Corporate Income Taxes, Financial Constraints and Innovation *

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First Version: October, 2013; This Version: June 5, 2015

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Abstract

We examine exogenous changes in state corporate income taxes over the 1988-2006 period and find that tax decreases significantly boost both the quantity, measured by the number of patents, and the quality, measured by citations per patent, of innovative output, while tax increases have little impact on innovation. Most of the impact of tax changes on innovation occurs two or more years after the tax change, which alleviates concerns of reverse causality. Further tests examine the channels through which tax decreases affect innovation. We document that tax decreases have stronger impact on innovation for more financially constrained firms, for firms with weaker governance and for firms that engage in tax avoidance to a greater extent. The latter result suggests that, after a tax decrease, firms can allocate more resources to innovative activities rather than to tax avoidance. We conduct numerous additional tests to demonstrate that our results are not spurious and not subject to endogeneity biases.

JEL Classification: G31, G32, G34, G38

Keywords: Taxes, Tax Avoidance, Financial Constraints, Innovation, Patents, Productivity, Economic growth

1. Introduction

Academics have extensively debated the role of corporate income taxes in promoting firm investment and economic growth. While research in macroeconomics has found conflicting evidence of a negative or no effect of higher taxes on economic growth and employment (Ramey and Shapiro (1998), Ramey (2011), Romer and Romer (2010), Barro and Redlick (2012)), several unresolved issues still remain. First, most of the prior research has looked at short-term economic growth and GDP fluctuations. 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 establish a causal relationship between taxes and economic growth.

In this paper, we address the gaps in the previous literature by examining the impact of state corporate income taxes on corporate innovation. The existing literature has largely agreed that innovation is the biggest determinant of long-term economic growth (e.g. Solow (1957), Romer (1990)). By looking at innovation, we can trace a possible channel through which economic growth is influenced. To overcome identification challenges, we use staggered changes in state corporate income tax rates. This strategy is similar to Heider and Ljungqvist (2014), who use changes in corporate income tax rates across U.S. states to demonstrate the importance of taxes on leverage. State income tax changes are largely exogenous to the decisions of the individual firm to innovate. We also eliminate the impact of time-varying economy-wide shocks (such as changes in monetary policy) by comparing the change in innovation in a treatment group of firms that experienced a tax change to an otherwise similar 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 country-specific characteristics. State tax changes are staggered over time, which can put the same firm both in the treatment and the control group over our time period, allowing us to control for unobservable firm characteristics. Finally, while economists disagree on the impact of taxes on economic growth, they usually agree that taxes that significantly distort firms' incentives are the ones that potentially have a more substantial impact on growth. Corporate income taxes are usually considered as one such example (Mankiew (2014), Gale and Samwick (2014)).

There are two opposing views about the relationship between corporate income taxes and innovation. The first view contends that taxes can distort the incentives of firms to produce innovative output. Higher taxes reduce after-tax profits and any stakeholder that depends on these profits will have less incentive to invest time, effort, or money in a firm that has a higher tax rate than in an otherwise similar firm with a lower tax rate. There are several theoretical arguments that support this view.

First, lower tax rates increase the after-tax profit and thereby the size of the income that firms can pledge to shareholders in return for their ex-ante investment (Tirole (2006)). In this way, the innovative project is more likely to be financed if tax rates are lower. Thus, in the presence of agency problems and private benefits of control, the tax rates and the after-tax profit will have a significant impact on the quantity and quality of ex-post innovation. We explore this argument more rigorously in the next section by developing a simple mathematical model based on Tirole (2006) and present testable hypotheses.

Second, lower tax rates also make alternative investments in firms with higher tax rates less lucrative, and decrease the opportunity cost of an innovative project. Therefore, if we assume competitive but scarce capital markets, given two otherwise similar firms, shareholders would prefer to invest ex-ante in the firm that has a lower corporate income tax rate and therefore higher after-tax profits.

Third, managers' and employees' incentives may depend on after-tax profits through annual bonuses, long-term incentive plans, stock ownership and stock options. Assuming a pool of scarce human capital, talented employees will prefer to join firms that have lower corporate income tax rates and higher after-tax profits. Fourth, firms can save their after-tax profits and use them as a cushion during difficult times. Since innovation is a highly uncertain process, firms with more cash savings will be better suited to weather unfavorable outcomes and continue to innovate.

Fifth, innovative firms often finance future projects with their internal cash. According to Myers and Majluf (1984), due to adverse selection in capital markets, there is a pecking order of financing new projects, where internal funds are at the top of the order. Because innovative firms are more susceptible to asymmetric information problems, they will be more dependent on internal funds to finance future innovation. Ceteris paribus, these funds will be higher for firms with lower tax rates, therefore those firms will innovate more.

Finally, input markets may not be perfectly flexible. If labor, and especially highly creative human capital is a scarce resource, the firm will operate along a production possibilities frontier, where this resource will be assigned to the activity that yields the highest marginal return. If taxes are high, the firm will devote relatively more resources to finding creative ways of avoiding taxes, and relatively less to innovative projects. If tax rates go down, some of these resources will be liberated and deployed in the creation of innovative output. In addition, firms may keep financial resources such as cash in jurisdictions that have lower tax rates, but also where the return on those resources is lower. If tax rates go down, firms will shift those financial resources to where they yield the highest return.

The alternative theoretical view predicts that tax rates either do not matter or have a positive impact on innovation for the following reasons. First, if all expenditures and investments are tax deductible, there are no private benefits of control or asymmetric information, and the after-tax profit does not affect the ex-ante incentives of the firm's stakeholders, then 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 profit is shared in the end, but will not affect the size of the economic pie. Second, any possible tax decrease may be accompanied either by an increase in the budget deficit, or by a decrease in government spending on public goods such as basic research, education, and infrastructure. As a result, there would be fewer positive spillover effects on firms, which will in turn inhibit their innovative output.

These two theoretical views have opposing predictions. Ultimately, it is an empirical question that we explore in this paper. 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. Our main results are striking. We find that changes in tax rates are negatively and significantly related to the number of patents and the number of citations per patent. The effect on citations per patent is stronger, suggesting that the novelty of innovation is affected even more by changes in state income tax rates. We also find that the effect is asymmetric - most of the significant effect comes from tax decreases while the impact of tax increases is insignificant.

The results are also economically significant: a decrease in the tax rates leads to a 9.7% and 13.5% increase in the number of patents and a 15.9% and 15.4% increase in the number of citations per patent 3 and 4 years into the future, respectively, relative to an otherwise similar firm, located in a state that does not experience a tax decrease. In contrast to tax decreases, tax increases have a small negative effect on innovation in only one of the four years after the tax changes. The reasons behind the asymmetric effect of tax changes are beyond the scope of the paper. A possible reason could be that the federal income tax rates of US firms are the third highest among OECD countries (The Tax Foundation (2014), OECD (1990-2014)). Therefore, further increases in state corporate income tax rates may not have a significant impact on firm behavior, while decreases provide a significant relief, which results in greater innovation. Since tax increases have little impact on innovation, we mostly focus on tax decreases in our subsequent analysis.

We should note that in our main analysis, by employing tax changes that are largely outside of the control of the individual firm, we largely address most endogeneity concerns.

Nevertheless, we pursue several additional strategies that strongly mitigate any residual biases that could possibly stem from reverse causality or omitted variables. First, we conduct a dynamic analysis and demonstrate that most of the impact of tax decreases on innovation comes two or more years after the tax changes are implemented. This pattern alleviates reverse causality concerns such as 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 control for many observable time variant factors such as firm size, leverage, profitability, physical assets, age, industry concentration, state real GDP, state unemployment rate, time fixed effects, and for unobservable time invariant characteristics such as corporate culture and willingness to take risks, by using firm fixed effects. In addition, we also specifically control for state capital gain tax rates, state personal income tax rates, and state R&D tax credits.

Third, we conduct a falsification test based on Heider and Ljungqvist (2014) using tax changes in neighboring states. We find that tax decreases in neighboring states have an opposite effect to tax decreases in the firm's own state, which is inconsistent with unobserved common economic conditions driving our results. Fourth, we conduct a placebo test using tax changes in a random state, further alleviating concerns of spurious correlation. Fifth, we perform an instrumental variable analysis using oil price shocks and the stringency of balanced budget rules for each state as instruments, and find results similar to our baseline findings.

Sixth, we show that our results are robust to the definition of the state to which we assign each firm. For 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 examine this notion further, we conduct several validity and robustness checks. First, we find 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. Second, instead of using the most relevant state, we find similar results using tax changes in the top three most mentioned states or all states that are mentioned at least 10%, 20%, or 30% of the times. We also restrict our analysis to firms that only operate in 1 to 3 states and find larger effects in this sample. Third, we use alternative definitions of the most relevant state based on headquarters, patentee, and subsidiary locations. Together, these analyses provide support for our identification of the most relevant state and confirm the robustness of our main findings.

Finally, despite our numerous tests, it is possible that tax changes are the product of some broader economic and policy changes and the effect we are capturing is from those changes. Given 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. Second, even if tax changes are always part of a broader policy change, such policy changes also may work in similar ways to tax changes - through affecting the pledgeable income of firms, facilitating the start and financing of innovative projects. In this case, tax changes are just a proxy for the broader changes but the main implications remain. We do not argue here that tax changes are random. They are certainly initiated as part of a broader policy change. All we demonstrate is that after tax changes are implemented, there is a significant change in innovation.

Our next step is to investigate the specific channels through which taxes affect innovation. As suggested in the theoretical motivation, tax decreases will increase pledgeable income and therefore increase the likelihood of obtaining external financing for the innovative project. Tax decreases also make alternative investments less lucrative and reduce the cost of capital. Therefore, we hypothesize that firms that are more financially constrained and have weaker corporate governance will experience a larger increase in innovation after a tax decrease because it would be easier for them to obtain external financing that they could not before. We find support for this hypothesis by using several measures of financial constraints.

Specifically, using the Kaplan and Zingales (1997) measure of financial constraints, we document that the positive impact of tax decreases on the number of patents is 77% and 119% 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 90% and 114%

greater 3 and 4 years into the future, respectively. We also find that smaller firms increase their innovation more after a tax decrease than larger firms. This evidence is consistent with smaller firms benefiting more from an increase in after-tax profits because they tend to be more financially constrained and have greater informational asymmetries than larger firms. This result also provides additional evidence that our results are not driven by the lobbying efforts of a few large firms, since small firms benefit the most.

To test the governance hypothesis, we use the hostile takeover index developed by Cain, McKeon, and Solomon (2014), which is based on the passage of 12 different types of state takeover laws, one federal statue and three state standards of review. This governance measure is more comprehensive than the Business Combination laws and has much better coverage than other governance indices such as the G-index. Consistent with the prediction, we find that the positive effect of the tax decrease on innovation is larger for firms with weaker corporate governance. A one standard deviation increase in the anti-takeover index increases the positive effects of tax decrease on the number of citations per patent by 62% and 63%, 3 and 4 years into the future.

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. Policymakers have vigorously debated such activities. For example, the 2013 hearings in the US Congress and the UK Parliament on the tax avoidance activities of high-tech innovative companies such as Apple, Google, and Amazon have generated a firestorm[1]. One rationale presented by these firms for such tax avoiding behavior is that they shift their tax burden to lower tax jurisdictions to preserve their incentives to innovate and protect shareholder wealth.

We examine the tax avoidance hypothesis using an indicator of tax avoidance based on industry and size adjusted cash effective tax rate suggested by Dyreng et al. (2008) and Balakrishnan et al. (2012). There are two opposing predictions. On the one hand, firms

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

that avoid taxes will be less affected by tax changes because they have already reduced their tax burden. On the other hand, both tax avoidance and innovative activities require scarce resources such as managerial 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 to innovative projects, and consequently innovation will increase. The results support the second prediction. We find that the positive impact of tax decreases on the number of patents and on the number of citations per patent is greater for firms that engage more in tax avoidance.

The paper makes several contributions to the Economics and Finance literature. First, we show that corporate income tax rates can have an impact on long-term economic growth by affecting corporate innovation. Second, we document that income taxes matter for firms' production decisions by distorting the incentives of firms and investors to allocate capital to its most productive use. Specifically, we demonstrate that tax reductions increase innovation by relieving financial constraints, and by reallocating creative resources from tax avoidance to innovation. Third, we demonstrate that corporate income taxes can have a significant impact on corporate policies such as innovation decisions. Prior research by Heider and Ljungqvist (2014) has shown that corporate income taxes are important determinants of capital structure choices, also using changes in state tax rates for identification.

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 empirical results. Section 5 concludes.

2. Theoretical Model and Hypotheses Development

In this section, we present a simple model based on Tirole (2006) to demonstrate how taxes affect the incentives of entrepreneurs to work rather than engage in non-productive activities, and the likelihood of them obtaining the necessary financing for profitable (positive NPV) projects. 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 lower tax rates increase the pledgeable income of entrepreneurs. We also show that the positive impact of tax decreases is stronger for firms that are more financially constrained.[2]

2.1. The Case with 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 has cash in the amount of A and the innovative project requires an investment I. This is a fixed-investment model, which assumes rapid decreasing returns after the project has reached its investment level I[3]. We assume that there is a principal-agent problem between the investors and the entrepreneur. 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 (1998)), theft or simply shirking and enjoying the quiet life (Bertrand and Mullainathan (2003)). In the case of innovation, perk consumption could involve pursuing pet projects that don't lead to the creation of novel, heavily cited patents. It could also lead to not innovating, 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 acquires external financing in the amount of $I - A$ and invests in the project. In the second period, the returns $R > 0$

[2]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 showing that taxes affect the likelihood of pursuing innovative projects, and that likelihood depends on financial constraints.

[3]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.

are realized if the project is successful, and shared between the entrepreneur, in the amount of R_e, and the financier 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[4]. 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 firm if they expect that the entrepreneur will misbehave. The firm and the financiers are risk neutral and the financier market is 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 financier needs to leave at least $\frac{B}{\Delta P}$ to the entrepreneur to incentivize him 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 financier market. 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 receive financing. Rearranging, we get that if $A \geq \bar{A} = I - P_H(R - \frac{B}{\Delta P})$, the entrepreneur will receive financing. Therefore, $\bar{A}$ is the minimum net worth that investors need to obtain financing.

[4] More generally, all the variables (A, I, B, R, etc.) can be considered as the difference between the innovative project and the routine project.

2.2. The Case with Income Taxes

Now let's introduce 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 the amount of financing that she will receive and therefore the faith of the innovative project. We have two simple assumptions.

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

Assumption 2: All investment is tax deductible.

That is, the investment requirement is only $I(1-t)$, and the additional financing needed by the entrepreneur is $I(1-t)-A$. This is a somewhat stringent requirement since in reality not all investment is tax-deductible, but given that we focus on innovation in this paper, much of the investment goes towards R&D expenditures that are tax deductible. 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 without loss of generality. We should note here that we do not suggest that all investment goes towards R&D expenditures. In fact, we believe that part of the investment that is very important for shaping top management incentives goes towards their explicit or implicit compensation, which is not part of R&D expenditures.

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, $R_f + R_e = R(1-t)$, we can substitute in the IC constraint and obtain:

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

Transforming further, we obtain:

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

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

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

If we take the difference between the minimum cash required to obtain financing with and without taxes, we get:

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

if the the firm has a positive NPV project and if t > 0. Therefore, firms with positive NPV projects that have cash A, such that: $\bar{A}_t > A > \bar{A}$, will not be able to obtain financing because of taxes, while they would have financed their projects if there were no taxes. 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 cash to obtain financing for innovative projects, the easier it would be to obtain financing, and therefore more innovations will be created. This is because lowering tax rates increases the pledgeable income and makes it more likely that the entrepreneur works and innovates rather than shirks and undertakes the routine project.

Hypothesis 1: Lower tax rates increase the ability of investors to finance positive NPV projects such as innovation.

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

Hypothesis 2: Financially constrained firms will benefit more from a reduction in tax rates.

Finally, the size of private benefits may also play a role in the influence of tax rates on innovation. It is not possible to show that in the simple model above, but intuitively, we hypothesize that the level of private benefits, and the strength of corporate governance can moderate the effect of corporate income taxes. The relationship is, however, not obvious. It depends on whether tax rates and private benefits are complements or substitutes. On the one hand, firms with greater private benefits (with poorer corporate governance) will be less likely to properly utilize (more likely to squander) the additional cash obtained from tax rate decreases. On the other hand, firms will greater private benefits will benefit more from lower tax rates because the additional income will increase their pledgeable income and provide them with better incentives to exert effort to innovate rather than shirk and enjoy the private benefits.

Hypothesis 3a: A reduction in the tax rates will have a stronger impact on innovation for firms with greater private benefits (worse corporate governance).

Hypothesis 3b: A reduction in the tax rates will have a weaker impact on innovation for firms with greater private benefits (worse corporate governance).

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

3. Data and Variable Construction

The sample of companies examined in this paper is created by first combining the NBER patent database assembled by Hall et al. (2006), and Compustat. The University of Michigan's World Tax Database and the Tax Foundation provide the state corporate income tax rates, and Garcia and Norli (2012) provides 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 states of incorporation and location come from Compustat and Compact D/SEC databases.

The sample is constructed by selecting all U.S. publicly traded firms from the NBER patent file, 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 D/SEC, 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 83,690 firm-years based on 8,394 firms over the period of 1988-2006.

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

The key explanatory variables in our analysis are two indicators, $TaxIncr_{st}$ and $TaxDecr_{st}$ that take a value of one if at time t state s there has been a major increase or decrease in state corporate income tax rates, respectively, and zero otherwise. 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. The tax variables equals 1 or -1, respectively, in the year of the change and all subsequent years unless the tax rate is reverted back to the level before the change.

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. If it is reverted in less than three years, it is not considered a change and the variable retains the value of 0. If the change is reverted three or more 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. We also make sure that the difference between the average tax rate during the treatment period and the average tax rate during the control period is at least 1%. The major tax increases and decreases are identified in Table I. From 1988 to 2006, eleven states experienced a major tax increase and eight states experienced a major tax decrease.

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 tax changes that are not reversed in three years. A contemporaneous paper by Mukherjee, Singh, and Zaldokas (MSZ) (2014) also examine the impact of state corporate taxes on innovation, but they use all tax changes. They also use first differences analysis instead of firm fixed effects as we do in this paper. Consistent with our study, MSZ find that corporate taxes are detrimental to innovative output measured by patents. However, MSZ find a significant effect mostly for tax increases, rather than tax decreases. This difference is likely attributed to the different methodology and the different identification of tax signals.

State tax rates come from the University of Michigan's World Tax Database 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 also check these data with the state corporate income tax rates reported in the Book of States to ensure consistency and accuracy. For each state-year observation, we compute the tax rate change from the prior year. For states with multiple tax brackets, we focus on changes in the top tax bracket.

There are several challenges associated with determining the relevant tax rate for a given firm. The approach taken by much of the previous research is to use the state of company headquarters based on the assumption that most of the profits of that company are generated in that state. While this assumption is often reasonable, in many cases it is not correct. For example, Boeing Company 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.

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. As we do not have specific information on these three components, we try to 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 use state count information from Garcia and Norli (2012), who compute the number of times a 10-K 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 properties and sales in different geographic areas.

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. As explained above, state taxes are computed based on the firm's sales, property, and payroll presence in a state. 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 4.4 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, we also use the time-varying most mentioned state 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.

3.2. Construction of the Dependent Variables

The main dependent variables that we use in our analysis are two types of metrics for innovative output: the number of patents to measure the quantity of innovation and the number of citations per patent to measure the novelty of innovation [5]. Since the second metric has the advantage that it can distinguish important innovations from incremental ones, we use the number of citations per patent as our main measure of innovative output.

The first metric, *Patent*, is a patent count for each firm in each year. The relevant year is the application year, which occurs close to the actual innovation and far before the innovation is transformed 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 patents. Hall et al. (2005), and Atanassov (2013) among others demonstrate that patent citations are an 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[6].

[5] All variables are defined in the Appendix.

[6] For robustness, we also correct for the truncation bias by using two methods suggested by Hall, Jaffe and Trajtenberg (2001) and find similar results.

3.3. 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.

3.4. Model Specification

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

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

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 *TaxChg*, *TaxIncr*, or *TaxDecr*, 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.

To understand this approach, 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.

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 in the main analysis because the Poisson model is a non-linear model 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. For robustness however, we verify that our main results still hold if we use a Poisson specification.

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 at the state of location level as suggested by Bertrand et al. (2002) and obtain similar findings.

3.5. 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 4.9% of the firm-years in the sample have a significant tax increase and about 8.6% 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

In Table IIIA, we study how changes in state corporate tax rates affect the number of patents created by firms. As Grilliches (1990) argues, the innovation lag is uncertain. Therefore, we look at the number of patents from 1 to 4 years into the future. The results show that tax changes have a significant negative effect on the number of patents, which is a measure of the quantity of innovation. The negative relation exists for years 1 to 4.

Other results from Tables IIIA show that larger firms and firms with more R&D expenditures, with less leverage, and more tangible assets create a larger number of patents. In support of Aghion et al. (2005), there is a non-linear (inverted-U) relation between industry concentration and innovation.

In Table IIIB, we examine the impact of tax changes on the number of citations per patent. Citations per patent is a measure of the quality and novelty of innovation. The previous literature (e.g. Hall et al. (2005)) has convincingly demonstrated that most of the firm value is contributed by a small number of highly cited patents.

The results of Table IIIB show a significant negative relation between tax changes and the quality of innovation. 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 in this section 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 the state of location and obtain similar results.

4.2. Tax Increases vs. Tax Decreases

In this subsection, we examine whether the effect of tax changes on innovation is asymmetrical for tax increases versus tax decreases. In Table IVA, we analyze how increases in state corporate tax rate affect the number of patents created by firms. The results show that tax increases have a negative effect on the quantity of innovation. However, the effect is only significant in the first year.

Table IVB presents the effect of tax decreases on the number of patents. There is a notable difference from Table IVA. Tax decreases are significantly and positively related to the number of patents for years 2 to 4. This suggests that most of the effect in Table III is coming from tax decreases. One possibility for this asymmetry is that tax increases force companies to avoid taxes, so they do not matter too much. The results in Table IVB are also economically significant. Tax decreases lead to a 3.9%, 6.8%, 9.7% and 13.5% increase in the number of patents in the number of patents, 2, 3, and 4 years later, respectively, and to an insignificant increase in the number of patents 1 year later.

In Tables VA and VB, we examine the quality of innovation measured as the number of citations per patent. The results of Table VA show that tax increases are largely unrelated to the quality of innovation. In contrast, Table VB shows a dramatic positive and significant effect of tax decreases on the number of citations per patent for all years. Again, these findings suggest an asymmetric impact of tax changes on the quality of innovation.

In terms of economic significance, the estimates in Table VB show that tax decreases lead to an increase in the number of citations per patent by 14.7%, 16.2%, 15.9% and 15.4% , for 1, 2, 3, and 4 years in the future, respectively. These results suggest that tax decreases not only increase the quantity, but also the quality of innovation, which is the more important measure of innovative output (Griliches (1990), Hall, Jaffe, and Trajtenberg (2005)).

4.3. Tax Changes and the Number of Citations per Patent: Additional Tests for Endogeneity

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. Nevertheless, in this section, we pursue a number of strategies to address concerns of endogeneity. Since tax increases have little impact on innovation, we mostly focus on tax decreases in subsequent analysis.

4.3.1. Dynamic and Placebo Effects

We examine 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 experience a decline in innovation, then we should see an effect prior to the enactment of tax reductions. To this end, we create four indicator variables for each of the three tax measures in Table VIA that allow us to investigate the dynamics of tax changes and their impact on the number of citations per patent.

For example, when *TaxDecr* is examined in column (3), TaxDecrMinus2 is an indicator variable equal to 1, if there is a significant tax decrease in year t+2 in the largest state of business of firm i, and 0 otherwise. TaxDecrMinus1 is an indicator variable equal to 1, if there is a significant tax decrease 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 decrease is implemented. TaxDecrFirst is an indicator variable equal to 1, if there is a significant tax decrease in year t or t-1 in the largest state of business of firm i, and 0 otherwise. TaxDecrAfter2 is an indicator variable equal to 1, if there is a significant tax decrease in year t-2 or earlier in the largest state of business of firm i, and 0 otherwise.

Column (1) of Table VIA examines the dynamic effects of *TaxChg*. The coefficients suggest that the impact on innovation comes two or more years after the tax change. There is no evidence of a pre-trend prior to the change, which is consistent with the parallel trend assumption. In columns (2) and (3), we examine tax decreases and increases separately. Consistent with the results in Tables IVA and VA, tax increases are not significantly related to the number of citations per patent. In contrast, we find a significant positive effect of *TaxDecr* on innovation quality two years after the tax decrease, with no evidence of a pre-existing trend.

In Table VIB, we conduct a placebo test by assigning a random state to each firm. This is an additional test that controls for endogeneity and is useful for assessing whether the documented effects are spurious. The key estimates show that tax decreases in a randomly assigned state has no impact on the number of citations per patent.

4.3.2. Other State-level Variables

We also address concerns of endogeneity by investigating a possible omitted variable bias. In Table VIB, we control for potential omitted variables such as state capital gain tax rate, state personal income tax rate, and state R&D tax credit. State capital gain tax and person income tax data come from Daniel Feenberg's website[7].

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 equals 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.

These variables are included as additional controls in Table VIB. The state personal income tax has no effect on the quality of innovation, while the capital gain tax has a positive effect and the state R&D tax credit has a negative effect on the number of citations per patent. More importantly, 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.

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

4.3.3. Falsification Test using Tax Changes in Neighboring States

We conduct a falsification test based on Heider and Ljungqvist (2014) in Table VIC. 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 states. Thus, if tax decreases in neighboring states have similar effects as tax decreases in the firm's own state, then results are likely due to common economic conditions rather than tax changes.

As seen in Table VIC, the coefficients on the tax decrease indicator continue to be positive and significant as in the baseline case. At the same time, tax decreases in neighboring states have a negative and significant effect on the number of citations per patent. Since tax decreases in neighboring states have opposite effects as tax decreases in the firm's own state, this evidence is not consistent with unobserved local economic conditions driving our results.

In addition, the negative impact of tax decreases in neighboring states is indicative of a competition effect. Specifically, when tax rates in neighboring states go down, investors are more willing to finance firms in those states instead of the state in question. Talented individuals are also more willing to work in neighboring states with lower tax rates if part of their compensation is based on after tax profits. As a result, firms in the state in question experience a reduction in innovative output due to higher relative financing costs and an outflow of talented workers.

4.3.4. Instrumental Variable Analysis

To further alleviate concerns of endogeneity, we conduct an instrumental variable analysis. The instruments are variables that are related to state tax rates but not to innovation except through tax rates. We use the interactions of oil prices, the historical sensitivity of state revenue to oil prices, and a measure of state balanced budget stringency (ACIR index). Each variable does not have to be a good instrument per se, but we believe the combination of the three (the triple interaction term) is outside of the control of the individual firm.

Oil prices are measured as inflation-adjusted OPEC crude oil price in year t. The historical sensitivity of state revenue to oil prices is estimated 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[8]. 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 past several decades. 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, oil price can be taken as exogenous since they are outside of the controls of the individual state. Thus, the instruments for tax changes are the oil price change, and its interaction with the historical sensitivity of state revenue to oil prices and the ACIR index. The idea behind the instruments is that depending on the state's balanced budget rules, states may adjust their tax rates when their revenues change due to an exogenous shock such as changes in oil prices[9]. However, the sensitivity of state revenue to oil prices and the stringency of balanced budget rules are not exogenous per se as they are partly determined by the state's economic and political environment. Thus, we do not use them as instruments by themselves and control for their effects by including fixed effects.

[8]http://www.indstate.edu/polisci/klarnerpolitics.htm

[9]We thank our NBER discussant Austan Goolsbee for suggesting this idea.

The results from the instrumental variable regressions are reported in Table VIE. In the first stage, the tax variables are regressed on the instruments and controls. Since oil prices do not vary by state, they are absorbed by year fixed effects. The key estimates are all statistically significant and the F-stats 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 changes have a significant negative effect on innovation quality and tax decreases have a significant positive effect. Moreover, the magnitudes of the key coefficients are also similar to the ones from the OLS regressions. These findings, together with the previous results in this section, provide substantial confidence that our results are not severely biased by endogeneity.

4.4. 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 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 VIIA confirm this prediction. The coefficient in column (1) suggests that on average tax increases raise the total state taxes paid by 27%, 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 19%.

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 VIIA, 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 VIIB. 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 positive and significant relation between tax changes in the time-varying most mentioned state and the number of citations per patent. As another robustness check, our tax change variable is equal to 1 if there is a significant tax change in any of the top-three most mentioned states, in which the firm operates, instead of only the top most mentioned state and find similar results.

Furthermore, instead of using the most mentioned state based on the 10-K reports, we use all states that are mentioned at least 10%, 20%, or 30% of the times on average. For this specification, the tax decrease dummy equals one if there is a tax decrease in any of these states. As seen in Table VIIB, 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. We find that the coefficients on tax decreases are positive and significant. The coefficients are also larger than those in the baseline case, consistent with the restricted sample containing firms that are more likely to be impacted by state corporate income tax changes.

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. Headquarter location data come from Compact Disclosure, which reports historical headquarters information. 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. 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.

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

5. Investigating the Channels through which Taxes Affect Innovation

Based on our theoretical motivation, 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 three possible channels through which tax decreases affect innovation - relieving financial constraints, reducing the negative impact of weak corporate governance, and reducing tax avoidance.

5.1. Tax Changes, Financial Constraints, and Innovation

The theoretical model demonstrated that tax rates reduce the pledgeable income available to firms and make it more difficult to finance innovative projects. Therefore, investors will be more willing to provide financing to firms that experience a decline in their income tax rate compared to an otherwise similar firm that does not experience such a decline. If firms do not need much additional financing, either because they hold enough cash, or because it's easier to tap external financing, the decline in tax rates will not have a big impact. Conversely, we expect that firms that are more financially constrained will benefit more from a tax decrease because their pledgeable income may increase above the required threshold to finance the project.

Tax decreases may relieve financial constraints and thereby free more resources. These resources can then be used to finance positive NPV projects that would otherwise not be financed. Tax decreases can also be used to increase future cash holdings over time and therefore make it easier to finance innovative projects that suffer from greater informational asymmetries from internal funds rather than external equity or debt (Myers and Majluf (1984)).

To test this hypothesis we construct a measure of financial constraints based on Kaplan and Zingales (1997), as implemented by Lamont, Polk, and Saa-Requejo (2001). Following the literature (e.g., Farre-Mensa and Ljungqvist (2013)), we sort firms into terciles each year based on their KZ index values. The indicator, FinConstraint, equals one for firms in the top tercile, and zero otherwise. We then interact FinConstraint with the tax decrease indicator variable.

Table VIIIA presents the results. The coefficient on the interaction term is positive and significant. This result suggests 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 patents is 77% and 119% 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 90% and 114% greater 3 and 4 years into the future, respectively. For robustness, we also use alternative measures of financial constraints from Whited and Wu (2006) and Hadlock and Pierce (2010) and find similar interactive effects.

In a related test, we examine if smaller firms benefit more from tax decreases. Presumably, smaller firms have more informational asymmetries and are more financially constrained.

These firms are also more constrained in terms of attracting and keeping talented employees. In Table VIIIB we interact the tax decrease dummy with a proxy for firm size, *LnSales*. The interaction term is negative and significant suggesting that the positive impact of tax decreases is 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. 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 scarce in smaller firms where the manager is directly responsible for most key decision making. Thus, the impact of tax changes should be stronger in smaller firms.

In sum, more financially constrained firms benefit to a greater extent by tax decreases because more resources are freed to provide entrepreneurs with incentives to innovate. Although less financially constrained firms benefit less, the impact of tax decreases on those firms is also positive and significant for the number of citations per patent, suggesting that financial constraint is not the only mechanism through which taxes impact innovation.

5.2. 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. 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)). Therefore, we expect firms with weaker governance to benefit more from the increase in internal cash that will be freed after a tax decrease than firms with stronger governance that can tap external capital markets more easily.

This section examines the corporate governance hypothesis. 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 (2014). The coverage of this takeover index (i.e., 14,441 firms from 1965 to 2011) is much better than the G-index from 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 potential endogeneity concerns. Thus, recent studies (Bertrand and Mullainathan (2003), Atanassov (2013)) have used largely exogenous measures such as the passage of Business Combination laws to measure the governance environment. Similar to the Business Combination laws, the takeover index mainly focuses on state-level variation in the takeover environment that is largely exogenous to firm-level decisions.

The takeover index is constructed based on the passage of 12 different types of state anti-takeover laws, one federal statue and three state standards of review. The 12 state takeover laws include first generation statues, business combination, fair price, control share acquisition, control share cash-out, poison pill, 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. Thus, while similar in nature to the Business Combination laws, the takeover index is richer and more comprehensive than the BC laws alone.

To construct a comprehensive measure of a firm's takeover environment, the 16 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 higher hostile takeover hazard. For ease of interpretation, we create an 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 decrease dummy with the Anti-takeover Index. We use this 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 IX. We note first that the Anti-takeover Index is negatively related to the number of patents and 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. The coefficients on the interaction term, TaxDecr*Anti-takeoverIndex, are positive and statistically significant at the 1% level. This finding suggests that the positive effect of tax decrease on innovation is larger for firms subject to a lower hostile takeover threat, or weaker governance, consistent with the prediction. A one standard deviation increase in the Anti-takeoverIndex (0.08) increases the positive effects of tax decrease on the number of citations per patent by 62% and 63%, 3 and 4 years into the future.

5.3. Tax Changes, Tax Avoidance and Innovation

This section examines the tax avoidance hypothesis. We hypothesize that higher tax rates increase the return on tax avoidance activities and incentivize firms to keep productive resources deployed in those activities and away from productive activities. When a tax decrease occurs, we expect that the firm will shift back those resources to producing innovative output.

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, thus captures 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 substracting 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 decrease dummy with our TaxAvoid measure. We use this interaction term to test whether firms that avoid taxes more are impacted differentially by tax changes. There are two opposing predictions. The null hypothesis is that tax changes will have a smaller impact on firms that avoid taxes more because they will be able to adjust the effective tax rate and minimize the tax burden. As a result, the prediction is that the interaction term between tax decreases and the TaxAvoid indicator variable will be negative.

The alternative hypothesis is that firms that avoid taxes more are fundamentally more vulnerable to tax changes. When tax rates go down, these firms will shift disproportionally more resources from dealing with tax avoidance to innovative projects. Because these resources are better suited for innovative projects, 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 decreases and the TaxAvoid indicator variable will be positive.

The results in Table X support the alternative hypothesis. Table X shows that firms that avoid taxes more are more impacted by tax decreases. The positive impact of tax decreases on the number of patents is 397% and 291% 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 is 183% and 200% 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 more in tax avoidance.

6. Conclusion

This paper presents new evidence on the impact of corporate income tax changes on the quantity and quality of innovation. We show that tax increases have little impact on innovation. In contrast, tax decreases have a large and significant positive impact on patents and citations per patent. We find that tax decreases have a positive impact on innovation by relieving financial constraints. We also examine the tax avoidance hypothesis, and find that firms that engage more in tax avoidance, are more impacted by tax decreases. Our results suggest that while preserving the incentives to innovate might be one reason why high-tech firms shift their tax burden to countries with lower corporate income tax rates, the shift is inefficient and ultimately has a negative impact on innovation. Our findings have strong implications for the impact of tax policy on long-term firm performance and economic growth.

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Appendix: Variable Definitions

1. Age_{it}: Age of firm i in year t based on the years in the Compustat sample (Source: Compustat).

2. $Assets_{it}$: Total assets of firm i in year t (Source: Compustat).

3. $Citations/Patent_{it}$: Measures the number of citations per patent applied for in year t by firm i. The weight of each patent is the number of citations received by a patent applied for in year t divided by the total number of citations received by all patents applied for in year t (Source: NBER Patent Data).

4. $EBIDTA_{it}$: Earnings before interest depreciation taxes and amortization of firm i in year t (Source: Compustat).

5. $FinConstraint_{it}$(An Indicator of Financial Constraint) = An indicator variable equal to one if the firm is in the top tercile of the yearly KZ index, and zero 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).

6. $Herfindahl_{it}$: 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).

7. $Leverage_{it}$: $\frac{TotalDebt}{TotalAssets}$, where Total Debt = Short-term debt + Long-term debt (Source: Compustat).

8. $NPPE_{it}$: Net property plant and equipment of firm i in year t (Source: Compustat).

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

10. $Profitability_{it}=(\frac{EBITDA}{Assets})_{it}$: Earnings before interest depreciation taxes and amortization of firm i in year t divided by its *Assets* (Source: Compustat).

11. RD_{it}: R&D Expenditure by firm i in year t (in $ million) (Source: Compustat).

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

13. $Sales_{it}$: Net Sales by firm i in year t (in $ million) (Source: Compustat).

14. $Anti\text{-}takeoverIndex_{it}$: The firm-level takeover index developed by Cain, McKeon, and Solomon (2014), which is constructed based on the passage of 12 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).

15. $Tangibility_{it}=(\frac{NPPE}{Assets})_{it}$: Total debt of firm i in year t divided by its *Assets* (Source: Compustat).

16. $TaxAvoid_{it}$(An Indicator of Tax Avoidance) = An indicator variable equal to one if the firm is in the bottom tercile of the yearly industry and size adjusted cash effective tax rate (ETR), and zero 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 (Compustat data item TXPD) divided by the three-year sum of pre-tax income (PI) less special items (SPI). (Source: Compustat).

17. $TaxChg_{st}$=1, if there has been a significant tax increase of at least 1% in the largest state of business of firm i at time t, =-1 if there has been a significant tax decrease of at least 1% in the largest state of business of firm i at time 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.

18. $TaxInc_{st}$=1, if there has been a significant tax increase of at least 1% in the largest state of business of firm i at time t, and 0 otherwise. 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.

19. $TaxDecr_{st}$=1, if there has been a significant tax decrease of at least 1% in the largest state of business of firm i at time t, and 0 otherwise. 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.

20. $UnemployRate_{st}$: 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
Iowa	1999	
Kentucky	1990	
Missouri	1990	
Nebraska	1991	
New Hampshire	1999	1994
New York		2000
North Carolina	1991	1994
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	-0.0372	0.3540
TaxIncr	0.0485	0.2148
TaxDecr	0.0857	0.2799
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
FinConstraint	0.3129	0.4637
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 *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. Data is for the period 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	-0.022**	-0.038**	-0.046**	-0.062***
	(0.011)	(0.015)	(0.018)	(0.022)
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**	0.114***	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***	0.644***	0.799***	0.855***
	(0.119)	(0.140)	(0.170)	(0.204)
Herfindahl^2	-0.503***	-0.616***	-0.770***	-0.813***
	(0.129)	(0.149)	(0.175)	(0.202)
LnRealGDP	0.243***	0.198**	0.160	0.167
	(0.080)	(0.094)	(0.112)	(0.134)
UnemployRate	0.008*	0.007	0.006	0.007
	(0.005)	(0.005)	(0.006)	(0.007)
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 IIIB:
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. Data is for the period 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	-0.060***	-0.066***	-0.060***	-0.058***
	(0.017)	(0.017)	(0.017)	(0.016)
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	0.167***	0.173***	0.181***	0.180***
	(0.034)	(0.036)	(0.036)	(0.038)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.795***	0.644***	0.576***	0.473**
	(0.178)	(0.187)	(0.191)	(0.191)
Herfindahl^2	-0.809***	-0.717***	-0.633***	-0.531***
	(0.181)	(0.189)	(0.194)	(0.193)
LnRealGDP	0.141	0.126	0.093	0.141
	(0.121)	(0.126)	(0.134)	(0.138)
UnemployRate	0.011*	0.008	0.004	0.001
	(0.006)	(0.006)	(0.006)	(0.006)
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 IVA:
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* ($\frac{R\&DExpenditures}{TotalAssets}$), *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. Data is for the period 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	-0.032*	-0.037	-0.024	-0.030
	(0.019)	(0.024)	(0.028)	(0.033)
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	0.055**	0.114***	0.175***	0.244***
	(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***	0.644***	0.797***	0.854***
	(0.119)	(0.140)	(0.171)	(0.204)
Herfindahl^2	-0.503***	-0.616***	-0.769***	-0.812***
	(0.129)	(0.149)	(0.175)	(0.202)
LnRealGDP	0.231***	0.177*	0.133	0.132
	(0.080)	(0.095)	(0.113)	(0.135)
UnemployRate	0.007	0.006	0.005	0.006
	(0.005)	(0.005)	(0.006)	(0.007)
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 IVB:
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* ($\frac{TDebt}{Total Assets}$), *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. Data is for the period 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	0.028	0.055**	0.078***	0.107***
	(0.018)	(0.024)	(0.030)	(0.037)
LnSales	0.034***	0.025***	0.017***	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***	0.177***	0.247***
	(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***	0.800***	0.857***
	(0.119)	(0.140)	(0.170)	(0.204)
Herfindahl^2	-0.503***	-0.617***	-0.771***	-0.815***
	(0.129)	(0.148)	(0.175)	(0.202)
LnRealGDP	0.245***	0.206**	0.177	0.191
	(0.080)	(0.094)	(0.112)	(0.133)
UnemployRate	0.008*	0.008	0.007	0.009
	(0.005)	(0.005)	(0.006)	(0.007)
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 VA: 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* ($\frac{R\&DExpenditures}{TotalAssets}$), *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. Data is for the period 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	-0.044	-0.050*	-0.030	-0.029
	(0.029)	(0.030)	(0.030)	(0.029)
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	0.166***	0.172***	0.181***	0.179***
	(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	0.794***	0.643***	0.575***	0.471**
	(0.178)	(0.187)	(0.192)	(0.191)
Herfindahl^2	-0.809***	-0.717***	-0.632***	-0.530***
	(0.181)	(0.189)	(0.195)	(0.193)
LnRealGDP	0.108	0.089	0.058	0.108
	(0.122)	(0.127)	(0.135)	(0.139)
UnemployRate	0.010	0.007	0.003	0.000
	(0.006)	(0.006)	(0.006)	(0.006)
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 VB:
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. Data is for the period 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	0.095***	0.104***	0.102***	0.099***
	(0.026)	(0.026)	(0.026)	(0.025)
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***
	(0.014)	(0.014)	(0.015)	(0.014)
Profitability	-0.000**	-0.000	-0.002**	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)
Tangibility	0.167***	0.173***	0.182***	0.181***
	(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	0.796***	0.645***	0.578***	0.474**
	(0.178)	(0.187)	(0.191)	(0.191)
Herfindahl^2	-0.809***	-0.719***	-0.634***	-0.532***
	(0.181)	(0.189)	(0.194)	(0.193)
LnRealGDP	0.158	0.145	0.115	0.162
	(0.120)	(0.126)	(0.134)	(0.138)
UnemployRate	0.013**	0.010	0.005	0.003
	(0.006)	(0.006)	(0.006)	(0.006)
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 VIA:
Tax Decreases 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 (for tax increase) or -1 (for tax decrease), 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 (for tax increase) or -1 (for tax decrease), if there is a significant tax change in year t+1 in the largest state of business of firm i, and 0 otherwise, on *TaxVarFirst*, which is an indicator variable equal to 1 (for tax increase) or -1 (for tax decrease), if there is a significant tax change in year t or t-1 in the largest state of business of firm i, and 0 otherwise, and on *TaxVarAfter2*, which is an indicator variable equal to 1 (for tax increase) or -1 (for tax decrease), 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. Data is for the period 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:	TaxChg	TaxIncr	TaxDecr
TaxVarMinus2	0.006	0.007	-0.011
	(0.024)	(0.049)	(0.028)
TaxVarMinus1	-0.019	-0.030	0.009
	(0.025)	(0.048)	(0.029)
TaxVarFirst	-0.036	-0.040	0.031
	(0.026)	(0.044)	(0.031)
TaxVarAfter2	-0.073***	-0.059	0.104***
	(0.025)	(0.037)	(0.036)
LnSales	0.006	0.006	0.006
	(0.005)	(0.005)	(0.005)
RD/TA	0.004	0.003	0.004
	(0.004)	(0.004)	(0.004)
Leverage	-0.039***	-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***	0.143***	0.144***
	(0.032)	(0.032)	(0.032)
Age	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Herfindahl	0.800***	0.798***	0.800***
	(0.167)	(0.167)	(0.167)
Herfindahl^2	-0.828***	-0.827***	-0.829***
	(0.171)	(0.171)	(0.171)
LnRealGDP	0.174	0.142	0.181
	(0.112)	(0.113)	(0.111)
UnemployRate	0.013**	0.012**	0.015**
	(0.006)	(0.006)	(0.006)
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 VIB:
Tax Decreases, State-level Variables and Innovation

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. Additional state-level variables include state capital gain tax rate, state personal income tax rate, and state R&D tax credit (recalculated, highest tier) 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. Data is for the period 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	0.081***	0.090***	0.088***	0.087***
	(0.026)	(0.026)	(0.026)	(0.024)
LnSales	-0.001	-0.006	-0.010*	-0.011**
	(0.005)	(0.005)	(0.006)	(0.006)
RD/TA	0.015	0.008	0.023	0.005
	(0.011)	(0.011)	(0.015)	(0.008)
Leverage	-0.047***	-0.042***	-0.045***	-0.045***
	(0.014)	(0.014)	(0.015)	(0.014)
Profitability	-0.000*	-0.001	-0.002**	-0.002**
	(0.000)	(0.000)	(0.001)	(0.001)
Tangibility	0.168***	0.164***	0.181***	0.172***
	(0.035)	(0.036)	(0.037)	(0.038)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.861***	0.738***	0.698***	0.605***
	(0.178)	(0.186)	(0.190)	(0.190)
Herfindahl^2	-0.870***	-0.796***	-0.729***	-0.644***
	(0.183)	(0.190)	(0.195)	(0.194)
LnRealGDP	0.165	0.153	0.112	0.149
	(0.122)	(0.128)	(0.135)	(0.139)
UnemployRate	0.007	0.002	-0.004	-0.007
	(0.006)	(0.006)	(0.007)	(0.007)
State Capital Gain Tax	0.025***	0.021**	0.025**	0.036***
	(0.009)	(0.009)	(0.010)	(0.012)
State Personal Income Tax	0.009	0.017	0.011	-0.003
	(0.012)	(0.012)	(0.013)	(0.015)
State R&D Tax Credit	-0.550***	-0.529**	-0.493**	-0.410*
	(0.212)	(0.219)	(0.227)	(0.223)
Obs.	80,010	75,405	70,716	66,139
N. of Firms	7,997	7,851	7,517	7,179
R-squared	0.556	0.553	0.551	0.546

Table VIC:
Falsification Test using Neighboring States

This table reports the results from a falsification using tax decreases in neighboring states. 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. *TaxDecr in Neighboring States* is an indicator variable equal to 1, if there has ben a significant tax decrease in any of the neighboring states 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. Data is for the period 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	0.090***	0.100***	0.098***	0.096***
	(0.026)	(0.026)	(0.026)	(0.025)
TaxDecr in Neighboring States	-0.090***	-0.079***	-0.076***	-0.063***
	(0.016)	(0.016)	(0.016)	(0.016)
LnSales	-0.002	-0.007	-0.012**	-0.013**
	(0.005)	(0.005)	(0.005)	(0.005)
RD/TA	0.010	0.019	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	0.163***	0.169***	0.178***	0.178***
	(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	0.799***	0.648***	0.581***	0.476**
	(0.177)	(0.186)	(0.190)	(0.190)
Herfindahl^2	-0.817***	-0.725***	-0.641***	-0.538***
	(0.180)	(0.188)	(0.193)	(0.192)
LnRealGDP	0.165	0.152	0.122	0.170
	(0.120)	(0.126)	(0.133)	(0.138)
UnemployRate	0.007	0.004	0.000	-0.001
	(0.006)	(0.006)	(0.006)	(0.006)
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 VID:
Placebo Test using a Random State

This table reports the results of a placebo test using tax changes in a randomly assigned state. Specifically we estimate the OLS model of $Ln(1+\frac{Citations}{Patent})$ on *TaxDecr*, which are indicator variables equal to 1, if there has been a significant tax decrease in a randomly assigned state 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. Data is for the period 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	0.003	0.001	-0.008	-0.010
	(0.029)	(0.030)	(0.030)	(0.028)
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	0.166***	0.172***	0.180***	0.179***
	(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	0.794***	0.643***	0.574***	0.471**
	(0.178)	(0.187)	(0.192)	(0.191)
Herfindahl^2	-0.809***	-0.718***	-0.632***	-0.530***
	(0.181)	(0.189)	(0.195)	(0.193)
LnRealGDP	0.106	0.088	0.057	0.107
	(0.122)	(0.127)	(0.135)	(0.139)
UnemployRate	0.010*	0.007	0.003	0.001
	(0.006)	(0.006)	(0.006)	(0.006)
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 VIE: Instrumental Variable Regressions

This table reports the results from instrumental variable regressions. The instruments are interactions of OilPrice (inflation-adjusted OPEC crude oil price), OilSensitivity (sensitivity of state revenue to oil prices), and ACIR (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 change variables on the instruments and controls. In the second stage, $Ln(1+\frac{Citations}{Patent})$ is regressed on the instrumented tax variable. Controls in first and second stage regressions 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 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. Data is for the period 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

Panel A: First Stage

	TaxChg	TaxChg	TaxDecr	TaxDecr
	(1)	(2)	(3)	(4)
OilPrice*ACIR	-0.002***	-0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
OilPrice*OilSensitivity	-0.120***	-0.120***	0.113***	0.114***
	(0.004)	(0.004)	(0.003)	(0.003)
OilPrice*ACIR*OilSensitivity	0.012***	0.012***	-0.011***	-0.011***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes
Obs.	73,327	68,449	73,327	68,449
F-stat of Instruments (p-value)	182.03	189.95	352.46	362.90
	(0.000)	(0.000)	(0.000)	(0.000)

Panel B: Second Stage

	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
Instrumented TaxChg	-0.135***	-0.108***		
	(0.032)	(0.029)		
Instrumented TaxDecr			0.150***	0.119***
			(0.034)	(0.030)
LnSales	-0.012**	-0.013**	-0.012**	-0.013**
	(0.006)	(0.006)	(0.006)	(0.006)
RD/TA	0.016	0.018	0.017	0.018
	(0.014)	(0.014)	(0.014)	(0.014)
Leverage	-0.043***	-0.048***	-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	0.183***	0.182***	0.183***	0.183***
	(0.036)	(0.038)	(0.036)	(0.038)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.587***	0.482**	0.588***	0.483**
	(0.191)	(0.191)	(0.191)	(0.191)
Herfindahl^2	-0.639***	-0.537***	-0.641***	-0.539***
	(0.194)	(0.193)	(0.194)	(0.193)
LnRealGDP	0.155	0.190	0.159	0.193
	(0.137)	(0.142)	(0.137)	(0.142)
UnemployRate	0.005	0.002	0.007	0.004
	(0.006)	(0.006)	(0.006)	(0.006)
Obs.	73,327	68,449	73,327	68,449
N. of Firms	7,433	7,000	7,433	7,000

Table VIIA:
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. Data is for the period 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)	0.754***			
	(0.228)			
TaxDecr (Most Mentioned State)		-0.513***		
		(0.167)		
TaxIncr (Least Mentioned State)			-0.204	
			(0.146)	
TaxDecr (Least Mentioned State)				0.130
				(0.182)
LnSales	0.139***	0.139***	0.139***	0.139***
	(0.028)	(0.028)	(0.028)	(0.028)
RD/TA	0.015	0.015	0.014	0.013
	(0.022)	(0.022)	(0.022)	(0.022)
Leverage	-0.279***	-0.279***	-0.277***	-0.276***
	(0.089)	(0.088)	(0.088)	(0.089)
Profitability	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Tangibility	-0.897***	-0.905***	-0.901***	-0.902***
	(0.235)	(0.235)	(0.235)	(0.236)
Age	-0.000	-0.000	-0.000	-0.000
	(0.003)	(0.003)	(0.003)	(0.003)
Herfindahl	-1.790*	-1.765*	-1.776*	-1.783*
	(0.948)	(0.948)	(0.947)	(0.947)
Herfindahl^2	2.187**	2.167**	2.184**	2.187**
	(1.042)	(1.043)	(1.042)	(1.042)
LnRealGDP	0.693	0.435	0.716	0.712
	(0.621)	(0.616)	(0.622)	(0.622)
UnemployRate	-0.035	-0.054	-0.042	-0.042
	(0.038)	(0.038)	(0.038)	(0.038)
Obs.	72,680	72,680	72,680	72,680
N. of Firms	8,094	8,094	8,094	8,094
R-squared	0.258	0.258	0.258	0.258

Table VIIB:
Robustness Checks of the Most Relevant State

This table reports the results relating the number of citations per patent to tax decreases while performing robustness checks for the most relevant state used to identify tax changes. 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. Data is for the period 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)
Time varying state	0.074***	0.065***	0.050***	0.037***
	(0.013)	(0.012)	(0.010)	(0.009)
Obs.	49,556	45,467	41,781	38,521
Top three most mentioned states	0.094***	0.094***	0.094***	0.085***
	(0.020)	(0.021)	(0.020)	(0.019)
Obs.	83,690	78,854	73,931	69,121
Firms with 1-3 equivalent states	0.161***	0.163***	0.158***	0.164***
	(0.038)	(0.039)	(0.037)	(0.035)
Obs.	36,492	34,151	31,755	29,449
States with at least 10% counts	0.087***	0.090***	0.085***	0.081***
	(0.019)	(0.019)	(0.019)	(0.019)
Obs.	83,690	78,854	73,931	69,121
States with at least 20% counts	0.108***	0.109***	0.106***	0.101***
	(0.023)	(0.023)	(0.023)	(0.021)
Obs.	83,690	78,854	73,931	69,121
States with at least 30% counts	0.096***	0.101***	0.107***	0.104***
	(0.025)	(0.026)	(0.025)	(0.023)
Obs.	83,690	78,854	73,931	69,121
Headquarter state	0.076***	0.087***	0.083***	0.084***
	(0.025)	(0.025)	(0.025)	(0.024)
Obs.	83,551	78,720	73,802	68,996
State with most patents	0.085**	0.102**	0.110***	0.108***
	(0.041)	(0.041)	(0.040)	(0.037)
Obs.	41,993	40,000	37,932	35,872
State with most subsidiaries	0.266***	0.289***	0.288***	0.294***
	(0.040)	(0.038)	(0.038)	(0.036)
Obs.	59,190	56,590	53,864	51,057

Table VIIIA:
Tax Decreases, Financial Constraints and Innovation

This table examines the role of financial constraints. Specifically we estimate the OLS model of *Ln(1+Patent)* (Columns (1) and (2)), or *Ln(1+$\frac{Citations}{Patent}$)* (Columns (3) and (4)) 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, and its interaction with FinConstraint, which is an indicator variable equal to 1 if the firm is in the highest tercile of the Kaplan-Zingales financial constraint index, 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. Data is for the period 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	Ln(1+Patent)$_{t+3}$	*Ln(1+Patent)*$_{t+4}$	*Ln(1+$\frac{Citations}{Patent}$)*$_{t+3}$	*Ln(1+$\frac{Citations}{Patent}$)*$_{t+4}$
	(1)	(2)	(3)	(4)
TaxDecr	0.064*	0.081*	0.081***	0.072***
	(0.034)	(0.042)	(0.029)	(0.028)
FinConstraint	-0.031***	-0.035***	-0.032***	-0.031***
	(0.009)	(0.010)	(0.009)	(0.009)
TaxDecr*FinConstraint	0.049*	0.096***	0.073***	0.082***
	(0.027)	(0.030)	(0.024)	(0.023)
LnSales	0.018***	0.010	-0.013**	-0.015**
	(0.006)	(0.006)	(0.006)	(0.007)
RD/TA	0.023*	0.032**	0.003	-0.005
	(0.013)	(0.014)	(0.013)	(0.013)
Leverage	-0.052***	-0.059***	-0.016	-0.023
	(0.018)	(0.019)	(0.018)	(0.018)
Profitability	-0.000	-0.003	-0.001	-0.005**
	(0.001)	(0.003)	(0.001)	(0.002)
Tangibility	0.194***	0.271***	0.223***	0.213***
	(0.040)	(0.047)	(0.042)	(0.043)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.709***	0.753***	0.583***	0.458**
	(0.176)	(0.214)	(0.207)	(0.205)
Herfindahl^2	-0.723***	-0.744***	-0.661***	-0.522**
	(0.186)	(0.215)	(0.210)	(0.206)
LnRealGDP	0.165	0.129	0.116	0.107
	(0.120)	(0.143)	(0.145)	(0.149)
UnemployRate	0.006	0.006	0.004	0.000
	(0.006)	(0.007)	(0.007)	(0.007)
Obs.	62,721	58,665	62,721	58,665
N. of Firms	7,152	6,766	7,152	6,766
R-squared	0.730	0.709	0.567	0.565

Table VIIIB:
Tax Decreases, Firm Size and Innovation

This table examines the role of firm size. Specifically we estimate the OLS model of *Ln(1+Patent)* (Columns (1) and (2)), or $Ln(1+\frac{Citations}{Patent})$ (Columns (3) and (4)) 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, 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. Data is for the period 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+Patent)_{t+3}$	$Ln(1+Patent)_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxDecr	0.396***	0.509***	0.315***	0.284***
	(0.057)	(0.072)	(0.048)	(0.047)
LnSales	0.021***	0.014**	-0.008	-0.010*
	(0.005)	(0.006)	(0.006)	(0.006)
TaxDecr*LnSales	-0.064***	-0.080***	-0.043***	-0.037***
	(0.015)	(0.018)	(0.010)	(0.010)
RD/TA	0.019**	0.017*	0.017	0.019
	(0.008)	(0.009)	(0.014)	(0.014)
Leverage	-0.067***	-0.077***	-0.045***	-0.049***
	(0.013)	(0.014)	(0.015)	(0.014)
Profitability	-0.001	-0.002***	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.182***	0.255***	0.186***	0.185***
	(0.034)	(0.041)	(0.036)	(0.037)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.815***	0.872***	0.588***	0.481**
	(0.170)	(0.204)	(0.191)	(0.191)
Herfindahl^2	-0.788***	-0.832***	-0.645***	-0.540***
	(0.175)	(0.201)	(0.194)	(0.193)
LnRealGDP	0.153	0.162	0.099	0.150
	(0.111)	(0.132)	(0.133)	(0.138)
UnemployRate	0.007	0.009	0.005	0.003
	(0.006)	(0.007)	(0.006)	(0.006)
Obs.	73,931	69,121	73,931	69,121
N. of Firms	7,886	7,529	7,886	7,529
R-squared	0.720	0.698	0.553	0.548

Table IX:
Tax Decreases, Governance and Innovation

This table examine the role of corporate governance. Specifically we estimate the OLS model of *Ln(1+Patent)* (Columns (1) and (2)), or $Ln(1+\frac{Citations}{Patent})$ (Columns (3) and (4)) 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, and its interaction with the Anti-takeoverIndex, which is developed by Cain, McKeon, and Solomon (2014) constructed based on the passage of 12 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* ($\frac{R\&DExpenditures}{TotalAssets}$), *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. Data is for the period 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+Patent)_{t+3}$	$Ln(1+Patent)_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxDecr	0.307***	0.397***	0.242***	0.228***
	(0.041)	(0.049)	(0.031)	(0.030)
Anti-takeoverIndex	-1.265***	-1.431***	-0.486***	-0.249
	(0.194)	(0.233)	(0.163)	(0.159)
TaxDecr*Anti-takeoverIndex	2.916***	3.679***	1.867***	1.727***
	(0.700)	(0.829)	(0.381)	(0.360)
LnSales	0.003	-0.007	-0.018***	-0.016***
	(0.005)	(0.005)	(0.005)	(0.005)
RD/TA	0.020**	0.018*	0.024*	0.004
	(0.009)	(0.010)	(0.014)	(0.008)
Leverage	-0.073***	-0.082***	-0.047***	-0.049***
	(0.013)	(0.015)	(0.015)	(0.015)
Profitability	-0.001	-0.002**	-0.002**	-0.002*
	(0.000)	(0.001)	(0.001)	(0.001)
Tangibility	0.184***	0.260***	0.191***	0.189***
	(0.035)	(0.042)	(0.037)	(0.039)
Age	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.772***	0.794***	0.524***	0.389**
	(0.172)	(0.206)	(0.194)	(0.194)
Herfindahl^2	-0.756***	-0.774***	-0.604***	-0.469**
	(0.177)	(0.204)	(0.196)	(0.195)
LnRealGDP	0.132	0.139	0.106	0.170
	(0.114)	(0.136)	(0.137)	(0.142)
UnemployRate	0.010*	0.013*	0.007	0.004
	(0.006)	(0.007)	(0.006)	(0.006)
Obs.	70,799	66,221	70,799	66,221
N. of Firms	7,581	7,219	7,581	7,219
R-squared	0.724	0.702	0.555	0.552

Table X:
Tax Decreases, Tax Avoidance and Innovation

This table examine the role of tax avoidance. Specifically we estimate the OLS model of *Ln(1+Patent)* (Columns (1) and (2)), or $Ln(1+\frac{Citations}{Patent})$ (Columns (3) and (4)) 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, 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. Data is for the period 1988 to 2006. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Ln(1+Patent)_{t+3}$	$Ln(1+Patent)_{t+4}$	$Ln(1+\frac{Citations}{Patent})_{t+3}$	$Ln(1+\frac{Citations}{Patent})_{t+4}$
	(1)	(2)	(3)	(4)
TaxDecr	0.038	0.065	0.072**	0.063**
	(0.043)	(0.053)	(0.034)	(0.031)
TaxAvoid	-0.046***	-0.052***	-0.043***	-0.040***
	(0.012)	(0.013)	(0.011)	(0.011)
TaxDecr*TaxAvoid	0.151***	0.189***	0.132***	0.126***
	(0.037)	(0.043)	(0.028)	(0.025)
LnSales	0.036***	0.024**	0.002	-0.003
	(0.010)	(0.011)	(0.010)	(0.009)
RD/TA	0.103**	0.120**	0.058**	0.054**
	(0.047)	(0.055)	(0.029)	(0.026)
Leverage	-0.087***	-0.089***	-0.063***	-0.051**
	(0.024)	(0.027)	(0.024)	(0.023)
Profitability	-0.001	-0.002	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	0.337***	0.425***	0.310***	0.276***
	(0.065)	(0.076)	(0.057)	(0.056)
Age	0.001	0.001*	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl	0.809***	0.857***	0.599**	0.544**
	(0.258)	(0.309)	(0.240)	(0.228)
Herfindahl^2	-0.776***	-0.780***	-0.593**	-0.523**
	(0.251)	(0.291)	(0.233)	(0.224)
LnRealGDP	0.132	0.101	0.081	0.088
	(0.180)	(0.213)	(0.172)	(0.169)
UnemployRate	0.003	0.004	0.018*	0.014
	(0.011)	(0.013)	(0.009)	(0.009)
Obs.	43,753	40,794	43,753	40,794
N. of Firms	5,870	5,538	5,870	5,538
R-squared	0.719	0.691	0.572	0.565