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Sharing Risk with the Government: On the Causal Effects of Taxes on Corporate Risk-Taking
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ABSTRACT

Using a natural experiment in the form of 113 staggered changes in corporate income tax rates across U.S. states, we provide causal evidence on how taxes affect corporate risk-taking decisions. Higher taxes are expected to reduce the expected profit per unit of risk, as the government shares in a firm's upside but not in its downside. Consistent with this prediction, we find that firms respond to tax increases by reducing risk. We find no corresponding sensitivity to tax cuts, suggesting that firms find it easier to reduce risk than to increase it. Tax loss-offset rules moderate firms' sensitivity to taxes by allowing firms to partly share downside risk with the government.

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Taxation is one of the most important tools governments use to influence the economy. Taxes affect every aspect of economic activity, from individuals' labor supply, consumption, and savings decisions to companies' hiring, location, and capital investment choices. In this paper, we ask how taxes on corporate income affect corporate risk-taking.

Prior literature on the effects of taxes on corporate choices largely focuses on debt policy and investment. Since Modigliani and Miller's (1958) seminal article, a large body of work has examined how tax incentives affect firms' optimal capital structures. The literature on corporate investment decisions is smaller and largely studies the relation between tax policy and aggregate levels of investment (Hall and Jorgenson 1967; Summers 1981; Edgerton 2010).

Firms' choice of risk has not previously been formally linked to corporate income taxes. However, a parallel economics literature exists that links *personal* income taxes to *individual* investors' risk-taking choices. Prominent contributions to this literature include Domar and Musgrave (1944), Feldstein (1969), and Stiglitz (1969). We apply the central logic of this literature to the context of corporate income taxes and corporate risk-taking.

A simple numerical example serves to illustrate the point. Suppose there are two projects (A and B) and two equally likely outcomes ("good" and "bad"). Project A yields a profit of $40 under both scenarios; project B yields a profit of $100 under the good scenario but a loss of $20 under the bad scenario. Absent taxes, the expected profit of each project is $40. Now suppose the tax rate increases from zero to 30%. The expected after-tax profit is $28 for the safe project A, but only $25 for the risky project B.[1] The greater reduction (of $3) in project B's expected profit stems from the fact that the government shares in the profit but not in the loss, that is, taxation

[1] For project A, $40×(1–0.3) = $28; for project B, 0.5×[(1–0.3)×$100–$20] = $25. The difference of $3 can be calculated as 0.5×$20×0.3, i.e., the product of the probability of incurring a loss, the magnitude of the loss, and the tax rate.

reduces the expected profit per unit of risk.[2] As this simple example illustrates, a tax increase reduces the expected return of a project by more, the greater the project's risk. All else equal, therefore, firms should respond to a tax increase by reducing the risks they take.

Introducing loss-offsets into the tax code can modify this prediction. Consider the extreme case in which losses can be completely written off against past or future profits. In this case, as Domar and Musgrave (1944) argue, the expected profit per unit of risk is invariant to taxes because both upside and downside are reduced at the same tax rate.[3] If the tax code only permits a partial offset of losses, the upside is reduced by more than the downside, so a tax increase will reduce the expected profit per unit of risk (though to a lesser degree than in the case of no offset of losses) and firms should respond by reducing risk.

In principle, these arguments apply equally to tax increases and tax cuts. Thus, firms should respond to tax cuts by increasing risk. In practice, there are reasons to expect asymmetry. Increasing risk damages the value of the claims of other stakeholders (such as lenders, employees, customers, and suppliers). Whether a firm can respond to a tax cut by increasing its risk then depends on the extent to which its stakeholders can constrain its behavior. Debt covenants, for example, often seek to prevent the firm from increasing risk in an effort to protect the interests of its lenders. In the presence of such constraints, the effect of a tax cut on risk-taking is likely attenuated for many firms.

A key challenge when testing how taxes affect corporate policies is that a firm's tax status is often endogenous to its policies (Graham 2013). For example, a firm's choice of investment projects will affect its future marginal tax rate. The capital structure literature confronts this

[2] In Domar and Musgrave's (1944) framework, risk is calculated as the product of the probability of incurring a loss and the magnitude of the loss (net of taxes). In our numerical example, the expected profit per unit of risk for project B is 4 before tax ($40/[$20×0.5]) and 2.5 after tax ($25/[$20×0.5]).

[3] In the above numerical example, project B's expected profit will be $28 with full loss offsets. B's expected profit per unit of risk after tax thus will be 4 ($28/[$20×0.5×(1–0.3)]), the same as before tax.

identification challenge in various ways. One approach is to exploit changes in federal income tax rates. Unfortunately, federal tax changes suffer from two shortcomings: they are few and far between, and they affect virtually all firms in the economy at the same time, making it difficult to find control firms with which to establish a plausible counterfactual. A second approach is to exploit cross-country differences in tax policies. This typically results in a larger number of tax "shocks" than in studies using federal tax changes, but often requires implausible assumptions about treated firms and their controls being comparable despite operating in different countries.

We adopt a third approach, pioneered by Heider and Ljungqvist (2015). The approach exploits the fact that U.S. companies pay not only federal income tax but also taxes in the various states in which they operate.

State taxes have three desirable features. First, unlike federal taxes, state tax rates change frequently: over our sample period (fiscal years 1990–2011), there were 113 changes in state corporate income tax rates. Power is thus not an issue. Second, state tax changes are staggered over time. This staggering allows us to disentangle the effects of tax changes from other macro-economic shocks that affect firms' risk-taking. Third, state tax changes affect only a subset of firms at a time. This feature allows us to establish a plausible counterfactual: what level of risk would firms have chosen absent the tax change? The counterfactual is based on firms that experience the same economic conditions (in time, space, and industry) but are not themselves subject to a tax change. Our empirical strategy is thus essentially a diff-in-diff approach.[4]

Our baseline specifications proxy for firms' risk-taking using earnings volatility, measured as the standard deviation of seasonally adjusted quarterly pre-tax returns either on total assets or on

[4] To isolate the effect of taxes on risk-taking, we further remove unobserved firm fixed effects by first-differencing and time-varying firm-level confounds by including a comprehensive set of time-varying firm characteristics. We also control for time-varying shocks at the industry and at the state level.

invested capital.[5] We find that firms respond to tax increases by reducing the amount of risk they take, consistent with the intuition derived from the literature on individual investor behavior. To illustrate, a treated firm reduces its earnings volatility by around 2% for every one-percentage-point increase in its home-state tax rate, compared to other firms in the same industry that are not subject to a tax change in their headquarter state that year. Given an average tax increase of 136 basis points in our sample, the average treated firm thus reduces its risk by 2.6%. This effect is estimated over the three years following a tax increase. It becomes stronger when we give firms more time to adjust their risk profiles. Over the six years following a tax increase, for example, the average treated firm reduces its risk by a cumulative 4.8%.

Under federal and state law, U.S. firms are taxed in every state in which they have operations (their so called "nexus" states). For a multi-state firm, a given state's tax change will therefore apply to less than the firm's entire tax base. This implies that tests that ignore the geographic distribution of firms' tax bases will understate the sensitivity of treated firms' risk-taking to corporate income taxes. To address this issue, we construct a measure of state tax changes that takes into account each treated firm's tax exposure to each state. Using this alternative measure of the magnitude of tax shocks, we show that a one-percentage-point increase in a firm's nexus-weighted tax rate reduces risk-taking by between 2.4% and 3.2%. In other words, the estimated tax sensitivities are indeed larger when we condition on a firm's tax footprint.

A related study by Asker, Farre-Mensa, and Ljungqvist (2015) provides nuance to our interpretation of these results. Asker, Farre-Mensa, and Ljungqvist show that stock market-listed firms barely change their level of capital expenditures in response to state corporate income tax changes. Our finding that firms reduce risk when tax rates increase therefore suggests that they substitute safer projects for riskier ones without, apparently, changing the level of capital

[5] Results are similar when we use measures of equity volatility instead.

expenditure materially.

In contrast to their response to tax increases, we find no evidence that treated firms respond significantly to tax cuts. This asymmetric tax sensitivity of corporate risk-taking is consistent with our argument that firms face constraints when increasing risk, for example, in the form of covenants imposed by their creditors.

We conduct several additional analyses to buttress the causal effect of taxes on corporate risk-taking. We provide evidence that treated and control firms exhibit similar trends in risk taking before the state tax rate changes, supporting the parallel-trends assumption that is critical for identification in a diff-in-diff setting. In addition, to better control for unobserved changes in local economic conditions that could confound our findings, we restrict the sample of controls to firms in states neighboring treated firms' home states. On the assumption that economic conditions are similar in neighboring states while tax policies stop at the state's border, we can then difference away any unobserved confounding effects, such as from local business cycles. Our results are robust to this design. State corporate income tax changes occasionally coincide with changes in state taxes on bank profits (which could affect the supply of bank loans) and investment incentive programs (such as tax credits for investment, R&D, and job creation). When we control for these directly, we continue to find that corporate risk-taking is sensitive to corporate income tax increases but not to corporate income tax cuts.

To test Domar and Musgrave's (1944) argument that the ability to offset losses against past or future profits should weaken the negative effect of income taxes on risk-taking, we collect detailed information on how state tax loss carryback and carryforward rules have evolved over our sample period. We use these data to condition how firms respond to changes in state tax rates. We also test how firms respond to the rule changes themselves using a diff-in-diff setup.

The results are consistent with Domar and Musgrave's prediction. First, when we sort firms by their ability to offset tax losses, we find that the negative effect of tax increases on risk-taking is largely driven by firms with a limited ability to offset losses. (The effect of tax cuts on risk-taking continues to be insignificant.) Second, firms' responses to changes in offset rules broadly mirror their responses to changes in tax rates. Firms reduce risk when their ability to carry back losses is reduced, but not when carrybacks become more favorable, nor when carryforward rules are either improved or made worse. One potential reason why firms are more responsive to changes in carrybacks than in carryforwards is that carrybacks allow firms to claim cash taxes back immediately when incurring losses, whereas the benefit of carryforwards is more uncertain.

Our study makes three main contributions. First, it contributes to the literature on the effect of taxes on corporate policies by showing that taxes affect risk-taking decisions and that they do so causally. Our causal inferences exploit two distinct sources of exogenous variation in corporate taxation: changes in state income tax rates and changes in state tax loss-offset rules. Second, our study relates to the literature on corporate risk-taking by identifying taxes as one of its determinants. Third, our study has potential policy implications. While increasing tax rates can increase the government's revenue, it may have the side effect of dampening risk-taking incentives in the corporate sector, which in turn may adversely affect innovation and economic growth. Moreover, if the government wishes to encourage risk-taking, our findings suggest that merely reducing tax rates is unlikely to be effective without other policy changes.

1. Related Literature

Taxes affect various corporate decisions (Shackelford and Shevlin 2001; Hanlon and Heitzman 2010; Graham 2013; Scholes, Wolfson, Erickson, Hanlon, Maydew, and Shevlin 2014), such as capital structure (Graham 1996; Doidge and Dyck 2015; Faccio and Xu 2015;

Heider and Ljungqvist 2015), investment (Asker, Farre-Mensa, and Ljungqvist 2015; Tsoutsoura 2015), dividend payouts (Moser 2007; Doidge and Dyck 2015), compensation policies (Graham, Lang, and Shackelford 2004; Dhaliwal, Erickson, and Heitzman 2009), and organizational form and corporate restructuring (Shevlin 1987; Ayers, Cloyd, and Robinson 1996; Erickson 1998; Maydew, Schipper, and Vincent 1999).

Prior literature on the link between income taxes and corporate investment focuses on the effect of taxes on the *level* of investment.[6] In the model of Hall and Jorgenson (1967), taxes increase the cost of investment, while allowances for depreciation and investment tax credits reduce it. Summers (1981) extends the *q* theory of investment to include taxes. Using aggregate investment data and relying on time-series changes in tax rates or tax regimes, early studies fail to find evidence of a link between taxes and investment. Hines (1998) comments, "The apparent inability of tax incentives to stimulate aggregate investment spending is one of the major puzzles in the empirical investment literature." Exploiting exogenous variation in corporate tax rates at the state level, Asker, Farre-Mensa, and Ljungqvist (2015) find that privately held firms increase investment spending in response to tax cuts and reduce it in response to tax increases, whereas stock market-listed firms' investment spending is insensitive to tax changes. We extend this stream of literature on the link between taxes and the level of corporate investment by investigating the effect of taxes on stock market-listed firms' choice of risk.

Our focus on the effect of corporate income taxes on risk-taking has a parallel in the literature investigating the link between personal income taxes and individual risk-taking pioneered by Domar and Musgrave (1944), Feldstein (1969), and Stiglitz (1969). In Domar and Musgrave's (1944) model, an investor weighs the advantage of a greater return ("yield") against

[6] See Hassett and Hubbard (2002), Desai and Goolsbee (2004), Hassett and Newmark (2008), and Hanlon and Heitzman (2010) for reviews of the literature on taxes and corporate investment.

the disadvantage of a possible loss ("risk"). Taxes reduce yields. How they affect risk depends on the extent to which losses are tax deductible. Without tax loss-offset, the investor will reduce risk once taxes are imposed. The rate of loss-offset attenuates the negative relation between taxes and the degree of risk taken.[7] Feldstein (1969) demonstrates that proportional taxation with full loss-offset does not generally cause individuals to increase risk-taking in the context of von Neumann-Morgenstern expected-utility maximization. Stiglitz (1969) investigates the effects of taxes on income, wealth, and capital gains on risk-taking with and without loss-offsets, using a general expected utility maximization model.

Our approach follows the economic logic of Domar and Musgrave (1944). As a result, we do not develop a full-fledged model. Our aim is to investigate empirically whether, and to what extent, corporate taxes affect corporate risk-taking using the intuition established in Domar and Musgrave's early work.

Our paper adds a new angle to the literature on corporate risk-taking. Prior research has studied several determinants of corporate risk-taking, including managerial incentives (May 1995; Demski and Dye 1999; Rajgopal and Shevlin 2002; Coles, Daniel, and Naveen 2006; Gormley, Matsa, and Milbourn 2013), corporate governance (John, Litov, and Yeung 2008), Sarbanes–Oxley (Bargeron, Lehn, and Zitter 2010), creditor rights (Acharya, Amihud, and Litov 2011), diversification (Faccio, Marchica, and Mura 2011), and inside debt (Cassell, Huang, Manuel Sanchez, and Stuart 2012; Choy, Lin, and Officer 2014).

Most related to our study is a concurrent working paper by Langenmayr and Lester (2015).

[7] In Domar and Musgrave's (1944) framework, this prediction is called the substitution effect (i.e., substituting safer investments for riskier ones). Domar and Musgrave also discuss an income effect: because taxes reduce expected returns, individuals may take on more risk to restore their desired rates of return. Domar and Musgrave suggest that the substitution effect likely dominates the income effect in practice. In the context of corporate risk-taking, the income effect, if present, works against us finding a significant substitution effect. Note also that reducing risk would reduce the value of shareholders' option to default; hence shareholders would only have an incentive to reduce risk-taking when the tax benefits of doing so more than offset the reduction in option value.

Using a cross-country firm-level panel dataset over the period 1998 to 2009, Langenmayr and Lester document two findings: (1) firm risk-taking increases in the number of tax loss periods, and (2) the association between firm risk-taking and corporate tax rates is positive for firms that can expect to use their tax losses but negative for those that cannot.

The findings in our paper are consistent with (but not exactly the same as) theirs. Our main advantage is identification: our difference-in-differences methodology establishes a set of counterfactuals and eliminates omitted-variable biases resulting from the confounding influence of unobservable variation in, for example, local economic conditions. Thus, we can interpret our results causally, which is critical for academic research to be informative to policymakers (Leuz and Wysocki 2015). In addition, our setting allows us to separately investigate the effects of tax increases and tax cuts and thereby to shed light on the effectiveness of fiscal policy changes.

2. Sample and Data

2.1 Sample

Our sample begins with all firm-year observations in the merged CRSP-Compustat database for fiscal years 1990 to 2011. The 1990 start date is chosen because one of our control variables requires two lags of cash flow statement data, and cash flow data are only available since 1988. The sample ends in 2011 to give firms time to adjust their risk profiles after taxes change.

We exclude financial firms (SIC=6; 27,197 observations), utilities (SIC=49; 7,174 observations), public-sector entities (SIC=9; 2,187 observations), non-U.S. firms (17,289 observations), and firms headquartered outside the U.S. (954 observations). We delete firms without stock return data, firms not traded on a major U.S. stock exchange (NYSE, Amex, or Nasdaq), and firms with a CRSP share code >11 (47,666 observations). Firm-year observations with negative or missing total assets (30,281 observations) are also excluded. Requiring non-

missing data for our risk measures and control variables and their lagged values leaves us with a final panel of 64,447 firm-year observations for 8,046 firms.

2.2 State corporate income taxes

2.2.1 Changes in state tax rates

To examine the effect of taxes on risk-taking, we exploit staggered changes in state corporate income tax rates across U.S. states over the period 1990 to 2011. As Heider and Ljungqvist (2015) note, state taxes are a meaningful part of U.S. firms' overall tax burden and account for about 21% of total income taxes paid for an average firm in the sample of Compustat firms. Compared to firm-level variation in marginal or effective tax rates, state tax rate changes are more likely to be exogenous to individual firms.

Appendix A provides details of the changes in state corporate income tax rates for our sample period. Panel A lists 40 tax increases in 24 states (including DC) affecting 1,152 sample firms in fiscal years 1990–2011, while Panel B lists 73 tax cuts in 27 states (including DC) affecting 4,920 firms in fiscal years 1990–2011.[8] The average tax shock increases tax rates by 93 basis points and the average tax cut reduces tax rates by 55 basis points.

Our main variables of interest are the *magnitude of tax increase* and *magnitude of tax cut* in a firm's headquarter state in a given fiscal year, in each case measured as this year's tax rate minus last year's tax rate. Thus, a larger value means a larger tax increase and a smaller tax cut, respectively. From time to time, firms move their headquarters from one state to another. Compustat provides information only on a firm's current headquarter state. To remedy this flaw,

[8] In coding which firms are affected by tax changes when, we are careful to capture whether a tax change affects firms with fiscal years *ending* or *beginning* on or after the effective date. This affects when it makes sense for a firm to react. We lose eight of Heider and Ljungqvist's (2015) 121 tax changes, partly because our sample starts later, partly because two of their tax changes (in ND in 2007 and 2009) affect none of the firms satisfying our sampling criteria, and partly because we lack a clear prediction for how changes from gross receipts taxes to income taxes (or vice versa) affect firm risk-taking.

we use Heider and Ljungqvist's (2015) hand-collected data on firms' historical headquarter states.[9] Based on these data, the average (median) treated firm experiences a tax increase of 136 (106) basis points and a tax cut of 53 (44) basis points.

In the U.S., firms are taxed in every state in which they have a physical presence (their so called "nexus" states).[10] Under the Uniform Division of Income for Tax Purposes Act, a multi-state firm apportions its federal taxable income to each nexus state using an apportionment formula based on an average of the fractions of the firm's total payroll, sales, and property located in that state. To capture tax shocks experienced by multi-state firms more precisely, we approximate the geographic distribution of their tax liabilities using location data for their subsidiaries, branches, and plants. Specifically, we match Compustat firms by name to the National Establishment Time Series (NETS) database, which contains a complete record of all business establishments in the U.S. since 1989.[11] We then calculate the weighted change in state tax rates in a firm's nexus states in a fiscal year as follows:

$$\Delta tax\ rate_{i,t} = \sum_{s} \left(\frac{1}{2} \frac{employees_{i,s,t}}{employees_{i,total,t}} + \frac{1}{2} \frac{sales_{i,s,t}}{sales_{i,total,t}} \right) \Delta T_{s,t}\,, \tag{1}$$

where $employees_{i,s,t}$ and $sales_{i,s,t}$ are firm i's number of employees and sales in state s in year t, respectively, and $employees_{i,total,t}$ and $sales_{i,total,t}$ are the corresponding firm totals across all nexus states in year t, respectively. $\Delta T_{s,t}$ is the change in the corporate income tax rate in state s in year t. Eq. (1) approximates a firm's nexus with each state using a 50/50 average of the fractions of the firm's total employment and sales in that state. Based on the magnitude and sign of the weighted tax change in Eq. (1), we define two alternative variables of interest: *nexus-weighted*

[9] Previous accounting research exploiting variation in state laws may give rise to inaccurate inferences if firms' historical headquarter states are not used (see, for example, Brown, Stice, and White 2015).
[10] As of 2011, three states (namely, Nevada, South Dakota, and Wyoming) do not impose income taxes, and three states (namely, Ohio, Texas, and Washington) impose gross receipts taxes rather than income taxes.
[11] The NETS database is created through a joint venture of Walls & Associates and Dun & Bradstreet. Neumark, Zhang, and Wall (2007) assess the database along various dimensions and conclude that it is generally reliable.

tax increase and *nexus-weighted tax cut.*

2.2.2 Tax loss carryback/carryforward rules

The effect of taxes on risk-taking is moderated by tax loss-offset provisions (Domar and Musgrave 1944). Most U.S. states have loss-offset rules. For example, in 2011, about a third of U.S. states allow firms to offset their current losses against income earned in the past two or three years, and all U.S. states allow firms to carry their current losses forward, for periods ranging from 5 to 20 years. To examine potential heterogeneous treatment effects, we collect detailed data on U.S. state tax loss carryback/carryforward rules over our sample period. In addition, we also use changes in state tax loss carryback/carryforward periods as an alternative source of exogenous shocks to examine the effect of corporate taxation on firm risk-taking.

Appendix B provides details of the changes in state tax loss carryback/carryforward rules for our sample period. Panel A lists 15 increases in the loss carryback period in 11 states (including DC) affecting 430 sample firms in fiscal years 1990–2011, while Panel B lists 36 reductions in the loss carryback period in 26 states (including DC) affecting 1,164 firms. At the state-level, the average increase is 2.13 years while the average reduction is 1.75 years. The average (median) treated firm experiences an increase of 2.04 (2) years and a reduction of 1.83 (1) years.

Panel C lists 47 increases in the loss carryforward period in 37 states (including DC) affecting 5,349 sample firms in fiscal years 1990–2011, while Panel D lists 10 reductions in the loss carryforward period in eight states affecting 1,828 firms. The variation in carryforward periods is larger than for carryback periods. At the state-level, increases average 6.43 years, while reductions average 8.2 years. The average (median) treated firm experiences an increase in the carryforward period of 6.65 (5) years and a reduction of 9.58 (10) years.

2.2.3 State-level confounds

Our identification strategy requires that state corporate income tax changes do not coincide systematically with variation in local business cycles or other tax or non-tax state policies that might independently affect firms' risk-taking. For example, if states raise taxes in economic downturns, and economic downturns motivate firms to reduce risk-taking, we would observe a spurious correlation between taxes and risk-taking.

To investigate the potential influence of state-level confounds, we relate changes in state corporate income tax rates and loss-offset rules to the economic and political conditions of that state. Table 1 reports the results. Column 1 shows that the magnitude of state corporate income tax increases is 4 percentage points larger (p=0.035) if the next gubernatorial election is three years away than in an election year. Tax increases are also significantly larger the larger the state's budget deficit the year before and smaller if the state's tax rate is already high relative to its neighbors' rates. Column 2 reports the results for tax cuts. Tax cuts are 2.8 percentage points smaller if the governor is a Democrat and 4.9 percentage points smaller when the state experiences a bond ratings downgrade. Tax cuts are significantly larger if the state's tax rate is high relative to its neighbors' rates.[12]

Columns 3 to 6 model the determinants of changes in tax loss carryback/carryforward rules. We find little systematic variation. Carryback rules are cut back more severely the lower is the real growth in gross state product (GSP) and become more generous just after a gubernatorial election and when growth is higher. Carryforward rules vary little with the political and economic factors included in Table 1, except that they are improved less aggressively after the state suffers a ratings downgrade on its bonds.

[12] The results in columns 1 and 2 are slightly different from those in Heider and Ljungqvist (2015) because we lose eight of Heider and Ljungqvist's (2015) 121 tax changes, as mentioned earlier.

Overall, Table 1 shows that several state-level political and economic factors (namely, the governor's political affiliation, the election cycle, the state's budget balance, ratings downgrades, growth, and tax competition) are significantly correlated with state tax changes. While we do not expect political factors to affect firms' risk-taking, the economic factors could well have an impact on risk-taking and thus cause omitted-variable biases. We address this problem in two ways. First, we include controls for observed variation in state economic conditions in our regressions. Second, in a separate robustness check, we restrict the sample of control firms to those in neighboring states to control for unobserved variation in local economic conditions.

Appendix C investigates whether changes in state corporate income tax rates and loss-offset rules coincide with each other or with state-level changes in taxes on bank profits or in investment incentive programs (i.e., tax credits for investment, R&D, and job creation). Overall, there is little overlap. The exception, as Panel A in Appendix C shows, is that 28 out of the 40 corporate tax increases coincide with increases in bank taxes and 56 out of the 73 corporate tax cuts coincide with reductions in bank taxes. Since changes in bank taxes could result in changes in the supply of bank loans (Smolyansky 2015), we verify that our results are robust to controlling for changes in bank taxes. Overall, we conclude that changes in state corporate income tax rates and loss-offset rules appear plausibly exogenous to firms' risk-taking decisions.

2.3 Risk-taking measures

Recall that in Domar and Musgrave's (1944) framework, risk is calculated as the product of the probability of incurring a loss and the magnitude of the potential loss. The most intuitive measure of corporate risk-taking is thus the volatility of a firm's pre-tax earnings: greater earnings volatility increases both the probability of a loss and the size of the loss. We thus define our first measure of risk-taking, *ROA volatility*, as the standard deviation of seasonally adjusted

quarterly pre-tax returns on assets (*ROA*) over a three-year period from year *t* to *t*+2 (Correia, Kang, and Richardson 2015). Seasonally adjusted pre-tax *ROA* for firm *i* in quarter *q* of year *t* is computed as follows:

$$\Delta ROA_{i,t,q} = ROA_{i,t,q} - ROA_{i,t-1,q}, \quad (2)$$

where pre-tax *ROA* is calculated as operating income after depreciation (i.e., earnings before interest and taxes) divided by the book value of total assets.

Our second measure of risk-taking, *ROIC volatility*, is the standard deviation of seasonally adjusted quarterly pre-tax returns on invested capital (*ROIC*) over a three-year period from year *t* to *t*+2. Following Lundholm and Sloan (2012), we compute *ROIC* as operating income after depreciation divided by the sum of debt, minority interests, preferred stock, and common stock.[13]

In robustness tests, we use two market-based measures as alternative measures of risk-taking, namely, the standard deviation of stock returns and the de-leveraged standard deviation of stock returns. We prefer the earnings-based risk measures because they more likely reflect a firm's choice of risk (stock returns not being under the firm's control).

2.4 Control variables and descriptive statistics

Following prior research (e.g., Coles, Daniel, and Naveen 2006), we include the following standard firm-level characteristics as control variables: firm age, firm size, market-to-book ratio, book leverage, cash surplus, loss carryforward, sales growth, and annual stock returns. Appendix D provides detailed definitions for all variables.

Table 2 presents summary statistics. The average (median) *ROA volatility* is 6.8% (3.8%), and the average (median) *ROIC volatility* is 10.6% (5.3%). Given the skewed distribution of

[13] *ROIC* is also called return on net operating assets (*RNOA*). Some researchers view non-operating cash as negative debt and subtract total cash from invested capital in computing *ROIC*. However, in the presence of financial frictions, non-operating cash should not be viewed as negative debt (Acharya, Almeida, and Campello 2007). Moreover, firms generally do not disclose how much cash they hold for non-operating purposes (Lundholm and Sloan 2012).

these two risk measures, we use their log-transformed values in our regression analysis. The average firm in our sample is 19.6 years old and has total assets of $1,755.2 million.

We also control for two state-level variables: the real growth rate in gross state product (GSP) and the state unemployment rate. The mean home-state GSP growth rate is 2.7% and the mean unemployment rate is 5.9%. We consider further state-level controls in robustness tests.

3. Empirical Strategy and Results

3.1 The effect of tax changes on risk-taking

We use a difference-in-differences framework to identify the effect of changes in state corporate income tax rates on firms' risk-taking choices. Specifically, we estimate the following regression model:

$$\Delta Risk_{i,j,s,t} = \beta \Delta T^{+}_{s,t} + \gamma \Delta T^{-}_{s,t} + \theta \Delta Z_{s,t} + \delta \Delta X_{i,t-1} + \alpha_{j,t} + \varepsilon_{i,j,s,t}, \quad (3)$$

where *i*, *j*, *s*, and *t* index firms, industries, states, and years. Δ is the first-difference operator. $Risk_{i,j,s,t}$ is a measure of risk-taking (*ROA volatility* or *ROIC volatility*). The first difference of *ROA* (*ROIC*) *volatility* for year *t* is the log-transformed standard deviation of seasonally adjusted quarterly pre-tax *ROA* (*ROIC*) computed over years *t* to *t*+2 minus the log-transformed standard deviation of seasonally adjusted quarterly pre-tax *ROA* (*ROIC*) computed over years *t*–3 to *t*–1.[14] In our baseline models, $\Delta T^{+}_{s,t}$ is the *magnitude of tax increase* in a firm's home state and $\Delta T^{-}_{s,t}$ is the *magnitude of tax cut* in a firm's home state in year *t*. Thus, firm risk is reduced in response to a tax increase if $\beta<0$ and increased in response to a tax cut if $\gamma<0$.

$Z_{s,t}$ represents the state-level control variables in year *t* (state real GSP growth rate and state unemployment rate). $X_{i,t-1}$ is the vector of time-varying firm-level control variables, measured as

[14] To construct these measures, we use data from Compustat Quarterly for fiscal years 1987 to 2013.

of year t-1.[15] $\alpha_{j,t}$ are SIC4 industry-year fixed effects, which remove unobserved time-varying industry shocks. Essentially, industry-year fixed effects allow us to compare treated and control firms in the same industry at the same point in time. $\varepsilon_{i,j,s,t}$ is the usual error term. Given the state-level nature of the variation we exploit, we cluster standard errors at the state level.

Estimating Eq. (3) in first-differenced form removes firm-specific fixed effects. An important advantage of a first-differenced specification over a levels specification with firm fixed effects is that first-differencing can easily accommodate repeated treatments, treatment reversals, and firms' asymmetric responses to tax changes, all of which exist in our setting.

To illustrate the logic of our identification strategy, consider Pennsylvania. In 1991, PA increased its top corporate income tax rate from 8.5% to 12.25%. Following this tax increase, stock market-listed firms headquartered in PA reduced their risk by roughly 10% on average. From the point of view of an individual firm in PA, this tax shock is plausibly exogenous: presumably, no firm would have lobbied for the tax increase. This exogeneity with respect to individual firms' characteristics is not, however, sufficient to establish causality: other coincident developments, such as changes in investment opportunities in PA, could be responsible for the reduction in corporate risk-taking.

To control for such contemporaneous developments, we compare risk changes among PA firms to the contemporaneous risk changes among firms located in other states without a tax change in 1991, say, in New York. To the extent that PA firms and NY firms are faced with similar changes in investment opportunities, the contemporaneous change in risk among NY firms provides a counterfactual estimate of how PA firms' risk would have evolved absent the tax increase. The difference-in-differences, that is, the difference across firms in different states

[15] Consistent with prior research, we use beginning-of-year (i.e., year t-1) values for the firm-level controls as these variables are likely affected by a firm's concurrent risk-taking choices (Gow, Larker, and Reiss 2015).

of the within-firm risk change around the tax increase, gives the desired estimate of the tax sensitivity of corporate risk-taking.

Eq. (3) generalizes this illustrative example in that it exploits variation in taxes across many states and years. For any change in corporate income taxes in state *s* and year *t*, the potential control states are all those states that did not change their corporate income taxes in that year. In addition to this, Eq. (3) also controls for time-varying firm and state factors, as well as unobserved time-invariant firm characteristics and time-varying industry shocks.

Table 3 reports the results of estimating Eq. (3). Columns 1 and 2 model how firms respond to tax changes in their headquarter states. In the regression with *ROA volatility* as the dependent variable (column 1), the coefficient on *magnitude of tax increase* is -0.019 (p=0.007), suggesting that firms reduce risk-taking in response to a tax increase. The effect is both statistically and economically significant. The point estimate suggests that the average treated firm, whose home-state tax rate increases by 136 basis points, reduces its risk-taking by 2.6% relative to other firms in the same industry that are not subject to tax changes in their own home state that year. In column 2, where we use *ROIC volatility* as the dependent variable, the coefficient on *magnitude of tax increase* is -0.020 (p= 0.006) – nearly identical to the point estimate in column 1.

The models shown in columns 1 and 2 relate the difference in volatility measured over fiscal years t to t+2 and volatility measured over fiscal years t–3 to t–1 to tax changes occurring in fiscal year t. In columns 3 and 4, we lag the tax changes by one year to allow for delays in firms' responses to tax changes. This produces stronger results for *ROA volatility* and similar results for *ROIC volatility*: *ROA volatility* falls by 2.6 percentage points for every one-percentage-point increase in the tax rate (p<0.001), while *ROIC volatility* falls by 1.9 percentage points (p=0.047).

Columns 5 and 6 of Table 3 model how firms respond to contemporaneous changes in their

nexus-state weighted income tax rates. As discussed earlier, the weighted tax-change measures arguably better capture the shock to a firm's actual state-tax burden. In column 5, where the dependent variable is *ROA volatility*, the coefficient on *nexus-weighted tax increase* is -0.024 (p=0.011), suggesting that a one-percentage-point increase in a firm's nexus-weighted tax rate reduces its risk-taking by 2.4% relative to control firms in the same industry and year. In column 6, the coefficient on *nexus-weighted tax increase* is -0.032 (p=0.005) when we use *ROIC volatility* as the dependent variable. Overall, the effects estimated for nexus-weighted tax changes are larger than those for home-state tax changes, confirming our prior that ignoring the geographic distribution of firms' tax bases understates the tax sensitivity of firms' risk-taking. Results using home-state tax changes are hence conservative.

The contemporaneous effect of tax cuts is to increase risk-taking. The effect is generally large, but unlike the effect of tax increases, it is not statistically significant. For example, in column 1, the coefficient on *magnitude of tax cut* is -0.016 with a p-value of 0.322. The results for *ROIC volatility* or when using nexus-weighted tax changes show a similar pattern. When lagged, the effect of tax cuts on risk-taking is close to zero.

While the difference in the sensitivity to tax increases and tax cuts is small and not statistically significant for contemporaneous tax changes, it is economically large and statistically significant for *ROA volatility* when we use lagged tax changes.[16]

Among the control variables, we find that risk increases by less as the firm ages or grows in size. Firms with a higher market-to-book ratio take more risk, while firms with higher financial leverage, more cash surplus, and higher stock returns take less risk. Firms with higher sales growth rates and loss carryforwards have higher risk. The two state-level control variables are

[16] As we will see in Table 5, when we control for additional state-level controls, the difference becomes significant for both volatility measures, whether we use contemporaneous or lagged tax changes.

also marginally significant. Firms increase risk as the GSP growth rate falls and as the state unemployment rate increases.[17]

3.2 Pre-trends, delayed responses, and reversals

A causal interpretation of the effect of tax changes on risk-taking requires that treated and control firms follow parallel trends before the tax changes. To test for parallel trends, Table 4 includes lead terms of the tax change variables. These are measured as of year t+3, given that we use 12 quarters of earnings data to construct our volatility measures. The point estimates for the lead terms are economically tiny and not statistically different from zero, suggesting that risk follows parallel trends at treated firms and controls before state income tax rate changes. One implication of these findings is that firms do not anticipate future changes in state income taxes (or if they do, that they wait to change risk until the tax changes affect shareholder wealth).

Table 4 also allows for potential delays in firms' responses to tax cuts and post-shock reversals in the effect of tax increases by including three-year lags. The coefficient for lagged tax increases is negative, indicating that firms do not subsequently reverse the reduction in risk following a tax increase. Given the relatively large point estimate, the effect of a tax increase appears not only persistent but also increasing over time. In column 1, the cumulative effect is -0.035 (p<0.001), suggesting that a one-percentage-point increase in the state corporate income tax rate in year t reduces *ROA volatility* by 3.5% over the next six years (i.e., *ROA volatility* measured over years t to t+2 and over years t+3 to t+5). Given an average tax increase of 136 basis points, the average treated firm thus reduces its risk by a cumulative 4.8%. For tax cuts, the coefficient on the lag term is economically small and statistically insignificant.

[17] Our results remain largely unchanged (in terms of magnitudes and statistical significance) to those reported in Table 3 when we control for the state-level factors listed in Table 1 (measured in either year t or t–1). None of the coefficients on these other state-level factors is statistically significant, with one exception: firms reduce *ROIC volatility* as the state's unionization rate increases. (Results available on request.)

3.3 Local business cycle effects and other state-level confounds

Our baseline regression model includes GSP growth rates and state unemployment rates to control for time-varying state-level economic conditions. In addition, by first-differencing, we have removed unobserved cross-state differences in rules or laws affecting business, to the extent that these rules or laws are persistent over time. There remains the possibility that unobserved changes in local economic conditions coincide with, or even drive, state changes in tax rates, and that it is these unobserved changes that cause firms to change their risk-taking.

To further address this potential omitted-variables problem, we drop all far-away control states and restrict the set of control firms to those located in states neighboring the treated state. This approach exploits the fact that economic conditions are likely to be similar in neighboring states whereas the effects of state tax policy stop at the state's border. This discontinuity in tax policy allows us to difference away *any* unobserved confound, as long as it affects both the treated state and its neighbors. Effectively, cross-border neighbors establish the counterfactual response to the unobserved confound of firms not affected by a tax change, and this counterfactual response is then subtracted from the treated firms' response to the tax change. In other words, by comparing treated firms to their immediate neighbors, we can ensure that trends are parallel after removing the effects (if any) of variation in local conditions.

Table 5 reports the results. A one-percentage-point increase in the corporate tax rate reduces *ROA volatility* and *ROIC volatility* by 2.1% (p=0.001) and 2.2% (p=0.003), respectively. Thus, controlling for unobserved local business cycles increases the point estimates a little compared to the baseline results reported in Table 3. Tax cuts continue to have no effect on risk-taking. Overall, these patterns confirm that our findings are not driven by any source of unobserved variation that coincides with the tax changes and that diffuses across state borders.

This leaves confounds whose variation coincides with the tax changes and whose influence stops at the state border, such as the state-level policy changes listed in Panel A of Appendix C. To address concerns stemming from the fact that corporate tax changes occasionally coincide with changes in state taxes on bank profits or in investment incentive programs (i.e., tax credits for investment, R&D, and job creation), columns 3 and 4 control explicitly for these concurrent changes.[18] Doing so leaves the estimated effect of tax increases largely unchanged. The effect of tax cuts, while still statistically insignificant, changes sign. The difference between the two tax sensitivities is economically large and statistically significant (p=0.012 in column 3 and p=0.037 in column 4). This asymmetric response of firms' risk-taking is consistent with our earlier argument that risk is easier to reduce than to increase: creditors and other stakeholders (e.g., unions or important trading partners) stand to lose out when risk increases and so have an incentive to constrain the firm's ability to increase risk unduly.

Columns 3 and 4 reveal two further patterns. First, lower taxes on bank profits are associated with significantly greater corporate risk-taking, possibly because they stimulate bank lending which in turn allows firms to take greater risks.[19] Second, reductions in R&D tax credits are associated with reduced risk-taking, consistent with the intuition that less generous R&D tax credits dampen firms' incentives to invest in potentially risky R&D projects.

Overall, the results in Table 5 support a causal interpretation of the estimated effect of tax increases on firm risk-taking and confirm that firms respond to tax changes asymmetrically.

[18] We also inspect individual tax changes to make sure that there are no coincident changes in economic policies around the time of the tax changes.

[19] Banks have a unique status for state tax purposes (Koch 2005). They are taxed on a different schedule from corporations and so are subject to their own tax changes. When a state increases its bank tax, it reduces the after-tax profit on every loan made to borrowers located in the state, regardless of the lender's own location. Variation in a state's bank taxes can thus induce variation in the supply of loans available to firms located in the state.

3.4 Equity volatility

Our baseline tests use *ROA volatility* and *ROIC volatility* to measure firm risk. As discussed earlier, these earnings-based risk measures are a good match to our research question and the underlying theory. Prior research on corporate risk-taking often uses stock return volatility to measure a firm's choice of risk. While these equity-based measures may not be best suited to our research question, as they are less directly under a firm's control, Table 6 investigates the robustness of our findings to using equity volatility instead.

The dependent variable in column 1 is the change in the firm's annual stock return volatility, measured as the annualized standard deviation of monthly stock returns over the fiscal year.[20] The tax-increase coefficient is -0.023 (p<0.001), implying that firms reduce equity risk in response to higher state tax rates. The tax-cut coefficient is close to zero and not statistically significant (p=0.693). Column 2 de-leverages equity volatility to remove the effect of financial leverage. Specifically, de-leveraged equity volatility is equity volatility times the ratio of market capitalization to the sum of market capitalization and the book value of debt. The tax-increase coefficient is again negative and significant while the tax-cut coefficient is insignificant. In either specification, the difference between the two tax sensitivities is economically large and statistically significant (p=0.003 in column 1 and p=0.006 in column 2). These patterns mirror our baseline findings for the earnings-based risk measures.

3.5 Earnings management

Our results may partly be driven by a firm's earnings management, which could vary in response to state income tax rate changes.[21] To investigate this concern, we test whether a firm's

[20] In this test, we use a one-year period instead of a three-year period because risk changes can be rapidly reflected in stock return volatility (but not necessarily in earnings realizations).

[21] Scholes, Wilson, and Wolfson (1992) find that firms respond to anticipated reductions in federal tax rates by delaying recognizing income. Maydew (1997) provides evidence that firms shift income to benefit from loss-offsets.

performance matched discretionary accruals (Kothari, Leone, and Wasley 2005) vary with state-level tax changes, but find no evidence that they do (results available on request). This is consistent with Graham's (2006) observation that "tax incentives appear to be a second-order consideration, rather than a dominant influence on earnings management" (p. 663). In addition, equity-based measures of risk-taking such as those modeled in Table 6 are not affected by earnings management, further alleviating this concern.

3.6 Discussion

The results in Tables 3 and 4 show that state corporate income tax increases have a persistent and causal negative effect on corporate risk-taking over the next several years. While we cannot pinpoint firms' precise risk choices with the available data, the dynamics of their observed responses may help shed light on the nature of the observed changes in risk-taking.

The observed increase in earnings volatility measured over the three-year period t to t+2 suggests that firms change the risk profile of their current operations or of "shovel-ready" investment projects that contribute to earnings relatively quickly. For example, salespeople may be given incentives to pursue lower-risk sales leads, production managers may be instructed to reduce operational leverage by keeping costs flexible, and business-development managers may be told to go after lower-risk acquisition targets.

The further reduction in risk-taking over the next few years (i.e., the three-year period t+3 to t+5 in Table 4) suggests that firms also make changes to the risk profiles of their longer-term investment programs. A prominent example is R&D: when their income tax rate increases, firms may choose safer R&D projects (say, to enhance the quality or variety of their existing products) over riskier ones (say, to invent new products). The shift to safer projects would eventually reduce earnings volatility as these R&D projects start to generate cash flows over time.

Mukherjee, Singh, and Zaldokas (2015) provide indirect evidence supporting this particular channel: following a state tax increase, affected firms in their sample bring fewer new products to market, consistent with a change in their risk profiles.

A natural caveat to our findings is that the available data do not permit us to neatly attribute the observed changes in risk-taking to particular operational or investment choices firms make. The estimated tax sensitivity of 2% to 3% (per one percentage-point increase in the corporate tax rate) suggests that firms tend to fine-tune their risk profiles in response to state tax rate changes. Moreover, our results are also consistent with the possibility that firms reduce the volatility of their earnings by changing their hedging activities (Graham and Smith 1999; Graham and Rogers 2002) or their working capital management.

4. State Tax Carryback/Carryforward Rules

4.1 Heterogeneous treatment effects

According to Domar and Musgrave's (1944) theory, the effect of personal income taxes on individual risk-taking is negative in the absence of loss-offsets. The same is true in the corporate arena. However, if firms can offset losses against past or future profits, the effect of taxes on risk-taking becomes more complex. On the one hand, income taxes discourage risk-taking by reducing the per-unit benefit of risk-taking. On the other hand, loss-offset rules essentially make the government shoulder part of the losses. Thus, both the benefit of risk-taking and the level of after-tax cash flow risk are reduced. If complete offset of losses is possible, taxes may have no net effect on risk-taking.

To test this prediction, we partition the sample based on the loss carryback and carryforward rules in effect in each firm's home state in a given fiscal year. Specifically, we code firms as having a low ability to offset losses when their home state allows no loss carrybacks and no more

than 10 years of loss carryforwards.[22] Otherwise, we code firms as having a high ability to offset losses. These cutoffs are arbitrary but not selective.

Table 7 presents the results of estimating Eq. (3) using the partitioned samples. Columns 1 and 3 report the results for the subsample of firms with a low loss-offset ability. The coefficients on *magnitude of tax increase* are -0.026 (p=0.010) and -0.033 (p=0.008) when we use *ROA volatility* and *ROIC volatility* as the dependent variable, respectively. In the subsample of firms with a high loss-offset ability, shown in columns 2 and 4, the coefficients are -0.010 (p=0.391) and -0.004 (p=0.817), respectively.[23] These results show that the negative effect of tax increases on risk-taking is largely driven by firms located in states with weak loss-offset provisions, consistent with the prediction that the impact of income taxes on risk-taking is attenuated by the ability to offset tax losses against past or future profits.

4.2 State loss-offset rules and risk-taking

Our baseline tests investigate firms' responses to state tax rate changes while our tests of heterogeneous treatment effects examine whether firms' responses to tax rate changes are moderated by tax loss-offset rules. We next examine whether changes in loss-offset rules have an independent effect on corporate risk-taking. A reduction in the number of years that losses can be carried back or forward essentially increases firms' after-tax income risk and reduces the benefit of risk-taking. Thus, we expect that reductions in the generosity of carryback or carryforward rules reduce firms' risk-taking, analogous to the case of tax rate increases. A similar argument can be made for an increase in the number of loss carryback or carryforward periods.

[22] About two-thirds of U.S. states have carryforward periods of 15 or 20 years.
[23] The difference between the coefficients on *magnitude of tax increase* in the two subsamples, although economically large, is not statistically significant when we use *ROA volatility* as the dependent variable. When we use *ROIC volatility* as the dependent variable, the difference is both statistically and economically significant.

We examine loss-offset rule changes both in a firm's home state and across its nexus states.[24] Table 8, Panel A reports the results for changes in home-state rules. As before, we allow for asymmetric responses by separately including increases and reductions in the number of loss carryback or carryforward periods. In column 1, the coefficient on *reduction in carryback period* is 0.023 (p=0.003), suggesting that firms reduce risk-taking as carryback rules are made less generous. In contrast, the coefficient on *increase in carryback period* is statistically insignificant. The results for *ROIC volatility*, shown in column 2, are similar. These patterns are consistent with our baseline finding that firms reduce risk-taking in response to an increased tax burden but do not significantly increase risk-taking in response to a reduced tax burden.

The coefficients on *increase in carryforward period* are positive and significant, suggesting that firms increase risk in response to increased risk-sharing by the government. Economically, however, these effects are small. The coefficients on *reduction in carryforward period* are both statistically and economically insignificant. The contrast between the results for changes in carryback and carryforward rules implies that firms are more responsive to changes in carryback rules, perhaps because carrybacks give firms immediate refunds of taxes paid in the past.[25]

Columns 3 and 4 add the tax rate changes from our baseline tests. This leaves the coefficients of the changes in loss-offset rules unchanged. Not surprisingly, the coefficients on the tax-rate change variables mirror those reported in Table 3: as Appendix C shows, changes in state corporate income tax rates rarely coincide with changes in state tax loss-offset rules.

Table 8, Panel B reports the results for the nexus-weighted changes in loss-offset rules. Conditioning on a firm's geographic footprint increases the impact of reductions in carryback

[24] For the latter, we estimate nexus-weighted changes in the number of tax loss carryback/carryforward periods using Eq. (1) (i.e., the formula used to estimate nexus-weighted changes in tax rates), after replacing tax rate changes with changes in loss carryback/carryforward periods.

[25] Wald tests reject the null that firms are equally sensitive to reductions in carryback periods and to increases in carryforward periods (p=0.003 in column 1 and p=0.027 in column 2).

periods on risk-taking. To illustrate, the coefficient on *nexus-weighted reduction in carryback period* in column 1 is 0.035 (p=0.001), compared to 0.023 (p=0.003) for home-state rule changes. Reductions in carryforward periods have no significant effect, nor do improvements in loss-offset rules (whether for carrybacks or carryforwards).

Overall, using changes in state tax loss-offset rules yields results that reinforce our conclusion from using tax-rate changes that increasing a firm's tax burden reduces its willingness to take risks.

5. Conclusions

We ask whether and how corporate income taxes affect firms' risk-taking. Based on theories of the effect of personal income taxes on individual risk-taking, we predict a negative effect of corporate income taxes on corporate risk-taking. Using a natural experiment in the form of 113 staggered changes in corporate income tax rates across U.S. states, we provide evidence that income tax increases causally reduce corporate risk-taking. In contrast, we find no evidence that firms increase risk-taking in response to corporate income tax cuts, perhaps because other stakeholders (such as creditors, unions, or trading partners) prevent firms from doing so via restrictive covenants or direct intervention.

In addition to using a difference-in-differences regression with a comprehensive set of firm-level and state-level control variables, we employ a battery of refinements to establish causality: including industry-year fixed effects to control for time-varying industry shocks, adding lead terms to confirm parallel trends, using neighboring states to control for local economic cycles, and controlling for other coincident state-level policy changes. Finally, when we allow for heterogeneous treatment effects, we find that the effect of tax increases on risk-taking is largely driven by firms located in states with few loss-offsetting opportunities, as predicted.

Our study contributes to the broad literature investigating how taxes affect corporate policies. Motivated by the theoretical framework of Modigliani and Miller (1958, 1963) and Miller and Modigliani (1961), most research in this literature examines how taxes affect corporate financial decisions. Several prior studies examine the effects of taxes on the level of corporate investment using aggregate data, with mixed results. Our research extends this line of research by examining the effects of taxes on individual firms' risk-taking decisions, and establishes a causal effect of taxes on corporate policies.

As in Heider and Ljungqvist (2015), an important caveat concerns the external validity of our findings. The state-level tax changes in our sample are generally small in magnitude, and it is possible that firms would respond differently if the tax shocks were larger. With this caveat in mind, we believe that the causal evidence documented in this study represents an important contribution to the tax literature.

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Appendix A. List of Changes in State Corporate Income Tax Rates.

Panel A. List of Tax Increases.

This table lists all U.S. state corporate income tax increases in calendar years 1989–2012 affecting firms in fiscal years 1990-2011. In states with more than one tax bracket, we report the change to the top bracket. Tax changes are identified from the Tax Foundation (an abbreviated version of which is available at http://www.taxfoundation.org), the *Book of the States*, a search of the "Current Corporate Income Tax Developments" feature published periodically in the *Journal of State Taxation*, and state tax codes accessed through Lexis-Nexis.

State	Year	Description	No. of affected sample firms
IL	1989	Increase in top corporate income tax rate from 4% to 4.8%	6
KY	1989	Increase in top corporate income tax rate from 7.25% to 8%	7
NJ	1989	Introduction of 0.375% tax surcharge	7
RI	1989	Increase in top corporate income tax rate from 8% to 9%	7
CT	1990	Introduction of 20% tax surcharge, increasing top marginal tax rate from 11.5% to 13.8%	64
MO	1990	Increase in top corporate income tax rate from 5% to 6.5%	34
MT	1990	Introduction of 5% tax surcharge on tax liability	2
NE	1990	Increase in top corporate income tax rate from 6.65% to 7.24%	5
OK	1990	Increase in top corporate income tax rate from 5% to 6%	27
AR	1991	Increase in top corporate income tax rate from 6% to 6.5%	14
ME	1991	Introduction of 10% tax surcharge on tax liability	3
NC	1991	Increase in top corporate income tax rate from 7% to 7.75% and introduction of 4% tax surcharge on tax liability	53
NE	1991	Increase in top corporate income tax rate from 7.24% to 7.81% and introduction of 15% tax surcharge on tax liability	9
PA	1991	Increase in top corporate income tax rate from 8.5% to 12.25%	132
RI	1991	Introduction of 11% tax surcharge on tax liability	12
DC	1992	Introduction of 2.5% surcharge on tax liability	4
KS	1992	Increase in top corporate income tax rate (including surcharge) from 6.75% to 7.35%	19
KY	1992	Increase in top corporate income tax rate from 8% to 8.25%	9
MT	1992	Re-introduction of tax surcharge on tax liability at 2.3% rate	1
MO	1993	Increase in top corporate income tax rate from 5% to 6.25% and reduction in federal income tax deductibility from 100% to 50%	43
MT	1993	Increase in tax surcharge on tax liability from 2.3% to 4.7%	1
DC	1994	Introduction of additional 2.5% surcharge on tax liability	1
VT	1997	Increase in top corporate income tax rate from 8.25% to 9.75%	7
NH	1999	Increase in top corporate income tax rate from 7% to 8%	13
AL	2001	Increase in top corporate income tax rate from 5% to 6.5%	20
NH	2001	Increase in top corporate income tax rate from 8% to 8.5%	13
KS	2002	Increase in tax surcharge on taxable income from 3.35% to 4.5%	23
TN	2002	Increase in top corporate income tax rate from 6% to 6.5%	44
AR	2003	Introduction of 3% tax surcharge on tax liability	15
CT	2003	Introduction of 20% tax surcharge on tax liability	77
IN	2003	Repeal of gross income tax (based on revenue rather than profits) and of supplemental income tax; effective adjusted gross income tax rate (on profits) increased from 7.75% to 8.5%	32
CT	2004	Increase in tax surcharge on tax liability to 25%	76
NJ	2006	Introduction of 4% tax surcharge on tax liability	116
MD	2008	Increase in top corporate income tax rate from 7% to 8.25%	40
CT	2009	Introduction of 10% tax surcharge on tax liability for companies with revenues > $100m	39
NC	2009	Introduction of 3% tax surcharge on tax liability	48
OR	2009	Increase in top corporate income tax rate from 6.6% to 7.9%	22
IL	2011	Increase in top corporate income tax rate from 4.8% to 7%	100
CT	2012	Unscheduled two-year extension of tax surcharge on tax liability and increase to 20%	1
MI	2012	Increase in top corporate income tax rate from 4.95% to 6%	6

Panel B. List of Tax Cuts.

This table lists all U.S. state corporate income tax cuts in calendar years 1989–2012 affecting firms in fiscal years 1990-2011. In states with more than one tax bracket, we report the change to the top bracket. Tax changes are identified from the Tax Foundation (an abbreviated version of which is available at http://www.taxfoundation.org), the *Book of the States*, a search of the "Current Corporate Income Tax Developments" feature published periodically in the *Journal of State Taxation*, and state tax codes accessed through Lexis-Nexis.

State	Year	Description	No. of affected sample firms
CO	1989	Reduction in top corporate income tax rate from 5.5% to 5.4%	68
WV	1989	Reduction in top corporate income tax rate from 9.6% to 9.45%	4
AZ	1990	Reduction in top corporate income tax rate from 10.5% to 9.3%	23
CO	1990	Reduction in top corporate income tax rate from 5.4% to 5.3%	74
WV	1990	Reduction in top corporate income tax rate from 9.45% to 9.3%	5
CO	1991	Reduction in top corporate income tax rate from 5.3% to 5.2%	85
MN	1991	Reduction in the legislated tax increase of 0.4%	117
MT	1991	Repeal of 5% tax surcharge	2
WV	1991	Reduction in top corporate income tax rate from 9.3% to 9.15%	6
CO	1992	Reduction in top corporate income tax rate from 5.2% to 5.1%	85
CT	1992	Reduction in tax surcharge from 20% to 10%	94
MO	1992	Reduction in top corporate income tax rate from 6.5% to 5%	41
NC	1992	Reduction in tax surcharge from 4% to 3%	65
WV	1992	Reduction in top corporate income tax rate from 9.15% to 9%	4
CO	1993	Reduction in top corporate income tax rate from 5.1% to 5.0%	81
CT	1993	Repeal of 10% tax surcharge	70
ME	1993	Repeal of 10% tax surcharge	3
NC	1993	Reduction in tax surcharge from 3% to 2%	51
NE	1993	Repeal of 15% tax surcharge	9
NH	1993	Reduction in top corporate income tax rate from 8% to 7.5%	9
AZ	1994	Reduction in top corporate income tax rate from 9.3% to 9%	31
MT	1994	Repeal of 4.7% tax surcharge	1
NC	1994	Reduction in tax surcharge from 2% to 1%	54
NH	1994	Reduction in top corporate income tax rate from 7.5% to 7%	17
NJ	1994	Repeal of 0.375% tax surcharge	154
PA	1994	Reduction in top corporate income tax rate from 12.25% to 11.99%	135
RI	1994	Repeal of 11% tax surcharge	9
CT	1995	Reduction in top corporate income tax rate from 11.5% to 11.25%	87
DC	1995	Reduction in top corporate income tax rate from 10% to 9.5% (+2 tax surcharges at 2.5% each)	6
NC	1995	Repeal of 1% tax surcharge	46
PA	1995	Reduction in top corporate income tax rate from 11.99% to 9.99%	144
CT	1996	Reduction in top corporate income tax rate from 11.25% to 10.75%	91
CA	1997	Reduction in top corporate income tax rate from 9.3% to 8.84%	554
CT	1997	Reduction in top corporate income tax rate from 10.75% to 10.5%	89
NC	1997	Reduction in top corporate income tax rate from 7.75% to 7.5%	65
AZ	1998	Reduction in top corporate income tax rate from 9% to 8%	44
CT	1998	Reduction in top corporate income tax rate from 10.5% to 9.5%	84
NC	1998	Reduction in top corporate income tax rate from 7.5% to 7.25%	59
CO	1999	Reduction in top corporate income tax rate from 5% to 4.75%	91
CT	1999	Reduction in top corporate income tax rate from 9.5% to 8.5%	77
NC	1999	Reduction in top corporate income tax rate from 7.25% to 7%	46
NY	1999	Reduction in top corporate income tax rate from 9% to 8.5%	265
OH	1999	Reduction in top corporate income tax rate from 8.9% to 8.5%	132
AZ	2000	Reduction in top corporate income tax rate from 8% to 7.968%	49
CO	2000	Reduction in top corporate income tax rate from 4.75% to 4.63%	80
CT	2000	Reduction in top corporate income tax rate from 8.5% to 7.5%	72
NC	2000	Reduction in top corporate income tax rate from 7% to 6.9%	61
NY	2000	Reduction in top corporate income tax rate from 8.5% to 8%	262

AZ	2001	Reduction in top corporate income tax rate from 7.968% to 6.968%	40
ID	2001	Reduction in top corporate income tax rate from 8% to 7.6%	7
NY	2001	Reduction in top corporate income tax rate from 8% to 7.5%	244
KS	2003	Reduction in tax surcharge from 4.5% to 3.35%	22
ND	2004	Reduction in top corporate income tax rate from 10.5% to 7%	1
AR	2005	Repeal of 3% tax surcharge	14
KY	2005	Reduction in top corporate income tax rate from 8.25% to 7%	18
OH	2005	Tax reform phasing out corp. income tax while phasing in gross receipts tax over period of 5 years	90
CT	2006	Reduction in tax surcharge from 25% to 20%	64
VT	2006	Reduction in top corporate income tax rate from 9.75% to 8.9%	2
NY	2007	Reduction in top corporate income tax rate from 7.5% to 7.1%	197
VT	2007	Reduction in top corporate income tax rate from 8.9% to 8.5%	2
WV	2007	Reduction in top corporate income tax rate from 9% to 8.75%	3
CT	2008	Repeal of 20% tax surcharge	63
KS	2008	Reduction in tax surcharge from 3.35% to 3.1%	12
KY	2008	Reduction in top corporate income tax rate from 7% to 6%	16
KS	2009	Reduction in tax surcharge from 3.1% to 3.05%	13
WV	2009	Reduction in top corporate income tax rate from 8.75% to 8.5%	3
MA	2010	Reduction in top corporate income tax rate from 9.5% to 8.75%	134
NJ	2010	Repeal of 4% tax surcharge	85
KS	2011	Reduction in tax surcharge from 3.05% to 3%	11
MA	2011	Reduction in top corporate income tax rate from 8.75% to 8.25%	123
NC	2011	Repeal of 3% tax surcharge	36
ND	2011	Reduction in top corporate income tax rate from 6.4% to 5.4%	1
OR	2011	Reduction in top corporate income tax rate from 7.9% to 7.6%	18

Appendix B. List of Changes in State Tax Loss Carryback/Carryforward Rules.

Panel A. List of Loss Carryback Period Increases.

This table lists all state-level increases in the number of tax loss carryback periods affecting firms in fiscal years 1990-2011. Tax loss carryback period changes are identified from the *Book of the States*.

State	Year	Description	No. of affected sample firms
DC	1991	Increase in loss carryback period from 0 to 3 years	7
ME	1991	Increase in loss carryback period from 0 to 3 years	3
MS	1992	Increase in loss carryback period from 0 to 1 year	7
MS	1993	Increase in loss carryback period from 1 to 2 years	7
VT	1993	Increase in loss carryback period from 0 to 3 years	4
MS	1994	Increase in loss carryback period from 2 to 3 years	6
AL	1995	Increase in loss carryback period from 0 to 3 years	21
VT	1998	Increase in loss carryback period from 0 to 2 years	8
NY	1999	Increase in loss carryback period from 0 to 2 years	282
AK	2002	Increase in loss carryback period from 0 to 2 years	2
LA	2002	Increase in loss carryback period from 2 to 3 years	23
OK	2002	Increase in loss carryback period from 0 to 2 years	23
NH	2005	Increase in loss carryback period from 0 to 3 years	12
KS	2008	Increase in loss carryback period from 0 to 2 years	12
KS	2011	Increase in loss carryback period from 0 to 3 years	13

Panel B. List of Loss Carryback Period Reductions.

This table lists all state-level reductions in the number of tax loss carryback periods affecting firms in fiscal years 1990-2011. Tax loss carryback period changes are identified from the *Book of the States*.

State	Year	Description	No. of affected sample firms
ME	1990	Removal of ability to carry back losses (reduction from 3 to 0)	4
NM	1991	Removal of ability to carry back losses (reduction from 3 to 0)	10
RI	1992	Removal of ability to carry back losses (reduction from 3 to 0)	10
VT	1992	Removal of ability to carry back losses (reduction from 3 to 0)	4
VT	1996	Removal of ability to carry back losses (reduction from 3 to 0)	7
AL	1997	Removal of ability to carry back losses (reduction from 3 to 0)	28
NY	1997	Removal of ability to carry back losses (reduction from 3 to 0)	293
OK	1997	Removal of ability to carry back losses (reduction from 3 to 0)	33
AK	1998	Reduction in loss carryback period from 3 to 2 years	2
DC	1998	Reduction in loss carryback period from 3 to 2 years	4
DE	1998	Reduction in loss carryback period from 3 to 2 years	11
GA	1998	Reduction in loss carryback period from 3 to 2 years	100
HI	1998	Reduction in loss carryback period from 3 to 2 years	5
IA	1998	Reduction in loss carryback period from 3 to 2 years	18
IL	1998	Reduction in loss carryback period from 3 to 2 years	153
IN	1998	Reduction in loss carryback period from 3 to 2 years	43
KY	1998	Reduction in loss carryback period from 3 to 2 years	18
MD	1998	Reduction in loss carryback period from 3 to 2 years	51
ME	1998	Reduction in loss carryback period from 3 to 2 years	7
MO	1998	Reduction in loss carryback period from 3 to 2 years	56
MS	1998	Reduction in loss carryback period from 3 to 2 years	11
ND	1998	Reduction in loss carryback period from 3 to 2 years	1
VA	1998	Reduction in loss carryback period from 3 to 2 years	79
WV	1998	Reduction in loss carryback period from 3 to 2 years	5
ID	1999	Reduction in loss carryback period from 3 to 2 years	9
DC	2000	Removal of ability to carry back losses (reduction from 2 to 0)	5
AK	2001	Removal of ability to carry back losses (reduction from 2 to 0)	1
LA	2001	Reduction in loss carryback period from 3 to 2 years	24
ME	2002	Removal of ability to carry back losses (reduction from 2 to 0)	2
ND	2003	Removal of ability to carry back losses (reduction from 2 to 0)	1
IL	2004	Removal of ability to carry back losses (reduction from 2 to 0)	118
KY	2006	Removal of ability to carry back losses (reduction from 2 to 0)	17
VT	2006	Removal of ability to carry back losses (reduction from 2 to 0)	2
NH	2008	Removal of ability to carry back losses (reduction from 3 to 0)	7
IA	2009	Removal of ability to carry back losses (reduction from 2 to 0)	12
KS	2009	Removal of ability to carry back losses (reduction from 2 to 0)	13

Panel C. List of Loss Carryforward Period Increases.

This table lists all state-level increases in the number of tax loss carryforward periods affecting firms in fiscal years 1990-2011. Tax loss carryforward period changes are identified from the *Book of the States*.

State	Year	Description	No. of affected sample firms
AL	1990	Increase in loss carryforward period from 5 to 15 years	11
ID	1990	Increase in loss carryforward period from 10 to 15 years	10
OH	1990	Increase in loss carryforward period from 5 to 15 years	120
TN	1991	Increase in loss carryforward period from 7 to 15 years	29
MS	1992	Increase in loss carryforward period from 5 to 15 years	7
UT	1993	Increase in loss carryforward period from 5 to 15 years	30
CA	1994	Increase in loss carryforward period from 5 to 15 years	458
PA	1995	Increase in loss carryforward period from 0 to 2 years	143
PA	1996	Increase in loss carryforward period from 2 to 3 years	145
NM	1997	Increase in loss carryforward period from 0 to 5 years	4
TX	1997	Increase in loss carryforward period from 0 to 5 years	316
AK	1998	Increase in loss carryforward period from 15 to 20 years	2
CA	1998	Increase in loss carryforward period from 4 to 5 years	583
CO	1998	Increase in loss carryforward period from 15 to 20 years	97
DE	1998	Increase in loss carryforward period from 15 to 20 years	11
FL	1998	Increase in loss carryforward period from 15 to 20 years	163
GA	1998	Increase in loss carryforward period from 15 to 20 years	100
HI	1998	Increase in loss carryforward period from 15 to 20 years	5
IA	1998	Increase in loss carryforward period from 15 to 20 years	18
IL	1998	Increase in loss carryforward period from 15 to 20 years	153
IN	1998	Increase in loss carryforward period from 15 to 20 years	43
KY	1998	Increase in loss carryforward period from 15 to 20 years	18
MD	1998	Increase in loss carryforward period from 15 to 20 years	51
ME	1998	Increase in loss carryforward period from 15 to 20 years	7
MO	1998	Increase in loss carryforward period from 15 to 20 years	56
MS	1998	Increase in loss carryforward period from 15 to 20 years	11
ND	1998	Increase in loss carryforward period from 15 to 20 years	1
NY	1998	Increase in loss carryforward period from 15 to 20 years	283
PA	1998	Increase in loss carryforward period from 3 to 10 years	140
VA	1998	Increase in loss carryforward period from 15 to 20 years	79
VT	1998	Increase in loss carryforward period from 15 to 20 years	8
WV	1998	Increase in loss carryforward period from 15 to 20 years	5
DC	1999	Increase in loss carryforward period from 15 to 20 years	7
ID	1999	Increase in loss carryforward period from 15 to 20 years	9
NC	1999	Increase in loss carryforward period from 5 to 15 years	56
SC	1999	Increase in loss carryforward period from 15 to 20 years	21
CA	2000	Increase in loss carryforward period from 5 to 10 years	574
CT	2000	Increase in loss carryforward period from 5 to 20 years	79
CA	2001	Increase in loss carryforward period from 10 to 20 years	528
LA	2001	Increase in loss carryforward period from 15 to 20 years	24
NH	2002	Increase in loss carryforward period from 5 to 10 years	13
OK	2002	Increase in loss carryforward period from 15 to 20 years	23
PA	2002	Increase in loss carryforward period from 10 to 20 years	136
OH	2003	Increase in loss carryforward period from 15 to 20 years	103
CA	2008	Increase in loss carryforward period from 10 to 20 years	454
MA	2010	Increase in loss carryforward period from 5 to 20 years	132
NJ	2011	Increase in loss carryforward period from 7 to 20 years	83

Panel D. List of Loss Carryforward Period Reductions.

This table lists all state-level reductions in the number of tax loss carryforward periods affecting firms in fiscal years 1990-2011. Tax loss carryforward period changes are identified from the *Book of the States*.

State	Year	Description	No. of affected sample firms
NM	1991	Reduction in loss carryforward period from 15 to 5 years	10
PA	1991	Removal of ability to carry forward losses (reduction from 3 to 0)	131
NM	1992	Removal of ability to carry forward losses (reduction from 5 to 0)	9
RI	1992	Reduction in loss carryforward period from 15 to 5 years	10
CA	1993	Reduction in loss carryforward period from 15 to 5 years	442
CA	1997	Reduction in loss carryforward period from 15 to 4 years	554
CA	2002	Reduction in loss carryforward period from 20 to 10 years	529
LA	2002	Reduction in loss carryforward period from 20 to 15 years	23
IL	2004	Reduction in loss carryforward period from 20 to 12 years	118
VT	2006	Reduction in loss carryforward period from 20 to 10 years	2

Appendix C. Coincident State-Level Changes.

Panel A. Coincident State-Level Changes for Tax Rate Changes.

This table reports state-level changes in economic quantities that coincide with either increases or cuts in state corporate income taxes and that have a plausible basis in theory to potentially affect corporate risk-taking decisions. We focus on changes in state taxes on banks and changes in state investment incentive programs (i.e., tax credits for investment, R&D, and job creation, as well as job creation grant programs). We also report state-level changes in the number of tax loss carryback/carryforward periods that coincide with state tax rate changes. For variable definitions and details of their construction, see Appendix D.

		Tax increases	Tax cuts
Number of tax changes		40	73
… of which coincide with	increase in state carryback periods	1	3
	cut in state carryback periods	0	2
	increase in state carryforward periods	0	4
	cut in state carryforward periods	1	2
	increase in state tax on banks	28	0
	cut in state tax on banks	0	56
	increase in state investment tax credit rate	1	6
	cut in state investment tax credit rate	0	0
	increase in state R&D credit rate	2	9
	cut in state R&D credit rate	1	2
	increase in state job creation credit	0	3
	cut in state job creation credit	0	1
	increase in state job creation grants	0	1
	cut in state job creation grants	0	0

Panel B. Coincident State-Level Changes for Tax Loss Carryback Changes.

This table reports state-level changes in economic quantities that coincide with either increases or cuts in the number of periods a state allows a company to carry back losses and that have a plausible basis in theory to potentially affect corporate risk-taking decisions. We focus on changes in state taxes on banks and changes in state investment incentive programs (i.e., tax credits for investment, R&D, and job creation, as well as job creation grant programs). For variable definitions and details of their construction, see Appendix D.

		Increases in carrybacks	Cuts in carrybacks
Number of carryback changes		15	36
… of which coincide with	increase in state tax on banks	1	0
	cut in state tax on banks	0	0
	increase in state investment tax credit rate	2	1
	cut in state investment tax credit rate	0	0
	increase in state R&D credit rate	0	2
	cut in state R&D credit rate	0	0
	increase in state job creation credit	2	0
	cut in state job creation credit	0	0
	increase in state job creation grants	0	0
	cut in state job creation grants	0	0

Panel C. Coincident State-Level Changes for Tax Loss Carryforward Changes.

This table reports state-level changes in economic quantities that coincide with either increases or cuts in the number of periods a state allows a company to carry forward losses and that have a plausible basis in theory to potentially affect corporate risk-taking decisions. We focus on changes in state taxes on banks and changes in state investment incentive programs (i.e., tax credits for investment, R&D, and job creation, as well as job creation grant programs). For variable definitions and details of their construction, see Appendix D.

		Increases in carryforwards	Cuts in carryforwards
Number of carryforward changes		47	10
… of which coincide with	increase in state tax on banks	1	0
	cut in state tax on banks	3	1
	increase in state investment tax credit rate	3	1
	cut in state investment tax credit rate	0	0
	increase in state R&D credit rate	2	2
	cut in state R&D credit rate	0	0
	increase in state job creation credit	2	0
	cut in state job creation credit	1	0
	increase in state job creation grants	0	0
	cut in state job creation grants	0	0

Appendix D. Variable Definitions.

State-level variables (Table 1)

Democratic governor is an indicator set equal to one if the state is governed by a Democratic governor, and zero otherwise. Data come from the *Congressional Quarterly* (through 2008) and state election websites (after 2008).

State budget balance equals the difference between a state's *general revenues* and its *general expenditures* scaled by its *general expenditures*. The data come from the U.S. Census Bureau's State & Local Finances database, available at http://www.census.gov/govs/local.

State budget deficit equals *state budget balance* if the state runs a budget deficit, and zero otherwise.

State budget surplus equals *state budget balance* if the state runs a budget surplus, and zero otherwise.

State bond rating downgrade is an indicator set equal to one if the state's credit rating is downgraded by either Standard & Poor's or Moody's.

GSP growth rate is the real annual growth rate in gross state product (GSP) using data obtained from the U.S. Bureau of Economic Analysis.

State unemployment rate is the state unemployment rate, obtained from the U.S. Bureau of Labor Statistics.

State union penetration is the fraction of private-sector employees in a state who belong to a labor union in year *t*. The data come from Hirsch and Macpherson (2003) as updated on their website, http://www.unionstats.com.

Tax competition is measured as the difference between a state's corporate income tax rate and the highest corporate income tax rate levied by any of the neighboring states.

State tax on banks captures changes in the rate at which a state taxes financial institutions with nexus to the state. (Both a physical presence in the state and out-of-state lending to borrowers located in the state constitute nexus.) The data come from the *Book of the States* and state codes accessed through Lexis-Nexis.

State investment tax credit rate is the rate at which a firm can deduct capital expenditures directly from its state corporate income tax liability (in addition to the usual depreciation deductions against taxable income). Data through 2006 come from Chirinko and Wilson (2008). Data for subsequent years come from tax forms available on state Department of Revenue websites.

State R&D credit rate is the percentage of a firm's R&D expenditures that it can deduct directly from its state corporate income tax liability (in addition to the usual deduction against taxable income). Data through 2006 come from Wilson (2009). Data for subsequent years come from tax forms available on state Department of Revenue websites.

State job creation credit is set equal to one if the state offers a tax credit in return for hiring new workers meeting certain requirements, and zero otherwise. The data come from Appendix A1 in Neumark and Grijalva (2013).

State job creation grants is set equal to one if the state offers grant payments in return for hiring new workers meeting certain requirements, and zero otherwise. The data come from Appendix A1 in Neumark and Grijalva (2013).

Firm-level dependent variables (Tables 2-8)

ROA volatility is defined as the standard deviation of the difference between quarterly *ROA* and *ROA* for the same quarter of the previous year, computed over a three-year period *t* to *t*+2 (requiring a minimum of four quarters of data). *ROA* (return on assets) is defined as operating income after depreciation (Compustat item *oiadpq*) over the book value

of assets (Compustat item *atq*). We annualize *ROA volatility* by multiplying it by $\sqrt{4}$.

ROIC volatility is defined as the standard deviation of the difference between quarterly *ROIC* and *ROIC* for the same quarter of the previous year, computed over a three-year period *t* to *t*+2 (requiring a minimum of four quarters of data). *ROIC* (return on invested capital) is defined as operating income after depreciation (Compustat item *oiadpq*) over the sum of debt (Compustat items *dlttq* + *dlcq*), minority interests (Compustat item *mibtq*), preferred stock (*pstkq*) and common stock (*ceqq*). We annualize *ROIC volatility* by multiplying it by $\sqrt{4}$.

Equity volatility is defined as the standard deviation of monthly returns over the 12-month period ending at the fiscal year end (measured using data from CRSP). We annualize equity volatility by multiplying it by $\sqrt{12}$.

Deleveraged equity volatility is defined as equity volatility times the ratio of market capitalization (Compustat items *prcc_f* × *csho*) to the sum of market capitalization and the book value of debt (Compustat items *dlttq* + *dlcq*).

Independent variables: State-level characteristics (Tables 2-8)

State unemployment rate is the state unemployment rate, obtained from the U.S. Bureau of Labor Statistics.

GSP growth rate is the real annual growth rate in gross state product (GSP) using data obtained from the U.S. Bureau of Economic Analysis.

Independent variables: Firm-level characteristics (Tables 2-8)

Firm age is defined as the Compustat age.

Firm size is defined as the book value of total assets (Compustat item *at*) in year 2009 real dollars (deflated using the GDP deflator available at http://www.bea.gov/national/xls/gdplev.xls).

Market/book is defined as the ratio of the market value of equity (Compustat items *prcc_f* × *csho*) to the book value of equity (Compustat item *ceq*).

Book leverage is defined as long-term debt (Compustat item *dltt*) over the book value of assets (Compustat item *at*).

Cash surplus is defined as cash from assets-in-place (Compustat items *oancf – dpc + xrd*) over the book value of assets (Compustat item *at*).

Loss carryforward is an indicator set equal to one if the firm has positive net operating loss carryforward (Compustat item *tlcf*), and zero otherwise.

Sales growth is defined as the log of current year sales over last year sales (Compustat item *sale*).

Stock return is defined as cumulated monthly returns over the 12-month period ending at the fiscal year end (measured using data from CRSP).

Table 1. Determinants of State Corporate Income Tax Changes.

This table models the determinants of the magnitude of changes in state corporate income rates (measured in percentage points) and in the number of state tax loss carryback/carryforward periods (measured in number of years). All specifications are estimated using ordinary least squares with state and year fixed effects (not shown for brevity). The sample covers 50 U.S. states plus DC in 1990–2011, for a total of 1,122 observations. Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

	Magnitude of …					
	Tax increase (1)	Tax cut (2)	Cut in carrybacks (3)	Increase in carrybacks (4)	Cut in carryforwards (5)	Increase in carryforwards (6)
Political conditions						
=1 if Democratic governor in year *t*-1	0.022	0.028**	-0.005	-0.011	-0.061	0.084
	0.018	*0.013*	*0.028*	*0.019*	*0.072*	*0.111*
=1 if 1 year to next gubernatorial election	0.024	-0.006	-0.067*	-0.001	-0.145*	-0.147
	0.016	*0.031*	*0.034*	*0.023*	*0.078*	*0.145*
=1 if 2 years to next gubernatorial election	0.014	0.015	-0.049**	0.000	-0.105	0.105
	0.017	*0.033*	*0.024*	*0.017*	*0.065*	*0.132*
=1 if 3 years to next gubernatorial election	0.040**	-0.006	0.006	0.055**	-0.064	-0.077
	0.019	*0.028*	*0.028*	*0.023*	*0.054*	*0.184*
Economic conditions (in year *t*-1)						
State budget deficit	-1.127**		-0.093		-2.402	
	0.448		*0.407*		*1.608*	
State budget surplus		-0.018		-0.138		1.297
		0.094		*0.233*		*0.879*
=1 if state bond rating downgraded	0.020	0.049**	0.004	-0.015	-0.331	-0.456***
	0.040	*0.021*	*0.039*	*0.017*	*0.266*	*0.176*
GSP growth rate	0.176	-0.109	0.985**	0.641*	1.520	-2.392
	0.252	*0.288*	*0.494*	*0.379*	*1.398*	*2.027*
State unemployment rate	-0.788	-0.846	-0.518	-0.021	-0.876	3.332
	0.643	*0.557*	*0.910*	*0.829*	*2.356*	*5.389*
State union penetration	-0.464	0.361	0.881	-0.422	0.402	1.524
	0.696	*0.462*	*1.000*	*0.810*	*2.062*	*4.413*
Tax competition (in year *t*-1)						
State's tax rate relative to highest tax rate among its neighboring states	-0.026**	-0.033***	0.010	0.003	0.032	0.057
	0.011	*0.010*	*0.010*	*0.004*	*0.030*	*0.055*
Adjusted R^2	5.6%	7.5%	3.5%	0.7%	5.0%	6.5%

Table 2. Firm-Level Summary Statistics.

The sample consists of 64,447 firm-years for all non-financial and non-utility U.S. companies that are traded on the NYSE, Amex, or Nasdaq in fiscal years 1990 through 2011, as per the merged CRSP-Compustat Fundamentals Annual database. The table reports summary statistics for our dependent variables and the controls. For variable definitions and details of their construction, see Appendix D. All variables are winsorized 1% in each tail.

			percentile		
	mean	s.d.	25th	50th	75th
Firm risk					
ROA volatility (in %)	6.804	10.971	2.255	3.754	7.180
ROIC volatility (in %)	10.582	17.196	3.145	5.258	10.195
Equity volatility (in %)	52.525	33.208	30.473	44.054	64.441
Deleveraged equity volatility (in %)	40.641	29.601	20.928	32.683	51.156
State characteristics					
GSP growth rate (in %)	2.693	2.628	1.100	2.700	4.200
state unemployment rate (in %)	5.928	1.870	4.642	5.450	6.867
Firm characteristics					
firm age	19.6	13.3	9.0	15.0	27.0
firm size (total assets, $m)	1755.2	4899.7	52.6	219.2	969.3
market/book	3.022	4.707	1.146	1.901	3.258
book leverage	0.162	0.179	0.002	0.111	0.267
cash surplus	0.035	0.199	-0.012	0.050	0.115
loss carryforward	0.363	0.481	0.000	0.000	1.000
sales growth	0.052	0.339	-0.057	0.050	0.166
stock return	0.166	0.744	-0.251	0.040	0.375

Table 3. Effect of Tax Changes on Firm Risk.

We estimate OLS regressions to test whether, and by how much, firms change their risk profile in response to changes in state corporate income taxes. The dependent variable *change in log ROA* (or *ROIC*) *volatility* is defined as the difference between log *ROA* (or *ROIC*) *volatility* at *t* (i.e., computed over *t* to *t*+2) and log *ROA* (or *ROIC*) *volatility* at *t*–3 (i.e., computed over *t*–3 to *t*–1). For variable definitions and details of their construction, see Appendix D. In columns 1 and 2, we use contemporaneous changes in the firm's home-state top marginal corporate income tax rate. In columns 3 and 4, we use lagged changes in the firm's home-state top marginal corporate income tax rate. Columns 5 and 6 use the contemporaneous nexus-weighted change in tax rates as defined in Eq. (1). The unit of analysis in each column is a firm-year. All specifications are estimated using OLS in first differences to remove firm fixed effects in the levels equations and include industry-year fixed effects to remove industry shocks. The fixed effects are not reported for brevity. Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively. Reflecting the signed nature of the predictions, the test for equal tax sensitivity (tax increase = tax cut) is one-sided.

	Change in log …					
	ROA volatility (1)	ROIC volatility (2)	ROA volatility (3)	ROIC volatility (4)	ROA volatility (5)	ROIC volatility (6)
magnitude of tax increase	-0.019***	-0.020***				
	0.007	*0.007*				
magnitude of tax cut	-0.016	-0.018				
	0.016	*0.015*				
lagged tax increase			-0.026***	-0.019**		
			0.007	*0.009*		
lagged tax cut			0.000	0.000		
			0.015	*0.017*		
nexus-weighted tax increase					-0.024**	-0.032***
					0.009	*0.011*
nexus-weighted tax cut					-0.014	-0.017
					0.024	*0.028*
Change in …						
GSP growth rate	-0.003**	-0.003*	-0.003**	-0.003*	-0.003**	-0.003*
	0.001	*0.001*	*0.001*	*0.002*	*0.001*	*0.001*
state unemployment rate	0.009**	0.010*	0.009*	0.009*	0.009**	0.009*
	0.005	*0.006*	*0.005*	*0.005*	*0.005*	*0.006*
Lagged change in …						
log firm age	-0.526***	-0.556***	-0.526***	-0.553***	-0.527***	-0.556***
	0.040	*0.041*	*0.040*	*0.040*	*0.039*	*0.041*
log firm size	-0.242***	-0.325***	-0.242***	-0.325***	-0.242***	-0.325***
	0.018	*0.027*	*0.017*	*0.027*	*0.018*	*0.027*
log market/book	0.123***	0.164***	0.121***	0.163***	0.123***	0.164***
	0.007	*0.007*	*0.007*	*0.008*	*0.007*	*0.007*
book leverage	-0.300***	-0.389***	-0.301***	-0.392***	-0.300***	-0.389***
	0.032	*0.035*	*0.034*	*0.037*	*0.032*	*0.035*
cash surplus	-0.250***	-0.253***	-0.248***	-0.247***	-0.249***	-0.253***
	0.021	*0.021*	*0.020*	*0.020*	*0.021*	*0.021*
loss carryforward	0.018*	0.030***	0.017*	0.029***	0.018*	0.030***
	0.010	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*
sales growth	0.042***	0.052***	0.042***	0.052***	0.042***	0.052***
	0.005	*0.005*	*0.005*	*0.005*	*0.005*	*0.005*
stock return	-0.047***	-0.055***	-0.046***	-0.054***	-0.047***	-0.055***
	0.002	*0.003*	*0.003*	*0.003*	*0.002*	*0.003*
Adjusted R^2	10.3%	10.0%	10.4%	10.1%	10.4%	10.0%
Equal tax sensitivity? (*F*)	0.03	0.02	2.03*	0.74	0.17	0.25
No. of firms	8,046	7,999	8,041	7,994	8,046	7,999
No. of observations	64,447	64,221	64,435	64,200	64,447	64,221

Table 4. Testing for Pre-Trends, Delays, and Post-Event Reversals.

To investigate possible pre-trends, delays, and reversals, we include lead and lag terms in the baseline regressions shown in Table 3, columns 1 and 2. Recall that the change in *ROA volatility* or *ROIC volatility* compares earnings volatility in the period t to t+2 to earnings volatility in the period t–3 to t–1. Accordingly, we use leads dated t+3 and lags dated t–3 to avoid inducing a mechanical correlation between the dependent variable and the lead or lag term. For variable definitions and details of their construction, see Appendix D. The unit of analysis is a firm-year. All specifications are estimated using OLS in first differences to remove firm fixed effects in the levels equations and include industry-year fixed effects to remove industry shocks. The full set of controls (as in Table 3) and fixed effects are included but not reported for brevity. Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

	Change in log …	
	ROA volatility (1)	ROIC volatility (2)
magnitude of tax increase at t = +3	-0.001	-0.005
	0.025	*0.028*
magnitude of tax increase at t = 0	-0.019**	-0.017**
	0.009	*0.008*
magnitude of tax increase at t = –3	-0.016*	-0.014
	0.008	*0.008*
magnitude of tax cut at t = +3	0.007	-0.007
	0.011	*0.013*
magnitude of tax cut at t = 0	-0.018	-0.018
	0.014	*0.014*
magnitude of tax cut at t = –3	0.001	0.002
	0.014	*0.018*
Adjusted R^2	10.9%	10.0%
No. of firms	6,183	6,171
No. of observations	47,966	47,879

Table 5. Potential Confounds: Local Business Cycle Effects and Other Tax Changes.

States may change corporate tax rates, and firms may change their risk profile, in response to unobserved changes in local business conditions. To examine this potential confound, we restrict the set of control firms to those located in a neighboring state, thus excluding far-away states (i.e., firms in states that neither experience a tax change nor border a state that does are excluded). This reduces the sample compared to the baseline models shown in Table 3. To address concerns stemming from the fact that corporate tax changes occasionally coincide with changes in state taxes on bank profits or in investment incentive programs (i.e., tax credits for investment, R&D, and job creation), columns 3 and 4 control explicitly for these concurrent changes. The unit of analysis in each specification is a firm-year. All specifications are estimated using OLS in first differences with industry-year fixed effects. The full set of controls (as in Table 3) and fixed effects are included but not reported for brevity. For variable definitions and details of their construction, see Appendix D. Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively. Reflecting the signed nature of the predictions, the test for equal tax sensitivity (tax increase = tax cut) is one-sided.

	Change in log …			
	ROA volatility (1)	ROIC volatility (2)	ROA volatility (3)	ROIC volatility (4)
magnitude of tax increase	-0.021***	-0.022***	-0.021**	-0.026**
	0.006	*0.007*	*0.010*	*0.011*
magnitude of tax cut	-0.012	-0.011	0.008	0.011
	0.016	*0.015*	*0.013*	*0.015*
Other coincident tax changes				
increase in state tax on banks			0.003	0.015
			0.019	*0.021*
cut in state tax on banks			-0.049**	-0.055***
			0.019	*0.017*
increase in state investment tax credits			-0.003	-0.004
			0.005	*0.005*
cut in state investment tax credits			-0.003	0.001
			0.005	*0.005*
increase in state R&D tax credits			0.001	0.001
			0.003	*0.003*
cut in state R&D tax credits			0.006	0.009***
			0.005	*0.003*
increase in state job tax credits			0.010	0.012
			0.023	*0.024*
cut in state job tax credits			-0.023	-0.060
			0.036	*0.037*
Adjusted R^2	8.6%	8.2%	8.6%	8.1%
Equal tax sensitivity? (F)	0.29	0.42	5.42**	3.34**
No. of firms	6,583	6,544	6,583	6,544
No. of observations	29,613	29,498	29,613	29,498

Table 6. Effect of Tax Changes on Equity Volatility.

We estimate OLS regressions to test whether, and by how much, firms change their equity volatility in response to changes in state corporate income taxes in their headquarter state. Column 1 models equity volatility, and column 2 models deleveraged equity volatility. For variable definitions and details of their construction, see Appendix D. The unit of analysis in each column is a firm-year. All specifications are estimated using OLS in first differences to remove firm fixed effects in the levels equations and include industry-year fixed effects to remove industry shocks. The fixed effects are not reported for brevity. Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively. Reflecting the signed nature of the predictions, the test for equal tax sensitivity (tax increase = tax cut) is one-sided.

	Change in log …	
	equity volatility (1)	deleveraged equity volatility (2)
magnitude of tax increase	-0.023***	-0.020**
	0.005	*0.006*
magnitude of tax cut	-0.002	0.003
	0.005	*0.006*
Change in …		
GSP growth rate	-0.003**	-0.002
	0.001	*0.001*
state unemployment rate	0.022***	0.025***
	0.005	*0.005*
Lagged change in …		
log firm age	-0.032*	-0.137***
	0.018	*0.020*
log firm size	-0.118***	-0.175***
	0.007	*0.010*
log market/book	-0.084***	-0.113***
	0.006	*0.008*
book leverage	0.167***	0.183***
	0.026	*0.028*
cash surplus	-0.114***	-0.062***
	0.016	*0.015*
loss carryforward	0.011*	0.015*
	0.006	*0.007*
sales growth	0.006	0.010**
	0.004	*0.005*
stock return	-0.024***	-0.011***
	0.004	*0.003*
Adjusted R^2	14.4%	11.3%
Equal tax sensitivity? (F)	8.57***	6.74***
No. of firms	7,867	7,865
No. of observations	63,017	62,992

Table 7. Heterogeneous Treatment Effects.

Tax loss carryback and carryforward rules dampen the impact of corporate income tax rate changes on firm risk. To test this, we partition sample firms based on the tax loss carryback and carryforward rules of their headquarter state. Columns 1 and 3 include firms headquartered in a state that (1) does not allow losses to be carried back and (2) does not permit losses to be carried forward for more than 10 years. Columns 2 and 4 include only the remaining sample firms. For variable definitions and details of their construction, see Appendix D. The unit of analysis is a firm-year. All specifications are estimated using OLS in first differences with industry-year fixed effects (not shown for brevity). Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively. Reflecting the signed nature of the predictions, the test for equal tax sensitivity is one-sided.

	Change in log …			
	ROA volatility		ROIC volatility	
	Low loss offset ability (1)	High loss offset ability (2)	Low loss offset ability (3)	High loss offset ability (4)
magnitude of tax increase	-0.026**	-0.010	-0.033***	-0.004
	0.009	*0.012*	*0.011*	*0.016*
magnitude of tax cut	-0.009	-0.012	-0.017	-0.014
	0.022	*0.017*	*0.019*	*0.019*
Change in …				
GSP growth rate	-0.003*	-0.003*	-0.002	-0.003
	0.002	*0.002*	*0.002*	*0.002*
state unemployment rate	0.006	0.014**	0.012	0.012*
	0.008	*0.006*	*0.010*	*0.007*
Lagged change in …				
log firm age	-0.563***	-0.528***	-0.635***	-0.522***
	0.070	*0.061*	*0.072*	*0.066*
log firm size	-0.240***	-0.251***	-0.314***	-0.341***
	0.027	*0.024*	*0.049*	*0.026*
log market/book	0.126***	0.120***	0.165***	0.163***
	0.010	*0.008*	*0.011*	*0.009*
book leverage	-0.273***	-0.291***	-0.369***	-0.379***
	0.054	*0.049*	*0.051*	*0.051*
cash surplus	-0.268***	-0.233***	-0.270***	-0.242***
	0.037	*0.021*	*0.039*	*0.022*
loss carryforward	0.001	0.031*	0.017	0.037**
	0.016	*0.016*	*0.015*	*0.016*
sales growth	0.042***	0.040***	0.049***	0.051***
	0.007	*0.007*	*0.008*	*0.007*
stock return	-0.048***	-0.045***	-0.053***	-0.056***
	0.004	*0.003*	*0.007*	*0.004*
Adjusted R^2	9.2%	10.0%	7.8%	9.7%
Equal tax sensitivity? (F)				
1 vs. 2 or 3 vs. 4 (for tax increase)	1.18		2.10*	
No. of firms	4,221	5,757	4,203	5,716
No. of observations	26,005	38,442	25,914	38,297

Table 8. Effect of Changes in Loss Carryback/Carryforward Rules on Firm Risk.

We estimate OLS regressions to test whether, and by how much, firms change their risk profile in response to changes in state tax loss carryback/carryforward rules. Panel A focuses on the change in the number of years a loss can be carried back or forward in a firm's headquarter state. Panel B focuses on the nexus-weighted change in the number of years a loss can be carried back or forward in the states a firm has nexus with. For variable definitions and details of their construction, see Appendix D. The unit of analysis is a firm-year. All specifications are estimated using OLS in first differences to remove firm fixed effects in the levels equations and include industry-year fixed effects to remove industry shocks. The full set of controls (as in Table 3) and fixed effects are not reported for brevity. Heteroskedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively. Reflecting the signed nature of the predictions, the test for equal tax sensitivity is one-sided.

Panel A. Home-State Rule Changes.

	Change in log …			
	ROA volatility (1)	ROIC volatility (2)	ROA volatility (3)	ROIC volatility (4)
increase in carryback period	0.016	0.022	0.016	0.022
	0.014	*0.016*	*0.014*	*0.016*
reduction in carryback period	0.023***	0.019**	0.023***	0.019**
	0.007	*0.008*	*0.007*	*0.008*
increase in carryforward period	0.002**	0.003***	0.002**	0.003***
	0.001	*0.001*	*0.001*	*0.001*
reduction in carryforward period	-0.001	-0.001	-0.001	-0.001
	0.001	*0.001*	*0.001*	*0.001*
magnitude of tax increase			-0.019***	-0.020***
			0.007	*0.007*
magnitude of tax cut			-0.014	-0.015
			0.016	*0.016*
Adjusted R^2	10.4%	10.0%	10.4%	10.0%
Equal tax sensitivity? (F)				
increase in carryback = reduction in carryback	0.24	0.03	0.23	0.04
increase in carryforward = reduction in carryforward	4.95**	5.49**	4.03**	4.66**
reduction in carryback = increase in carryforward	8.02***	3.89**	8.21***	3.93**
No. of firms	8,046	7,999	8,046	7,999
No. of observations	64,447	64,211	64,447	64,211

Panel B. Nexus-Weighted Rule Changes.

	Change in log …			
	ROA volatility (1)	ROIC volatility (2)	ROA volatility (3)	ROIC volatility (4)
nexus-weighted increase in carryback period	0.025	0.038	0.025	0.038
	0.024	*0.028*	*0.024*	*0.028*
nexus-weighted reduction in carryback period	0.035***	0.028***	0.035***	0.028***
	0.010	*0.010*	*0.010*	*0.010*
nexus-weighted increase in carryforward period	0.002	0.003**	0.002	0.003*
	0.002	*0.001*	*0.002*	*0.001*
nexus-weighted reduction in carryforward period	0.000	0.000	0.000	0.000
	0.002	*0.002*	*0.002*	*0.002*
nexus-weighted tax increase			-0.024**	-0.031***
			0.009	*0.011*
nexus-weighted tax cut			-0.012	-0.015
			0.024	*0.028*
Adjusted R^2	10.4%	10.0%	10.4%	10.0%
Equal tax sensitivity? (F)				
increase in carryback = reduction in carryback	0.22	0.13	0.21	0.15
increase in carryforward = reduction in carryforward	0.52	0.84	0.47	0.76
reduction in carryback = increase in carryforward	10.56***	5.70**	10.65***	5.70**
No. of firms	8,046	7,999	8,046	7,999
No. of observations	64,447	64,211	64,447	64,211