Taxes, Pledgeable Income and Innovation *

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Abstract

We hypothesize that corporate income taxes distort firms' incentives to innovate by reducing their pledgeable income. Using a differences-in-differences methodology, we empirically document that large state income tax increases (decreases) stifle (stimulate) corporate innovation over the 1988-2006 period. Exploring the mechanisms, we show that tax changes have a stronger impact on innovation for firms with lower pledgeable income: firms with weaker governance, more financially-constrained firms, firms with fewer tangible assets, with a smaller patent stock, and firms that avoid taxes more. We further alleviate endogeneity concerns by conducting numerous additional tests, such as showing that most of the impact of tax changes on innovation occurs two or more years after the change, and that tax changes have the opposite effect on firms operating in neighboring states.

JEL Classification: G31, G32, G34, G38

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1. Introduction

Current academic research has extensively debated the role of taxes in promoting economic growth (e.g. Romer and Romer (2010), Barro and Redlick (2011), Ramey (2011)). The existing evidence is conflicting and several unresolved issues still remain. First, most of the prior research has looked at short-term economic growth. Less is known about how taxes affect long-term economic growth. Second, there is little evidence on the specific channels through which taxes affect growth. Third, it is often difficult to control for simultaneity and omitted variables biases in a macroeconomic setting. As a result, it is hard to convincingly argue for a causal relationship between taxes and economic growth.

In this paper, we address the gaps in the previous literature by examining the impact of taxes on innovation. Seminal work by Solow (1957) and Romer (1990) has demonstrated that innovation is the most important driver of long-term economic growth. By looking at innovation, we can trace a possible channel through which taxes influence economic growth. We theoretically argue and empirically document that corporate income taxes significantly affect innovation by changing firms' pledgeable income and distorting their incentives to innovate. More importantly, we provide theoretical motivation and empirical evidence for several mechanisms through which that relationship occurs.

To overcome identification challenges, we use staggered changes in state corporate income tax rates that are largely exogenous to the decisions of the individual firm to innovate. We eliminate the impact of time-varying economy-wide shocks (such as changes in monetary policy, federal regulation and fiscal policy) by comparing the change in innovation in a treatment group of firms that experienced a tax change to a control group of firms that did not, over the same time period. We also eliminate omitted variable biases that could result from cross-country studies due to large differences in unobservable country-specific characteristics. State tax changes are staggered over time, which can put the same firm both in the treatment and control groups over our time period, allowing us to control for unobservable firm characteristics.

There are two opposing theoretical views about the relationship between corporate income taxes and innovation. The first view contends that taxes distort the incentives of firms to innovate. In the next section, we develop a simple model that takes a novel approach by viewing the impact of taxes on firm behavior in the presence of agency problems. We use Tirole's (2006) notion of firms' pledgeable income to demonstrate that in the presence of private benefits of control and differential effort, higher taxes make it more lucrative for managers and other employees to shirk by enjoying the quiet life or undertaking routine projects rather than working hard and innovating[1]. Consequently, profitable projects that would be undertaken when taxes are low, will not be undertaken when taxes are high because they are not incentive compatible.

Tirole (2006) contends that pledgeable income depends on firms' after-tax profits as well as on the size of the private benefits of control and the assets at hand such as cash, and other tangible and intangible assets that can be used in the innovative project. We derive several predictions from the model that allow us to trace some of the mechanisms, through which taxes affect innovation. We show that the negative impact of taxes is greater for firms with weaker governance, for financially constrained firms, and for firms with fewer tangible assets and a smaller patent stock.

In addition to reducing pledgeable income, there are at least two other reasons why corporate income taxes can stifle innovation. First, innovative firms often save their after-tax profits and use the internal cash as a cushion during difficult times. Internal cash, combined with imperfect external capital markets, allows greater flexibility and tolerance to experimentation which, according to Manso (2011), is key to motivating innovation. Since innovation is a highly uncertain process, firms with more cash savings will be better suited to weather unfavorable outcomes and continue to innovate. Second, innovative firms also often prefer to use after-tax internal funds for innovative projects (Brown et al. (2009)) rather than tap external markets. Ceteris paribus, internal funds will be higher for firms with lower tax rates, therefore those firms will innovate more.

The alternative view argues that tax rates either do not matter or have a positive impact on innovation for the following reasons. First, any possible tax decrease may result in an increase in the state budget deficit, or in a decrease in state government spending on public goods such as research, education, and infrastructure. As a result, there would be fewer positive spillover effects on firms, which will in turn inhibit their innovative output. Second, changes in state taxes, even large ones, could have only a small effect on firms and not significantly change their innovation policies. Finally, assuming all expenditures and investments are tax deductible, perfect capital markets and no private benefits of control or asymmetric information, tax rates would not matter and any positive NPV project will be financed no matter how high tax rates are. If a project is profitable (has a positive NPV) on a pre-tax basis, it will be profitable on an after-tax basis, because both revenues and expenses are multiplied by the tax rate. The tax rate will only determine how the economic pie is divided, but will not affect its size.

[1] This result is similar to Desai, Dyck and Zingales (2007), who demonstrate that higher tax rates increase the amount of income insiders divert, which in our case is analogous to shirking or choosing the routine project rather than innovating.

The two views presented above generate opposing testable predictions that we explore in the empirical section. To ensure consistency and relevance, we examine the impact of taxes on innovation using significant changes of at least 1% (e.g., 8% to 7%) in the top-bracket state corporate income tax rate from 1988 to 2006. We use statutory rather than effective tax rates because the former are outside of the control of the individual firm while the latter are endogenous.[2] While prior studies typically use company headquarters to define states, in many cases a firm's corporate office is not where its major operations are located. Thus, to better identify the most relevant state to which the tax rate is applied, we use the most mentioned state in a firm's 10-K reports based on data from Garcia and Norli (2012). We follow the existing literature (e.g. Hall et al. (2001)) and use patents and citations per patent to measure the quantity and quality of innovation.

Our main results are striking. We find that tax increases significantly reduce, while tax decreases significantly increase the number of patents and the number of citations per patent. The effect on citations per patent is stronger, suggesting that the quality of innovation is affected even more by changes in state corporate income tax rates. The results are also economically significant, for both tax increases and decreases. A major increase in the tax rates leads to a 3.8% and 5.5% reduction in the number of patents, and a 10.3% and 9.6% reduction in the number of citations per patent 3 and 4 years after the tax increase, respectively, relative to an otherwise similar firm, operating in a state that does not experience a tax increase. A major decrease in the tax rates leads to a 10.1% and 13.4% increase in the number of patents, and a 14.9% and 13.4% increase in the number of citations per patent 3 and 4 years after the tax decrease, respectively.[3] Intuitively, these effects suggest that on average, firms create 0.2 and 0.3 fewer patents after experiencing a major tax increase, and 0.5 and 0.7 more patents after experiencing a major tax decrease, 3 and 4 years later, respectively.

A recent paper by Mukherjee, et al. (2016) also studies the impact of corporate income taxes on innovation.[4] Our paper is very different in several important dimensions. First, our motivation and underlying mechanisms that explain the relation between taxes and innovation are completely different. While their story is based on occupational choice and tax progressivity, we propose an agency model based on Tirole's (2006) notion of pledgeable income and demonstrate that private benefits of control and differential effort are essential for

[2]As we show in our empirical section, the statutory rates are strongly positively related to the actual state income taxes firms pay.

[3]The economic significance is comparable in magnitude to similar state level shocks such as state anti-takeover laws, state labor laws and banking deregulations.

[4]Our paper also chronologically precedes Mukherjee at al. (2016), as their first draft is dated November 2013 and ours is October 2013. Unlike their paper, our paper was also submitted (in October 2013) and accepted to the UNC Tax Conference shortly thereafter.

understanding the impact of taxes on the incentives to innovate. We also provide evidence on the new channels that drive the relation between taxes and innovation based on a unique set of predictions generated by our model. Second, our paper focuses mostly on patent citations, which is the more important measure of innovation, as most of the impact of innovation on firm value and economic growth comes from a small number of highly cited patents (Griliches (1990), Hall et al. (2001, 2005)).[5]

Third, the main results are also different and suggest different policy implications. The Congressional Budget Office (2017) reports that the U.S. has the highest top statutory corporate tax rate among the G20 nations[6], and the topic of lowering the tax rate has been hotly debated, especially in the context of spurring innovation and economic growth. Relevant to this debate, our paper suggests that lowering the tax rate stimulates corporate innovation.[7] In contrast, Mukherjee et al. (2016) suggest that government policies to cut corporate income taxes on the state level and, if we extrapolate, on the federal level will not matter. Mukherjee at al. (2016) find that tax increases have a negative impact on innovation measured by patents and tax decreases have *no impact*. The asymmetrical effect of taxes that they document is hard to motivate and cannot be derived from a theoretical model. We also explicitly test and find no support for their story. We believe that the problem is instead created by the way they define the tax variable and their methodology.[8] Fourth, their main results are only significant for the first one or two years, which is hard to explain since innovation is a long process and innovative output can take several years to materialize. All of these issues make it difficult to interpret their findings regarding the relation between corporate income taxes and innovation. At the very least, a systematic reexamination of this important research question, which we conduct in this paper, is much needed.

Having illuminated our understanding of whether taxes matter at all, our next step is to study the specific channels through which taxes affect innovation. Understanding the mechanisms is important for two reasons. First, it improves our understanding of how taxes work and provides better insight into future research and policy making. Second, it also reduces the concern that the relation between taxes and innovation is spurious and driven by other changes that may have occurred at the same time. Such a criticism will have the burden of explaining not only the main relation but also all the channels that we document.

To test the governance hypothesis derived from our model, we use the hostile takeover

[5]Mukherjee et al. (2016) focus on patent counts and only conduct one robustness check using patent citations, where the results are weak and only significant for the first one or two years.

[6]Congressional Budget Office, International Comparisons of Corporate Income Tax Rates, March 2017.

[7]Our paper is also consistent with Giroud and Rauh (2016) who find that both large state tax increases and decreases have a significant effect on the number of establishments and employees.

[8]The full details are provided in Section 4.1.

index developed by Cain, McKeon, and Solomon (2016), which is based on the passage of 13 different types of state takeover laws, one federal statue and three state standards of review. This governance measure is more comprehensive than other measures used in previous studies and has much better coverage than other governance indices such as the G-index. Unlike the G-index, it is also outside of the control of the individual firm and therefore fairly exogenous. Consistent with our prediction, we find that the effect of tax changes on innovation is larger for firms with weaker corporate governance. A one standard deviation increase in the anti-takeover index increases the negative effect of tax increases on the number of citations per patent by 40% and 42%, while it increases the positive effect of tax decreases on the number of citations per patent by 67% and 67%, 3 and 4 years into the future, respectively.

To test the financial constraints hypothesis, we use several measures of financial constraints based on Whited and Wu (2006), and for robustness, on Kaplan and Zingales (1997) and Hadlock and Pierce (2010). We find that the negative impact of tax increases on the number of citations per patent is 30% and 131% greater for firms that are more financially constrained, 3 and 4 years into the future, while the positive impact of tax decreases on the number of citations per patent is 138% and 192% greater 3 and 4 years later, respectively. We also find that smaller firms are impacted more by tax changes. This evidence is consistent with smaller firms benefiting more from larger after-tax profits because they tend to be more financially constrained and have greater informational asymmetries than larger firms. This finding also provides additional evidence that our results are not driven by the lobbying efforts of a small number of large firms.

Consistent with the assets at hand hypothesis, we also provide evidence that firms with fewer tangible assets are affected more by tax changes. Tangible assets are easier to liquidate and therefore firms with more tangible assets have higher pledgeable income. We also argue that while firms mainly use tangible assets as collateral, intangible assets such as the current patent stock can also be used as collateral (Hochberg, Serrano, and Ziedonis (2015)). Motivated by this idea, we further examine a firm's existing patent stock and find evidence that firms with a lower patent stock are more impacted by tax changes. Thus, we again confirm our main hypothesis that taxes affect firms' pledgeable income and therefore their incentives to innovate.

Another possible channel through which taxes may affect innovation is through distorting firm behavior and resource allocation by encouraging firms to engage in tax shifting activities. For example, for a given amount of resources, firms may find it more profitable to dedicate a larger proportion of resources to tax minimization activities instead of innovation. That may include financial resources or the time and effort of productive employees including the CEOs.

For example, top managers of Apple and Google have spent numerous hours responding to legislators about their tax practices instead of focusing on innovative strategies. Policymakers have vigorously debated the cause and effects of tax avoidance activities. Hearings in the US Congress and the UK Parliament on those activities have generated a firestorm.[9]

We examine the tax avoidance hypothesis using an indicator of tax avoidance based on industry and size adjusted cash effective tax rates suggested by Dyreng et al. (2008) and Balakrishnan et al. (2012). There are two opposing predictions. On the one hand, firms that avoid taxes would be less affected by tax changes because they can readily shift their tax burden. On the other hand, both tax avoidance and innovative activities require scarce resources such as managerial and employee creativity and effort. When the return on tax avoidance increases relative to the return on innovation, firms will shift more resources to tax avoidance. In contrast, if tax rates go down, firms are able to deploy resources that are previously used for tax avoidance back to innovative projects, consequently innovation will increase. The results support the second prediction. We find that the impact of tax changes on the number of citations per patent is greater for firms that engage more in tax avoidance. This finding is again consistent with our general hypothesis that higher tax rates distort firms' incentives to innovate.

In our main analysis, by employing tax changes that are largely outside of the control of the individual firm and a differences-in-differences methodology, we address many of the potential endogeneity concerns. We also control for numerous observable time variant factors such as firm size, leverage, profitability, physical assets, age, industry concentration, state real GDP, state unemployment rates, time fixed effects, and for unobservable time invariant characteristics such as corporate culture and risk-aversion, by using firm fixed effects. Furthermore, we pursue several strategies that further mitigate residual biases that could stem from reverse causality or omitted variables.

First, we conduct a dynamic analysis and demonstrate that most of the impact of tax changes on innovation occurs two or more years after the tax changes are implemented. Moreover, there is no relation between tax changes and innovation in the years prior to the tax change. This pattern alleviates reverse causality concerns that tax reductions are the result of a coordinated lobbying effort by firms who experienced a change in their innovative activity before the tax change. Second, we restrict tax changes to those that are unanticipated similarly to Ljungqvist and Smolyansky (2016). In a separate test, we also use a narrative approach to identify exogenous tax changes that are passed independently of local economic

[9] In another example, in 2014 President Obama shamed firms that decide to incorporate abroad for tax purposes after merging with foreign firms, by calling them "corporate deserters".

conditions and find similar results[10]. Third, we further control for state-specific time trends, industry-year fixed effects, and variables such as the political affiliation of the state governor and the state legislature, state capital gains tax rates, state personal income tax rates, and state R&D tax credits. Fourth, we address the possibility that industry concentration and growth in certain states are biasing our coefficient estimates (Lerner and Seru (2015)) by controlling for state-level labor share in different industries and state labor concentration, as well as excluding California or Massachusetts from our analysis.

Fifth, we conduct a falsification test based on Heider and Ljungqvist (2014). We find that tax changes have the opposite effect on firms in neighboring states that did not have the change compared to the firms in the states that did, which is inconsistent with region-specific economic conditions common to neighboring states driving both innovation and tax changes. Sixth, we perform an instrumental variable analysis using the triple-interaction between oil price shocks, the sensitivity of state revenues to oil shocks and the stringency of state balanced budget rules as an instrument. The findings of all the additional tests are similar in statistical and economic significance to the main results.

Finally, it is possible that tax changes are the product of broader economic and policy changes and most of the effects we capture are from those changes. We already mostly address this concern by including additional controls for the political affiliation of the governors and the legislatures, and for other accompanying measures such as capital gains taxes, personal income taxes, and R&D tax credits. Furthermore, given that we have a staggered adoption of tax changes in many states over a long period of time, it has to be the case that in most states the tax changes are always part of a broader change. Even if tax changes are part of broader reforms in every state we consider, they are usually one of the most important measures of such policy reforms (The Tax Foundation (2015)), working in ways similar to the other measures, to affect firms' after-tax profits and therefore, their incentives to innovate. In that case, our tax variables just proxy for the broader changes and the main implications and conclusions of the paper still remain.

In our main analysis, we use state count information from 10-K reports based on the notion that more frequently mentioned states tend to be more important for tax purposes. To test for its validity, we show that the amount of total state taxes paid is significantly related to tax changes in the most mentioned state, while it is unrelated to tax changes in the least mentioned state. Also, we find similar results using tax changes in the top three most mentioned states and alternative state definitions based on headquarters, patentee, and

[10]We use a methodology similar to Romer and Romer (2010), Giroud and Rauh (2016) and Mukherjee et al. (2016) to manually define the exogenous tax changes. We also verify our results with data provided by Mukherjee et al. (2016) and find similar results.

subsidiary locations. Together, these results provide strong support for our identification of the most relevant state and confirm the robustness of our main findings.

The paper contributes to several strands of literature. First, we build upon and complement the previous literature that has looked at the relation between taxes and firm investment and financing decisions (Cummins, Hassett, and Hubbard (1994), Hassett and Hubbard (2002), Djankov et al. (2010), Heider and Ljungqvist (2014) and Giroud and Rauh (2016)). Different from the extant research, we show that private benefits of control and differential effort are essential for understanding the impact of taxes on the incentives to innovate. We focus on innovative output rather than input and demonstrate that both corporate income tax increases and decreases have a significant impact on the quantity and quality of innovation. We also propose and document several mechanisms through which taxes affect innovation. Our results on which firms are disproportionally affected by tax changes can help policy makers tailor tax mandates to minimize their negative impact on corporate innovation. In addition, to the best of our knowledge, this is the first tax paper to use a novel measure, different from firm headquarters, to better identify the state relevant for corporate income tax purposes.

Second, our paper also contributes to the growing corporate governance literature, where one of the key research questions is how governance mechanisms impact corporate performance (e.g. Gompers, Ishii, and Metrick (2003)). Using corporate innovation as a measure of long-term performance, Atanassov (2013) finds that anti-takeover laws have a significant negative impact on innovative output. In this paper, we show that the negative impact of antitakeover laws on innovation is amplified by tax increases and mitigated by tax decreases. Our finding highlights an important interactive effect between state anti-takeover laws and state corporate income taxes that is relatively understudied. Additionally, the paper is complementary to Desai, Dyck and Zingales (2007), who analyze the interaction between tax rates, private benefits of control and corporate governance. They show that when corporate governance is weak, governments have a harder time raising tax revenues because insiders tend to divert more resources. In the U.S. context, our finding is similar, because we show that when states raise tax rates, firms innovate less, especially those with weaker governance. Consequently, since innovation is the biggest contributor to long-term economic growth, states will collect less tax revenues as long-term GDP decreases.

Third, the impact of financial constraints on firm behavior is a central question in both corporate finance (e.g., Kaplan and Zingales (1997), Whited (1992)) and asset pricing (e.g., Whited and Wu (2006)). Recently, Farre-Mensa and Ljungqvist (2016) question whether popular measures of financial constraints can identify firms that are truly constrained using a natural experiment based on increases in state corporate income taxes. Also using changes in state corporate income taxes, we find that financial constraints are detrimental to corporate innovation and tax decreases relieve, while tax increases exacerbate the effects of financial constraints, consistent with predictions from our model. We find consistent results measuring financial constraints using the Whited and Wu (2006) index, the Kaplan and Zingales (1997) index, and the Hadlock and Pierce (2010) index, providing some supportive evidence that these measures can identify constrained firms.

Finally, we also contribute to the tax avoidance literature (e.g., Dyreng, Hanlon, and Maydew (2008)) by documenting a novel finding that tax avoidance is harmful to corporate innovation, partly by shifting scarce resources such as managerial and employee creativity and effort away from innovative activities. This finding suggests that, while preserving the incentives to innovate might be one reason why high-tech firms shift their tax burden to states and countries with lower corporate income tax rates, the shift is inefficient and ultimately has a negative impact on innovation.

The rest of the paper is organized as follows. Section 2 presents a theoretical model and develops the main hypotheses. Section 3 describes the data and the empirical methodology. Section 4 presents the main empirical results. Section 5 investigates the channels through which taxes affect innovation. Section 6 provides additional endogeneity and robustness tests. Section 7 concludes.

2. Theoretical Model and Hypotheses Development

In this section, we present a simple model based on Tirole (2006) to explain how taxes affect the incentives of entrepreneurs to innovate rather than engage in routine or non-productive activities, and the incentives of financiers to provide financing based on whether entrepreneurs behave or misbehave. Here, we assume that "entrepreneur" is a general name for firm stakeholders such as managers and employees that take part in the innovative process, while "financier" is a name for shareholders or creditors that decide whether or not to finance the project.

We start by presenting the baseline model where entrepreneurs enjoy private benefits of control if they shirk, and there are no taxes. We then introduce taxes and show that they affect the incentives of entrepreneurs. We also show that the impact of tax changes is stronger for firms with greater private benefits of control or with weaker balance sheets (more financially constrained). The novelty of this model, compared to the previous literature that studies the effect of taxes on investment (Hall and Jorgenson (1967), Auerbach and Hassett (1992), Cummins, Hassett, and Hubbard (1994), Hines and Rice (1994), Hassett and Hubbard (2002), and Djankov et al. (2010)), is we show that private benefits of control and differential effort are essential for understanding the impact of taxes on the incentives to innovate.[11]

2.1. The Case of No Income Taxes

For continuity, we first present the baseline model without taxes. We assume that there is an entrepreneur that has a choice between an innovative risky project and a routine risk-free project. She provides initial resources in the form of cash, and other tangible (property, plant, equipment) and intangible (patents, trademarks, know-how, trade secrets) assets in the amount of A and the innovative project requires a total investment in the amount of I. Therefore, the entrepreneur needs an additional financing, which does not have to be only monetary, equal to I - A. This is a fixed-investment model, which assumes rapid decreasing returns after the project has reached its investment level I.[12]

We assume that there is a principal-agent problem between the firm's financiers and the entrepreneur (managers and creative employees in publicly traded firms). In this model, the problem is depicted by the size of the private benefits of control B. Larger values of B imply greater private benefits of control. They can take the form of perk consumption (Yermack (2006)), theft, or simply shirking and enjoying the quiet life (Bertrand and Mullainathan (2003)). In the case of innovation, perk consumption could involve not innovating at all, pursuing routine projects, or creating low impact patents. We assume that the size of private benefits is determined by the strength of corporate governance. Ceteris paribus, firms with stronger governance will have smaller private benefits of control B.

This is a two-period model. In the first period, the entrepreneur invests in the project if she is able to obtain the additional financing in the amount of $I - A$. In the second period, the return $R > 0$ is realized if the project is successful, and shared between the entrepreneur, in the amount of R_e, and the financiers in the amount of R_f where $R_e + R_f = R$. If the project is not successful, the return is equal to 0. For simplicity, the model assumes that the risk-free discount rate is equal to 0, and the return, the investment, the cash and the private benefits of the routine project are normalized to 0. More generally, all the variables (A, I, B,

[11]Because we follow very closely the base model presented in Tirole (2006), we do not go over all the details and justify all the assumptions. For more thorough explanations, the reader should consult the original text. Our contribution here is to extend Tirole's model by introducing taxes and showing that changes in the tax rates affect the likelihood of pursuing innovative projects, and that the likelihood depends on financial constraints.

[12]The results hold also in the variable investment model that assumes constant returns to scale. We assume fixed investment here to keep the model as simple as possible.

R, etc.) can be considered as the difference between the innovative project and the routine project. In the first period, the entrepreneur decides whether to behave (work hard, stay focused, be creative, not steal, etc.) or misbehave (shirk, enjoy the quiet life, pursue routine projects, steal, etc.). If she behaves, the probability of success is P_H and if she misbehaves, the probability of success is P_L, where $P_H > P_L$. To keep the analysis interesting, the model assumes that if the entrepreneur behaves, the project is profitable and if she misbehaves, the project is not profitable. That is $P_H R - I > 0$ and $P_L R - I + B < 0$. Therefore, financiers will not invest in the project if they expect that the entrepreneur will misbehave. The entrepreneur and financiers are risk neutral and the financial markets are competitive, and therefore the financiers make zero profit in equilibrium.

The incentive compatibility constraint (IC) for the entrepreneur is $P_H R_e \geq P_L R_e + B$. Rearranging, we get $R_e \geq \frac{B}{\Delta P}$, where $\Delta P = P_H - P_L$. This inequality tells us that the financiers need to leave at least $\frac{B}{\Delta P}$ to the entrepreneur to incentivize her to behave. The participation constraint for the financiers is $P_H R_f = I - A$. The participation constraint is satisfied with an equality due to the competitive nature of the financial markets. It follows that the return to the financiers is $R_f = \frac{I-A}{P_H}$. Since $R_e + R_f = R$, we can substitute in the IC constraint and obtain: $R - \frac{I-A}{P_H} \geq \frac{B}{\Delta P}$. Transforming further, we get $P_H(R - \frac{B}{\Delta P}) \geq I - A$. This inequality says that the expected pledgeable income has to be greater than the investment by the financiers for the entrepreneur to have an incentive to behave and pursue the innovative project and therefore to receive that additional financing to complete the project. Rearranging, we get that if $A \geq \bar{A} = \frac{P_H B}{\Delta P} - (P_H R - I)$, the entrepreneur will behave, receive the additional financing, and complete the innovative project. Therefore, $\bar{A}$ is the minimum net worth (initial resources) that the entrepreneur needs to have to obtain the additional financing.

2.2. The Case of Income Taxes

Now we introduce income taxes and compare the outcome to the outcome without taxes. We will investigate whether income tax rates can affect the incentives of the entrepreneur to behave and hence if she receives additional financing and undertakes the innovative project. We introduce two simple assumptions.

Assumption 1: An amount equal to TR is collected by the government.

Assumption 2: All investment is tax deductible.

The consequence from these assumptions is that the total investment requirement is only $I(1-T)$, and the additional investment needed by the entrepreneur is $I(1-T)-A$. That is the case because effectively the firm will obtain a tax credit in the amount of TI after the project is completed, and the discount rate is normalized to 0[13]. The assumption that all investment is tax deductible is somewhat stringent. If part of the investment is not tax-deductible, our results below would be even stronger and in the same direction. Therefore, we adopt the second assumption to be more conservative and without loss of generality[14].

The IC constraint for the entrepreneur with taxes is then $R_e \geq \frac{B}{\Delta P}$. The participation constraint for the financiers is $P_H R_f = I(1-T) - A$. It follows that the return to the financiers is $R_f = \frac{I(1-T)-A}{P_H}$. In the case of taxes, R_f and R_e are the after-tax returns to the financiers and the entrepreneur. Therefore, $R_f + R_e = R(1-T)$, and we can substitute in the IC constraint and obtain:

$$P_H\left(R\left(1-T\right)-\frac{B}{\Delta P}\right) \geq I\left(1-T\right)-A.$$

The minimum level of assets that the entrepreneur must have to obtain financing in the presence of taxes is then:

$$\bar{A}_T = \frac{P_H B}{\Delta P} - \left(1-T\right)\left(P_H R - I\right).$$

If we take the difference between the minimum assets required to obtain additional investment with and without taxes, we get:

$$\bar{A}_T - \bar{A} = \frac{P_H B}{\Delta P} - \left(1-T\right)\left(P_H R - I\right) - \frac{P_H B}{\Delta P} + \left(P_H R - I\right) = T(P_H R - I) > 0,$$

if the firm has a positive NPV project and if T > 0. Therefore, firms with positive NPV projects that have assets A, such that: $\bar{A}_T > A > \bar{A}$, will not have the incentives to behave and therefore would not be able to obtain additional financing because of taxes, while they would have undertaken the project if there were no taxes. The government in this case acts as an additional financier. By demanding a higher cut, they do not leave enough income to the entrepreneur to incentivize her to behave and pursue the innovative project.

More generally, differentiating $\bar{A}_T$ with respect to T, we obtain:

$$\frac{\partial \bar{A}_T}{\partial T} = P_H R - I > 0$$

That is, ceteris paribus (for a given distribution of A, R, I, P_H, P_L and B), the lower the tax rate, the smaller the necessary additional financing for innovative projects, the easier it

[13] This is without loss of generality.

[14] The additional financing can be in the form of extra incentive compensation to top managers, and not necessarily for R&D expenditures. In the Internet Appendix, we investigate this prediction and find supportive evidence that stock option-based compensation to top-level executives decreases (increases) after a significant tax increase (decrease).

would be to create more innovations. In other words, lowering the tax rate increases the pledgeable income and makes it more likely that the entrepreneur works and innovates rather than shirks and undertakes the routine project. This finding is consistent with Desai, Dyck and Zingales (2007), who demonstrate that tax rate increases exacerbate agency problems and lead to greater resource diversion, which in our case is analogous to shirking or undertaking routine projects rather than innovating.

Hypothesis 1: Tax rates are negatively related to the ability of firms to undertake positive NPV innovative projects.

2.3. Financial Constraints, Tangible Assets and Patent Stock

It is easy to extend the above analysis to show that firms that are more financially constrained will benefit more from lower tax rates. In this simple model, we measure financial constraints by the availability of assets in hand that includes cash A. We can see that a firm that has a level of cash A_c where, $\bar{A}_T \geq A_c \geq \bar{A}$, will not obtain additional financing for its innovative project, while a firm with cash equal to $A_{nc} \geq \bar{A}_T$ will obtain additional financing. Under the no tax case, both firms will obtain additional financing and innovate. Therefore, the financially constrained firm will benefit more from a reduction in tax rates that will bring $\bar{A}_T$ below A_c and make additional investment in the innovative project possible.

Hypothesis 2: Financially constrained firms will benefit more from a reduction in the tax rates and will be hurt more by an increase in the tax rates.

While A mostly represents cash, it can also be a measure of other tangible assets or patent stock that the entrepreneur or the firm will bring into the innovative project. We would therefore expect that firms with fewer tangible assets (property, plant and equipment), or fewer assets that can be collateralized such as previous patent stock (Hochberg, Serrano, and Ziedonis (2015)) will benefit (lose) more from tax decreases (increases).

Hypothesis 3: Firms with fewer tangible assets or a smaller previous patent stock will benefit more from a reduction in the tax rates and will be hurt more by an increase in the tax rates.

2.4. Private Benefits of Control and Corporate Governance

Finally, the size of private benefits may also affect the relation between tax rates and innovation. It is obvious that if private benefits of control are absent, and the entrepreneur always exerts the high effort (no agency problems), positive NPV projects will always be financed with or without taxes. To derive a prediction for the effect of private benefits, we start with the key inequality for the case of no income taxes that $P_H(R - \frac{B}{\Delta P}) \geq I - A$. Rearranging, we get that if $B \leq \bar{B} = \Delta P(R - \frac{I}{P_H}) + \frac{\Delta P}{P_H}A$, the entrepreneur will receive the additional investment. Therefore, $\bar{B}$ is the maximum size of private benefits that the entrepreneur can have to obtain the additional investment.

The analogous inequality for the case with income taxes is $P_H\left(R(1-T) - \frac{B}{\Delta P}\right) \geq I(1-T) - A$. Rearranging, the maximum size of private benefits that the entrepreneur can have to obtain additional investment is $\bar{B}_T = \Delta P(1-T)(R - \frac{I}{P_H}) + \frac{\Delta P}{P_H}A$. If we take the difference between the maximum size of private benefits allowed to obtain additional investment with and without taxes, we get $\bar{B}_T - \bar{B} = \Delta P(1-T)(R - \frac{I}{P_H}) + \frac{\Delta P}{P_H}A - \Delta P(R - \frac{I}{P_H}) - \frac{\Delta P}{P_H}A = -T\Delta P(R - \frac{I}{P_H}) < 0$ if the firm has a positive NPV project and if T > 0. Therefore, firms with positive NPV projects that have private benefits B^H, where $\bar{B}_T < B^H < \bar{B}$, will not obtain additional financing when there are corporate income taxes, while a firm with $B^L < \bar{B}_T$ will. Under the no tax case, both firms will obtain additional financing and innovate.

More generally, differentiating $\bar{B}_T$ with respect to T, we obtain $\frac{\partial \bar{B}_T}{\partial T} = -\Delta P(R - \frac{I}{P_H}) < 0$, which indicates that $\bar{B}_T$ increases with decreasing tax rates. Therefore, the firm with more private benefits (weaker governance) will benefit more from a reduction in tax rates that will bring $\bar{B}_T$ above B^H and make additional investment in the innovative project possible. Thus, we have the following prediction:

Hypothesis 4: Firms with greater private benefits (weaker corporate governance) will benefit more from a reduction in the tax rates and will be hurt more by an increase in the tax rates.

In the empirical section, we test these four hypotheses and provide a detailed analysis of the impact of taxes on innovation.

3. Data and Variable Construction

We acquire state corporate income tax information from the University of Michigan's World Tax Database, the Book of States, and the Tax Foundation. Garcia and Norli (2012) provide the number of times a state is mentioned in a firm's 10-K reports, which we use to determine the most relevant state to which the tax rate is applied. The historical states of incorporation and location come from the Compact Disclosure database and the parsed 10-K data from Bill

McDonald's website.[15]

The sample is constructed by selecting all U.S. publicly traded firms from the NBER patent file[16], which have financial data available in the S&P's Compustat database. We also include all firms from Compustat, which operate in the same 4-digit SIC industries as the firms in the patent database, but do not have patents. Including these firms alleviates sample selection concerns since the sampling procedure is independent of whether the firm has patents or not. A drawback of this approach may be that for some firms or industries patenting might not be an accurate measure of innovation, or that some industries might not be innovative at all. To address these concerns, we also conduct our analysis only on innovative companies or industries, and find similar and generally stronger results.

We start our sample in 1988 due to the availability of Compact Disclosure, which is used to construct an alternative measure of the most relevant state. Only firms that are incorporated and headquartered in the U.S. are included. Firms in the financial (SIC=6), utilities (SIC=49), and public (SIC=9) sectors are excluded. The final sample includes 88,207 firm-years based on 8,435 firms over the period of 1988-2006.

3.1. Main Explanatory Variables: Major Increases and Decreases in State Corporate Income Tax Rates

To examine the impact of corporate income taxes on innovation, we need to properly define the tax signals that would most likely affect firm incentives. There are two issues to consider here. First, innovation is a long-term activity that requires significant amount of both tangible and intangible firm resources. Thus, it is unlikely that firms will react to small tax changes especially those that are expected to be reversed. Firms are more likely to respond to large tax changes that may signal a change in tax policy that lasts for an extended period of time.

Second, as Griliches (1990) argues, the innovation lag is poorly defined as it may take years from the change in incentives to the creation of patents. Therefore looking at numerous small tax changes that could be reversed within one or two years will introduce noise into our estimates. Our measure of tax changes largely avoid these two problems.

Specifically, in order to identify more permanent tax signals that are likely to have a long-lasting impact on corporate innovation, we focus on major state corporate income tax changes that are not reversed in three years. The key explanatory variables in our analysis are two indicators, $TaxIncr_{st}$ ($TaxDecr_{st}$) that take a value of one if at time t state s there

[15] `http://www3.nd.edu/~mcdonald/10-K_Headers/10-K_Headers.html.`

[16] For a detailed description of the patent dataset, see Hall et al (2001).

has been a major increase (decrease) in state corporate income tax rates, respectively, and zero otherwise.[17] The tax variable equals one in the year of the change and all subsequent years unless the tax rate is reverted back to the level before the change. We also create a combined categorical tax variable, $TaxChg_{st}$, which is equal to 1 if at time t state s there has been a major increase in state corporate income tax rates, equal to -1 if there has been a major decrease in state corporate income tax rates, and 0 otherwise.

A major increase or decrease in tax rates is defined as greater than or equal to 1% (e.g. from 7% to 8%), as long as that change is not reverted within the next three years. We consider major tax changes of greater than or equal to 1% that are enacted in one or two consecutive years.[18] If it is reverted within the next three years, it is not considered a change and the variable retains the value of 0. If the change is reverted more than three years later, the variable takes a value of 1 in the year of the change and any year after when the change is present, and switches back to zero after the change is reverted.[19] For robustness, we include the short-term tax rate reversals and consider tax changes of greater than or equal to 0.5%, and find similar, although expectantly weaker, impact on innovation as shown in Table V.

To identify the major tax changes, we use state tax rates from the University of Michigan's World Tax Database, the Book of States, and the Tax Foundation. The World Tax Database provides state corporate tax rates from 1941 to 2002 and the Tax Foundation provides state corporate tax rates from 2000 to 2013. We check these data with the state corporate income tax rates reported in the Book of States to ensure consistency and accuracy. For states with multiple tax brackets, we focus on changes in the top tax bracket while accounting for tax surcharges. The major tax increases and decreases are identified in Table I. From 1988 to 2006, ten states experienced a major tax increase and eight states experienced a major tax decrease.[20] The average major tax increase is 1.5% and the average major tax decrease is also

[17]We choose to use indicator variables to implement a differences-in-differences methodology. For robustness, we use the actual change in the tax rate (i.e., from 1% to 3.75%) or the percentage change in the tax rate instead of a dummy and find similar results.

[18]For example, Nebraska increased the corporate income tax rate from 6.65% to 7.24% in 1990 and again from 7.24% to 7.81% in 1991. Over the two-year period of 1990 to 1991, the corporate income tax rate increased by 1.16%.

[19]For example, New Hampshire experienced a major tax decrease in 1994 and the tax rate returned to the level prior to the change in 1999. In this case, the tax decrease indicator equals one for years 1994 to 1998 and zero for all other years.

[20]Of the 15 distinct states that experienced major tax changes, only two states (Arizona and Connecticut) have multiple major tax changes in the same direction. Arizona has major tax decreases in 1990, 1999, and 2001. Since we cannot use all three years to create the tax decrease variable, we choose the year 1999 because there are only 63 firm-year observations prior to 1990, and 2001 is already included in the treatment period, where the tax decrease indicator equals one. For robustness, we also use 1990 and 2001 to create the tax decrease variable and find similar results. Connecticut has tax decreases in 1999 and 2000. We use the year 1999 to create the tax decrease variable because 2000 is already included in the treatment period, where the

1.5%, which is 22% of the average top marginal state tax rate of 6.9% in our sample.

We also verify our major tax changes with the list of tax changes from Heider and Ljungqvist (2014) and Giroud and Rauh (2016).[21] There are a few small differences between the three sets of tax changes, which we verify using other data sources and perform robustness checks to make sure the differences do not affect our results.[22] In Heider and Ljungqvist (2014), there are around 90 tax changes during our sample period. Of the 90 tax changes, 33 are changes of 0.25% or smaller, 12 are changes of greater than 0.25% and less than 0.5%, and 21 are reversals within three years. 27 of the 90 tax changes are greater than or equal to 1% that are enacted in one or two consecutive years, 6 of which are reverted within three years and 3 additional ones are close to an earlier large tax change in the same direction, thus are already included in the treatment period[23]. Giroud and Rauh (2016) also use a list of 56 state corporate income tax changes of greater than or equal to 1% from 1978 to 2011 for their differences-in-differences analysis, which is similar to the fixed effects model specification that we use. When restricted to our sample period, they have 21 large tax changes, where 2 are reversals within one year and 3 are already included in the treatment period of an earlier large tax change in the same direction. Thus, our list of large tax changes is very similar to the ones based on Heider and Ljungqvist (2014) and Giroud and Rauh (2016) after dropping reversals within three years and tax changes that are already included in the treatment period of an earlier tax change in the same direction.

3.2. Determining the Most Relevant State for Corporate Income Tax Purposes

There are several challenges associated with determining the most relevant state for tax purposes. In practice, state tax is assessed based on three main firm characteristics: percentage of sales, of employees and of physical assets in a given state. Different states assign different weights on these three characteristics. Unfortunately, specific information on these three components is not publicly available. Therefore, we approximate the most relevant state to which the tax rate is applied by deducing where the firm conducts most of its business.

To this end, we follow Garcia and Norli (2012), who compute the number of times a 10-K

tax decrease indicator equals one. For robustness, we also use a count variable to accommodate multiple tax changes in the same direction and find similar results.

[21] We thank the authors for sharing their data.

[22] For example, we find a large tax decrease in Connecticut in 1999, while Heider and Ljungqvist (2014) find one for 1998.

[23] For example, Missouri had a significant tax decrease in 1992 that was reversed in 1993, so these two years are not included in the list of major changes.

report mentions a U.S. state name for all 10-K filings from the SEC's online database from 1994 to 2008. All public firms are required to file a 10-K report with the SEC within 90 days of their fiscal year end. These annual reports contain detailed information regarding the firm's operations and financial performance during the year. More importantly, these reports can also contain information on the location of the firm's sales, property, and employees in different geographic areas. For example, firms may list factories by state under the Properties section or report sales in stores by state under the Business section. To capture these locations, Garcia and Norli (2012) count the occurrence of state names in four sections: "Item 1: Business", "Item 2: Properties", "Item 6: Consolidated Financial Data", and "Item 7: Management's Discussion and Analysis".

The approach taken by much of the previous literature is to use the state of company headquarters based on the assumption that most of the profits of that company are generated in the headquarter state. While this assumption is often reasonable, in many cases it is not correct. For example, Boeing is currently headquartered in Illinois, while its main factory is located in Washington. According to its website, as of May 29, 2014, 81,305 of 168,693 employees are located in Washington compared to around 600 employees in Illinois. Since a firm's corporate office may not be where its major operations are located, we do not use the state of headquarters as the most relevant state for tax purposes in the main analysis.

The state count data consist of 84,117 firm-year observations for 11,811 publicly-traded firms from 1994 to 2008. For each firm-year observation, each state's share of the total number of state counts is reported. California, Texas, New York, Florida, and Illinois are among the most mentioned states, whereas Rhode Island, South Dakota, and North Dakota are among the least mentioned states. To the extent that the state mentions in 10-K filings are related to the location of the firm's sales, properties, and employees, more frequently mentioned states tend to be more important for tax purposes than less frequently mentioned states. Consistent with this idea, we show in Section 6.2 that the amount of state taxes paid is significantly related to tax changes in the most mentioned state, but is not related to tax changes in the least mentioned state.

To construct the relevant state for firms in our sample, we first find the most mentioned state for each firm-year observation, then use the most frequently occurring most mentioned state across all years for a given firm as the most relevant state for that firm. In our main analysis, we use a single time-invariant state that is mentioned the most for each firm during the sample period to match a firm's long-run planning horizon and also to alleviate problems with endogenous state moves. For robustness in subsequent tests, we also use the time-varying most mentioned state and the top-three most mentioned states, and obtain similar findings.

For reference, for 36% of the firms in the sample, the most mentioned state is different from the state of the headquarters. Finally, in Section 6.2, we perform a series of robustness checks to ensure that our results are not driven by the definition of relevant state. For instance, instead of the most mentioned state, we also use alternative definitions of the most relevant state based on the headquarters, the locations of the patent grants, and subsidiary locations and find similar results.

3.3. Construction of the Dependent Variables

The main dependent variables are two metrics for innovative output: the number of patents to measure the quantity, and the number of citations per patent to measure the quality of innovation[24]. The first metric, *Patent*, is a patent count for each firm in each year. The relevant year is the application year, which occurs closer to the actual innovation and far before the innovation is incorporated into a finished product ready for the market (Griliches, Pakes, and Hall (1987), Hall, Jaffee, and Trajtenberg (2001)). For robustness, we also use a patent measure that is equal to the number of patents for each firm-year divided by the mean number of patents for the same year in the same technology class. This weighting adjustment is made to correct for the truncation bias in patent grants, which results from the fact that patents have on average a two year lag from the time a patent is applied for until the time it is granted.

The second metric, *Citations per Patent*, assesses the significance or quality of innovative output. Pakes and Shankerman (1984) and Griliches, Pakes, and Hall (1987) show that the distribution of the value of patents is extremely skewed, and most of the value is concentrated in a small number of highly cited patents. Hall et al. (2005), and Atanassov (2013) among others demonstrate that patent citations are a good measure of the value of innovations. Intuitively, the rationale behind using patent citations to identify important innovations is that if firms are willing to further invest in a project that is building upon a previous patent, they have to cite that patent. This in turn implies that the patent that is cited is technologically influential and economically important.

Patent citations, however, also suffer from truncation bias because they are received for many years after the patent is applied for and granted. For example, a patent that was created in 1988 will have much more time to receive citations than a patent created in 1995 because the sample of patent citations ends in 2006. Another potential concern is that different industries might have different propensities to cite patents. Therefore, for robustness, we also correct for

[24]All variables are defined in greater detail in the Appendix.

the truncation bias by using two methods (the fixed effects method and the quasi-structural method) suggested by Hall, Jaffe and Trajtenberg (2001) and find similar results.

3.4. Control Variables

Control variables include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). GDP data come from the Bureau of Economic Analysis and the historical state unemployment rate come from the Cleveland Federal Reserve.

In the empirical specification where innovation is the dependent variable, we follow Hall and Ziedonis (2001) among others and include firm size, *Ln(Sales)*, as a control variable. For robustness, we use the number of employees as an alternative proxy for firm size. Following Aghion, et al. (2005), we control for industry competition using the Herfindahl index constructed at the 4-digit SIC level. We also use the squared Herfindahl index to control for non-linear effects of industry concentration. We construct the variable *Age* that measures the age of the firm as the number of years that it appears in the Compustat database. All accounting variables are winsorized at the 1st and 99th percentiles to remove the influence of extreme outliers.

3.5. Model Specification

We use a differences-in-differences methodology by estimating the following model:

$$y_{is(t+n)} = \alpha_t + \beta_i + \gamma TaxVar_{st} + \delta X_{ist} + \epsilon_{ist}, \tag{E-1}$$

where i indexes firms, s indexes the most mentioned state, t indexes time, $y_{is(t+n)}$ is the dependent variable, which is either *Ln(1+Patent)* or *Ln(1+Citations/Patent)*, and n is equal to one, two, three or four. $TaxVar_{st}$ is either *TaxIncr*, *TaxDecr*, or *TaxChg*, which are indicator variables to indicate significant tax changes. X_{ist} is a vector of control variables described above. We control for time invariant unobservable firm characteristics by using firm fixed effects β_i . Year indicator variables α_t control for economy wide shocks and changes in federal tax rates and regulations, which vary by year and do not vary across states.

We use a log-linear model when the dependent variable is the number of patents or the number of citations per patent, since they are count variables. The log-linear model is preferred to the Poisson model because the Poisson model is non-linear and, when it is estimated with fixed effects, the maximum likelihood algorithm drops all firms that do not change their innovation throughout the sample period (see Chamberlain (1980) for more details). Because those firms might carry valuable information, excluding them from the analysis might weaken the power of the tests and introduce noise in the estimation procedure.

To control for serial correlation, we cluster the standard errors at the firm level as suggested by Petersen (2005). For robustness, we also cluster the standard errors by year, by firm and year, by the state of location (as suggested by Bertrand et al. (2002)), and by state and year. We obtain similar findings in all cases.

Since the dependent variables, measures of innovative output, are slow moving and have uncertain lags, we use a differences-in-differences methodology to capture changes in innovative output following prior studies in the literature (e.g., Atanassov (2013), Acharya et al. (2014), Cornaggia et al. (2015)). Compared to the fixed effects approach, as we illustrate in the Internet Appendix with a simple example, the first-difference approach may not be well suited to capture changes in innovative output when the lags are uncertain.

To understand the differences-in-differences approach better, it is helpful to consider an example. The table below reports state-level means and standard errors. In 1999, Arizona has experienced a significant tax reduction from 9% to 8%. Suppose we want to estimate the effect of a tax reduction in Arizona on innovation, which is measured as *Ln(1+Patent)*. The first difference is to subtract the level of innovation before the tax change (0.081) from the level of innovation after the change (0.106) for firms whose most relevant state is Arizona. However, economy-wide shocks may occur at the same time and affect innovation. To control for such factors, we calculate the same difference at the same time in a control state such as Mississippi that does not experience a tax change at that time. Then, the difference of these two differences, which is 0.034, represents the incremental effect of the tax decrease on firm innovation.

	Before 1999	After 1999	Δ Ln(1+Patent)
Arizona	0.081	0.106	0.025
	(0.004)	(0.008)	(0.009)
Mississippi	0.092	0.083	-0.009
	(0.006)	(0.007)	(0.009)
ΔLn(1+Patent)	-0.011	0.023	0.034
	(0.007)	(0.011)	(0.013)

The tests used in this paper are even more stringent than the simple intuition provided above since they control not only for state-wide differences but also for other firm-specific unobservable differences. Another advantage is that different states introduce the tax changes at different times, which allows the firms operating in a given state to be both in the treatment and control groups.

3.6. Summary Statistics

Table II presents the summary statistics. The average firm in the sample has 5.1 patents and 2.1 citations per patent. The standard deviations are large suggesting that most of the innovation comes from a small number of highly innovative firms. About 7.6% of the firm-years in the sample have a significant tax increase and about 7.6% have a significant tax decrease. The average firm spends 7.7% of total assets on R&D and has debt to assets ratio of 0.26. The average age of the firms in the sample is 12.6 years.

4. Multivariate Results

4.1. Tax Changes and Corporate Innovation

First, we study how changes in state corporate tax rates affect the quantity of innovation measured by the number of patents created by firms. As Grilliches (1990) argues, the innovation lag (from the initial investment to the actual patent) is poorly defined. Therefore, our dependent variable measures the number of patents from 1 to 4 years into the future. The full set of results for years 1 to 4 are reported in the Internet Appendix. For brevity, we present the main results for years 3 and 4 in Table IIIA.

Following equation E-1, we estimate an OLS model of *Ln(1+Patent)* on one of the three tax variables. *TaxIncr* is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise. *TaxDecr* is an indicator variable equal to 1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. We also combine tax increase and tax decrease into one measure, *TaxChg*, which is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, equal to -1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise.

The estimates in columns (1) and (2) show that tax increases are significantly and negatively related to the number of patents, while the estimates in columns (3) and (4) show that tax decreases are significantly and positively related to the number of patents. These effects are also economically significant. Tax increases lead to a 3.8% and 5.5% reduction in the number of patents 3 and 4 years later, respectively. Tax decreases lead to a 10.1% and 13.4% increase in the number of patents 3, and 4 years later, respectively. Alternatively, these effects suggest that firms produce 0.2 and 0.3 fewer patents after experiencing a tax increase and produce 0.5 and 0.7 more patents after experiencing a tax decrease, 3 and 4 years later, respectively.

In columns (5) and (6), we use the combined tax measure and find a significant negative relation between *TaxChg* and the number of patents. The results suggest that significant increases in state corporate tax rate reduce the quantity of innovation and significant decreases in state corporate tax rate enhance the quantity of innovation.

Other results from Table IIIA show that larger firms and firms with more R&D expenditures, with less leverage, and with more tangible assets create a greater number of patents. Consistent with Aghion et al. (2005), there is a non-linear (inverted-U) relation between industry concentration and innovation. As for the state level controls, there is little relation between state level real GDP, state unemployment rate and the number of patents.

In Table IIIB, we examine the impact of tax changes on the number of citations per patent, which is a measure of the quality of innovation. The results in columns (1) and (2) show a significant negative relation between tax increases and the number of citations per patent 3 and 4 years later, while the results in columns (3) and (4) show a significant positive relation between tax decreases and the number of citations per patent 3 and 4 years later. As for the combined tax measure, the estimates in columns (5) and (6) show a negative relation between *TaxChg* and the quality of innovation.

In terms of economic significance, the estimates in Table IIIB show that tax increases lead to a reduction in the number of citations per patent by 10.3% and 9.6%, for 3 and 4 years in the future, respectively. In addition, tax decreases lead to an increase in the number of citations per patent by 14.9% and 13.4%, for 3 and 4 years in the future, respectively. These effects translate into a 0.2 and 0.2 reduction in the number of citations per patent for firms experiencing a tax increase and a 0.3 and 0.3 increase in the number of citations per patent for firms experiencing a tax decrease, 3 and 4 years later, respectively. Moreover, these results suggest that tax changes not only impact the quantity, but also the quality of innovation, which is the more important measure of innovative output (Griliches (1990), Hall, Jaffe, and Trajtenberg (2005)).

Other results from Tables IIIB suggest that tangible assets have a positive effect on the number of citations per patent, while firm size, leverage, and profitability have a negative effect. There is also a non-linear relation between industry competition, measured by the Herfindahl index, and the quality of innovation.

All regressions include time fixed effects to control for economy-wide events that could affect innovation, and firm fixed effects to control for firm specific, industry specific and state specific characteristics that are unobservable, or are not accounted for by the control variables. The standard errors are clustered by firm to mitigate serial correlation. For robustness, we also cluster the standard errors by other groups (i.e., year, firm and year, state of location, state and year), and obtain similar results. In unreported regressions, we include the lagged values of the main dependent variables as additional controls for unobserved firm-specific factors that could affect innovation and find similar results.

Overall, Tables IIIA and IIIB show that tax increases have a significant negative impact on corporate innovation and tax decreases have a significant positive impact on corporate innovation. Tax changes impact both the quantity and the quality of innovation. For brevity, we focus on the number of citations per patent for the rest of the paper since it is the more important measure of the quality of innovation. Results are similar for the number of patents.

It is worth noting that our results are different from the ones of Mukherjee, Singh, and Zaldokas (2016). They find that corporate tax increases have a significant negative impact on innovative output measured by patents, while corporate tax decreases have no effect, without offering a convincing explanation for the asymmetry. They hypothesize that it could be due to labor market frictions, which lead to asymmetric adjustment costs because it is easier to reduce the workforce following tax increases than to acquire new innovators following tax decreases.[25] We explore their rationale in the Internet Appendix by interacting their tax measures with wrongful discharge labor laws, but do not find evidence consistent with their hypothesis.[26] Thus, the asymmetric effect that Mukherjee, Singh, and Zaldokas (2016) find is puzzling and could be well due to the different methodology or variable construction as explained below. In addition, as another indication of noisy findings, the significant negative impact of tax increases on innovation that they document does not show up consistently across different model specifications and robustness checks. The significant effect in some cases only shows up in year one and in other cases only in year two.

In contrast, our results are stronger, robust, and do not exhibit asymmetry. This difference can be attributed to several factors. First, we use state mentions in 10-K filings to better define

[25]Mukherjee, Singh, and Zaldokas (2016) also considered other reasons for the asymmetrical effect such as the debt channel, the internal cash flows channel, and the concavity between innovation inputs and outputs, but do not find much support for these rationales.

[26]The idea is that since wrongful discharge laws make it more difficult to fire employees, if their rationale is correct, the passage of these laws should attenuate the negative impact of tax increases (i.e., a positive coefficient on the interaction between tax increase and wrongful discharge laws), thus making the impact of tax changes more symmetrical. However, in the Internet Appendix Table IA.12, we find a significant negative interaction between tax increase and wrongful discharge laws, inconsistent with their rationale.

the most relevant state while they use headquarter states. Second, they use all tax changes, many of which are small and transitory. Since it is unlikely that firms will change their innovation activities so quickly in response to these small changes, their estimates are likely noisy. In contrast, we focus on major tax changes that are not reversed within three years in order to identify permanent tax signals that are more likely to have an impact on a long-lasting process such as corporate innovation. Third, many of the smaller tax changes occur around the same time making it difficult to assess their impact on a long-term process such as innovation especially with uncertain lags.[27] This problem is especially exacerbated when tax increases and decreases occur within a short period of time. For example, Connecticut has a tax increase in 1990 and a tax decrease in 1992. So, the change in innovation in 1993 would be year $t + 3$ for the tax increase and also year $t + 1$ for the tax decrease, which is problematic since tax increases and decreases are predicted to have opposing effect on innovation. This issue is not isolated as it happens in 30 of the 83 tax changes that Mukherjee et al. (2016) examine. Fourth, we use a fixed-effects model following prior studies in the innovation literature (e.g., Atanassov (2013), Acharya et al. (2014), Cornaggia et al. (2015)) since the innovation lag is poorly defined and tax changes do not dissipate quickly and can impact firm innovation for several years. As we illustrate in the Internet Appendix with a simple example, the first difference methodology that they use may not be well suited to capture changes in innovative output when the lags are uncertain.

To further explore these issues in their study, we replicate the main results of Mukherjee et al. (2016) in the Internet Appendix using their tax signals, model specifications, methodology and sample construction. The tax increase and decrease variables are defined as in Mukherjee et al. (2016) and are based on historical headquarters state of the firm, which is obtained from Compact Disclosure and 10-K filings (parsed 10K location data are obtained from Bill McDonald's website).[28] We find that tax increases are negatively related to the number of patents, consistent with their study. However, tax increases are not significantly related to the number of citations per patent, which is arguably the more important measure of innovation. Moreover, when an alternative state definition based on the most mentioned state is used, all the effects disappear: neither tax increases nor decreases are significantly related to innovation quantity or quality. These results suggest that the documented effects in Mukherjee et al.

[27] For example, North Carolina has tax decreases of -0.08% to -0.25% in years 1992, 1993, 1994, 1995, 1997, 1998, 1999, and 2000. When looking at innovation one to four years after the tax changes, many of the treatment periods overlap, making it difficult to assess the impact in year $t + 1$ to $t + 4$.

[28] Mukherjee et al. (2016) also use historical headquarter location information from 10-K filings. We obtain historical headquarter location from both Compact Disclosure and 10-K filings because Compact Disclosure offers coverage from 1988 and electronic 10-K filings are not available for years earlier than 1994. Thus, using both sources give us better data coverage, which may be why our sample size is slightly larger than the one in Mukherjee et al. (2016).

(2016) may be noisy and less robust, likely due to the factors mentioned above.

4.2. Dynamic Analysis of Tax Changes

We conduct a dynamic analysis of the impact of tax changes on corporate innovation in Table IV. This analysis addresses potential concerns of reverse causality by examining if there are any pre-existing trends in innovative activity that were followed by tax changes. For instance, if tax decreases were implemented in response to political pressure from a broad coalition of firms that started to experience a decline in innovation, then we should see an effect prior to the enactment of tax reductions. To this end, we create five indicator variables for each of the three tax measures in Table IV that allow us to investigate the dynamics of tax changes and their impact on the number of citations per patent.

For example, when *TaxIncr* is examined in column (1), *TaxIncrMinus2* is an indicator variable equal to 1, if there is a significant tax increase in year *t+2* (2 years after the patent is applied for) in the largest state of business of firm *i*, and 0 otherwise. *TaxIncrMinus1* is an indicator variable equal to 1, if there is a significant tax increase in year *t+1* in the largest state of business of firm *i*, and 0 otherwise. These indicators allow us to see if there is any change in innovation one or two years *before* the tax increase is implemented. *TaxIncrZero* is an indicator variable equal to 1, if there is a significant tax increase in year *t* in the largest state of business of firm *i*, and 0 otherwise. *TaxIncrPlus1* is an indicator variable equal to 1, if there is a significant tax increase in year *t-1* in the largest state of business of firm *i*, and 0 otherwise. *TaxIncrPlus2andMore* is an indicator variable equal to 1, if there is a significant tax increase in year *t-2* or earlier in the largest state of business of firm i, and 0 otherwise.

In columns (1) and (2), we examine tax increases and decreases separately. Consistent with the results in Table IIIB, we find a significant negative effect of *TaxIncr* on innovation quality two or more years after the tax increase. We also find a significant positive effect of *TaxDecr* on innovation quality two or more years after the tax decrease. There is no relation between tax changes and innovation in the years prior to the change, which is consistent with the assumption that there were no pre-existing trends of a decrease (increase) in innovation before an increase (decrease) in the tax rate. Column (3) of Table IV examines the dynamic effects of *TaxChg*, where the coefficients again suggest that the impact on innovation comes two or more years after the tax change, with no evidence of a pre-existing trend.

Thus, these results suggest that tax changes have their strongest impact on innovation two or more years after the change. This pattern is consistent with other studies in the literature (e.g., Atanassov (2013), Acharya et al. (2014)). In contrast, Mukherjee, Singh, and Zaldokas

(2016) find that the significant impact on innovation mostly for years one and two and the effect even starts at year zero (based on the figure they provide). The quick reaction and the disappearance of results after the second year is puzzling since innovation is a long process and innovative output can take several years to materialize (Griliches (1990) and Hall et al. (2001, 2005)).[29]

4.3. Tax Signals

In this section, we perform several robustness checks for the tax signals that are used to construct the main measures. As suggested by Hennessy and Strebulaev (2015), measured treatment responses may not uncover causal effects if the policy changes are anticipated. We address this concern in two ways. First, the lack of a relation between tax changes and innovation in the years prior to the tax changes in Table IV lessens the concern of potential anticipation effects since the impact on innovation should show up earlier if firms do anticipate future changes in taxes. Second, Hennessy and Strebulaev (2015) show that the policy variable being a Martingale is a necessary and sufficient condition for correct inference of causal effects, which in this case indicates that state tax rates should follow a random walk. Ljungqvist and Smolyansky (2016) test the null hypothesis of a random walk using state corporate income tax rates from 1969 to 2013. They fail to reject the null in all cases when the states are tested separately. When taking into account that some states may base their tax policy on those of their neighbors, the null is only rejected in the New England region at the 10% level. Thus, we exclude firms located in New England states (i.e., Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) in Panel A of Table V and obtain similar results, suggesting that our findings are robust to controlling for potential anticipation effects.

To address the concern that tax changes may be driven by local economic conditions that can impact innovation directly, we examine exogenous tax changes defined using a narrative approach. Following the methodology of Romer and Romer (2010), we search news articles using Lexis-Nexis to identify state corporate income tax changes that are passed independent of existing and future economic conditions. Giroud and Rauh (2006) and Mukherjee et al. (2016) use a similar approach to identify exogenous tax changes. According to Romer and Romer (2010), tax changes that are passed with the motivation of dealing with an inherited budget deficit or achieving some long-run goal such as higher normal growth, increased fairness,

[29] Mukherjee et al. (2016) also look at new product announcements and find a significant effect of tax increase in year 1, which is even more puzzling. While there should be a lag between tax changes and changes in patent outputs, there is another lag between innovation and the launching of new products, so the effect in year 1 is too quick to rationalize.

or a smaller role for government are classified as exogenous. We redefine the main measures based on these exogenous tax changes and continue to find similar results as presented in Panel B of Table V[30].

Finally, to construct the main tax signals, we drop reversals in tax rates within three years. To address the concern that firms may not know these tax changes will be reversed back shortly in the future and thus react to them, we include these short-term reversals when constructing the main tax measures in Panel C. We also create the tax increase and decrease indicators based on major tax changes of 0.5% or greater instead of 1% or greater in Panel D. In both panels, the key estimates are similar to those in the baseline case.

5. Exploring the Mechanisms

Based on our theoretical model, we hypothesize that income taxes may distort the incentives of the firm and its stakeholders to optimally invest time, effort and money in innovative activities. The rest of the paper examines several possible channels through which lower tax rates can affect innovation - relieving financial constraints, reducing the negative impact of smaller collateral, reducing the negative impact of weak corporate governance, and improving resource allocation by decreasing tax avoidance. This is also one of the main differences between our paper and Mukherjee et al. (2016) since they do not explore any of the new channels that we examine here. Understanding the mechanisms is important for two main reasons. First, it improves our understanding of how taxes work and provides better insight into future research and policy making. Second, it reduces the concern that the relation between taxes and innovation is spurious and driven by other changes that may have occurred at the same time. Such a criticism will have the burden of explaining not only the main results in the previous section but also all the channels demonstrated in this section.

5.1. Tax Changes, Financial Constraints and Innovation

Our theoretical model demonstrates that lower tax rates increase firms' pledgeable income, thus allowing them to obtain additional financing and increase their investment in innovative projects. If some firms do not need much additional financing, either because they hold enough cash, or because it is easier for them to tap external markets, the decline in tax rates will not have a big impact on innovation. Conversely, we predict that more financially constrained

[30] We obtain similar results by using an alternative classification of exogenous changes provided by Mukherjee, Singh, and Zaldokas (2016). We thank the authors for sharing their data.

firms will benefit more from a tax decrease because their pledgeable income may increase above the required threshold to finance the project. By the same rationale, our model predicts that firms that are more financially constrained will experience a greater decline in innovation from a tax increase than firms that are less financially constrained.

To test this hypothesis we construct a measure of financial constraints using the Whited and Wu (WW) (2010) index, which is based on coefficients obtained from a structural model. Following the literature (e.g., Farre-Mensa and Ljungqvist (2016)), we sort firms into terciles each year based on their WW index values. The indicator, WWFinConstraint, equals one for firms in the top tercile, and zero otherwise. We then interact WWFinConstraint with the tax increase indicator or the tax decrease or increase indicator.

Table VIA presents the results. We use the Whited and Wu (2010) index in Panel A and alternative measures of financial constraints in Panel B. In columns (1) and (2) of Panel A, the coefficients on the interaction term are both negative, while only year 4 is significant. This result suggests that the impact of tax increases is larger for firms that are more financially constrained. Specifically, the negative impact of tax increases on the number of citations per patent is 30% and 131% greater for firms that are more financially constrained, 3 and 4 years into the future, respectively.

In columns (3) and (4), the coefficient on the interaction term is positive and significant, suggesting that the impact of tax decreases is larger for firms that are more financially constrained. Specifically, the positive impact of tax decreases on the number of citations per patent is 138% and 192% greater for firms that are more financially constrained, 3 and 4 years into the future, respectively. For robustness, in Panel B, we also use alternative measures of financial constraints from Kaplan and Zingales (1997) (as implemented by Lamont, Polk, and Saa-Requejo (2001)) and Hadlock and Pierce (2010) and find similar interactive effects.

In a related test, we examine if smaller firms are hurt more by tax increases and benefit more from tax decreases. Presumably, smaller firms have greater informational asymmetries and are thus more financially constrained. These firms are also more constrained in terms of attracting and keeping talented employees. In Table VIB, we interact the tax increase and decrease indicators with a proxy for firm size, *LnSales*. Consistent with the prediction, the coefficients on the interaction term suggest that the negative impact of tax increases is larger for smaller firms and the positive impact of tax decreases is also larger for smaller firms.

This result provides additional relief for the concern that our results could be driven by the lobbying efforts of a few large firms that expected a decline in their innovative output for reasons unrelated to taxes, and then lobbied for tax changes. If this was the case, we would see that larger firms benefit more from the tax decrease. Our results show that the opposite is true. The size interaction results also provide some indirect evidence that innovative inputs such as creativity and work effort may be driving the documented relations. The rationale is that resources such as entrepreneurial creativity and effort tend to be more salient in smaller firms where the manager is directly responsible for most key decision making. Therefore, tax decreases increase the after-tax profit and pledgeable income and improve the incentives of firm stakeholders to commit additional resources to innovation.

In sum, more financially constrained firms and smaller firms are impacted more by tax changes. Although less financially constrained firms are impacted less, the impact of tax changes on innovation quality for those firms is still significant economically and statistically, suggesting that financial constraints are not the only mechanism through which taxes impact innovation.

5.2. Tax Changes, Collateral and Innovation

In this section we continue our investigation about whether firms with lower pledgeable income will be more sensitive to tax changes. We focus here on collateral, which mainly comes from tangible assets but could also arise from intangible assets such as previous patents. Therefore, we conduct two tests. The first one investigates whether firms with fewer tangible assets will benefit (lose) more from tax decreases (increases). The second test examines if firms with lower patent stock at the time of the tax change will benefit (lose) more from tax decreases (increases). The results in Tables VII confirm these predictions.

In Panel A of Table VII, we sort firms into terciles each year based on their asset tangibility, which is calculated as net property, plant and equipment divided by total assets. The indicator, *Intangibile*, equals one for firms in the bottom tercile of the tangibility measure, and zero otherwise. We then interact Intangible with the tax increase indicator or the tax decrease indicator. In columns (1) and (2), the coefficients on the interaction term are both negative and significant, suggesting that the impact of tax increases is larger for firms with fewer tangible assets. Specifically, the negative impact of tax increases on the number of citations per patent is 166% and 122% greater for firms that have fewer tangible assets, 3 and 4 years into the future, respectively. In columns (3) and (4), the coefficient on the interaction term is positive and significant, suggesting that the impact of tax decreases is larger for firms with fewer tangible assets. Specifically, the positive impact of tax decreases on the number of citations per patent is 194% and 182% greater for firms with fewer tangible assets, 3 and 4 years into the future, respectively.

In Panel B of Table VII, we test whether firms with a lower patent stock at the time of the tax change will benefit (lose) more from tax decreases (increases). This investigation is motivated by the previous literature (Hochberg, Serrano, and Ziedonis (2015)), which argues that the patent stock has a significant value as it can be used as a collateral to attract additional financing. For a given firm in year t, its patent stock is calculated as the total number of patents the firm has accumulated over the last twenty years, divided by total assets. The rolling period of twenty years is motivated by the term of patent, which is 20 years from the filing date for applications filed on or after June 8, 1995 and either 17 years from the issue date or 20 years from the filing date for applications filed before June 8, 1995. We normalize the cumulative patent count by total assets in order to account for the effect of firm size since larger firms tend to have more patents[31]. We then interact the patent stock measure with the tax increase indicator or the tax decrease indicator. In columns (1) and (2), the coefficients on the interaction term are both positive and significant, suggesting that the impact of tax increases is larger for firms with a lower patent stock. In columns (3) and (4), the coefficients on the interaction term are both negative and significant, suggesting that the impact of tax decreases is also larger for firms with a lower patent stock.

Together, the results support the model's prediction that firms with less collateral either in the form of tangible assets or patent stock are more sensitive to tax changes, consistent with the pledgeable income rationale.

5.3. Tax Changes, Governance and Innovation

As Tirole (2006) explains, managers in firms with weaker corporate governance enjoy greater private benefits of control because they are not monitored and disciplined properly. As hypothesized in Section 2, a reduction in the tax rate will have a stronger impact on innovation for firms with weaker corporate governance if the additional after-tax profit increases their pledgeable income and provides them with better incentives to exert effort and innovate, rather than shirk and enjoy the private benefits of control. Also, firms with weaker corporate governance cannot raise external financing as easily because shareholders are concerned that they will not get an adequate return on their investment (Shleifer and Vishny (1997)).

To proxy for the strength of corporate governance, we use the threat of hostile takeovers that has been documented as one of the most important mechanisms through which shareholders exercise their power (Jensen (1988)). We measure the threat of hostile takeovers with the takeover index developed by Cain, McKeon, and Solomon (2016). The coverage of this takeover index (i.e., 14,441 firms from 1965 to 2011) is much better than the G-index from

[31]For robustness, we also normalize the cumulative patent count by sales and find similar results.

Gompers, Ishii, and Metrick (2003), which covers only firms in the S&P 500 index and around 900 to 1300 additional firms. The G-index is also subject to endogeneity concerns. Recent studies (Bertrand and Mullainathan (2003), Atanassov (2013)) have used largely exogenous measures such as the passage of Business Combination (BC) laws to measure the threat of hostile takeovers. Similar to the BC laws, the takeover index mainly focuses on state-level variation in the takeover environment that is largely exogenous to firm-level decisions. We use the takeover index developed by Cain, McKeon, and Solomon (2016), which is richer and more comprehensive than the BC laws alone.

The takeover index is based on the passage of 13 different types of state anti-takeover laws, one federal statue and three state standards of review.[32] To construct a comprehensive measure of a firm's takeover environment, the 17 laws and court decisions are regressed on the probability of the firm being acquired through a hostile takeover in a given year, while controlling for firm characteristics such as firm age, size, and capital liquidity. The predicted value from the best fit model is used to construct the firm-level takeover index, where higher values indicate a higher threat of hostile takeovers. For ease of interpretation, we create the variable Anti-takeoverIndex by multiplying the takeover index by -1, so that higher index values correspond to lower hostile takeover hazard, or weaker governance.

To test the governance hypothesis, we interact the tax increase and the tax decrease indicators with the Anti-takeoverIndex variable. We use the interaction term to test whether firms facing less discipline from the takeover market are impacted differentially by tax changes. The results are reported in Table VIII. We note first that the Anti-takeoverIndex is negatively related to the number of citations per patent. This finding is consistent with Atanassov (2013), which documents a significant decline in innovative output after the the passage of state anti-takeover laws.

In columns (1) and (2), the coefficients on the interaction term, TaxIncr*Anti-takeoverIndex, are negative and statistically significant at the 1% level. This finding suggests that the negative effect of tax increases on innovation is larger for firms subject to a lower hostile takeover threat, or weaker governance, consistent with the prediction that firms with more private benefits of control are harmed more by tax increases. A one standard deviation increase in the Anti-takeoverIndex (0.08) increases the negative effect of tax increases on the number of

[32]The 13 state takeover laws include first generation statutes, business combination, fair price, control share acquisition, control share cash-out, poison pill, mandatory staggered board, expanded constituency, disgorgement, anti-greenmail, golden parachute restriction, tin parachute blessing, and assumption of labor contracts laws. The state laws are matched to the firms based on their state of incorporation. The federal statue is the Williams Act in 1968, which regulates tender offers requiring SEC filings, disclosure, and waiting periods for all firms. The three standards of review are based on court decisions including Revlon, Inc. v. MacAndrews & Forbes Holdings, Unocal v. Mesa Petroleum, and Blasius Industries v. Atlas Corp.

citations per patent by 40% and 42%, 3 and 4 years into the future.

In columns (3) and (4), the coefficients on the interaction term, TaxDecr*Anti-takeoverIndex, are positive and statistically significant at the 1% level, suggesting that the positive effect of tax decreases on innovation is larger for firms subject to weaker governance. This is consistent with the prediction that firms with more private benefits of control benefit more from tax decreases. A one standard deviation increase in the Anti-takeoverIndex (0.08) increases the positive effect of tax decreases on the number of citations per patent by 67% and 67%, 3 and 4 years into the future. Thus, the evidence is consistent with the prediction that the impact of tax changes is stronger for firms with weaker governance.

5.4. Tax Changes, Tax Avoidance and Innovation

This section continues to explore the mechanisms through which taxes affect innovation by examining the interaction between state tax changes and tax avoidance. There are two opposing hypotheses. The null hypothesis states that tax changes will have a smaller impact on firms that avoid taxes more, because they are better at adjusting the effective tax rate and minimizing the tax burden. As a result, the prediction is that the interaction term between tax increases and the tax avoidance variable will be positive and the interaction term between tax decreases and the tax avoidance variable will be negative.

The alternative hypothesis states that firms that avoid taxes more are fundamentally more sensitive to tax changes. On the one hand, when tax rates go up, to preserve firm value, these firms will shift disproportionally more resources from innovative projects to dealing with tax avoidance. On the other hand, when tax rates go down, these firms will shift disproportionally more resources from dealing with tax avoidance to innovative projects. If these resources are better suited for innovative projects (if the production possibilities frontier between innovation and tax avoidance is concave), the negative impact of tax increases on innovation will be greater for firms that engage more in tax avoidance than firms that do not. Similarly, the the positive impact on innovation will be greater for firms that engage more in tax avoidance than for firms that do not. As a result, the prediction is that the interaction term between corporate income tax increases and the tax avoidance variable will be negative and the interaction term between corporate income tax decreases and the tax avoidance variable will be positive.

Following Dyreng, Hanlon, and Maydew (2008), we use the long-run cash effective tax rate to measure the degree of tax avoidance, which is based on the firm's ability to pay a low amount of cash taxes per dollar of pre-tax earnings over a long period of time. The long-run effective tax rate (ETR) is calculated as the ratio of the three-year sum (from year t-2 to t) of cash taxes paid (Compustat data item TXPD) divided by the three-year sum of pre-tax income (PI) less special items (SPI). This measure reflects all transactions that have an effect on the firm's explicit tax liability, thereby capturing both legal and more aggressive tax avoidance activities. Using this measure, Dyreng, Hanlon, and Maydew (2008) document large cross-sectional variation in tax avoidance in their sample, where one-fourth of the firms are able to maintain long-run cash effective rates below 20 percent.

To account for industry and size effects, we follow Balakrishnan, Blouin, and Guay (2012) to calculate industry and size adjusted ETR by subtracting the same year's ETR for the portfolio of firms in the same quintile of total assets and the same Fama-French 48 industry from the firm's ETR. Every year, we sort firms into terciles based on their industry and size adjusted ETRs. Our main variable that measures tax avoidance, TaxAvoid, equals one if the firm is in the bottom tercile, and zero otherwise. To test the tax avoidance hypothesis, we interact the tax increase or decrease indicator with our TaxAvoid measure. We use this interaction term to test whether firms that avoid taxes more are impacted differentially by tax changes.

The results in Table IX support the alternative hypothesis. Table IX shows that firms that avoid taxes more are more impacted by tax changes. The negative impact of tax increases on the number of citations per patent is 74% and 196% greater for firms that avoid taxes more, 3 and 4 years into the future, respectively. The positive impact of tax decreases on the number of citations per patent is 208% and 258% greater 3 and 4 years into the future, respectively. For robustness, we also use the unadjusted ETR to construct the TaxAvoid measure and find similar results. In sum, the evidence suggests that higher taxes are more detrimental to innovation for firms that engage in tax avoidance more.

6. Tax Changes and Innovation: Additional Tests for Endogeneity and Robustness Checks

6.1. Addressing Endogeneity Concerns

The changes in state corporate taxes are mostly exogenous to the innovative activity of the individual firm. There is no evidence suggesting that there is a coordinated effort by firms who experienced a decline in their innovative activity to lobby for tax reductions. Furthermore, even if there was, that would still indicate that corporate income taxes are detrimental to innovation because firms seek to lower taxes to boost their innovative output. It is also important to understand that for many of the firms in the sample, the states where firms conduct most of their operations and where they pay income taxes are different from the state where the patenting activity occurs. This adds another layer of protection from the concern that economic factors could be driving both the changes in taxes and innovation. Nevertheless, in this section, we pursue a number of strategies to further address concerns of endogeneity. For brevity, we focus on the number of citations per patent since we believe it is the more important measure of the quality of innovation (Griliches (1990), Hall, Jaffe, and Trajtenberg (2005)). Results are similar for the number of patents.

6.1.1. Controlling for Additional State-level Variables and State-specific Time Trends

We investigate a possible omitted variable bias in several ways. In Table XA, we directly control for a number of state-level variables. First, we control for changes in state capital gain tax, the state personal income tax, and the state R&D tax credit rates. State capital gain tax and personal income tax data come from Daniel Feenberg's website[33]. We obtain historical state-level R&D tax credit rates from Wilson (2009). Some states allow companies to take a tax credit against their state taxable income, which is equal to a percentage of their qualified R&D expenditures over some base amount. As documented by Wilson (2009), 32 states provide such tax credits as of 2006. In the same paper, Wilson shows that these tax incentives are effective in increasing R&D investment within the state. Thus, if the timing of R&D tax credit changes coincides with the timing of state corporate income tax changes, then our results may be attributable to R&D tax credits. Similar to the construction of our main tax measures, we create three indicator variables based on state capital gain tax changes, state personal income tax changes, and state R&D tax credit changes. The indicator variable equals to 1 if at time t state s there has been a major increase in tax rate or tax credit, equal to -1 if there has been a major decrease, and 0 otherwise. A major change is defined as greater than or equal to 1% (e.g. from 7% to 8%), as long as that change is not reverted within the next three years.[34]

Second, we control for the political affiliation of the state governor and the legislature using data from Klarner (2013). Governor Party is an indicator that equals 1 is the governor is a Democrat, -1 if the governor is a Republican, and 0 otherwise. Legislature Party is an indicator that equals 1 if Democrats control both chambers, -1 if Republicans control both

[33] http://users.nber.org/ taxsim/state-rates

[34] For robustness, we use continuous measures of the last three variables and still find that our main results are unaffected.

chambers, and 0 otherwise. The idea here is that political affiliation could be driving both tax changes and innovation.

Third, some industries may experience growth opportunities that induce them to lobby for tax changes or are spuriously correlated with tax changes for another reason. Moreover, if these industries are geographically clustered in certain locations, then it may create a non-causal correlation between state-level tax changes and corporate innovation (Lerner and Seru (2015)). To address this concern, we first exclude firms from California or Massachusetts from our analysis and find similar results. Second, we follow the methodology of Cornaggia et al. (2015) to control for state-level labor force concentration and state-level labor share, which is defined as the fraction of gross product in state i in year t that is from mining, construction, manufacturing, transportation, trade, finance, services, and government industries.[35]

These 14 state-level variables are included as additional controls in Table XA. Changes in state personal income tax and changes in state R&D tax credit have no effect on the quality of innovation, while changes in state capital gain tax have a positive effect on the number of citations per patent. Democratic governors and legislatures are associated with less innovation. More importantly, increases in state corporate tax rates continue to have a significant negative effect on the quality of innovation and decreases in state corporate tax rates continue to have a significant positive effect on the quality of innovation. The magnitudes of the effects are also similar to the baseline case, suggesting that our prior results are not driven by these additional state-level variables.

In Table XB, we control for additional time-varying state characteristics through state-specific time trends. In addition, we control for industry-year fixed effects to account for any time-varying industry characteristics such as changes in growth opportunities. The main effects of tax increases and decreases still remain, suggesting that the documented relations are not driven by state-specific time trends and time-varying industry factors.

6.1.2. Falsification Test using Neighboring States

To further address concerns of omitted variables, we conduct a falsification test based on Heider and Ljungqvist (2014) by comparing the effect of tax changes on neighboring states and the firms' own state in Table XC. The idea is that, if some local economic conditions are driving our results, these conditions likely affect both the state in question and its neighboring

[35] To see the rationale behind these measures consider the mining industry for instance. If the mining industry is experiencing a sudden growth in product opportunities and the industry is concentrated in Wyoming, West Virginia, and Kentucky, then mining firms in these states may lobby for tax decreases, which creates a positive correlation between tax decreases and innovation that is caused by growth opportunities.

states.[36] Thus, if tax changes in neighboring states have similar effects as tax changes in the firm's own state, then results are likely due to common economic conditions rather than tax changes. It is worth noting that, the test does not rely on firms on either side of the border to be randomly distributed. It takes as given that firms are already residing in the state of their choice for whatever reason and ask if firms in that state experience a tax change, how does this change affect firms in neighboring states.

As seen in Table XC, the coefficients on the tax increase and tax decrease indicators are significant and have the same signs as in the baseline case. At the same time, tax increases in neighboring states have a positive and significant effect on the firm's number of citations per patent, while tax decreases in neighboring states have a negative and significant effect on the firm's number of citations per patent. Since tax changes in neighboring states have opposite effects as tax changes in the firm's own state, the evidence is not consistent with unobserved region-specific economic conditions common to neighboring states driving both innovation and tax changes.

Instead, the opposite impact of tax changes in neighboring states is indicative of a competition effect. Take the case of tax decreases in neighboring states, for instance. Firms in those states will have higher pledgeable income and are more likely to attract additional investment, time and effort from their stakeholders. Financiers are likely more willing to invest in firms with higher after-tax profits. Talented individuals are also more likely to move to, or stay in firms operating in states with lower tax rates if their incentives are affected by after-tax profits. As a result, when the neighboring states of the focal state s have tax decreases, firms in the focal state s experience a reduction in innovative output due to higher relative financing costs and a net outflow of talented workers. It is worth noting that although tax changes in the firm's own state and the neighboring states have opposite effects, the two effects do not completely cancel out, so the overall effect still remains.

An alternative way to conduct the test is to examine pairs of firms straddled along neighboring counties across state borders motivated by the idea that they are subject to the same local economic conditions, but different state tax regimes. However, this test has an important caveat. As implemented by Mukherjee et al. (2016), location is based on the county of the firm's headquarters. This overlooks the fact that for many firms the location of the headquarters is not where the firm's major operations are located and most firms operate in multiple states, thus subject to economic conditions elsewhere. Therefore, the premise that

[36]As described in Heider and Ljungqvist,"if tax changes are driven by unobserved changes in local economic conditions (besides the ones already controlled), then both firms in treated states and their neighbors in untreated states just across the state border will spuriously appear to react to the tax change, as long as economic conditions, unlike state tax law, have a tendency to spill across state borders".

firms headquartered in neighboring counties across state borders are subject to the same local economic conditions is likely not met. Ideally, one would examine firms with operations only in one state and straddled across state borders. However, this condition would result in a very small sample that is not necessarily representative of the overall firm population and the test based on this sample would have very low power. Due to these concerns, we pursue a falsification test based on neighboring states, which is not perfect, but has higher power and is based on the entire firm population.

6.1.3. Instrumental Variable Analysis

To further alleviate endogeneity concerns, we conduct an instrumental variable analysis. We use interactions based on oil prices, the historical sensitivity of state revenue to oil prices, and a measure of the strength of state balanced-budget rules (ACIR index) as instruments. The idea is that depending on the state's balanced budget stringency, states may change their tax rates when their revenues change due to an exogenous shock such as changes in oil prices.[37]

Oil prices are measured as inflation-adjusted OPEC crude oil prices in year t. The historical sensitivity of state revenue to oil prices is estimated by using data from the 1960-1987 period, prior to the start of our sample. State revenue data come from the State Politics and Policy Website[38]. We regress state revenue on oil prices for each state using the observations from 1960 to 1987, where the coefficient on oil prices is our estimate of the sensitivity of state revenue to oil prices.

The ACIR index is the Advisory Council on Intergovernmental Relations (1987) index of budget stringency, which rates the stringency of balanced budget rules for each state, ranging from 0 (lax) to 10 (stringent). Although the index is constructed based on data from 1984, there have been virtually no changes in states' requirements during the subsequent years. The index is composed of five types of balanced budget requirements: the governor has to submit a balanced budget; the legislature has to pass a balanced budget; the state may carry over a deficit but must correct it in the subsequent budget period; the state may not carry over a deficit into the next budget period; and the state may not carry over a deficit into the next fiscal year. If the restriction is written in the constitution, then the value is 2, otherwise it is 1.

Of the three variables above, the sensitivity of state revenue to oil prices and the stringency of balanced budget rules could be influenced by the state's economic and political environment.

[37]We thank our NBER discussant Austan Goolsbee for suggesting this idea.
[38]http://www.indstate.edu/polisci/klarnerpolitics.htm

Thus, we control for these two variables and their interaction (OilSensitivity*ACIR) in the first and second stage regressions, and do not use them as instruments.[39]

However, oil prices are outside of the control of the individual state and can be considered as exogenous. Thus, our instruments for tax changes are oil prices, the interaction between oil prices and the historical sensitivity of state revenue to oil prices, the interaction between oil prices and the ACIR index, and the triple interaction between oil prices, the historical sensitivity of state revenue to oil prices, and the ACIR index. Since oil prices are collinear with year fixed effects, only the other three instruments are used in the first stage regression.

The results from the instrumental variable regressions are reported in Table XD. In the first stage, the tax variables are regressed on the three instruments and controls. The F-statistics of the instruments suggest that we do not have a weak instrument problem. In the second stage, the number of citations per patent is regressed on the instrumented tax variables and the same set of controls. The results show that tax increases have a significant negative effect on innovation quality, tax decreases have a significant positive effect, and tax changes have a significant negative effect. While the coefficients on tax increases are larger than the baseline case, the magnitudes of the coefficients on tax decreases and tax changes are similar to the ones from the OLS regressions. These findings, together with the previous results in this section, provide greater confidence that our results do not suffer from endogeneity biases.

6.1.4. Analysis based on Non-Moving Firms

We already conduct a dynamic analysis of the impact of tax changes on corporate innovation in Table IV to address concerns of reverse causality. The results suggest that the impact on innovation comes two or more years after the tax change, with no evidence of a pre-existing trend. In addition, in this section we address the concern that firms planning to engage in innovative activities may choose to move to certain states following, or in anticipation of, tax changes. Specifically, we conduct the main tests on a sample of firms that do not change their most mentioned state during the entire sample period, thus alleviating concerns of endogenous state moves. The results are presented in Table XE. Although the sample size is smaller due to the restriction, the coefficients on the tax increase indicator are still negative and significant and the coefficients on the tax decrease indicator are still positive and significant. The estimates also have larger magnitudes than the baseline results, suggesting that the main documented effects are not driven by this alternative explanation.

[39]Since these variables (OilSensitivity, ACIR, OilSensitivity*ACIR) are collinear with state/firm fixed effects, we cannot directly estimate and report their coefficients.

6.1.5. Controlling for Merger and Acquisition Activities

Another alternative explanation may suggest that our results are not due to firms creating more patents on their own, but rather acquiring other firms with patents. In Table XF, we test this story in two ways. First, we control for the firms' merger and acquisition activities in the year, in which innovation is recorded. Second, we run regressions only on observations of firms with no mergers or acquisitions. In both tests, the key coefficients on tax increases and decreases remain significant and similar to the baseline case.

6.1.6. Anticipating Tax Changes Based on Tax Changes in Neighboring States

Another alternative story for our results is that firms observe tax changes in neighboring states and anticipate similar changes in their own states, thus withholding innovation until tax changes are implemented. Since the innovation lag is highly uncertain, it would require that managers possess a great predictive power to time the tax change and the resulting innovation. The premise of this story is that firms can predict tax changes in their own states based on tax changes in neighboring states. We test this premise in the Internet Appendix Table IA.2. The results show that tax changes in state s are unrelated to tax changes in the neighboring states. This finding does not support the alternative story and further corroborates our hypothesis of a causal impact of tax changes on innovation.

6.2. Additional Tests for the Most Relevant State

In this subsection, we conduct additional robustness analysis to ensure that our results are not driven by the definition of the most relevant state. We start with the observation that many firms operate in multiple states. As described earlier, we use state count information from 10-K reports to identify the most relevant state for a firm in terms of the burden of corporate income taxes. In this section, we examine the validity of this definition by relating the amount of total state taxes paid to tax changes in the most mentioned state. If the identified state is indeed important for tax purposes, then we should expect to see a significant negative relation between tax decreases in that state and the total state taxes paid, and a positive relation between tax increases in that state and the total state taxes paid.

The results in Table XIA confirm this prediction. The coefficient in column (1) suggests that on average tax increases raise total state taxes paid by 16.8%, evaluated at the state taxes paid to pre-tax income ratio for the average firm of 2.74%. Similarly, the coefficient in column (2) suggests that on average tax decreases reduce the total state taxes paid by 20.3%.

By the same rationale, we should not expect to see a significant relation between total state taxes paid and tax changes in the least mentioned state if using state counts to identify the location of businesses is valid. We find results consistent with this prediction in columns (3) and (4) of Table XIA, providing additional support for our identification of the most relevant state.

Moreover, we perform several robustness checks for the identification of the most relevant state in Table XIB. In the main analysis, we use the most mentioned state over the 1988-2006 period, so there is one corresponding state per firm and it does not vary over time. For robustness, we identify the most mentioned state for each firm-year and continue to find a similar and significant relation between tax changes in the time-varying most mentioned state and the number of citations per patent.

As another robustness check, instead of the single top most mentioned state, we look at the top three most mentioned states and define the tax variable to be one if there is a significant tax change in any of the top-three most mentioned states in which the firm operates. Alternatively, instead of using the single most mentioned state based on the 10-K reports, we use all states that are mentioned at least 30% of the times on average. As seen in Table XIB, our main findings are robust to using multiple states, rather than the top most mentioned state.

We also restrict the sample to firms with fewer than three equivalent states, where the number of equivalent states is calculated as one divided by the Herfindahl Index of state distribution for each firm. The rationale behind this is that if a firm operates only in a small number of states, the impact of tax changes will be more significant than if the firm's operations are spread out in many states. Consistent with this idea, we find that the coefficients are not only significant, but also larger than those in the main analysis.

Finally, we use alternative definitions of the most relevant state based on the headquarters, the locations of patent grants, and subsidiary locations and find similar results.[40] As another robustness check, we also restrict the sample to firms that have the same headquarter as the most mentioned state.

Together, the analyses in this section provide strong support for our identification of the most relevant state and confirm the robustness of our main findings.

[40] Historical headquarter location comes from Compact Disclosure and parsed 10K data from Bill McDonald's website. Patent location data come from NBER, where we identify the most relevant state as the state where most of the firm's patents are assigned. The number of observations is smaller for this sample because patent location is only available for firms with at least one patent in a given year. Firms' subsidiaries information comes from Exhibit 21 of the 10-K reports collected by Dyreng and Lindsey (2009). Using this data, we identify the most relevant state as the state with the highest number of subsidiaries.

6.3. Other Robustness Checks

We conduct a series of robustness checks in the Internet Appendix Table IA.1 to document that our results are robust to subsample analysis, different clustering, and variable definitions. We perform several subsample analysis. First, we restrict the treatment group sample (firms that experience a tax change) to five years before and after the tax change. Second, we exclude non-innovative firms (i.e., firms with no patent during the entire sample period). Third, we end the sample in 2003 rather than 2006 to account for the increased patent citation truncation bias during the 2003-2006 period.

In the main analysis, we cluster the standard errors by firm. For robustness, we also cluster the standard errors by year, or by the state of location. In addition, we cluster standard errors by both firm and year, which accounts for correlations among different firms in the same year and different years in the same firm. Similarly, we also cluster standard errors by both state of location and year. To further address concerns of serial correlation, we also run regressions at the state-year level and find similar results.

Next, instead of using the number of citations per patent, we use different variable definitions for our dependent variables. First, we use the fixed effects methodology that controls for truncation and construct a measure of innovation that purges the citations per patent measure from time fixed effects and only compares patents applied for in the same year. Second, we construct another measure of innovation that purges the citations per patent measure from both time and technology class fixed effects. It controls for the fact that different technology classes have different propensity to patent their innovations and to be cited subsequently. Third, we also use the truncation adjusted citations per patent measure created by using a quasi-structural model to estimate the citations lag (Hall et al. (2001)).

6.4. Tax Changes and R&D Expenditures

As we discuss in our theoretical model, state income taxes can affect the incentives of various stakeholders to increase their investment of time, effort and money into the innovative process. There are several inputs in the creation of innovation. Some of them, such as R&D expenditures are observable and easier to measure. Others, such as creativity, time and work effort are mostly unobservable. In this section, we examine if the impact of tax rates on innovative output is transmitted through R&D expenditures or other unobservable inputs.

We test this prediction in Internet Appendix Table IA.4, where the dependent variable is R&D expenditures divided by total assets. The dependent variable is measured a year later than the explanatory variables. The results indicate that tax changes are largely unrelated to R&D expenditures. This finding is also consistent with Ljungqvist, Zhang, and Zuo (2016), who find that firms do not change their R&D spending in response to state corporate income tax changes.

This evidence suggests that taxes likely affect innovation through unobservables such as creativity and effort to innovate rather than through the amount spent on R&D. These findings also underline the importance of studying the quantity and quality of innovation rather than only looking at one input such as R&D expenses. One possible explanation for this result is that R&D expenditures are deducted from the taxable income and in addition firms receive R&D tax credits.

7. Conclusion

This paper presents new evidence on the impact of corporate income taxes on the quantity and quality of innovation. We show that significant tax increases reduce innovation, while significant tax decreases increase innovation. Exploring the channels, we find that tax changes have a larger impact on innovation for firms that are more financially constrained, firms with smaller collateral, and for firms that have weaker corporate governance and firms that avoid taxes more. Our results are confirmed after a battery of additional endogeneity checks and robustness tests. These findings suggest that, by affecting firms' pledgeable income, corporate income tax policies can significantly affect firms' incentives to innovate and therefore have strong implications on long-term firm performance and economic growth.

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Appendix: Variable Definitions

1. *ACIR Index*$_s$: The Advisory Council on Intergovernmental Relations (1987) index of budget stringency, which rates the stringency of balanced budget rules for each state, ranging from 0 (lax) to 10 (stringent). The index is composed of five types of balanced budget requirements: the governor has to submit a balanced budget; the legislature has to pass a balanced budget; the state may carry over a deficit but must correct it in the subsequent budget period; the state may not carry over a deficit into the next budget period; and the state may not carry over a deficit into the next fiscal year. If the restriction is written in the constitution, then the value is 2, otherwise it is 1.

2. *Age*$_{it}$: Age of firm i in year t based on the years in the Compustat sample (Source: Compustat).

3. *Anti-takeoverIndex*$_{it}$: The firm-level takeover index developed by Cain, McKeon, and Solomon (2016), which is constructed based on the passage of 13 different types of state takeover laws, one federal statue and three state standards of review. The original takeover index is multiplied by -1, so that higher values indicate lower hostile takeover hazard (Source: Steve McKeon's website).

4. *Citations/Patent*$_{it}$: The number of citations per patent applied for in year t by firm i (Source: NBER Patent Data).

5. *WWFinConstraint*$_{it}$: An indicator variable equal to 1 if the firm is in the top tercile of the yearly Whited and Wu (WW) (2006) index, and 0 otherwise. WW Index is constructed following Whited and Wu (2006) and Hennessy and Whited (2007) as

$$-0.091 \times \frac{ib_t + dp_t}{at_t} - 0.062 \times I(dvc_t + dvp_t > 0) + 0.021 \times \frac{dltt_t}{at_t} - 0.044 \times log(at_t) + 0.102 \times salesgrowth_{3sic} - 0.035 \times salesgrowth$$

where sales growth is the annual percentage increase in sales and $salesgrowth_{3sic}$ is the average industry sales growth for each 3-digit SIC industry and year. (Source: Compustat).

6. *KZFinConstraint*$_{it}$: An indicator variable equal to 1 if the firm is in the top tercile of the yearly Kaplan and Zingales (KZ) (1997) index, and 0 otherwise. KZ Index is constructed as

$$-1.0019 \times \frac{ib_t + dp_t}{ppent_{t-1}} + 0.2826 \times \frac{at_t + prccf_t csho_t - ceq_t - txdb_t}{at_t} + 3.1391 \times \frac{dltt_t + dlc_t}{dltt_t + dlc_t + seq_t} - 39.3678 \times \frac{dvc_t + dvp_t}{ppent_{t-1}} - 1.3147 \times \frac{che_t}{ppent_{t-1}}$$

(Source: Compustat).

7. *HPFinConstraint*$_{it}$: An indicator variable equal to 1 if the firm is in the top tercile of the yearly Hadlock and Pierce (HP) (2010) index, and 0 otherwise. HP Index is constructed as $-0.737 \times size + 0.043 \times size^2 - 0.040 \times age$, where size is the log of inflation-adjusted total assets, capped at the log of 4.5 billion, and age is the number of years the firm is listed with a non-missing stock price on Compustat, capped at 37 years. (Source: Compustat).

8. *Herfindahl*$_{it}$: Herfindahl index of firm i in year t constructed based on sales at both a 4 digit SIC and for robustness for the Fama and French (1997) *48* industries (Source: Compustat; Kenneth French's web site).

9. *Leverage*$_{it}$: Total Debt of firm i in year t divided by Total Assets, where Total Debt = Short-term Debt + Long-term Debt (Source: Compustat).

10. *OilPrice*$_t$: The inflation-adjusted OPEC crude oil prices in year t (Source: www.opec.org).

11. *OilSensitivity*$_s$: State revenue is regressed on oil prices for each state using the observations from 1960 to 1987, where the coefficient on oil prices is our estimate of the historical sensitivity of state revenue to oil prices. (Source: State Politics and Policy Website (http://www.indstate.edu/polisci/klarnerpolitics.htm) for state revenue data).

12. *Patent*$_{it}$: Count of the number of patents in application year t by firm i (Source: NBER Patent Data).

13. *Profitability*$_{it}$: Earnings Before Interest Depreciation Taxes and Amortization (*EBIDTA*) of firm i in year t divided by Total Assets (Source: Compustat).

14. *RD/TA*$_{it}$: R&D Expenditure (*XRD*) of firm i in year t divided by Total Assets (Source: Compustat).

15. *RealGDP*$_{st}$: State level real GDP in state s and year t (Source: Cleveland Federal Reserve and the Bureau of Economic Analysis).

16. *Sales*$_{it}$: Net Sales of firm i in year t (in $ million) (Source: Compustat).

17. $\frac{StateTaxes}{PretaxIncome}{}_{it}$: State Taxes (*TXS*) of firm i in year t divided by Pretax Income (*PIDOM* or *PI* if missing) (Souce: Compustat).

18. $Tangibility_{it}$: Net property plant and equipment ($PPENT$) of firm i in year t divided by Total Assets (Source: Compustat).

19. $TaxAvoid_{it}$: An indicator variable equal to 1 if the firm is in the bottom tercile of the yearly industry and size adjusted cash effective tax rate (ETR), and 0 otherwise. Industry and size adjusted ETR is calculated by substracting the same year's three-year ETR for the portfolio of firms in the same quintile of total assets and the same Fama-French 48 industry from the firm's ETR. ETR is the ratio of the three-year sum (from year t-2 to t) of cash taxes paid ($TXPD$) divided by the three-year sum of pre-tax income (PI) less special items (SPI) (Source: Compustat).

20. $TaxChg_{st}$: An indicator variable equal to 1 if there has been a significant tax increase of at least 1% in the largest state of business of firm i in year t, equal to -1 if there has been a significant tax decrease of at least 1% in the largest state of business of firm i in year t, and 0 otherwise. The tax variable equals 1 or -1 in the year of the change and all subsequent years unless the tax rate is reverted back to the level before the change.

21. $TaxIncr_{st}$: An indicator variable equal to 1 if there has been a significant tax increase of at least 1% in the largest state of business of firm i in year t, and 0 otherwise. The tax variable equals 1 in the year of the change and all subsequent years unless the tax rate is reverted back to the level before the change.

22. $TaxDecr_{st}$: An indicator variable equal to 1 if there has been a significant tax decrease of at least 1% in the largest state of business of firm i in year t, and 0 otherwise. The tax variable equals 1 in the year of the change and all subsequent years unless the tax rate is reverted back to the level before the change.

23. $UnemployRate_{st}$: State level unemployment rate in state s and year t. (Source: Cleveland Federal Reserve).

Table I:
Significant Changes in State Corporate Income Tax Rates from 1988 to 2006

State	Year of Tax Increase	Year of Tax Decrease
Alabama	2001	
Arizona		1999
Connecticut		1999
Kentucky		2005
Missouri	1990	
Nebraska	1991	
New Hampshire	1999	1994
New York	1990	2000
North Carolina	1991	
North Dakota		2005
Oklahoma	1990	
Pennsylvania	1991	1995
Rhode Island	1989	
South Carolina		1989
Vermont	1997	

Table II:
Summary Statistics

This table reports summary statistics for the key variables used in the analysis. The sample period is from 1988 to 2006. Patent information comes from the NBER patent dataset provided by Hall, Jaffe, and Trajtenberg (2001). This dataset includes the number of patents by each firm and the number of citations received by each patent. We select all U.S. public firms from the NBER patent file, which have financial data available in the S&P's Compustat database. Firms in the financial (SIC=6) , utilities (SIC=49), and public (SIC=9) sectors are excluded. We also include all the firms in Compustat which operate in the same SIC industries as the firms in the patent database, but do not have patents.

Variable	**Mean**	**Standard Deviation**
Patents	5.0986	54.8300
Citations per Patent	2.0893	7.9557
TaxChg	0.0001	0.3889
TaxIncr	0.0757	0.2645
TaxDecr	0.0756	0.2643
LnSales	4.4031	2.5048
RD/TA	0.0767	0.3264
Leverage	0.2647	0.3147
Profitability	-0.0753	10.0679
Tangibility	0.2694	0.2243
Age	12.5795	10.8329
Herfindahl Index	0.2217	0.1723
LnRealGDP	12.7924	0.9962
UnemployRate	5.5625	1.4603
StateTaxes/PretaxIncome (%)	2.7443	5.9722
WWFinConstraint	0.3406	0.4739
KZFinConstraint	0.3281	0.4695
HPFinConstraint	0.3230	0.4676
TaxAvoid	0.3002	0.4584
OilPrice	16.0935	5.7490
ACIR Index	7.9189	2.6328
OilSensitivity	0.3884	0.3210
Anti-takeoverIndex	-0.0685	0.0830

Table IIIA:
Tax Changes and the Number of Patents

This table reports the results relating the number of patents to tax changes. Specifically we estimate the OLS model of *Ln(1+Patent)* on one of the three tax variables. *TaxIncr* is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise. *TaxDecr* is an indicator variable equal to 1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. *TaxChg* is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, equal to -1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1{+}Patent)_{t+3}$	$Ln(1{+}Patent)_{t+4}$	$Ln(1{+}Patent)_{t+3}$	$Ln(1{+}Patent)_{t+4}$	$Ln(1{+}Patent)_{t+3}$	$Ln(1{+}Patent)_{t+4}$
	(1)	(2)	(3)	(4)	(5)	(6)
TaxIncr	-0.032*	-0.047**				
	(0.019)	(0.023)				
TaxDecr			0.081***	0.106***		
			(0.031)	(0.039)		
TaxChg					-0.038**	-0.052***
					(0.016)	(0.020)
LnSales	0.016***	0.008	0.016***	0.008	0.016***	0.008
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
RD/TA	0.018**	0.016*	0.018**	0.016*	0.018**	0.016*
	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)
Leverage	-0.064***	-0.073***	-0.064***	-0.074***	-0.064***	-0.073***
	(0.013)	(0.014)	(0.013)	(0.014)	(0.013)	(0.014)
Profitability	-0.001	-0.002***	-0.001	-0.002***	-0.001	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.176***	0.246***	0.178***	0.248***	0.177***	0.248***
	(0.035)	(0.041)	(0.035)	(0.041)	(0.035)	(0.041)
Age	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.799***	0.856***	0.802***	0.860***	0.801***	0.859***
	(0.170)	(0.204)	(0.170)	(0.204)	(0.170)	(0.204)
Herfindahl^2	-0.771***	-0.814***	-0.773***	-0.817***	-0.772***	-0.817***
	(0.175)	(0.202)	(0.175)	(0.202)	(0.175)	(0.202)
LnRealGDP	0.146	0.150	0.187*	0.202	0.174	0.187
	(0.113)	(0.135)	(0.112)	(0.133)	(0.112)	(0.134)
UnemployRate	0.005	0.007	0.007	0.009	0.007	0.008
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529	7,886	7,529
R-squared	0.766	0.742	0.719	0.696	0.719	0.696

Table IIIB:
Tax Changes and the Number of Citations per Patent

This table reports the results relating the number of citations per patent to tax changes. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on one of the three tax variables. *TaxIncr* is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise. *TaxDecr* is an indicator variable equal to 1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. *TaxChg* is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, equal to -1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)	(5)	(6)
TaxIncr	-0.072***	-0.067***				
	(0.023)	(0.022)				
TaxDecr			0.096***	0.087***		
			(0.027)	(0.025)		
TaxChg					-0.058***	-0.053***
					(0.016)	(0.015)
LnSales	-0.012**	-0.013**	-0.012**	-0.013**	-0.012**	-0.013**
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
RD/TA	0.017	0.018	0.017	0.018	0.017	0.018
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Leverage	-0.042***	-0.047***	-0.043***	-0.048***	-0.043***	-0.048***
	(0.015)	(0.014)	(0.015)	(0.014)	(0.015)	(0.014)
Profitability	-0.002**	-0.001	-0.002**	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.182***	0.181***	0.183***	0.182***	0.184***	0.183***
	(0.036)	(0.038)	(0.036)	(0.037)	(0.036)	(0.037)
Age	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.578***	0.474**	0.580***	0.476**	0.581***	0.477**
	(0.192)	(0.191)	(0.191)	(0.191)	(0.191)	(0.191)
Herfindahl^2	-0.634***	-0.532***	-0.636***	-0.534***	-0.636***	-0.534***
	(0.195)	(0.193)	(0.194)	(0.193)	(0.194)	(0.193)
LnRealGDP	0.088	0.135	0.122	0.165	0.121	0.165
	(0.134)	(0.138)	(0.134)	(0.138)	(0.134)	(0.138)
UnemployRate	0.004	0.002	0.006	0.003	0.005	0.003
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529	7,886	7,529
R-squared	0.552	0.548	0.552	0.547	0.552	0.548

Table IV:
Tax Changes and the Number of Citations per Patent: Dynamics

This table reports the results relating the number of citations per patent to the dynamics of tax changes. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxVarMinus2*, which is an indicator variable equal to 1 if there is a significant tax change in year t+2 in the largest state of business of firm i, and 0 otherwise, on *TaxVarMinus1*, which is an indicator variable equal to 1 if there is a significant tax change in year t+1 in the largest state of business of firm i, and 0 otherwise, on *TaxVarZero*, which is an indicator variable equal to 1 if there is a significant tax change in year t in the largest state of business of firm i, and 0 otherwise, *TaxVarPlus1*, which is an indicator variable equal to 1 if there is a significant tax change in year t-1 in the largest state of business of firm i, and 0 otherwise, and on *TaxVarPlus2andMore*, which is an indicator variable equal to 1 if there is a significant tax change in year t-2 or earlier in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_t$	$Ln(1+\frac{Citations}{Patent})_t$	$Ln(1+\frac{Citations}{Patent})_t$
	(1)	(2)	(3)
TaxVar:	TaxIncr	TaxDecr	TaxChg
TaxVarMinus2	0.024	-0.005	0.015
	(0.042)	(0.029)	(0.022)
TaxVarMinus1	-0.013	0.012	0.007
	(0.040)	(0.030)	(0.020)
TaxVarZero	0.028	0.028	0.015
	(0.041)	(0.033)	(0.021)
TaxVarPlus1	-0.042	0.055	-0.030
	(0.038)	(0.035)	(0.021)
TaxVarPlus2andMore	-0.066**	0.119***	-0.067***
	(0.026)	(0.038)	(0.017)
LnSales	0.006	0.006	0.006
	(0.005)	(0.005)	(0.005)
RD/TA	0.003	0.004	0.004
	(0.004)	(0.004)	(0.004)
Leverage	-0.040***	-0.040***	-0.040***
	(0.013)	(0.013)	(0.013)
Profitability	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Tangibility	0.144***	0.145***	0.145***
	(0.032)	(0.032)	(0.032)
Age	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Herfindahl	0.802***	0.803***	0.806***
	(0.167)	(0.167)	(0.167)
Herfindahl^2	-0.832***	-0.831***	-0.835***
	(0.172)	(0.171)	(0.171)
LnRealGDP	0.147	0.199*	0.169
	(0.115)	(0.112)	(0.112)
UnemployRate	0.014**	0.016***	0.017***
	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	88,207	88,207	88,207
N. of Firms	8,435	8,435	8,435
R-squared	0.560	0.559	0.560

Table V: Tax Signals

This table tests the robustness of the tax signals. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr* or *TaxDecr*. In panel A, we examine unanticipated tax changes by excluding firms located in New England states, where the null hypothesis of state corporate income taxes following a random walk is rejected. In panel B, we define the tax increase and decrease indicators based on exogenous tax changes that are passed independent of local economic conditions using a narrative approach. In Panel C, we use the original major tax changes of 1% or greater, but also include short-term reversals within three years. In Panel D, we create the tax increase and decrease indicators based on major tax changes of 0.5% or greater instead of 1% or greater. The same set of controls from Table III is included. All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
Panel A: Unanticipated tax changes				
TaxIncr	-0.069***	-0.063***		
	(0.024)	(0.023)		
TaxDecr			0.101***	0.095***
			(0.028)	(0.026)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	69,046	64,592	69,046	64,592
N. of Firms	7,341	7,009	7,341	7,009
Panel B: Exogenous tax changes according to the narrative approach				
TaxIncr	-0.083***	-0.074***		
	(0.029)	(0.028)		
TaxDecr			0.108***	0.100***
			(0.030)	(0.028)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
Panel C: Tax changes including short-term reversals				
TaxIncr	-0.061***	-0.054**		
	(0.023)	(0.022)		
TaxDecr			0.093***	0.085***
			(0.026)	(0.025)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
Panel D: Tax changes of 0.5% or greater				
TaxIncr	-0.045**	-0.042**		
	(0.020)	(0.020)		
TaxDecr			0.102***	0.096***
			(0.026)	(0.024)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529

Table VIA:
Tax Changes, Financial Constraints and Innovation

This table examines the role of financial constraints. We estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1 (0 otherwise), if there has been a significant tax increase in the largest state of business of firm i, or *TaxDecr*, which is an indicator variable equal to 1 (0 otherwise), if there has been a significant tax decrease in the largest state of business of firm i, and its interaction with WWFinConstraint, which is an indicator variable equal to 1 (0 otherwise) if the firm is in the highest tercile of the Whited and Wu (2006) financial constraint index. KZFinConstraint, which is an indicator variable equal to 1 (0 otherwise) if the firm is in the highest tercile of the Kaplan and Zingales (1997) financial constraint index. HPFinConstraint, which is an indicator variable equal to 1 (0 otherwise) if the firm is in the highest tercile of the Hadlock and Pierce (2010) financial constraint index. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

Panel A: Using the Whited and Wu (2006) Measure of Financial Constraints

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.060**	-0.045*		
	(0.028)	(0.027)		
TaxIncr*WWFinConstraint	-0.018	-0.059**		
	(0.029)	(0.026)		
TaxDecr			0.061**	0.049*
			(0.031)	(0.029)
TaxDecr*WWFinConstraint			0.084***	0.094***
			(0.027)	(0.025)
WWFinConstraint	-0.038***	-0.044***	-0.046***	-0.056***
	(0.008)	(0.008)	(0.008)	(0.008)
LnSales	-0.012*	-0.016**	-0.011*	-0.016**
	(0.006)	(0.007)	(0.006)	(0.007)
RD/TA	0.009	0.005	0.009	0.005
	(0.010)	(0.010)	(0.010)	(0.010)
Leverage	-0.035**	-0.041**	-0.037**	-0.043***
	(0.017)	(0.016)	(0.017)	(0.016)
Profitability	-0.001	-0.002	-0.001	-0.002
	(0.001)	(0.002)	(0.001)	(0.002)
Tangibility	0.204***	0.186***	0.206***	0.188***
	(0.040)	(0.041)	(0.040)	(0.041)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.576***	0.476**	0.586***	0.485**
	(0.202)	(0.199)	(0.202)	(0.199)
Herfindahl^2	-0.638***	-0.527***	-0.647***	-0.535***
	(0.203)	(0.200)	(0.203)	(0.200)
LnRealGDP	0.138	0.156	0.170	0.182
	(0.142)	(0.146)	(0.142)	(0.146)
UnemployRate	0.006	0.002	0.007	0.004
	(0.006)	(0.006)	(0.007)	(0.007)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	68,584	64,158	68,584	64,158
N. of Firms	7,451	7,021	7,451	7,021
R-squared	0.557	0.554	0.557	0.554

Panel B: Alternative Measures of Financial Constraints

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
Using the Kaplan and Zingales (1997) Measure of Financial Constraints				
TaxIncr	-0.070**	-0.056**		
	(0.028)	(0.028)		
TaxIncr*KZFinConstraint	-0.034	-0.046*		
	(0.027)	(0.027)		
TaxDecr			0.073**	0.063**
			(0.030)	(0.029)
TaxDecr*KZFinConstraint			0.069***	0.070***
			(0.026)	(0.025)
KZFinConstraint	-0.024***	-0.021**	-0.031***	-0.029***
	(0.008)	(0.009)	(0.009)	(0.009)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	62,721	58,665	62,721	58,665
N. of Firms	7,152	6,766	7,152	6,766
Using the Hadlock and Pierce (2010) Measure of Financial Constraint				
TaxIncr	-0.047*	-0.036		
	(0.027)	(0.026)		
TaxIncr*HPFinConstraint	-0.082**	-0.103***		
	(0.034)	(0.033)		
TaxDecr			0.061**	0.059**
			(0.031)	(0.030)
TaxDecr*HPFinConstraint			0.139***	0.115***
			(0.037)	(0.037)
HPFinConstraint	-0.033**	-0.031**	-0.047***	-0.046***
	(0.015)	(0.015)	(0.015)	(0.015)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529

Table VIB: Tax Changes, Firm Size and Innovation

This table examines the role of firm size. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise, and its interaction with *Ln(Sales)*. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.179***	-0.181***		
	(0.043)	(0.042)		
TaxIncr*LnSales	0.024**	0.025***		
	(0.010)	(0.009)		
TaxDecr			0.316***	0.280***
			(0.049)	(0.049)
TaxDecr*LnSales			-0.044***	-0.038***
			(0.010)	(0.010)
LnSales	-0.013**	-0.015***	-0.009	-0.011*
	(0.006)	(0.006)	(0.006)	(0.006)
RD/TA	0.017	0.018	0.017	0.019
	(0.014)	(0.014)	(0.014)	(0.014)
Leverage	-0.042***	-0.047***	-0.045***	-0.049***
	(0.015)	(0.014)	(0.015)	(0.014)
Profitability	-0.002**	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.183***	0.182***	0.187***	0.185***
	(0.036)	(0.037)	(0.036)	(0.037)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.581***	0.477**	0.588***	0.481**
	(0.192)	(0.191)	(0.191)	(0.191)
Herfindahl^2	-0.638***	-0.536***	-0.646***	-0.541***
	(0.195)	(0.193)	(0.194)	(0.193)
LnRealGDP	0.094	0.141	0.101	0.147
	(0.135)	(0.139)	(0.134)	(0.138)
UnemployRate	0.004	0.002	0.005	0.003
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
R-squared	0.552	0.547	0.553	0.548

Table VII:
Tax Changes, Collateral and Innovation

This table examines the role of collateral. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise, and its interaction with Intangibile in Panel A or Patent Stock in Panel B. Intangibile is an indicator variable equal to 1 if the firm is in the lowest tercile of the tangibility measure (PPENT/AT), and 0 otherwise. Patent Stock is the total number of patents the firm has created in the last twenty years from year t-19 to year t, divided by total assets in year t. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

Panel A: Interactions with Intangible Assets

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.050*	-0.050**		
	(0.026)	(0.025)		
TaxIncr*Intangible	-0.083**	-0.061*		
	(0.033)	(0.031)		
TaxDecr			0.067**	0.062**
			(0.029)	(0.028)
TaxDecr*Intangible			0.130***	0.113***
			(0.032)	(0.032)
Intangible	0.001	-0.003	-0.013	-0.015
	(0.011)	(0.012)	(0.012)	(0.012)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
R-squared	0.552	0.548	0.552	0.548

Panel B: Interactions with Patent Stock

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.094***	-0.088***		
	(0.022)	(0.022)		
TaxIncr*Patent Stock	0.226***	0.211***		
	(0.057)	(0.053)		
TaxDecr			0.137***	0.121***
			(0.025)	(0.024)
TaxDecr*Patent Stock			-0.333***	-0.275***
			(0.061)	(0.060)
Patent Stock	-0.270***	-0.277***	-0.233***	-0.245***
	(0.031)	(0.031)	(0.031)	(0.030)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
R-squared	0.557	0.552	0.556	0.552

Table VIII:
Tax Changes, Governance and Innovation

This table examines the role of corporate governance. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise, and its interaction with the Anti-takeoverIndex, which is developed by Cain, McKeon, and Solomon (2016) constructed based on the passage of 13 different types of state takeover laws, one federal statue and three state standards of review, where higher values indicate lower hostile takeover hazard. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.123***	-0.117***		
	(0.027)	(0.026)		
TaxIncr*Anti-takeoverIndex	-0.613***	-0.612***		
	(0.214)	(0.205)		
TaxDecr			0.246***	0.224***
			(0.032)	(0.031)
TaxDecr*Anti-takeoverIndex			2.072***	1.887***
			(0.424)	(0.400)
Anti-takeoverIndex	-0.377**	-0.139	-0.465***	-0.228
	(0.161)	(0.155)	(0.163)	(0.159)
LnSales	-0.018***	-0.016***	-0.018***	-0.016***
	(0.005)	(0.005)	(0.005)	(0.005)
RD/TA	0.023	0.004	0.024*	0.004
	(0.014)	(0.008)	(0.014)	(0.008)
Leverage	-0.045***	-0.047***	-0.047***	-0.049***
	(0.015)	(0.015)	(0.015)	(0.015)
Profitability	-0.002**	-0.002*	-0.002**	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.191***	0.189***	0.191***	0.189***
	(0.038)	(0.039)	(0.037)	(0.039)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.526***	0.391**	0.520***	0.385**
	(0.195)	(0.194)	(0.194)	(0.193)
Herfindahl^2	-0.604***	-0.469**	-0.599***	-0.465**
	(0.196)	(0.195)	(0.195)	(0.194)
LnRealGDP	0.105	0.167	0.102	0.163
	(0.139)	(0.143)	(0.138)	(0.143)
UnemployRate	0.005	0.002	0.007	0.003
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	70,799	66,221	70,799	66,221
N. of Firms	7,581	7,219	7,581	7,219
R-squared	0.554	0.551	0.555	0.552

Table IX:
Tax Changes, Tax Avoidance and Innovation

This table examines the role of tax avoidance. Specifically we estimate the OLS model of *Ln(1+$\frac{Citations}{Patent}$)* on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise, and its interaction with TaxAvoid, which is an indicator variable for firms in the lowest tercile of industry and size adjusted cash effective tax rate. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.069*	-0.056		
	(0.040)	(0.039)		
TaxIncr*TaxAvoid	-0.051	-0.110***		
	(0.037)	(0.035)		
TaxDecr			0.063*	0.050
			(0.036)	(0.032)
TaxDecr*TaxAvoid			0.131***	0.129***
			(0.030)	(0.027)
TaxAvoid	-0.026**	-0.019*	-0.041***	-0.039***
	(0.011)	(0.010)	(0.011)	(0.011)
LnSales	0.000	-0.004	0.001	-0.003
	(0.010)	(0.009)	(0.010)	(0.009)
RD/TA	0.057**	0.054**	0.058**	0.054**
	(0.028)	(0.025)	(0.029)	(0.026)
Leverage	-0.058**	-0.046**	-0.063***	-0.051**
	(0.024)	(0.023)	(0.024)	(0.023)
Profitability	-0.002**	-0.002**	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.313***	0.278***	0.312***	0.278***
	(0.057)	(0.056)	(0.057)	(0.056)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.601**	0.548**	0.602**	0.547**
	(0.241)	(0.229)	(0.240)	(0.228)
Herfindahl^2	-0.596**	-0.529**	-0.595**	-0.524**
	(0.234)	(0.225)	(0.234)	(0.224)
LnRealGDP	0.068	0.081	0.087	0.090
	(0.174)	(0.170)	(0.173)	(0.170)
UnemployRate	0.014	0.010	0.018*	0.014
	(0.009)	(0.009)	(0.009)	(0.009)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	43,753	40,794	43,753	40,794
N. of Firms	5,870	5,538	5,870	5,538
R-squared	0.571	0.565	0.572	0.565

Table XA: Controlling for Additional State-level Variables

In this table, we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. The regression includes additional state-level variables consisting of a state capital gain tax change indicator, a state personal income tax change indicator, a state R&D tax credit (recalculated, highest tier) change indicator, a governor party indicator, a legislature party indicator, state-level labor share (the fraction of gross product in state i in year t that is from mining, construction, manufacturing, transportation, trade, finance, services, or government industries), and labor force concentration (the sum of the squared labor shares for state i in year t). Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{T Debt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.081***	-0.073***		
	(0.024)	(0.023)		
TaxDecr			0.083***	0.074***
			(0.026)	(0.024)
State Capital Gain TaxChg	0.090**	0.150***	0.099**	0.158***
	(0.039)	(0.043)	(0.039)	(0.043)
State Personal Income TaxChg	0.022	-0.045	0.020	-0.047
	(0.042)	(0.045)	(0.042)	(0.045)
State R&D Tax Credit Chg	-0.026	-0.027	-0.022	-0.023
	(0.018)	(0.018)	(0.018)	(0.018)
Governor Party	-0.017***	-0.012***	-0.016***	-0.012***
	(0.003)	(0.003)	(0.003)	(0.003)
Legislature Party	-0.017***	-0.023***	-0.017***	-0.023***
	(0.006)	(0.006)	(0.006)	(0.006)
Mining	-0.010	-0.015**	-0.010	-0.015*
	(0.008)	(0.008)	(0.008)	(0.008)
Construction	0.047***	0.040***	0.044***	0.038***
	(0.013)	(0.013)	(0.013)	(0.013)
Manufacturing	0.020***	0.017**	0.020***	0.017**
	(0.007)	(0.007)	(0.007)	(0.007)
Transportation	0.020	0.026	0.019	0.024
	(0.025)	(0.025)	(0.025)	(0.025)
Trade	0.024	0.017	0.024	0.017
	(0.015)	(0.015)	(0.015)	(0.015)
Finance	-0.010	-0.010	-0.008	-0.008
	(0.008)	(0.008)	(0.008)	(0.008)
Service	0.013	0.008	0.014	0.008
	(0.010)	(0.011)	(0.010)	(0.011)
Government	-0.049***	-0.047***	-0.048***	-0.047***
	(0.015)	(0.015)	(0.015)	(0.015)
Labor Force Concentration	0.013	0.015	0.009	0.011
	(0.013)	(0.013)	(0.013)	(0.013)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,627	68,831	73,627	68,831
N. of Firms	7,859	7,502	7,859	7,502

Table XB: Controlling for State-specific Time Trends and Industry-year Fixed Effects

This table reports the results relating the number of citations per patent to tax changes. Specifically we estimate the OLS model of *Ln(1+* $\frac{Citations}{Patent}$*)* on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. We also control for state-specific time trends and industry-year fixed effects. Other controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.053**	-0.046**		
	(0.022)	(0.022)		
TaxDecr			0.069***	0.067***
			(0.026)	(0.025)
LnSales	-0.023***	-0.024***	-0.023***	-0.024***
	(0.005)	(0.005)	(0.005)	(0.005)
RD/TA	0.010	0.013	0.010	0.013
	(0.015)	(0.012)	(0.015)	(0.012)
Leverage	-0.040***	-0.050***	-0.041***	-0.050***
	(0.014)	(0.014)	(0.014)	(0.014)
Profitability	-0.002**	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.124***	0.130***	0.124***	0.130***
	(0.033)	(0.034)	(0.033)	(0.034)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.065	-0.033	0.065	-0.033
	(0.189)	(0.189)	(0.188)	(0.189)
Herfindahl^2	-0.084	0.010	-0.084	0.010
	(0.193)	(0.192)	(0.192)	(0.191)
LnRealGDP	0.184	0.227*	0.209*	0.253**
	(0.123)	(0.127)	(0.123)	(0.127)
UnemployRate	0.003	0.003	0.005	0.004
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
State Time Trends	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
Obs.	73,250	68,368	73,250	68,368
N. of Firms	7,427	6,993	7,427	6,993
R-squared	0.589	0.589	0.590	0.589

Table XC:
Falsification Test using Neighboring States

This table reports the results from a falsification test using tax changes in neighboring states. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. *TaxIncr in Neighboring States* is an indicator variable equal to 1, if there has been a significant tax increase in any of the neighboring states of firm i, and 0 otherwise. *TaxDecr in Neighboring States* is an indicator variable equal to 1, if there has been a significant tax decrease in any of the neighboring states of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{T Debt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.071***	-0.066***		
	(0.023)	(0.022)		
TaxIncr in Neighboring States	0.047***	0.037**		
	(0.015)	(0.015)		
TaxDecr			0.093***	0.085***
			(0.027)	(0.025)
TaxDecr in Neighboring States			-0.076***	-0.063***
			(0.016)	(0.016)
LnSales	-0.012**	-0.013**	-0.012**	-0.013**
	(0.005)	(0.006)	(0.005)	(0.005)
RD/TA	0.017	0.018	0.016	0.018
	(0.014)	(0.014)	(0.014)	(0.014)
Leverage	-0.042***	-0.047***	-0.043***	-0.048***
	(0.015)	(0.014)	(0.015)	(0.014)
Profitability	-0.002**	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.181***	0.180***	0.179***	0.179***
	(0.036)	(0.037)	(0.036)	(0.037)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.578***	0.474**	0.583***	0.478**
	(0.191)	(0.191)	(0.190)	(0.190)
Herfindahl^2	-0.636***	-0.534***	-0.643***	-0.539***
	(0.194)	(0.193)	(0.194)	(0.192)
LnRealGDP	0.058	0.112	0.130	0.172
	(0.135)	(0.139)	(0.134)	(0.138)
UnemployRate	0.005	0.002	0.000	-0.001
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
R-squared	0.551	0.547	0.552	0.548

Table XD:
Instrumental Variable Regressions

This table reports the results from instrumental variable regressions. The instruments are OilPrice*ACIR, OilPrice*OilSensitivity, and OilPrice*ACIR*OilSensitivity, where OilPrice is the inflation-adjusted OPEC crude oil price, OilSensitivity is the historical sensitivity of state revenue to oil prices, and ACIR is the Advisory Council on Intergovernmental Relations index of budget stringency ranging from 0 lax to 10 stringent. In the first stage, we regress the tax variables on the instruments, a set of controls including OilSensitivity, ACIR, and OilSensitivity*ACIR. In the second stage, $Ln(1+\frac{Citations}{Patent})$ is regressed on the instrumented tax variable, a set of controls including OilSensitivity, ACIR, and OilSensitivity*ACIR. The other controls in first and second stage regressions are *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All first and second stage regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

Panel A: First Stage

	TaxIncr	TaxIncr	TaxDecr	TaxDecr	TaxChg	TaxChg
	(1)	(2)	(3)	(4)	(5)	(6)
OilPrice*ACIR	-0.001***	-0.001***	0.002***	0.002***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.0001)	(0.0001)	(0.000)	(0.000)
OilPrice*OilSensitivity	-0.004***	-0.004***	0.114***	0.116***	-0.152***	-0.151***
	(0.000)	(0.000)	(0.002)	(0.002)	(0.004)	(0.004)
OilPrice*ACIR*OilSensitivity	0.0004***	0.0004***	-0.012***	-0.012***	0.015***	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Include OilSensitivity, ACIR, OilSensitivity*ACIR	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	73,327	68,449	73,327	68,449	73,327	68,449
F-stat of Instruments (p-value)	14.60	13.37	314.36	317.18	157.27	158.30
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Panel B: Second Stage

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)	(5)	(6)
Instrumented TaxIncr	-0.438***	-0.373***				
	(0.116)	(0.107)				
Instrumented TaxDecr			0.159***	0.127***		
			(0.034)	(0.030)		
Instrumented TaxChg					-0.118***	-0.096***
					(0.027)	(0.024)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Include OilSensitivity, ACIR, OilSensitivity*ACIR	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	73,327	68,449	73,327	68,449	73,327	68,449
N. of Firms	7,433	7,000	7,433	7,000	7,433	7,000

Table XE:
Non-Moving Firms during the Sample Period

This table reports the results relating the number of citations per patent to tax changes. The sample only includes firms that have the same time-varying most mentioned state during the entire sample period. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.123***	-0.119***		
	(0.036)	(0.038)		
TaxDecr			0.142***	0.150***
			(0.047)	(0.044)
LnSales	-0.045***	-0.046***	-0.045***	-0.045***
	(0.010)	(0.011)	(0.010)	(0.011)
RD/TA	-0.009	-0.007	-0.009	-0.008
	(0.013)	(0.012)	(0.013)	(0.012)
Leverage	-0.010	-0.033	-0.012	-0.035
	(0.027)	(0.027)	(0.027)	(0.027)
Profitability	-0.000	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.242***	0.235***	0.243***	0.237***
	(0.065)	(0.068)	(0.065)	(0.068)
Age	0.000	-0.000	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Herfindahl	0.110	0.065	0.125	0.085
	(0.357)	(0.372)	(0.356)	(0.371)
Herfindahl^2	-0.024	0.025	-0.036	0.007
	(0.333)	(0.348)	(0.333)	(0.348)
LnRealGDP	0.086	0.168	0.137	0.230
	(0.245)	(0.263)	(0.246)	(0.264)
UnemployRate	0.018	0.008	0.019*	0.010
	(0.011)	(0.011)	(0.011)	(0.011)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	24,589	22,511	24,589	22,511
N. of Firms	3,116	2,907	3,116	2,907
R-squared	0.570	0.569	0.570	0.569

Table XF:
Controlling for Merger and Acquisition Activities

This table reports the results relating the number of citations per patent to tax changes. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Panel A controls for the number of acquisitions and the value of these acquisitions divided by total assets in year 3 or 4 depending on when innovation is measured. Panel B incudes only firm-year observations that do not have any mergers or acquisitions. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

Panel A: Controlling for Merger and Acquisition Activities

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.069***	-0.065***		
	(0.023)	(0.023)		
TaxDecr			0.097***	0.089***
			(0.027)	(0.026)
N. of Acquisitions$_{t+3}$	-0.013***		-0.013***	
	(0.003)		(0.003)	
Acquisition Value$_{t+3}$	-0.000		0.000	
	(0.002)		(0.002)	
N. of Acquisitions$_{t+4}$		-0.011***		-0.011***
		(0.003)		(0.003)
Acquisition Value$_{t+4}$		0.001		0.002
		(0.002)		(0.002)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	73,529	68,712	73,529	68,712
N. of Firms	7,872	7,516	7,872	7,516

Panel B: Only Observations with No Mergers or Acquisitions

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.062***	-0.054**		
	(0.022)	(0.022)		
TaxDecr			0.078***	0.061**
			(0.027)	(0.026)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	56,499	53,170	56,499	53,170
N. of Firms	7,627	7,299	7,627	7,299

Table XIA:
Tax Changes and State Taxes Paid

This table examines the relation between the state taxes paid and state tax changes. Specifically we estimate the OLS model of $\frac{StateTaxes}{PretaxIncome}$ on *TaxIncr* and *TaxDecr*, which are indicator variables equal to 1, if there has been a significant tax increase (decrease), respectively, in the most (or least) mentioned state for firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*,*Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$\frac{StateTaxes}{PretaxIncome}_{t+1}$	$\frac{StateTaxes}{PretaxIncome}_{t+1}$	$\frac{StateTaxes}{PretaxIncome}_{t+1}$	$\frac{StateTaxes}{PretaxIncome}_{t+1}$
	(1)	(2)	(3)	(4)
TaxIncr (Most Mentioned State)	0.459***			
	(0.166)			
TaxDecr (Most Mentioned State)		-0.555***		
		(0.178)		
TaxIncr (Least Mentioned State)			-0.026	
			(0.147)	
TaxDecr (Least Mentioned State)				0.092
				(0.182)
LnSales	0.141***	0.141***	0.140***	0.141***
	(0.028)	(0.028)	(0.028)	(0.028)
RD/TA	0.016	0.016	0.014	0.014
	(0.020)	(0.020)	(0.020)	(0.020)
Leverage	-0.280***	-0.279***	-0.274***	-0.274***
	(0.081)	(0.081)	(0.081)	(0.081)
Profitability	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Tangibility	-0.974***	-0.983***	-0.968***	-0.970***
	(0.234)	(0.234)	(0.234)	(0.234)
Age	0.000	0.000	0.000	0.000
	(0.003)	(0.003)	(0.003)	(0.003)
Herfindahl	-1.631*	-1.616*	-1.621*	-1.615*
	(0.953)	(0.954)	(0.953)	(0.953)
Herfindahl^2	2.012*	1.999*	2.010*	2.004*
	(1.067)	(1.069)	(1.068)	(1.068)
LnRealGDP	0.533	0.388	0.721	0.716
	(0.602)	(0.599)	(0.603)	(0.603)
UnemployRate	-0.057	-0.067*	-0.053	-0.053
	(0.039)	(0.039)	(0.039)	(0.039)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	63,465	63,465	63,465	63,465
N. of Firms	8,019	8,019	8,019	8,019
R-squared	0.259	0.259	0.259	0.259

Table XIB: Robustness Checks of the Most Relevant State

This table reports the results relating the number of citations per patent to tax increases or decreases while performing robustness checks for the most relevant state used to identify tax changes. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxVar:	TaxIncr	TaxIncr	TaxDecr	TaxDecr
Time varying most mentioned state	-0.043**	-0.039**	0.052***	0.038***
	(0.020)	(0.018)	(0.011)	(0.009)
Obs.	41,781	38,521	41,781	38,521
Top three most mentioned states	-0.066***	-0.053***	0.096***	0.084***
	(0.019)	(0.018)	(0.021)	(0.020)
Obs.	73,931	69,121	73,931	69,121
States with at least 30% counts	-0.074***	-0.071***	0.099***	0.090***
	(0.022)	(0.022)	(0.026)	(0.024)
Obs.	73,802	68,996	73,802	68,996
Firms with 1-3 equivalent states	-0.137***	-0.127***	0.168***	0.163***
	(0.033)	(0.032)	(0.039)	(0.036)
Obs.	31,755	29,449	31,755	29,449
Headquarter (hq) state	-0.076***	-0.071***	0.070***	0.058**
	(0.022)	(0.022)	(0.025)	(0.023)
Obs.	64,628	60,004	64,628	60,004
State with most patents	-0.089**	-0.077**	0.102**	0.093**
	(0.037)	(0.036)	(0.041)	(0.038)
Obs.	37,932	35,872	37,932	35,872
State with most subsidiaries	-0.172***	-0.158***	0.282***	0.284***
	(0.037)	(0.037)	(0.042)	(0.039)
Obs.	53,864	51,057	53,864	51,057
Same hq and most mentioned state	-0.108***	-0.110***	0.132***	0.130***
	(0.035)	(0.034)	(0.039)	(0.035)
Obs.	36,177	34,391	36,177	34,391

Internet Appendix for
Corporate Income Taxes, Pledgeable Income and Innovation

Table IA.1:
Robustness Checks

This table reports the results relating the number of citations per patent to tax increases or tax decreases while performing various robustness checks. In row 1, the treatment group sample (firms that experience a tax decrease) are restricted to five years before and after the tax change. In row 2, non-innovative firms (i.e., firms with no patent during the entire sample period of 1988 to 2006) are excluded. In row 3, the sample ends in 2003 instead of 2006. In rows 4 to 7, the standard errors are clustered by different groups as specified. In row 8, the dependent innovation variables are adjusted for truncation using fixed effects methodology, which purges the citations per patent measure from time fixed effects. In row 9, the dependent innovation variables are adjusted for truncation using fixed effects methodology, which purges the citations per patent measure from both time and technology class fixed effects. In row 10, the dependent innovation variables are adjusted for truncation using a quasi-structural model to estimate the citations lag, where each patent citation is multiplied by an index created by econometrically estimating the distribution of the citation lag (the time from the application of the patent until a citation is received). In all regressions, controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level (unless otherwise indicated). The sample consists of firm-year observations from 1988 to 2006 except in row 3. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxVar:	TaxIncr	TaxIncr	TaxDecr	TaxDecr
1.Five years before and after tax change	-0.063***	-0.061***	0.107***	0.082***
	(0.019)	(0.019)	(0.021)	(0.018)
Obs.	70,027	65,477	67,609	63,169
2.Exclude firms with no patent	-0.108***	-0.100***	0.115***	0.110***
	(0.040)	(0.038)	(0.043)	(0.040)
Obs.	36,223	34,314	36,223	34,314
3.End sample in 2003	-0.065***	-0.060***	0.088***	0.083***
	(0.021)	(0.021)	(0.025)	(0.023)
Obs.	64,202	60,111	64,202	60,111
4.Cluster standard errors by year	-0.072***	-0.067**	0.096***	0.087***
	(0.016)	(0.024)	(0.014)	(0.018)
Obs.	73,931	69,121	73,931	69,121
5.Cluster standard errors by firm and year	-0.072***	-0.067**	0.096***	0.087***
	(0.024)	(0.029)	(0.027)	(0.028)
Obs.	73,495	68,608	73,495	68,608
6.Cluster standard errors by state	-0.072**	-0.067**	0.096**	0.087**
	(0.028)	(0.027)	(0.046)	(0.043)
Obs.	73,931	69,121	73,931	69,121
7.Cluster standard errors by state and year	-0.072***	-0.067**	0.096**	0.087**
	(0.026)	(0.030)	(0.044)	(0.043)
Obs.	73,495	68,608	73,495	68,608
8.Time-adjusted dep. variable	-0.018**	-0.021***	0.038***	0.042***
	(0.007)	(0.008)	(0.010)	(0.010)
Obs.	73,931	69,121	73,931	69,121
9.Time and tech class-adjusted dep. variable	-0.019**	-0.021***	0.040***	0.043***
	(0.007)	(0.008)	(0.010)	(0.011)
Obs.	73,931	69,121	73,931	69,121
10.Quasi-adjusted dep. variable	-0.077***	-0.084***	0.132***	0.134***
	(0.027)	(0.028)	(0.035)	(0.035)
Obs.	73,931	69,121	73,931	69,121

Table IA.2:
Tax Changes in Neighboring States

This table reports the results relating tax changes in neighboring states to tax changes in state i. *TaxIncr in Neighboring States* is an indicator variable equal to 1 if there has been a significant tax increase in any of the neighboring states of state i, and 0 otherwise. *TaxDecr in Neighboring States* is an indicator variable equal to 1 if there has been a significant tax decrease in any of the neighboring states of state i, and 0 otherwise. Controls include *LnRealGDP* (Log of state level real GDP) and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and state fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the state level. The sample consists of state-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$TaxChg_t$	$TaxChg_{t+1}$	$TaxChg_{t+2}$
	(1)	(2)	(3)
TaxIncr in Neighboring States	0.144	0.156	0.163
	(0.092)	(0.103)	(0.119)
TaxDecr in Neighboring States	-0.038	-0.022	-0.013
	(0.088)	(0.087)	(0.088)
LnRealGDP	-0.244	-0.171	-0.134
	(0.394)	(0.412)	(0.410)
UnemployRate	-0.011	-0.016	-0.027
	(0.018)	(0.017)	(0.018)
State FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	931	931	931
R-squared	0.604	0.645	0.676

Table IA.3: Tax Changes and Executives' Incentive Compensation

This table reports the results relating the average option-based compensation for top-level executives to tax changes. Specifically we estimate the OLS model of *Average Value of Stock Options Granted* on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise, or *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. *Average Value of Stock Options Granted* is calculated as the average options grant value (`option_awards_blk_value`) across all top-level executives reported in Execucomp in a given firm-year. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1992 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	Average Value of Stock Options Granted	*Average Value of Stock Options Granted*
	(1)	(2)
TaxIncr	-0.237***	
	(0.067)	
TaxDecr		0.132**
		(0.060)
LnSales	0.372***	0.374***
	(0.034)	(0.034)
Rd/TA	-0.379	-0.390
	(0.251)	(0.251)
Leverage	-0.593***	-0.600***
	(0.090)	(0.090)
Profitability	0.275*	0.269*
	(0.150)	(0.149)
Tangibility	-0.428**	-0.425**
	(0.187)	(0.187)
Age	-0.000	-0.000
	(0.001)	(0.001)
Herfindahl	-0.143	-0.178
	(0.429)	(0.428)
Herfindahl^2	0.345	0.374
	(0.400)	(0.399)
LnRealGDP	0.632**	0.566*
	(0.307)	(0.306)
UnemployRate	-0.010	-0.005
	(0.021)	(0.022)
Firm FE	Yes	Yes
Year FE	Yes	Yes
Obs.	15,841	15,841
N. of Firms	1,987	1,987
R-squared	0.587	0.587

Table IA.4:
Tax Changes and R&D Expenditures

This table reports the results relating the R&D expenditure to tax changes. Specifically we estimate the OLS model of ($\frac{R\&DExpenditures}{TotalAssets}$) on *TaxIncr* and *TaxDecr*, which are indicator variables equal to 1, if there has been a significant tax increase (decrease), respectively, in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$\frac{R\&DExpenditures}{TotalAssets}_{t+1}$	$\frac{R\&DExpenditures}{TotalAssets}_{t+1}$	$\frac{R\&DExpenditures}{TotalAssets}_{t+1}$
	(1)	(2)	(3)
TaxChg	-0.000		
	(0.001)		
TaxIncr		0.001	
		(0.002)	
TaxDecr			0.002
			(0.002)
LnSales	-0.009***	-0.009***	-0.009***
	(0.001)	(0.001)	(0.001)
Leverage	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)
Profitability	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Tangibility	0.021***	0.021***	0.021***
	(0.004)	(0.004)	(0.004)
Age	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Herfindahl	-0.010	-0.010	-0.010
	(0.016)	(0.016)	(0.016)
Herfindahl^2	0.009	0.009	0.009
	(0.014)	(0.014)	(0.014)
LnRealGDP	0.005	0.004	0.006
	(0.010)	(0.010)	(0.010)
UnemployRate	0.000	0.000	0.001
	(0.001)	(0.001)	(0.001)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	83,690	83,690	83,690
N. of Firms	8,394	8,394	8,394
R-squared	0.751	0.751	0.751

Table IA.5:
Tax Increases and the Number of Patents

This table reports the results relating the number of patents to tax increases. Specifically we estimate the OLS model of *Ln(1+Patent)* on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{T Debt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	Ln(1+Patent)$_{t+1}$	*Ln(1+Patent)*$_{t+2}$	*Ln(1+Patent)*$_{t+3}$	*Ln(1+Patent)*$_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.011	-0.023	-0.032*	-0.047**
	(0.013)	(0.016)	(0.019)	(0.023)
LnSales	0.034***	0.025***	0.016***	0.008
	(0.004)	(0.005)	(0.005)	(0.006)
RD/TA	0.013*	0.023***	0.018**	0.016*
	(0.007)	(0.009)	(0.008)	(0.009)
Leverage	-0.045***	-0.054***	-0.064***	-0.073***
	(0.010)	(0.011)	(0.013)	(0.014)
Profitability	-0.000	-0.000	-0.001	-0.002***
	(0.000)	(0.000)	(0.001)	(0.001)
Tangibility	0.056**	0.114***	0.176***	0.246***
	(0.025)	(0.029)	(0.035)	(0.041)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.537***	0.645***	0.799***	0.856***
	(0.119)	(0.140)	(0.170)	(0.204)
Herfindahl^2	-0.503***	-0.617***	-0.771***	-0.814***
	(0.129)	(0.149)	(0.175)	(0.202)
LnRealGDP	0.235***	0.185*	0.146	0.150
	(0.081)	(0.095)	(0.113)	(0.135)
UnemployRate	0.008*	0.007	0.005	0.007
	(0.005)	(0.005)	(0.006)	(0.007)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	83,690	78,854	73,931	69,121
N. of Firms	8,394	8,242	7,886	7,529
R-squared	0.766	0.742	0.719	0.696

Table IA.6: Tax Decreases and the Number of Patents

This table reports the results relating the number of patents to tax decreases. Specifically we estimate the OLS model of *Ln(1+Patent)* on *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{T Debt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	Ln(1+Patent)$_{t+1}$	*Ln(1+Patent)*$_{t+2}$	*Ln(1+Patent)*$_{t+3}$	*Ln(1+Patent)*$_{t+4}$
	(1)	(2)	(3)	(4)
TaxDecr	0.036*	0.062**	0.081***	0.106***
	(0.019)	(0.025)	(0.031)	(0.039)
LnSales	0.034***	0.025***	0.016***	0.008
	(0.004)	(0.005)	(0.005)	(0.006)
RD/TA	0.013*	0.022***	0.018**	0.016*
	(0.007)	(0.009)	(0.008)	(0.009)
Leverage	-0.045***	-0.054***	-0.064***	-0.074***
	(0.010)	(0.011)	(0.013)	(0.014)
Profitability	-0.000	-0.000	-0.001	-0.002***
	(0.000)	(0.000)	(0.001)	(0.001)
Tangibility	0.056**	0.115***	0.178***	0.248***
	(0.025)	(0.029)	(0.035)	(0.041)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.538***	0.646***	0.802***	0.860***
	(0.119)	(0.140)	(0.170)	(0.204)
Herfindahl^2	-0.504***	-0.618***	-0.773***	-0.817***
	(0.129)	(0.148)	(0.175)	(0.202)
LnRealGDP	0.254***	0.217**	0.187*	0.202
	(0.081)	(0.094)	(0.112)	(0.133)
UnemployRate	0.009*	0.009*	0.007	0.009
	(0.005)	(0.005)	(0.006)	(0.007)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	83,690	78,854	73,931	69,121
N. of Firms	8,394	8,242	7,886	7,529
R-squared	0.766	0.742	0.719	0.696

Table IA.7:
Tax Changes and the Number of Patents

This table reports the results relating the number of patents to tax changes. Specifically we estimate the OLS model of *Ln(1+Patent)* on *TaxChg*, which is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, equal to -1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	Ln(1+Patent)$_{t+1}$	*Ln(1+Patent)*$_{t+2}$	*Ln(1+Patent)*$_{t+3}$	*Ln(1+Patent)*$_{t+4}$
	(1)	(2)	(3)	(4)
TaxChg	-0.016	-0.028**	-0.038**	-0.052***
	(0.010)	(0.013)	(0.016)	(0.020)
LnSales	0.034***	0.025***	0.016***	0.008
	(0.004)	(0.005)	(0.005)	(0.006)
RD/TA	0.013*	0.022***	0.018**	0.016*
	(0.007)	(0.009)	(0.008)	(0.009)
Leverage	-0.045***	-0.054***	-0.064***	-0.073***
	(0.010)	(0.011)	(0.013)	(0.014)
Profitability	-0.000	-0.000	-0.001	-0.002***
	(0.000)	(0.000)	(0.001)	(0.001)
Tangibility	0.056**	0.115***	0.177***	0.248***
	(0.025)	(0.029)	(0.035)	(0.041)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.538***	0.646***	0.801***	0.859***
	(0.119)	(0.140)	(0.170)	(0.204)
Herfindahl^2	-0.504***	-0.618***	-0.772***	-0.817***
	(0.129)	(0.148)	(0.175)	(0.202)
LnRealGDP	0.247***	0.207**	0.174	0.187
	(0.081)	(0.095)	(0.112)	(0.134)
UnemployRate	0.008*	0.008	0.007	0.008
	(0.005)	(0.005)	(0.006)	(0.007)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	83,690	78,854	73,931	69,121
N. of Firms	8,394	8,242	7,886	7,529
R-squared	0.766	0.742	0.719	0.696

Table IA.8:
Tax Increases and the Number of Citations per Patent

This table reports the results relating the number of citations per patent to tax increases. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxIncr*, which is an indicator variable equal to 1, if there has been a significant tax increase in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&D Expenditures}{Total Assets}$), *Leverage* ($\frac{TDebt}{Total Assets}$), *Profitability* ($\frac{EBIDTA}{Total Assets}$), *Tangibility* ($\frac{NPPE}{Total Assets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+1}$	$Ln(1+\frac{Citations}{Patent})_{t+2}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxIncr	-0.052**	-0.064***	-0.072***	-0.067***
	(0.022)	(0.023)	(0.023)	(0.022)
LnSales	-0.002	-0.007	-0.012**	-0.013**
	(0.005)	(0.005)	(0.006)	(0.006)
RD/TA	0.010	0.020	0.017	0.018
	(0.011)	(0.012)	(0.014)	(0.014)
Leverage	-0.047***	-0.042***	-0.042***	-0.047***
	(0.013)	(0.014)	(0.015)	(0.014)
Profitability	-0.000**	-0.000	-0.002**	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)
Tangibility	0.167***	0.173***	0.182***	0.181***
	(0.035)	(0.036)	(0.036)	(0.038)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.797***	0.646***	0.578***	0.474**
	(0.178)	(0.187)	(0.192)	(0.191)
Herfindahl^2	-0.811***	-0.719***	-0.634***	-0.532***
	(0.181)	(0.189)	(0.195)	(0.193)
LnRealGDP	0.130	0.115	0.088	0.135
	(0.122)	(0.127)	(0.134)	(0.138)
UnemployRate	0.011*	0.008	0.004	0.002
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	83,690	78,854	73,931	69,121
N. of Firms	8,394	8,242	7,886	7,529
R-squared	0.557	0.555	0.552	0.547

Table IA.9:
Tax Decreases and the Number of Citations per Patent

This table reports the results relating the number of citations per patent to tax decreases. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxDecr*, which is an indicator variable equal to 1, if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+1}$	$Ln(1+\frac{Citations}{Patent})_{t+2}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxDecr	0.101***	0.109***	0.096***	0.087***
	(0.027)	(0.027)	(0.027)	(0.025)
LnSales	-0.002	-0.007	-0.012**	-0.013**
	(0.005)	(0.005)	(0.005)	(0.006)
RD/TA	0.010	0.020	0.017	0.018
	(0.011)	(0.012)	(0.014)	(0.014)
Leverage	-0.047***	-0.042***	-0.043***	-0.048***
	(0.014)	(0.014)	(0.015)	(0.014)
Profitability	-0.000**	-0.000	-0.002**	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)
Tangibility	0.169***	0.175***	0.183***	0.182***
	(0.034)	(0.035)	(0.036)	(0.037)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.798***	0.648***	0.580***	0.476**
	(0.178)	(0.187)	(0.191)	(0.191)
Herfindahl^2	-0.811***	-0.721***	-0.636***	-0.534***
	(0.181)	(0.189)	(0.194)	(0.193)
LnRealGDP	0.173	0.160	0.122	0.165
	(0.121)	(0.126)	(0.134)	(0.138)
UnemployRate	0.013**	0.010*	0.006	0.003
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	83,690	78,854	73,931	69,121
N. of Firms	8,394	8,242	7,886	7,529
R-squared	0.558	0.555	0.552	0.548

TableIA.10:
Tax Changes and the Number of Citations per Patent

This table reports the results relating the number of citations per patents to tax changes. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxChg*, which is an indicator variable equal to 1 if there has been a significant tax increase in the largest state of business of firm i, equal to -1 if there has been a significant tax decrease in the largest state of business of firm i, and 0 otherwise. Controls include *Ln(Sales)*, *RD/TA* ($\frac{R\&DExpenditures}{TotalAssets}$), *Leverage* ($\frac{TDebt}{TotalAssets}$), *Profitability* ($\frac{EBIDTA}{TotalAssets}$), *Tangibility* ($\frac{NPPE}{TotalAssets}$), *Age*, *Herfindahl*, *Herfindahl*^{2}, *LnRealGDP* (Log of state level real GDP), and *UnemployRate* (state level unemployment rate). All regressions are estimated with time and firm fixed effects and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. The sample consists of firm-year observations from 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+\frac{Citations}{Patent})_{t+1}$	$Ln(1+\frac{Citations}{Patent})_{t+2}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxChg	-0.052***	-0.059***	-0.058***	-0.053***
	(0.016)	(0.016)	(0.016)	(0.015)
LnSales	-0.002	-0.007	-0.012**	-0.013**
	(0.005)	(0.005)	(0.006)	(0.006)
RD/TA	0.010	0.020	0.017	0.018
	(0.011)	(0.012)	(0.014)	(0.014)
Leverage	-0.047***	-0.042***	-0.043***	-0.048***
	(0.013)	(0.014)	(0.015)	(0.014)
Profitability	-0.000**	-0.000	-0.002**	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)
Tangibility	0.168***	0.175***	0.184***	0.183***
	(0.034)	(0.036)	(0.036)	(0.037)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.799***	0.648***	0.581***	0.477**
	(0.178)	(0.187)	(0.191)	(0.191)
Herfindahl^2	-0.812***	-0.721***	-0.636***	-0.534***
	(0.181)	(0.189)	(0.194)	(0.193)
LnRealGDP	0.164	0.153	0.121	0.165
	(0.121)	(0.127)	(0.134)	(0.138)
UnemployRate	0.012**	0.009	0.005	0.003
	(0.006)	(0.006)	(0.006)	(0.006)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs.	83,690	78,854	73,931	69,121
N. of Firms	8,394	8,242	7,886	7,529
R-squared	0.558	0.555	0.552	0.548

Table IA.11: Replication of Mukherjee, Singh, and Zaldokas (2016)

This table replicates the main results of Mukherjee, Singh, and Zaldokas (2016) using their tax signals, model specifications, and sample exclusions. In Panel A, tax increase and decrease variables are defined as in Mukherjee, Singh, and Zaldokas (2016) and are based on historical headquarters state of the firm, which is obtained from Compact Disclosure and 10K filings (parsed 10K location data are obtained from Bill McDonald's website). In Panel B, tax increase and decrease variables are defined as in Mukherjee, Singh, and Zaldokas (2016) and are based on an alternative definition of state using the most mentioned state from 10K reports collected by Garcia and Norli (2012). The sample period is from 1990 to 2006. Firms in the financial sector (6000s SICs) and the public sector (9000s SICs) are excluded. Observations where the firms sales or assets are less than 1 million, the firms reported stock price is negative, or the firm has fewer than four observations are also excluded. Only firms with headquarters in the US are included. The dependent variable in columns (1) to (3) is the natural log of 1 plus the number of patents. The dependent variable in columns (4) to (6) is the natural log of 1 plus the number of citations per patent. All control variables are defined as in Mukherjee, Singh, and Zaldokas (2016), which include changes in log of sales, in log of PPENT divided by the number of employees, in HHI, in HHI squared, in R&D expenditure divided by sales, in profitability, in tangibility, in the availability of S&P debt rating, in log of state's GSP, in tax revenue as a percentage of GSP, in log of state population, and in state employment rate. All regressions are with year fixed effects. Standard errors are clustered at state-level and reported in parentheses. *,**, and *** indicate significance at 10%, 5% and 1% respectively.

Panel A: Using Historical Headquarters States

	$\Delta Ln(1{+}Patent)_{t+1}$	$\Delta Ln(1{+}Patent)_{t+2}$	$\Delta Ln(1{+}Patent)_{t+3}$	$\Delta Ln(1{+}\frac{Citations}{Patent})_{t+1}$	$\Delta Ln(1{+}\frac{Citations}{Patent})_{t+2}$	$\Delta Ln(1{+}\frac{Citations}{Patent})_{t+3}$
	(1)	(2)	(3)	(4)	(5)	(6)
MSZ TaxIncr	-0.032***	-0.043**	-0.068**	-0.022	-0.025	-0.004
	(0.011)	(0.020)	(0.029)	(0.015)	(0.016)	(0.010)
MSZ TaxDecr	-0.004	0.001	0.008	-0.005	0.015	-0.005
	(0.007)	(0.007)	(0.010)	(0.013)	(0.014)	(0.012)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	52,561	48,313	44,460	52,561	48,313	44,460

Panel B: Using Most Mentioned States

	$\Delta Ln(1{+}Patent)_{t+1}$	$\Delta Ln(1{+}Patent)_{t+2}$	$\Delta Ln(1{+}Patent)_{t+3}$	$\Delta Ln(1{+}\frac{Citations}{Patent})_{t+1}$	$\Delta Ln(1{+}\frac{Citations}{Patent})_{t+2}$	$\Delta Ln(1{+}\frac{Citations}{Patent})_{t+3}$
	(1)	(2)	(3)	(4)	(5)	(6)
MSZ TaxIncr	-0.023	-0.023	-0.037	-0.013	-0.022	-0.012
	(0.016)	(0.014)	(0.029)	(0.017)	(0.015)	(0.013)
MSZ TaxDecr	-0.004	0.006	0.009	0.004	0.012	-0.008
	(0.006)	(0.006)	(0.007)	(0.013)	(0.008)	(0.011)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	62,017	57,933	53,979	62,017	57,933	53,979

Table IA.12: Examining the Tax Asymmetry Effect in Mukherjee, Singh, and Zaldokas (2016)

This table examines the tax asymmetry effect in Mukherjee, Singh, and Zaldokas (2016), which shows that tax increase has a significant negative impact on innovation, while tax decrease has no impact. We test their rationale for the asymmetry by interacting tax changes with the passage of wrongful discharge laws in the headquarter state. There are three types of wrongful discharge laws. The good faith exception requires employers to treat workers in a fair manner or in good faith and not take actions that would deprive employees of the benefit of employment without just cause. The public policy exception protects employees from termination for refusing to violate an established public policy or commit an illegal act. The implied contract exception protects workers from termination when an employer has implicitly promised employees that they will not be discharged without good cause. In Panel A, the tax changes are interacted with Strong Labor, which equals to the sum of the three indicators (Good Faith+Public Policy+Implied Contract). In Panel B, the tax changes are interacted with Good Faith, which is an indicator that equals to one (zero otherwise) if the state in which a firm is headquartered has adopted the good faith exception by year t. In Panel C, the tax changes are interacted with Public Policy, which is an indicator that equals to one (zero otherwise) if the state in which a firm is headquartered has adopted the public policy exception by year t. In Panel D, the tax changes are interacted with Implied Contract, which is an indicator that equals to one (zero otherwise) if the state in which a firm is headquartered has adopted the implied contract exception by year t. The model specifications follow Mukherjee, Singh, and Zaldokas (2016). MSZ tax increase and decrease variables are defined as in Mukherjee, Singh, and Zaldokas (2016) and are based on historical headquarters state of the firm, which is obtained from Compact Disclosure and 10K filings (parsed 10K location data are obtained from Bill McDonald's website). The sample period is from 1990 to 2006. Firms in the financial sector (6000s SICs) and the public sector (9000s SICs) are excluded. Observations where the firms sales or assets are less than 1 million, the firms reported stock price is negative, or the firm has fewer than four observations are also excluded. Only firms with headquarters in the US are included. The dependent variable in columns (1) to (3) is the natural log of 1 plus the number of patents. All control variables are defined as in Mukherjee, Singh, and Zaldokas (2016), which include changes in log of sales, in log of PPENT divided by the number of employees, in HHI, in HHI squared, in R&D expenditure divided by sales, in profitability, in tangibility, in the availability of S&P debt rating, in log of state's GSP, in tax revenue as a percentage of GSP, in log of state population, and in state employment rate. All regressions are with year fixed effects. Standard errors are clustered at state-level and reported in parentheses. *,**, and *** indicate significance at 10%, 5% and 1% respectively.

Panel A: Interaction with the Strong Labor Index

	$\Delta Ln(1{+}Patent)_{t+1}$	$\Delta Ln(1{+}Patent)_{t+2}$	$\Delta Ln(1{+}Patent)_{t+3}$
	(1)	(2)	(3)
MSZ TaxIncr	0.005	0.026	0.078*
	(0.022)	(0.056)	(0.041)
MSZ TaxIncr*Strong Labor	-0.014	-0.027	-0.061***
	(0.009)	(0.020)	(0.019)
MSZ TaxDecr	-0.002	-0.016	0.010
	(0.011)	(0.011)	(0.014)
MSZ TaxDecr*Strong Labor	-0.001	0.009	-0.001
	(0.006)	(0.006)	(0.008)
Strong labor	-0.010***	-0.011***	-0.011***
	(0.003)	(0.002)	(0.002)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	52,561	48,313	44,460

Panel B: Interaction with the Good Faith Exception

	Δ*Ln(1+Patent)*$_{t+1}$	Δ*Ln(1+Patent)*$_{t+2}$	Δ*Ln(1+Patent)*$_{t+3}$
	(1)	(2)	(3)
MSZ TaxIncr	-0.016	-0.007	-0.013
	(0.014)	(0.018)	(0.015)
MSZ TaxIncr*Good Faith	-0.021	-0.064***	-0.103***
	(0.017)	(0.022)	(0.025)
MSZ TaxDecr	-0.003	0.003	0.010
	(0.007)	(0.008)	(0.008)
MSZ TaxDecr*Good Faith	0.004	-0.000	-0.000
	(0.014)	(0.011)	(0.018)
Good Faith	-0.018***	-0.015**	-0.016***
	(0.006)	(0.006)	(0.005)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	52,561	48,313	44,460

Panel C: Interaction with the Public Policy Exception

	Δ*Ln(1+Patent)*$_{t+1}$	Δ*Ln(1+Patent)*$_{t+2}$	Δ*Ln(1+Patent)*$_{t+3}$
	(1)	(2)	(3)
MSZ TaxIncr	-0.002	-0.086	0.075*
	(0.020)	(0.064)	(0.041)
MSZ TaxIncr*Public Policy	-0.028	0.047	-0.144***
	(0.022)	(0.066)	(0.049)
MSZ TaxDecr	-0.007	-0.010	0.011
	(0.006)	(0.008)	(0.013)
MSZ TaxDecr*Public Policy	0.003	0.013	-0.005
	(0.009)	(0.011)	(0.015)
Public Policy	-0.015**	-0.019***	-0.016*
	(0.006)	(0.007)	(0.008)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	52,561	48,313	44,460

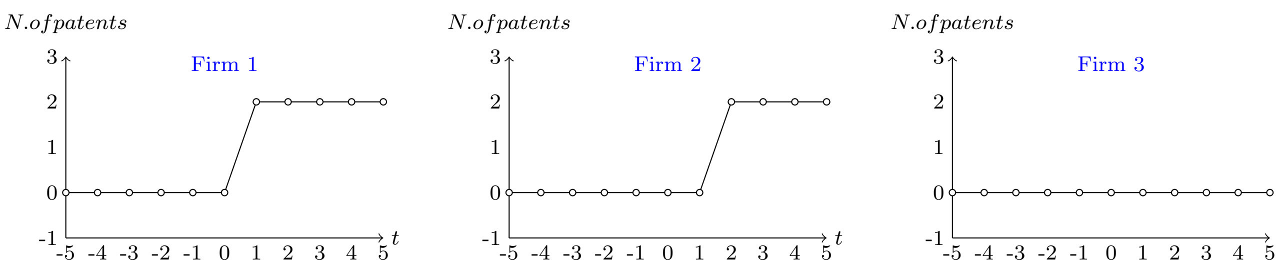
Panel D: Interaction with the Implied Contract Exception

	Δ*Ln(1+Patent)*$_{t+1}$	Δ*Ln(1+Patent)*$_{t+2}$	Δ*Ln(1+Patent)*$_{t+3}$
	(1)	(2)	(3)
MSZ TaxIncr	-0.027*	-0.044	-0.039
	(0.016)	(0.039)	(0.026)
MSZ TaxIncr*Implied Contract	-0.006	0.002	-0.034
	(0.016)	(0.045)	(0.036)
MSZ TaxDecr	0.002	-0.033***	0.000
	(0.009)	(0.008)	(0.012)
MSZ TaxDecr*Implied Contract	-0.007	0.041***	0.009
	(0.013)	(0.011)	(0.017)
Implied Contract	-0.011	-0.021***	-0.018**
	(0.008)	(0.007)	(0.008)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	52,561	48,313	44,460

TableIA.13: Regressions based on Sample Data using Different Model Specifications

This table reports the results based on sample data. The data consist of three firms for the same sample period. Firms 1 and 2 experience a tax decrease in year 0 and firm 3 does not experience any tax changes. Panel A plots the number of patents for each firm during the sample period, where firm 1's patent count starts to increase in year 1 (one year after the tax decrease) and firm 2's patent count starts to increase in year 2 (two years after the tax decrease). In Panel B, the regression results are reported. In columns (1) to (3), we use the first difference specification of Mukherjee, Singh, and Zaldokas (2016), where the dependent variable is the change in the number of patents and the key independent variable, MSZ TaxDecr, is one in year 0 and zero in other years. In columns (4) to (6), we use our fixed effects model, where the dependent variable is the number of patents and the key independent variable, Our TaxDecr, is zero before year 0 and one from year 0 onward. Year and firm fixed effects are included as specificed. Standard errors are clustered at firm-level and reported in parentheses. *,**, and *** indicate significance at 10%, 5% and 1% respectively. Panel C presents the data used for the regressions.

Panel A: Graphs of Patent Count Across Time



Panel B: Regression Results

	ΔPatent$_{t+1}$	ΔPatent$_{t+2}$	ΔPatent$_{t+3}$	Patent$_{t+1}$	Patent$_{t+2}$	Patent$_{t+3}$
	(1)	(2)	(3)	(4)	(5)	(6)
MSZ TaxDecr	1.000	1.000	-0.000			
	(1.070)	(1.071)	(0.000)			
Our TaxDecr				1.800**	1.800**	1.400**
				(0.226)	(0.228)	(0.230)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes	Yes
Obs.	30	27	24	30	27	24
R-squared	0.375	0.370	0.273	0.907	0.904	0.827
Method		First Difference			Fixed Effects	

Panel C: Data

FirmId	t	Patents	ΔPatents	MSZ TaxDecr	Our TaxDecr
1	-5	0	0	0	0
1	-4	0	0	0	0
1	-3	0	0	0	0
1	-2	0	0	0	0
1	-1	0	0	0	0
1	0	0	0	1	1
1	1	2	2	0	1
1	2	2	0	0	1
1	3	2	0	0	1
1	4	2	0	0	1
1	5	2	0	0	1
2	-5	0	0	0	0
2	-4	0	0	0	0
2	-3	0	0	0	0
2	-2	0	0	0	0
2	-1	0	0	0	0
2	0	0	0	1	1
2	1	0	0	0	1
2	2	2	2	0	1
2	3	2	0	0	1
2	4	2	0	0	1
2	5	2	0	0	1
3	-5	0	0	0	0
3	-4	0	0	0	0
3	-3	0	0	0	0
3	-2	0	0	0	0
3	-1	0	0	0	0
3	0	0	0	0	0
3	1	0	0	0	0
3	2	0	0	0	0
3	3	0	0	0	0
3	4	0	0	0	0
3	5	0	0	0	0