial t) / \Gamma_t$ for $\Gamma_t = p_t(1 - \tau(\phi + z))$. This expression is quite similar to the seminal user cost of capital result in Hall and Jorgenson [1967].

1.3.2 The Value of Bonus Depreciation

Recent tax provisions have changed the timing of the depreciation deductions that businesses are allowed on purchases of new equipment; in the model, these provisions raise z and lower the cost of capital. Table 1.2 summarizes the “bonus depreciation” tax incentives included in recent legislation. The Job Creation and Worker Assistance Act of 2002 included a 30% bonus depreciation provision, which allowed firms to deduct 30% of the purchase price of new equipment from taxable income in the year the equipment was placed in service. The remaining 70% was deducted under the standard schedules of the Modified Accelerated Cost Recovery System (MACRS). The provisions were signed into law on March 9, 2002, and applied retroactively to equipment placed in service after September 10, 2001. They were to remain in effect for equipment placed in service prior to September 11, 2004. On May 28, 2003,

Table 1.2: Bonus Depreciation Provisions in Recent Legislation

Legislation	Proposed	Signed	Bonus Amt	Until
Job Creation and Worker Assistance Act	10/11/2001	03/09/2002	30%	09/10/2004
Jobs and Growth Tax Relief Reconciliation Act	01/07/2003	05/28/2003	50%	12/31/2004
Economic Stimulus Act	01/24/2008	02/13/2008	50%	12/31/2008

however, new legislation increased the deductible percentage to 50% and extended the provisions through December 31, 2004. On February 13, 2008, similar 50% bonus depreciation was enacted for equipment placed in service by December 31, 2009.⁶ At the time of this writing, the US Congress has begun discussing an additional round of economic stimulus legislation, so an extension of bonus depreciation into 2009 appears likely. Bonus depreciation applies only to new equipment. Newly purchased used equipment continues to be depreciable under the same MACRS schedules that determine depreciation allowances for new equipment when bonus depreciation is not in effect.

Table 1.3 summarizes the value of 50% bonus depreciation for construction machinery by displaying the value of $\ln(1 - \tau(\phi + z))/(1 - \tau(\phi + z^B))$ under different configurations of parameter values. When z^B is the present value of depreciation deductions under bonus depreciation, this quantity approximates the value of bonus depreciation as a percentage of the after-tax price of a machine. As I describe below, I will estimate the magnitude of this quantity implied by the wedge between new and used machine prices.

The predicted value of bonus depreciation is rather sensitive to parameter values. If a buyer is taxed at 25% on marginal income, has no ability to borrow against the value of a newly-purchased machine, and discounts future tax savings at a rate of 5%, then bonus depreciation would be worth only 1.3% of the after-tax price of a new machine. On the other hand, if a buyer is taxed at the top corporate or individual rate of 35%, can borrow the entire cost of a machine, and discounts future tax savings

⁶The JGTRRA and ESA also altered rules related to Section 179 expensing of equipment for small businesses. It is feasible that eligibility for Section 179 expensing could make bonus depreciation irrelevant for marginal equipment buyers. Were this the case, however, we should observe differential movements in prices for equipment likely to be eligible and ineligible for Section 179 expensing. In results not reported, I found no evidence of such price movements.

Table 1.3: Predicted Value of 50% Bonus Depreciation from Neoclassical Model

	$\tau = 0.25$	$\tau = 0.35$	$\tau = 0.35$	$\tau = 0.35$	$\tau = 0.35$
	$\phi = 0$	$\phi = 0$	$\phi = 0.5$	$\phi = 0.8$	$\phi = 1$
$r = 0.05$	0.013	0.021	0.029	0.037	0.045
$r = 0.10$	0.024	0.038	0.051	0.064	0.077
$r = 0.15$	0.033	0.051	0.068	0.085	0.102

Figures in the table are values of $\ln(1 - \tau(\phi + z))/(1 - \tau(\phi + z^B))$ under the indicated configurations of parameters, where τ is the marginal tax rate, z is the present value of depreciation deductions, r is the rate used to discount depreciation allowances, and ϕ is the fraction of a machine's purchase price that may be borrowed. These approximate the value of bonus depreciation as a percentage of the after-tax price for five-year property under the Modified Accelerated Cost Recovery System.

at 15%, then she would value bonus depreciation at 10.2% of the after-tax price.

The predicted value of bonus depreciation is particularly sensitive to the rate at which future depreciation deductions are discounted. Summers [1987] argues that firms should discount depreciation deductions at a rate close to the risk-free Treasury rate, since they are essentially obligations of the U.S. government. However, he reports results from a survey of firms suggesting that few, if any, firms followed this practice. At least 93% of respondent firms indicated that they discounted depreciation deductions at the same rate as all other cash flows associated with their investment projects. The median reported nominal discount rate was 15%. Meier and Tarhan [2006] report results from a similar survey conducted during the first bonus depreciation episode in October 2003. The median reported nominal discount rate in their sample was 14%.

In light of this evidence it would seem perfectly reasonable to assume that marginal buyers of construction machinery discount depreciation deductions at 15% or more. Even if one were to assume that marginal buyers discount deductions at a 10% rate, Table 1.3 suggests that the value of bonus depreciation could easily exceed 5% of the after-tax price.

As I explain below, I attempt to estimate the value of bonus depreciation by comparing the prices of new and used machines when bonus depreciation was and

was not in effect. Point estimates of this value are clustered close to zero. With only fifteen years of data on used machine prices and two short episodes of bonus depreciation, the power of statistical tests to reject null hypotheses close to zero will be somewhat limited. Nonetheless, I can reject values of bonus depreciation larger than 3% in many specifications. Thus I will still reject a large range of the plausible values from Table 1.3.

1.3.3 New versus Used Machines

In the model just discussed, new and used machinery were perfect substitutes. Output depended only on the total machinery stock, which consisted of a mix of machinery of various vintages. To match features of the data which will soon be discussed, I now extend the model to allow new and used machinery to enter the production function as imperfect substitutes. Firms solve,

$$\max \int_0^{\infty} e^{-rt} [(1 - \tau)(F(K_t^N, K_t^U) - rD_t) - (1 - \tau z^N)p_t^N I_t^N - (1 - \tau z^U)p_t^U I_t^U + B_t] dt, \quad (1.3)$$

subject to,

$$\begin{aligned} \dot{K}_t^N &= I_t^N - \delta K_t^N - e^{-\delta T^N} I_{t-T^N}^N \\ \dot{K}_t^U &= I_t^U - \delta K_t^U + e^{-\delta T^N} I_{t-T^N}^N \\ \dot{D}_t &= B_t \\ B_{it} &\leq \phi(p_t^N I_t^N + p_t^U I_t^U). \end{aligned}$$

The prices of equivalent units of new and used machines are p_t^N and p_t^U .⁷ The stocks of new and used machines are K_t^N and K_t^U . I_t^N and I_t^U are investments in new and used machines. That is, I_t^U represents new acquisitions of previously-owned machines for an individual firm, or imports of used machines for the aggregate economy.

⁷One might think of p_t^N and p_t^U as the prices of machines that can provide the same (discounted) number of hours of service over their remaining lifetimes. Hours of service of new and used machines enter the production function as imperfect substitutes. Physical depreciation reduces the number of hours of service that a machine can provide per year.

The present values of the depreciation deductions available on newly purchased new and used machines are z^N and z^U . Other variables are as above.

The dynamics of the new and used capital stocks embed the assumption that newly manufactured machines remain “new” for a period of T^N years, at which point they become “used.” This somewhat crude formulation captures the notion that used machines may become less substitutable for new machines as they age, in addition to physically depreciating. This imperfect substitutability could come from a variety of sources. Perhaps technological changes are embodied in new machines, inducing changes in production processes that make old machines imperfect substitutes. Or perhaps fixed costs of transporting machines make it optimal for firms to deploy their newest, most reliable, machines to construction sites and keep older machines warehoused as backups.

The solution to (1.3) requires,

$$F_U(K_t^N, K_t^U) = p_t^U (r + \delta - \pi_t^U) \frac{1 - \tau(\phi + z^U)}{1 - \tau}, \quad (1.4)$$

where F_U denotes the first derivative of the production function with respect to the used capital stock. This expression is quite similar to the one derived in the previous section. A similar expression applies for the new capital stock,

$$F_N(K_t^N, K_t^U) = p_t^N (r + \delta + \tilde{\lambda}_t - \pi_t^N) \frac{1 - \tau(\phi + z^N)}{1 - \tau}, \quad (1.5)$$

where the term $\tilde{\lambda}_t$ captures the shadow cost or benefit incurred by buyers of new machines that is associated with their eventual transformation into used machines. These results are derived in an appendix, which also discusses the case where firms face explicit costs of adjusting their machinery stock.⁸

⁸In previous versions of the paper, I explicitly modeled the possibilities that contractors lease machines from third-party lessors and that buyers may resell machines prior to the end of their useful lives, triggering recapture of tax benefits. Both possibilities results in modifications to the user cost expressions in equations (1.4) and (1.5). If contractors lease machines from competitive lessors, it is the lessors’ tax variables that determine the user cost. If contractors or lessors sell machines before their useful lives end, triggering recapture of tax savings, then, essentially, z^N and z^U must be modified to reflect the value of recapture. Neither modification affects the empirical approach I take in this paper, so I omit them.

I will study substitution between new and used machines by considering the ratio of these equations. In the case where new and used machines are, in fact, perfect substitutes, then $F_U = F_N$ and $\pi_t^U = \pi_t^N - \tilde{\lambda}_t$. Taking logs of the ratio of (1.4) and (1.5) then produces,

$$\ln \frac{p_t^N}{p_t^U} = \ln \frac{1 - \tau(\phi + z^U)}{1 - \tau(\phi + z^N)}. \quad (1.6)$$

When new and used machines are perfect substitutes and both are used in production, their prices must be equal, unless taxes drive a wedge between them. These assumptions underlie the large literature based on the asset price approach to incidence cited previously.⁹

Suppose instead that new and used machines are combined to create a composite stock of machines such that,

$$F_t(K_t^N, K_t^U) = A_t[G_t(K_t^N, K_t^U)]^\alpha,$$

with $G_t(K_t^N, K_t^U)$ taking the familiar constant elasticity of substitution form,

$$G_t(K_t^N, K_t^U) = \left[(A_t^N K_t^N)^{\frac{\sigma-1}{\sigma}} + (A_t^U K_t^U)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}.$$

This formulation would allow, for example, production to take a Cobb-Douglas form in labor, materials, and the CES composite capital stock. Shocks to output prices, labor supply, labor productivity, total factor productivity, and the like are all captured as changes in A_t .

In this more general case, taking logs of the ratio of the marginal products of new and used capital produces,

$$\ln \frac{p_t^N}{p_t^U} = \ln \frac{1 - \tau(\phi + z^U)}{1 - \tau(\phi + z^N)} - \frac{1}{\sigma} \ln \frac{K_t^N}{K_t^U} + \frac{\sigma - 1}{\sigma} \ln \frac{A_t^U}{A_t^N} + \ln \frac{r + \delta - \pi_t^U}{r + \delta + \tilde{\lambda}_t - \pi_t^N}. \quad (1.7)$$

From the last three terms we see that the log ratio of new and used prices is inversely

⁹Eisfeldt and Rampini [2007] study a model where new and used capital are perfect substitutes in production, but used capital requires the payment of maintenance costs. Credit constraints can then create an additional wedge between their prices.

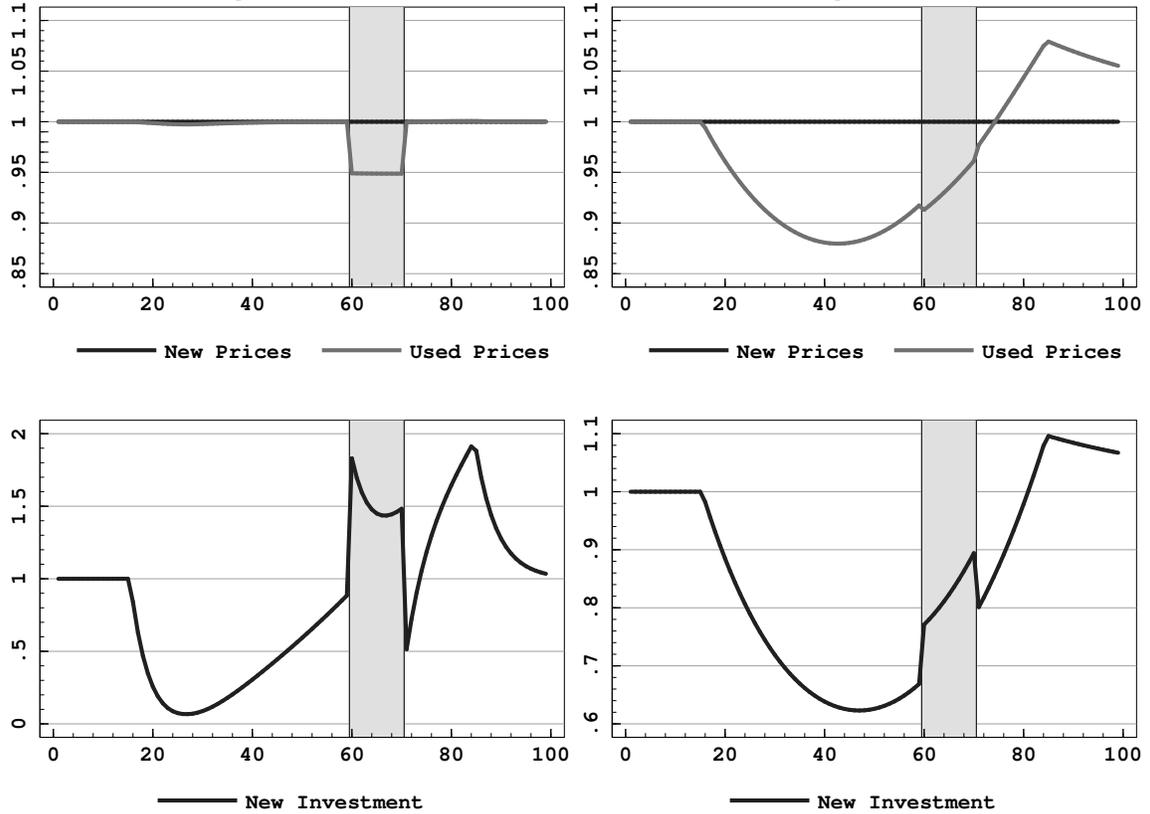
related to the log ratio of new and used capital and affected by time variation in relative productivity (A_t^U/A_t^N) and forecasted price changes (π_t^U , π_t^N , and $\tilde{\lambda}_t$). Note that when new and used capital are perfect substitutes, $A_t^U = A_t^N$, $\sigma \rightarrow \infty$, and (1.7) reduces to (1.6).

Most importantly, any difference in the tax treatment of new and used machines continues to drive a wedge between new and used prices, now conditionally on the chosen ratio of new and used capital. Figure 1-1 presents simulations of the path of used prices and new investment over the course of an unexpected downturn and recovery in A_t . This could represent, for example, a downturn and recovery in the demand for construction output. In the simulation, the value of A_t declines by 20% between period 15 and period 50, and rises back to its original level by period 85. The left panel of the figure simulates the case where $\sigma = 1000$, and the right panel simulates $\sigma = 3$. The path of A_t and the other parameters were chosen so that the $\sigma = 3$ case loosely matches the path of used prices and new investment in the US market for construction machinery in the late 1990s and early 2000s. These data will be discussed in subsequent sections of the paper. In the simulation, new machines are inelastically supplied at a constant price, and the stock of used machines depreciates but is otherwise constant ($I_t^U = 0$ in the model). Bonus depreciation worth 5% of the after-tax price of a new machine is in place between periods 60 and 70.¹⁰

In the left panel, where new and used machines are nearly perfect substitutes, the effect of bonus depreciation is quite visibly evident in the used price series. The price of used machines simply drops below the price of new machines by the value of bonus depreciation. In the right panel, where new and used machines are imperfect substitutes, effects of bonus depreciation on the used price series itself are less prominent. On the other hand, the general comovement of used prices and new investment over the course of the downturn is quite apparent. There is a clear shift in the relationship between used prices and new investment during the bonus depreciation episode, as

¹⁰The simulations assume that both the implementation and expiration of bonus depreciation were unanticipated by firms. Allowing firms to anticipate the expiration of bonus depreciation is straightforward and results in a more pronounced spike in new investment and decline in used prices just prior to expiration. There is little change in the relationship between these variables, however, so I ignore these changes for clarity.

Figure 1-1: Simulated New and Used Prices and Investment
Sigma = 1000 **Sigma = 3**



This figure simulates the effects of a downturn in demand for construction on the paths of new and used construction machine prices and investment in new machines. As described in the text, the output price variable A_t declines smoothly by 20% between periods 15 and 50, and rises back to its original level by period 85. New machines are inelastically supplied at a constant price, and the stock of used machines depreciates but is otherwise fixed. Bonus depreciation worth 5% of the after-tax new machine price is in place in the shaded regions between periods 60 and 70. The left panel presents the case where new and used machines are nearly perfect substitutes ($\sigma = 1000$). The right panel presents the case where $\sigma = 3$.

one would expect from equation (1.7). This shift will form the basis for an empirical test of the effects of bonus depreciation.

The movements in used prices induced by bonus depreciation in Figure 1-1 reflect the impact of investment in new machines on the marginal product of used machines. When new and used machines are imperfect substitutes, an increase in new investment may either increase or decrease the marginal product of used machines. In the model above, the marginal product of used capital is decreasing in new capital if and only if $\sigma(1 - \alpha) > 1$.¹¹ The existing literature on the asset price approach to incidence assumes that new and used capital are perfect substitutes ($\sigma \rightarrow \infty$), and thus that increased investment in new capital sharply decreases the marginal product of used capital. This paper will estimate σ and assess the validity of this assumption.

I will begin with empirical tests of the effects of bonus depreciation based on the perfect substitution assumption adopted in most of the literature. Sending $\sigma \rightarrow \infty$ in equation (1.7) produces,

$$\ln \frac{p_t^N}{p_t^U} = \ln \frac{1 - \tau(\phi + z^U)}{1 - \tau(\phi + z^N)} + \ln \frac{A_t^U}{A_t^N} + \ln \frac{r + \delta - \pi_t^U}{r + \delta + \tilde{\lambda}_t - \pi_t^n}. \quad (1.8)$$

I assume the final two terms on the right-hand side can together be represented as the sum of a flexible function of time and an idiosyncratic error term, $f(t) + \epsilon_t$. When bonus depreciation is not in effect, the first term on the right-hand side is equal to zero.¹² I will thus estimate equations of the form,

$$\ln \frac{p_t^N}{p_t^U} = \eta_0 \text{BONUS}_t + f(t) + \epsilon_t.$$

The dummy variable BONUS_t will take the value of 1 when bonus depreciation pro-

¹¹The derivative of the marginal product of used capital with respect to new capital is,

$$\frac{\partial^2 F(K^N, K^U)}{\partial K^U \partial K^N} = \alpha A_t A_t^U A_t^N \frac{\sigma(\alpha - 1) + 1}{\sigma} (K_t^U K_t^N)^{\frac{-1}{\sigma}} \left[(A_t^N K_t^N)^{\frac{\sigma-1}{\sigma}} + (A_t^U K_t^U)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma(\alpha-2)+2}{\sigma-1}}.$$

This quantity is negative if and only if $\sigma(1 - \alpha) > 1$.

¹²Even if ϕ or r vary across new and used assets when bonus depreciation is not in effect, this value will be absorbed by a level shift in the time-varying term. The BONUS dummy will still pick up the percentage change in the value of depreciation deductions for new equipment.

visions were in effect. The coefficient η_0 on this variable will measure $\ln(1 - \tau(\phi + z^U))/(1 - \tau(\phi + z^N))$, the value of bonus depreciation implied by market prices. Estimates of these equations will describe in a transparent manner the average wedge between new and used prices when bonus depreciation was in effect.

I will also present estimates based on,

$$\ln \frac{p_t^N}{p_t^U} = \eta_0 \text{BONUS}_t + \eta_1' X_t + f(t) + \epsilon_t, \quad (1.9)$$

where X_t is a set of variables taken to be exogenous to the market for construction machinery, and on,

$$\ln \frac{p_t^U}{p_t^N} = \eta_0 \text{BONUS}_t + \eta_1 \ln \frac{K_t^N}{K_t^U} + f(t) + \epsilon_t, \quad (1.10)$$

as well as the reverse version of the same equation,

$$\ln \frac{K_t^N}{K_t^U} = \eta_0 \text{BONUS}_t + \eta_1 \ln \frac{p_t^U}{p_t^N} + f(t) + \epsilon_t, \quad (1.11)$$

where $\ln p_t^U/p_t^N$ or $\ln K_t^N/K_t^U$ is instrumented with a subset of X_t .

Equation (1.9) can be interpreted in two ways. First, the coefficient on BONUS_t can be thought of as simply describing the mean of the wedge between new and used prices when bonus depreciation was in effect, now conditionally on variables that typically vary with this wedge. Second, the equation could be seen as the reduced form of a system of simultaneous supply and demand equations in $\ln p_t^U/p_t^N$ and $\ln K_t^N/K_t^U$. Equation (1.11), a rearrangement of (1.7), is the demand equation in this same system. Parameters of the reduced form equation can be consistently estimated by OLS estimation of (1.9). Parameters of the demand equation can be consistently estimated by instrumental variables estimation of (1.10) or (1.11). The coefficient on BONUS_t in (1.10) measures the value of bonus depreciation implied by observed market prices and investment. The coefficient on $\ln p_t^U/p_t^N$ in (1.11) measures σ , the elasticity of substitution between new and used machines.

Equation (1.11) also bears resemblance to investment equations based on “Q”

models of investment. On the left-hand side is the ratio of new capital to the stock of used capital. On the right-hand side is a measure of the wedge between the market value of a unit of existing capital and the cost of replacing that unit with new capital. In a Q model, this wedge is created by costs associated with adjusting the capital stock to its desired level, and the market value is measured using stock market valuations. In the current model, the wedge is created by the imperfect substitutability of used machines for new machines, and the market value is measured with the true market price of used machines. Fluctuations in demand for construction output will produce fluctuations in this wedge when the supply of new and used machines are not equally elastic. This difference in elasticities combines with imperfect substitution to play a role like that of adjustment costs in a Q model. It prevents firms from adjusting their capital stocks to equalize the marginal products of new and used capital.

Thus one could also interpret equation (1.11) as testing whether bonus depreciation affected investment, conditional on the information about construction demand contained in used machine prices. This exercise is similar in spirit to the approach taken by the empirical Q literature, particularly that of Desai and Goolsbee [2004]. It will be quite apparent in the data that used prices covary with new investment far more strongly than the stock market value measures used in the Q literature.

1.3.4 New Machine Price Data

Before presenting estimates, I discuss the data on new and used construction machinery prices. I use the Producer Price Index (PPI) component for construction machinery as a measure of new machine prices. Like the other PPI components, it is constructed by the Bureau of Labor Statistics based on monthly surveys of US manufacturers. The PPI measures the price received by the manufacturer, and thus it does not include things like excise taxes or dealer markups. The PPI does, however, capture the effects of manufacturer-to-customer price incentives like rebates and low-interest financing plans.¹³

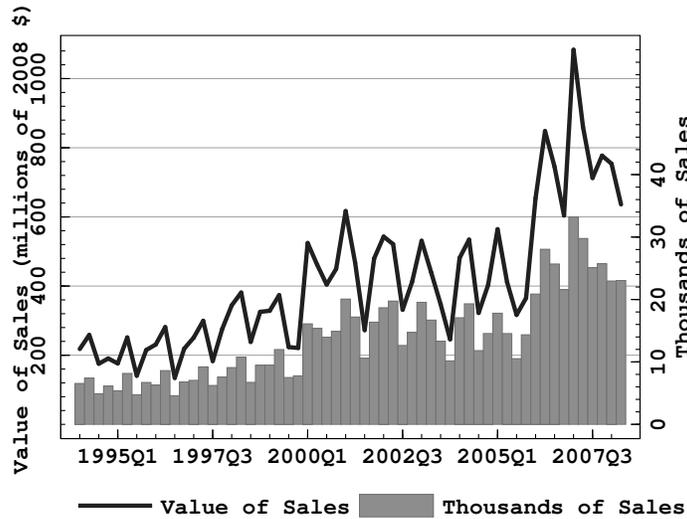
¹³According to the BLS Handbook of Methods, “Because the PPI is meant to measure changes in net revenues received by producers, changes in excise taxes—revenues collected on behalf of the

It is possible, unfortunately, that price changes relevant to the results of this paper may appear in dealer markups as well as manufacturer-to-dealer prices and manufacturer-to-customer incentives. It is also possible that the PPI surveys simply fail to capture some of the relevant movements in machine prices. I am not aware of any data that would permit systematic analysis of prices for new machinery in transactions between dealers and customers. Data from markets for new and used cars, however, can arguably bear on the likely importance of dealer markups and systematic measurement error for interpreting the results in this paper. The BLS collects PPI data on manufacturer-level new car prices and CPI data on retail-level new car prices. The CPI measure of new car prices includes dealer markups and manufacturer rebates, but excludes manufacturer financing incentives. The PPI measure includes manufacturer rebates and financing incentives, but excludes dealer markups. The PPI series fluctuates far more over the course of the model year cycle than does the CPI.¹⁴ The declines in PPI prices over each model year are about the same size as the declines in customer-level prices net of rebates and financing incentives that are documented by Copeland, Dunn, and Hall [2005] using detailed data on transactions between dealers and customers. Thus, on the assumption that data on cars are relevant for interpreting data on construction machines, it appears that the PPI should capture the vast majority of movements in the prices faced by potential buyers of new machines.

government—are not reflected in the index. But changes in rebate programs, low-interest financing plans, and other sales promotion techniques are reflected to the extent that these policies affect the net proceeds ultimately realized by the producer for a unit sale. If an auto manufacturer offers retail customers a rebate of \$500, the manufacturer’s net proceeds are reduced by \$500 and the PPI for new cars would reflect a lower price. . . . The statistical accuracy of producer price indexes depends heavily on the quality of the information voluntarily provided by respondents. BLS emphasizes to cooperating businesses the need for reports of realistic transaction prices, including all discounts, premiums, rebates, allowances, and so forth, rather than list or book prices. (Bureau of Labor Statistics [2008])”

¹⁴Over the 1994 to 2008 period, I find that a one percentage point increase in the new car CPI was associated with a 2.6 percentage point increase in the new car PPI, suggesting that fluctuations in manufacturer-to-customer financing incentives reflected in the PPI are at least 2.6 times as large as fluctuations in dealer markups reflected in the CPI. If these two sources of price changes were the only ones in the data, then the PPI would capture $2.6/3.6 = 72\%$ of price fluctuations. If other sources of fluctuations like the manufacturer-to-dealer price and manufacturer-to-customer rebates are reflected in both the PPI and CPI, then the PPI captures an even larger percentage of total price fluctuations.

Figure 1-2: Value and Number of US Sales in Dataset



As further evidence that PPI data reflect relevant price changes, Goolsbee [1998] reports large effects of tax incentives on new machine prices in similar data. He found that about one half of the value of investment tax credits were passed into manufacturers' prices of construction machines. At most, the remaining one half could have been passed into dealer markups or lost to inaccurate measurement.

1.3.5 Used Machine Price Data

Several firms collect data from auctions of construction machinery, farm machinery, and trucks. They sell or give the data to market participants who use them to make more informed buying and selling decisions. By far the largest number of sales observations are available for construction machines. I present results based on data from two firms. Equipment Watch sells online subscriptions to auction results beginning in 1996, and I obtained from them additional auction results beginning in 1994. Machinery Trader provides free online auction results from a larger set of auctions than Equipment Watch, and I collected data from their website for auctions beginning in 2006.

Figure 1-2 presents the number and total value of US machine sales appearing in the dataset in each quarter. In total, the dataset includes more than a million

Table 1.4:
Distribution of Prices

Percentile	Price
0.01	995
1	2,036
25	8,675
50	17,512
75	35,277
90	66,294
99	190,153
99.99	702,379

Prices are in PPI-
adjusted 2007 dollars.

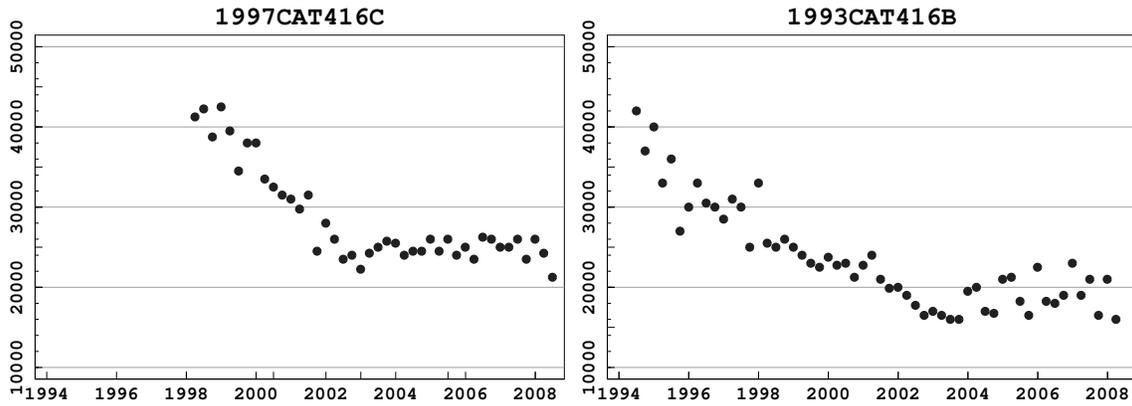
auction price observations. Note that the dataset is much smaller in earlier years, and grew larger as Equipment Watch began collecting results from a larger set of auctions. The dataset gets much larger again in 2006, when the Machinery Trader data become available. In most of the work that follows, I will be measuring price changes within machine make-model-year combinations, so there is little reason to suspect that changes in the sample of auctions from which data is collected will bias the results in any way. In any case, there is little visible relationship between the number of sales in the data in Figure 1-2 and the price indices presented later.

For each machine sold, the data include the make and model of the machine (e.g. Caterpillar 416C), the model year, the serial number, the sale price in US dollars, the state or country where the auction took place, the firm conducting the auction, and the date of the auction.¹⁵ About 74% of sales take place in the United States, 11% in Canada and Mexico, 10% in Europe, and 5% in Asia, Australia, or the Middle East. The model year and serial number are missing in 23% and 15% percent of observations, respectively, but the other fields are never missing.¹⁶ The data include no characteristics of the buyer or of the seller.

¹⁵The date listed is actually the first day of the auction at which the machine was sold. Some auctions last several days.

¹⁶Unreported regressions of a dummy variable indicating a missing model year on other sale characteristics show that there are only small variations over time in the propensity for the model year data to be missing, on the order of 1 to 2 percentage points. Thus it is unlikely that changes in the probability of the model year being reported could bias results.

Figure 1-3: Median Price of Cat 416 Vintages



Each dot is the median current-dollar sale price in a quarter with at least three sales.

Table 1.4 presents basic information on the distribution of prices of machines sold in the dataset. The first and ninety-ninth percentiles of the price distribution are about \$2,000 and \$190,000, respectively, in 2007 dollars. The median sale price is about \$17,000. Inspection of the data reveals that typical machines near the bottom of the price distribution include generators, air compressors, forklifts, personnel lifts, and wood chippers. Typical machines in the middle range of the data include quintessential construction machines like bulldozers, wheel loaders, excavators, backhoes, and skidsteers. The most expensive machines include large earth-moving equipment like scrapers and graders, along with particularly large bulldozers, excavators, and the like.

Some of the most frequently sold assets in the dataset are various vintages of the Caterpillar 416 backhoe loader. Backhoe loaders resemble a tractor with a loader bucket on the front for scooping loose material and a backhoe arm on the back for digging. They are used intensively on construction sites both large and small. There are about 10,000 Cat 416 sales in the dataset, ranging from the original 1986 Cat 416 through the 2007 Cat 416E.

Figure 1-3 plots simple median price series for two vintages of the Cat 416. The left panel shows that the 1997 Cat 416C began appearing on the used market in early 1998, selling for over \$40,000. Prices declined steadily to around \$25,000 by early 2003. Prices then held steady or even rose for several years, before arguably turning

downward after 2006. One could feasibly conclude from this panel that backhoe prices typically decline over their first six years of life and then flatten thereafter. The right panel dispels this notion by plotting a similar price series for the 1993 Cat 416B. These machines sold for over \$30,000 in 1996. Rather than flattening in their seventh year of life in 2000, 1993 Cat 416B prices continued to decline until early 2003, at which point they turned up for several years before declining again after 2006. One might surmise from these data that there was a general turn upward in used machine prices beginning in early 2003 and a turn downward after 2006, relative to what one would expect given the typical pattern of machine price depreciation.

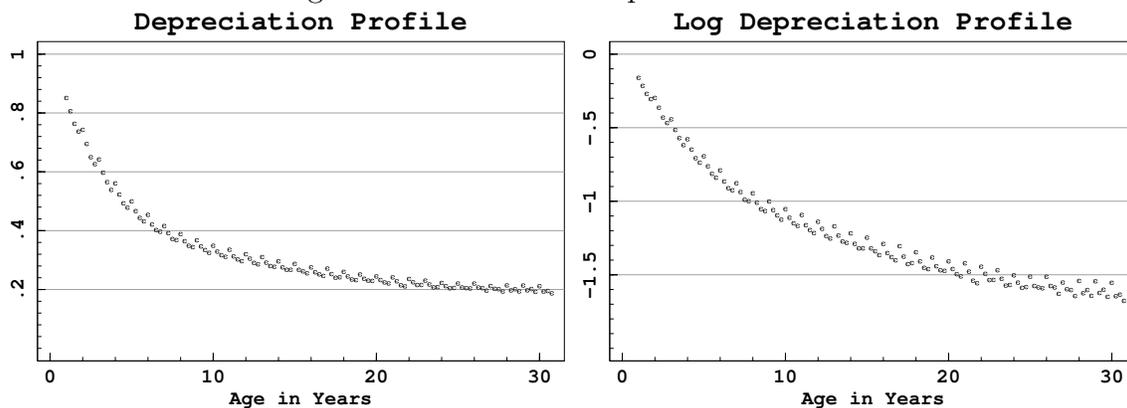
I create a price index to measure the time series variation in machine prices more formally. I regress the logs of machine prices on a set of dummies for assets (e.g. 1997 Cat 416C), age (e.g. 14 quarters old), and time (e.g. 2004Q2). The series of estimated time fixed effects is a detrended, quality-adjusted, and depreciation-adjusted price index for used machines. Any changes in machine quality over time—for example, between the 1993 Cat 416B and the 1997 Cat416C—are absorbed by the asset dummies. Price changes resulting from normal depreciation patterns are absorbed by the age fixed effects. The age fixed effects also absorb any average change in prices over time and any seasonality in prices.¹⁷

Figure 1-4 plots the estimated depreciation pattern.¹⁸ The left panel shows that, on average, machines lose about half of their value by their fifth year of life, and more than three-quarters of their value by their twentieth year. A small amount of seasonality is visible in the plot. The right panel plots the same data on a log scale. If machines depreciated geometrically, this plot would approximate a straight line. Although it is clearly not straight, I have made no attempt to correct for selection out of the sample of lower quality machines, nor for repair and refurbishment, both of which would tend to bias the estimated pattern upward.

¹⁷Only the year in which a machine was manufactured is observable. So, for example, the seventh quarter of a machine's life, as I measure it, will always fall in the third quarter of the year.

¹⁸It is possible to estimate depreciation patterns separately by machine types (e.g. backhoes, excavators, etc.) or even by asset (e.g. Cat 416) but it has little impact on results.

Figure 1-4: Estimated Depreciation Pattern



1.3.6 Estimation Results

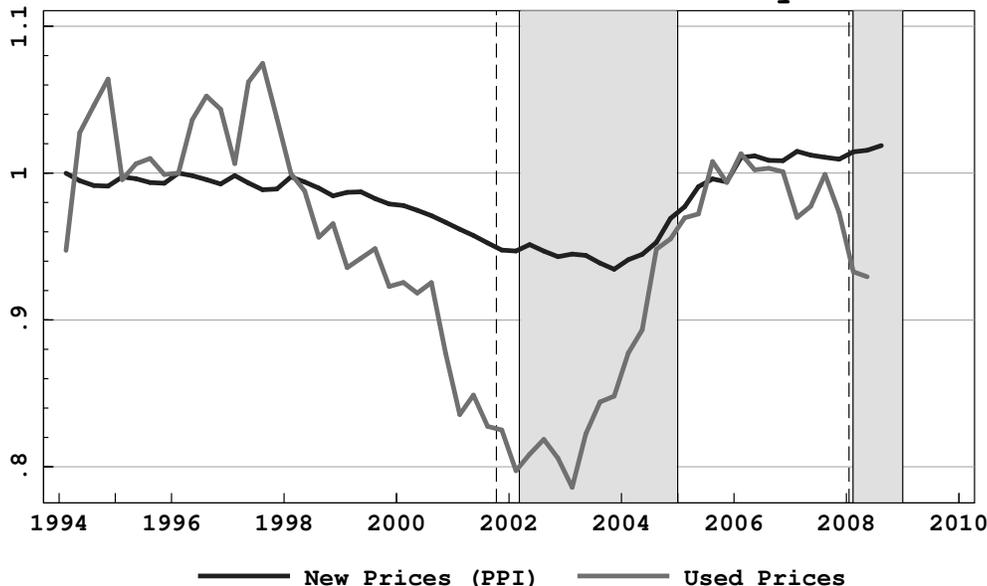
Figure 1-5 presents my index of used construction machinery prices graphed against a detrended version of the PPI for new construction machinery.¹⁹ Both series are indexed to 1996Q1. It is immediately clear from the figure that used prices declined far more than new prices around the 2001 recession and during the current housing downturn. Used prices fell and rose more than 20% over the 2001 recession cycle, while new prices fell only 7%.

It is also clear from the figure, however, that there is no transparent relationship between bonus depreciation and the gap between new and used prices. The relative price of used machines began to fall as early as 1997, long before the enactment of the first round of bonus depreciation. From 1998Q1 to 2001Q2, used prices fell by 15%, while new prices fell by only 4%. There is no reason to think this decline in relative used prices reflects anticipated effects of bonus depreciation. Discussion of an economic stimulus package involving incentives for business investment began only after the terrorist attacks of September 11, 2001. On October 5, 2001, President Bush mentioned the need to “stimulate investment by allowing for enhanced expensing of capital expenditures.” On October 11, HR 3090, which included 30% bonus

¹⁹One might consider weighting the machinery types in the dataset of used prices so that the basket of machines comprising the used price index is comparable to that comprising the PPI. It appears, however, that the various machinery types in the used data exhibit similar movements in prices over time, so such a weighting would make little difference.

Figure 1-5:

New vs. Used Construction Machinery Prices



Both series are detrended and indexed to 1996Q1.
 Bonus depreciation was first proposed at the dashed lines and was in place during the shaded periods.

depreciation, was introduced in the House of Representatives. A Senate bill introduced on October 24 included only 10% bonus depreciation. Bonus depreciation was eventually passed by both Houses and signed by President Bush on March 9, 2002. From 2002Q1 to 2004Q4, while bonus depreciation was in effect, relative used prices increased sharply. Used prices rose by 18.8% over this period, while new prices rose by 2.4%. These facts do not support the notion that bonus depreciation drove down the relative price of used machines.

Table 1.5 presents estimates of,

$$\ln \frac{p_t^N}{p_{it}^U} = \eta_0 + \eta_1 \text{BONUS}_t + \eta_2' X_t + f(t) + g(\text{AGE}_{it}) + \epsilon,$$

from the sample of US used machine sales. The dependent variable is the logarithm of the ratio of the PPI for new machines to the sale price of used machine i . All specifications include dummies for the age of machine i to absorb depreciation patterns, as in the estimation of the price index just described. Each column of Table 1.5 presents results from a different regression.

Table 1.5: Regressions of New to Used Price Ratio on Bonus Depreciation Indicator, Time Controls, and Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
Time Controls	None	Quadr. Trend	Year FE	None	Quadr. Trend	Year FE
BONUS	.025 (.012)**	.012 (.013)	-.004 (.017)	-.009 (.011)	-.002 (.011)	.006 (.021)
Construction Spending				-.181 (.024)***	-.170 (.021)***	-.173 (.044)***
Steel Price				-.149 (.049)***	-.188 (.048)***	.047 (.054)
Prime Rate				-.079 (.019)***	-.071 (.019)***	-.059 (.024)**
Exchange Rate				.260 (.065)***	.312 (.058)***	.209 (.074)***
Observations	488732	488732	488732	488732	488732	488732

This table presents OLS estimates of the equation,

$$\ln \frac{p_t^N}{p_{it}^U} = \eta_0 + \eta_1 \text{BONUS}_t + \eta_2' X_t + f(t) + g(\text{AGE}_{it}) + \epsilon_t.$$

The dependent variable is the logarithm of the ratio of the PPI for new machines to the sale price of used machine i .

BONUS takes the value of 1 when 50% bonus depreciation is in effect and 0.6 when 30% bonus depreciation is in effect. A positive coefficient on BONUS would provide evidence that bonus depreciation drove down the relative price of used machines.

All specifications include used machine age dummies. Columns 1 and 4 include no control for time trends. Columns 2 and 5 include a quadratic time trend. Columns 3 and 6 include year dummies. Standard errors are clustered by asset and month.

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

The estimated coefficient on BONUS in column 1, equal to 2.5%, is simply the mean additional wedge between new and used machine prices when bonus depreciation was in effect. However, it is clear in Figure 1-5 that bonus depreciation was enacted when a large wedge between new and used prices had already developed. Thus the column 1 coefficient would be biased upward if one interpreted it as an estimate of the causal effect of bonus depreciation on relative used prices. Perhaps the simplest way to mitigate this bias is to include additional regressors that may explain variation in relative prices that occurred contemporaneously with bonus depreciation.

Column 2 includes a quadratic function of time, so the effect of bonus depreciation is identified only from price movements relative to a smooth underlying trend. Column 3 includes year fixed effects so the coefficient on BONUS is identified only from price movements within years where bonus depreciation was enacted or changed. Columns 4 to 6 include a set of controls for the logarithms of new residential construction spending, steel prices, trade-weighted exchange rates, and the bank prime lending rate. These variables can quite reasonably be considered exogenous to the price of construction machinery. Construction spending in the United States totals well over one trillion dollars per year. If the user cost on the \$150 billion stock of construction machinery were \$30 billion per year, the cost of machinery would account for at most 3% of construction spending. The construction machinery manufacturing industry purchases about 1.2% of US steel output, according to data from the Input-Output Accounts of the Bureau of Economic Analysis. One would thus expect shocks to the price of construction machinery to have a negligible impact on construction spending or steel prices.

Reading across the top row of Table 1.5, it is clear that these rather simple sets of controls are sufficient to reduce the estimated effect of bonus depreciation essentially to zero. In column 4, with year fixed effects, the coefficient on bonus is reduced to -0.4%. In column 5, with no time controls but including the other controls, the estimated coefficient is -0.6%. In column 6, with a quadratic trend and the additional controls, the estimated coefficient is 0.2%.

I am interested in the range of plausible coefficient values that can be rejected, so

I pay particular attention to the estimation of standard errors for the coefficients in Table 1.5. The functions of time included in specifications in Table 1.5 are common to all assets, so it is likely that errors are correlated over time within assets when asset-specific time trends may differ from aggregate trends. Thus it is appropriate to calculate standard errors robust to an arbitrary form of within-asset error correlation. The dependent variable for all specifications in Table 1.5 is the log of a ratio where the numerator varies only at a monthly frequency. Thus it is also appropriate to allow for arbitrary within-month correlation of errors across assets. The standard errors in Table 1.5 are robust to correlation both within assets across months and within months across assets. These are calculated with the method proposed by Thompson [2006] and Cameron, Gelbach, and Miller [2007], which extends the familiar “clustering” method of Arellano [1987] to allow for multiple dimensions of within-group error correlation.

Clustering by month raises the standard errors by an order of magnitude relative to unclustered, unreported results, but the upper bounds of the 95% confidence intervals for the coefficients in Table 1.5 are still small. The very largest estimate, in column 1, has a 95% confidence interval bounded above by 5%. The estimate in columns 4 and 5 have confidence intervals bounded above by 1.3% and 2.0%, respectively.

Table 1.6 tests the robustness of results by replicating the regression in column 5 for several subsamples of the used sales observations. Column 1 limits the sample to backhoes, excavators, bulldozers, and loaders from the three largest US manufacturers in the data—Caterpillar, Deere, and Case. Columns 2, 3, and 4 limit the sample to machines that are 20, 10, and 5 years old or younger. Columns 5, 6, and 7 limit the sample to assets with 10 or more, 50 or more, and 100 or more sales observations in the dataset.

Results from these robustness tests are centered around the Table 1.5 result of -0.2%. They range from 0.8% in column 1 to -1.1% in column 3. Upper bounds on 95% confidence intervals range from 3.0% in column 1 to 1.1% in column 3. Again there is little evidence to support a tax-induced wedge between new and used prices, and standard errors can rule out large effects.

Table 1.6: Regressions of New to Used Price Ratio on Bonus Depreciation Indicator, Time Controls, and Covariates: Subsample Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Major Assets	≤ 20 Years	≤ 10 Years	≤ 5 Years	≥ 10 Sales	≥ 50 Sales	≥ 100 Sales
BONUS	.008 (.011)	-.002 (.011)	-.011 (.011)	-.007 (.014)	-.001 (.011)	-.003 (.011)	.004 (.010)
Construction Spending	-.147 (.020)***	-.184 (.020)***	-.204 (.018)***	-.165 (.021)***	-.164 (.021)***	-.141 (.021)***	-.122 (.023)***
Steel Price	-.210 (.044)***	-.174 (.045)***	-.139 (.041)***	-.107 (.043)**	-.185 (.047)***	-.173 (.048)***	-.158 (.049)***
Prime Rate	-.055 (.019)***	-.061 (.019)***	-.059 (.018)***	-.042 (.021)**	-.070 (.019)***	-.068 (.019)***	-.055 (.019)***
Exchange Rate	.266 (.062)***	.330 (.058)***	.307 (.056)***	.236 (.056)***	.317 (.058)***	.290 (.061)***	.299 (.062)***
Observations	174653	443482	329868	135839	367898	197158	111398

This table presents OLS estimates of the equation,

$$\ln \frac{p_t^N}{p_{it}^U} = \eta_0 + \eta_1 \text{BONUS}_t + \eta_2' X_t + f(t) + g(\text{AGE}_{it}) + \epsilon_t.$$

The dependent variable is the logarithm of the ratio of the PPI for new machines to the sale price of used machine i .

Column 1 limits the sample to backhoes, excavators, bulldozers, and loaders from the three largest US manufacturers. Columns 2, 3, and 4 limit the sample to machines that are 20, 10, and 5 years old or younger. Columns 5, 6, and 7 limit the sample to assets with 10 or more, 50 or more, and 100 or more sales observations in the dataset. All specifications include used machine age dummies and a quadratic time trend. Standard errors are clustered by asset and month.

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

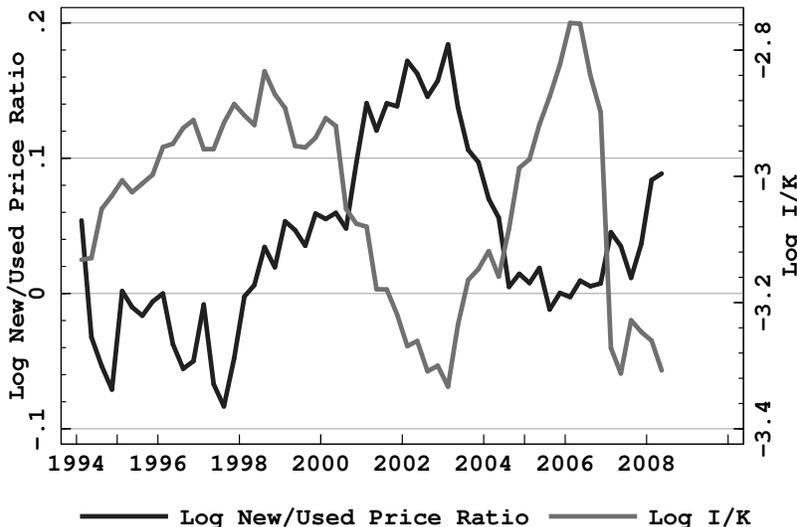
I showed above that if new and used machines are CES substitutes, the tax-induced wedge between new and used prices may appear only conditionally on chosen levels of new and used capital. The large divergence between new and used prices in Figure 1-5 suggests that new and used machines are indeed imperfect substitutes. In particular, I showed that firms will choose investment such that,

$$\ln \frac{p_t^N}{p_t^U} = \ln \frac{1 - \tau(\phi + z^U)}{1 - \tau(\phi + z^N)} - \frac{1}{\sigma} \ln \frac{K_t^N}{K_t^U} + f(t) + \epsilon_t,$$

where σ is the elasticity of substitution between new and used capital. In the empirical work that follows, I will assume that the stock of new capital, K_t^N is simply equal to new investment in the current period. Figure 1-6 graphs the log ratio of new and used prices against the log ratio of new investment to the existing capital stock. It is

Figure 1-6:

Log New/Used Price Ratio and Investment Ratio



clear that the two series indeed have a strong negative covariance. The data used to construct the investment ratio are described in greater detail in Section 4.

Table 1.7 presents estimates of the price wedge from bonus depreciation that explicitly allow for the possibility that new and used capital enter the production function as imperfect substitutes. Columns 1 through 4 present estimates of,

$$\ln \frac{p_t^U}{p_t^N} = \eta_0 \text{BONUS}_t + \eta_1 \ln \frac{I_t^N}{K_t^U} + f(t) + \epsilon_t.$$

Columns 5 through 7 present the reverse regression,

$$\ln \frac{I_t^N}{K_t^U} = \tilde{\eta}_0 \text{BONUS}_t + \tilde{\eta}_1 \ln \frac{p_t^U}{p_t^N} + \tilde{f}(t) + \tilde{\epsilon}_t.$$

The bottom line presents estimates of the value of bonus depreciation. In columns 1 to 4, this is η_0 ; in columns 5 to 7 it is $-\tilde{\eta}_0/\tilde{\eta}_1$. The penultimate line presents estimates of σ , the elasticity of substitution between new and used machines. In columns 1 to 4, this is $-1/\eta_1$; in columns 5 to 7, it is $-\tilde{\eta}_1$.

Columns 1 through 3 present OLS estimates with the price ratio as the dependent variable and three different sets of time controls. Thus they are quite similar in

Table 1.7: Forward and Reverse OLS and IV Regressions of the Ratio of New to Used Prices on Bonus Depreciation Indicator and the Ratio of New Investment to Used Capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Variable	Log $\frac{p^N}{p^U}$	Log $\frac{p^N}{p^U}$	Log $\frac{p^N}{p^U}$	Log $\frac{p^N}{p^U}$	Log $\frac{I}{K}$	Log $\frac{I}{K}$	Log $\frac{I}{K}$
Time	None	Quadr.	Year	None	None	Quadr.	Year
Controls		Trend	FE			Trend	FE
Estimator	OLS	OLS	OLS	2SLS	2SLS	2SLS	2SLS
BONUS	.017 (.010)*	.004 (.009)	-.0005 (.018)	.010 (.014)	.016 (.030)	.004 (.028)	.125 (.103)
Log I/K	-.247 (.027)***	-.244 (.022)***	-.030 (.025)	-.512 (.049)***			
Log Price Ratio					-1.838 (.187)***	-2.603 (.197)***	-5.546 (3.88)
Observations	486649	486649	486649	486649	486649	486649	486649
Implied Sigma	4.044	4.102	33.171	1.952	1.838	2.603	5.546
Bonus Value	.017	-.004	.0005	.010	.009	.002	.022

Columns 1 through 4 present estimates of, $\ln \frac{p_t^U}{p_t^N} = \eta_0 \text{BONUS}_t + \eta_1 \ln \frac{I_t^N}{K_t^U} + f(t) + \epsilon_t$.

Columns 5 through 7 present the reverse regression, $\ln \frac{I_t^N}{K_t^U} = \tilde{\eta}_0 \text{BONUS}_t + \tilde{\eta}_1 \ln \frac{p_t^U}{p_t^N} + \tilde{f}(t) + \tilde{\epsilon}_t$.

The bottom line presents estimates of the value of bonus depreciation. In columns 1 to 4, this is η_0 ; in columns 5 to 7 it is $-\tilde{\eta}_0/\tilde{\eta}_1$. The penultimate line presents estimates of σ , the elasticity of substitution between new and used machines. In columns 1 to 4, this is $-1/\eta_1$; in columns 5 to 7, it is $-\tilde{\eta}_1$. 2SLS estimates use the steel price and trade-weighted exchange rate as instruments. Standard errors are clustered by asset and month using the method of Cameron, Gelbach, and Miller (2007).

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

spirit to the estimates presented in Tables 1.5 and 1.6. The coefficient on BONUS measures the mean increase in relative new prices when bonus depreciation was in effect, conditional on a variable known to covary strongly with the price ratio—in this case, the ratio of new investment to used capital. Again the estimated effect of bonus depreciation is close to zero when including quite simple controls for underlying trends.

These equations, however, could also be considered relative demand equations in a system of simultaneous supply and demand equations. Consistent estimation of their parameters would thus require instrumental variables that shift the relative supply of new and used machines without otherwise affecting relative demand. Columns 4

presents two-stage least squares estimates where the investment ratio is instrumented with the price of steel and the trade-weighted exchange rate. Identification requires that these variables contain information about the relative supplies of new and used machinery, but do not contain information about relative demand for new and used machinery.

Columns 5 through 7 present instrumental variables estimates of the “reverse” equation of the log investment ratio on the log price ratio. These estimates serve two purposes. First, they are a robustness check on the results in Column 4. When instruments are valid, the coefficient on the investment ratio in Column 4 should be the inverse of the coefficient on the price ratio in Column 5.²⁰ Second, they illustrate the potential interpretation of results as a modified version of a Q equation for investment, as discussed previously. Results measure how much the investment ratio changed during bonus depreciation, conditional on the information on demand for construction output contained in the relative price of used construction machinery. The estimates of σ from the forward and reverse instrumental variables regressions in columns 4 and 5 are quite similar, suggesting that the instruments perform well. The estimated effects of bonus depreciation in the bottom row of Table 1.7 are again quite close to zero.

To summarize, Tables 1.5, 1.6, and 1.7 have presented estimates of the effect of bonus depreciation on the ratio of new to used machine prices under a variety of different assumptions. The estimated effects are clustered close to zero. Standard errors permit the rejection of estimates larger than 2 to 3% in many specifications. In Table 1.3, I showed that a neoclassical model would predict effects greater than 5% under quite reasonable parameter values. I conclude that the data suggest that firms behaved as if they placed a considerably lower value on bonus depreciation than the neoclassical model would predict. I discuss further departures from the neoclassical model which could explain this discrepancy in the conclusion of the paper.

Estimates of the elasticity of substitution between new and used machines in Table 1.7 are quite low, ranging from about 2 to 4 in most specifications. These results are

²⁰Hahn and Hausman [2002] provide a formal test based on this idea.

driven by the simple fact that investment in new machinery remains fairly high even when there are substantial declines in the relative price of used machines. If new and used machines were nearly perfect substitutes, few firms would invest in new machines when used prices fall in relation to new prices. These results suggest that the perfect substitution assumption adopted in much of the literature based on the asset price approach to incidence is too stark—a proliferation of new capital in response to tax incentives will have more modest effects on the marginal product of used capital than is typically assumed.

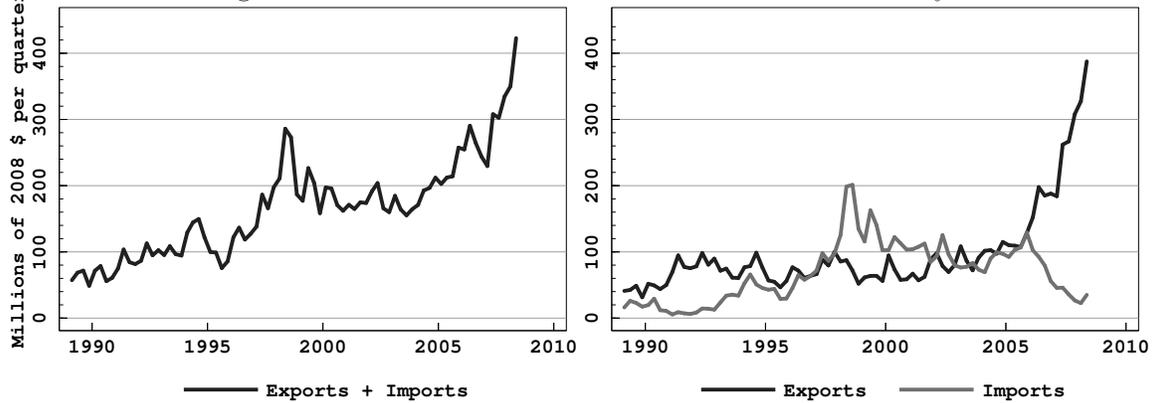
1.4 The Supply of Construction Machines

To complete a picture of the effects of tax incentives in the market for construction machines, this section turns to the other side of the market—the supply of machinery. The vast majority of the literature on taxes and investment derives and estimates investment demand equations and pays little attention to the supply of investment goods. A notable exception is Goolsbee [1998], who points out that if the supply of new capital is not perfectly price elastic, tax-induced demand shifts will be reflected in capital goods prices, as well as quantities. He estimates large pass-throughs of tax incentives into equipment prices and low price elasticities of supply.²¹ His estimates of tax pass-through in construction machinery prices are quite close to those estimated on the pooled sample of all assets, suggesting that construction machinery supply elasticities are typical of other equipment types.

I provide evidence in this paper that is directly at odds with Goolsbee’s estimates. First, I point out that imports and exports of used machinery provide a channel for supply adjustment that does not require manufacturers to scale production up or

²¹Hassett and Hubbard [1998] argue that Goolsbee’s regression results are not robust when run in first differences, and Whelan [1999] argues that they are not robust to including controls for materials prices. The first result may ignore useful information in the levels relationship and exacerbate classical measurement error. The second result relies on the exogeneity of materials prices. In many specifications in both papers, standard errors are large enough that Goolsbee’s original results cannot be rejected. Shea [1993] estimates upward-sloping supply curves for most of the manufacturing industries in his sample, but downward sloping supply curves for construction machinery and aircraft manufacturing, the only investment goods in his sample. He concludes that, “further research into the nature of equipment supply curves seems warranted,” to explain his anomalous results.

Figure 1-7: US Trade in Used Construction Machinery



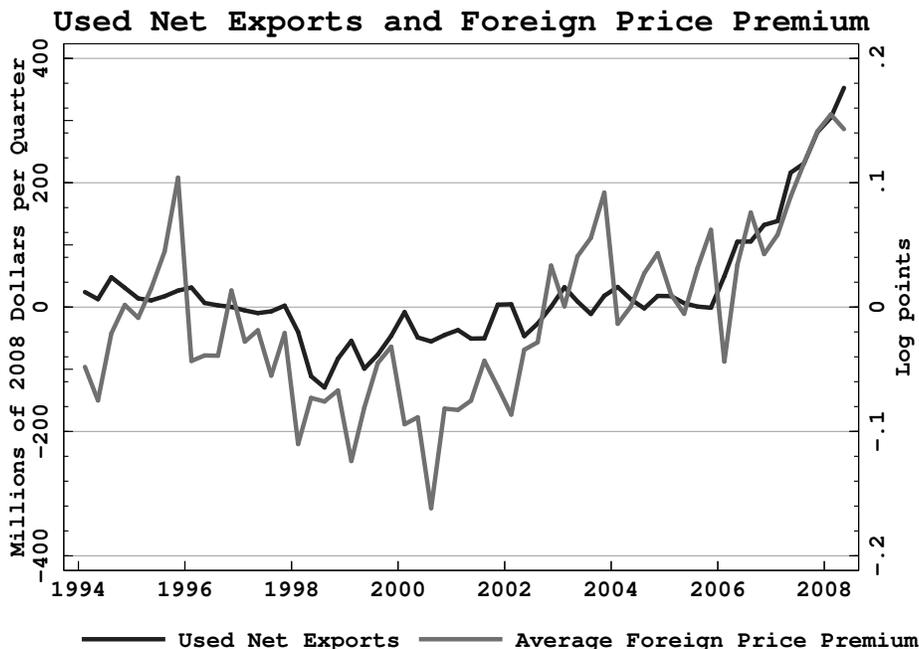
down. I provide the first estimates of the price sensitivity of net exports of used machines by constructing international used machinery price indices from the auction sales data discussed previously. Then I provide new estimates of the price elasticity of the total supply of construction machines. The recent boom and bust in US housing markets provide particularly stark evidence on the ability of machinery supply to expand and contract with little impact on prices.

1.4.1 Net Exports of Used Machines

In this section, I argue that imports and exports of used construction machines have grown to become an important component of movements in the total supply of machinery to the United States. I make use of Census Bureau data tracking US imports and exports of used machinery. These data come from a census of all goods passing into or out of the United States through US Customs and Border Protection. Figure 1-7 presents data on US imports and exports of used construction machinery for the period since 1989, when consistent data are available. The left panel shows that real gross flows of used machines have grown by 600% since 1989. The right panel shows that the most recent increase in gross flows is driven by an unprecedented surge in exports.

Figure 1-8 graphs net exports of used construction machinery alongside a measure of the average price difference between foreign markets and the United States

Figure 1-8:



constructed from the auction price data discussed previously. The series clearly move together, particularly in the latter part of the sample, where foreign sales observations are more prevalent. Since early 2006, the average price of used machines in foreign markets has risen almost 15% above the US price. This steady rise coincided with a steady and unprecedented increase in net exports of used machinery.

Table 1.8 presents regression estimates of a simple equation relating total net exports to used machinery price differentials between the United States and several foreign regions,

$$I_t^X = \eta_0^X + \sum_c [\eta_{1c}^X (p_t^{cU} - p_t^U)] + \epsilon_t^X, \quad (1.12)$$

where p^{cU} represents the price of used machines in region c . The foreign price premia on the right hand side are calculated for three regions—Europe, Asia, and Canada and Mexico combined. For example, the first coefficient in the table indicates that a ten percentage point increase in the gap between Canadian and US prices would induce exports to Canada of 120 million dollars per quarter. The first and second columns present estimates for the entire 1994Q1 to 2008Q2 period for which data are available. The third and fourth columns present estimates for 2004Q1 to 2008Q2,

Table 1.8: Regressions of Net Exports of Used Construction Machinery on the Premium of Foreign Prices over U.S. Prices

	(1)	(2)	(3)	(4)
Estimator	OLS	2SLS	OLS	2SLS
Sample Begins	1994	1994	2004	2004
Canada and Mexico Price Premium	1212.3 (389.8)***	1563.7 (246.5)***	1469.0 (209.7)***	1434.6 (193.5)***
Europe Price Premium	332.4 (109.4)***	341.8 (108.8)***	744.4 (110.9)***	783.6 (121.4)***
Asia Price Premium	60.3 (54.7)	-5.2 (77.6)	251.6 (95.6)***	268.6 (120.1)**
Observations	58	58	18	18

This table presents estimates of,

$$I_t^X = \eta_0^X + \sum_c [\eta_{1c}^X (p_t^{cU} - p_t^U)] + \epsilon_t^X,$$

The dependent variable is net exports of used construction machinery in millions of 2008 dollars per quarter. Columns 1 and 2 use the full sample from 1994Q1 to 2008Q2. Columns 3 and 4 use only 2004Q1 to 2008Q2. Columns 2 and 4 instrument for the price premia with exchange rates. Standard errors are Newey-West with a lag length of 2.

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

where the relationship between price premia and exports appears most apparent in the chart. The coefficient on the Canada/Mexico vs. US price premium changes little or even decreases over time, while we see that the Europe and Asia price premia predict export flows more strongly in the latter part of the sample. This result is consistent with greater integration of distant global markets over time, but it is likely driven in part by improved measurement of the foreign price series as the number of foreign sales in the dataset increases.

One would suspect that both simultaneity and measurement error could bias the OLS coefficients downward. A positive shock to exports to Canada would require a price decline in Canada to equilibrate Canadian demand, so the Canadian price will be negatively correlated with the disturbance in equation (1.12). Plus, there are far fewer observations for foreign auctions than US auctions in the dataset, so the foreign price series appear much more volatile than the US series, suggesting they are measured poorly. To address both issues, Columns 2 and 4 present estimates where

the price premia are instrumented with US trade-weighted exchange rates, along with exchange rates for Canada, the UK, China, and Japan. The Canada/Mexico coefficient for the entire sample increases modestly when instrumented, but the other coefficients change little.

Taking the sum of the coefficients in the final column indicates that a *ceteris paribus* ten percent increase in US used prices would induce additional net imports of about \$249 million per quarter. In a regression not reported, I estimate that a 10% increase in US new prices is associated with a 28.2% increase in US used prices. Thus we would expect a 10% increase in US new prices to induce a \$702 million increase in used imports. This figure represents about 13% of total US investment in construction machinery in 2008Q2. To put this number in perspective, recall that Goolsbee [1998] estimated a price elasticity of supply of about 1, suggesting that a 10% increase in new prices would induce a 10% increase in total supply. Thus, I find that the responsiveness of used net exports alone is as large as the total supply response estimated by Goolsbee [1998].

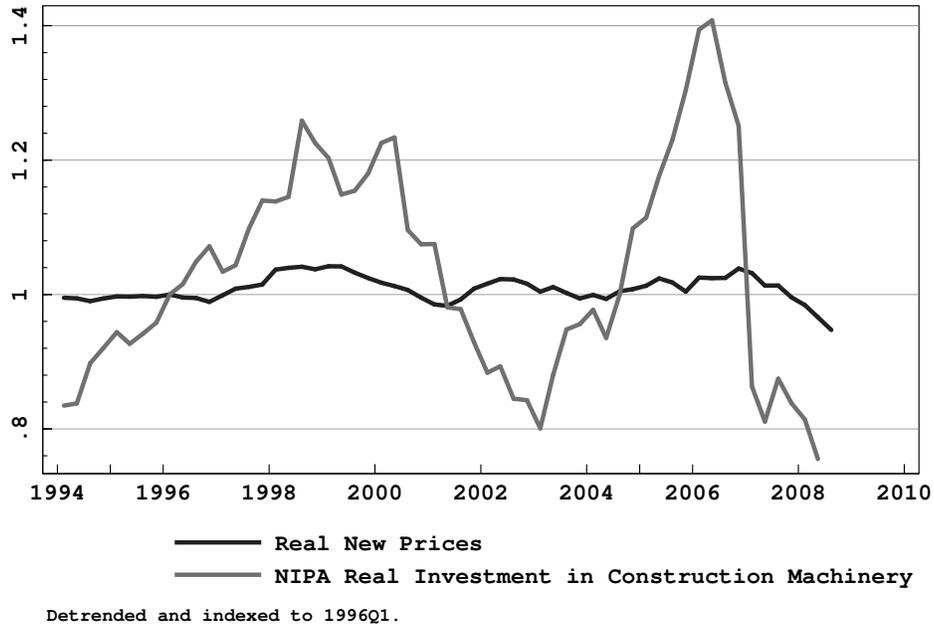
1.4.2 The Total Supply of Machines

Finally, I turn to estimates of the price elasticity of the total quantity of machinery supplied to the US market. As a measure of total investment in machines, I use data on real investment in construction machinery from the Fixed Assets Accounts of the Bureau of Economic Analysis. These data are based on the monthly “M3” survey of domestic manufacturers conducted by the Census Bureau. The BEA takes shipments reported in the M3 and adjusts them for imports and exports of new and used machines using the Census Bureau trade data just described. They then create measures of real investment using price indices based on the PPI.

Figure 1-9 presents the new and used price indices from Figure 1-5 deflated by the PPI finished goods index, along with the measure of investment in new construction machinery from the National Income and Product Accounts. All are detrended and indexed to 1996Q1. It is immediately clear from the figure that percentage fluctuations in new investment are far larger than fluctuations in prices. New investment

Figure 1-9:

Construction Machinery Prices and Quantities



increased by about 80% from its trough in 2003Q1 to the peak of the housing expansion in 2006Q2, while new machinery prices increased by only 5% from trough to peak, and used machinery prices increased by 20% from trough to peak. With large swings in the quantity supplied contemporaneous with far smaller swings in prices, it is clear that I will estimate large elasticities of supply.

Figure 1-10:

Private Residential Construction Spending

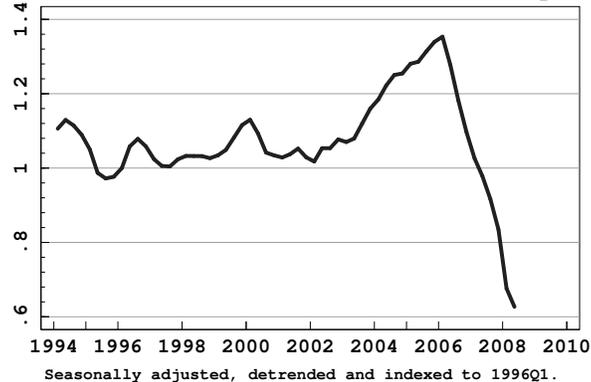


Table 1.9: OLS and IV Regressions of Log NIPA Investment in Construction Machinery on Log New Machine Prices and Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
Estimator	OLS	OLS	2SLS	2SLS	2SLS	2SLS
Instrument	–	–	Spending	Spending	Starts	Starts
Log Real New Machine Price	5.35 (.88)***	3.26 (1.49)**	14.69 (3.41)***	27.03 (11.31)**	12.30 (2.08)***	24.68 (10.35)**
Log Real Steel Price	-.17 (.14)	.70 (.19)***	.20 (.24)	-.96 (.88)	.16 (.20)	-.66 (.81)
Log Real Wage	-.29 (.67)	-.25 (.63)	-1.33 (.98)	-2.79 (1.72)	-.47 (.69)	-1.99 (1.35)
Log Prime Rate	.27 (.11)**	.10 (.13)	-.07 (.16)	-.53 (.35)	.07 (.12)	-.32 (.28)
Log Real Oil Price		.15 (.18)		1.41 (.64)**		1.33 (.62)**
Log Exchange Rate		1.03 (.45)**		-.29 (1.13)		.42 (.94)
Log Real GDP		3.78 (1.87)**		2.97 (4.25)		.82 (3.99)
Observations	70	70	62	62	70	70

This table presents estimates of,

$$\ln I_t^N = \eta_0 + \eta_1 \ln p_t^N + \eta_2' \text{COST}_t + \epsilon_t^S.$$

The dependent variable is the log of NIPA real investment in construction machinery. Columns 1 and 2 are OLS estimates. Columns 3 and 4 instrument for the new machine price with the log of real residential construction spending. Columns 5 and 6 instrument for the new machine price with the log of housing starts.

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

Table 1.9 presents estimates of a simple supply equation,

$$\ln I_t^N = \eta_0 + \eta_1 \ln p_t^N + \eta_2' \text{COST}_t + \epsilon_t^S,$$

where COST_t is a vector of variables that may shift the cost of producing machines. Column 1 of Table 1.9 presents OLS estimates of the supply relationship over the 1990Q1 to 2008Q2 sample for which the BEA data are available quarterly. Column 2 presents estimates including an additional set of regressors. The estimated supply elasticities in these equations are 5.35 and 3.26. These are already considerably larger than the Goolsbee estimates around 1.

One would further expect the OLS estimates to be biased downward in a textbook simultaneous equations setting like this one. Positive shocks to supply must be accompanied by decreases in price for demand to equilibrate with supply, so price is negatively correlated with the error term in the supply equation. Consistent estimation of the supply relationship requires instruments that shift demand without otherwise affecting supply.

Columns 3 through 6 of Table 1.9 estimate the supply elasticity using measures of residential construction activity as an instrument for the new machine price. Figure 1-10 presents data on private residential construction spending over the relevant period. While the series was relatively flat from 1994 to 2003, it rose approximately 30% between mid-2003 and 2006Q1. It then entered a dramatic decline, which has not yet ended. These dramatic swings in housing construction provide a source of variation useful in identifying the supply relationship for construction machinery. There is a clear first stage relationship between the peak and crash in housing construction in Figure 1-10 and the peak and crash in construction machinery investment in Figure 1-9.

The exclusion restriction necessary for identification of the supply equation requires that data on housing construction contain information only about the demand for construction machinery and not about its supply. I observed previously that the user cost of machinery accounts for at most 3% of construction spending, so it is unlikely that shocks to the supply of machinery could drive movements in construction spending. The exclusion restriction could also fail if a third variable—for example, interest rates—drove increases in construction spending at the same time as increases in the *supply* of construction machinery. One can mitigate this concern by including interest rates as regressors, but one must still assume that the included regressors correctly capture all relevant variation. However, many authors, notably Shiller [2008], have argued that the dramatic expansion and contraction of the housing market over this period resulted from a speculative bubble and was thus largely unrelated to fundamentals like interest rates or construction costs. If this is indeed the case, then housing construction measures provide an ideal instrument for construction machin-

ery prices.

Estimated elasticities in columns 3 through 6 of Table 1.9 range from 12.3 to 27.03, though the largest estimates come with relatively large standard errors. These supply elasticity estimates are an order of magnitude larger than the Goolsbee [1998] estimates. They suggest that tax-induced shifts in demand for construction machinery will have extremely modest effects on the price of new machines.

1.5 Conclusions

In this paper, I have presented new evidence on the supply elasticity of new and used construction machines and on the elasticity of substitution between them. I have also taken a new approach to measuring the effect of tax incentives on the demand for machines. Many papers in the literature create a measure of the change in the user cost of capital implied by tax changes and include this variable on the right-hand side of an investment regression. Instead, I have attempted to measure the change in the user cost implied by the market prices of new and used machines.

Results suggest that the supply of construction machines is highly elastic. Real quantities of construction machinery supplied to the US market rose and fell by 80% over the course of the housing boom and bust, with little impact on prices. The effectiveness of tax incentives that succeeded in stimulating investment demand would hardly be constrained by the inelasticity of supply. It appears, however, that recent bonus depreciation incentives did little to stimulate demand. Prices of new and used construction machines imply that marginal machine buyers placed almost no value on bonus depreciation. Stated differently, results suggest that bonus depreciation failed to induce a change in the user cost of capital perceived by firms.

The results of this paper are silent as to why exactly bonus depreciation failed to induce a change in the user cost. In other work, I have explored two reasons why this might be the case. In the next chapter of this dissertation, I document recent dramatic increases in the prevalence of tax losses by large corporations, and I study how the system of carryforwards and carrybacks of operating losses may blunt the effectiveness

of tax incentives. I estimate that firms facing a marginal tax rate of zero due to losses or loss carryforwards were about 60% as responsive to historical tax incentives for investment as fully taxable firms, in line with model predictions. In Edgerton [2008], I estimate that investment tax credits were considerably more effective in stimulating investment than accelerated depreciation provisions, a difference that I attribute to accounting rules that obscure the effects of accelerated depreciation in the measure of income that publicly traded firms report to shareholders.

I will conclude with a story about the effects of taxes on investment that is consistent with almost all of the empirical literature cited thus far.²² For most of the post-war period, markets for investment goods were largely shielded from import competition, and markets for used capital goods were illiquid. Most US investment was made by fully taxable firms, and changes in tax rules often took the form of adjustments to tax rates or the investment tax credit. These tax changes succeeded in shifting demand, as in Cummins, Hassett, and Hubbard [1994] and Desai and Goolsbee [2004], but supply elasticities were low, and tax incentives were partially passed into prices, as estimated by Goolsbee [1998].

In more recent decades, the world has changed. Domestic manufacturers of capital goods compete fiercely with foreign manufacturers, importers of used goods, and domestic sellers of used goods. Policymakers respond to recessions with bonus depreciation rather than investment tax credits. Many firms face a low marginal tax rate due to tax losses. Investment responds little to bonus depreciation, as estimated by Cohen and Cummins [2006], and many firms do not even claim deductions for which they are eligible, as noted by Knittel [2007]. Price elasticities of new supply and used imports are large, but there is little evidence for any effect of bonus depreciation on demand, as I conclude in this paper.

²²The conclusions of House and Shapiro [2008] are surprising in light of the results presented here, though perhaps not directly at odds with them. The assets which drive their results are “quasi-structures” with particularly long tax lives, which include assets like phone and power lines, farm structures, and power generation equipment. These assets comprise about 7% of total equipment investment. It is feasible that bonus depreciation had negligible effects on investment in asset types with shorter tax lives, which comprises the vast majority of equipment investment, but measurable effects on these quasi-structures.

1.6 Appendix

The firm solves,

$$\max \int_0^{\infty} e^{-rt} [(1-\tau)(F(K_t^N, K_t^U) - rD_t - \psi(I_t^N, I_t^U, K_t^N, K_t^U)) - (1-\tau z^N)p_t^N I_t^N - (1-\tau z^U)p_t^U I_t^U + B_t] dt,$$

subject to,

$$\begin{aligned} \dot{K}_t^N &= I_t^N - \delta K_t^N - e^{-\delta T^N} I_{t-T^N}^N \\ \dot{K}_t^U &= I_t^U - \delta K_t^U + e^{-\delta T^N} I_{t-T^N}^N \\ \dot{D}_t &= B_t \\ B_t &\leq \phi(p_t^N I_t^N + p_t^U I_t^U). \end{aligned}$$

The Hamiltonian is,

$$\begin{aligned} H &= e^{-rt} [(1-\tau)(F(K_t^N, K_t^U) - rD_t - \psi(I_t^N, I_t^U, K_t^N, K_t^U)) - (1-\tau z^N)p_t^N I_t^N - (1-\tau z^U)p_t^U I_t^U + B_t] \\ &\quad + \lambda_t^N [I_t^N - \delta K_t^N - e^{-\delta T^N} I_{t-T^N}^N] + \lambda_t^U [I_t^U - \delta K_t^U + e^{-\delta T^N} I_{t-T^N}^N] + \mu_t B_t + \gamma_t [\phi(p_t^N I_t^N + p_t^U I_t^U) - B_t], \end{aligned}$$

where λ_t^N , λ_t^U , μ_t , and γ_t are Lagrange multipliers on the four constraints above. The first order conditions for I_t^N , I_t^U , and B_t are,

$$0 = -e^{-rt} [(1-\tau)\psi_{I_t^N} + p_t^N (1-\tau z^N)] + \lambda_t^N + e^{-\delta T^N} (\lambda_{t+T^N}^U - \lambda_{t+T^N}^N) + \gamma_t \phi p_t^N \quad (1.13)$$

$$0 = -e^{-rt} [(1-\tau)\psi_{I_t^U} + p_t^U (1-\tau z^U)] + \lambda_t^U + \gamma_t \phi p_t^U \quad (1.14)$$

$$0 = e^{-rt} + \mu_t - \gamma_t, \quad (1.15)$$

where $\psi_X = \partial\psi/\partial X$.

The costate equations for K_t^N, K_t^U , and D_t are,

$$\dot{\lambda}_t^N = -e^{-rt}(1 - \tau)[F_{K_t^N} - \psi_{K_t^N}] + \delta\lambda_t^N \quad (1.16)$$

$$\dot{\lambda}_t^U = -e^{-rt}(1 - \tau)[F_{K_t^U} - \psi_{K_t^U}] + \delta\lambda_t^U \quad (1.17)$$

$$\dot{\mu}_t = e^{-rt}(1 - \tau)r \quad (1.18)$$

From (1.18) and (1.15), we see $\gamma_t = e^{-rt}\tau$.

We see from (1.14),

$$\lambda_t^U = e^{-rt}[p_t^U(1 - \tau(z^U + \phi)) + \psi_{I_t^U}(1 - \tau)]$$

$$\dot{\lambda}_t^U = -r\lambda_t^U + e^{-rt}[\dot{\Gamma}_t^U + \dot{\psi}_{I_t^U}(1 - \tau)],$$

for $\dot{\Gamma}_t^U = \partial(p_t^U(1 - \tau(z^U + \phi)))/\partial t$. Combining with (1.17) and assuming no adjustment costs ($\psi = 0$) produces equation (1.4) in the text, and similar steps produce equation (1.5).

With nonzero adjustment costs, further manipulation produces,

$$F_{K_t^U} - \psi_{K_t^U} - \psi_{I_t^U}(r + \delta) + \dot{\psi}_{I_t^U} = p_t^U(r + \delta - \pi_t^U) \frac{1 - \tau(z^U + \phi)}{1 - \tau}.$$

The equivalent of equation (1.7) is then,

$$\ln \frac{p_t^N}{p_t^U} = \ln \frac{1 - \tau(z^U + \phi)}{1 - \tau(z^N + \phi)} + \ln \frac{r + \delta - \pi_t^U}{r + \delta + \tilde{\lambda}_t - \pi_t^N} + \ln \frac{F_{K_t^N} - \psi_{K_t^N} - \psi_{I_t^N}(r + \delta) + \dot{\psi}_{I_t^N}}{F_{K_t^U} - \psi_{K_t^U} - \psi_{I_t^U}(r + \delta) + \dot{\psi}_{I_t^U}}.$$

In the case of perfect substitution in both the production and adjustment cost functions, the final two terms vanish, and we are again left with a price wedge determined solely by the tax wedge.

Chapter 2

Investment Incentives and Corporate Tax Asymmetries

2.1 Introduction

In 2002, U.S. corporations running operating losses reported a total of \$418 billion in losses on their tax returns. This amounts to more than 60% of the \$676 billion in profits reported by profitable corporations. Such a high ratio of losses to profits suggests that economists who wish to understand the effects of the corporate income tax on the behavior of corporations must understand the effects of the tax treatment of losses and the behavior of loss-making firms.

Economists have done a great deal of research on the effects of tax policy on business investment for at least two reasons. First, we have long been concerned that taxes on income from capital can affect the long-run level and composition of the capital stock, with potentially adverse welfare consequences. Second, business cycle fluctuations in investment have been an important component of fluctuations in aggregate output. Policymakers have repeatedly instituted tax incentives to spur investment in the wake of downturns.

In 2002, the same year as the surge in losses noted above, President Bush signed the Job Creation and Worker Assistance Act (JCWAA), which included “bonus depreciation” provisions that allowed firms to deduct 30% of their expenditures on new

capital equipment from their taxable income. Bonus depreciation provided incentives through the tax system for firms to increase their investment in the wake of the 2001 recession. Bonus depreciation was later increased to 50% and extended through 2004. Similar incentives were then again enacted in 2008 and remain in place at the time of this writing. Several observers have concluded that the bonus depreciation incentives had little effect on investment activity.¹ In this paper, I attempt to understand how recent increases in corporate losses may have mitigated the impact of tax incentives like bonus depreciation.

I adapt the tax-adjusted Q model pioneered by Hayashi [1982] and Summers [1981] to a setting featuring carrybacks and carryforwards of operating losses, as well as debt, tax credits, and financing constraints. I consider the effects of investment incentives on two groups of firms. The first group, taxable firms, pay the statutory tax rate on a marginal increase in income, either in the form of an increased tax liability or a decreased carryback refund. The second group, nontaxable firms, face a tax rate of zero on a marginal increase in income. When taxable firms increase their income, they gain carrybacks, or the ability to carry back future losses against their current tax payments. When nontaxable firms increase their income, they lose carryforwards, or the ability to offset future tax payments with current losses. I show how investment choices depend on a familiar tax-adjusted Q expression, modified for the shadow values to the firm of these carrybacks and carryforwards and for the tightness of a binding financing constraint. Investment responses to tax incentives differ between taxable and nontaxable firms, and they depend on these shadow values.

I then turn to empirical estimates of the asymmetry in investment responses between taxable and nontaxable firms. I carefully construct measures of taxable status and related tax variables for firms in the Compustat panel. Following the literature, I merge the Compustat panel with industry-level measures of tax incentives for investment that I construct from information published by the Internal Revenue Service

¹Cohen and Cummins [2006] find no effect of the incentives on investment quantities by comparing aggregate investment in assets most and least affected by the incentives. The first chapter of this dissertation finds no evidence for any effect of the incentives on the relative prices of new and used construction machinery, where used machinery did not qualify for the incentives. See House and Shapiro [2008] for a dissenting view.

and the Bureau of Economic Analysis. I first run familiar tax adjusted Q regressions of the kind presented by Poterba and Summers [1985], Bernanke, Bohn, and Reiss [1988], and Desai and Goolsbee [2004], but I allow taxable and nontaxable firms to respond differently to the tax variables. Results indicate that nontaxable firms respond about 60% as strongly to tax incentives as do taxable firms. The estimated ratio is consistent with shadow values of carrybacks and carryforwards calculated by Altshuler and Auerbach [1990] using data on taxable status from corporate tax returns.

However, the asymmetry between taxable and nontaxable firms appears to depend importantly on the cash flows earned by both groups of firms, consistent with the presence of binding financing constraints in the model. Estimates suggest that firms are considerably more responsive to investment incentives when their ratio of cash flows to assets is high. Including controls for cash flows in this manner considerably dampens the effects of taxable status on the impact of tax incentives.

In 2002, about 30% of aggregate assets and employees were in non-taxable firms. If one assumes that nontaxable firms are 60% as responsive to tax incentives—consistent with the shadow values in Altshuler and Auerbach [1990]—one would expect bonus depreciation to be perhaps 10% less effective than it would be in the absence of tax asymmetries. Using estimates from this paper that control for the effects of cash flows reduces this estimate from 10% to 5%. I thus conclude that corporate tax asymmetries played at most a modest role in mitigating responses to bonus depreciation.

Results on cash flows themselves are a bit stronger. The aggregate ratio of cash flows to assets across all Compustat firms fell to .06 during the 2001 recession from an average near 0.11 prior to 1985. Estimates suggest that a decline in cash flows of this magnitude could make firms as much as 24% less responsive to bonus depreciation than they would have been if cash flows had remained near their historical averages.

The following section of the paper provides additional motivation by documenting the prevalence of losses among U.S. corporations in recent years, reviewing their treatment under the tax code, and reviewing related literature. Section 3 presents a model of firm investment decisions incorporating financing constraints and the tax

treatment of losses. Section 4 describes the Compustat sample of financial statements and details the calculation of proxies for tax-related variables. Section 5 presents regression results, and section 6 concludes.

2.2 Motivation

2.2.1 Facts on Corporate Losses

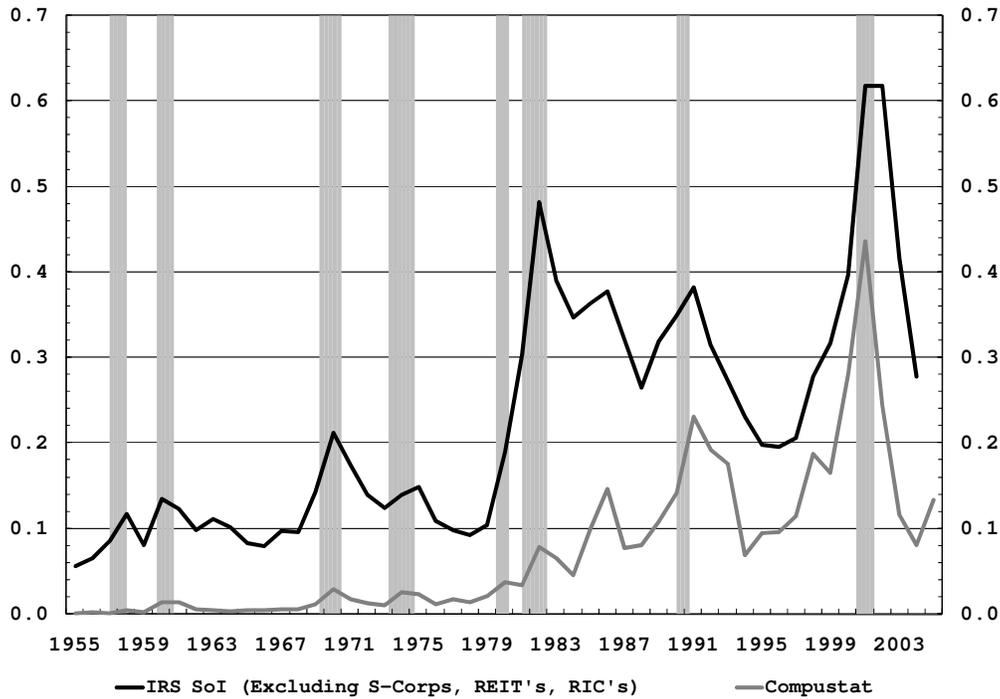
Here, I discuss two broad facts on corporate losses in the United States. First, I document that corporate losses have been quite large relative to positive profits during recent recessions.² Second, most losses are not used quickly to offset profits through carrybacks or carryforwards, but tend to be carried forward for several years or expire unused. Together, these facts suggest that the asymmetric treatment of losses may have important effects on investment decisions.

Figure 2-1 plots two historical measures of the ratio of corporate losses to corporate income in the United States. The numerator in this ratio is the sum of losses across all corporations that report losses. The denominator is the sum of positive profits across all corporations that report positive profits. The black line shows this loss ratio calculated from the Internal Revenue Service's Statistics of Income data for all firms that file corporate income tax returns. The grey line shows the loss ratio calculated for all nonfinancial, U.S.-incorporated firms in Standard and Poor's Compustat dataset. Details on this calculation appear in Appendix 2.

The underlying IRS and Compustat data differ in several ways. The IRS data include tax income for all firms that file corporate income tax returns. In 2003, there were over 2 million such firms, even after excluding subchapter S corporations, Real Estate Investment Trusts, and Regulated Investment Companies. The Compustat data include book income for large, publicly-traded firms. The number of firms included in the Compustat sample has grown from about 1,000 in 1955 to 10,000

²Based on work done independently of and contemporaneously with the work in this paper, Altshuler, Auerbach, Cooper, and Knittel [2008] also document this fact and explore in more detail the behavior of losses among subsets of firms.

Figure 2-1: Ratio of U.S. Corporate Losses to Net Income



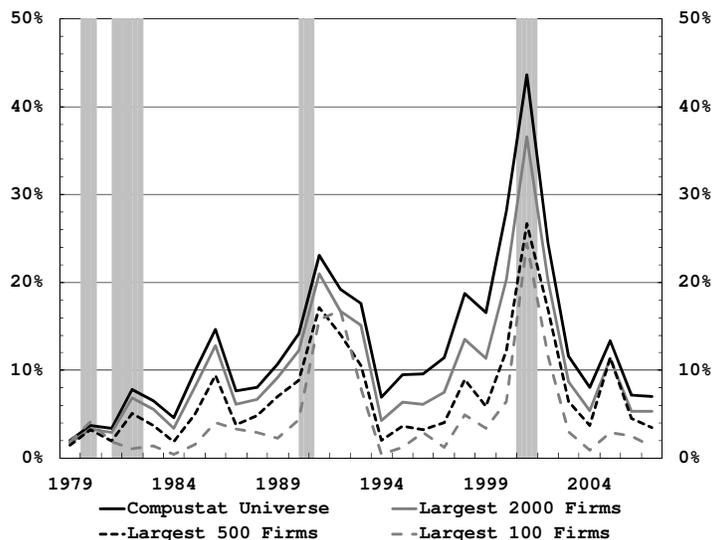
today. The IRS ratio in Figure 2-1 persistently exceeds the Compustat ratio for two reasons. First, the Compustat sample is composed primarily of large firms, which realize losses less frequently than smaller firms. Second, book income as reported in Compustat typically exceeds tax income as reported to the IRS.³

Despite these differences, the two series share important features. The levels of both series increase dramatically between the first half of the sample and today. The loss ratio in the IRS data averaged 0.12 from 1973 to 1977, while it averaged 0.47 from 1999 to 2003, an increase of 280 percent.⁴ Both five-year periods include a single recession. A second notable feature of both the IRS and Compustat loss ratio series is the height of their peaks near the relatively mild 1990 and 2001 recessions. Both

³See Hanlon [2003] for more on the differences between tax and book income.

⁴The average loss ratio in the Compustat data rose from 0.02 to 0.25 between these periods, although this 1,300 percent increase can be attributed largely to the expansion of the Compustat sample to include more smaller firms.

Figure 2-2: Loss Ratios by Firm Size



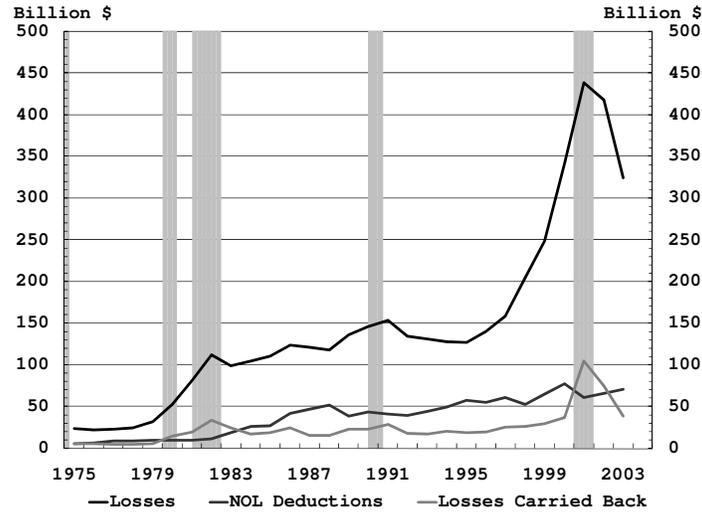
series peaked at over 0.2 in the early 1990's and over 0.4 in the early 2000's. Figure 2-2 plots similar ratios for subsets of the firms in Compustat sorted by the book value of their assets. Even among the 100 largest industrial firms in the United States, the ratio of losses to profits peaked at more than 0.25 in 2001, far higher than in any previous recession.

2.2.2 Tax Treatment of Corporate Losses

In the United States, a firm earning positive profits typically must pay a percentage of its profits in tax, while a firm running a loss need not receive an immediate refund. Instead, losses may be carried back to offset profits in prior years which have not yet been offset. The carryback period, or the length of time for which a prior profit may be used to offset a loss, is currently two years in the United States.⁵ If there are no profits in the prior two years which may be used to offset a current loss, then the loss may be carried forward and used to offset future profits. The carryforward period, or the length of time for which a prior loss may be used to offset a profit,

⁵JCWAA extended the carryback period to five years for losses realized in 2001 and 2002. A similar provision was almost included in the American Recovery and Reinvestment Act of 2009, but in the end, the five-year carryback was made available only to small businesses.

Figure 2-3: Losses, NOL Deductions, and Losses Carried Back



is currently twenty years. Losses carried forward do not earn interest and are not protected against inflation.

Evidence shows that a large fraction of realized losses expire unused or remain unused for many years. Figure 2-3 presents data on the amount of losses realized each year, the amount of these losses carried back, and the amount of prior years' losses used to offset current profits. For example, in 2001, U.S. corporations realized \$438 billion in losses and were able to immediately carry back about \$105 billion to receive a refund of about \$37 billion.⁶ Sixty billion dollars of profits realized in 2001 were offset with losses from prior years. By subtracting the latter two series from the first series, one can create a measure of the annual net flow into the stock of unused carryforwards. A glance at Figure 2-3 suggests that this flow is always positive and has been quite large since at least the early 1980's. Calculating this flow for each year since 1988 and summing over the 15 years from 1988 to 2002 produces a sum of \$1.9 trillion. Since losses realized in 1988 could be carried forward up to 15 years, this figure represents a lower bound on the amount of losses that would have been available to offset 2003 profits, if none had been lost in bankruptcies or acquisitions.

⁶The carryback figures are based on data in Cooper and Knittel [2006] for 1993 to 2003 and on data provided by Greg Key of the Bureau of Economic Analysis for earlier years.

Total profits realized by profitable firms in 2003 were \$780 billion. Thus the stock of unused potential loss offsets was about 2.5 times as large as all realized profits. This ratio highlights the magnitude of unused losses and hence the importance of the tax treatment of losses relative to profits.

Cooper and Knittel [2006] present data compiled from a sample of confidential tax returns that corroborate these aggregates. Of the losses realized by firms in their sample in 1993, the first year for which data are available, 13 percent were used immediately as carrybacks, and 38 percent had been used as carryforwards by 2003, the last year in their sample. Another 18 percent remained outstanding for potential future use, while 31 percent were lost from the sample as firms went out of business or were taken over by other firms. Some fraction of these 31 percent may have been used subsequently by acquiring firms or may remain outstanding for future use, but the authors are unable to measure these amounts.⁷

Thus, I have documented that corporate losses are large relative to profits and that they are used slowly, if at all, to offset profits. These facts suggest that the tax treatment of losses may be a quite important component of the investment incentives that the tax code presents to firms. It may have important effects on the long-run level of the capital stock, and it may create important distortions between types of capital that differ in their depreciation rates, return volatilities, and cyclical properties. The prevalence of losses may also influence the effectiveness of short-run investment incentives. In particular, the effects of investment incentives like bonus

⁷Two sets of rules govern the use of carryforwards and carrybacks by acquiring firms. Sections 381 and 382 of the Internal Revenue Code concern situations where a shareholder owning 5% or more of a corporation increases its ownership share by 50 percentage points or more. The separate return year limitation (SRLY) rules govern situations when a subsidiary joins a consolidated group for tax purposes, which requires an 80% ownership share. Section 381 prevents a loss-making firm from purchasing a profitable firm to use its carrybacks, and it prevents a profitable firm from purchasing a loss firm to offset profits previously earned by the acquirer. Only profits earned after the acquisition may be offset with carryforwards from the target firm. Section 382 limits the amount of these carryforwards that can be used in any single year to the market value of the target firm's equity prior to acquisition multiplied by a measure of the long-term tax exempt interest rate. Essentially, this provision limits the present value of carryforwards at the time of acquisition to the market value of the target firm. Under the SRLY rules, the amount of losses incurred by the target firm prior to acquisition that can be used to offset profits of the group is limited by the amount of profits that the target has contributed to the group subsequent to the acquisition. In situations where both Section 382 and the SRLY rules would be relevant, only Section 382 applies.

depreciation may be severely blunted when firms are losing money or when they hold large stocks of net operating losses from prior years.

2.2.3 Existing Literature

Most theoretical and empirical work on taxes and investment has ignored carryforward and carryback provisions and assumed symmetric treatment of profits and losses. Seminal examples include Hall and Jorgenson [1967], Hayashi [1982], and Summers [1981], who developed models of the user cost of capital and Tobin's Q adjusted for the effects of taxes. This theory inspired a great deal of empirical work that also ignored the carryforward and carryback provisions. Examples include Poterba and Summers [1985], Bernanke, Bohn, and Reiss [1988], Auerbach and Hassett [1991], and Cummins, Hassett, and Hubbard [1994]. Prominent recent papers on investment incentives like Desai and Goolsbee [2004] and House and Shapiro [2008] make no mention of the tax treatment of losses.

There do, however, exist a number papers that have explicitly studied the effects of the system of carryforwards and carrybacks on investment incentives. Majd and Myers [1987] calculate net present values of example projects to example firms facing asymmetric taxes, assuming exogenous processes for firm and project cash flows. Auerbach and Poterba [1987] calculate effective tax rates on investment in new equipment and structures, assuming riskless cash flows but an exogenous process for taxable status. Altshuler and Auerbach [1990] calculate effective tax rates on current income under a similar assumption of exogenous, stochastic taxable status. Graham [2000] computes effective tax rates on current income for each firm-year in the Compustat panel, assuming an exogenous process for earnings before interest and taxes. None of these papers relate their numerical estimates of the values of carryforwards and carrybacks to observed investment behavior by firms.

Auerbach [1986] presents a dynamic model of investment with the stock of loss carryforwards as a single state variable. He assumes 100 percent physical depreciation of capital in each period, full expensing of capital purchases, independent and identically distributed shocks, no adjustment costs, and no carryback provisions. This

restrictive set of assumptions makes it difficult to relate results from the model to observed behavior by firms, and no such exercise is attempted. Mayer [1986] also presents a dynamic model of firm behavior with the stock of loss carryforwards as a state variable. His focus is on capital structure rather than investment decisions, and his primary result is that the carryforward system can create optimal interior debt ratios, even in the absence of costs of financial distress. MacKie-Mason [1990] presents empirical evidence that carryforward stocks indeed influence the decision to issue new debt or equity.

Empirical evidence on the effects of tax asymmetries on investment decisions is scarce. Devereux, Keen, and Schiantarelli [1994] run tax-adjusted Q and user cost investment regressions on a panel of UK firms, attempting to adjust their tax variables for carryforward provisions. They conclude that “Careful modelling of asymmetries does not noticeably improve the empirical performance of these equations.” Cummins, Hassett, and Hubbard [1995] present a specification where separate user cost coefficients are estimated for Compustat firms with and without carryforward stocks under the Compustat definition. The user cost coefficients for firms with carryforwards are statistically indistinguishable from zero and from the coefficients for firms without carryforwards.

Empirical estimates of the effects of tax incentives on investment typically include controls for cash flows. However, explicitly modeling a firm facing financing constraints, as I do below, provides the insight that financing constraints can mitigate the effectiveness of tax incentives, as well as directly influence the level of investment. I am not aware of any empirical work that allows for this simple interaction between financing constraints and tax incentives.

2.3 A Model of the Firm

The firm will choose how much to invest and how much to borrow in each year in order to maximize the present discounted value of its after-tax cash flows. The firm’s cash flows before interest, taxes in year t , $F(K_t, x_t)$, depend on its current capital

stock, K_t , and a firm-level stochastic shock, x_t .⁸

The capital stock, K_t , evolves according to,

$$K_{t+1} = (1 - \delta)K_t + I_t$$

where δ is physical depreciation and I_t is investment in year t . In the United States and elsewhere, the deduction from taxable income attributed to depreciation is allowed to be larger than actual physical depreciation. Thus the stock of capital not yet depreciated for tax purposes, \tilde{K}_t , evolves separately from the physical capital stock, according to,

$$\tilde{K}_{t+1} = (1 - \tilde{\delta})\tilde{K}_t + (1 - z_t^0)p_t I_t,$$

where $\tilde{\delta}$ is the depreciation rate allowed for tax purposes, z_t^0 is the fraction of new investment deductible in its first year, and p_t is the price of physical capital in year t .

The firm can lend or borrow a limited amount at the riskless rate, r . The stock of debt, D_t , evolves according to,

$$D_{t+1} = D_t + B_t,$$

where B_t represents new borrowing. When D_t or B_t are negative, they represent savings. A debt or saving stock D_t entails payment or receipt of an amount rD_t , which is tax-deductible or taxable, respectively.

To invest or borrow, the firm bears a cost of adjustment $\psi(I_t, K_t)$ or $\varphi(B_t, D_t)$. For investment, ψ may represent costs from shutting down production to install new machinery or retraining workers to use new software. For borrowing, φ may represent costs like bankers' fees or time spent by management. Both forms of adjustment costs are assumed to be tax deductible.

The firm's taxable income, that is, the income measure that will determine its tax

⁸One can think of F as resulting from maximization over any factors which can be costlessly adjusted within year t , like labor, L_t :

$$F(K_t, x_t) = \max_{L_t} A(x_t)\tilde{F}(K_t, L_t) - L_t w(x_t)$$

liability, is then,

$$TI_t = F(K_t, x_t) - p_t \psi(I_t, K_t) - z_t^0 p_t I_t - \tilde{\delta} \tilde{K}_t - r D_t - \varphi(B_t, D_t).$$

Along with TI_t and the statutory tax rate, τ_t , the firm's tax liability or tax refund will be determined by any available investment tax credits, other tax credits, carryforwards, and carrybacks. A firm making investment I_t is entitled to investment tax credits in the amount $p_t I_t ITC_t$. Other tax credits, ranging from the research and experimentation credit to the Indian employment credit, are assumed to be exogenous to debt and investment choices and in the amount CR_t .

Carryforwards and carrybacks expire if unused after T_t^F and T_t^B years, respectively, where T_t^F and T_t^B are currently twenty and two in the United States. For this reason, a carryforward earned s years ago has a lower value to the firm than a carryforward earned $s - 1$ years ago, since it is somewhat more likely to expire unused. To solve the firm's investment problem, one should track the entire vectors of T_t^F carryforwards and T_t^B carrybacks, plus any more distant carryforwards and carrybacks that might become relevant if T^F or T^B were to increase in the future.⁹ For now, I abstract from this complication in the case of carryforwards, but respect it in the case of carrybacks. I assume that carryforwards last forever, so that a scalar variable, CF_t , is sufficient to track the potential carryforwards available to the firm in year t . I track the entire vector of carrybacks, $CB_t \in \mathbb{R}^{T_t^B}$, where $CB[s]_t$ represents the carryback available in year t from taxes paid s years ago, in year $t - s$. Let \tilde{CB}_t be the total amount of carrybacks available to the firm in year t ,

$$\tilde{CB}_t = \sum_{i=1}^{T_t^B} CB_t[i]. \quad (2.1)$$

To write the firm's tax liability or refund in year t , first define the variable NT_t ,

⁹Legislative changes in the carry period lengths have come in two forms—one which extends the life of carry stocks already earned, and the other which applies only to newly earned carry stocks.

a dummy variable indicating that the firm is nontaxable,

$$NT_t = \mathbf{1} \left(\tau_t(TI_t - CF_t) - CR_t - p_t I_t ITC_t > -\tilde{C}B_t \right).$$

With this notation, the tax bill in year t , TB_t , can be written,

$$TB_t = \begin{cases} \tau_t(TI_t - CF_t) - CR_t - p_t I_t ITC_t & \text{if } 1 - NT_t \\ -\tilde{C}B_t & \text{if } NT_t. \end{cases} \quad (2.2)$$

A negative tax bill indicates a carryback refund. Note that I classify a firm as taxable ($NT_t = 0$) when a \$1 increase in taxable income causes a $\$ \tau_t$ increase in the tax bill. When the firm is nontaxable ($NT_t = 1$), a \$1 increase in taxable income has no effect on the tax bill.

This notation compactly nests a number of special cases. In the first case in (2.2), when the firm is taxable, it may have positive taxable income (TI_t) exceeding its NOL deduction (CF_t) and few enough credits ($CR_t + p_t I_t ITC_t$) that it pays positive taxes. Or, it may have negative taxable income that does not exceed the amount it may carry back, even after further deducting tentative credits, so that it receives a carryback refund. Or, it may have positive taxable income, but enough credits to more than offset potential taxes and thus to receive carrybacks. In the second case in (2.2), when the firm is nontaxable, the firm may have positive taxable income that is exceeded by its available carryforwards, resulting in a tax bill of zero. Or, it may have negative taxable income that exhausts its available carrybacks, resulting in a refund of the full carryback amount. Or, it may have positive or negative taxable income that exhausts its available carrybacks only when combined with credits.

The dynamics of the carryback stock may be written,

$$\begin{aligned}
 CB[1]_{t+1} &= \text{Max}(TB_t, 0) & (2.3) \\
 CB[s|s > 1]_{t+1} &= \begin{cases} CB[s-1]_t & \text{if } -TB_t < \sum_{i=s}^{T_t^B} CB[i]_t \text{ or } s > T_t^B + 1 \\
 TB_t + \sum_{i=s-1}^{T_t^B} CB[i]_t & \text{if } \sum_{i=s}^{T_t^B} CB[i]_t \leq -TB_t < \sum_{i=s-1}^{T_t^B} CB[i]_t \\
 0 & \text{if } \sum_{i=s-1}^{T_t^B} CB[i]_t \leq -TB_t. \end{cases}
 \end{aligned}$$

Suppose the firm enters year t with zero carrybacks. If the firm pays positive taxes in year t , the carryback available in year $t+1$ from taxes paid one year before, or $CB[1]_{t+1}$, is the full amount of taxes paid in year t , TB_t . Now suppose that the firm receives a carryback refund in year $t+1$ that is smaller than the amount of taxes paid in year t . Then the amount of potential carryback in year $t+2$ from taxes paid in year t , or $CB[2]_{t+2}$, is equal to the taxes paid in year t , or $CB[1]_{t+1}$, less the amount received as a carryback refund, or TB_{t+1} . This situation is captured in the third case above. If instead the firm uses no carrybacks in year $t+1$, then $CB[2]_{t+2}$ is equal to the full amount of taxes paid in year t , or $CB[1]_{t+1}$, as in the second case above. If the firm uses its entire stock of carryforwards in year $t+1$, then $CB[2]_{t+2}$ is equal to zero, as in the final case.

The dynamics of the scalar carryforward stock are simpler,

$$CF_{t+1} = \begin{cases} 0 & \text{if } 1 - NT_t \\
 -TI_t + CF_t + (CR_t + p_t I_t ITC_t) / \tau_t - \tilde{C}B_t & \text{if } NT_t. \end{cases}$$

If the firm is taxable, it can have no losses or credits to carry forward, as it would have either used them to reduce its taxes further or to receive a larger carryback. If the firm is nontaxable, it carries forward the excess of losses or credits over any amount that was available to carry back.

A few comments are in order on the system of loss and credit carryforwards and carrybacks as I have modeled it here. First, I have ignored the limits on credit usage that allow firms to offset only 75% of tentative tax liability with general business

credits. Altshuler and Auerbach [1990] treat this issue in detail. Its importance has likely declined in the years since their sample period due to the elimination in 1987 of the investment tax credit, a key component of the general business credit. The foreign tax credit, now far larger in magnitude, can offset 100% of income before credits.

Second, note that I track carryforwards in pre-tax income amounts, but carrybacks in the amount of taxes paid. I judge this treatment to be the best simple way to handle situations where tax rates change. It correctly relates the amount of carrybacks available at any time to the amount of taxes paid under rates in effect in prior years, and it correctly allows the carryforward of losses regardless of any future rate changes. The amount carried back by taxable firms, however, should be related to rates in effect in prior years rather than the current rate, and credit carryforwards as I have written them should be adjusted for future rate changes. Tracking the vector of tax rates in effect when each carryback or credit was earned would require a burdensome addition to the state space, so I abstract from these complications.

Finally, I have assumed that firms always carry back any excess loss or credit. In reality, firms may elect either to carry back or to carry forward. There are two reasons why a firm might choose to carry forward without first carrying back. First, a loss carried back is, in practice, used to recalculate the net operating loss deduction on a prior year's tax return. The NOL deduction is applied prior to the calculation of any applicable credits. It may be the case that applying the NOL deduction reduces taxes before credits to a level lower than the amount of credits available. If the newly displaced credits cannot be immediately carried back or forward to a prior return, then they must be carried forward to a future return. It is thus possible that a firm might opt not to carry back losses to a return on which it had claimed credits, if those credits cannot be used immediately on another return and are close enough to expiration that they have little value as carryforwards. This is a rather special case, and it is unlikely that I lose much by abstracting from it. A second situation in which firms might choose to carry forward occurs if they expect the statutory tax rate to rise in the future. There has not been a substantial increase in the top statutory rate in the United States since 1949 to 1951, when it rose from 42% to 52%. There is no

reason to expect that firms currently expect any rate increase or that they expected a rate increase at any time in the period covered by the Compustat data.

To the dynamics of physical capital, capital for tax purposes, debt, carrybacks, and carryforwards, I add two constraints on the firm's financing activities in each year. First, I require that debt remain below some threshold, \bar{D} ,

$$D_{t+1} \leq \bar{D}, \quad (2.4)$$

to capture crudely the inability of the firm to issue unlimited debt without paying a risk premium. Equilibrium determination of risky debt levels, interest rates, and defaults is beyond my scope in this paper. Second, I require that the firm's cash flows, including any related to its debt financing, exceed 0,

$$F(K_t, x_t) - p_t I_t - p_t \psi(I_t, K_t) - TB_t - rD_t + B_t - \varphi(B_t, D_t) \geq 0. \quad (2.5)$$

In this setting, where I have not allowed for issuance of new equity, this constraint ensures limited liability for equity holders, that is, dividends must be nonnegative in every year.

Subject to the financing constraints in (2.4) and (2.5), plus the dynamics of physical capital, capital for tax purposes, debt, carrybacks, and carryforwards discussed above, the firm solves,

$$\max_{\{I_t, B_t\}} \mathbb{E}_0^* \left[\sum_{t=0}^{\infty} \frac{1}{(1+r)^t} [F(K_t, z_t) - p_t I_t - p_t \psi(I_t, K_t) - TB_t - rD_t + B_t - \varphi(B_t, D_t)] \right],$$

where \mathbb{E}_0^* is the expectation operator under the risk-neutral, or Martingale, measure, and r is the risk free rate.¹⁰

Consider the first-order condition with respect to I_0 , investment in the current

¹⁰Under the risk-neutral measure, the probability of each state of nature is adjusted for its Arrow-Debreu state price in such a way that it is appropriate to discount expected values at the risk-free rate. See Duffie [2001], Chapters 1 and 2 for details. In this application, working with the risk-neutral measure obviates the need to specify appropriate discount rates for different components of cash flows.

year.¹¹ In effect, there are four different first-order conditions, one for non-taxable firms, and one each for firms determining on the margin the levels of each of the three different vintages of carrybacks. For non-taxable firms,

$$p_0(1 + \psi_{I0})(1 + \eta_0) = \lambda_0 + (1 - z_0^0)p_0\tilde{\lambda}_0 + \gamma_0^F p_0(z_0^0 + ITC_0/\tau_0 + \psi_{I0}), \quad (2.6)$$

where η_0 is the multiplier on the financing constraint, λ_0 is the multiplier on the capital accumulation equation, $\tilde{\lambda}_0$ is the multiplier on the tax capital accumulation equation, and γ_0^F is the multiplier on the carryforward accumulation equation. I have arranged terms so that costs of marginal investment appear on the left side, and benefits on the right. Costs include the price of the marginal unit of capital, p_0 , plus its marginal impact on adjustment costs, ψ_{I0} , and an additional shadow cost, η_0 , if the financing constraint binds. Benefits include the shadow value of capital in the next year, λ_0 , and the shadow value of capital for tax purposes in the next year, $(1 - z_0^0)p_0\tilde{\lambda}_0$. Most interesting is the last term, $\gamma_0^F p_0(z_0^0 + ITC_0/\tau_0 + \psi_{I0})$. In a model with symmetric taxation, this term would be replaced by $\tau_0 p_0(z_0^0 + ITC_0/\tau_0 + \psi_{I0})$, representing the immediate tax savings associated with first-year depreciation allowances, investment tax credits, and adjustment expenses. Nontaxable firms under a system of carryforwards do not receive these immediate tax benefits from the marginal investment, but receive instead only the shadow value, γ_0^F , of associated carryforwards.

The first order condition for taxable firms is,

$$p_0(1 + \psi_{I0})(1 + \eta_0) = \lambda_0 + (1 - z_0^0)p_0\tilde{\lambda}_0 + (1 - \gamma_0^{Bi} + \eta_0)p_0\tau_0(z_0^0 + ITC_0/\tau_0 + \psi_{I0}). \quad (2.7)$$

Note that a taxable firm does receive the immediate tax benefits, $p_t\tau_0(z_0^0 + ITC_0/\tau_0 +$

¹¹Caballero and Leahy [1996] argue against the usefulness of the Q model of investment on the observation that there need not exist a monotonic relationship between investment and Q (here λ_0/p_0) when the firm faces a fixed cost of adjustment and is in a region of the state space where it chooses $I_t = 0$. However, firms choosing $I_t = 0$ are infrequently observed in practice. In the sample of manufacturing plants studied by Cooper and Haltiwanger [2006], only eight percent of observations show investment with an absolute value less than one percent of the capital stock, which is their measure of inactivity. In the Compustat sample that I study, only two percent of firm-year observations meet this criterion. I will thus proceed under the assumption that these first order conditions are indeed relevant. Note also that there may be states where the firm chooses kink points like $TB_t = 0$ and the first order conditions do not apply.

ψ_{I0}), associated with the marginal investment, as well as the shadow value, η_0 , of the loosening of the finance constraint by those tax benefits. Note, however, that the value of the tax benefits is also reduced by the shadow value of a carryback, γ_0^{Bi} , where the i indexes the vintage of the carrybacks foregone by realizing the tax benefits. When a firm reduces positive tax payments by qualifying for tax incentives, it foregoes the opportunity to carry future losses back against those tax payments. When a firm is already carrying back, a further reduction in its taxable income uses up carrybacks that might otherwise have been available in subsequent years.

It is instructive to examine further the nature of the shadow values λ_0 , $\tilde{\lambda}_0$, γ_0^B , and γ_0^F in a slightly modified version of the model above, where carrybacks are allowed to last forever in the same manner as carryforwards, and where the debt and financing constraints do not bind. Of most interest are the shadow values of carryforwards and carrybacks. Taking the first-order condition with respect to CF_1 and expanding forward produces

$$\gamma_0^F = \mathbb{E}_0^* \left[\sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \left(\prod_{s=1}^{t-1} NT_s \right) (1 - NT_t) \tau_t (1 - \gamma_t^B) \right]. \quad (2.8)$$

And similarly for CB_1 ,

$$\gamma_0^B = \mathbb{E}_0^* \left[\sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \left(\prod_{s=1}^{t-1} (1 - NT_s) \right) NT_t (1 - \gamma_t^F / \tau_t) \right]. \quad (2.9)$$

Equations (2.8) and (2.9) illustrate the essential nature of carrybacks and carryforwards as contingent claims. A carryforward is a claim that pays nothing as long as the firm continues to be nontaxable. If the firm regains taxable status in year t , the marginal carryforward entitles it to tax savings of τ_t . Those tax savings, however, reduce the carrybacks accrued by the firm in year t , so that the total payoff from using the carryforward is $\tau_t(1 - \gamma_t^B)$. Similarly, a carryback pays nothing as long as the firm remains taxable. If the firm regains nontaxable status in year t , the marginal carryback provides a refund of \$1. This refund, however, reduces the excess loss that can be carried forward by the firm, so the total payoff from using the carryback is

$$1 - \gamma_t^F / \tau_t.$$

Taking the first-order condition with respect to K_1 and expanding forward produces,

$$\lambda_0 = \mathbb{E}_0^* \left[\sum_{t=1}^{\infty} \frac{(1 - \delta)^{t-1}}{(1 + r)^t} (1 - MR_t)(F_{Kt} - p_t \psi_{Kt}) \right], \quad (2.10)$$

where F_{Kt} is the derivative of cash flows in year t with respect to K , ψ_{Kt} is the adjustment cost derivative in year t with respect to K , and,

$$MR_t \equiv (1 - \gamma_t^B) \tau_t (1 - NT_t) + \gamma_t^F NT_t,$$

bb is the effective marginal rate in effect in year t , which depends on the firm's taxable status in that year. Thus, λ_0 is the present discounted value of the after-tax cash flows created by the marginal unit of capital. This quantity, when divided by the current price of a unit of capital, p_0 , is known as marginal Q.

One can also derive,

$$\tilde{\lambda}_0 = \mathbb{E}_0^* \left[\sum_{t=1}^{\infty} \frac{(1 - \tilde{\delta})^{t-1}}{(1 + r)^t} \tilde{\delta} MR_t \right], \quad (2.11)$$

the present value of the future depreciation allowances on capital for tax purposes. The expressions in (2.10) and (2.11) do not differ radically from what one would derive in a model with symmetric taxes. The key difference is that MR_t , a random variable determined endogenously with future investment policy and taxable status, replaces the statutory tax rate, τ_t . Note that the tax payments in (2.10) and the tax savings in (2.11) also have the nature of contingent claims. Only when the firm is taxable are cash payments made, and these cash payments entitle the firm to a new contingent claim in the form of future carrybacks. When the firm is nontaxable, no cash payment is made, but the firm forfeits a contingent claim in the form of a carryforward.

2.3.1 Investment Responses to Tax Incentives

Solving the first-order conditions in (2.6) and (2.7) for the adjustment cost derivative, ψ_{I0} , produces, for taxable firms,

$$\psi_I = \frac{\frac{\lambda}{p} - \left(1 - (1 - \gamma^{Bi})\tau(z^0 + ITC/\tau) - (1 - z^0)\tilde{\lambda}\right)}{1 - (1 - \gamma^{Bi})\tau + \eta(1 - \tau)} - \frac{\eta(1 - \tau z^0 - ITC)}{1 - (1 - \gamma^{Bi})\tau + \eta(1 - \tau)}, \quad (2.12)$$

and for nontaxable firms,

$$\psi_I = \frac{\frac{\lambda}{p} - \left(1 - \gamma^F(z^0 + ITC/\tau) - (1 - z^0)\tilde{\lambda}\right)}{1 - \gamma^F + \eta} - \frac{\eta}{1 - \gamma^F\tau + \eta}, \quad (2.13)$$

where I have suppressed the time 0 subscript on all terms.

Next, define,

$$FC_t \equiv NT_t \frac{\eta_t}{1 - \gamma_t^F \tau_t + \eta_t} + (1 - NT_t) \frac{\eta_t(1 - \tau_t z_t^0 - ITC_t)}{1 - (1 - \gamma_t^{Bi})\tau_t + \eta_t(1 - \tau_t)},$$

representing the component of the adjustment cost expression attributable to the financing constraint. Then, assume that the adjustment cost function takes the form

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

where c is a parameter governing the convex component of adjustment costs.¹² Differentiating this function with respect to I_t , plugging into (2.12) and (2.13), and rearranging produces,

$$\frac{I}{K} = a + c \left[\frac{\frac{\lambda}{p} - \left(1 - (1 - \gamma^{Bi})\tau(z^0 + ITC/\tau) - (1 - z^0)\tilde{\lambda}\right)}{1 - (1 - \gamma^{Bi})\tau + \eta(1 - \tau)} \right] + cFC, \quad (2.14)$$

¹²Note that the following results will still hold for nonzero I_t if the adjustment cost function also includes a fixed cost component:

$$\psi(I_t, K_t) = \frac{1}{2c} \left[\frac{I_t}{K_t} - a \right]^2 K_{t-1} + B\mathbf{1} \left(\frac{I_t}{K_t} \neq 0 \right).$$

for taxable firms, and,

$$\frac{I}{K} = a + c \left[\frac{\frac{\lambda}{p} - \left(1 - \gamma^F(z^0 + ITC/\tau) - (1 - z^0)\tilde{\lambda}\right)}{1 - \gamma^F + \eta} \right] + cFC, \quad (2.15)$$

for nontaxable firms.

Several authors, including Poterba and Summers [1985] and Desai and Goolsbee [2004], have estimated equations like this using OLS or GMM, but have ignored the differences between taxable and nontaxable firms and the presence of the shadow value of the financing constraint. Replacing $MR \equiv (1 - \gamma^B)\tau(1 - NT) + \gamma^F NT$ with the statutory rate, τ , in either expression above produces,

$$\frac{I}{K} = a + c \left[\frac{\frac{\lambda}{p} - (1 - \tau z - ITC)}{1 - \tau} \right], \quad (2.16)$$

where I have also assumed nonbinding financing constraints ($\eta = 0$), and defined z as the present value of depreciation allowances in a symmetric setting,

$$z \equiv z^0 + (1 - z^0) \sum_{i=1}^{\infty} \frac{(1 - \tilde{\delta})^{i-1}}{(1 + r)^i} \tilde{\delta}.$$

The expression in brackets in (2.16) is known as tax-adjusted Q, because it consists of marginal Q, or λ/p , adjusted for the effects of tax rates, depreciation allowances, and investment tax credits. Equations (2.14) and (2.15) show how tax-adjusted Q should be further adjusted by the shadow values of carrybacks and carryforwards and for the potential impact of a binding financing constraint.

When estimating a and c from (2.16), some measure of the market value of a firm divided by the replacement cost of its capital has been used as a proxy for λ/p . Typically, an additional control for the ratio of current cash flows to the firm's capital is also included. This control could be interpreted here as a proxy for the effect of financing constraints in FC_t .

The suspected poor performance of market value over asset value as a proxy for marginal Q has inspired several attempts to improve the estimate of c , notably by

Cummins, Hassett, and Hubbard [1994], and Desai and Goolsbee [2004]. Desai and Goolsbee observe that,

$$\frac{\frac{\lambda}{p} - (1 - \tau z - ITC)}{1 - \tau} = \frac{\frac{\lambda}{p}}{1 - \tau} - \frac{1 - \tau z - ITC}{1 - \tau},$$

and they estimate,

$$\frac{I_{ti}}{K_{ti}} = \beta_1 \left[\frac{\frac{\lambda_{ti}}{p_t}}{1 - \tau_t} \right] + \beta_2 \left[\frac{1 - \tau_t z_{ti} - ITC_{ti}}{1 - \tau_t} \right] + \beta_3 \left[\frac{CashFlow_{ti}}{K_{ti}} \right] + \alpha_i + \epsilon_{ti},$$

where subscripts index firm i in year t in the Compustat panel. That is, they simply allow different coefficient estimates on the “Q” and “tax term” components of tax-adjusted Q, so that problems measuring Q do not contaminate estimates of the effects of the tax variables.

For comparison with the previous literature, I first estimate equations of the form,

$$\begin{aligned} \frac{I_{ti}}{K_{ti}} = & \beta_1 \left[\frac{1 - \tau_t z_{ti} - ITC_{ti}}{1 - \tau_t} \right] + \beta_2 \left[NT_t \frac{1 - \tau_t z_{ti} - ITC_{ti}}{1 - \tau_t} \right] \\ & + \beta_3 \left[\frac{CashFlow_{ti}}{K_{ti}} \right] + \beta_4 \left[\frac{\frac{\lambda_{ti}}{p_t}}{1 - \tau_t} \right] + \beta_5 NT_t + \alpha_i + \epsilon_{ti}, \end{aligned}$$

where I allow different coefficients on the tax variables for currently taxable and nontaxable firms. I find estimates of $(\beta_1 + \beta_2)/\beta_1$ around 0.6, suggesting that nontaxable firms are about 60% as responsive to tax incentives as fully taxable firms. This ratio is within the range of ratios consistent with the calculations of the present values of carryforwards and carrybacks in Altshuler and Auerbach [1990].

I then estimate equations of the form,

$$\begin{aligned} \frac{I_{ti}}{K_{ti}} = & \beta_1 \left[\frac{1 - \tau_t z_{ti} - ITC_{ti}}{1 - \tau_t} \right] + \beta_2 \left[NT_t \frac{1 - \tau_t z_{ti} - ITC_{ti}}{1 - \tau_t} \right] \\ & + \beta_3 \left[\frac{CashFlow_{ti}}{K_{ti}} \times \frac{1 - \tau_t z_{ti} - ITC_{ti}}{1 - \tau_t} \right] + \beta_4 \left[\frac{CashFlow_{ti}}{K_{ti}} \right] \\ & + \beta_5 \left[\frac{\frac{\lambda_{ti}}{p_t}}{1 - \tau_t} \right] + \beta_6 NT_t + \alpha_i + \epsilon_{ti}, \end{aligned}$$

where the effect of tax incentives may also vary with cash flows. The magnitude and significance of the coefficient on the interaction of the tax incentive variables with nontaxable status is greatly reduced, and β_3 , the coefficient on the cash flow–tax incentive interaction, is economically and statistically significant.

2.4 Data

Standard and Poor’s gathers financial statements from firms that are traded publicly in the United States or Canada. They code the information reported by each firm into a standardized set of income, cash flow, balance sheet, and supplementary data items. The resulting panel dataset is known as the Compustat North America Database. In 1967, the first year for which all relevant data items are widely available,¹³ about 2,000 firms appear in the dataset, though only 750 observations feature nonmissing values for all relevant items. The sample has expanded over time and now includes all firms traded on American and Canadian stock exchanges, including American Depository Receipts for foreign firms, as well as many firms traded over-the-counter and some firms that file financial statements even though they are not publicly traded. In recent years, over 10,000 firms have appeared in the sample, with 5,000 reporting all relevant data items. I exclude from the estimation sample all firms in North American Industry Classification System sectors 52, Finance and Insurance, and 22, Utilities.

2.4.1 Consolidation Issues

Compustat includes financial statements for many entities that are not appropriate entities for computing U.S. tax variables. I attempt to eliminate from the sample as many of these as possible. I drop all observations designated by Compustat as “pro forma” statements, which are primarily fictitious statements for entities created by merger, added retroactively to the dataset for years prior to the merger. However, casual inspection of the data reveals many observations that appear to be pro forma,

¹³The limiting “relevant data items” are those needed to construct measures of Q, as described below.

but which are not so designated by Compustat. I hand-inspected all cases where two firms in the same year contain the same value for total assets, as typically happens in merger years when an observation appears for both the newly created entity and the pro forma entity. When further inspection reveals that one entity is pro forma, I drop all observations of that entity. I also drop all observations designated as “pre-SFAS #94” statements, which appear when firms reported one set of results under the new accounting rules in Statement of Financial Accounting Standards (SFAS) 94, and a separate set of results under the rules they used prior to the adoption of SFAS 94 in 1987.

Differences in consolidation rules for tax and financial reporting purposes mean that some financial statements that appear Compustat in do not correctly represent entities that file corporate income tax returns. I drop all statements from entities designated by Compustat as wholly-owned subsidiaries of other entities. I also drop all statements designated by Compustat as consolidated financial statements for groups who are not themselves publicly traded, but whose subsidiaries include two or more firms that are publicly traded. In case of wholly-owned subsidiaries, I always drop the appropriate entity, as wholly-owned subsidiaries do not file their own tax returns. Instead their income flows through to the consolidated tax return filed by their parent. In the case of nonpublic consolidated groups, I may sometimes drop the parent, when it would be more appropriate to drop the subsidiaries. Groups of corporations may file consolidated financial statements when 50% or more of each subsidiary is owned by the parent. However, a consolidated tax return may be filed only when 80% or more of each subsidiary is owned by the parent. By dropping parents instead of subsidiaries, I correctly handle cases where subsidiaries are 50% to 80% owned, but I may mishandle cases where subsidiaries are more than 80% owned. In this case, I act as if the subsidiaries each file a tax return, where in fact the parent files a single consolidated tax return.

Other firms whose status as a taxable entity might be misclassified include groups whose parent and subsidiaries are all publicly traded and whose parent files a consolidated financial statement. The parent and subsidiary entities will all appear in

Compustat. When subsidiaries are 50% to 80% owned, I will correctly identify the subsidiaries as taxpaying units, but I will incorrectly assume that the parent pays taxes on the income of its subsidiaries. When subsidiaries are more than 80% owned, I will correctly assume that the parent pays taxes on the income of subsidiaries, but I will incorrectly identify the subsidiaries as taxpaying units. There is no way to disentangle all of these relationships with the data available in Compustat. See Hanlon (2003) for more details on differences in consolidation for tax and financial reporting purposes.

2.4.2 Construction of Tax Variables

To fix terminology and review the computation of the corporate income tax, Table 1 presents book measures of corporate income that appear in Compustat and their relationship to tax variables that would appear on the corporate tax return. The top half of the table presents the items that would be necessary to reconcile book pretax income, as appears in Compustat item pi170,¹⁴ with taxable income that would appear on Line 28 of the corporate income tax return, setting aside any differences in consolidation for book and tax purposes. The second half of the table presents the steps necessary to compute the firm's ultimate current tax liability or refund, after accounting for special deductions, credits, and carrybacks. Acronyms refer to items preceding them in a straightforward way.

The items related to tax credits in lines (15) through (18) deserve a few comments. First, the general business credit, of which the investment credit and the research and experimentation credit are the most important components, can offset only 75% of income tax liability above \$25,000,¹⁵ and any excess must be carried back or carried forward. As previously discussed, I ignore this percentage limit, assuming instead

¹⁴For many years Compustat variables were identified with data item numbers. Recently, Compustat switched to a system of nonnumeric mnemonics. When referring to Compustat variables in this paper, I will use their new mnemonic appended to their old data item number. For pretax income, for example, the new mnemonic is pi and the old item number was 170, so I refer to the variable as pi170.

¹⁵These parameters have changed over time, and the percentage limit has been as high as 85% in the past.

Table 2.1: Relationship Between Book and Tax Variables

Pretax Income from Continuing Operations	(1)	[Compustat pi170]
+ Permanent Tax-Book Differences in PICO	(2)	
+ Temporary Tax-Book Differences in PICO	(3)	
+ Extraordinary Items and Discontinued Operations, Net of Tax	(4)	[Compustat xido48]
+ Tax Provision for EIDO	(5)	
+ Permanent Tax-Book Differences in EIDO	(6)	
+ Temporary Tax-Book Differences in EIDO	(7)	
= Taxable Income before Special Deductions	(8)	[IRS Form 1120, Line 28]
– Dividends Received Deduction	(9)	[Line 29b]
= Taxable Income after Dividend Deduction	(10)	
– Net Operating Loss Deduction	(11)	[Line 29a]
= Taxable Income after NOL Deduction	(12)	[Line 30]
$\times \tau$	(13)	
= Tentative Tax Before Credits	(14)	
+ $\text{Max}(-\text{TTBC} - \text{Carryback Stock}, 0)$	(15)	
= Taxes Before Credits	(16)	
– $\text{Max}(\text{Min}(\text{TBC}, \text{Credit}), 0)$	(17)	[Compustat itci51]
– $\text{Max}(\text{Min}(\text{Credit}, \text{TTBC} + \text{CBS}), 0)$	(18)	
+ $\text{Max}(\text{Min}(\text{TBC}, \text{Credit}), 0)$		
= Tax Bill	(19)	
– Tax Bill Allocated to EIDO	(20)	
= Tax Bill for Continuing Operations	(21)	[Compustat txfed63]

that credits can be used to offset 100% of tax liability.

Second, I have written the items related to credits in the convoluted manner of lines (14) through (18) to highlight which component of credits is observable in Compustat. Only credits used to offset positive taxes, as in line (17), appear in itci51. Credit carrybacks that contribute to a tax refund, as in line (11), do not appear.¹⁶

¹⁶Even this is only accurate for firms using the flow-through method of accounting for tax credits. Firms using the deferral method allocate the entire amount of a credit earned to a balance sheet account, which is then amortized over the life of the asset, with the amortization amount appearing in data51 each year. Of the observations with itci51 > 0, the related footnote in afnt8 shows that 52% are reported using the flow-through method, 8% using the deferral method, and the remaining 40% using some combination of the two methods.

Taxable Income

Below, I will use a measure of Taxable Income after Dividend Deduction (TIDD), or line (10) of Table 1, to identify firms making Alternative Minimum Tax payments and to calculate an alternative measure of outstanding carryforward stocks. No direct measure of this quantity appears in Compustat, so I attempt to infer it from available data. Other authors have constructed a taxable income measure using `txfed63`, the current U.S. federal tax liability allocated to continuing operations, and its foreign equivalent, `txfo64`, along with Compustat's measure of outstanding carryforwards, `tlcf52`. In effect, they attempt to work up from the bottom of Table 1 to reach the taxable income variables in the middle.¹⁷

My aim in constructing a taxable income measure is to make small adjustments to `txfed63` and to recalculate `tlcf52`, so these measures are inappropriate for my purposes. I instead work down to a measure of line (10) starting from the Compustat items at the top of Table 1.¹⁸ I screen for alternative minimum tax payments on income from continuing operations using `pi170` alone, and I construct carryforward stocks using

$$TIDD_t = \text{pi170} + \text{xido48}.$$

¹⁷Hanlon, Laplante, and Shevlin (2005) construct,

$$\text{Taxable Income} = \frac{\text{txfed63}_t + \text{txfo64}_t}{\tau_t} + \text{tlcf52}_{t-1} - \text{tlcf52}_t,$$

where they use the change in the Compustat measure of the carryforward stock, `tlcf52`, as a measure of NOL deductions in line (11).

¹⁸One might attempt to measure the items in lines (3), (5), (7), and (9) with proxies constructed from Compustat variables, but I decided against it. For example, line (3), temporary Tax-Book Differences in Pretax Income from Continuing Operations, might be gleaned from the deferred federal tax item on the income statement (`txdfed269`), since this item primarily reflects the tax effects of temporary differences. However, this relationship breaks down in loss situations, since any newly generated carryforwards appear as deferred tax assets, subject to a valuation allowance if they are thought likely to expire unused. See FASB Statement 109 for more on accounting for deferred taxes. Similarly, one might think it possible to use `xido48`, the net-of-tax measure of income from extraordinary items and discontinued operations, and gross it up to reach a pretax amount and related tax expense. Again, however, the accuracy of this proxy would likely suffer most when loss provisions complicate the calculation of tax expenses for the extraordinary items. Finally, one might consider constructing a measure of the dividends received deduction in line (9) using a Compustat measure of dividends received. However, the only dividend information available in Compustat is lumped together with gains on marketable securities and income from equity-method nonconsolidated subsidiaries in `nopio190`, so it is unlikely to be of much use in measuring the dividend deduction.

I discuss each of these in more detail below.¹⁹

Adjustments for the Alternative Minimum Tax

The corporate alternative minimum tax (AMT) presents a few surmountable complications for my analysis. AMT provisions require firms to compute an alternative measure of taxable income, from which fewer deductions are permitted. A 20% rate is then applied to this income, and fewer credits are allowed to offset the resulting tax liability. Notably, the depreciation allowances allowed under the AMT are less accelerated than under the regular tax, and the General Business Credit cannot offset AMT liability.²⁰ If the firm's AMT liability is larger than its regular income tax liability, it must pay the AMT amount. AMT payments are then carried forward as AMT credits, which can be used to offset regular income tax liability if the firm returns to regular income tax eligibility. Alternatively, there exists a parallel system of carrybacks and carryforwards of AMT NOL's, so if a firm makes an AMT payment in year t , and runs an AMT loss in year $t + 1$, it can carry back the AMT loss and receive a refund on its prior AMT payment.

Firms that are "permanent" AMT payers fit well into my framework, as they operate entirely within this system of AMT NOL carrybacks and carryforwards, with the exception that they face a lower marginal rate when taxable and enjoy less accelerated depreciation. Firms that alternate between AMT eligibility and eligibility for the regular income tax are more problematic. When they make an AMT tax payment, they acquire a potential carryback of future AMT losses, as well as a credit carryforward against future regular tax liability. I do not capture any effects of the AMT credit carryforward.

There is one group of firms whose data I adjust before proceeding with the calculations of taxable status and the carryback and carryforward stocks. The AMT

¹⁹I also adjust extraordinary items and special items for recent accounting changes, as discussed in Appendix 2.

²⁰Whereas the MACRS provides 200% double declining balance depreciation with an optimal switchover to straight line, only 150% double declining balance with the optimal switchover is allowed for AMT purposes. Special provisions in the JCWAA did allow bonus depreciation deductions from AMT income. For details on the corporate AMT, see IRS Form 4626 and its instructions.

permits NOL deductions only up to 90% of AMT taxable income. Thus we observe some firms with carryforwards large enough to offset the entirety of their taxable income who still pay small positive taxes. These firms are taxable on marginal AMT income who still pay small positive taxes. These firms are taxable on marginal AMT income at a rate of 2%, i.e. 10% of the AMT rate of 20%. Because 2% is closer to 0% than to 35%, I choose to classify these firms as nontaxable. I construct a dummy for AMT status, AMT_t equal to 1 when the firm has tax payments (txfed63) plus credits utilized (itci51) less than or equal to 2% of taxable income (pi170), Less than 3% of observations in the eventual estimation sample are classified as AMT payments by this criterion. I then construct a measure of the tax bill excluding these small AMT payments as,

$$TB_t = \text{txfed63}_t \times (1 - AMT_t).$$

Carryback Stocks

Constructing a measure of the potential federal income tax carrybacks available to a firm in a given year is relatively straightforward given the tax bill information constructed above. Using the notation introduced earlier, where $CB[s]_t$ represents the potential carryback in year t still remaining from taxes paid in year $t - s$, I first construct,

$$CB[s]_0 = \text{Max}(TB_0, 0) \quad \forall s,$$

that is, in each firm's first year in the sample I set its potential carrybacks from each prior year to equal its tax payment in the year, if and only if it is nonnegative. Then I evolve the carryback stocks forward using each year's tax bill, exactly as discussed above in equations (2.3) and (2.1).

Taxable Status

I classify firms as taxable if they currently face the marginal income tax rate, either by paying positive taxes or receiving carrybacks. I construct the nontaxable dummy,

$$NT_t = 1 - \mathbf{1}(TB_t > 0 | (0 > TB_t > -\tilde{C}B_t)).$$

Carryforward Stocks

I also construct a measure of the firm's outstanding carryforward stocks based on its history of tax bills, taxable incomes, and carryback stocks. In a firm's second year in the sample, I set its carryback amount at the beginning of the year to the Compustat-reported NOL amount at the end of the previous year,

$$CF_1 = \text{tlcf52}_0.$$

Then I evolve the carryforward stock forward using the data constructed above. I set,

$$CF_{t+1} = \begin{cases} 0 & \text{if } TB_t > 0 \\ 0 & \text{if } TB_t = 0 \text{ and } CR_t + p_t ITC_t > 0 \\ \text{Max}(0, CF_t - TIDD_t) & \text{if } TB_t = 0 \text{ and } CR_t + p_t ITC_t = 0 \\ 0 & \text{if } 0 > TB_t > -\tilde{C}B_t \\ \text{Max}(0, -TIDD_t + TB_t/\tau_t) & \text{if } 0 > TB_t \text{ and } -\tilde{C}B_t \geq TB_t \end{cases}$$

In the first case, when the firm pays positive taxes (excluding any small AMT payments as discussed above) I conclude that the firm has exhausted its carryforwards and will carry none into the following year. In the second case, the firm pays no taxes, but indicates that it offset positive Taxes Before Credits by using a credit, implying that Taxable Income after NOL Deductions was positive and that any carryforwards were exhausted.²¹ In the third case, the firm pays zero taxes and reports zero credit offsets. In this case, the firm may have had either positive taxable income fully offset by carryforwards, or negative taxable income that it was unable to carry back. If taxable income is positive, it is subtracted from the carryforward stock. If taxable income is negative, its absolute value is added to the carryforward stock. Because my measures of taxable income and carryforward stocks are both imperfect, there

²¹I exclude credits reported using the deferral or combination methods of accounting when making this determination, since these need not represent actual credit offsets in the current year.

are observations where the taxable income measure exceeds the carryforward stock measure, but no tax payments are reported. In this case, I set the following year's carryforward stock to zero.

In the fourth case, the firm receives carrybacks that do not exceed its stock of potential carrybacks. Since it had potential carrybacks at the beginning of the year, it should not have had carryforwards at the beginning of the year. And since its losses did not exhaust its carrybacks, it creates no new carryforwards for the following year. In the fifth case, the firm's losses exhaust its carrybacks, and new carryforwards are created. The new carryforward is the firm's (negative) taxable income, reduced by the portion carried back. It is feasible that the firm's taxable income was not negative enough to exhaust its carryback (and perhaps even positive), but its credits were large enough to bring it to carryback exhaustion. There is no way to measure any excess of credits over the carryback limit, since only credits offsetting positive income are reported in Compustat. In this case, as well as any case where poor measures of taxable income and carrybacks would produce a negative carryforward, I set the following year's carryforward to zero.

Internal Consistency Checks

The three constructed variables I will use in regressions are taxable status, carryforward stock, and carryback stock, or NT_t , CF_t , and CB_t , respectively. If constructed correctly, these variables should be related in certain ways. Whenever $CF_t > 0$, we should see $NT_{t-1} = 1$ and $CB_t = 0$. And we should never see $CF_t > 0$ when $NT_{t-1} = 0$ or $CB_t > 0$. In Table 2, I present the percent of relevant observations that fail each of these four checks. The first column performs the checks using the carryforward stocks that I constructed. The second uses the carryforward data provided by Compustat in `tlcf52`.

The second column demonstrates that the Compustat NOL data from `tlcf52` are largely inconsistent with the Compustat tax data in `txfed63`. In 34.7% of the observations where Compustat reports the presence of a carryforward, Compustat also reports that the firm paid positive taxes or received a refund not exceeding its poten-

Table 2.2: Observations with Inconsistent Tax Variables

Inconsistency	CF	tlcf52
$NT_{t-1} = 0$ given $CF_t > 0$	0%	34.7%
$CF_t > 0$ given $NT_{t-1} = 0$	0%	12.9%
$CB_t > 0$ given $CF_t > 0$	7.7%	40.2%
$CF_t > 0$ given $CB_t > 0$	2.0%	14.4%

tial carryback in the prior year. Hand comparisons of randomly selected observations with the original financial statements show that the Compustat variable lumps together carryforwards for federal, state, and foreign purposes and sometimes contains pure coding errors.

The absence of any inconsistencies in the upper left cells of the table is by construction. I constructed NT_t and CF_t from the underlying txfed63 information in such a way that they cannot conflict. The 7.7% and 2.0% inconsistencies in the lower left come from inconsistencies in the underlying txfed63 information itself, for example, in situations where a firm pays positive taxes for some time, then reports negative taxable income accompanied by zero taxes paid, instead of the carrybacks that one would expect.

I follow prior literature in constructing the many other variables that enter the estimation results to be presented. See Appendix 1 for more detail on the construction of these variables.

Table 2.3: Regressions of Investment to Capital Stock Ratio on Tax Variables and Controls

	All Firms	All Firms	Largest 3500	Largest 3500	Largest 2500	Largest 2500	Largest 1500	Largest 1500	Largest 500	Largest 500	Largest 100	Largest 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Equipment tax term (ETT)	-1.184 (.381)***	-1.161 (.379)***	-.909 (.369)**		-.842 (.337)**		-.527 (.318)*		-.614 (.352)*		-.400 (.485)	
ETT X taxable dummy				-.909 (.369)**		-.842 (.337)**		-.527 (.318)*		-.614 (.352)*		-.400 (.485)
ETT X nontaxable dummy		.0006 (.100)	.102 (.101)	-.807 (.382)**	.304 (.096)***	-.537 (.351)	.233 (.107)**	-.294 (.336)	.057 (.133)	-.557 (.339)	.298 (.119)**	-.102 (.509)
Nontaxable dummy		-.101 (.104)	-.191 (.105)*	-.191 (.105)*	-.383 (.099)***	-.383 (.099)***	-.295 (.111)***	-.295 (.111)***	-.088 (.140)	-.088 (.140)	-.334 (.126)***	-.334 (.126)***
Structures tax term	-.073 (.064)	-.066 (.063)	-.059 (.061)	-.059 (.061)	-.029 (.055)	-.029 (.055)	.019 (.054)	.019 (.054)	-.038 (.057)	-.038 (.057)	-.066 (.099)	-.066 (.099)
Q over $(1 - \tau)$	.036 (.001)***	.035 (.001)***	.048 (.002)***	.048 (.002)***	.052 (.002)***	.052 (.002)***	.040 (.002)***	.040 (.002)***	.021 (.003)***	.021 (.003)***	.018 (.005)***	.018 (.005)***
Cash flow	-.009 (.001)***	-.010 (.001)***	-.002 (.002)	-.002 (.002)	.018 (.003)***	.018 (.003)***	.041 (.006)***	.041 (.006)***	.078 (.018)***	.078 (.018)***	.111 (.022)***	.111 (.022)***
Response Ratio	.	.999	.888	.888	.638	.638	.558	.558	.907	.907	.255	.255
Firms	12416	12416	11215	11215	8204	8204	4751	4751	1496	1496	275	275
Observations	123100	123100	108870	108870	85169	85169	56340	56340	19500	19500	3900	3900
R^2	.345	.349	.391	.391	.428	.428	.424	.424	.483	.483	.552	.552

Columns 1 and 2 include all Compustat firms with non-missing data. Columns 3 through 12 include only the n largest firms by assets in the sample in each year if the number of firms is larger than n , where n is specified in the column header. The response ratio line reports the ratio of the responsiveness of nontaxable firms to that of taxable firms. In the even-numbered columns, this is simply the ratio of the coefficients in the third and second rows. All specifications include firm and year fixed effects. Standard errors are clustered at the firm level.

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

2.5 Results

Table 2.3 presents baseline regressions of I_t/K_{t-1} on the tax term, Q , and cash flows. In all regressions that follow, I include firm and year fixed effects and cluster standard errors at the firm level. Results in Column 1 of Table 2.3 are quite similar to those in Desai and Goolsbee [2004]. The coefficient on the tax term for equipment is statistically significant and economically important. Desai and Goolsbee [2004] report that the average tax term across industries in their sample reached a high of about 1.2 in the early 1960's and a low of about 0.95 in the early 1980's. Thus the estimated coefficient suggests that historical tax variation could have accounted for differences of up to 30 percentage points in investment ratios.

Columns 2 through 12 of Table 2.3 allow responses to the tax term to differ between taxable and nontaxable firms. Column 2 shows that responses of taxable and nontaxable firms are not statistically different in the full sample of firms. It is also true that cash flow has a negative effect on investment in this sample. Columns 3 through 12 successively restrict the sample to include the largest 3500, 2500, 1500, 500, and 100 firms by assets in the sample in each year. Since the distribution of assets and investment across firms is highly skewed, responses at the top of the firm distribution will be most important in determining the response of aggregate investment.

The Response Ratio line in the table displays the estimated ratio of the responsiveness of nontaxable firms to taxable firms. This ratio takes the values of .64, .56, .91, and .26 in the sample of the top 2500, 1500, 500, and 100 largest firms, respectively. As the mean of these numbers is .59, I conclude that nontaxable firms are about 60% as responsive to tax incentives as fully taxable firms. Standard errors in the odd-numbered columns suggest taxable and nontaxable firm responses are statistically different from each other in the largest 2500, 1500, and 100 firm samples. The odd-numbered columns indicate that the responsiveness of nontaxable firms is statistically different from zero only in the full and largest 3500 firm samples. The responsiveness of taxable firms is statistically different from zero at the ten percent

significance level in all samples except the largest 100 firm sample. The declining magnitude and significance of the coefficient estimates as the sample is restricted to larger and larger firms suggests that the effect of tax incentives may be least important in exactly those firms that matter most for aggregate investment. It is also true, however, that the tax variables calculated at the industry level may be most poorly measured for large firms active in many markets.

Table 2.4: Regressions of Investment to Capital Stock Ratio on Tax Variables and Controls, with Cash Flow Interactions

	(1)	(2)	(3)	(4)	(5)
Equipment Tax Term (ETT)				-.527 (.318)*	-.524 (.320)
ETT × taxable dummy	-.527 (.318)*	-.495 (.316)			
ETT × nontaxable dummy	-.294 (.336)	-.226 (.334)		.233 (.107)**	.087 (.120)
ETT × taxable dummy × positive income dummy			-.479 (.316)		
ETT × taxable dummy × nonpositive income dummy			-.408 (.328)		
ETT × nontaxable dummy × positive income dummy			-.208 (.335)		
ETT × nontaxable dummy × nonpositive income dummy			-.172 (.337)		
ETT × Cash flow / PPE					-.474 (.157)***
Nontaxable dummy	-.295 (.111)***	-.325 (.111)***	-.314 (.117)***	-.295 (.111)***	-.143 (.125)
Structures depreciation allowance	.019 (.054)	.023 (.053)	.025 (.053)	.019 (.054)	.003 (.054)
Q / (1 - τ)	.040 (.002)***	.040 (.002)***	.040 (.002)***	.040 (.002)***	.041 (.002)***
Cash flow / PPE	.041 (.006)***	.039 (.006)***	.038 (.006)***	.041 (.006)***	.537 (.165)***
Negative income dummy		-.031 (.004)***	-.093 (.088)		
Firms	4751	4751	4751	4751	4751
Observations	56340	56340	56340	56340	56340
R ²	.424	.425	.425	.424	.425

All columns include only the largest 1500 firms by assets in each year. All specifications include firm and year fixed effects. Standard errors are clustered at the firm: level.

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

Another notable aspect of Table 2.3 is the pattern of cash flow coefficients. As there is a large literature on the positive effects of cash flow on investment, the negative coefficients on cash flows in columns 1 and 2 are surprising. Regressions not reported reveal that these negative coefficients are driven by the bottom 5% of cash flow observations, where the magnitude of negative cash flows exceeds that of the capital stock by a factor of five or more. Inspection of the data suggests that these consist largely of firms with little capital running large losses early in their lives. When the sample is restricted on firm size in Table 2.3, the negative relationship between investment and cash flow reverses.²²

Altshuler and Auerbach [1990] calculate average values of γ^B and γ^F , the shadow values of carrybacks and carryforwards, from estimates of second-order transition probabilities among taxable status states in a panel of tax returns from 2,808 firms. The range of estimated shadow values reported in their paper and the current statutory tax rate of 0.35 together imply a range of implied response ratios of 0.40 to 0.57. The estimated response ratios in Table 2.3 are centered around this range, with the estimate from columns 7 and 8 inside it. Thus, the shadow values estimated by Altshuler and Auerbach, when placed in the context of the investment model developed above, imply response ratios roughly consistent with what I estimate from observed investment decisions.²³

One could be concerned, however, that the observed asymmetry in responsiveness to tax incentives is driven not by the shadow values of carrybacks and carryforwards, but by unrelated firm characteristics that are correlated with taxable status. In the model discussed previously, for example, binding financing constraints would produce a lower sensitivity of investment to tax incentives. If nontaxable firms are more

²²Much of the cash flow literature, notably Fazzari, Hubbard, and Petersen [1988], Hoshi, Kashyap, and Scharfstein [1991], Blanchard, de Silanes, and Shleifer [1994], Kaplan and Zingales [1997], Lamont [1997], and Rauh [2006], focus on selected samples of larger firms, for which this issue does not arise.

²³The Altshuler and Auerbach shadow values were calculated under the 1982 tax rules, when the carryback period was three years and the carryforward period was fifteen years. In 1997, these numbers changed to two and twenty years, respectively. Since a decrease in the carryback period would decrease the response ratio while an increase in the carryforward period would increase the ratio, I ignore any change in the response ratio that would be induced by the rule change.

likely to face binding financing constraints, we could observe nontaxable firms responding less to tax incentives even if they ignore the shadow values of carrybacks and carryforwards. In this situation, the estimates above would still be relevant for forecasting short-run responses by nontaxable and taxable firms to changes in depreciation allowances. They would not be relevant, however, for predicting the effect of new policies that change the shadow values, such as changes in the carryback and carryforward periods.

Table 2.5: Regressions of Investment to Capital Stock Ratio on Tax Variables and Controls, with Cash Flow Details

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equipment tax term (ETT)	-1.184 (.381)***	-1.203 (.383)***	-1.061 (.377)***	-.870 (.380)**	-.623 (.327)*	-.629 (.326)*	-.545 (.328)*	-.269 (.332)
ETT \times CashFlow / PPE		-.257 (.059)***				-.409 (.207)**		
ETT \times CashFlow / Assets				-1.983 (.426)***				-2.634 (.579)***
Q / (1 - τ)	.036 (.001)***	.036 (.001)***	.038 (.001)***	.038 (.001)***	.035 (.003)***	.035 (.003)***	.031 (.003)***	.032 (.003)***
CashFlow / PPE	-.009 (.001)***	.260 (.061)***			.041 (.008)***	.469 (.217)**		
CashFlow / Assets			.090 (.014)***	2.160 (.446)***			.497 (.051)***	3.240 (.595)***
Firms	12416	12416	12416	12416	3222	3222	3222	3222
Observations	123100	123100	123100	123100	38563	38563	38563	38563
R^2	.345	.346	.345	.346	.432	.433	.438	.439

Columns 1 through 4 include all Compustat firms with non-missing data. Columns 4 through 8 include only the 1000 largest firms in the sample by assets in each year. All specifications include firm and year fixed effects. Standard errors are clustered at the firm level.

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

Table 2.4 presents results suggesting that this concern is quite relevant. The sample in all columns is limited to the largest 1500 firms in each year, for which the asymmetry between taxable and nontaxable firms seemed to work well in Table 2.3. Column 5 includes the interaction between the cash flow to capital stock ratio and the equipment tax term in addition to the interaction between the tax term and nontaxable status. The coefficient on the cash flow interaction is statistically significant at the one percent level, while the nontaxable status interaction is no longer significant at conventional levels. The point estimate of the response ratio estimate rises from 0.56 in Table 2.3 to 0.83 in column 5 of Table 2.4, suggesting that low cash flows in nontaxable firms drive their sluggish response to tax incentives more than nontaxable status itself.

Table 2.5 investigates the effects of the cash flow interactions in more detail. Columns 1 through 4 include all firms in the Compustat sample in each year, while columns 5 through 8 include only the 1000 largest firms by assets in each year. The ratios of cash flows to physical capital (PPE) and cash flows to total assets are both used as cash flow measures.

The within-firm standard deviation of the cash flow to PPE ratio in the full sample is 2.70, while the equivalent figure for cash flow to total assets ratio is about 0.28.²⁴ Thus the results in columns 1 and 2 suggest that a one standard deviation increase from the mean of cash flows to assets would change the coefficient on the tax term from -1.184 to -1.877, an increase of 59%. Using the cash flow to assets ratios in columns 3 and 4 suggests that a one standard deviation increase in the cash flow ratio would produce an increase of 52% in the tax term coefficient. Among the largest 1000 firms in each year, the within-firm standard deviation of the cash flow to PPE ratio is 0.70 and that of the cash flow to assets ratio is 0.07. One standard deviation increases in these cash flow ratios would thus produce 46% and 35% increases in tax term sensitivity. Thus it seems that variation in cash flows over time produces important differences in the responsiveness of investment to tax incentives.

²⁴That is, the root mean squared error in a regression of the cash flow ratio on a set of firm fixed effects.

Figure 2-4 presents data useful in assessing the potential importance of taxable status and cash flows in mitigating the effectiveness of bonus depreciation. The top panel indicates that the fraction of aggregate assets owned by nontaxable firms peaked in 2003 and 2004 at around 0.3. If we use the Table 2.3 average estimate that nontaxable firms are 60% as responsive to tax incentives, we might conclude that bonus depreciation was about 12% less effective than it would have been had these firms been taxable. If instead we use the Table 2.4 column 5 estimate that nontaxable firms are 83% as responsive as taxable firms, we would conclude that bonus depreciation was 5.1% less effective than it would have been had all firms been fully taxable. Thus it seems that taxable status alone can do relatively little to explain any lack of response to bonus depreciation.

The bottom panel of Figure 2-4 plots the aggregate ratio of cash flows to assets for all Compustat firms from 1950 to 2007. Restricting the sample to the largest 500 or 1000 firms in each year produces a very similar figure because income and assets are highly concentrated among the largest firms. The figure shows that the aggregate ratio averaged 0.11 from 1950 to 1985, before falling as low as 0.06 in 2001 and 0.08 in 2003. Applying the estimates in Table 2.5 column 8 to a drop in the cash flow to assets ratio of 0.05 suggests that the decline in ratio of aggregate cash flows to assets could explain a 24% decrease in the sensitivity of investment to tax incentives. Applying the estimates in column 4, however, would imply only a 9% decrease.

2.6 Conclusions

I developed a model of investment by a firm facing financing constraints and a system of carrybacks and carryforwards of operating losses. I showed how responses to investment incentives in the form of depreciation allowances or investment tax credits will differ between taxable and nontaxable firms and will vary with the tightness of the financing constraint. I carefully constructed measures of taxable status and related tax variables from the financial statement data available in Compustat. I estimated the extent to which responses to tax incentives differ between taxable and nontaxable

firms, concluding that nontaxable firms are about 60% as responsive to tax incentives as currently taxable firms. The magnitude of this ratio is consistent with the predictions of the model when combined with the shadow values of carrybacks and carryforwards that previous authors have calculated by observing firms' probabilities of transitioning between taxable and nontaxable states.

I also estimate that firms' responsiveness to tax incentives varies with their cash flows, as predicted by the model if cash flows provide information about financing constraints. However, the effects of taxable status on the responsiveness to incentives are not robust when also allowing responsiveness to vary with cash flows, although one cannot rule out the possibility that difficulties in measuring taxable status may be partly to blame. Coefficients imply that a within-firm one-standard deviation change in the ratio of cash flows to assets is associated with a 50% increase in the sensitivity of investment to tax incentives.

Implications for the aggregate effectiveness of recent bonus depreciation tax incentives are relatively modest. Estimates suggest that corporate tax asymmetries made bonus depreciation about 5% less effective than it would have been if all firms were fully taxable. The aggregate decline in cash flows made bonus depreciation as much as 24% less effective than it would have been if cash flow ratios had remained at their historical norms.

2.7 Appendix 1: Data Construction

I follow the literature in constructing the many non-tax variables for used in the estimation. The dependent variable in most regressions is the investment to capital stock ratio easily observed in Compustat,

$$\frac{I_t}{K_t} = \frac{\text{capx128}_t}{\text{ppent8}_{t-1}},$$

the ratio of reported Capital Expenditure in the current year to Property, Plant, and Equipment, Net of Accumulated Depreciation, observed at the end of the prior year.

I follow Kaplan and Zingales [1997] in constructing a measure of Q, which is intended to proxy for the increase in the value of the firm’s cash flows created by a marginal dollar of capital, or λ_t/p_t .²⁵ I construct,

$$QKZ_t = \frac{\text{prcc199}_t \times \text{csho25}_t + \text{at6}_t - \text{ceq60}_t - \text{txdb74}_t}{\text{at6}_t}.$$

In essence, this ratio is the market value of equity plus the book value of liabilities, excluding deferred taxes, divided by the book value of assets. Where appropriate, this variable will appear in some regressions divided by $1 - \tau_t$, for τ_t the current statutory tax rate.

I again follow Kaplan and Zingales [1997] in constructing a cash flow measure,

$$\text{CashFlow}_t = \frac{\text{ib18}_t + \text{dp14}_t}{\text{ppent8}_{t-1}}.$$

This ratio is Income Before Extraordinary Items plus Depreciation and Amortization, scaled by the capital stock at the beginning of the year. Following Desai and Goolsbee [2004] and others, I truncate the sample at the 1st and 99th percentiles of I/K , QKZ , and CashFlow .

I follow Cummins, Hassett, and Hubbard [1994] and Desai and Goolsbee [2004]

²⁵Desai and Goolsbee [2004] show that this “corporate finance Q” performs better in investment regressions than the “public finance Q” constructed a bit differently by Salinger and Summers [1984] and Cummins, Hassett, and Hubbard [1994].

in constructing measures of the depreciation allowances and investment tax credits available to each Compustat firm. The depreciation allowances and investment tax credits allowed on corporate investment vary over time and across industries and asset types. Using IRS Publication 946: How to Depreciate Property, I coded the depreciation schedule applicable to each industry and asset combination that appears in the Capital Flows table published by the Bureau of Economic Analysis. The Capital Flows table, published every five years, records the amount of investment made by each industry in each asset category.²⁶ I construct depreciation schedules at the industry level by taking a weighted average across the assets purchased by each industry, with the weights equal to the percentage of the industry's spending accounted for by each asset. The depreciation schedules are then merged by industry with the Compustat firm-level data. Following the literature, I construct the schedules separately for equipment and for structures. Like the prior literature, I will find that the equipment measures are much more successful in explaining investment behavior than the structures measures.

Using these depreciation allowance and investment tax credit data, I construct the depreciation allowance for firm i in year t ,

$$\text{Depreciation allowance}_{it} \equiv z_{it} = \sum_{j=0}^{\infty} \frac{z_{it}^j}{(1+r_t)^j},$$

where z_{it}^j is the depreciation deduction allowed in year $t+j$ on investment made in year t and r_t is the 10-year corporate bond rate, net of taxes. I then construct the tax term component of tax-adjusted Q,

$$\text{Tax term}_{it} \equiv \frac{1 - \tau_t z_{it} - ITC_{it}}{1 - \tau_t},$$

for τ_t the statutory tax rate in year t . Both the depreciation allowance and the tax

²⁶There are 28 equipment categories, with examples including Computers and Peripheral Equipment, Metalworking Machinery, and Autos. There are 23 structures categories, with examples including Industrial Buildings, Railroads, and Petroleum Pipelines. There are 123 industries, which are roughly at the three-digit NAICS level. Examples include Coal Mining, Plastic and Rubber Products Manufacturing, and Air Transportation.

term are constructed separately for equipment investment and structures investment.

2.8 Appendix 2: Accounting Changes and the Ratio of Losses to Profits

In June 2001, the Financial Accounting Standards Board issued its Statement No. 142, which changed the way that firms accounted for goodwill. Prior to FAS 142, acquiring firms would recognize an amount of goodwill on their balance sheet essentially equal to the difference between the purchase price of an acquired firm and the value at which the acquirer would carry the acquired firms' assets on the acquirer's balance sheet. This goodwill would then be slowly amortized (depreciated) over time.

FAS 142 instead required that firms conduct an initial and then annual review of the value of their goodwill to determine whether changing market conditions had "impaired" its value. Many firms conducting such impairment reviews in 2001 and 2002 discovered significant impairments to the goodwill that they had acquired by purchasing firms during the dotcom boom. Many of these firms recorded these impairment charges as "Special Items," which appear on the income statement as deducted from Earnings Before Interest and Taxes in the calculation of Pre-tax Income. Other firms recorded these impairments as "Extraordinary Items," which appear on the income statement after the subtraction of taxes in the calculation of Net Income. Firms report and Compustat records the component of Special Items accounted for by goodwill impairment as a separate variable, although the breakdown of Special Items has only appeared in Compustat since the late 1990s. Compustat also includes a measure of the component of Extraordinary Items attributable to accounting changes, of which goodwill impairment is one example.

Figure 2-5 displays the aggregates across all Compustat firms of Special Items, Goodwill Impairments, Other Write-downs, Extraordinary Items, and Accounting Changes. Extraordinary Items and Accounting Changes move almost one-for-one, suggesting that the vast majority of the \$247 billion in extraordinary items booked

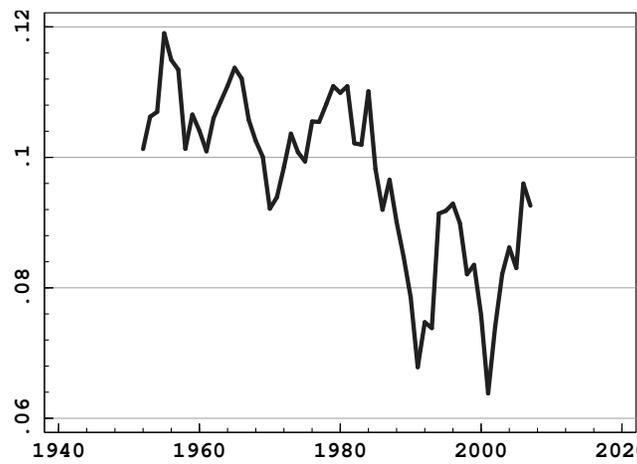
in 2002 is explained primarily by the goodwill accounting change. The Goodwill Impairments item, however, is considerably smaller than Special Items. About \$348 billion in Special Items were booked in 2001, but only \$102 billion of this was recorded by Compustat as related to goodwill impairments. An additional \$120 billion was related to non-cash write-downs of other assets. The majority of the remainder of the deductions recorded as Special Items relate to cash restructuring costs like employee severance and facility shutdowns.

Figure 2-6 displays Compustat aggregate ratios of the negative income earned by firms with negative income to positive income earned by firms with positive income for several different measures of income. The treatment of Goodwill Impairment and Other Write-downs indeed makes a material difference to this ratio, although even income measures that exclude these items still achieve historical highs around 2001. The middle measure—book pre-tax income, with non-cash charges for goodwill and other asset impairments added back in—seems the most appropriate to compare to similar ratios constructed from IRS data on taxable income.

Figure 2-4: Nontaxable Firms and Cash Flows



(a) Fraction of Assets and Employees in Nontaxable Firms



(b) Aggregate Cash Flow / Assets

Figure 2-5: Compustat Aggregate Special and Extraordinary Items

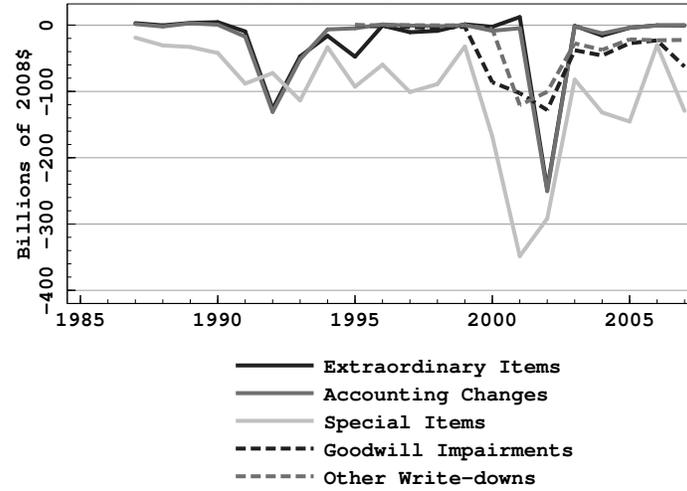
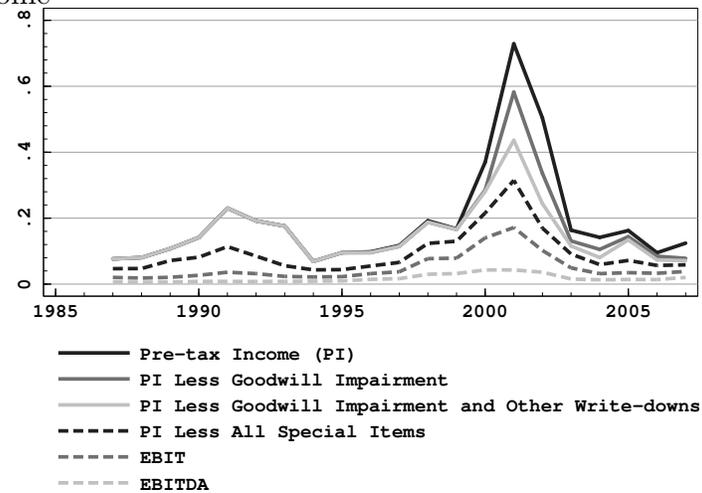


Figure 2-6: Compustat Aggregate Ratio of Losses to Positive Profits for Different Measures of Income



Chapter 3

Effects of the 2003 Dividend Tax Cut: Evidence from Real Estate Investment Trusts

3.1 Introduction

The effect of taxing dividend income has long been a focus of research in economics. The taxation of income from capital, of which dividend payments are one example, presents a particularly stark version of the familiar tradeoff between equity and efficiency that confronts tax policy makers. Dividends are paid disproportionately to high-income households, so one might wish to tax them heavily in order to redistribute from high-income households to low-income households. On the other hand, seminal theoretical results like those in Chamley [1986] and Judd [1985] suggest that distortions from taxing capital income can be so large that efficiency concerns require a zero tax rate on income from capital under an optimal tax system.

Under the traditional, or “old view,” of dividend taxation, these efficiency arguments are relevant for understanding the effects of dividend taxes. Under the “new view” of dividend taxation, however, they do not apply. The new view, which dates at least to King [1977], posits that the funds needed to finance marginal investments

are already held by firms in the form of retained earnings. Dividend taxes would be collected if the firm invested its retained earnings and paid out subsequent returns to shareholders, but dividend taxes would also be collected if the firm immediately paid out its retained earnings as dividends. Thus there is no distortion to the investment decision imposed by the dividend tax and no efficiency costs from dividend taxation.

Under the old view, however, marginal investments must be financed by funds from outside investors. When proceeds from these investments are returned to investors, they face the dividend tax rate. Thus the dividend tax distorts investment decisions, with potentially adverse welfare consequences. More recently, Gordon and Dietz [2006] and Chetty and Saez [2007] have advanced the view that dividend behavior is driven by agency concerns—that is, dividend payouts limit free cash flows and provide a means for preventing managers from using internal funds to provide themselves with private benefits. Dividend taxes can create large efficiency costs in such a model by exacerbating pre-existing distortions from the conflict of interest between managers and diffuse shareholders.

The response of dividend payouts to changes in tax rates can provide evidence on which view of dividend taxation is most relevant for understanding the impact of dividend taxes on welfare. Under the new view, we would expect no change in dividend payouts in response to a dividend tax cut.¹ Under the old or agency views, however, a tax cut would cause an increase in dividend payouts.

Recent literature, notably Blouin, Raedy, and Shackelford [2004], Chetty and Saez [2005], and Brown, Liang, and Weisbenner [2006], has documented a large increase in dividend payouts following a cut in the dividend tax rate in 2003. Chetty and Saez [2005] estimate that the tax cut caused total regular dividend payouts to rise by 20% within 1.5 years of the reform.² This effect is far larger than would have been predicted by prior estimates in the literature, for example, those in Poterba [2004].

¹A caveat arises if the dividend tax cut is believed to be temporary.

²Chetty and Saez [2005], p. 793, write, “Aggregating the changes in amounts along the extensive and intensive margins, we estimate that the tax cut raised total regular dividend payments by about \$5 billion per quarter (20 percent), a change that is statistically significant at the 1 percent level. This implies an elasticity of regular dividend payments with respect to the marginal tax rate on dividend income of -0.5. All of these results are robust to controlling for a variety of potential confounding factors such as levels and lags of profits, assets, cash holdings, industry, and firm age.

Such a large effect of the tax cut on dividend payouts would imply that dividend taxation imposes large welfare costs under either the old or agency views of dividend taxation. In a subsequent paper, Chetty and Saez [2007] argue that the estimates from their first paper imply that the efficiency cost of raising the dividend tax rate from its current level would be extremely large—of the same order of magnitude as the amount of revenue raised.

This paper provides new evidence on the response of dividend payouts to dividend tax changes by comparing the dividend behavior of the majority of U.S. firms who benefited from the 2003 tax cut to a smaller control group of firms—real estate investment trusts (REITs)—that did not benefit from the tax cut. There are at least two compelling reasons to believe that previous authors' estimates of responses to the tax cut might be confounded by events contemporaneous with the tax cut. The first is that the recovery of the U.S. economy from the 2001 recession began in earnest in early 2003, just as the tax cut legislation was debated and passed. The second is that a series of accounting scandals at firms like Enron and Worldcom played out from 2001 through 2003. It may be that the investing public developed a stronger taste for dividend payouts around this time, as it realized that firms' reported earnings were a less reliable guide to cash flows than had previously been believed.

I find that REIT dividend payouts rose sharply following the tax cut even though their dividends did not benefit from the cut. I estimate simple differences-in-differences models of the effects of the tax cut on aggregate regular dividend payouts, the ratio of dividends to earnings, and the probability that firms pay dividends. Most estimates of the effects of the tax cut in these specifications range from zero to one-fourth the size of estimates that attribute all changes to the tax cut. I also document a large increase in corporate earnings whose beginning coincided with the tax cut. In fact, there was no increase in the ratio of dividend payouts to earnings after the tax cut. I thus argue that the bulk of the increase in dividend payouts documented by previous authors is easily explained by the increase in earnings, with little or no role for the tax cut. Thus there is little reason to think that an increase in the dividend tax rate would create large efficiency costs.

This paper contributes to a longstanding debate over the likely impact of dividend taxation on the cost of capital and on welfare. Poterba and Summers [1985] and Desai and Goolsbee [2004] provide evidence using firm-level investment data, with the former paper supporting the old view and the latter supporting the new view. Using data on dividend payout responses to tax changes, Poterba and Summers [1985] and Poterba [2004] provide evidence supporting the old view, although the estimated effects of taxes on dividend payouts are modest relative to the more recent literature. Auerbach and Hassett [2003] investigate the sensitivity of dividend payouts to investment and cash flows, and they find considerable heterogeneity across firms, but significant support for the new view. Auerbach and Hassett [2007] find evidence in favor of the new view from stock price reactions to news about the passage of the tax cut. Finally, this paper contributes to a small literature attempting to use the special rules that apply to REITs to learn more general lessons about the effects of taxation. Examples include Gentry, Kemsley, and Mayer [2003], Sinai and Gyourko [2004], and Amromin, Harrison, and Sharpe [2005].

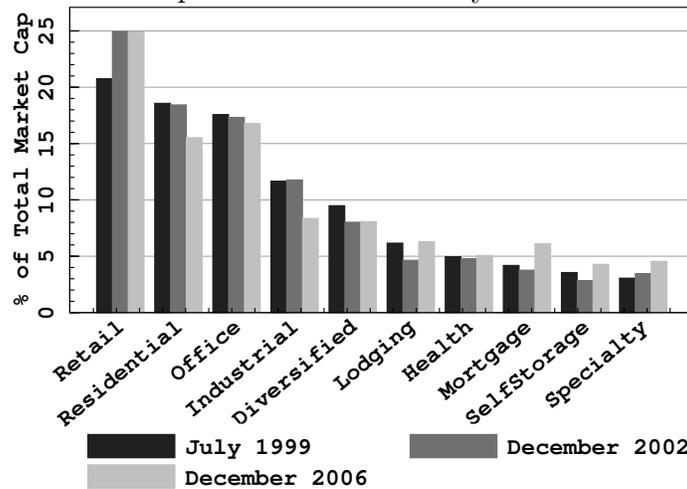
The following section of the paper discusses the legislation governing REITs and the 2003 tax cut in more detail. Section 3 discusses the data used in this paper, and Section 4 contains the paper's results. Section 5 concludes.

3.2 Background

3.2.1 Real Estate Investment Trusts

Real estate investment trusts are corporations that invest in real estate assets, primarily office and apartment buildings, malls, hotels, and big-box stores. REITs are essentially "C" corporations under the corporate income tax code, but their dividend payouts are deductible from their taxable income as long as certain requirements on their activities, payouts, and ownership are met. Chief among these requirements are that at least 90% of their otherwise-taxable income be paid out as dividends and that at least 75% of their income come in the form of rental income, mortgage interest

Figure 3-1: Market Capitalization of Publicly-Traded REITs by Sector



payments, or other passive real estate investment income. REITs must also have at least 100 shareholders, with no more than 50% of shares owned by any 5 shareholders. When a REIT meets these requirements it can avoid taxation at the corporate level. Essentially, REITs are intended to resemble mutual funds that invest in real estate related assets.

The REIT structure was first established by Congress in 1960, but REITs did not reach their current level of prominence until further legislative changes in the 1980s and 1990s, which set the stage for a large flow of capital into REITs during the mid-1990s.³ The market capitalization of publicly-traded REITs swelled from less than \$9 billion at the end of 1990 to \$140 billion at the beginning of 1998. This bulk of this paper will focus on data beginning in 1998.

REITs are active participants in a broad spectrum of real estate sectors. Figure 3-1 displays the fraction of total REIT market capitalization accounted for by REITs

³The Tax Reform Act of 1986 allowed REITs to play a more active role in operating their properties and providing services for tenants, mitigating agency problems that may have arisen when REITs were required to hire third parties to manage their assets. The Act also made other arrangements for owning real estate relatively less attractive by lengthening depreciation schedules and tightening passive loss rules. A budget bill in 1993 dropped the rule that an institutional investor representing many individuals be considered a single investor when calculating the fraction of shares owned by the five largest shareholders. This permitted more institutional investors to purchase larger blocks of REIT shares. Finally, in the early 1990s, the creation of umbrella partnership REITs, or UPREITs, permitted REITs to acquire existing properties without triggering a taxable capital gain for the seller. See Block [2006], Chan, Erickson, and Wang [2003], and Imperiale [2002] for more information.

in different real estate sectors based on data from the National Association of Real Estate Investment Trusts (NAREIT). The retail sector, consisting primarily of REITs that own malls, shopping centers, and big-box stores, comprised about 25% of REIT market capitalization at the end of 2002. Residential REITs, which primarily own apartment buildings, were next at 18%, followed by office and industrial REITs at 17% and 12%, respectively. Less than 5% of REIT market capitalization was accounted for by each of health REITs (which own primarily nursing homes and assisted-living facilities), lodging REITs (hotels and resorts), specialty REITs (golf courses, timber investments, etc.), and self-storage facility REITs. Mortgage REITs, which hold mortgage-related loans and securities rather than physical properties, also comprised around 5% of market capitalization.

That REITs own many forms of real estate used by firms in many industries suggests that REIT performance may track the aggregate economy rather well. In fact, over the ten years from February 1999 to February 2009, the coefficient in a regression of monthly total returns for an index of US REITs on total returns for the S&P 500 (that is, REITs' beta) was 0.76. Over the five years from February 2004 to February 2009, REITs had a beta of 1.6.⁴ This figure reflects the fact that REIT stocks followed a similar path to the aggregate market's boom and bust over the past five years, but with even more dramatic swings in value. Figure 3-1 also presents the sector shares of REIT market capitalization at year-end 2006, near the peak of REIT market cap. The shares of REIT market cap in different sectors are little changed from the period before the boom.

One might suspect that dividend payouts by REITs are determined by one of two potential corner solutions. REITs are required to pay at least 90% of their taxable income as dividends each year to maintain their REIT status. One might thus conjecture that REITs would pay out the minimum required 90% of income and retain the rest to fund future operations or investments. This strategy would

⁴See <http://finance.yahoo.com/q/rk?s=VGSIX>. This observation may call into question the justification for REITs' special tax-exempt status. Presumably, the REIT structure exists so that small investors can diversify their portfolios by participating in real estate investments that would otherwise be available only to large and sophisticated investors. It appears, however, that modern REITs provide little in the way of portfolio diversification.

entail that REITs pay corporate-level tax on the remaining 10% of income not paid as dividends. One might also conjecture that REITs would pay exactly 100% of taxable income as dividends, minimizing their tax liability at zero and retaining the remainder of their cash flows.

In fact, it appears that REITs regularly pay dividends in excess of 100% of taxable income. It is feasible for REITs to make cash payouts in excess of taxable income when non-cash deductions from taxable income make cash flows higher than taxable income. REITs, of course, often have very large non-cash depreciation deductions on the properties they own. When REITs make payouts in excess of taxable income (or of accumulated taxable income, if they have paid dividends lower than taxable income in previous years), these payments are not considered ordinary dividend income for their recipient, but “return of capital,” which lowers the recipient’s basis in her REIT shares. REITs may also distribute income from the sale of property as a long-term capital gain, rather than a dividend. Data from NAREIT suggest that these types of non-ordinary dividends constitute more than 20% of REIT dividend payouts and have increased in importance over time. The vast majority of REITs for which data are available report paying both return of capital and long-term capital gain as part of their cash dividend payouts, in addition to ordinary dividends.

Thus it appears that REITs usually choose an interior solution to their dividend payout decision where payouts exceed 100% of taxable income. That is, they balance the perceived costs and benefits of paying dividends, just like other firms. Benefits of payment could include the transmission of a signal of quality to outsiders or the resolution of agency concerns. Costs could include the disadvantages of being required to raise external funds for future activities. In any case, these are concerns similar to those faced by other firms deciding their level of dividend payouts.

In this paper, I use REITs as a control group to study the dividend behavior of the rest of the firms in the United States from 1998 to 2007. The data presented in this section suggest this comparison is quite reasonable. After a period of rapid growth and change in the early 1990s, REITs had largely assumed their modern form by the beginning of 1998. Since then, REITs have participated in a relatively

stable set of investment activities whose performance has largely reflected that of the aggregate market. REIT dividend payouts are not governed by a tax-induced corner solution, but can fluctuate as REITs perceive changes in the costs and benefits of paying dividends.

3.2.2 The 2003 Dividend Tax Cut

Prior to the 2003 tax legislation, dividend income was considered ordinary income under the U.S. income tax code for individuals, and thus it was taxed at the ordinary individual income tax rates. The federal top marginal tax rate declined from 39.6% in 2000 to 35% in 2003, and Poterba [2004] estimates that the weighted average marginal tax rate on dividends collected by U.S. households was about 32% over this period.

The Jobs and Growth Tax Relief Reconciliation Act of 2003 reduced tax rates on “qualified” dividends to the rates applying to capital gains, and it reduced the top tax rate on capital gains to 15%. Unqualified dividends include those paid by foreign corporations and by REITs. Because these entities are essentially untaxed by the U.S. at the corporate level, they were not thought to be unduly burdened by the double taxation of corporate income that the Act intended to alleviate. Thus the vast majority of dividends paid by U.S. corporations faced a far lower tax rate at the individual level after the 2003 tax cut, while dividends paid by REITs did not.⁵ I will hereafter refer to firms that are not REITs as “nonREITs.”

In fact, I argued above that marginal payout decisions for the vast majority of REITs would involve marginal changes to return of capital, rather than ordinary dividend payouts. Thus the tax rate on ordinary dividend income may have been irrelevant for marginal REIT dividend payouts both before and after the tax cut. In any case, the role of individual-level dividend taxes in the REIT dividend payout decision was not changed by the tax cut. Changes in REIT payout decisions surrounding the tax cut must have been driven by other perceived changes in the costs or benefits

⁵An exception to this exception applies to dividends paid by so-called “taxable REIT subsidiaries,” which are regular C corporations that can be owned by REITs. REITs are limited to holding 20% of their assets in taxable REIT subsidiaries. Data from NAREIT indicate that qualified dividends paid by TRSs constitute a negligible portion of total REIT dividend payouts.

of paying dividends.

One could feasibly argue that a tax-induced increase in dividend payouts by non-REITs might induce REITs to increase dividend payments in order to compete with nonREITs for investor clienteles that favor dividend payouts. First of all, I will argue in this paper that nonREIT dividend payout increases were driven by large increases in corporate earnings. There was little change in the ratio of dividend payouts to earnings or market capitalization for nonREITs, suggesting that investors seeking a high dividend yield would have had little reason to substitute away from REITs. Second, had REITs increased payouts in response to increases by nonREITs, we might expect to observe REIT payouts lagging those of nonREITs. It appears, however, that payout increases by REITs and nonREITs occurred simultaneously.

The dividend tax cut was first proposed on January 7, 2003, and was eventually passed by Congress on May 23, 2003, and signed by President Bush on May 28, 2003. The special tax treatment of qualified dividends applied retroactively to dividends paid after January 1, 2003. Thus, firms that paid qualified dividends between January 7 and May 28 may have inferred that those dividends would have some probability of receiving favorable tax treatment. Firms paying dividends after May 28 could be certain that those dividends would receive this treatment.

3.3 Data

For nonREITs, I use the same data from the Center for Research in Securities Prices (CRSP) that are used by Blouin, Raedy, and Shackelford [2004], Chetty and Saez [2005], and Brown, Liang, and Weisbenner [2006]. The CRSP sample comprises the universe of firms whose stocks are traded on the New York Stock Exchange, American Stock Exchange, and the Nasdaq, and I follow the other authors by excluding financial firms and utilities. The CRSP data include information on each firm's stock price, shares outstanding, and dividends payments per share, along with the announcement, ex-day, and payment dates for each dividend payment. Where possible, I match the CRSP data to Compustat, a dataset of financial statement information gathered by

Table 3.1: Descriptive Statistics

	All NonREITs	Largest 180 NonREITs	All REITs	Largest 180 REITs
Unique Firms	8,559	345	333	318
Firm-Quarter Observations	175,052	7200	7,958	7,167
Market Cap: Mean	2,352	36,675	1,203	1,323
Market Cap: Std. Dev.	13,961	57,646	2,112	2,185
Market Cap: Median	195	15,455	489	595
Assets: Mean	2,207	35,585	2,688	2,958
Assets: Std. Dev.	14,753	62,693	4,361	4,499
Assets: Median	205	19,497	1,241	1,448
Percent with Regular Dividend Payment	20.5%	69.9%	87.3%	89.4%
Regular Dividend Payment: Mean	7.3	142.5	18.1	19.9
Regular Dividend Payment: Std. Dev.	68.2	303.8	27.5	28.4
Regular Dividend Payment: Median	0.0	42.0	9.4	11.2
Payment Among Payers: Mean	35.7	203.8	20.7	22.3
Payment Among Payers: Std. Dev.	147	345.7	28.5	29.1
Payment Among Payers: Median	3.8	80.3	11.8	13.2

Market cap and dividend payment figures are in millions of 2006 dollars. Sample is from 1998Q1 to 2007Q4.

Standard and Poors, which provides data on balance sheet and income statement items like assets, liabilities, and earnings.

To construct a sample of REITs, I combine data from three sources—CRSP, Compustat, and SNL Financial. SNL Financial provides data on real estate related firms, including a number of private REITs which do not appear in CRSP or Compustat. Beginning with all of the data from all firms ever listed as a REIT in any of the three datasets, I identified all firm-quarter observations where there was any disagreement among the data sources over a firm's status as a REIT and hand-checked financial statements to verify their status. For REITs that appear only in CRSP, I observe market capitalization but not assets, while for REITs that appear only in SNL Financial, I often observe assets but not market capitalization. For REITs only, I impute assets from market capitalization, or vice versa, when one is missing by using the median ratio of market capitalization to assets in the sample of REITs where both are observed.

Table 3.1 presents descriptive statistics on the samples of REITs and nonREITs

for the period 1998Q1 to 2007Q4, on which this paper focuses. There are, of course, far more nonREITs than REITs. The mean market capitalization of nonREITs is about twice that of REITs, while the median market capitalization of REITs is about 2.5 times that of nonREITs. The distribution of nonREITs includes many of the very largest firms in the world, which are far larger than any REIT, as well as a large number of small firms.

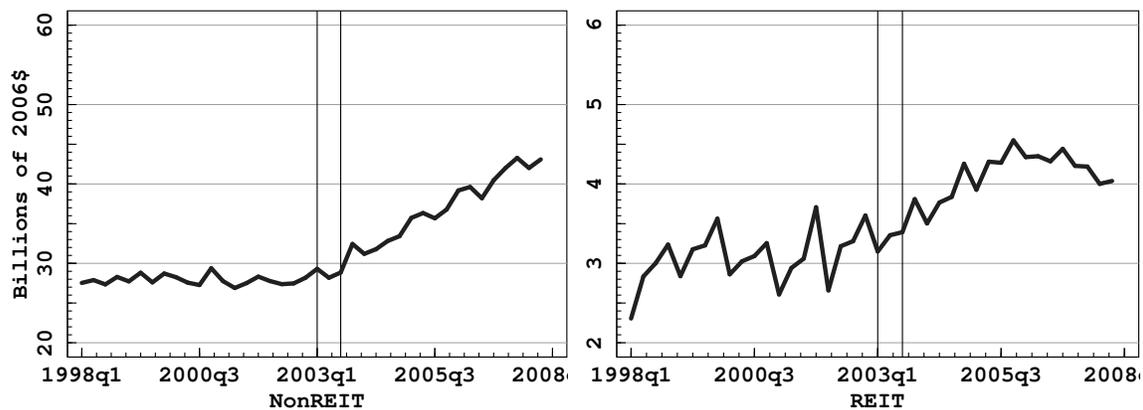
REITs and nonREITs do differ significantly in their dividend behavior as evidenced by the last seven lines of Table 3.1. Although REITs must make dividend payments in each year they are profitable to retain their REIT status, there is no requirement that they make a dividend payment in any given quarter. Table 3.1 shows that regular dividend payments are observed in 87.3% of the firm-quarter observations in the sample of REITs. In the sample of nonREITs, only 20.5% of observations feature a dividend payment. Limiting the sample of nonREITs to the 180 largest firms in each quarter by assets, however, raises this fraction to 69.9%. I will present some results related to the fraction of firms paying dividends in each quarter for this sample, because the baseline fraction of dividend payers is more comparable to that of REITs than in the entire sample of nonREITs. Despite the many differences between REITs and nonREITs evident in Table 3.1, the next section of the paper will show that aggregate statistics on REIT and nonREIT dividend payouts were moving similarly in the early part of the sample and continued to move similarly after the tax cut.

3.4 Results

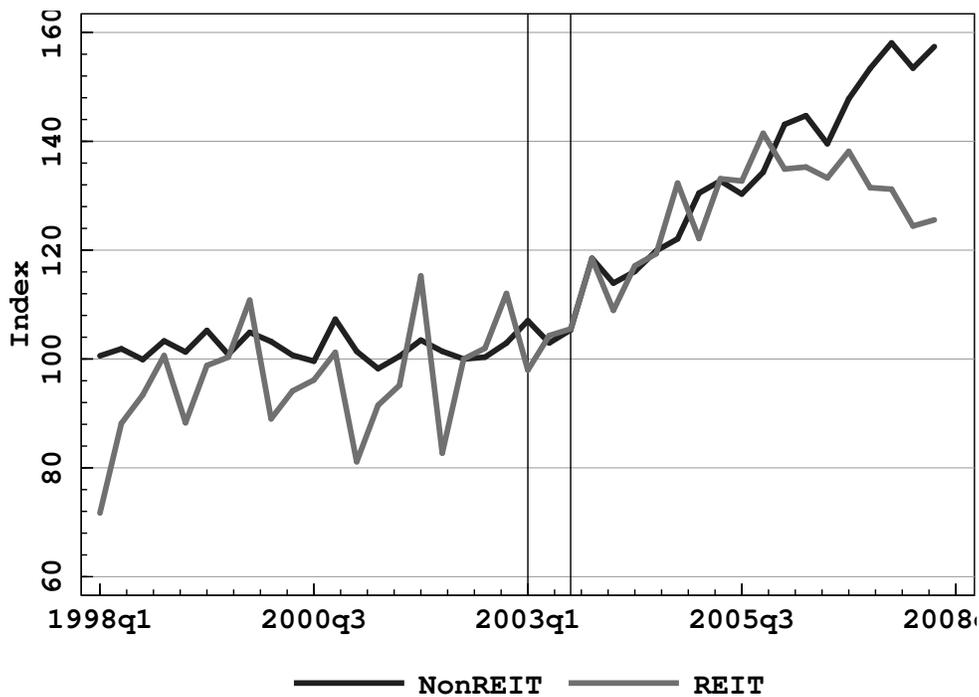
3.4.1 Aggregate Regular Dividend Payouts

The left panel of Figure 3-2 graphs quarterly aggregate regular dividend payouts in the nonREIT sample from 1998 to 2007. Similar data are presented in Figure 1 of Chetty and Saez [2005]. The first vertical line in the figure intersects the observation for 2003Q1, when firms might first have suspected that their dividend payments

Figure 3-2: Aggregate Regular Dividend Payouts, Full Sample



(a) Billions of 2006\$



(b) Indexed 2002Q2 = 100

would qualify for more favorable tax treatment. The second vertical line intersects 2003Q3, after the tax cut was enacted. It is quite clear in the figure that aggregate regular dividend payouts began rising sharply soon after the tax cut was enacted and continued rising for more than three years afterward. The timing of the beginning of the increase certainly suggests a causal role for the tax cut, and the arguments in Chetty and Saez [2005] are based on the data through the second quarter of 2004. That dividends continued rising for at least an additional two years after this point perhaps already suggests that other factors were at work.

The top right panel of Figure 3-2 plots the series of aggregate regular dividend payouts by REITs. This series is visibly more volatile and seasonal than the nonREIT payout series, and the magnitude of aggregate REIT dividends is about one-tenth that of nonREIT payouts. Still it seems quite clear in the figure that aggregate dividend payouts by REITs rose in a manner quite similar to payouts by nonREITs. The bottom panel of Figure 3-2 presents the same data with both the REIT and nonREIT series indexed to 100 at 2002Q2. It is strikingly clear that REIT and nonREIT dividend payouts moved together after the tax cut, even though REIT dividends did not benefit from the tax cut. By 2005Q4, REIT and nonREIT dividend payouts had both increased by about 40% from their level prior to the tax cut.

Table 3.2: Regressions of Log Aggregate Regular Dividend Payouts on Treatment Status Variables and Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Post	.247 (.031)***	.098 (.029)***	.077 (.058)	.264 (.033)***	.092 (.034)***	.179 (.026)***	.061 (.046)	.059 (.043)	.048 (.047)	.059 (.044)	.044 (.049)	.052 (.045)
NonREIT				2.211 (.033)***	-.009 (.246)	.628 (.192)***	-.058 (.251)	.158 (.229)	-.123 (.259)	.136 (.234)	-.073 (.299)	.146 (.236)
Post × NonREIT				-.017 (.046)	.022 (.036)	-.095 (.035)***	.057 (.050)	.036 (.051)	.086 (.058)	.044 (.054)	.099 (.070)	.063 (.063)
Log EBITDA		.733 (.104)***	.847 (.198)***		.654 (.073)***		.569 (.112)***		.546 (.115)***		.507 (.162)***	
Log EBIT						.494 (.060)***		.352 (.070)***		.344 (.072)***		.323 (.082)***
Log Assets			.986 (.466)**				.111 (.112)	.304 (.091)***	.270 (.195)	.368 (.156)**	.252 (.204)	.340 (.164)**
Log Cash			-.266 (.195)						-.078 (.078)	-.032 (.063)	-.083 (.080)	-.044 (.067)
Log Market Cap			-.226 (.152)								.038 (.111)	.047 (.082)
Observations	40	40	40	80	68	80	68	80	68	80	68	80
R^2	.624	.84	.862	.992	.996	.996	.996	.996	.996	.996	.996	.996

The dependent variable is the log of aggregate quarterly regular dividend payouts. In columns 1, 2, and 3, this is the aggregate for NonREITs only. In other columns there are two observations for each quarter—the aggregate for REITs and the aggregate for nonREITs. However, the EBITDA variable is not observed for REITs prior to 2001q1, so specifications including this variable include fewer observations. Post takes the value of one in 2003Q1 and later.

Table 3.2 presents regression results supportive of the visual evidence in Figure 3-2. Columns 1 through 3 present time-series regressions of the form,

$$\ln(\text{DividendPayments})_t = \beta_1 \text{Post}_t + \beta_2' \mathbf{X}_t + \epsilon_t,$$

for the sample of NonREITs only. Post is a dummy variable taking the value of one in 2003Q1 and later.⁶ The estimated coefficient in Column 1 indicates that aggregate dividend payouts averaged about 25% higher in quarters after the tax cut than in quarters prior to the tax cut.

Column 2 includes a control for the logarithm of aggregate corporate earnings. From Lintner [1956] through Feldstein [1970] and Fama and French [2002], empirical studies of dividend behavior have often modeled dividend payouts as targeting a particular payout ratio of dividends to earnings. Earnings are typically the key independent variable in any dividend regression. In this paper, I will consider the relationship between dividends and two different measures of earnings—earnings before interest, taxes, depreciation, and amortization (EBITDA), and earnings before interest and taxes (EBIT). Measures of income that subtract additional items like interest and taxes become negative for nonREITs in some quarters immediately prior to the tax cut, making it impossible to compute their logarithms and inappropriate to use them as denominators in computing dividend payout ratios. See the Appendix for a detailed discussion of the construction and behavior of different measures of corporate income. Unfortunately, the data required to measure EBITDA for REITs were not collected by Compustat until 2001Q1, so REIT observations are missing EBITDA prior to that quarter.

The result in column 2 shows that including only a control for EBITDA in the regression for nonREITs is enough to reduce the estimated effect of the tax cut from 25% to 10%. In column 3, adding controls for assets, cash holdings, and market capitalization is enough to reduce the estimated effect to 8%, and this estimate is not statistically different than zero at conventional levels. Adding additional lags of

⁶Results are very similar if Post is equal to one in 2003Q3 and later, or if observations from 2003Q1 and 2003Q2 are excluded from the sample.

EBITDA produces quite similar results.

Columns 4 through 12 present similar regressions with two observations in each quarter—one for REITs and one for nonREITs—of the form,

$$\ln(\text{DividendPayments})_{it} = \beta_1 \text{Post}_t + \beta_2 \text{NonREIT}_i + \beta_3 \text{Post} \times \text{NonREIT}_{it} + \beta_4' \mathbf{X}_{it} + \epsilon_{it},$$

where i indexes REIT status and t indexes quarters. They include a dummy for NonREIT status and the interaction of this dummy with the Post dummy. The difference-in-differences estimate of the effect of the tax cut on aggregate NonREIT dividend payouts is β_3 , the coefficient on this interaction term. In column 4, with no additional controls, the estimated coefficient is -1.7%, with a standard error of 4.6%. Thus, the point estimate would suggest that the tax cut had a small, negative effect on aggregate dividend payouts by treated firms, although the standard errors cannot rule out positive and economically significant effects.

In column 5, which includes the NonREIT and Post \times NonREIT variables as well as EBITDA, the estimated effect of the tax cut is 2.2%. Columns 7 through 12 include additional controls for aggregate assets, cash on hand, and market capitalization. In fact, capital disproportionately entered the REIT sector in the period after the tax cut, and adding these controls tends to raise the estimated effect of the tax cut. The estimate in column 12, which includes all control variables, suggests that the tax cut may have raised aggregate dividend payouts by 6%. This is a bit less than one-fourth of the naive estimate in column 1.

3.4.2 Payout Ratios

The results in Table 3.2 suggest that EBITDA is the most important predictor of dividend payouts. In columns 5, 7, 9, and 11 that include EBITDA, no other variable in the specification is statistically significant at conventional levels. Figure 3-3 presents striking evidence on the relationship between EBITDA and dividend payouts for the sample of NonREITs. From 1995 through the present, dividends and EBITDA have moved together quite closely, albeit with dividends more stable than EBITDA dur-

Figure 3-3: Relationship Between Regular Dividend Payouts and Earnings for Non-REITs

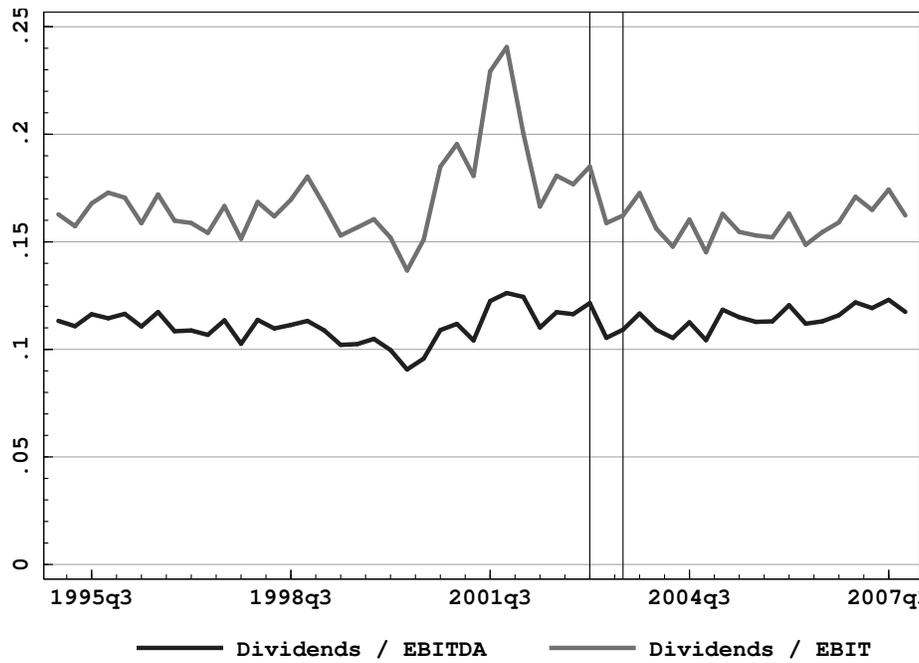
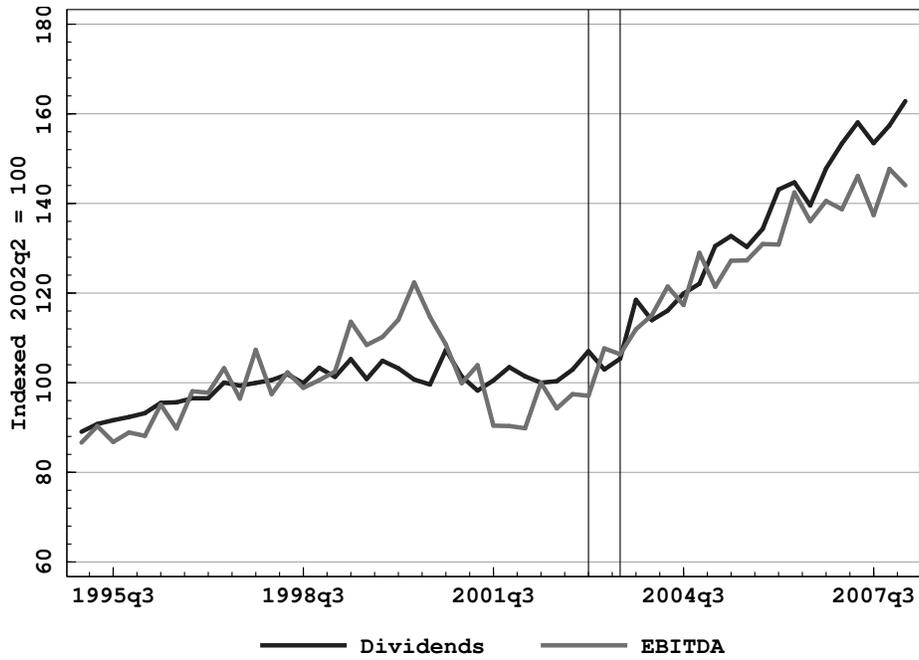
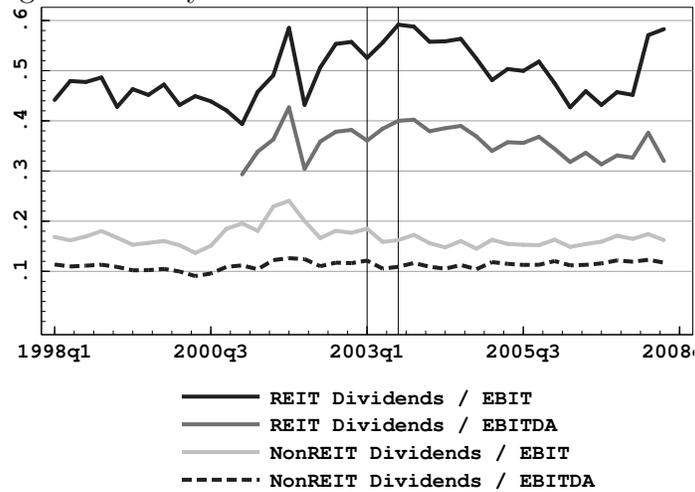


Figure 3-4: Payout Ratios for REITs and NonREITs



ing the dotcom boom and the 2001 recession. Most striking, however, is the rapid increase in both EBITDA and dividends that began around the time of the tax cut. From 2002Q2 to 2007Q4, EBITDA increased by 48%.

The bottom panel of Figure 3-3 presents the same data in the form of the ratio of regular dividend payouts to EBITDA and EBIT. After falling steadily from the 1980s to early 1990s, the ratio of dividends to earnings has been remarkably stable for more than 10 years. The ratio of dividends to earnings actually fell immediately after the tax cut due to strong growth in the denominator amidst recovery from recession. By 2004, the payout ratio had returned to its level in the mid-1990s.

Of course, it is feasible that the payout ratio may have fallen in the absence of a tax cut, but that the tax cut was just large enough to keep the payout ratio approximately constant. It is thus useful to compare movements in payout ratios for NonREITs, whose dividends were affected by the tax cut, with the payout ratios of REITs, whose dividends were not affected. Figure 3-4 plots REIT payout ratios against the NonREIT payout ratios from the bottom panel of figure 3-3. REITs paid out about 47% of EBIT as dividends from 1998 to 2007, or about three times as much as NonREITs. REIT payout ratios also rose around the 2001 recession, but remained high through the tax cut before returning to their levels from the late 1990s.

Table 3.3 presents simple regressions of aggregate payout ratios for REITs and

NonREITs on Post and NonREIT dummies and their interaction,

$$(\text{DividendPayments}/\text{Earnings})_{it} = \beta_1 \text{Post}_t + \beta_2 \text{NonREIT}_i + \beta_3 \text{Post} \times \text{NonREIT}_{it} + \epsilon_{it},$$

Column 1 indicates that the ratio of aggregate regular dividend payouts to EBITDA for NonREITs averaged 0.5 percentage points higher after the tax cut on a base of about 10%. Column 2 indicates that the ratio of regular dividend payouts to EBIT for NonREITs averaged 1.5 percentage points lower after the tax cut on a base of about 17%. Adding REITs as a control group in column 4 actually produces an estimate of the effect of the tax cut on the EBIT payout ratio of -6 percentage points. From figure 3-4 we see that this result is driven by the fact that the average EBIT payout ratio for REITs actually rose several percentage points from before the tax cut to after. Since average NonREIT payouts fell slightly, this produces a negative estimate of the effect of the tax cut. Column 3 presents similar results with EBITDA in the denominator of the payout ratio. Since EBITDA is missing for REITs before 2001, only the part of the pre-period in which REIT payouts were relatively high enters the sample. Thus, there was little change in the average REIT payout ratio, and the estimated effect of the tax cut is a 0.2 percentage point increase in the payout ratio. On a base payout ratio of 10%, this estimate implies that dividend payouts would have increased by about 2 percent if earnings had been held constant.

3.4.3 Fraction of Firms Paying

After many years of decline, the percentage of publicly-traded firms paying a regular dividend began increasing in early 2001 and accelerated considerably in late 2002 and early 2003, too early to have been caused by the tax cut. Chetty and Saez [2005] argue that these facts give a misleading impression of the evolution of dividend behavior, because the denominator in this ratio was rapidly declining as dotcom flameouts delisted. They thus focus instead on a constant-number-of firms sample constructed by taking the sample of the largest n firms in each quarter, where n is the number of firms in the sample in the quarter with the smallest number of firms. In the nonREIT

Table 3.3: Regressions of Payout Ratio on Treatment Status

	EBITDA	EBIT	EBITDA	EBIT
	(1)	(2)	(3)	(4)
Post	.005 (.002)*	-.015 (.006)**	.002 (.009)	.045 (.012)***
NonREIT			-.246 (.009)***	-.295 (.012)***
Post \times NonREIT			.002 (.011)	-.060 (.017)***
Observations	40	40	68	80
R^2	.086	.139	.97	.949

The dependent variable is the ratio of regular dividend payouts to the income measure in the first row of the table. In columns 1 and 2, this is the aggregate for NonREITs only. In other columns there are two observations for each quarter—the aggregate for REITs and the aggregate for nonREITs. The EBITDA variable is not observed for REITs prior to 2001q1.

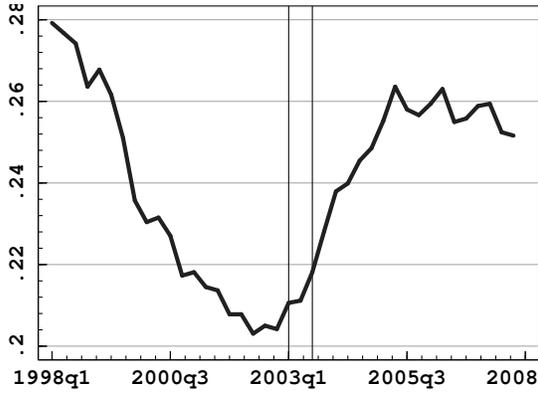
*** indicates statistical significance at the 1% level, ** at 5%, and * at 10%.

sample that I have constructed using data from 1998Q1 to 2007Q4, $n = 3585$. The first panel in Figure 3-5 graphs the fraction of firms in this constant-size sample of nonREITs paying a regular dividend in each quarter. Much like Figure 4 of Chetty and Saez [2005], the percentage of firm paying dividends declines from about 27% in 1998 to 21% in 2002. The percentage of firms paying dividends then rose steadily for two years, reaching 26% in 2005. One could argue that the turnaround in the downward trend in dividend payments begins a bit too early to have been caused by the tax cut, even when constructing the sample in this way.

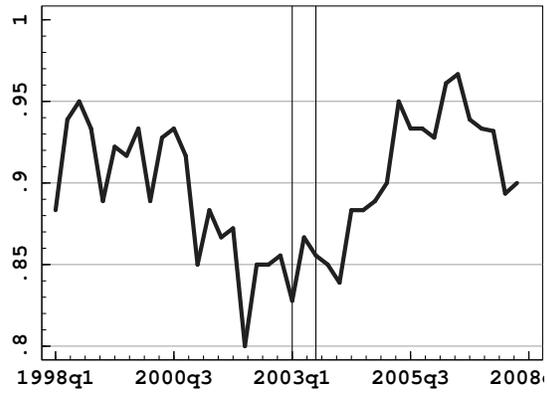
Panel (b) in Figure 3-5 plots a similar series for a constant-size sample of 180 REITs, and panel (c) plots the two series together on different scales.⁷ Although REITs are required to pay dividends of at least 90% of taxable income on an annual basis, there is no requirement that they pay a dividend in any given quarter. We see in Figure 3-5 that the percentage of REITs paying a dividend is always far higher than the percentage of nonREITs paying a dividend. And again the REIT series is more

⁷The number of REITs in the sample began to drop rapidly at the end of 2007 as the 2008 recession approached. There are 176, 169, and 160 REITs in the sample in 2007Q2, Q3, and Q4, respectively. Limiting the constant-size sample to the number of REITs in the sample in 2007Q4 produces a similar U-shaped in the percent of REITs paying a regular dividend, although the series is more volatile due to the smaller sample size.

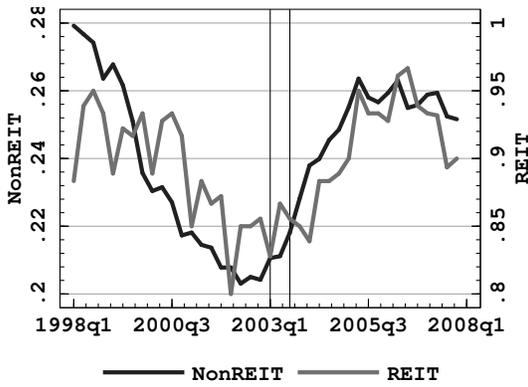
Figure 3-5: Percent of Firms Paying Regular Dividend



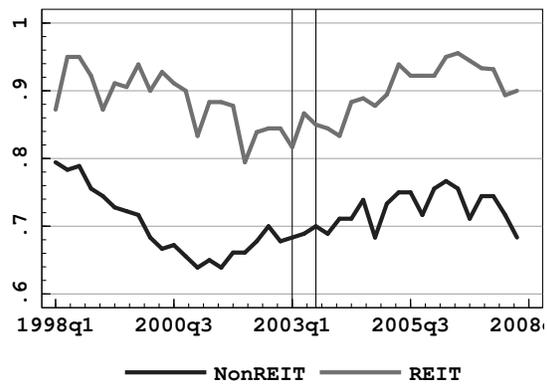
(a) Constant-size Sample of NonREITs



(b) Constant-size Sample of REITs



(c) Constant-size Samples



(d) 180 Largest Firms

The constant-size sample of NonREITs consists of the largest 3585 firms by market capitalization in each quarter, where 3585 is the number of observations in the quarter with the fewest observations from 1998Q1 to 2007Q3. The constant-size sample of REITs consists of the largest 180 REITs by market capitalization in every quarter, except for 2007Q2, Q3, and Q4, when there are 176, 169, and 160 REITs in the sample. The 180 largest firms samples consist of the 180 largest NonREITs and the 180 largest REITs by assets in each quarter, with the same exceptions for REITs.

volatile than the nonREIT series due to the small sample of REITs. Nonetheless, it is quite clear that REIT dividend decisions moved similarly to nonREIT dividend decisions around the time of the tax cut, even though REIT dividends did not benefit from the tax cut.

Panel (d) of Figure 3-5 plots similar series constructed from the 180 largest NonREITs and the 180 largest REITs by assets in each quarter. The fraction of NonREITs paying dividends in this sample is far higher than for the sample of all NonREITs and comparable to the fraction of REITs paying dividends. This sample experienced a decline in the fraction of firms paying a dividend in the first part of the sample followed by a recovery during and after the tax cut, just like the full samples of NonREITs and REITs. In fact, the fraction of the 180 largest NonREITs paying a dividend begins to increase in 2001, too early to have been caused by the tax cut.

Table 3.4: Regressions of Percent of Firms Paying a Regular Dividend on Treatment Status and Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Post	.058 (.011)***	.038 (.016)**	-.015 (.027)	.058 (.013)***	.021 (.012)*	.029 (.010)***	-.008 (.017)	.002 (.016)	-.003 (.017)	.007 (.016)	.005 (.017)	.012 (.016)
NonREIT				-.181 (.016)***	-.650 (.082)***	-.587 (.061)***	-.680 (.079)***	-.666 (.069)***	-.653 (.083)***	-.633 (.074)***	-.721 (.088)***	-.669 (.072)***
Post \times NonREIT				.0003 (.018)	-.002 (.014)	-.024 (.014)*	.040 (.023)*	.016 (.022)	.027 (.026)	.002 (.025)	.002 (.029)	-.017 (.025)
Log EBITDA		.081 (.047)*	.107 (.090)		.159 (.027)***		.070 (.047)		.077 (.047)		.143 (.057)**	
Log EBIT						.143 (.021)***		.092 (.031)***		.096 (.031)***		.129 (.033)***
Log Assets			-.020 (.446)				.108 (.047)**	.082 (.037)**	.053 (.070)	.025 (.060)	.108 (.074)	.105 (.067)
Log Cash			.127 (.064)**						.027 (.026)	.029 (.024)	.037 (.026)	.038 (.023)
Log Market Cap			-.042 (.085)								-.086 (.044)*	-.084 (.037)**
Observations	28	28	28	56	56	56	56	56	56	56	56	56
R^2	.521	.572	.677	.908	.944	.951	.95	.956	.951	.957	.955	.961

The dependent variable is the percent of firms paying a regular dividend. The sample consists of the 180 largest REITs and NonREITs by assets in each quarter.

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

Table 3.4 presents regression results supportive of the visual evidence in Figure 3-5 using the 180 largest firms samples from panel (d) of Figure 3-5. I restrict the sample in the pre-period to begin in 2001Q1, when the percent of NonREITs paying dividends reached its bottom and when EBITDA becomes observed for REITs. Columns 1 through 3 present time series regressions of the form,

$$\text{PercentPayingDividend}_t = \beta_1 \text{Post}_t + \beta_2' \mathbf{X}_t + \epsilon_t,$$

for the sample of NonREITs only. Column 1 presents a regression of the percent of firms paying dividends on a Post dummy. The coefficient indicates that NonREITs were 5.8 percentage points more likely to pay a regular dividend in quarters after the tax cut. Adding a control for EBITDA in column 2 reduces this estimate to 3.8 percentage points, and adding additional controls in column 3 reduces it to a statistically insignificant -1.5 percentage points.

Columns 4 through 12 include the Post and NonREIT dummies and their interaction in regressions of the form,

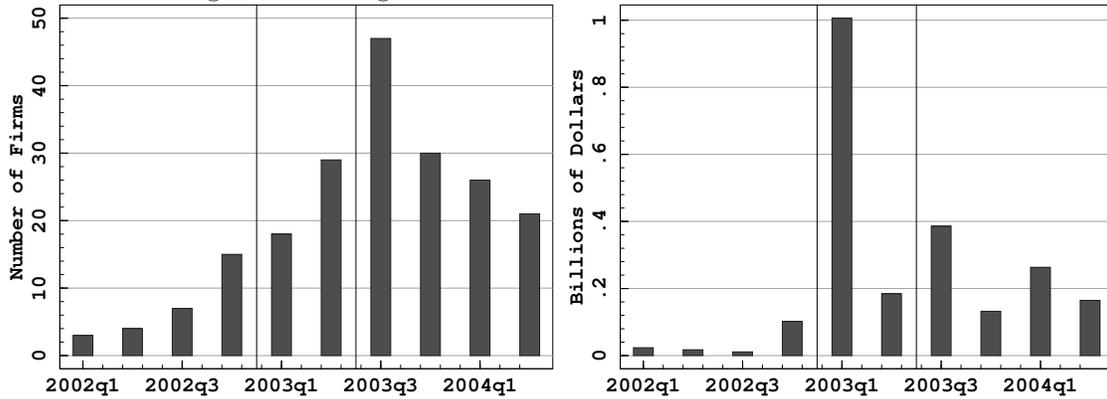
$$\text{PercentPayingDividend}_{it} = \beta_1 \text{Post}_t + \beta_2 \text{NonREIT}_i + \beta_3 \text{Post} \times \text{NonREIT}_{it} + \beta_4' \mathbf{X}_{it} + \epsilon_{it}.$$

In column 4, the coefficient of 0.03 percentage points on the interaction term is the difference-in-differences estimate of the effect of the tax cut. Columns 5 through 12 again include various controls for earnings and assets. Estimates of the effect of the tax cut in these specifications fluctuate considerably, ranging from -2.4 percentage points to 4 percentage points. The estimate in column 11, which includes controls for EBITDA, assets, cash holdings, and market capitalization, suggests that the tax cut raised the fraction of large NonREITs paying dividends by 0.2 percentage points on a base of 70%.

3.4.4 Initiations

Chetty and Saez [2005] documented sharp increases in aggregate dividend payouts

Figure 3-6: Regular Dividend Initiation Announcements



and the percentage of firms paying dividends in the quarters following the 2003 tax cut. I have replicated their results and showed that similar results hold for real estate investment trusts, whose dividends did not benefit from the tax cut. Chetty and Saez [2005] and Brown, Liang, and Weisbenner [2006] also present a great deal of evidence related to firms that initiated dividends after the tax cut, that is, to firms that began paying a regular dividend after not paying one for four or more quarters. Some of the most compelling evidence in these papers involves the relationship between the propensities of firms to initiate dividends and the fractions of their ownership comprised by insiders or institutions. Unfortunately, REITs must pay a dividend in every year that they are profitable, so there are very few REITs that initiate dividends by this definition. Thus, I cannot perform the same falsification exercises using REITs that I have performed for other measures of dividend behavior.

I will briefly criticize the results on initiations from these other authors, and then interpret their results in the context of mine. First, it appears that the surge in dividend initiations began too early to be attributed entirely to the tax cut. Figure 3-6 presents data on firms announcing a dividend initiation in the 10 quarters surrounding the tax cut.⁸ Recall that the dividend tax cut was first proposed in early January 2003, before being enacted in late May. Thus it is feasible that firms initiating

⁸Figure II of Chetty and Saez [2005] presents data on firms *paying* a dividend for the first time in more than a year, while here I present data on firms *announcing* a dividend initiation. As many firms announce dividend payments in the quarter before they are paid, the series presented by Chetty and Saez [2005] has a more pronounced spike in 2003Q3.

dividends in quarters one and two of 2003 may have believed that these dividends would qualify for reduced taxation with some probability, but they would not have been certain until 2003Q3. Both sets of authors argue that the introduction of the dividend tax cut legislation came as a surprise to market participants, so we should see no anticipatory effects of the legislation prior to 2003Q1.

It is clear in Figure 3-6, however, that initiations had already begun to increase in 2002, and continued to increase sharply in quarters 1 and 2 of 2003, when the tax cut was only a probability. Second, the amount of money involved in dividend initiations was quite small relative to aggregate dividend payouts. The second panel of Figure 3-6 shows that firms announced dividend initiations in 2003Q3, immediately after enactment of the tax cut, of \$386 million, or about 1.3% of aggregate dividend declarations.⁹

The evidence on dividend initiations presented by previous authors could be further criticized, but I will not pursue such criticism here. Instead, I simply note that any dividend initiations induced by the tax cut could have made only a very small contribution to aggregate dividend payouts. Thus, even if one believed that much of the increase in initiations was caused by the tax cut, one could still believe the conclusion of this paper—that aggregate dividend payouts responded very little to the tax cut.

3.5 Conclusions

A number of authors, notably, Blouin, Raedy, and Shackelford [2004], Chetty and Saez [2005], and Brown, Liang, and Weisbenner [2006], have observed the sharp increase in dividend payout activity following the the 2003 dividend tax cut and argued that the tax cut caused this increase. Chetty and Saez [2005] estimate that the tax cut caused

⁹The biggest spike in the figure, however, is actually in 2003Q1, when Microsoft announced a \$900 million dividend. This payment was announced on January 16, 2003, nine days after President Bush announced his intention to push for a dividend tax cut, 42 days before legislation including a dividend tax cut was introduced in the House of Representatives, and 132 days before it became law. It is unlikely that the tax cut played a significant role in Microsoft's decision to begin paying regular dividends.

a 20% increase in aggregate regular dividend payouts within 1.5 years of enactment. Chetty and Saez [2007] argue that responses this large imply that the efficiency cost of raising the dividend tax would be of the same order of magnitude as the amount of revenue raised. In this paper, I have presented evidence that casts doubt on the claim that the tax cut caused a large increase in dividend payouts. I have identified a group of firms—real estate investment trusts—whose dividends did not qualify for the tax cut, and I have shown that the time series patterns of their dividend payout activities look quite similar to those of other firms. Simple differences-in-differences estimates of the effects of the tax cut using REITs as a control group are far smaller than the effects found by previous authors. Further, I have documented that the tax cut coincided with the beginning of a striking rise in corporate earnings. There was no increase in the ratio of dividends to earnings following the tax cut, suggesting that the increase in dividend payouts was driven primarily by the increase in earnings and not by the tax cut. Thus, evidence from the tax cut provides little reason to think that an increase in the dividend tax rate would create large efficiency costs.

3.6 Appendix: Measures of Corporate Earnings

In this paper, I relate dividend payout decisions to measures of corporate earnings or profits. Since at least Lintner [1956], economists have often studied dividend payouts as a fraction of corporate earnings. This exercise is complicated a bit when earnings turn negative. As documented previously by Altshuler, Auerbach, Cooper, and Knittel [2008] and in the second chapter of this dissertation, U.S. corporations ran unprecedented levels of losses around the 2001 recession.

Figure 3-7 graphs several measures of aggregate corporate earnings for the Compustat nonREIT and REIT samples from 1990 to 2007. Beginning with a firm's sales and subtracting the costs of goods sold and selling and administrative expenses produces earnings before interest, taxes, and depreciation and amortization, or EBITDA. Subtracting depreciation and amortization produces EBIT. Subtracting interest expenses, nonoperating income, and special items produces pretax income. Subtracting income taxes and minority interest produces income before extraordinary items. Subtracting preferred dividends, common stock equivalents, and extraordinary items and discontinued operations then produces net income. A measure of cash flows can be created by adding depreciation, amortization, and deferred taxes back to income before extraordinary items or to net income.

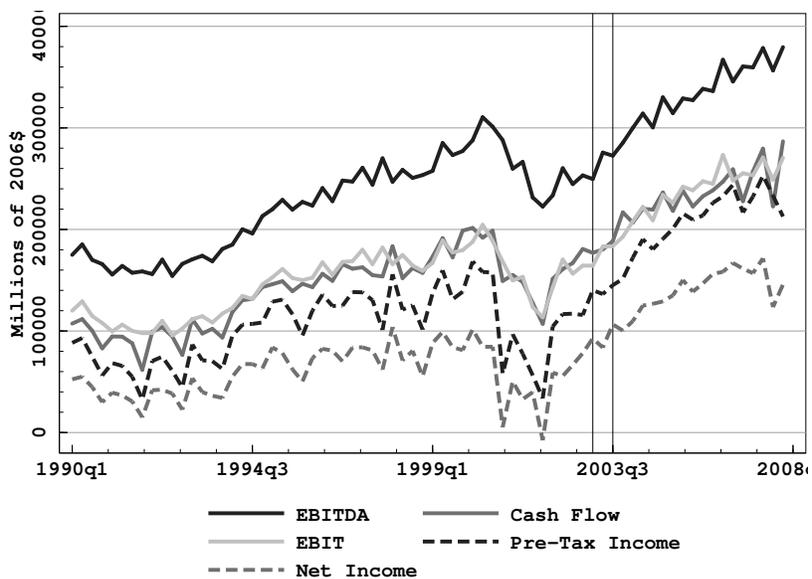
In June 2001, the Financial Accounting Standards Board issued its Statement No. 142, which changed the way that firms accounted for goodwill. Prior to FAS 142, acquiring firms would recognize an amount of goodwill on their balance sheet essentially equal to the difference between the purchase price of an acquired firm and the value at which the acquirer would carry the acquired firms' assets on the acquirer's balance sheet. This goodwill would then be slowly amortized (depreciated) over time.

FAS 142 instead required that firms conduct an initial and then annual review of the value of their goodwill to determine whether changing market conditions had "impaired" its value. Many firms conducting such impairment reviews in 2001 and 2002 discovered significant impairments to the goodwill that they had acquired by

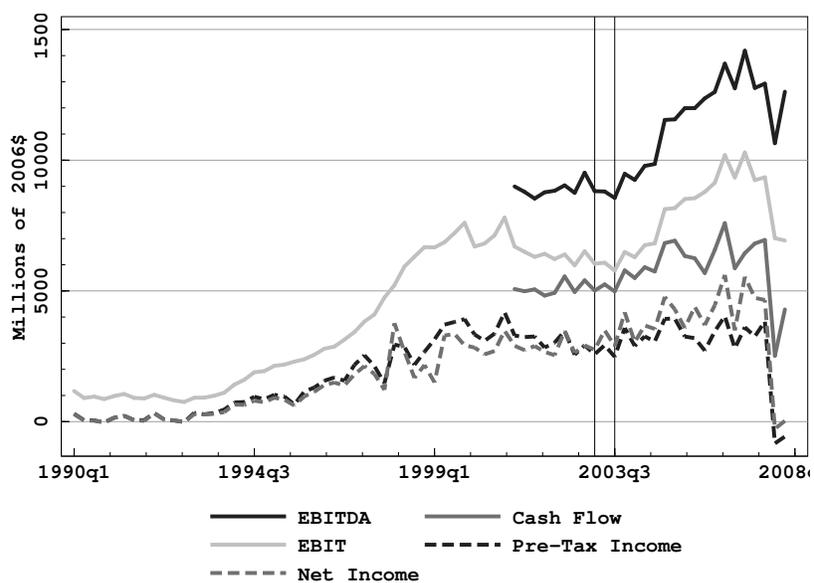
purchasing firms during the dotcom boom. Many of these firms recorded these impairment charges as “Special Items,” which appear on the income statement as deducted from Earnings Before Interest and Taxes in the calculation of Pre-tax Income. Other firms recorded these impairments as “Extraordinary Items,” which appear on the income statement after the subtraction of taxes in the calculation of Net Income. Firms report and Compustat records the component of Special Items accounted for by goodwill impairment as a separate variable, although the breakdown of Special Items has only appeared in Compustat since the late 1990s. Compustat also includes a measure of the component of Extraordinary Items attributable to accounting changes, of which goodwill impairment is one example. I subtracted off the accounting charges for goodwill impairment, other writedowns and accounting changes when constructing the measures of pre-tax income and net income that appear in Figure 3-7.

As Figure 3-7 attests, pre-tax income and net income fell below or close to zero for the nonREIT sample in some quarters surrounding the 2001 downturn. Focusing on percentage changes in these measures or on ratios with these measures in the denominator might give misleading impressions about movements in corporate income. I thus focus in this paper on EBITDA and EBIT, which remain comfortably positive. It is also clear in the figure that cash flow and EBIT are close to equal in most quarters (because interest and taxes are nearly equal to depreciation), so focusing on cash flows would give similar results to EBIT.

Figure 3-7: Measures of Corporate Earnings



(a) NonREITs



(b) REITs

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