Do Sales and Use Tax Exemptions Promote Firm Innovation?

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Abstract

This study examines whether sales tax exemptions for research and development (R&D) purchases increase firm innovation. Using a stacked cohort difference-in-differences research design, we exploit the staggered introduction of R&D sales tax exemptions across states to identify their effect on R&D expenditures and patenting activity. We find some evidence of increased R&D expenditures among affected firms broadly following the implementation of an R&D sales tax exemption, with a significant positive effect concentrated in high-tech and manufacturing firms. The positive effect is also stronger among financially constrained and loss firms, suggesting that an exemption's upfront cost reduction is especially helpful to these firms. However, we do not find evidence of a corresponding increase in firms' patenting activity, and even find evidence of reduced patent quantity among manufacturing firms and loss firms. Tests of R&D expenditures and patent applications at the aggregate state level are generally consistent with firm-level results. Overall, our evidence suggests that R&D sales tax exemptions are partially effective in promoting innovative activities through increased inputs to innovation, but not necessarily increased outputs.

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1. INTRODUCTION

This study examines whether sales and use tax ("sales tax") exemptions for research and development ("R&D") promote firm innovation.[1] Innovation is a key driver of economic growth that governments often seek to promote. R&D's nature as a risky investment, and the beneficial knowledge spillovers that arise when investing firms are not able to fully appropriate all knowledge from their innovative activity, provide a rationale for governments to encourage R&D through various regulatory tools (Bond and Van Reenen 2007). One such tool is to subsidize innovation through tax policy. Existing literature on the role of taxation in promoting innovation generally focuses on income taxes (e.g., Berger 1993; Hall and Van Reenen 2000; Wilson 2009; Gupta, Hwang, and Schmidt 2011; Ernst, Richter, and Riedel 2014; Rao 2016). However, we know less about the effect of sales tax exemptions, a policy measure that many U.S. states use in hopes of increasing investment and innovation within their borders. Our study of R&D sales tax exemptions helps provide a more complete picture of the effects of tax policy on firm innovation by examining a policy which functions differently from income tax innovation incentives.

Although sales tax is often perceived as a tax on consumer purchases, firms must also pay tax on purchases for use in their business unless an exemption applies.[2] One common exemption applies to qualified R&D purchases. Of the 46 states that impose sales tax, 31 now offer a general sales tax exemption for purchases used in qualified R&D activities.[3] Although specific rules vary by state, R&D sales tax exemptions generally apply to equipment and supplies used in the same types of activities that constitute qualified research for the federal R&D tax credit. With combined state and

[1] Tax jurisdictions imposing sales taxes also impose compensating use tax on the use, storage, or consumption of taxable items on which sales tax has not been paid. Because rates and exemptions are generally the same between the two taxes for a given jurisdiction, we use the term sales tax for brevity.
[2] Ring (1999) estimates that approximately 40% of sales tax collections are from business, rather than consumer, purchases. Businesses receive exemptions on purchases of items for resale. Section 2 discusses other exemptions.
[3] We focus on statutory R&D sales tax exemptions that are broadly available to all qualified taxpayers. Negotiated incentives or programs limited to specific firms are beyond the scope of this study.

local sales tax rates typically ranging between five and ten percent, an exemption can provide significant savings for R&D purchases, potentially increasing the opportunities for projects with a positive net present value (NPV).

Prior literature has examined the impact of income tax R&D credits in state, federal, and international settings, generally finding that R&D credits increase innovative activity (e.g., Bloom, Griffith, and Van Reenen 2002; Klassen, Pittman, and Reed 2004; Wilson 2009). A growing body of literature also explores the effects of IP box regimes, with multiple studies finding that such policies impact firms' investment and location decisions (e.g., Ernst, Richter, and Riedel 2014; Bornemann, Laplante, and Osswald 2023; Chen, De Simone, Hanlon, and Lester 2023).[4] In contrast to R&D credits and IP boxes, sales tax exemptions represent a different type of tax incentive that aims to increase innovation by providing an upfront reduction in the cost of R&D equipment and supplies. That is, sales tax exemptions provide above-the-line savings and do not require a firm to have taxable income in order to immediately benefit. This distinction may be especially important for small growth firms that engage in R&D, but which may not yet be profitable. Due to structural differences compared with other tax incentives, it is unclear ex ante whether sales tax exemptions will have a similar effect on firms' innovative activities.

The innovation literature considers the importance of both inputs to and outputs from innovative activity. Similarly, states enacting R&D incentives often emphasize the potential benefits to both in-state investment and the state's competitive position with regard to innovation. For example, Texas legislation enacting R&D tax incentives stated among its purposes to "make Texas economically competitive in the field of research and development… encourage new investment in the state… and complement the state's manufacturing industries by encouraging innovation and

[4] IP box regimes provide for a reduced income tax rate on intellectual property-related income as a way to incentivize R&D activities that lead to commercially viable products.

efficiency."[5] Because of the importance placed on both sides of the innovation process, we examine the effect of R&D sales tax exemptions on both inputs (using R&D expenditures as a proxy) and outputs (using patents as a proxy). Using a stacked cohort difference-in-differences design, we exploit the staggered introduction of R&D exemptions in various states between 2003 and 2019 to test their effect on R&D expenditures and patents. Of the 31 states that offer R&D sales tax exemptions, ten were introduced between 2003 and 2019.[6]

Overall, we find some evidence that R&D sales tax exemptions increase firms' R&D spending, but do not find evidence of an increase in patenting activity. With regard to inputs, our tests suggest a marginally significant ($p<0.10$) increase in R&D expenditures among firms headquartered in states that enact an R&D exemption compared to firms headquartered in states with no exemption. However, these significant results only occur when testing the existence of an exemption, and not when the independent variable of interest is a continuous measure of the percentage savings afforded by an exemption. At a minimum, these somewhat mixed results suggest that at least R&D spending does not decrease. Spending would mechanically decrease if a firm purchases the same items after the exemption as it does before, but enjoys a reduced price due to the exemption. We therefore also test a measure of R&D expenditures grossed up for the sales tax that would have applied absent the exemption, but find similar results as our main test of R&D expense.

Given the somewhat mixed results among a broad set of firms, we next perform cross-sectional tests to determine if firms in industries more likely to benefit from the exemption demonstrate an increase in R&D spending. Consistent with expectations, we observe a larger increase in R&D spending for high-tech and manufacturing firms compared to other industries. We find that high-tech (manufacturing) firms experience a 16.65% (7.47%) increase in R&D expense following

[5] H.B. 800, 2013 Leg., Sess. 83(R). (Tex. 2013).
[6] Appendix A lists states with and without R&D sales tax exemptions, as well as effective dates for states implementing exemptions during our sample period.

implementation of an R&D sales tax exemption ($p<0.01$). Stated in relation to the magnitude of the exemption, each percentage point decrease in the sales tax rate on R&D purchases is associated with a 2.63% (0.90%) increase in R&D expense for high-tech (manufacturing) firms ($p<0.05$). These effects are similar in magnitude to the range of findings from prior studies of the R&D income tax credit. For example, prior research has found that a 10% reduction in the user cost of R&D from the federal R&D credit increases research intensity between 1% and 19% (Hall and Van Reenen 2000; Rao 2016). At the state level, Wilson (2009) finds that a one percentage point increase in a state's effective R&D credit rate increases in-state R&D by 1.7% in the short run and 3% in the long run.

Regarding innovation outputs, we do not find evidence that firms file more patent applications following enactment of an R&D sales tax exemption in their headquarter state. We continue to find a lack of statistically significant results when testing the patent activity of high-tech firms. Interestingly, we observe a significant negative result among manufacturing firms. Taken together, our patent results suggest that even if R&D sales tax exemptions motivate firms to increase R&D expenditures, this increased R&D activity does not necessarily yield additional outcomes in the form of patents within our sample period. It is possible that firms could be using their increased R&D budget to pursue projects with less certain or less productive outcomes. Projects that provide a positive NPV only once sales tax costs are removed may involve higher risk or be of lower quality compared to projects that a firm already pursued without the exemption. Alternatively, firms may be instead using their increased R&D budgets less efficiently or protecting their innovations through methods other than patenting (e.g., through secrecy).[7]

In additional cross-sectional analyses, we examine financially constrained and loss firms to test whether the upfront savings of a sales tax exemption or the ability to benefit even when in a loss

[7] There is little research estimating the effect of income tax R&D credits on patent applications, but for comparison, Bradley, Dauchy, and Robinson (2015) examine IP box regimes and find a 3% increase in patent applications for every percentage point decrease in the tax rate on patent income.

position results in a stronger effect. We generally find a stronger positive effect on R&D spending among financially constrained and loss firms following a new R&D sales tax exemption relative to other treated firms, consistent with expectations. However, the effect on patents is generally significantly negative for financially constrained or loss firms, relative to other treated firms. Overall, the results in our main sample thus appear to be amplified among these firms.

We round out our findings by examining the timing of observed firm-level effects, and testing R&D spending and patents at the aggregate state level. In terms of timing effects, the increase in R&D spending that we find in the broad sample of firms appear to begin in year three and four after the exemption becomes effective. Testing the dynamic effects of R&D sales tax exemptions on patent activity yields insignificant results in years following the event year, similar to the null results in our main patent tests. Our tests of aggregate state activity provide evidence of increased R&D spending and decreased patent applications which is generally consistent with our state-level tests, with the caveat that these results are sensitive to research design choices.

This study primarily contributes to two streams of research. First, it contributes to the literature on tax incentives by examining the effects of sales tax incentives. Much of the tax incentives literature focuses on income tax, even though non-income tax incentives are available and can be sizeable in magnitude. Dyreng and Maydew (2018) identify non-income-based taxes as one area of tax where research is particularly needed, specifically with outcomes for investment and public policy. In terms of innovation, Lester and Olbert (2024) observe that the literature has little evidence on R&D incentives other than income tax credits, IP box regimes, and a generally favorable tax environment. Because sales tax exemptions function differently from income tax credits or IP boxes, it is important to evaluate their effects. Our findings suggest that an upfront reduction in the cost of R&D activities via a sales tax exemption results in increased R&D spending among certain firms (high-tech, manufacturing, and financially constrained firms), but does not necessarily lead to greater innovative output in the form of patents. To our knowledge, this finding is unique among studies examining the effects of innovation tax incentives and is informative to policymakers evaluating how outcomes align with their goals to promote innovation.

Second, we add to the literature on corporate innovation by introducing sales tax exemptions as a new consideration in what promotes innovative activity. The sales tax setting provides an opportunity to explore how firms adjust their investment and patent activity following a plausibly exogenous reduction in the cost of R&D, since removing sales tax effectively reduces the cost of R&D equipment and supplies. Importantly, and beyond characterizing R&D sales tax exemptions as simply a cost reduction to innovative inputs, such exemptions carry real costs to tax jurisdictions in the form of reduced sales tax revenue. For example, Texas estimates that the 2018 cost of its R&D sales tax exemption is $152.1 million, and Florida estimates $50.5 million (Hegar 2017; Florida Revenue Estimating Conference 2018).[8]

2. INSTITUTIONAL BACKGROUND

Forty-five states and the District of Columbia levy general sales and use taxes on tangible personal property and certain services.[9] Although sales tax is often perceived as a tax only paid by individual consumers, firms also pay sales tax on items that they use in their business. For example, equipment and supplies that are used by a business, rather than resold, are generally subject to tax unless an exemption applies. Each state allows exemptions for certain transactions, with some common exemptions including those based on the nature of the item (e.g., groceries or electricity), the identity of the purchaser (e.g., government or nonprofit organizations), or the use of the item (e.g., goods the firm will resell or equipment used in manufacturing).

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[8] By comparison, Texas estimates the cost of its franchise tax R&D credit at $178.3 million, and Florida estimates the cost of its income tax R&D credit at $13 million for the same year.

[9] In the case of interstate transactions, sales tax rates and rules typically apply based on the purchaser's location.

An exemption for purchases used in R&D is one such use-based exemption available in multiple states. As of December 31, 2023, 31 states offer a sales tax exemption for qualified R&D purchases. Because sales tax is administered at the state (and occasionally local) level, specific requirements for exemption vary by location. For example, some states require that the item be used "exclusively" and/or "directly" in R&D activity, or specify certain qualifying industries such as manufacturing. Some states provide a partial exemption which effectively functions as a reduced tax rate on qualified R&D purchases, while others provide a full exemption. While differences exist among the specific rules between states, the exemption generally applies to purchases of tangible personal property used in qualified R&D activities.

Since both income tax and sales tax provide beneficial treatment for R&D, it is helpful to consider how these two tax types compare.[10] Income tax R&D credits and R&D sales tax exemptions are similar in the sense that they incentivize investment in innovation by reducing the cost of R&D projects.[11] Also, qualified R&D activity is usually similar for both federal income tax and state sales tax purposes. In fact, many states refer directly to the Internal Revenue Code definition of qualified research or use language similar to that in the federal R&D credit to define qualified research.[12]

Despite these similarities, important differences exist between income tax credits and sales tax exemptions. Qualified expenditures for calculating the U.S. federal R&D credit include wages, contract research, basic research payments, and certain purchases of supplies, but not capital equipment.[13] Sales tax exemptions can apply to tangible personal property such as capital equipment

[10] The U.S. has historically provided incentives for innovation through both the R&D credit and the R&D deduction. We focus on the R&D credit in this section because prior literature has primarily studied the credit. The R&D deduction, which allows taxpayers to immediately deduct a broader range of R&D expenditures, incentivizes R&D investment by lowering the after-tax present value cost of R&D. Cowx, Lester, and Nessa (2024) examine the effects of amortizing rather than expensing R&D for tax purposes.
[11] This differs from IP box regimes which incentivize the subsequent income stream. See discussion in Section 3 below.
[12] For federal purposes, qualifying R&D requires the activity to eliminate uncertainty, and to discover information which is technological in nature and is useful in a new or improved business component, through a process of experimentation. (I.R.C. Sec. 41(d)).
[13] I.R.C. Sec. 41(b).

and supplies, as well as utilities and services performed on exempt R&D equipment (e.g., repairs and maintenance), depending on the state. Wages and contract research are not subject to sales tax in the first place, so R&D sales tax exemptions are not relevant to these expenditures. Further, the R&D credit in the U.S. (and several foreign jurisdictions) functions as a credit on incremental activities such that firms earn the credit for qualified R&D expenditures in the current year that exceed some base amount (Gupta, Hwang, and Schmidt 2011). R&D sales tax exemptions do not typically share this incremental nature, which potentially broadens their benefit for repeating R&D purchases. The process for obtaining savings also differs. Sales tax exemptions effectively reduce the upfront cost of otherwise taxable purchases by the amount of the sales tax at the time of purchase. Purchasers generally claim the exemption by providing their vendor a signed statement called an exemption certificate stating that the item will be used in an exempt manner, relieving the seller of their tax collection obligation on the sale.[14] Income tax credits, in contrast, function as a reduction to income tax paid to the tax authority. A taxpayer does not need to have taxable income to currently claim a sales tax exemption on R&D purchases, in contrast to income tax credits which offset tax liability.[15]

Finally, differences also exist in financial reporting for sales tax and income tax. As part of the cost of purchases, sales tax is included in various sections of the financial statements including capital assets, research and development expense, or selling, general, and administrative expenses, and generally is not directly observable. A sales tax exemption would reduce the cost of the related purchase in the financial statements resulting in higher pretax income, though with some delay if the purchases are depreciable assets. Material uncertainties in sales tax treatment are considered for inclusion in the reserve for contingencies under ASC 450 (formerly FAS 5). Income tax R&D credits,

[14] Certain states administer the exemption differently. For example, until June 30, 2015, Minnesota required purchasers to pay tax to their vendor and then claim a refund from the state.
[15] The Protecting Americans from Tax Hikes (PATH) Act of 2015 allows certain qualified small businesses (QSBs) to monetize R&D credits in the near term by offsetting R&D credits against employer-paid Social Security tax, instead of carrying over unused R&D credits to future years when they are profitable.

however, only affect net (after-tax) income, with uncertain tax benefits reflected in the reserve for uncertain tax benefits under ASC 740 (formerly FIN 48).

Although many states have longstanding R&D exemptions that date back to the early days of their sales tax regimes, a growing number of states have enacted R&D exemptions in recent years. California, Florida, Idaho, Illinois, Indiana, Missouri, Tennessee, Texas, Utah, and Wisconsin have each enacted an R&D sales tax exemption since 2003. The staggered introduction of these exemptions across states provides a useful setting for testing their effects. Appendix A summarizes which states offer R&D sales tax exemptions and provides the effective dates for states whose exemptions begin during our sample period.

3. RELATED LITERATURE AND HYPOTHESIS

3.1 Related Literature

A substantial body of research across accounting, finance, and economics examines the factors that influence firm innovation. As noted by He and Tian (2018) and Reeb and Zhao (2022), a desire to understand how to promote innovative activity has motivated a body of capital markets research that examines potential determinants. For example, Reeb and Zhao (2022) summarize thirty-five covariates that prior research has studied in relation to patent activity. The number and variety of determinants suggests the complexity of innovation and interest in uncovering its drivers.

In addition to firm-related factors, external shocks such as tax policy can also affect firm innovation. As summarized in recent reviews on the real effects of taxation, prior research generally finds that income tax incentives at the federal, state, and international levels have positive effects on firm innovation (Jacob 2022; Lester and Olbert 2024). U.S. federal taxation provides significant benefits for R&D investment through the R&D credit and the immediate deductibility of R&D expenditures. Early studies of the R&D credit during the 1980s include estimates of the tax price elasticity of demand ranging from insignificant (Collins 1983) to 1.6 (Hines 1991; Berger 1993).

Gupta, Hwang, and Schmidt (2011) examine subsequent changes to the R&D credit calculation in 1989, finding that firm investment is sensitive to the credit calculation and that the response varies cross-sectionally between high-tech firms and other firms. Using confidential IRS data from 1981-1991 to fine-tune estimates of the federal R&D tax credit's effect, Rao (2016) concludes that a 10% reduction in the user cost of R&D translates into a 19.8% increase in R&D intensity in the short run. Although the longstanding federal R&D deduction has been less studied than the R&D credit, Cowx et al. (2024) find that 2022 tax law changes limiting R&D deductibility lead to decreased R&D spending by domestic-only, research-intensive, and financially constrained firms. Overall, the federal income tax literature suggests that tax benefits related to innovation have a positive effect on firms' real investment, but that the impact varies with firm characteristics and calculation details.

Income tax R&D credits are available not only at the federal level, but also at the state level. In a state-level study over 1979-1995, Wu (2005) concludes that state R&D credits increase R&D spending within the state. In a more detailed study, Wilson (2009) finds that state R&D credits increase in-state R&D investment, but that nearly all of this increase is attributable to investment being drawn away from other states, essentially resulting in a "zero-sum game." Studies focusing on characteristics of state corporate income tax regimes other than R&D credits find that state income tax rates and addback statutes (combined reporting requirements) have a significant negative (positive) relation on R&D spending and/or patent activity (Mukherjee, Singh, and Žaldokas 2017; Atanassov and Liu 2020; Li, Ma, and Shevlin 2021; Akcigit, Grigsby, Nicholas, and Stantcheva 2022; Welsch 2023). Overall, research on state tax innovation incentives has found that state R&D credits increase investment, although Wilson (2009) suggests this may be the movement of investment between states rather than an increase in overall R&D spending.[16]

[16] In addition to studying state tax for its own sake, various studies use state R&D credits as an instrument for R&D activity in the state, and rely on the assumption that state R&D credits increase R&D investment in the state (see, e.g., Hombert and Matray 2018; Falato and Sim 2014).

Like the U.S. federal and state findings, studies on R&D credits in international settings generally conclude that R&D tax incentives increase innovative activity, with outcomes varying depending on the specifics of the credit and tax regime (Hall and Van Reenen 2000; Bloom, Griffith, and Van Reenen 2002; Klassen, Pittman, and Reed 2004; Agrawal, Rosell, and Simcoe 2020). The international setting also allows for analysis of different incentive types, including those that target innovation inputs such as R&D credits, and those that target innovation outputs such as decreased tax rates on patent income (Ernst, Richter, and Riedel 2014). A number of subsequent studies have further examined output-focused incentives, commonly known as patent boxes, innovation boxes, or IP boxes. Research finds increased patent activity following implementation of IP box regimes, and that these incentives impact firms' investment and location decisions (e.g., Bradley, Dauchy, and Robinson 2015; Bradley, Robinson, and Ruf 2021; Bornemann et al. 2023; Chen et al. 2023).

Despite the extensive focus on income tax R&D incentives, little if any empirical evidence exists on consumption tax innovation incentives. Jacob, Michaely, and Müller (2019) study the effects of value-added tax (VAT) on firm investment more generally, finding that higher VAT rates reduce capital expenditures with elasticities comparable to that of income taxes. However, data limitations prevent Jacob et al. (2019) from examining the effect of VAT on R&D investment specifically. A few studies have examined sales tax on business inputs, particularly manufacturing equipment (Joulfaian and Mackie 1992; Mikesell and Ross 2017). Most similar to our research question, Hageman, Bobek, and Luna (2015) test whether the sales tax burden affects manufacturing firms' capital expenditures and employment using aggregate state-level data during the period 1983-2006. Like R&D purchases, many states offer an exemption for manufacturing machinery, equipment, raw materials, and/or supplies. The results in Hageman et al. (2015) suggest that a higher sales tax burden on manufacturing purchases results in lower capital investment and employment in the manufacturing sector, though the economic magnitude of the effect is relatively small. Although Hageman et al.

(2015) and our study both examine firm responses to sales tax exemptions on business inputs, the nature of R&D differs from other types of investment because R&D is a highly risky investment with large adjustment costs, qualifies for other significant tax incentives, and can involve strategic gaming (e.g., through patent races) (Bond and Van Reenen 2007). Due to these differences, the results in Hageman et al. (2015) do not necessarily translate to the R&D setting.

3.2 Hypothesis Development

We extend the literature on the effects of tax policy on firm innovation by testing whether R&D sales tax exemptions affect a) innovative inputs as measured by R&D expenditures, and b) innovative outputs as measured by patents. Although states cite increased investment and enhanced innovation as reasons for enacting R&D sales tax exemptions, it is not immediately clear whether these desired outcomes necessarily result from this type of tax incentive.

With regard to inputs, R&D sales tax exemptions are similar to income tax R&D credits in that they reduce the cost of R&D projects. Exempting R&D materials, supplies, and equipment from sales tax effectively reduces the cost of such items by the amount of the tax (generally 5-10%).[17] This cost reduction potentially expands firms' opportunities for positive NPV R&D projects, leading to increased investment. Sales tax exemptions' direct reduction to above-the-line costs may further enhance their appeal for firms looking for ways to expand their R&D programs. Edgerton (2012) finds that tax incentives that affect accounting profits have larger effects on investment than less salient tax incentives that do not affect accounting profits, such as accelerated depreciation. Similarly, Robinson (2010) finds that firms are willing to incur costs to avoid having an expense classified as an operating expense which reduces pre-tax earnings. Finally, the cost reduction afforded by sales tax exemptions may be especially beneficial for unprofitable firms that engage in R&D but are not able

[17] A price reduction occurs to the extent sales tax savings are not offset by vendor price increases (i.e., implicit taxes). Evidence of implicit taxes on capital assets is mixed, with some studies documenting their existence (e.g., Berger 1993; Goolsbee 1998), and others not (e.g., Hassett and Hubbard 1998; Desai and Goolsbee 2004; House and Shapiro 2008).

to benefit currently from an income tax credit.[18] Taken together with past research that has documented increased investment in response to cost reductions via R&D credits (e.g., Hines 1991; Berger 1993; Wu 2005; Rao 2016), these additional advantages suggest that firms may also increase investment in response to cost reductions via sales tax exemptions.

Despite the similarity of sales tax and income tax R&D incentives in reducing the cost of innovation, however, the positive effects of income tax incentives found in prior literature may not necessarily translate to sales tax exemptions (Hageman et al. 2015). It is possible that the magnitude of sales tax savings does not rise to the level of savings that R&D income tax credits provide. Wages are the largest category of qualified expense for the federal R&D credit, historically making up 66.5% of qualified research expenses (Rao 2016), but wages are not relevant for sales tax exemptions because they are not subject to sales tax. If sales tax savings on supplies and equipment do not rise to a material level, an R&D sales tax exemption may not prompt firms to increase their R&D spending.

With regard to outputs, R&D sales tax exemptions may improve innovative productivity by reducing the cost of R&D. As discussed above, this cost reduction may expand opportunities for positive NPV R&D projects, leading to more projects and more outputs in the form of patents. Even if the number of R&D projects or overall R&D spending does not increase, firms may use their R&D funding more efficiently because money that previously went to taxes can be reallocated to productive capital or labor. However, we may not observe an effect if firms increase spending on projects that yield less innovative output, or if vendors capture tax savings in the form of increased prices.

Whether R&D sales tax exemptions have the desired effect on firm innovation is thus an empirical question. We state our hypothesis as follows:

Hypothesis: Implementation of a sales and use tax exemption for R&D purchases increases firm innovative activities.

[18] R&D credits can generally be carried over to future years, but delay in monetizing them reduces their present value.

4. RESEARCH DESIGN

4.1 Variable Measurement

Sales Tax Exemptions for R&D

R&D sales tax exemptions eliminate or reduce the sales tax that firms must pay on their purchases for use in R&D activities. We measure state R&D sales tax exemptions in two ways to capture both the existence and magnitude of such exemptions. The first measure is the indicator variable *RD_Exempt*, which represents the existence of an exemption. *RD_Exempt* equals one for firm-year observations where the firm's headquarter state offers a general R&D sales tax exemption, and zero otherwise. In order to identify the presence of an exemption, we begin with the BNA Sales & Use Tax Chartbuilder tool for the topic "Research and Development" and confirm the exemptions and their effective dates by examining state statutes, regulations, department of revenue websites, and legislative histories. The second measure is *RD_Savings*, which represents the magnitude of an exemption. *RD_Savings* is the percentage point savings provided by an R&D sales tax exemption, based on a state's sales tax rate in effect as of January 1 of each year.[19] Assuming a state sales tax rate of 7%, for example, a state with no exemption would have *RD_Savings* equal to zero, a state offering a 50% exemption would have *RD_Savings* equal to 3.5, and a state with a full exemption would have *RD_Savings* equal to 7. Following the recommendation in Glaeser and Lang (2024), our primary analyses use the R&D exemption variable applicable in the firm's headquarter state because firms have strong incentives to locate inventors near headquarters, and because a firm's headquarters is likely more exogenous than inventor location in relation to state tax R&D incentives.[20] Because

[19] We use state-level rates rather than combined state and local rates due to a lack of easily accessible data on local rates. There are nearly 10,000 sales tax rate jurisdictions in the U.S. when including the various county, city, and district level rates which can apply in addition to the state rate (Kessler 2018). Local tax rates typically range from 0-3%, but in extreme cases can exceed the state rate. We acknowledge that using only the state rate rather than the combined rate introduces noise into the results for tests using *RD_Savings*.

[20] Glaeser, Glaeser, and Labro (2022) find in a sample of large public firms that half of R&D facilities are located within 60 miles of headquarters. In an earlier study, Orlando (2004) finds that 87% of firms in his sample with R&D location information conduct all of their R&D in their headquarter state.

Compustat data reflects only the current headquarter location, we identify firms' historical headquarter state using 10-K header data from the Notre Dame Software Repository for Accounting and Finance (SRAF).[21] Importantly, because an exemption is based on the purchaser's location, it is unlikely that pre-existing R&D exemptions in other states would dilute the effect of a newly enacted exemption. If sales tax is not charged on a taxable purchase, the purchaser is responsible for paying the equivalent use tax to the state. For example, if a Wisconsin firm goes to Michigan to purchase R&D equipment to use in Wisconsin prior to Wisconsin's R&D exemption, the fact that Michigan allows an R&D sales tax exemption does not negate the purchaser's obligation to pay Wisconsin use tax on the item. Absent a Wisconsin R&D exemption, the purchaser would be required to pay use tax on the item used in Wisconsin.[22]

Firm Innovation

We measure innovation using both an input and output approach, which are both common in the innovation literature (He and Tian 2018). Evaluating effects on both inputs and outputs provides evidence related to two stated goals of implementing R&D sales tax exemptions: increasing investment in innovation and creating new technologies.

To capture innovation inputs, we use the R&D expense variable from Compustat. A potential limitation of using R&D expense in this setting is that sales tax exemptions mechanically reduce the cost of tangible personal property used in R&D. Assuming no other changes, a firm which purchases the same R&D items before and after an exemption goes into effect would show a *decrease* in R&D spending after the exemption is in place because sales tax is no longer part of R&D expense. To

[21] We thank Tim Loughran and Bill McDonald for making this information publicly available at https://sraf.nd.edu/sec-edgar-data/10-x-header-data/.

[22] Although this example depicts in-person cross-border shopping in a state that has an R&D exemption, similar logic applies to a scenario where a purchaser buys goods from an out-of-state supplier with no sales tax nexus in the purchaser's state. Even if the remote seller is not required to collect sales tax, the purchaser would still be required to self-assess use tax. Further, use tax evasion is less likely in our setting because we examine publicly traded firms that are more likely to be audited for sales and use tax in their headquarter states.

explore this possibility, we also use an alternative measure that adjusts the amount of R&D expense in firm-years with an active exemption so that years before and after exemption introduction are comparable on a tax-included basis. Specifically, we gross up R&D expense by the general state sales tax rate that would apply if no exemption were available. Because not all of the R&D expense amount in Compustat is eligible for sales tax exemption (e.g., R&D expense includes wages which are irrelevant for sales tax), we gross up only 50% of the R&D expense by the sales tax rate. While this approach is admittedly imperfect due to applying only the state-level sales tax rate and imposing an assumption about the portion of R&D expense potentially subject to sales tax, it addresses potential limitations of the unadjusted R&D expense measure by reversing the mechanical reduction of R&D expense potentially created by sales tax exemptions.

To capture innovative output, we use measures of firms' patenting activity. Firms' patents are useful because R&D expense captures only an observable input into innovation while patents can capture both observable and unobservable inputs. Furthermore, patents also measure innovation success (He and Tian 2018). R&D tax incentives can also lead to firms potentially reclassifying which investments are R&D for tax purposes (Mukherjee et al. 2017). For our patent measures, we use data from Kogan et al. (2017), in which the authors download all U.S. patent documents from Google Patents and match patent assignees to firms in the CRSP database.[23] Our primary output measure is based on the count of a firm's patent applications filed within the firm's fiscal year, with more patent applications reflecting greater quantity of firm innovation. Following Hall et al. (2001), we use the application date rather than the grant date because it more closely aligns with the timing of innovative activity leading to the patent. In addition to patent counts, we also perform tests of innovation quality by examining patent originality. A patent's originality score is low if it cites previous patents only

[23] We thank the authors for making patent data publicly available on their website, including years beyond their original study: https://github.com/KPSS2017/Technological-Innovation-Resource-Allocation-and-Growth-Extended-Data. The authors detail the patent data download and matching process in the online appendix to Kogan et al. (2017).

within a narrow variety of fields, whereas a more original patent will cite other patents in a wide variety of technologies (Hall et al. 2001).

4.2 Empirical Model

This study exploits the staggered introduction of R&D sales tax exemptions across states to identify their effect on firms' innovation activities. As recent research has highlighted the potential bias that can occur in a generalized difference-in-differences research design due to comparing later-treated firms to earlier-treated firms, we use a stacked cohort design following Baker, Larcker, and Wang (2022).[24] We construct a cohort for the ten-year window around each of the event years in which an R&D sales tax exemption becomes effective. Each cohort consists of treatment observations (firms headquartered in the state implementing an exemption) and control observations (firms headquartered in states that do not implement an exemption).[25] We then stack the cohorts in event time and estimate the following equation:

$$Innovation_{itc} = \beta_0 + \beta_1(Exemption_{itc}) + \beta_k(Controls_{itc}) + Firm\text{-}CohortFE_{ic} + Year\text{-}CohortFE_{tc} + \varepsilon_{itc} \quad (1)$$

The subscripts *i*, *t,* and *c* denote firm, year, and cohort based on R&D exemption implementation years. The dependent variable, *Innovation*, is one of our measures of firm innovative activity. To examine innovative inputs, *Ln(RD_Exp)* is the log of one plus R&D expense for firm *i* in year *t*. R&D expense is set to zero for missing values, and we include a dummy variable for firms missing R&D expense in Compustat following Koh and Reeb (2015). We alternatively use *Ln(RD_GrossUp)* as a dependent variable, which grosses up 50% of R&D expense in firm-years with an R&D sales tax exemption for the sales tax rate that would have otherwise applied to R&D purchases. To examine innovative outputs, *Ln(Patents)* is the log of one plus the number of patent

[24] Recent tax papers using a stacked cohort research design to study regulatory changes include Chen et al. (2023) and Krupa (2024).
[25] In untabulated analysis, we find that are results are robust to additionally including in our control group all firms headquartered in states that enact an R&D exemption prior to the beginning of our sample period.

applications filed by firm *i* in year *t,* using patent application data from Kogan et al. (2017). Similar to the R&D specification, we include a dummy variable for firm-years that do not have patent applications in the Kogan et al. (2017) data. The primary independent variable of interest, *Exemption,* is alternately the indicator variable *RD_Exempt* for the existence of an R&D sales tax exemption, or the continuous variable *RD_Savings* for the magnitude of tax rate savings associated with an available R&D sales tax exemption.

Equation (1) includes time-varying firm-level controls which may affect firms' innovative activities, including *size*, *leverage*, market-to-book ratio (*MTB*), return on assets (*ROA)*, *Firm Age*, cash flow from operations (*CFO*), and Herfindahl–Hirschman Index (*HHI*). We also control for the percentage of a firm's total assets that consists of property, plant, and equipment (*Tangibility*), since sales tax is typically only relevant for purchases of tangible personal property. Further, we include an indicator variable for whether a firm received a subsidy in their headquarter state in year *t*, based on data from the Good Jobs First Subsidy Tracker (*State Subsidy*).[26]

To control for time-varying state characteristics, Equation (1) also includes control variables for state tax and economic developments that could potentially impact R&D activity in the firm's headquarter state. *CIT_Creditrate* equals the state income tax R&D credit rate for the lowest tier of qualified R&D spending. Because states sometimes enact income tax and sales tax legislation at the same time, including this variable controls for possible concurrent changes in state income tax R&D credits (Wilson 2009). Following Hageman et al. (2015), we include an indicator variable for whether the state has mandatory combined reporting (*Comb_Rptg*) and a variable for the income tax burden associated with owning property in the state (*CIT_Burden*). Including a variable for state combined

[26] The Subsidy Tracker database includes data on economic development subsidies and other forms of government financial assistance to businesses. Because Subsidy Tracker does not specifically identify subsidies related to R&D projects, *State Subsidy* controls for whether a firm receives targeted state government assistance of any type. We use an indicator variable rather than the subsidy amount because approximately 14% of the subsidies matched to observations in our sample are missing the state subsidy amount in the Subsidy Tracker.

reporting requirements controls for potential changes in firms' tax planning opportunities which may relate to intellectual property and R&D activity.[27] *CIT_Burden* controls for the potential state income tax impact of a firm locating property in a state. To the extent a state's apportionment formula depends on a firm's in-state property, choosing to increase R&D property in that state may lead to a greater portion of income being apportioned to the state for state income tax purposes. We include a variable for gross state product in real dollars (*Ln(GSP)*) to control for general economic activity in the state. *State_SUT_Rate* controls for the state sales tax rate in effect as of the beginning of each calendar year. We include firm-cohort and year-cohort fixed effects following Baker et al. (2022) to control for time-invariant firm characteristics and macroeconomic trends, respectively, within each cohort. We winsorize firm-level covariates at the 1st and 99th percentile to account for potential outliers, and we cluster standard errors by firm. Appendix B provides full variable definitions.

4.3 Sample

Table 1 details our sample selection process before implementing the stacked design. We begin with 151,300 firm-year observations in Compustat from 2003-2019 with positive total assets. The sample begins in 2003 due to data availability, and ends in 2019 to avoid potential interference from the Covid-19 pandemic, as well as to avoid potential truncation issues in the patent data. Since the extended Kogan et al. (2017) patent dataset includes patents granted through 2022, ending our sample period in 2019 allows for the minimum three-year lag recommended by Hall et al. (2001) when dating patents based on application year. We next exclude financial (SIC 6000) and public sector (SIC 9000) firms because R&D expenditures and patents may not accurately reflect innovation in these industries. We link the remaining sample observations to 10-K header information from

[27] Combined reporting requirements vary by state and have changed over time as more states have enacted mandatory combined reporting legislation. States with mandatory combined reporting generally require related corporations that are part of the same unitary group to file one state income tax return rather than separate company state income tax returns, thus combining the profits and apportionment for the group when calculating taxable income. Separate company reporting may provide opportunities for firms to shift profits to lower-tax states, and profit shifting strategies may rely on where firms hold intellectual property (see, e.g., Dyreng, Lindsey, and Thornock 2013).

SRAF to identify the applicable headquarter state for each firm-year. We then drop observations with a missing or non-U.S. headquarter state, observations with a headquarter state that does not impose sales tax, observations headquartered in states with R&D sales tax exemptions effective prior to 2003, and observations missing data for control variables.[28] Finally, we exclude observations that are outside any ten-year cohort window and singleton observations, which are not used in our stacked cohort difference-in-differences design. For our R&D analysis, this results in a sample of 17,349 firm-year observations across 2,803 unique firms, which yields a total of 30,837 stacked firm-year cohort observations.

For tests of firms' innovative outputs, we then combine our sample with patent data from Kogan et al. (2017) which includes patents granted to publicly traded firms. After excluding firm-years without a *permno* identifier for matching to the Kogan et al. (2017) dataset, the sample for our patent analysis consists of 13,834 firm-year observations across 2,131 unique firms, which yields a total of 24,250 stacked firm-year cohort observations. The samples for R&D expenditures and patent activity cover R&D sales tax exemption enactment in ten states, as listed in Appendix A: California, Florida, Idaho, Illinois, Indiana, Missouri, Tennessee, Texas, Utah, and Wisconsin.[29]

5. RESULTS

5.1 Descriptive Statistics

Table 2, Panel A presents summary descriptive statistics for the primary sample prior to implementing the stacked design. R&D sales tax exemptions exist in approximately 34 percent of firm-years. Although only a subset of firm-years have R&D expense and patent applications, they make up a substantial portion of the sample: 47 percent of firm-years in the R&D expense sample have positive R&D expense, and 28 percent of firm-years in the patent sample have at least one patent

[28] We exclude non-sales tax states to improve comparability in tax regimes between treatment and control states.
[29] Results are robust to dropping Illinois from the treatment group, as its exemption is effective starting in 2019.

application (untabulated). The average firm is in a loss position (mean ROA= -0.833), although the median ROA is positive. Importantly, being in a loss position does not prevent a firm from availing itself of a sales tax exemption because unlike income tax R&D credits, a firm does not have to be profitable in order to currently claim a sales tax exemption on a purchase.

Table 2, Panel B provides further detail on the subset of observations relating to states that enact R&D sales tax exemptions during the sample period. This panel compares R&D expenditures and patents from before a firm's headquarter state implements an exemption to after the exemption is available. The data show increases in mean (median) R&D spending after exemption enactment in three (one) states, significant at a five percent level. With regard to patenting activity, mean (median) patent applications in California are *lower* after the R&D sales tax exemption becomes effective, significant at the ten (one) percent level. Table 2, Panel C reports Spearman and Pearson correlations above and below the diagonal, respectively. Both the existence and extent of R&D sales tax exemptions are positively correlated with R&D spending and patent measures, although the correlation between *RD_Savings* and the patent measures are not statistically significant p>0.05). Overall, Panels B and C provide some initial evidence of R&D sales tax exemptions having the anticipated positive effect on firms' R&D expenditures, although the effect on patents is less clear.

5.2 Innovation Inputs – R&D Expense

Table 3 reports results from estimating Equation (1) with measures of R&D expense as the dependent variable. We estimate the coefficients on *RD_Exempt* and *RD_Savings* both with and without control variables to evaluate how controls affect our inferences (Whited, Swanquist, Shipman, and Moon 2022). We observe a positive and marginally significant relationship between R&D sales tax exemptions and firms' R&D expenditures for our *RD_Exempt* treatment indicator (columns 1 and 3). Results are similar, though somewhat stronger in significance, when using the measure of R&D expense grossed up for exempted sales tax as the dependent variable (columns 5 and 7. This specification provides some insight into the sensitivity of the results to the mechanical decrease in R&D costs arising from exempted sales tax. We do not find a significant relationship for our *RD_Savings* measure across any of our four specifications, suggesting that magnitude of the exemption is not as important.

Given the mixed results in the full sample, we next examine whether results are observable among firms in industries that are more likely to be affected by an R&D sales tax exemption. Based on survey data from the National Science Foundation (NSF), the share of R&D capital expenditures relative to total capital expenditures tends to be higher for scientific and technical service providers and for manufacturing firms (Moris and Shackelford 2023). To the extent tangible assets play a larger role in these high-tech and manufacturing industries' R&D activities, we expect a stronger effect of R&D sales tax exemptions for firms in these industries.[30]

First, we test whether high-tech firms are more likely to increase their R&D expenditures due to R&D sales tax exemptions. Table 4, Panel A reports results of estimating Equation (1), modified to include the interactive effect between the independent variable of interest for sales tax exemption and an indicator for firms in high-tech industries as defined by Kile and Phillips (2009).[31] As reported in columns 1 and 2, high-tech firms increase their R&D spending following implementation of an R&D sales tax exemption more than non-high-tech firms. Further, the combination of the main effect of *RD_Exempt* and its interaction with *HighTech* suggests that high-tech firms increase their R&D spending by 16.65% following the introduction of an R&D sales tax exemption relative to control firms (F-test=4.86).[32] Similarly, the combination of the main effect of *RD_Savings* and its interaction with *HighTech* suggests that for each one percent of savings from an R&D sales tax exemption, high-

[30] R&D capital expenditures are not a perfect reflection of the purchases eligible for an R&D sales tax exemption because they include some items that are not subject to sales tax in the first place (e.g., land and buildings), and exclude some items that do qualify for the exemption (e.g., supplies). However, this NSF measure provides a rough idea of which industries use more tangible resources in their R&D activities.
[31] Results are robust to defining high-tech industries following Kasznik and Lev (1995).
[32] $100*(e^{0.154}-1) = 16.65$

tech firms increase their R&D spending by 2.63% (F-test=4.64).[33] Results using grossed-up R&D expense as the dependent variable, reported in columns 3 and 4, are similar.

Second, we test whether manufacturing firms are more likely to increase their R&D expenditures due to R&D sales tax exemptions. In addition to the importance of tangible property in manufacturers' R&D activities discussed above, we also expect a stronger response among manufacturers because the R&D sales tax exemptions in some states target manufacturing firms. For example, Wisconsin allows the exemption for persons engaged in manufacturing or biotechnology in the state (Wis. Stat. Sec. 77.54(57d)(b)1). Table 4, Panel B reports results of estimating Equation (1), modified to include the interaction between the independent variable of interest for sales tax exemption and the indicator variable *Mfg* for firms in manufacturing industries (SIC 2000 through 3999). Similar to high-tech firms, coefficients on the interaction terms suggest that manufacturing firms increase their R&D spending following implementation of an R&D sales tax exemption more than non-manufacturing firms.

Taken together, tests of R&D inputs provide limited evidence of a broad effect of R&D sales tax exemptions on firms' R&D spending generally. However, results do suggest a significant positive effect of R&D sales tax exemptions on R&D spending by high-tech and manufacturing firms.

5.3 Innovation Outputs - Patents

States enact sales tax exemptions for R&D purchases not only with the hope of increasing investment, but also to encourage creation of new technologies in their state. We therefore examine the effect of R&D sales tax exemptions on innovative output by using measures of firm patent activity as the dependent variable in Equation (1), as reported in Table 5. Columns 1 through 4 show an insignificant negative relationship between states introducing R&D sales tax exemptions and patent applications filed by firms headquartered in those states. This insignificant result suggests that firms

[33] $100*(e^{0.026}-1) = 2.63$

could be using their increased R&D budget to pursue projects with less certain outcomes. Projects that provide a positive NPV only once sales tax costs are removed may be of lower quality or involve higher risk compared to projects that a firm already pursued without the exemption, which is consistent with our null results for patent quantity. Alternatively, firms may be instead using their increased R&D budgets less efficiently, spending more on R&D equipment and supplies that do not seem to yield new patents.

In addition to examining the effect of R&D sales tax exemptions on innovation quantity, we report the effect on an aspect R&D quality by using patent *Originality* as the dependent variable in columns 5 through 8. Our tests reflect an insignificant effect of R&D sales tax exemptions on patent originality, which suggests that both the total firm innovation and the originality of that innovation is unchanged. In untabulated analysis, we use alternative measures of patent quality as the dependent variable, including citation count, citations per patent, and patent value as defined by Kogan et al. (2017). Results for these tests are generally not statistically significant, failing to provide other evidence of a change in patent quality.

Given the lack of results in the full patent sample, we next repeat the industry cross-sectional tests described in Section 5.2 using patent quantity and originality as the dependent variables in Table 6. When we modify Equation (1) to include the interaction between the sales tax exemption variable and an indicator for high-tech or manufacturing firms, we fail to find a significant interactive effect for tests of innovation outputs for high-tech firms, but we do document a significant decrease for manufacturing firms. However, we note that the combination of the main effect and the interaction is significantly different from zero only for the number of patents filed by manufacturing firms. Taken together with the positive results we describe above for high-tech and manufacturing firms' R&D spending, it is possible that these firms are increasing their inputs to R&D but do not necessarily see an increase in the output, or are choosing to protect new technologies in a way other than patenting (e.g., through secrecy). In additional untabulated analysis, we assess whether these firms may choose to protect their innovations with trade secrecy by replacing the dependent variable in Equation (1) with the indicator variable from Glaeser (2018) which identifies the presence of a trade secret based on 10-K discussion of trade secrecy.[34] We find that manufacturing firms have a positive and significantly higher likelihood of discussing trade secrets in their 10-K following the enactment of an R&D sales tax exemption, which suggests that these firms may only have a decrease in observable innovation output (i.e., patents). Overall, the tests of firms' patenting activity fail to provide evidence on average of a change to the quantity of firm patent applications and the originality of those patents. Industry cross-sectional tests continue to document either no relation to firm patenting activity for high-tech firms, or even a negative relation for manufacturing firms. Take together with our tests of R&D expenditures, this suggests that R&D sales tax exemptions may lead to an increase in R&D investment, but may not necessarily lead to the creation of new patented technologies.

6. ADDITIONAL ANALYSES

6.1 Financially Constrained Firms

Unlike income tax R&D credits, sales tax exemptions for R&D purchases do not require that firms be profitable in order to benefit in the current period. This may be particularly important for growth firms for which R&D is an important activity, but which face financial constraints or are not yet profitable. To examine whether the effect of R&D sales tax exemptions is stronger among such firms, we incorporate measures of financial constraint or loss in our model.

Table 7 presents results of estimating Equation (1) modified with the interactive effect between the independent variable of interest for sales tax exemption and an indicator for financially constrained (Panel A) or loss (Panel B) firms. To measure financial constraints, we use a measure of

[34] We thank Stephen Glaeser for making this data available at https://stephenglaeser.web.unc.edu/data/, including years after his original sample period.

firms' financial constraints developed by Linn and Weagley (LW) (2023).[35] The authors use a random forest model to measure firms' financial constraints using financial variables, extending the coverage of text-based constraint measures such as Hoberg and Maksimovic (2015) and improving upon previous indices such as Kaplan and Zingales (1997) and Hadlock and Pierce (2010) by using a broader training set and incorporating nonlinearities and interactions that are not possible to capture in a linear model. Using the LW equity-focused constraint measure estimated using a full set of accounting variables, we identify financially constrained firms as those in the top quintile of the LW measure for each sample year. We then interact an indicator variable for high financial constraints (*HighFC*) with our independent variables for the existence or extent of an R&D sales tax exemption.

When R&D expense is the dependent variable, the coefficient on the interaction term is positive and statistically significant. This suggests financially constrained firms are able to take advantage of these exemptions and increase their R&D budgets. When the dependent variable is based on patent quantity, the interaction term coefficient is negative and significant at the ten percent level when the measure of exemption is *RD_Exempt*. Although the structure of a sales tax exemption may appear to seem particularly useful for a firm facing financial constraints by providing upfront savings, the negative effect on firm patenting activity mimics the observed negative earlier in the manufacturing industry cross-sectional analysis, reiterating that an increase in R&D may not be matched with a similar increase in patenting activity.

Next, we examine whether loss firms respond differently to the enactment of an R&D sales tax exemption by including an interaction between the exemption variable and a loss indicator in Equation (1). We identify loss firms as those with negative income before extraordinary items (Compustat variable *ib*) in a given year. Similar to the financial constraint results, the coefficient on

[35] We thank the authors for making their financial constraint measures publicly available at https://www.danielweagley.com/data.html.

the interaction term is significant for one of the tests of firm R&D expense (Panel B, column 1), but results are negative for tests of firm patent quantity (columns 3 and 4, $p<0.05$). Taken together, the results presented in Table 7 suggest that the positive effect of R&D sales tax exemptions on firm R&D activity is in part attributable to firms that are in a worse financial position, but such firms do not experience a corresponding increase in patenting activity. These results echo the findings in Bethmann, Jacob, and Müller (2018), who find that refunds from tax loss carrybacks encourage overinvestment by granting refunds to loss firms regardless of future prospects. In a similar way, sales tax exemptions claimed by loss firms may also contribute to unproductive R&D spending.

6.2 Dynamic Effects

We next perform a dynamic analysis to examine treated firms' innovation activity in the years surrounding enactment of a new R&D sales tax exemption. This approach allows us to test whether any pre-trends exist that could be driving our difference-in-differences results, and also allows us to observe the timing of effects following treatment. To perform this analysis, we estimate the following regression:

$$\begin{aligned} Innovation_{itc} = {} & \beta_0 + \beta_1(Event\ Year\ Minus\ 4_{itc}) + \beta_2(Event\ Year\ Minus\ 3_{itc}) + \beta_3(Event\ Year\ Minus\ 2_{itc}) + \beta_4(Event\ Year\ Minus\ 1_{itc}) + \beta_5(Event\ Year_{itc}) + \beta_6(Event\ Year\ Plus\ 1_{itc}) + \\ & \beta_7(Event\ Year\ Plus\ 2_{itc}) + \beta_8(Event\ Year\ Plus\ 3_{itc}) + \beta_9(Event\ Year\ Plus\ 4_{itc}) + \beta_k(Controls_{itc}) \\ & + Firm\text{-}CohortFE_{ic} + Year\text{-}CohortFE_{tc} + \varepsilon_{itc} \qquad (2) \end{aligned}$$

The dependent variable *Innovation* is alternately a measure of firm R&D expense or patenting activity, as in our primary tests. To measure dynamic effects, we create an indicator variable for each of the years within a cohort window around the event year. *Event Year Minus 4* is equal to 1 if the observation is four years before a firm's headquarter state enacts an R&D sales tax exemption, and zero otherwise. *Event Year Minus 3, Event Year Minus 2, Event Year Minus 1, Event Year*, *Event Year Plus 1, Event Year Plus 2*, *Event Year Plus 3, and Event Year Plus 4* are defined similarly for years relative to the event year. Control variables are the same as those included in Equation (1), we include firm-cohort and year-cohort fixed effects, and standard errors are clustered by firm.

Table 8 reports results from estimating Equation (2). Across all dependent variables, the estimated coefficients on pre-event indicator variables are generally not statistically significant, failing to suggest evidence of changes in firms' innovative activities before enactment of an R&D sales tax exemption. When the dependent variable is R&D expense (column 1), we observe positive, significant coefficients for the last two post-event indicators. The estimated coefficients grow from 0.018 ($p>0.10$) in the event year to 0.071 ($p<0.10$) in the fourth year after an exemption's effective date. The positive effect of R&D sales tax exemptions on R&D appears to be concentrated in later years, suggesting that firm response to these laws may not be immediate. We see similar results for our grossed-up R&D (column 2), where we also observe positive, significant coefficients for the last two post-event indicators. Similarly, the coefficient magnitude increases as time progresses, from 0.028 ($p>0.10$) in the event year to 0.081 ($p<0.05$) in the fourth year after an exemption's effective date. Dynamic effects for R&D expenditures are presented visually in Figure 1. Turning to tests of patent activity presented in Table 8, tests of firm's patent filings (*Ln(Patents)*) in column 3 and patent originality (*Originality*) in column 4 do not result in any significant coefficients for post-event years, consistent with the lack of results in the primary patent analysis.

Overall, our test of the dynamic effects of R&D sales tax exemptions provides comfort that the results are not driven by pre-trends in firms' innovative activities, and provides insight into the timing of the R&D effects that we observe in the primary analyses.

6.3 State-Level Analysis

While the firm-level sample allows us to examine the innovation activities of individual firms in response to R&D sales tax exemptions and to test specific firm characteristics, there are some limitations to using firm-level data. Specifically, Compustat includes only publicly traded firms, and a significant number of observations are missing R&D expense. There is also noise in the firm-level measure arising from the assumption that R&D takes place in the firm's headquarter state. Further, firm-level measures of R&D spending and patenting activity can reveal whether firms change their overall level of innovation activities, but not whether they move those activities between states.

To overcome some limitations of the firm-level analysis and complement our main results, we perform tests of R&D expenditures and patent applications at the state level. By using state-level data, we are able to incorporate both public and private firms, both of which may be intended beneficiaries of the enacted exemptions. Including small firms may be especially important for our setting because sales tax exemptions could be particularly useful to the extent small firms are not (yet) profitable and are therefore unable to currently monetize R&D income tax credits. Further, by using R&D expense gathered by survey data, state-level R&D spending measures are not subject to reporting choices of firms that may lead to missing R&D expense in Compustat. Lastly, because the research design for state-level tests compares innovation measures between states, it will pick up effects of firms changing the state location of R&D investments. We estimate the following state-level model using a stacked cohort difference-in-differences design:

$$Innovation_{stc} = \beta_0 + \beta_1(Exemption_{stc}) + \beta_k(Controls_{stc}) + State\text{-}CohortFE_{sc} + Year\text{-}CohortFE_{tc} + \varepsilon_{stc} \quad (3)$$

The subscripts *s*, *t,* and *c* denote state, year, and cohort based on R&D exemption implementation years. The dependent variable, *Innovation,* equals either state-level R&D expenditures scaled by gross state product (*State_RD/GSP)* or the log of state-level patents (*Ln(State_patents)*). *State_RD* represents state-year aggregate totals of R&D expense from NSF surveys of business R&D which are conducted annually by the U.S. Census Bureau.[36] These surveys gather responses from a probability sample of for-profit companies in manufacturing and nonmanufacturing industries, and the NSF publishes the resulting aggregate state-level R&D expenditure estimates on its website.[37] Response to these surveys is confidential and required by law (NSF 2007; NSF 2018).[38] *State_patents* represents the number of patent applications filed by residents

[36] The survey to collect R&D expenditure information was the Survey of Industry Research and Development (SIRD) prior to 2008, the Business Research and Development and Innovation Survey (BRDIS) for 2008-2016, the Business Research and Development Survey (BRDS) for 2017-2018, and the Business Enterprise Research and Development (BERD) Survey thereafter. While the agencies administering these surveys made efforts to preserve the comparability of the data series, a drawback of using state-level R&D expenditure data is that slight differences in the methodology among these surveys may affect comparability over time (NCSES 2021).
[37] https://ncses.nsf.gov/surveys/business-enterprise-research-development/2021#data, last accessed July 31, 2024.
[38] Additional detail on survey methodology is available in NSF (2007, 2018) and NCSES (2021).

of state *s* in year *t,* calculated using patent data from PatentsView. This patent database includes invention patents filed within the U.S. with information on inventor and applicant location.[39] We fractionally allocate patent counts among states based on the residence of each patent's named inventors. Our independent variable of interest, *Exemption*, is alternately *RD_Exempt* or *RD_Savings*, as defined in our primary firm-level tests. We include the same state-level control variables as in the firm-level tests, as well as state-cohort and year-cohort fixed effects.[40]

Table 9, columns 1 through 4 present results from the state-level R&D expenditure analysis, with the first two columns using robust standard errors, and the last two columns clustering the standard errors by state. While the coefficient on the exemption variable is consistently positive, it is only statistically significant across the first three columns. Results from tests of state-level patent counts, as reported in columns 5 through 8, suggest a negative relation between R&D sales tax exemptions and patents, although the coefficient is only significant in columns 5 and 6. We note that the results are sensitive to the choice of how the standard errors are clustered, and that clustering by state may yield too few clusters, which can bias the standard errors (Petersen 2008).[41] Taken together, the state-level regressions provide evidence of R&D sales tax exemptions increasing R&D expenditures at the aggregate state level, but not necessarily patenting activity, which conforms with our firm-level results.

7. CONCLUSION

This study examines whether sales tax exemptions for R&D purchases promote firm innovation, with regard to both inputs to and outputs of the innovation process. R&D sales tax exemptions allow firms to purchase items for use in their R&D activities without sales tax that would

[39] The data from PatentsView can be accessed here: https://patentsview.org/ download/data-download-tables
[40] When State_RD/GSP is the dependent variable, we exclude Ln(GSP) as a control variable.
[41] Because our sample includes only states that implement an R&D sales tax exemption during our period and states that do not have an R&D exemption, we have only 25 clusters when clustering standard errors by state.

otherwise be due, reducing the upfront cost of innovation. We exploit the staggered introduction of R&D sales tax exemptions across U.S. states to test their effect on firms' R&D expenditures and patent activity. While prior research has generally found positive effects of income tax incentives for innovative activity, income tax and sales tax differ significantly and therefore sales tax incentives for innovation do not guarantee similar outcomes.

Overall, we find evidence that sales tax exemptions increase firm investment in innovation, particularly among high-tech and manufacturing firms. However, we do not find evidence of increased patent quantity or originality among treated firms broadly, and we even observe a negative effect among manufacturing and loss firms. Taken together, these results suggest that sales tax exemptions may incentivize firms to invest more in R&D, but that this investment does not necessarily lead to increased innovative outputs in the form of patents. As state policymakers consider various economic policies to promote innovation, our study offers evidence on the effects of an R&D sales tax exemption as one policy option.

Appendix A: State Sales and Use Tax Exemptions for Qualified R&D Purchases

Treatment States Enacting Sales/Use Tax R&D Exemption During Sample Period
Idaho (eff. 4/1/2005)
Indiana[1] (eff. 7/1/2005)
Florida (eff. 7/1/2006)
Missouri[2] (eff. 8/28/2007)
Wisconsin (eff. 1/1/2012)
Utah (eff. 7/1/2012)
Texas[3] (eff. 1/1/2014)
California[4] (eff. 7/1/2014)
Tennessee (eff. 7/1/2015)
Illinois[5] (eff. 7/1/2019)

Control States with No Sales/Use Tax R&D Exemption
Alabama
Arkansas
Colorado
District of Columbia
Georgia
Hawaii
Kentucky
Louisiana
Mississippi
Nebraska
Nevada
New Mexico
North Dakota
South Dakota
Wyoming

Excluded States with Sales/Use Tax R&D Exemptions Effective Prior to Sample Period
Arizona
Connecticut[6]
Iowa
Kansas
Maine
Maryland
Massachusetts
Michigan
Minnesota[7]
New Jersey
New York
North Carolina[8]
Ohio
Oklahoma
Pennsylvania
Rhode Island
South Carolina
Vermont
Virginia
Washington
West Virginia

Excluded States that Do Not Impose Sales/Use Tax
Alaska
Delaware
Montana
New Hampshire
Oregon

Appendix A lists which states offer a general sales/use tax exemption for qualified R&D purchases. These exemptions may be for the full tax amount or a partial exemption. For purposes of this study, negotiated incentives are not considered to be general sales tax exemptions.

1. Indiana phased in the R&D sales tax exemption. Qualified R&D equipment was eligible for a refund of 50% of sales tax during the period 7/1/05 - 6/30/07. A full upfront exemption applies starting 7/1/07.

2. Qualified R&D purchases are exempt from Missouri state sales and use tax and local use tax. Until 1/1/23, local sales tax still applies if purchased from a Missouri vendor.

3. Taxpayers can claim either the sales tax exemption or the franchise tax credit for R&D, but not both.

4. From 7/1/14-12/31/16 (1/1/17-6/30/30), California exempts qualified R&D purchases from 4.1785% (3.9375%) state sales tax. Remaining state, local, and district taxes still apply during both periods.

5. Between 9/1/04 and 8/30/14, manufacturers could earn Manufacturer's Purchase Credit (MPC) when purchasing manufacturing machinery and equipment. MPC could be used to pay state sales tax on certain future purchases, including those used in R&D.

6. Connecticut exempts qualified R&D purchases from half of the general sales tax rate.

7. Prior to 7/1/15, Minnesota administered the exemption as a refund of tax paid on qualified R&D purchases.

8. Prior to 7/1/18, North Carolina, imposed a 1% mill machinery privilege tax in place of the general sales tax on qualified R&D purchases. Effective 7/1/18, qualified R&D purchases are fully exempt.

Appendix B: Variable Definitions

Variable	Definition
RD_Exempt	Indicator variable equal to 1 if firm *i*'s headquarter state offers an R&D sales tax exemption in year *t*, 0 otherwise. Sources: BNA Sales & Use Tax Chartbuilder, state statutes, regulations, and department of revenue websites.
RD_Savings	Magnitude of state sales tax exemption on R&D purchases in firm *i*'s headquarter state in year *t*. This variable equals the state sales tax rate if the state fully exempts R&D purchases, or equals the exempt portion of the state sales tax rate if the state offers a partial exemption. This variable equals 0 for a state that fully taxes R&D purchases. Sources: BNA Sales & Use Tax Chartbuilder, state statutes, regulations, and department of revenue websites.
Ln(RD_Exp)	Natural logarithm of one plus R&D expense (XRD), where XRD is replaced with zero if missing. Source: Compustat.
Ln(RD_GrossUp)	Natural logarithm of one plus grossed-up R&D expense. For years when an R&D sales tax exemption applies, 50% of XRD is grossed up by the state sales tax rate that would have applied, absent an exemption. Source: Compustat, BNA Sales & Use Tax Chartbuilder.
Ln(Patents)	Natural logarithm of one plus the number of patent applications filed by firm *i* in fiscal year *t*. Value is set to zero if missing. Source: Kogan, Papanikolaou, Seru, and Stoffman (2017).
Originality	Mean originality of a firm *i*'s patent applications in fiscal year *t*, calculated following Hall, Jaffe, and Trajtenberg (2001) as: 1 - (citations to patents of the same patent class as the filing patent)/(total citations made). Source: Kogan, Papanikolaou, Seru, and Stoffman (2017).
CIT R&D Credit	State corporate income tax R&D credit rate for lowest tier of qualified R&D spending for firm *i*'s headquarter state. Sources: Moretti and Wilson (2017) for years 2003-2011; BNA Sales & Use Tax Chartbuilder, state statutes and regulations thereafter.
Combined Reporting	Indicator variable equal to 1 if firm *i*'s headquarter state has mandatory combined reporting, 0 otherwise. Sources: Moretti and Wilson (2017) for years 2003-2011; BNA Sales & Use Tax Chartbuilder, state statutes and regulations thereafter.
CIT Burden	Top state statutory corporate income tax rate times state property apportionment factor, for firm *i*'s headquarter state. Sources: Moretti and Wilson (2017) for years 2003-2011; BNA Sales & Use Tax Chartbuilder, state statutes and regulations thereafter.
Ln(GSP)	Natural logarithm of real gross state product for firm *i*'s headquarter state, in millions. Source: Bureau of Economic Analysis.

State SUT Rate	State sales tax rate for firm *i*'s headquarter state in year t. Sources: State department of revenue websites, BNA Sales & Use Tax Chartbuilder, and Book of the States.
Population	Natural log of the population of firm *i*'s headquarter state. Source: Bureau of Economic Analysis.
Unemployment Rate	Annual average unemployment rate for firm *i*'s headquarter state. Source: Bureau of Labor Statistics.
Size	Natural logarithm of total assets (AT). Source: Compustat.
Leverage	Long-term debt (DLTT) deflated by total assets (AT) at the beginning of year *t*. Source: Compustat.
MTB	Ratio of the firm's market value to book value, calculated as: (AT-CEQ+CSHO*PRCC_F)/AT. Source: Compustat.
ROA	Income before extraordinary items (IB) divided by beginning-of-year total assets (AT). Source: Compustat.
Firm Age	Firm age in years. Source: Compustat.
HHI	An industry-year level measure of competition computed using firms' market share within four-digit SIC.
Tangibility	Net property, plant, and equipment (PPENT) divided by total assets (AT). Source: Compustat.
CFO	Operating cash flow (OANCF) deflated by beginning-of-year total assets (AT). Source: Compustat.
State Subsidy	Indicator variable equal to 1 if firm *i* received a state-provided subsidy in its headquarter state in year *t*; zero otherwise. Note that this includes subsidies of any type, not limited to R&D. Source: Good Jobs First.
Missing R&D	Indicator variable equal to 1 if the firm-year is missing R&D expense (XRD) in Compustat, 0 otherwise. Source: Compustat.
Zero Patents	Indicator variable equal to 1 if the firm-year has no patents in the Kogan, Papanikolaou, Seru, and Stoffman (2017) dataset, 0 otherwise
HighTech	Indicator variable equal to 1 if firm *i* is in a high-tech SIC following Kile and Phillips (2009); zero otherwise.
Mfg	Indicator variable equal to 1 if firm *i* is in SIC 2000 – 3999; zero otherwise.
HighFC	Indicator variable equal to 1 if firm *i* is in the top quintile of Linn and Weagley's (2023) equity financial constraint measure in year *t*; 0 otherwise.
Loss	Indicator variable equal to 1 if firm *i* has a loss in year *t* (ib<0); 0 otherwise. Source: Compustat.

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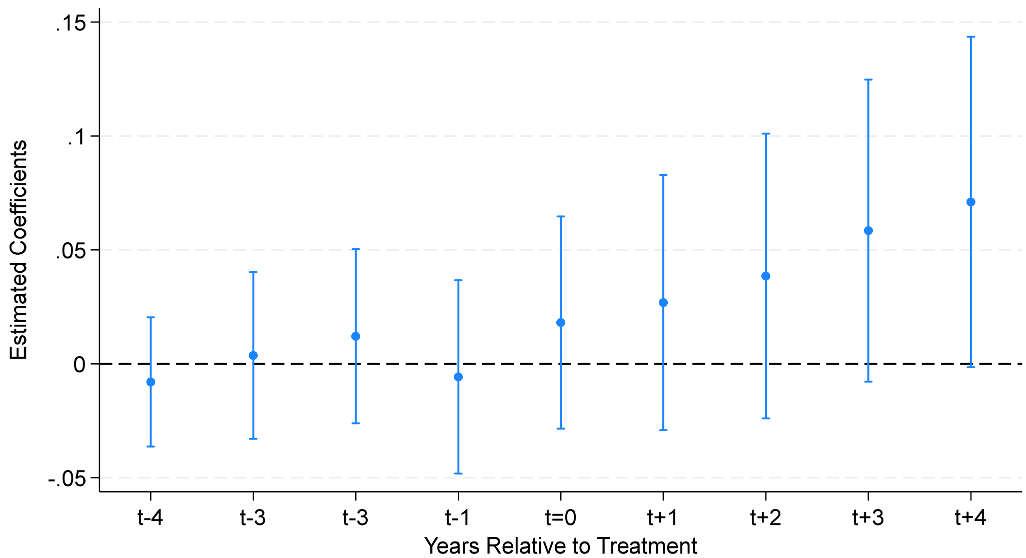
Figure 1: Dynamic Effects of R&D Sales Tax Exemptions on Firm Innovation

Panel A: R&D Expenditures



Panel B: Grossed-Up R&D Expenditures

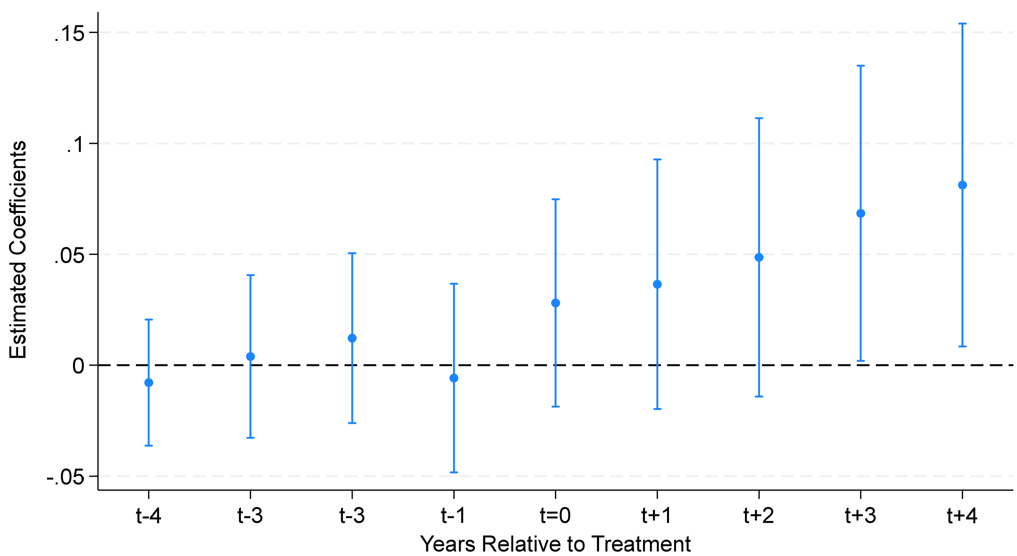


Table 1: Sample Selection

Compustat firm-years with positive total assets, 2003-2019	151,300
Less:	
Observations in financial or public sector industries (SIC 6000 or 9000)	(27,884)
Observations missing historical headquarter state	(59,439)
Observations with foreign headquarter state	(3,609)
Observations with headquarters in a non-sales tax state	(1,127)
Observations with headquarters in state with pre-existing R&D exemption	(26,103)
Observations missing data for control variables	(3,788)
Observations not used in stacked cohort difference-in-differences design (outside ten-year window or singleton observations)	(12,001)
R&D expenditure sample	**17,349**
Less:	
Observations without permno for matching to patent data	(3,515)
Patent sample	**13,834**

Table 2: Descriptive Statistics

Panel A: Summary Statistics

Variable	N	Mean	Std Dev	25th Pctl	50th Pctl	75th Pctl
RD_Exempt	17,349	0.339	0.473	0.000	0.000	1.000
RD_Savings	17,349	1.750	2.520	0.000	0.000	4.188
Ln(RD_Exp)	17,349	1.241	1.799	0.000	0.000	2.371
Ln(RD_GrossUp)	17,349	1.244	1.803	0.000	0.000	2.387
Ln(Patents)	13,834	0.622	1.213	0.000	0.000	0.693
Originality	13,834	0.109	0.212	0.000	0.000	0.100
CIT R&D Credit	17,349	7.224	9.901	0.000	5.000	15.000
Combined Reporting	17,349	0.675	0.468	0.000	1.000	1.000
CIT Burden	17,349	0.582	0.853	0.000	0.000	1.375
Ln(GSP)	17,349	13.510	1.085	12.572	13.691	14.583
State SUT Rate	17,349	5.939	1.513	5.000	6.250	7.250
Population	17,349	16.387	1.026	15.511	16.715	17.433
Unemployment Rate	17,349	6.521	2.627	4.483	5.875	8.017
Size	17,349	5.301	2.897	3.529	5.626	7.371
Leverage	17,349	0.215	0.289	0.000	0.123	0.324
MTB	17,349	6.740	23.598	1.201	1.727	3.097
ROA	17,349	-0.833	3.935	-0.223	0.003	0.063
Firm Age	17,349	17.843	14.986	6.000	14.000	24.000
HHI	17,349	0.240	0.199	0.104	0.174	0.308
Tangibility	17,349	0.281	0.279	0.053	0.161	0.478
CFO	17,349	-0.246	1.286	-0.085	0.059	0.126
State Subsidy	17,349	0.020	0.141	0.000	0.000	0.000
Missing R&D	17,349	0.446	0.497	0.000	0.000	1.000
Zero Patents	13,834	0.716	0.451	0.000	1.000	1.000

Table 2: Descriptive Statistics (Continued)

Panel B: Firms Headquartered in States Enacting R&D Sales Tax Exemptions, Pre- vs. Post-Implementation

		Pre-Exemption						Post-Exemption							
	State	N	Mean	StdDev	Q1	Median	Q3	N	Mean		StdDev	Q1	Median		Q3
Ln(RD_Exp)	CA	2,406	2.193	1.962	0.000	2.076	3.686	2,500	2.556	***	2.080	0.093	2.699	***	4.101
Ln(RD_Exp)	FL	591	0.476	0.958	0.000	0.000	0.440	736	0.588	**	1.115	0.000	0.000		0.831
Ln(RD_Exp)	ID	21	0.652	1.366	0.000	0.000	0.260	52	0.418		1.139	0.000	0.000		0.016
Ln(RD_Exp)	IL	540	1.673	2.203	0.000	0.000	3.324	98	1.895		2.286	0.000	0.257		3.814
Ln(RD_Exp)	IN	58	1.674	2.191	0.000	0.674	3.112	156	1.353		1.969	0.000	0.000		2.048
Ln(RD_Exp)	MO	199	1.094	1.603	0.000	0.000	2.084	221	1.233		1.767	0.000	0.000		2.526
Ln(RD_Exp)	TN	155	0.729	1.319	0.000	0.000	1.458	155	0.701		1.380	0.000	0.000		0.954
Ln(RD_Exp)	TX	1,593	0.600	1.381	0.000	0.000	0.000	1,578	0.706	**	1.505	0.000	0.000		0.179
Ln(RD_Exp)	UT	225	1.180	1.490	0.000	0.613	1.836	195	1.292		1.601	0.000	0.687		2.232
Ln(RD_Exp)	WI	176	1.737	1.779	0.000	1.298	3.495	195	1.970	*	1.794	0.000	1.832		3.586
Ln(Patents)	CA	1,895	1.197	1.467	0.000	0.693	2.197	2,076	1.110	*	1.485	0.000	0.000	***	1.946
Ln(Patents)	FL	380	0.153	0.507	0.000	0.000	0.000	505	0.201		0.670	0.000	0.000		0.000
Ln(Patents)	ID	11	0.063	0.209	0.000	0.000	0.000	37	0.140		0.381	0.000	0.000		0.000
Ln(Patents)	IL	505	0.853	1.544	0.000	0.000	1.099	91	0.802		1.507	0.000	0.000		1.099
Ln(Patents)	IN	48	1.071	1.518	0.000	0.000	1.946	132	0.881		1.425	0.000	0.000		1.386
Ln(Patents)	MO	162	0.491	1.080	0.000	0.000	0.000	198	0.530		1.080	0.000	0.000		0.693
Ln(Patents)	TN	141	0.463	1.048	0.000	0.000	0.000	149	0.407		1.021	0.000	0.000		0.000
Ln(Patents)	TX	1,322	0.383	1.040	0.000	0.000	0.000	1,348	0.335		1.023	0.000	0.000		0.000
Ln(Patents)	UT	133	0.682	1.199	0.000	0.000	1.099	137	0.787		1.273	0.000	0.000		1.099
Ln(Patents)	WI	158	0.872	1.100	0.000	0.693	1.609	178	0.864		1.147	0.000	0.000		1.792

Table 2: Descriptive Statistics (Continued)

Panel C: Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12
1	*Ln(RD_Exp)*		**1.00**	**0.60**	**0.54**	**0.13**	**0.06**	**0.37**	**0.18**	**-0.04**	**0.31**	**0.29**	**0.31**
2	*Ln(RD_GrossUp)*	**1.00**		**0.60**	**0.54**	**0.13**	**0.06**	**0.37**	**0.18**	**-0.04**	**0.31**	**0.29**	**0.31**
3	*Ln(Patents)*	**0.66**	**0.66**		**0.94**	**0.05**	0.01	**0.27**	**0.15**	**-0.04**	**0.22**	**0.24**	**0.22**
4	*Originality*	**0.46**	**0.46**	**0.64**		**0.05**	0.01	**0.25**	**0.14**	**-0.03**	**0.19**	**0.22**	**0.20**
5	*RD_Exempt*	**0.14**	**0.14**	**0.06**	**0.04**		**0.97**	**0.25**	**0.17**	**-0.16**	**0.46**	**0.29**	**0.47**
6	*RD_Savings*	**0.07**	**0.07**	0.02	0.00	**0.97**		**0.16**	**0.14**	**-0.14**	**0.39**	**0.22**	**0.39**
7	*CIT R&D Credit*	**0.26**	**0.26**	**0.17**	**0.18**	**0.19**	**0.11**		**0.39**	**-0.16**	**0.63**	**0.57**	**0.63**
8	*Combined Reporting*	**0.19**	**0.19**	**0.15**	**0.12**	**0.17**	**0.13**	**0.29**		**-0.36**	**0.52**	**0.35**	**0.49**
9	*CIT Burden*	**-0.07**	**-0.07**	**-0.05**	**-0.03**	**-0.15**	**-0.12**	**-0.14**	**-0.37**		**-0.37**	**-0.23**	**-0.34**
10	*Ln(GSP)*	**0.28**	**0.28**	**0.18**	**0.14**	**0.40**	**0.34**	**0.31**	**0.51**	**-0.35**		**0.74**	**1.00**
11	*State SUT Rate*	**0.26**	**0.26**	**0.20**	**0.16**	**0.31**	**0.26**	**0.30**	**0.25**	**-0.12**	**0.63**		**0.75**
12	*Population*	**0.26**	**0.26**	**0.17**	**0.13**	**0.38**	**0.33**	**0.29**	**0.46**	**-0.32**	**0.99**	**0.63**	
13	*Unemployment Rate*	**0.14**	**0.14**	**0.14**	**0.14**	**-0.30**	**-0.32**	**0.22**	**0.11**	**0.10**	**0.26**	**0.38**	**0.28**
14	*Size*	**0.23**	**0.23**	**0.23**	**0.08**	**0.03**	**0.04**	0.01	**0.02**	**-0.05**	0.01	**-0.05**	0.01
15	*Leverage*	**-0.13**	**-0.13**	**-0.10**	**-0.10**	0.01	**0.03**	**-0.07**	**-0.06**	**-0.04**	**-0.05**	**-0.05**	**-0.05**
16	*MTB*	**-0.09**	**-0.09**	**0.06**	**0.07**	0.01	0.00	-0.01	**-0.02**	**-0.02**	**-0.02**	**0.05**	**-0.02**
17	*ROA*	**0.09**	**0.09**	**0.02**	**-0.02**	-0.01	0.00	0.00	0.01	**0.03**	-0.01	**-0.05**	-0.01
18	*Firm Age*	0.01	0.01	**0.10**	**0.06**	-0.01	0.01	0.01	**-0.06**	0.01	**-0.10**	**-0.09**	**-0.10**
19	*HHI*	-0.01	-0.01	**0.04**	**0.03**	0.01	**0.02**	0.01	**-0.04**	**0.02**	**0.02**	0.01	**0.02**
20	*Tangibility*	**-0.36**	**-0.36**	**-0.22**	**-0.21**	**-0.08**	**-0.03**	**-0.20**	**-0.06**	**-0.02**	**-0.22**	**-0.20**	**-0.21**
21	*CFO*	**0.08**	**0.08**	**0.03**	**-0.04**	**-0.02**	-0.01	-0.01	0.00	**0.03**	**-0.03**	**-0.06**	**-0.02**
22	*State Subsidy*	**0.07**	**0.07**	**0.11**	**0.06**	-0.01	-0.01	0.01	0.00	-0.01	**-0.03**	0.00	**-0.03**
23	*Missing R&D*	**-0.62**	**-0.62**	**-0.36**	**-0.31**	**-0.06**	-0.01	**-0.19**	**-0.07**	0.01	**-0.15**	**-0.19**	**-0.14**
24	*Zero Patents*	**-0.58**	**-0.58**	**-0.81**	**-0.80**	**-0.04**	0.00	**-0.20**	**-0.15**	**0.03**	**-0.18**	**-0.20**	**-0.17**

		13	14	15	16	17	18	19	20	21	22	23	24
1	*Ln(RD_Exp)*	**0.13**	0.00	**-0.21**	**0.28**	**-0.06**	**-0.05**	**0.04**	**-0.39**	**-0.06**	**0.03**	**-0.79**	**-0.57**
2	*Ln(RD_GrossUp)*	**0.13**	0.00	**-0.21**	**0.28**	**-0.06**	**-0.05**	**0.04**	**-0.39**	**-0.06**	**0.03**	**-0.79**	**-0.57**
3	*Ln(Patents)*	**0.16**	**0.12**	**-0.14**	**0.26**	**0.03**	**0.05**	**0.04**	**-0.22**	**0.03**	**0.09**	**-0.40**	**-0.97**
4	*Originality*	**0.15**	**0.08**	**-0.13**	**0.25**	0.00	**0.04**	**0.04**	**-0.21**	0.00	**0.08**	**-0.37**	**-0.93**
5	*RD_Exempt*	**-0.29**	**0.02**	-0.01	**0.04**	**-0.08**	**-0.03**	**0.02**	**-0.09**	**-0.07**	-0.01	**-0.06**	**-0.04**
6	*RD_Savings*	**-0.31**	**0.05**	**0.02**	0.00	**-0.05**	-0.01	**0.02**	**-0.04**	**-0.04**	-0.01	-0.01	0.00
7	*CIT R&D Credit*	**0.26**	**-0.02**	**-0.14**	**0.12**	**-0.07**	**-0.04**	**0.05**	**-0.29**	**-0.08**	0.01	**-0.26**	**-0.26**
8	*Combined Reporting*	**0.10**	0.00	**-0.09**	**0.05**	**-0.09**	**-0.07**	**-0.06**	**-0.09**	**-0.06**	0.00	**-0.07**	**-0.15**
9	*CIT Burden*	**0.02**	**-0.06**	**-0.02**	**-0.02**	**0.08**	**0.02**	**0.03**	0.01	**0.05**	-0.01	0.01	**0.03**
10	*Ln(GSP)*	**0.20**	**-0.03**	**-0.13**	**0.12**	**-0.14**	**-0.11**	**0.03**	**-0.27**	**-0.12**	**-0.03**	**-0.19**	**-0.20**
11	*State SUT Rate*	**0.39**	**-0.06**	**-0.13**	**0.15**	**-0.14**	**-0.12**	0.01	**-0.24**	**-0.13**	-0.01	**-0.22**	**-0.23**
12	*Population*	**0.23**	**-0.02**	**-0.12**	**0.12**	**-0.13**	**-0.10**	**0.03**	**-0.26**	**-0.12**	**-0.03**	**-0.19**	**-0.20**
13	*Unemployment Rate*		**-0.02**	**-0.10**	0.01	**-0.02**	**-0.03**	-0.01	**-0.09**	-0.01	0.00	**-0.10**	**-0.16**
14	*Size*	**-0.04**		**0.43**	**-0.36**	**0.52**	**0.36**	**-0.06**	**0.32**	**0.52**	**0.17**	**0.18**	**-0.07**
15	*Leverage*	**-0.08**	**0.15**		**-0.21**	**0.13**	**0.14**	**-0.04**	**0.36**	**0.17**	**0.06**	**0.22**	**0.15**
16	*MTB*	0.00	**-0.47**	**0.04**		**-0.20**	**-0.28**	-0.01	**-0.30**	**-0.17**	**-0.03**	**-0.28**	**-0.25**
17	*ROA*	0.00	**0.42**	**-0.06**	**-0.59**		**0.33**	**0.06**	**0.15**	**0.77**	**0.09**	**0.11**	0.00
18	*Firm Age*	**-0.06**	**0.39**	**0.03**	**-0.14**	**0.15**		**0.07**	**0.18**	**0.27**	**0.10**	**0.08**	**-0.04**
19	*HHI*	**-0.02**	**-0.03**	**-0.04**	**-0.02**	**0.02**	**0.08**		**-0.17**	-0.01	**0.02**	**-0.12**	**-0.04**
20	*Tangibility*	**-0.11**	**0.25**	**0.22**	**-0.09**	**0.10**	**0.15**	**-0.16**		**0.26**	**0.05**	**0.38**	**0.23**
21	*CFO*	0.00	**0.46**	**-0.04**	**-0.53**	**0.84**	**0.18**	**0.03**	**0.14**		**0.08**	**0.14**	0.00
22	*State Subsidy*	-0.01	**0.16**	**0.03**	**-0.03**	**0.03**	**0.12**	**0.02**	**0.03**	**0.04**		-0.01	**-0.08**
23	*Missing R&D*	**-0.12**	**0.15**	**0.15**	**-0.02**	**0.03**	**0.12**	**-0.08**	**0.43**	**0.07**	-0.01		**0.40**
24	*Zero Patents*	**-0.17**	**-0.09**	**0.13**	**-0.08**	0.01	**-0.05**	**-0.03**	**0.26**	**0.03**	**-0.08**	**0.40**	

This table presents descriptive statistics for variables used in the main analyses, as measured among unique firm-years prior to creating the stacked difference-in-differences sample. Panel A presents summary statistics for unique firm-year observations in the sample period 2003-2019. Panel B compares outcome measures pre- versus post-exemption for firms headquartered in states which implement an R&D sales tax exemption during the sample period. ***, **, and * indicate significant differences in means or medians between pre- and post-exemption measures at the one percent, five percent, or ten percent level, respectively. Panel C presents Pearson (Spearman) correlation coefficients in the lower (upper) triangle, with significant correlations (at p-value < 0.05) in bold. Continuous variables are winsorized at the 1st and 99th percentile to remove the effect of potential outliers. See Appendix B for variable definitions.

Table 3: Effect of R&D Sales Tax Exemptions on Firms' Innovation Inputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln(RD_Exp)	Ln(RD_Exp)	Ln(RD_Exp)	Ln(RD_Exp)	Ln(RD_GrossUp)	Ln(RD_GrossUp)	Ln(RD_GrossUp)	Ln(RD_GrossUp)
RD_Exempt	**0.038***		**0.036***		**0.048****		**0.046****	
	(0.021)		**(0.019)**		**(0.021)**		**(0.019)**	
RD_Savings		**0.000**		**0.002**		**0.002**		**0.004**
		(0.003)		**(0.003)**		**(0.003)**		**(0.003)**
CIT R&D Credit			0.000	0.000			0.000	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Combined Reporting			-0.045	-0.046			-0.045	-0.046
			(0.048)	(0.048)			(0.048)	(0.048)
CIT Burden			-0.003	-0.003			-0.004	-0.004
			(0.011)	(0.011)			(0.011)	(0.011)
Ln(GSP)			0.190	0.230			0.190	0.230
			(0.180)	(0.180)			(0.180)	(0.180)
Population			-0.170	-0.200			-0.170	-0.210
			(0.19)	(0.190)			(0.190)	(0.190)
Unemployment Rate			-0.012**	-0.012**			-0.013**	-0.012**
			(0.006)	(0.006)			(0.006)	(0.006)
State SUT Rate			-0.010	-0.011			-0.010	-0.011
			(0.015)	(0.016)			(0.016)	(0.016)
Size			0.16***	0.160***			0.160***	0.160***
			(0.013)	(0.013)			(0.013)	(0.013)
Leverage			-0.051**	-0.051**			-0.052**	-0.051**
			(0.022)	(0.022)			(0.022)	(0.022)
MTB			0.002***	0.002***			0.002***	0.002***
			(0.000)	(0.000)			(0.000)	(0.000)
ROA			0.002	0.0022			0.002	0.002
			(0.002)	(0.0016)			(0.002)	(0.002)
Firm Age			-0.019	-0.018			-0.018	-0.017
			(0.110)	(0.110)			(0.110)	(0.110)
Tangibility			-0.022	-0.023			-0.023	-0.023
			(0.048)	(0.047)			(0.048)	(0.047)
CFO			0.006	0.006			0.006	0.006
			(0.005)	(0.005)			(0.005)	(0.005)
HHI			-0.073	-0.073			-0.074	-0.074
			(0.053)	(0.053)			(0.054)	(0.054)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State Subsidy			-0.038	-0.039			-0.038	-0.039
			(0.031)	(0.031)			(0.031)	(0.031)
Missing R&D			-0.71***	-0.71***			-0.710***	-0.710***
			(0.099)	(0.099)			(0.099)	(0.099)
Constant	0.980***	0.990***	1.180	1.240	0.980***	0.990***	1.180	1.240
	(0.004)	(0.003)	(2.250)	(2.260)	(0.004)	(0.003)	(2.260)	(2.270)
Observations	30,837	30,837	30,837	30,837	30,837	30,837	30,837	30,837
Adjusted R-squared	0.966	0.966	0.971	0.971	0.966	0.966	0.971	0.971
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm

This table presents stacked cohort regression estimates of the effect of R&D sales tax exemptions on firms' R&D expenditures. The dependent variable *Ln(RD_Exp)* is the logarithm of firm-year R&D expense. The dependent variable *Ln(RD_GrossUp)* grosses up 50% of R&D expense for the sales tax rate in the year an exemption applies. The independent variable *RD_Exempt* is an indicator for the presence of an exemption, and *RD_Savings* represents the percentage point savings on R&D purchases that is provided by an R&D sales tax exemption. Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors clustered by firm appear in parentheses. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4: R&D Sales Tax Exemptions and Firms' Innovation Inputs – Industry Cross-Sections

Panel A: High-Tech Industries

	(1)	(2)	(3)	(4)
	Ln(RD_Exp)	Ln(RD_Exp)	Ln(RD_GrossUp)	Ln(RD_GrossUp)
RD_Exempt	-0.018		-0.011	
	(0.019)		(0.019)	
RD_Exempt*HighTech	**0.170*** **		**0.180*** **	
	(0.031)		**(0.031)**	
RD_Savings		-0.006*		-0.005
		(0.003)		(0.003)
RD_Savings*HighTech		**0.032*** **		**0.034*** **
		(0.006)		**(0.0057)**
HighTech	0.100**	0.100**	0.100**	0.100**
	(0.042)	(0.042)	(0.042)	(0.042)
Observations	30,837	30,837	30,837	30,837
Adjusted R-squared	0.971	0.971	0.971	0.971
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm
Test: Exemption + Exemption*HighTech = 0	0.154***	0.026***	0.171***	0.030***
	[4.86]	[4.64]	[5.39]	[5.2]

Panel B: Manufacturing Industries

	(1)	(2)	(3)	(4)
	Ln(RD_Exp)	Ln(RD_Exp)	Ln(RD_GrossUp)	Ln(RD_GrossUp)
RD_Exempt	-0.001		0.003	
	(0.019)		(0.019)	
RD_Exempt*Mfg	**0.073*** **		**0.084*** **	
	(0.026)		**(0.026)**	
RD_Savings		-0.004		-0.003
		(0.003)		(0.003)
RD_Savings*Mfg		**0.013*** **		**0.015*** **
		(0.004)		**(0.005)**
Mfg	0.060	0.061	0.058	0.059
	(0.059)	(0.059)	(0.059)	(0.059)
Observations	30,837	30,837	30,837	30,837
Adjusted R-squared	0.971	0.971	0.971	0.971
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm
Test: Exemption + Exemption*Mfg = 0	0.072***	0.009**	0.087***	0.012***
	[2.79]	[2.14]	[3.35]	[2.74]

This table presents estimates of industry effects on the relation between R&D sales tax exemptions and firms' R&D expenditures. Panel A (B) reports results of estimating Equation (1) modified to include the interactive effect between the independent variable of interest for sales tax exemption and an indicator for High-Tech (Manufacturing) industries. Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors clustered by firm appear in parentheses. Probability values from F-tests of coefficients appear in brackets. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5: Effect of R&D Sales Tax Exemptions on Firms' Innovation Outputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln(Patents)	Ln(Patents)	Ln(Patents)	Ln(Patents)	Originality	Originality	Originality	Originality
RD_Exempt	**-0.029**		**-0.010**		**-0.005**		**0.001**	
	(0.023)		**(0.017)**		**(0.006)**		**(0.004)**	
RD_Savings		**-0.001**		**-0.000**		**-0.000**		**0.000**
		(0.004)		**(0.003)**		**(0.003)**		**(0.001)**
CIT R&D Credit			-0.000	-0.000			0.000	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Combined Reporting			-0.029	-0.029			0.0011	0.001
			(0.033)	(0.033)			(0.012)	(0.012)
CIT Burden			-0.009	-0.009			0.0011	0.001
			(0.011)	(0.011)			(0.0025)	(0.003)
Ln(GSP)			0.089	0.073			-0.015	-0.015
			(0.190)	(0.190)			(0.059)	(0.059)
Population			-0.130	-0.110			0.033	0.033
			(0.200)	(0.200)			(0.062)	(0.062)
Unemployment Rate			0.011*	0.011*			0.000	0.000
			(0.007)	(0.007)			(0.002)	(0.002)
State SUT Rate			0.003	0.003			0.004	0.004
			(0.012)	(0.012)			(0.004)	(0.004)
Size			0.042***	0.042***			0.000	0.000
			(0.010)	(0.010)			(0.003)	(0.003)
Leverage			-0.065**	-0.065**			-0.006	-0.006
			(0.025)	(0.025)			(0.009)	(0.009)
MTB			0.002***	0.002***			-0.000	-0.000
			(0.001)	(0.001)			(0.000)	(0.000)
ROA			0.002	0.002			-0.003	-0.003
			(0.003)	(0.003)			(0.002)	(0.002)
Firm Age			-0.039	-0.040			0.017	0.017
			(0.052)	(0.052)			(0.031)	(0.031)
Tangibility			0.018	0.018			-0.019	-0.019
			(0.046)	(0.046)			(0.014)	(0.014)
CFO			-0.001	-0.001			0.006	0.006
			(0.009)	(0.009)			(0.005)	(0.005)
HHI			0.130***	0.130***			-0.005	-0.005
			(0.047)	(0.046)			(0.016)	(0.016)

State Subsidy			0.052*	0.052*			-0.003	-0.003
			(0.031)	(0.031)			(0.007)	(0.007)
Zero Patents			-1.030***	-1.030***			-0.390***	-0.390***
			(0.024)	(0.024)			(0.014)	(0.014)
Constant	0.510***	0.510***	2.600*	2.570*	0.093***	0.092***	-0.300	-0.310
	(0.005)	(0.004)	(1.350)	(1.350)	(0.0012)	(0.0010)	(0.68)	(0.68)
Observations	24,250	24,250	24,250	24,250	24,250	24,250	24,250	24,250
Adjusted R-squared	0.893	0.893	0.941	0.941	0.542	0.542	0.743	0.743
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm

This table presents stacked cohort regression estimates of the effect of R&D sales tax exemptions on firms' patenting activity. The dependent variable *Ln(Patents)* is the logarithm one plus the number of patent applications filed by firm *i* in fiscal year *t*. The dependent variable *Originality* is the mean originality of a firm *i*'s patent applications in fiscal year *t*, calculated following Hall, Jaffe, and Trajtenberg (2001). The independent variable *RD_Exempt* is an indicator for the presence of an exemption, and *RD_Savings* represents the percentage point savings on R&D purchases that is provided by an R&D sales tax exemption. Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors clustered by firm appear in parentheses. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.

Table 6: R&D Sales Tax Exemptions and Firms' Innovation Outputs – Industry Cross-Sections

Panel A: High-Tech Industry

	(1) Ln(Patents)	(2) Ln(Patents)	(3) Originality	(4) Originality
RD_Exempt	0.003		0.001	
	(0.018)		(0.004)	
RD_Exempt*HighTech	**-0.048**		**-0.000**	
	(0.035)		**(0.008)**	
RD_Savings		0.002		0.000
		(0.003)		(0.001)
RD_Savings*HighTech		**-0.009**		**0.000**
		(0.006)		**(0.002)**
HighTech	0.030	0.030	-0.014	-0.014
	(0.036)	(0.036)	(0.010)	(0.010)
Observations	24,250	24,250	24,250	24,250
Adjusted R-squared	0.941	0.941	0.743	0.743
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm
Test: Exemption + Exemption*HighTech = 0	-0.045	-0.007	0.000	0.000
	[-1.33]	[-1.18]	[0.05]	[0.29]

Panel B: Manufacturing Industry

	(1) Ln(Patents)	(2) Ln(Patents)	(3) Originality	(4) Originality
RD_Exempt	0.033*		0.007	
	(0.018)		(0.004)	
RD_Exempt*Mfg	**-0.090*** **		**-0.013** **	
	(0.028)		**(0.006)**	
RD_Savings		0.006**		0.001
		(0.003)		(0.001)
RD_Savings*Mfg		**-0.014*** **		**-0.002* **
		(0.005)		**(0.001)**
Mfg	0.025	0.022	0.0054	0.005
	(0.023)	(0.023)	(0.008)	(0.008)
Observations	24,250	24,250	24,250	24,250
Adjusted R-squared	0.941	0.941	0.743	0.743
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm
Test: Exemption + Exemption*Mfg = 0	-0.057**	-0.008*	-0.006	-0.001
	[-2.21]	[-1.9]	[-0.94]	[-0.89]

This table presents estimates of industry effects on the relation between R&D sales tax exemptions and firms' patenting activity. Panel A (B) reports results of estimating Equation (1) modified with the interactive effect between the independent variable of interest for sales tax exemption and an indicator for High-Tech (Manufacturing) industries. Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors clustered by firm appear in parentheses. Probability values from F-tests of coefficients appear in brackets. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.

Table 7: Effects of Financial Constraints

Panel A: Financially Constrained Firms

	(1) Ln(RD_Exp)	(2) Ln(RD_Exp)	(3) Ln(Patents)	(4) Ln(Patents)
RD_Exempt	0.026		-0.006	
	(0.019)		(0.017)	
RD_Exempt*HighFC	**0.078****		**-0.052***	
	(0.032)		**(0.030)**	
RD_Savings		0.001		0.000
		(0.003)		(0.003)
RD_Savings*HighFC		**0.014****		**-0.009**
		(0.006)		**(0.006)**
HighFC	0.014	0.015	0.038*	0.037*
	(0.021)	(0.021)	(0.020)	(0.020)
Observations	30,837	30,837	24,250	24,250
Adjusted R-squared	0.971	0.971	0.941	0.941
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm
Test: Exemption + Exemption*HighFC = 0	0.104***	0.015**	-0.058*	-0.009
	[2.98]	[2.47]	[-1.81]	[-1.45]

Panel B: Loss Firms

	(1) Ln(RD_Exp)	(2) Ln(RD_Exp)	(3) Ln(Patents)	(4) Ln(Patents)
RD_Exempt	0.018		0.007	
	(0.019)		(0.018)	
RD_Exempt*Loss	**0.037****		**-0.048****	
	(0.018)		**(0.020)**	
RD_Savings		0.000		0.002
		(0.003)		(0.003)
RD_Savings*Loss		**0.005**		**-0.008****
		(0.003)		**(0.003)**
Loss	0.040***	0.043***	0.022**	0.021**
	(0.009)	(0.008)	(0.009)	(0.009)
Observations	30,837	30,837	24,250	24,250
Adjusted R-squared	0.971	0.971	0.941	0.941
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year & Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm
Test: Exemption + Exemption*Loss = 0	0.055**	0.005	-0.041*	-0.005
	[2.46]	[1.26]	[-1.93]	[-1.56]

This table presents estimates of the effects of financial constraints on the relation between R&D sales tax exemptions and firms' innovation activities. Panel A (B) reports results of estimating Equation (1) modified with the interactive effect between the independent variable of interest for sales tax exemption and an indicator for financially constrained (loss) firms. Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors clustered by firm appear in parentheses. Probability values from F-tests of coefficients appear in brackets. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.

Table 8: Dynamic Effects of R&D Sales Tax Exemptions on Firm Innovation

	(1) Ln(RD_Exp)	(2) Ln(RD_GrossUp)	(3) Ln(Patents)	(4) Originality
Event Year Minus 4	-0.0080	-0.0078	0.041*	0.015
	(0.014)	(0.014)	(0.024)	(0.011)
Event Year Minus 3	0.0037	0.0039	0.0081	0.0042
	(0.019)	(0.019)	(0.030)	(0.011)
Event Year Minus 2	0.012	0.012	0.021	0.0079
	(0.019)	(0.020)	(0.032)	(0.011)
Event Year Minus 1	-0.0057	-0.0058	0.0051	-0.0036
	(0.022)	(0.022)	(0.036)	(0.013)
Event Year	0.018	0.028	0.013	-0.0036
	(0.024)	(0.024)	(0.039)	(0.012)
Event Year Plus 1	0.027	0.037	0.037	0.012
	(0.029)	(0.029)	(0.043)	(0.014)
Event Year Plus 2	0.039	0.049	0.024	0.0021
	(0.032)	(0.032)	(0.046)	(0.014)
Event Year Plus 3	**0.058***	**0.068****	0.039	0.014
	(0.034)	**(0.034)**	(0.048)	(0.015)
Event Year Plus 4	**0.071***	**0.081****	0.034	0.020
	(0.037)	**(0.037)**	(0.050)	(0.015)
Observations	30,837	30,837	19,940	19,940
Adjusted R-squared	0.971	0.971	0.910	0.559
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Year & Firm	Year and Firm	Year & Firm	Year & Firm
Cluster	Firm	Firm	Firm	Firm

This table presents stacked cohort regression estimates of the dynamic effects of R&D sales tax exemptions on firms' R&D expenditures and patenting activities from Equation (2). The dependent variable *Ln(RD_Exp)* is the logarithm of firm-year R&D expense. The dependent variable *Ln(RD_GrossUp)* grosses up 50% of R&D expense for the sales tax rate in the year an exemption applies. The dependent variable *Ln(Patents)* is the logarithm one plus the number of patent applications filed by the firm in fiscal year *t*. The dependent variable *Originality* is the mean originality of a firm *i*'s patent applications in fiscal year *t*, calculated following Hall, Jaffe, and Trajtenberg (2001). Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors clustered by firm appear in parentheses. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.

Table 9: Effect of R&D Sales Tax Exemptions on State-Level Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	State_RD/GSP	State_RD/GSP	State_RD/GSP	State_RD/GSP	Ln(State_Patents)	Ln(State_Patents)	Ln(State_Patents)	Ln(State_Patents)
RD_Exempt	**0.002*** **		**0.002***		**-0.065*** **		**-0.065**	
	(0.001)		**(0.001)**		**(0.025)**		**(0.044)**	
RD_Savings		**0.000*** **		**0.000**		**-0.012*** **		**-0.012**
		(0.000)		**(0.000)**		**(0.004)**		**(0.008)**
CIT R&D Credit	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Combined Reporting	0.000	0.000	0.000	0.0002	0.099**	0.098**	0.099*	0.098*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.044)	(0.043)	(0.056)	(0.056)
CIT Burden	0.000	0.000	0.000	0.000	-0.040***	-0.040***	-0.040	-0.040
	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.011)	(0.028)	(0.028)
Population	-0.009***	-0.009***	-0.009	-0.009	0.790***	0.800***	0.790	0.800
	(0.004)	(0.004)	(0.006)	(0.006)	(0.300)	(0.300)	(0.870)	(0.870)
Unemployment Rate	0.000*	0.000	0.000	0.000	-0.010**	-0.010**	-0.010	-0.010
	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.005)	(0.014)	(0.014)
Ln(State Subsidies)	-0.000	-0.000	-0.000	-0.000	0.001	0.001	0.001	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.003)	(0.003)
State SUT Rate	-0.001*	-0.001*	-0.001	-0.001	-0.002	0.001	-0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.037)	(0.037)	(0.077)	(0.076)
Ln(GSP)					0.076	0.076	0.076	0.076
					(0.120)	(0.120)	(0.280)	(0.280)
Constant	0.150***	0.150***	0.150	0.150	-6.580*	-6.790*	-6.580	-6.790
	(0.052)	(0.052)	(0.093)	(0.095)	(3.790)	(3.770)	(10.600)	(10.600)
Observations	984	984	984	984	987	987	987	987
Adjusted R-squared	0.919	0.917	0.918	0.916	0.991	0.991	0.991	0.991
Cohort Fixed Effects	Year & State	Year & State	Year & State	Year & State	Year & State	Year & State	Year & State	Year & State
Cluster	Robust	Robust	State	State	Robust	Robust	State	State

This table presents stacked cohort regression estimates of the effect of R&D sales tax exemptions on state-level innovation activity. The dependent variable *State_RD/GSP* equals R&D expenditures for R&D activities performed in the state scaled by gross state product. The dependent variable *Ln(State_Patents)* is the logarithm of the number of patent applications filed by state residents in year *t,* using data from PatentsView. Patents are fractionally allocated among states based on the residences of the named inventors. The independent variable *RD_Exempt* is an indicator for the presence of an exemption, and *RD_Savings* represents the percentage point savings on R&D purchases that is provided by an R&D sales tax exemption. Appendix B provides complete variable definitions. Continuous variables are winsorized at the 1st and 99th percentiles. Standard errors are presented with and without clustering by state in parentheses. ***, **, and * denote two-tailed statistical significance at the 1%, 5% and 10% levels, respectively.