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and Innovation in Start-ups**

By *Lora Dimitrova* and *Sapnoti K. Eswar*

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Capital Gains Tax, Venture Capital and Innovation in Start-ups*

Lora Dimitrova[†]

University of Exeter Business School

Sapnoti K. Eswar

University of St Andrews

Abstract

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Keywords: Innovation, Capital gains tax, Venture capital, Entrepreneurship.

JEL Classification Numbers: G24, H25, L26, O31.

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[†]Correspondence: Lora Dimitrova, University of Exeter, Streatham Court, Rennes Drive, Exeter EX4 4PU, U.K. Tel.: +44(0)13-9272-5979, e-mail address: l.dimitrova@exeter.ac.uk.

Entrepreneurial firms supported by Venture Capital (VC) investors play an important role in innovation and productivity growth. VC is associated with some of the most influential and high-growth, entrepreneurial firms in the world (Lerner and Nanda (2020)). As of May 2020, seven of the eight largest firms based on market capitalization had been backed by venture capital before their initial public offerings: Alphabet, Apple, Amazon, Facebook, and Microsoft in the United States, and Alibaba and Tencent in China.

Studies have shown the power of VC firms in accelerating the quantity of innovation and in improving the quality of innovation (Kortum and Lerner (2000), Hellmann and Puri (2000), Bernstein et al. (2016), Howell et al. (2020)). Given the relevance of VC for firm-level innovation, we focus on the effect of taxation on VC firms' incentives and the innovation outcomes of start-ups. So far, studies have not evaluated this question because a large proportion of the partners in VC firms are tax-exempt (Poterba (1989a)).

There are two categories of investors, or partners, in VC firms. The partners in charge of managerial decision-making are called general partners (GPs) and the outside investors are limited partners (LPs). Limited partners provide the financial capital and have limited liability. They are predominantly institutional investors such as pension funds, insurance companies, and corporations (Lerner and Nanda (2020)). The largest share of the VC firm's funding comes from pension funds and foundations which are tax-exempt in the US. However, the incentives of GPs, who are taxed as individuals, are affected by changes in the taxes on capital gains (Kortum and Lerner (2000), Keuschnigg and Nielsen (2002), (2004)). An increase in the tax rate on capital gains decreases the return to GPs and therefore reduces their incentives to invest, advise, and support existing portfolio start-ups that can have an effect on their innovation and success. In this study, we investigate the direct effect of capital gains taxes faced by VC firms on the innovation outcomes of start-ups.

In the US, VC firms are structured as "pass-through entities" which means that the firm itself does not pay taxes; the profits are distributed to the partners who pay taxes as a part of their individual tax returns. When partners sell capital assets for a profit, they typically face federal and state taxes on the gain from the sale. Pass-through distributions account for around 50% of the total realized capital gains in the US (Sarin et al. (2021)). Given that the tax policy on capital gains is arguably one of the more important ones for VC firms, we focus on those taxes.

Capital gains taxes can affect the expected returns of both VC firms and entrepreneurs. VC firms can respond to increases in taxes by reducing the supply of capital and reducing engagement with and support to start-ups (the VC channel) (Keuschnigg and Nielsen (2002), (2004), Keuschnigg (2004)). Entrepreneurs can respond by reducing their demand for capital and their level of risk-taking (the entrepreneur channel) (Poterba (1989a), Gentry (2016)).

Our dataset comprises 5,102 predominantly private, US VC-backed start-ups. This dataset has two advantages. First, start-ups are more likely to be the ones in which both entrepreneurs and VC firms contribute effort to promote their success in a double moral hazard setting. Second, the focus on VC-backed start-ups allows us to disentangle the two channels: the VC channel and the entrepreneur channel. Using detailed geographic information on entrepreneurs and VC firms, we are able to identify these two channels separately. This identification represents an important contribution of the paper and provides valuable policy implications. The literature has focused on the volume of VC being raised and invested. Our results suggest that incentivizing VC firms to become more actively involved in their portfolio of start-ups could significantly benefit innovation.

To evaluate the VC channel, we define the changes in the capital gains tax based on the state where the lead VC firm is headquartered. Therefore, our treated firms are those in which the lead VC firm is in a state that is affected by a tax change, and the control firms are those where their lead VC firm is in a state that is not affected by a tax change. To evaluate the entrepreneur channel, we define the changes in the capital gains tax based on the state where the start-up is headquartered. We include the tax changes for both start-ups and the VC firms in the same specification to ensure that we partial out any common changes due to the start-up and the VC firm being located in the same state while identifying the separate, incremental effect of tax changes coming from observations in which the start-up and the VC firm are located in different states. In addition, the magnitude of the effect coming through the entrepreneur channel serves as a benchmark for the VC channel.

We find that an increase in the capital gains tax leads to a decrease in the quantity and quality of start-ups' innovations (as measured by the patent count and cite-weighted patents, respectively). For instance, the elasticity of patents to changes in the capital gains tax for VC firms is -0.45 to -0.75.¹ VC firms provide not only capital but also managerial support and expertise to young firms. Changes in the capital gains tax alter the incentives of VC firms to support and advise their portfolio firms (Keuschnigg and Nielsen (2004)).

Empirically identifying the effect of tax changes on innovation can be challenging because changes in the capital gains tax at the state level are small in magnitude and may not be very salient. The average tax increase in our sample is 69 basis points, and the average tax

¹The magnitude of the effect of changes in the capital gains tax compares well with the effect of changes in personal income tax on state- and firm-level innovation. Our estimates of the elasticity of patents with respect to changes in the capital gains tax is lower than the elasticity of patents to changes in the personal income tax at the state level (-2 to -3.4) (Akcigit et al. (2019)). We predict the effect of the capital gains tax will be small because this effect will likely work through the channel of GPs' actions and not through LPs' actions. In addition, our estimates at the firm level are comparable to the elasticity of patents to changes in the personal income tax at the individual level (-0.6 to -0.7) (Akcigit et al. (2019)).

decrease is 41 basis points. To address this concern, we rely on two approaches. For the first approach, we use changes in the combined federal and state tax rates for capital gains as our main tax variable. Using this tax rate directly addresses the concern on the magnitudes of the tax changes. This method also yields stable coefficients that facilitates the interpretation of the results as elasticities (Agersnap and Zidar (2020), Gravelle (2020)). For our second approach, we focus on large changes in the state-level tax rates on capital gains, that is, changes which are more than one percentage point (Agersnap and Zidar (2020)).

We carry out a series of robustness tests to validate our main results. To begin with, we evaluate the dynamics around the year of a tax change. We find that there are no discernible pre-trends in innovation and that there is a significant effect on innovation in the first year after the tax change. The immediate effect is due to the fact that we measure the growth rate of patents and not the level of patenting. Since our regression specification is in terms of *changes* in patents, our result indicates that the growth rate in patents changes in the first year after the tax change. The effect on the level of patenting can appear in later years.

Next, we test for various subsamples (not to overstate the effect of taxes, we exclude start-up firms which move their headquarters to another state within our sample period; to show that the results are not driven entirely by two clusters of innovative firms, we exclude firms in California and Massachusetts), use different clustering methods (at the firm-level, industry-level, and year-level), and add firm fixed effects. We also add controls for industry concentration, and two control variables to account for other contemporaneous changes in tax policy which can potentially affect innovation: the Bonus Depreciation Tax policy and the Domestic Production Activities Deduction scheme (Zwick and Mahon (2017), Ohrn (2018)).

Further, we examine the mechanisms behind the effect of the capital gains tax on real innovation. These tests comprise the investments, size of portfolios, support, and lock-in of VC firms.

Successful innovation depends on effort provided by both the entrepreneur and the financier (Casamatta (2003)). When the VC firms have to pay a higher capital gains tax, the marginal benefit of advice shrinks and thus, decreases advice for any given equity share (Keushnigg (2004)). When the VC firm advises less, then the start-up is less likely to succeed, which destroys the entrepreneur's return on effort. The entrepreneur must then be compensated with a higher share of profits to ensure a high level of critical effort. A lower share of profits for the VC firm means that its investment is lower. For a given number of start-ups in the VC firm's portfolio, a decrease in the profit share of the VC firm decreases the effect of profit creation. Consequently, the VC firm consolidates its portfolio. So a higher capital gains tax can lead to lower investment by VC firms and consequently smaller portfolios. We argue that less investments by VC firms, and investments in fewer start-ups

can lead to fewer innovation outcomes. We find strong, empirical evidence in favour of taxes having a negative effect on the investments and the size of the portfolios of VC firms.

To provide a more direct test of a VC firm's effort, we evaluate the innovation exchanges between firms in the same VC firm's portfolio. As strategic investors, VC firms have incentives to finance firms with complementary innovation resources in an attempt to increase investment returns. VC firms can act as arbiters to the start-ups within their portfolios that leads to an increase in innovation exchanges between those start-ups which may not have occurred due to negative rivalry in the product market or expropriation risk (Gonzalez-Uribe (2020)). To examine the effect of the capital gains tax on VC firms' effort, we test whether this tax affects the level of innovation exchanges within their portfolio. As successful inventions typically benefit from such exchanges, we argue that an increase in the capital gains tax for the VC firm can lead to fewer innovation exchanges that thereby lead to fewer innovation outcomes for start-ups. Our results provide strong evidence that the changes in taxes change the VC firm's incentives which affects the level of innovation exchanges between their portfolio start-ups.

Changes in the capital gains tax can also affect innovation by encouraging VC firms and entrepreneurs to delay the sale of profitable firms when faced with unfavorable taxes (Dammon et al. (2001), Chari et al. (2005)), Jin (2006)). A higher capital gains tax can incentivize VC firms to lock-in their investments, although the average time span of a VC firm at 10 years can limit that ability to a certain extent. Tax changes can also influence VC firms' exits from unsuccessful start-ups in the form of write-offs. As VC firms' advice and support are critical to start-ups' success, we argue that their exits lead to lower innovation outcomes. We test whether the number of firms going public and the number of start-ups being written-off by the lead VC firm changes in response to changes in the capital gains tax. We find strong evidence in favor of write-offs by VC firms: the number of firms written-off by the lead VC firm increases after a tax increase in the state of its headquarters.

We also test for other alternative mechanisms. When the capital gains tax changes, it affects not only entrepreneurs and start-up investors but also other investors, and public firms. Our specification is particularly sensitive to these alternative mechanisms because increases in the capital gains tax causes investors in public firms to become more patient (Holt and Shelton (1961), Feldstein et al. (1980)). This difference in behavior can lead to changes in innovation in public firms and their private counterparts. Nevertheless, we find no evidence in favor of this alternative mechanism.

This paper makes three contributions. First, by studying VC-backed start-up firms, our paper contributes to the literature on entrepreneurial finance. Since both the entrepreneur and the financier need to simultaneously provide effort to advance the firm's innovative

projects, the relation between entrepreneur and financier suffers from a double moral hazard (Schmidt (2003), Inderst and Mueller (2004)). Our paper is one of the few in the literature to focus on the GPs of VC firms that are the individuals who are more likely to be affected by tax changes. GPs can influence the level of investment, the size of the VC firm’s portfolio, and the exchange of innovation across firms in the portfolio as well as its decision to exit in response to tax changes. The theoretical research finds that even a small capital gains tax involves a first-order welfare loss, because it exacerbates a preexisting distortion and further discourages entrepreneurial effort and the VC firm’s managerial support (Keuschnigg and Nielsen (2002), (2004)). Empirical studies provide evidence that the capital gains tax is an important driver of both entrepreneurship and VC firms’ investment (Poterba (1989a), (1989b)). Higher tax rates on capital gains are associated with fewer start-ups being financed, less venture capital being raised, and less entries and exits by firms.²

Second, by focusing on one aspect of growth, innovation, this paper adds to the literature on the real effects of state and federal fiscal policies. A body of empirical literature has studied the effects of corporate taxes on investment, productivity, and economic growth.³ Further, a number of papers have provided evidence on the effects of corporate tax changes on corporate policies.⁴ The research has also shown that the tax rates on capital gains affect entrepreneurship.⁵

Third, our paper contributes to the literature on finance and innovation. This strand of the literature studies the effect of market characteristics such as banking deregulation, bankruptcy laws, labor laws, competition, credit markets, banking relationships, liquid options markets, and derivatives on innovation.⁶

²For a reference, see Gompers and Lerner (1999), Bock and Watzinger (2017), Bruce (2000), Bruce (2002), and Cullen and Gordon (2007). Similarly, Da Rin et al. (2006) find that a reduction in capital gains taxation increases both early stage and high-tech VC investments, albeit the economic effect is not very large.

³Examples include Jorgenson (1963); Hall and Jorgenson (1967); Levine (1991); Auerbach and Hassett (1992); Cummins et al. (1996); Cullen and Gordon (2007); Djankov et al. (2010); Romer and Romer (2010); Mertens and Ravn (2012). Moreover, two recent papers have examined the effect of corporate income taxes on firm innovation using a sample of large publicly traded US firms (Mukherjee et al. (2017), Atanassov and Liu (2020)).

⁴See Graham (2006); Blouin et al. (2010); Asker et al. (2015); Heider and Ljungqvist (2015); Faulkender and Smith (2016).

⁵In addition to the papers mentioned in footnote 2 please refer to Gentry and Hubbard (2004) and Gentry (2016).

⁶Cornaggia et al. (2015), Amore et al. (2013), Chava et al. (2013), Acharya and Subramanian (2009), Acharya et al. (2013), and (2014), Aghion et al. (2005), Hsu et al. (2014), Hombert and Matray (2016), and Blanco and Wehrheim (2017).

1. Institutional Setting

VC firms raise money from individuals and institutional investors to make equity investments in start-up firms that offer high potential but at a high risk. Investments are typically held for the medium to long term and include management rights. The managers of the VC firm are called general partners and the outside investors are called limited partners.⁷ A typical business arrangement for the GPs would comprise a flat management fee (2% of invested capital) and a share of profits or carried interest (20% of returns on the investment). Figure 1 shows the ownership structure of an average VC firm in the US.

INSERT Figure 1 ABOUT HERE

A VC firm is typically organized as a limited partnership. This organizational form has tax advantages for investors. Partnership income is not subject to corporate taxation; instead income is taxable to the individual partners.⁸ Also, partnerships can distribute securities without triggering immediate recognition of taxable income: partners recognize the gain or loss on the underlying asset after they sell the asset. When an individual sells a capital asset for a profit, they face a tax on the gain. In the US the tax rate on capital gains varies with respect to how long the individual held the asset and the amount of income they earn. If an individual holds an asset for less (more) than one year and then sells it for a profit, the tax authority classifies it as a short-term (long-term) capital gain and taxes it as ordinary income (capital gain). The top federal tax rate on long-term capital gains in the US for the 2019 tax year was 23.8%. In addition to federal taxes on capital gains, most states in the US levy income taxes that apply to capital gains, which vary from 0% to 13.3%. This state tax means long-term capital gains currently can face up to a top marginal rate of 37.1%.

The empirical findings on the sensitivity of the supply of VC to capital gains taxes are mixed.⁹ Although the largest share of VC comes from pension funds and foundations,

⁷Limited partners provide the financial capital and have limited liability. They are predominantly institutional investors but they can also be corporates, wealthy individuals, or governments looking to stimulate the start-up ecosystem. While the liability of the general partners is unlimited, their exposure is minor as they typically do not borrow and are rarely exposed to the risk of having liabilities in excess of assets (Sahlman (1990)).

⁸To qualify for this form of tax treatment, partnerships must meet several conditions: 1) A firm's life must have an agreed-upon date of termination that it establishes before signing the partnership agreement. 2) The transfer of LP units is restricted; unlike most registered securities, they cannot be easily bought and sold. 3) Regulation prohibits withdrawal from the partnership before the termination date. 4) LPs cannot participate in the active management of a fund if their liability is to be limited to the amount of their commitment.

⁹Poterba (1989a) argues against any effect because most LPs are tax-exempt in the US. Some authors

which are tax-exempt in the US, a number of theoretical papers argue that the incentives of GPs, who are taxed as individuals, are affected by changes in the capital gains tax. An increase in the tax rate on capital gains decreases the return to GPs that hence reduces their incentives to invest, advise, and support existing portfolio firms that can have an effect on their innovation and success (Kortum and Lerner (2000), Keushnigg and Nielsen (2002), (2004)). In line with this argument, we test whether the capital gains tax affects firm innovation through the mechanism of GPs' effort and involvement. We call this channel the VC channel.

The effect of the capital gains tax on firm innovation can also be entrepreneur-driven. An increase in this tax rate can induce some entrepreneurs to resort to regular employment that reduces their incentives to grow and innovate as well as their demand for VC. Since entrepreneurs are relatively less diversified compared to the shareholders of publicly traded firms, the capital gains tax may create a form of asymmetric "success tax" where the government discourages entrepreneurs from taking risk by taxing their upside returns but does not share symmetrically in projects that fail (Poterba (1989a); Gentry (2016)). This potential reduction in risk-taking may lead to a lower level of innovation generated by entrepreneurs. We call this channel the entrepreneur channel.

In this study, we take advantage of the richness of our data and the heterogeneity in the tax treatment across different types of investors to identify the effect of the capital gains tax on innovation. In our setting, we identify the effect on innovation through the entrepreneur and the VC channels. The magnitude of the entrepreneur channel serves as a benchmark for the VC channel.

2. Data

Our dataset combines information on patents, state taxes and tax loss rules, and other firm characteristics from several data sources. We begin with a sample of firms which received VC financing between January 1, 1987, and December 31, 2014, that are based on Thomson Financial's VentureXpert database. The patent data comes from Thomson Reuters' Derwent World Patents Index (DWPI) database. DWPI is a value-added worldwide patents database that contains patent applications and grants from 48 patent issuing authorities worldwide on more than 23 million unique inventions for over 50 million patent documents.¹⁰ We match

find a negative effect of the capital gains tax on funding raised by VC firms (Bock and Watzinger (2017), Da Rin et al. (2006), Cumming (2005)). Others show the lack of an effect of the capital gains tax on investments by VC firms (Jeng and Wells (2000)).

¹⁰To ensure the completeness of the DWPI database, we compare the US patents data from DWPI to the data obtained from the US Patent and Trademark Office (or USPTO) as made available publicly by Google

patent assignees in the DWPI database to US start-up firms' names from the VentureXpert database. We exclude financial firms with codes (Standard Industrial Classification (SIC)) between 6000 and 6799, utility firms with SIC codes between 4900 and 4949, and firms in the public sector with SIC codes between 9100 and 9729 from the final dataset as patents may not be good measures of the output of innovative activities in these sectors. The entire sample comprises 27,608 firms of which 5,102 have patents.

2.1. Firm-level Data

We use the patent count to represent a firm's innovative activity. Specifically, our measure of innovative output is the natural logarithm of (1 + the number of newly granted patents filed by the firm in a given year), $LnPat$. However, patent counts cannot distinguish between breakthrough innovation and incremental discoveries (e.g., Griliches (1990)). To test for the quality of patents we use the natural logarithm of (1 + cite-weighted patents), $CwPat$. Patent citations are not only a good measure of innovation quality but also of economic importance (Hall et al. (2005)). In alternative specifications, we also use the natural logarithm of patents and cite-weighted patents: $Ln(Patents)$ and $Ln(Cite-wt\ patents)$. Further, because many firms in our sample do not have patents granted in every year, we use an alternative measure of innovation, $Inventor$ that is an indicator variable which equals one if the firm has filed for at least one new successful (eventually granted) patent in a given year.

2.2. State Tax Policies

We combine our dataset with information on the tax rates for long-term capital gains obtained from the NBER TAXSIM Data. The data contain marginal tax rates by year and state for a representative household with \$1,500,000 income (split evenly between husband and wife).¹¹ Given that the actual tax rate for an individual is endogenous, the maximum state tax rate is a better independent variable to use in a cross-state regression analysis because this variable is exogenous to the labor supply and investment decisions of individuals. Therefore, changes in the maximum tax rates within states has the potential to be a valid instrument (Feenberg and Coutts (1993)). The key explanatory variables in our analysis are Δ^- Tax rate ($\Delta^- Tax\ rate\ VC$) and Δ^+ Tax rate ($\Delta^+ Tax\ rate\ VC$). These variables capture the decrease and increase for a given year in the capital gains tax of the state that the start-up (the lead VC firm) is located in.

Patents and documented by Kogan et al. (2017), hereinafter KPSS. KPSS is the most widely used, public dataset on US patents. We find that the DWPI contains more patents for matched Compustat firms than available in KPSS. Further details are provided in Appendix B.

¹¹Please refer to the description of the TAXSIM program in Feenberg and Coutts (1993). The simulation and the resulting data are available online at: <http://www.nber.org/~taxsim/state-rates>.

INSERT Figure 2 ABOUT HERE

A large fraction of US states increased their capital gains taxes in 1987. This change was a part of the 1986 tax reform.¹² We exclude this nationwide change in taxes and begin our sample five years after the event, in 1992. The number of states with tax changes per year are reported in Figure 2. There are a total of 98 tax increases and 210 tax decreases across states and across years in our sample.¹³ To determine the relevant tax rate for VC firms (or the GP, as in Figure 1) we follow the literature and use the state in which the VC firm has its headquarters (Heider and Ljungqvist (2015)). Given the partnership structure of VC firms, the capital gains tax is determined by the state of residence of the GPs and not by the state of incorporation of the VC firm.¹⁴ This is because states tax the carried interest received by GPs (and LPs) as a part of the total income of the partner if the partner is an individual. We assume that the state of residence of GPs is the same as the state where the VC firm is headquartered. VC firms' headquarters are likely to reflect the need to be proximate to their sources of capital and not their portfolio firms (Gompers and Lerner (1999), Lerner (1995)). Using similar logic, we also determine the relevant tax rate for a given start-up by using the state where it is headquartered.

In our tests we control for alternative tax policies such as the rules on tax loss, R&D tax credit, and the corporate income tax of the state. When firms suffer losses in a given year, states allow them to deduct those losses against previous or future tax returns.¹⁵ These provisions are called net operating loss (NOL) carrybacks and carryovers. We test the effect of tax loss rules by creating two variables: Δ *Carryback* and Δ *Carryover*. For them, we use hand collected data from the websites of local state tax authorities. Δ *Carryback* (Δ *Carryover*) is a variable(s) that equals one in years in which there is an increase in the length of the state's tax NOL carryback (carryover) period in years, minus one in years in which

¹²The Tax Reform Act of 1986 was signed into law by President Ronald Reagan and was the most extensive review and overhaul of the Internal Revenue Code by the US Congress since the inception of the income tax in 1913 (the Sixteenth Amendment). Its purpose was to simplify the tax code, broaden the tax base, and eliminate many tax shelters and preferences.

¹³A list of all of the states and the years of changes in the capital gains tax for each state, is provided in Table A.1 of Appendix A.

¹⁴The majority of US-based VC firms are incorporated in Delaware to benefit from its well-established legal environment and body of law relating to limited partnerships.

¹⁵Losses in pass-through firms can be used to offset other sources of income if the owner is a "material participant" in the firm (section 172 of the Tax Reform Act of 1986). Passive investors, however, face limitations on their ability to use losses (section 469). In other words, losses from passive activities may only be deducted from the income of those activities. For tax purposes, a firm you merely invest in but do not materially participate in is considered a passive activity.

there is a decrease, and otherwise zero.¹⁶

Some states give firms a credit against their state taxable income which is equal to a percentage of their qualified R&D expenditures over a minimum amount. We gather the historical state-level R&D tax credit rates from Wilson (2009).¹⁷ Other studies have shown that corporate income taxes affect innovation (Mukherjee et al. (2017); Atanassov and Liu (2020)). We use corporate income tax data from Heider and Ljungqvist (2015) and Atanassov and Liu (2020).

2.3. Control Variables

In this subsection, we create control variables for changes in real gross domestic product (GDP), per capita income, and unemployment rate in a state. GDP and per capita income data are from the Bureau of Economic Analysis (BEA); the historical state unemployment rate is from the Cleveland Federal Reserve. Given that the firms in our sample are young, private start-ups, the data on firm-level control variables are limited. We collect the firm’s industry SIC code. Following Aghion et al. (2005), we control for industry concentration using the Herfindahl-Hirschman index (HHI) that is constructed at the 3-digit SIC code level and for nonlinear effects of industry concentration using the squared Herfindahl index. We calculate the index for all public firms within the Compustat database for each 3-digit industry-year. We apply this value to the private firms in the same industry-year category. We also add a variable that captures the number of years since the firm’s founding (as reported in VentureXpert) to control for its age.

From VentureXpert, we also retrieve detailed information on the investment round such as the date, estimated amount of investment, the number, and types of VC partners. We also retrieve the address of the start-up as well as the location of the VC firm which we use in determining the relevant state tax rate for both start-ups and VC firms. The definitions of the variables are summarized in Table 1.

¹⁶The loss carrybacks generate real and immediate cash flows for firms in the loss year. Carryovers, however, offer a more uncertain tax benefit, because the economic benefit of a loss carryover is a function of expected future profits, the expected year of profitability, the expected future tax rate, and the firm’s discount rate. These tax loss rules create ex-ante incentives for corporate risk-taking because the loss rules shift some risk to the government (Lester and Langenmayr (2017)). However, the tax loss rules are likely to be disadvantageous for many entrepreneurs, because firms that take longer to turn a profit, suffer a greater tax penalty (Hodge (2017)).

¹⁷Wilson (2009) shows that these tax incentives are effective in increasing R&D investment within the state. He shows that 32 states had provided such tax credits as of 2006. We also gather state tax credits for R&D from Lucking (2019). These data span the entire sample period from 1992 to 2014. We add a robustness test that uses tax credits for R&D up to 2014.

2.4. Summary Statistics

Table 2 presents the summary statistics of the variables used in the analysis.

INSERT Table 2 ABOUT HERE

Panel A of Table 2 provides the details of the firm- and state-level variables. The average patent count (US and international patents) for a start-up firm in the sample is 35.01 patents. The average US patent count for a start-up in the sample is 14.37. The average number of cite-weighted patents is 34.02, and the average number of citations is 211.8. On average, there is a 33% likelihood that a start-up is an innovative one, that is, the start-up has at least one successful patent in the year. The average (median) GDP in the start-up's state is 46.53 (49.40) billion dollars. The mean (median) per capita state income is \$38,153 (\$38,025). The average age of a start-up in the sample is 15.71 years, while the median start-up in the sample is 12 years old. In an average year, there is a 1.9% likelihood of a decrease in state corporate income taxes and a 5.8% likelihood of an increase in the state R&D tax credit. The average (median) unemployment rate is 6.53% (6.06%).

Panel B provides the details on state-level tax variables. The average (median) state capital gains tax rate is 5.02% (5.20%). The average decrease in the state capital gains tax is 0.41%, and the average increase in the state capital gains tax is 0.69%. In an average year, there is a 4.1% likelihood of an increase in allowances for carryback losses and a 1.4% likelihood of an increase in carryover loss allowances.

3. Identification Strategy and Main Results

We are interested in identifying the effect of changes in the capital gains tax at the VC firm-level on changes in start-ups' innovation. Following the methodology of Heider and Ljungqvist (2015), we use a difference-in-differences (DID) specification which controls for time-varying firm-specific omitted variables as well as time-varying industry trends and nationwide shocks.

We estimate the following OLS specification:

$$\begin{aligned} \Delta Y_{i,s,t+1} = & \beta_1 \cdot \Delta^- Tax\ rate_{s,t} + \beta_2 \cdot \Delta^+ Tax\ rate_{s,t} + \beta_3 \cdot \Delta^- Tax\ rate\ VC_{s,t} \\ & + \beta_4 \cdot \Delta^+ Tax\ rate\ VC_{s,t} + \beta_X \cdot \Delta X_{i,s,t} + \lambda_{j,t} + \epsilon_{i,s,t+1} \end{aligned} \quad (1)$$

where i , s , and t index firms, states, and years; Δ is the first-difference operator; $Y_{i,s,t+1}$ is a measure of innovative activity for firm i in state s one year after the current year, t ; Δ^-

Tax rate and Δ^+ *Tax rate* capture the decreases and increases in the capital gains tax rate in the headquarter state of the start-up respectively; Δ^- *Tax rate VC* and Δ^+ *Tax rate VC* capture the decreases and increases in the capital gains tax rate in the state of the VC firm respectively; $X_{i,s,t}$ are time-varying state- and firm-level controls; and $\lambda_{j,t}$ are industry-year fixed effects which remove unobserved time-varying industry shocks.

First-differencing removes unobserved firm-specific fixed effects from the corresponding levels equation, and can accommodate repeated treatments, treatment reversals, and asymmetry in the firms' response to tax changes (Heider and Ljungqvist (2015)). In our sample, 40 states experience repeated treatments, that is, a sequence of tax increases or tax cuts; 32 states experience tax reversals, that is, a tax increase followed by a tax cut or vice versa.

Equation 1 uses the variation in taxes across many states and years such that for any change in the capital gains tax in state s in year t , the potential control firms are those headquartered in states that did not change their tax in the same year. In fact, most states in the US either have an increase or a decrease in the capital gains tax rate or both.¹⁸ Therefore, most firms in our sample are both in the treated and control groups at different points in time. The inclusion of the tax changes for both the start-ups and the VC firms in the same specification partials out any common changes due to the start-up and the VC firm being located in the same state while identifying the separate, incremental effect of tax changes coming from observations in which the start-up and the VC firm are located in different states. In our sample, 62.11% of our observations are those in which the VC firm and the start-up are located in different states.

This specification controls for time-varying factors at the state level that may be correlated with state taxes and firm innovation. These factors are the GDP, per capita income, and unemployment rate of the state. We also use firm age as a control that studies have found to covary with innovation policy. We add industry-year fixed effects to compare treated and control firms within the same industry at the same time. Since our tax treatment is defined at the state level, we cluster standard errors by state (Bertrand and Mullainathan (2003) and Bertrand, Duflo, Mullainathan (2004)). As we show in Table 7, clustering at the year, industry, or firm level does not change our conclusions.

We first present large scale evidence from all firms over the period from 1992 to 2014 and all tax changes. However, we recognize two potential concerns with such an analysis. The first concern is that changes in the capital gains tax at the state level are small in magnitude and may not be very salient. The average tax increase in our sample is 69 basis points, and

¹⁸Figure 2 shows that at least 30 states implemented either a tax increase or a tax decrease or both. During the sample period, there are only 12 states which did not experience any change in their capital gains tax rate. More details are provided in Table A.1 of Appendix A.

the average tax decrease is 41 basis points. To address this concern, we use two approaches. For the first approach, we use an alternative specification:

$$\Delta Y_{i,s,t+1} = \beta_1 \cdot \Delta \text{Ln}(1 - \tau) + \beta_2 \cdot \Delta \text{Ln}(1 - VC\tau) + \beta_X \cdot \Delta X_{i,s,t} + \lambda_{j,t} + \epsilon_{i,s,t+1} \quad (2)$$

where $(1 - \tau) = 1 - \tau^{fed} - \tau^{st}$ in which τ^{fed} is the federal capital gains tax rate, and τ^{st} is the capital gains tax rate in the state where the start-up is located; $(1 - VC\tau) = 1 - \tau^{fed} - \tau^{state}$ in which τ^{state} is the capital gains tax rate in the state of the lead VC firm. Using the combined federal and state taxes directly addresses the concern on the magnitudes of the tax changes. This method has two additional advantages. This specification yields stable coefficients that allows us to interpret the results as elasticities (Agersnap and Zidar (2020), Gravelle (2020)).

For our second approach, we focus on large changes in state capital gains taxes, that is, changes which are more than one percentage point (Agersnap and Zidar (2020)). This approach also helps address the issue of the economic magnitude of our main effect.

The second concern is related to the exclusion restriction. A key threat to our identification is that the tax-innovation relationship can work through channels other than the actions of VC firms and entrepreneurs. Although we cannot entirely rule out such general equilibrium effects, we address this concern in two ways. To account for contemporaneous changes in other “business-friendly” policies, we add state-level control variables to all of our specifications. We recognize that a change in capital gains taxes in the state can affect not only the supply and demand of capital among start-up firms, but also the supply and demand for capital among publicly listed firms (Feldstein et al. (1980), Holt and Shelton (1961)). We conduct a direct test for this alternative mechanism to address the concern.

3.1. Large Sample Evidence

Using the headquarters state of the VC firm and the state of the start-up firm, we estimate our main OLS specification related to the VC channel and the entrepreneur channel simultaneously. The results are reported in Table 3.

INSERT Table 3 ABOUT HERE

3.1.1. VC Channel

The dependent variable in Panel A of Table 3 is $\Delta \text{LnPat}_{t+1}$. To begin our analysis, we include all firms that own and do not own patents. Column (1) shows the result for the main specification (as in Equation 1). The coefficient for $\Delta^+ \text{Tax rate VC}$ is negative and

statistically significant at the 1% level. This result indicates that VC firm-level taxes have an effect on patenting. In column (2), we limit our sample to only firms with patents. In this specification we exclude all control variables and fixed effects. The coefficient of interest is larger in magnitude and statistically significant at the 1% level. This result indicates that the effect of the capital gains tax on innovation is very likely driven by firms which have a propensity to patent. We limit ourselves to this sample for all further specifications.¹⁹

In column (3), we include all state- and firm-level controls. In column (4) we add industry-year fixed effects. Neither the magnitude nor the significance of the coefficient of interest changes compared to that in the specification in column (2).

As a final test, we focus on tax changes that are larger in magnitude than one percentage point. In column (5) we use the variable(s) *Tax decrease VC high* (*Tax increase VC high*) if the tax decrease (increase) for the VC firm is larger in magnitude than one percentage point and zero otherwise. The result shows that the coefficient for *Tax increase VC high* is negative and significant that confirms that our result is driven by large tax increases for VC firms. Put together, these results show that an increase in the capital gains tax for VC firms has a negative effect on the level of innovation. In terms of economic significance, our estimates indicate that in the first year following a tax increase (which raises capital gains taxes by around 0.685 percentage points), approximately 31% of the innovative treated firms file for one less successful innovation project.²⁰

The magnitude of the effect of changes in the capital gains tax compares well with the effect of changes in the corporate income tax on public firms. Mukherjee et al. (2017) show that 37% of treated firms patent one fewer innovation project in the second year after the year of the tax increase. While Atanassov and Liu (2020) find that a significant decrease in corporate income tax rate leads to a 9.7% increase in the number of patents in the third year after the year of the tax change.

The negative and significant coefficient for Δ^- *Tax rate VC* in columns (2) and (3) of Table 3 can seem surprising, as it indicates that a tax decrease leads to a reduction in innovation. This result is not robust: the coefficient for Δ^- *Tax rate VC* becomes insignificant in column (4), when we add industry-year fixed effects. Figure 3 of subsection 3.3 shows the dynamics around the tax changes for VC firms. They show that in the years after a tax decrease for VC firms, there are no coefficients that are significantly different from zero. Put together, these findings show that the effect of decreases in the tax rates of VC firms is not

¹⁹Additional results for the full sample of firms are reported in Table A.2 of Appendix A.

²⁰A sample average tax hike of 0.685 percentage points leads to a 0.89% (coefficient in column (4) of Table 3, -0.013 times 0.685) decline in the number of patents. Relative to an average of 35.01 patents per firm-year, this is a reduction of 0.312 (-0.0089 times 35.01) patents.

statistically significant. Further, in Table 4, we use an alternative to our main specification which estimates the symmetric effect of tax changes on innovation and provide additional evidence in support of our main finding that tax increases for VC firms reduce innovation.

Nevertheless, the effect of tax changes for VC firms on innovation is asymmetric, as VC firms react to tax increases but not to tax decreases. A potential explanation for this result is the related asymmetry in stopping innovative projects compared to completing effective ones. It takes less time to stop existing innovative projects after a tax increase, than to build new innovative capacity after a tax cut.²¹

The coefficients for the control variables agree with the literature. The effect of the corporate tax rate is consistently negative. Entrepreneurial firms could be influenced by corporate tax rates if they decide to incorporate, or in a more indirect way by competition (for capital) from public firms. We also find that changes in the R&D tax credit and firm age have a positive effect on innovation.

INSERT Table 4 ABOUT HERE

In Panel A of Table 4, we use the natural logarithm of the number of patents as the dependent variable. This variable definition addresses issues of robustness related to the form of our main dependent variables. In addition, it helps us report elasticities and compare these to the literature.

To enable a comparison between the VC channel and the entrepreneur channel, we add both tax rates as independent variables. We add one-year and two-year leads and lags of the start-up's state and the VC firm's state net-of-tax rates to account for other changes in tax policies (Agersnap and Zidar (2020), Zidar(2019)). Column (1) of Panel A shows the results. The coefficient for the net-of-tax rate at the VC firm-level, $Ln(1 - VC\tau)$ is positive and significant. The positive coefficient means that increases in taxes for the VC firm have a significant and negative effect on patents. A linear restriction F-test for the equality of coefficients for the tax rate of the start-up and that of the VC firm are rejected at the 5% level. In column (2), we add time-varying state- and firm-level control variables. The coefficient for net-of-tax rate at the VC firm-level is positive, although not significant. However, in column (3), when we add industry-year fixed effects, the coefficient of interest is significant at the 1% level. This result shows that there is likely a large variation in the propensity to patent across industries. We are able to identify the effect of capital gains taxes

²¹As Mukherjee et al. (2017) show, firms are quick to lose their innovative personnel following tax increases, but they need more time to build the knowledge workforce following tax cuts.

only after accounting for this variation by adding industry-year fixed effects. The elasticity of patents with respect to the VC firm’s capital gains tax ranges from -0.45 to -0.75.²² The F-test for the equality of coefficients for the start-up’s tax rate and that of the VC firm are rejected at the 5% level. This result provides evidence that the capital gains tax for VC firms has a larger effect on patenting than that for start-ups.

We argue that our elasticity estimates are in the right ballpark. The elasticity of patents with respect to the capital gains tax at the firm level (-0.45 to -0.75) is lower than the elasticity of patents to the personal income tax at the state level (-2 to -3.4) (Akcigit et al. (2019)). We predict that the effect of the capital gains tax will be small because this effect will likely work through the channel of GPs’ actions, and not through LPs’ actions. Also, given the different level of aggregation, we feel our estimates compare well with the literature. The elasticity of patents to the capital gains tax at the firm level is comparable to the elasticity of patents to the personal income tax at the individual level (-0.6 to -0.7) (Akcigit et al. (2019)). To summarize, the elasticity of patents to the capital gains tax of VC firms is significantly negative and lower than the elasticity with respect to the personal income tax.

In column (4), we interact the net-of-tax rates with indicator variables for tax changes at the state level which are larger than one percentage point, and an indicator for small tax changes. The coefficient of the interaction between the tax change for VC firms and the large tax change indicator is positive and significant at the 1% level. The F-test, in this case, is for the equality of the coefficients for that interaction and the interaction between the start-up’s tax rate and large tax changes. The F-test rejects the null at the 10% level. This result provides evidence that the effect of capital gains taxes on innovation is likely driven by large changes in those taxes.

Our results provide evidence that capital gains taxes affect the level of innovation of start-ups through the actions of VC firms. The increase in capital gains taxes can affect the incentives of VC partners: VC firms are likely to become less willing to support, advise, and invest in start-ups after a tax increase. Most VC partners are tax-exempt in the US which makes it unlikely that they will respond to changes in capital gains taxes (Poterba (1989a)).²³ GPs, however, are subject to the capital gains tax; our results show that the

²²The coefficient for $\ln(1 - VC\tau)$ measures the elasticity of patents with respect to the net-of-tax rate. In column (3) of Table 4, this coefficient is 2.653. We multiply this coefficient by $\frac{-0.22}{1-0.22}$ to obtain the elasticity of patents with respect to the combined capital gains tax rate. We use a combined capital gains tax rate of 22% to make our results comparable to other studies (Gravelle (2020), Agersnap and Zidar (2020)).

²³Furthermore, some tax-exempt partners may face corporate income taxes. While tax-exempt partners are not taxed on their share of a fund’s capital gains, they are subject to US federal and state income taxes on their “unrelated business taxable income” (UBTI). UBTI is the gross income of US tax-exempt investors

involvement and support of GPs can be an important channel through which that tax on VC firms affects innovation.

3.1.2. Entrepreneur Channel

In this subsection, we address the entrepreneur channel and discuss the coefficients for the variables $\Delta^- \text{ Tax rate}$ and $\Delta^+ \text{ Tax rate}$. Column (1) in Panel A of Table 3 shows the result for the main specification for all firms (as in Equation 1). The coefficient for $\Delta^- \text{ Tax rate}$ is positive while the coefficient for $\Delta^+ \text{ Tax rate}$ is negative, and both are statistically significant at the 5% level. These results indicate that the taxes have an effect on patenting. In column (2), we focus on the sample of firms which have at least one patent. We find that both coefficients of interest are larger in magnitude but only one is statistically significant: the coefficient for $\Delta^- \text{ Tax rate}$. In column (3), we control for state-level variables, and in column (4), we add industry-year fixed effects. In all these specifications, the coefficient for $\Delta^- \text{ Tax rate}$ is positive and significant at least at the 5% level.

As a final test, we use only tax changes which are larger in magnitude than one percentage point. This specification is driven by the observation that changes in state taxes are small in magnitude but frequent. In column (5), we use the variable *Tax decrease high* (*Tax increase high*) which equals the state-level tax decrease (increase) if its decrease (increase) is larger in magnitude than one percentage point and zero otherwise. The result shows that the coefficient for *Tax decrease high* is positive and significant that confirms that our result is driven by large capital gains tax cuts.

In Panel A of Table 4, we report the results from our alternative specification. The coefficient for the net-of-tax rate at the start-up level, $\text{Ln}(1 - \tau)$ is negative and significant in column (1). This result is not robust. In column (2), we add control variables, and in column (3) we add industry-year fixed effects. In both of these specifications, the coefficient for the net-of-tax rate for start-ups is not statistically significant. These results show that within our sample of VC-backed start-ups, the start-ups' tax does not affect innovation.

The results so far suggest an asymmetry in the responses of VC firms and entrepreneurs. Panel A of Table 3 shows that the decreases in taxes matter for entrepreneurs, while tax

that is derived from commercial activities unrelated to their tax-exempt purpose. The most obvious way in which a US tax-exempt partner in a VC firm can incur the UBTI is when the firm invests in a portfolio firm that has been incorporated as a pass-through entity (a partnership or LLC) as the income earned by such a portfolio firm is characterized as income from an active business. Start-ups are often organized as pass-through entities; however, VC firms often require the start-ups to convert to a corporation prior to the investment (Allen et al. (2018)). This way tax-exempt partners are protected from incurring the UBTI but the new corporation would be subject to normal corporate income taxes. Therefore, a tax-exempt partner either has to pay tax on the UBTI if the start-up is a pass-through entity or be subject to a corporate tax on its share in a start-up if the start-up is a C-corporation.

increases matter for VC firms. A potential reason for this asymmetry is the capital structure of VC-backed US start-ups. Most VC firms invest in portfolio firms through convertible preferred stock, while the compensation for entrepreneurs is usually in the form of common stock and options (Gilson and Schizer (2003), Schmidt (2003), Kaplan and Stromberg (2003)).²⁴ Therefore, while VC firms are more likely to take action in terms of innovation policies in bad states of the world (when capital gains taxes increase), the opposite is true for entrepreneurs (when capital gains taxes decrease).

Panel A of Table 4 shows that the capital gains tax matters less for entrepreneurs than for VC firms. A potential reason is the ability of entrepreneurs to delay or defer capital gains. GPs may not be able to defer the realization of capital gains due to the limited lifespan of VC firms. So we expect VC firms to react more to changes in the capital gains tax than entrepreneurs.

3.2. Heterogeneity, Quality, and Dispersion of Innovation

To establish whether our result is indeed due to changes in capital gains taxes, we evaluate the heterogeneity of the result across young and older firms. Capital gains taxes may not be a primary consideration for founders of early-stage firms, given that they do not expect to sell their stake in the firms in the near future. Taxes may become more important for older start-ups, as they approach a potential sale.²⁵

In column (1) of Panel B in Table 3, we use a modified definition of the dependent variable *LnPat* to estimate the effect on patents of “young” start-ups. The variable, *LnPatYoung* is the natural logarithm of (1 + the number of newly granted patents filed by the firm) if the start-up firm was founded within the last three years. Analogously in column (2) of Panel B in Table 3, we use a modified definition of the dependent variable *LnPat* to estimate the effect on patents of “old” start-ups. The variable, *LnPatOld* is the natural logarithm of (1 + the number of newly granted patents filed by the firm) if the start-up firm was founded more than three years before the current year. In column (1), we report that the coefficients of interest are not statistically significant. In column (2), we report the results for patents of older start-ups. We find that the coefficients for both $\Delta^+ \text{Tax rate}$ and $\Delta^+ \text{Tax rate VC}$ are negative and statistically significant.

²⁴This compensation structure means that the fraction of total cash flows that goes to entrepreneurs increases with the performance of the firm. While VC firms get all of the cash flows in the bad state, a fixed debt payment (or dividend) in the medium state, and a constant fraction of the cash flows in the good state.

²⁵Recent survey of US entrepreneurs finds that, in contrast to younger firms, firms older than four years list high taxes on capital gains and limited tax deductibility of business losses as key factors that discourage entrepreneurship (Thawani (2019)). The same survey shows that a few years after creation firms are less concerned with taxes.

In column (1) of Panel B in Table 4, we use a modified definition of the dependent variable $Ln(Patents)$ to estimate the effect on patents of young start-ups. The variable $Ln(PYoung)$ is the natural logarithm of the number of patents if the start-up firm was founded within the last three years. Analogously, in column (2) of Panel B in Table 4, we also define a variable $Ln(POld)$ as the natural logarithm of the number of patents if the start-up firm was founded more than three years before the current year. We report that the coefficient for net-of-tax rate at the VC firm-level in column (2) is positive and significant. Consistent with surveys, the negative effect of the capital gains tax on innovation is driven primarily by older, private firms. These results also indicate that our tests capture the effect of the capital gains tax on innovation rather than the effect of the personal income tax. In subsection 3.5, we provide further evidence in support of the relevance of the capital gains tax for our setting.

In columns (3) and (4) of Panel B in Table 3, we test our main specification using measures of innovation quality, $\Delta CwPat_{t+1}$ and ΔCit_{t+1} , as the dependent variables. The coefficient for $\Delta^- Tax\ rate$ is positive and statistically significant in each of the two columns that indicates a decrease in the capital gains tax in the start-up's state has a positive effect on the quality of innovation. An increase in the tax in the VC firm's state, $\Delta^+ Tax\ rate\ VC$, has a negative effect on the quality of innovation. In column (5), we use the indicator variable, $Inventor$, that equals one if the start-up has at least one newly granted patent as the dependent variable. The coefficient for $\Delta^+ Tax\ rate$ is negative and significant. This result indicates that an increase in the tax in the start-up's state has a negative effect on the dispersion of innovation that leads to fewer innovative firms.

In Panel B of Table 4, we use the natural logarithm of cite-weighted patents and citations as dependent variables. The results are reported in columns (3) and (4). The coefficient of interest is positive and statistically significant in each of the two columns that indicates an increase in the VC firm's state tax has a negative effect on the quality of innovation. In column (5), we use the indicator variable, $Inventor$, that equals one if the start-up has at least one newly granted patent as the dependent variable. The coefficient of interest is positive but not statistically significant.

3.3. Reverse Causality, Delayed Reactions, and Pre-trends Concerns

Changes in capital gains tax rates are usually exogenous to the innovation of firms. Nevertheless, a concern remains that tax changes are endogenous to the future patenting (and investment) opportunity in the state.

We investigate the dynamics around tax changes to ensure that there are no pre-trends

in the data which could invalidate our results. We estimate the following OLS specification:

$$\Delta Y_{i,s,t} = \sum_{k=-3}^3 \beta_k \cdot Rate(k) + \beta_X \cdot \Delta X_{i,s,t} + \lambda_{j,t} + \epsilon_{i,s,t}, \quad (3)$$

The specification is similar to Equation 1 except that the variable $\Delta^- Tax rate VC$ ($\Delta^+ Tax rate VC$) is replaced by a series of variables $Rate(k)$ that is a variable which equals $\Delta^- Tax rate VC$ ($\Delta^+ Tax rate VC$) exactly k years from the year of the decrease (increase) in the capital gains tax for the VC firm. We add the tax changes for start-ups to the set of control variables, $X_{i,s,t}$.

INSERT Figure 3 ABOUT HERE

In the top panel of Figure 3, we plot the effect of tax decreases for VC firms on changes in the number of eventually successful patent applications which a start-up files, or $LnPat_{i,s,t}$. The coefficients represent the difference in innovation between the treated and control firms averaged by event time and the 5% confidence interval around this difference. First, the figure shows that there are no discernible pre-trends in innovation - the difference in innovation between the treated and control groups is statistically insignificant in the three years prior to the tax decrease. In addition, there are no coefficients in the years around the tax change which are significantly different from zero. In the bottom panel of Figure 3, we plot the effect of tax increases on VC firms. In this figure, we find a similar lack of pre-trends in innovation as in the previous figure. The coefficient in the year before the tax increase is positive. However, the lack of significance in other coefficients before the event year indicates that there is no trend in patenting before the event. In the first year after the tax increase, there is a significant and negative effect on the innovation of the treated firms. The negative effect continues in the second and third years after the tax increase.

We use an alternative specification to investigate the dynamics around tax changes. Thus, we estimate the following OLS specification:

$$\Delta Y_{i,s,t} = \sum_{h=-3}^3 \beta_h \cdot \Delta Ln(1 - VC\tau_{s,t-h}) + \beta_X \cdot \Delta X_{i,s,t} + \lambda_{j,t} + \epsilon_{i,s,t}, \quad (4)$$

The specification is similar to Equation 2 except that the variable $\Delta Ln(1 - VC\tau)$ is replaced by a series of variables $\Delta Ln(1 - VC\tau_{s,t-h})$, where $VC\tau_{s,t-h}$ is a variable which equals the combined federal and state capital gains tax rates for VC firms exactly h years

from the current year. We add the tax changes for start-ups to the set of control variables, $X_{i,s,t}$.

INSERT Figure 4 ABOUT HERE

In the top panel of Figure 4, we plot the effect of tax changes for VC firms on the changes in the number of eventually successful patent applications which a start-up files, or $\text{Ln}(\text{Patents})$. The coefficients represent the difference in innovation between the treated and control firms averaged by event time and the 5% confidence interval around this difference. First, the figure shows that there are no discernible pre-trends in innovation. The response to the tax change is the largest in the first year after the tax change. In the second and third years, we see positive coefficients although these are not statistically significant at the 5% level. In the bottom panel of Figure 4, we plot the effect of large tax changes for VC firms. We replace each variable $\Delta \text{Ln}(1 - VC\tau_{s,t-h})$ with two variables; the first is an interaction of the variable with an indicator for a large tax change, and the second is an interaction of the variable with an indicator for a small tax change. A large tax change is defined as a change in the VC firm's state tax of more than one percentage point. In this figure, we plot the coefficients for the interaction of the net-of-tax rates and the indicator for large tax changes. We find a similar lack of pre-trends in innovation as in the previous figure. In the first year after the tax change for VC firms, there is a significant and negative effect on innovation. The positive and statistically significant coefficient indicates a negative effect on patenting. The negative effect continues in the third year after the tax change.

The response to the tax change occurs in the first year after the change. This response is curious given the fact that changes in innovative activities, as a result of changing tax incentives, are likely to be reflected in patent applications two or three years in the future.²⁶ This immediate response can occur due to our first-difference specification which measures a change in the growth rate of patents as opposed to a change in the level of patenting.

A first-difference specification is more likely to find a treatment effect when the treatment is small and frequent (Meer and West (2015)). This type of regression specification can identify a change in the *growth rate* of the dependent variable. In our case, we find a negative effect on the growth rate of patents with increases in VC firms' capital gains taxes. We argue that although the level of patenting may not change immediately, there is an immediate effect on the growth rate of patents which shows up in the first year after a

²⁶Hall et al. (2001) show that the average patent and investment lag is two years for US firms.

tax treatment. Other studies have shown an immediate effect on patents (Mukherjee et al. (2017), Chu et al. (2019)). On this aspect, our results agree with the literature.

3.4. Other Robustness Tests

3.4.1. Differential Taxation in States of VC firms

A VC firm is a flow-through entity for US federal income taxation purposes that is codified as Subchapter K of Chapter 1 in the US Internal Revenue Code. As such, the entity pays no income tax itself, instead, its partners are allocated distributive shares of the firm’s income, expense, gain, loss, or credit (Code Section 701; Reg. § 1.701-1). The partners then report that income on their individual or corporate income tax returns and pay taxes. In general, state income tax statutes largely conform to the federal tax classification of entities. Thus, for example, an LLC VC firm that is classified federally as a partnership is likewise classified for state income tax purposes as a partnership rather than as a corporation or some other form of entity (Lee, Ely and Rimkunas (2010)).

The pass-through nature of VC firms potentially separates the in-state business from out-of-state taxpayer-partners. An individual partner in a partnership earning income from *operations* in various states generally is required to file income tax returns in each of those states and report the pro rata share of the income derived from that state (Lee, Ely and Rimkunas (2010)). However, the Internal Revenue Service (IRS) views most VC firms as being engaged in “*investing*” activities and not engaged in “*operations*” such as trade or business (Kuusisto (2008)). As a result, VC partners’ income, which consists of interest, dividends, and gains from the sale or exchange of qualifying investment securities that is distributed to the nonresident partners, is taxed in the partners’ state of residence rather than the state where the income was created (Bergmann and Gray (2019)).

We are able to find information related to VC firm taxation rules for the top 20 states in our sample, which account for 96% of the start-ups in the sample. Table 5 presents the details.

INSERT Table 5 ABOUT HERE

States fall into three groups related to VC firm taxation: (1) states which effectively exempt out-of-state investment partnerships, such as VC firms, from state taxes on their in-state created income; (2) states which do not exempt out-of-state investment partnerships from taxes on their in-state created income; and (3) states which do not levy taxes on income, and therefore nonresident VC partners are exempt from state taxes.

Among the top 20 states in our sample, Colorado, Michigan, Missouri, Pennsylvania, and Illinois before the year 2005, as well as the District of Columbia did not apply exemptions for nonresident partners of investment partnerships. These states belong to group (2) as defined above.

Our original identification strategy relies on the assumption that a VC partner is taxed based on their state of residence. Our assumption does not apply to states in group (2). We address this issue with two separate specifications.

We exclude firm-year observations when the start-up is located in one of the four states in group (2) and the District of Columbia; but if the start-up is located in Illinois, we exclude firm-years before 2005. In a separate specification, we change the tax variable for VC firms in the five aforementioned states and the District of Columbia to be equal to the tax variable for start-ups: $\text{Ln}(1 - VC\tau \text{ corr.})$. For example, for a start-up located in Pennsylvania that is backed by an out-of-state VC firm, we use the Pennsylvania tax rate as the relevant one for the VC firm. Table 6 shows these new updated results.

INSERT Table 6 ABOUT HERE

In column (1) of Table 6, we include all states except those in group 2. We add, but do not report, the entire list of control variables as in our main specification. The results show that even after excluding states which tax investing activities of out-of-state VC firms, our main result continues to stand. An increase in taxes for VC firms leads to a decrease in patents which is significant at the 1% level. In column (2), we replace the VC firm tax variables with the corrected VC firm tax variables, that is, $\Delta^- \text{Tax rate VC corr.}$ and $\Delta^+ \text{Tax rate VC corr.}$. In this specification, we see a very similar result. We repeat these specifications and limit our sample to the top 20 states. Columns (3) and (4) give the results. Within this limited sample, for which we have a degree of confidence around VC taxation, we find that our main result holds true. An increase in taxes for VC firms has a negative effect on patents that is significant at the 5% level.

In columns (5) to (8), we use our alternative specification of $\text{Ln}(\text{Patents})$ as our dependent variable and $\Delta \text{Ln}(1 - \tau)$ and $\Delta \text{Ln}(1 - VC\tau)$ as our main independent variables. We repeat each of the tests, as specified in the earlier paragraph. In all of the specifications, we find support for our main result.

3.4.2. Different Subsample Analyses

We conduct a series of additional tests to check if our results are robust to different clustering, additional control variables, and subsample analysis.

INSERT Table 7 ABOUT HERE

Panel A of Table 7 shows the robustness results for patents as the dependent variable, while Panel B shows those for cite-weighted patents. First, we cluster the standard errors by year, industry, and firm. Next, we add firm fixed effects to soak up the firm-specific time-invariant variations in the growth rate of patents. Next, we exclude firms which change the location of their headquarters, as including them may overstate the effect of tax changes on innovation (the reduction in firm innovation after a tax increase may be due to innovative firms relocating to states with lower tax rates).²⁷ Further, we exclude firms located in the states of California and Massachusetts to address the concern that our results are driven entirely by these two clusters of innovative firms.

Next, we address the concern that investment-patent lags are around two or more years long which means that the effect of tax changes on patenting is likely to show up in the second and later years after tax changes (Hall et al. (2001)).²⁸ Focusing only on industries with short investment-patent lags, we find that the coefficient for $\Delta^+ \text{Tax rate VC}$ is negative and significant. This result indicates that our findings are largely driven by start-ups with short investment-patent lags. Next, we exclude states with no tax changes from the sample. Then, we add updated R&D tax credits (Lucking (2019)) for the entire time period from 1992 to 2014 to our specification.

INSERT Table 8 ABOUT HERE

In Table 8, we re-estimate our main analysis by adding control variables. *HHI* controls for industry competition using the Herfindahl-Hirschman index, while *HHI*² accounts for non-linearities in the competition-innovation relationship (Aghion et al. (2005)). Consistent with the research, we find that competition has a negative effect on innovation (Atanassov and Liu (2020)).

We also control for potential confounding variables: the Bonus Depreciation Tax (BDT) policy and the Domestic Production Activities Deduction (DPAD) scheme. These tax incentive policies both affect firm-level investment (Zwick and Mahon (2017), Ohrn (2018)). Given

²⁷In Table A.3 of Appendix A, we also test if changes in the capital gains taxes lead to changes in the number of firms in a given state. If innovative firms are relocating to states with lower tax rates, this move would lead to relatively less innovation in their home state but that would be due to an increase in the level of innovation in the controlling states (those that have not changed the tax rate) rather than due to a decrease in innovation in their home state. We find no significant changes in the number of firms in a given state a year after the tax change.

²⁸We exclude start-ups in industries with investment-patent lags of more than one year, that is, the industries of Chemical, Health, Medical, and Drugs (Brav et al. (2018)).

the importance of firm investment for innovation, we consider the effect of those policies by adding two control variables, *BDT* and *DPAD*, to our main specification.²⁹ Our findings are robust to those additional control variables. In additional robustness tests reported in Table A.4 of Appendix A, we also show that our results are not significantly affected by truncation bias, time trends, and technological class trends.

3.4.3. Potential Confound: Local Economic Conditions

In this subsection, we report additional tests to confirm the causality of the observed correlations between start-up tax changes and firm innovation. We address two key concerns. First, some omitted factor may drive both the state-level changes in taxes and changes in innovation for start-ups. Second, the state tax changes may occur simultaneously with some other policy change by the state that is in fact responsible for the change in innovation.

To address the first issue, we study tax changes in neighbouring states (Heider and Ljungqvist (2015)). If some unobservable economic conditions in the state drive tax changes and innovation other than those for which we already control (state growth and unemployment rates), then these economic conditions should have a similar effect on start-ups that are located on either side of a neighbouring border. Therefore, we should not find any difference between start-ups in treated states and their neighbours in untreated states just across the state border. Table A.5 in Appendix A presents the results. We find no evidence that the innovation of start-ups reacts to tax changes in neighbouring states.

One concern with the previous test is that start-ups in adjacent states may not necessarily share the same economic conditions, especially if they are located at opposite ends of two large states. We address the issue by focusing on those headquartered in contiguous counties on either side of a state border (Heider and Ljungqvist (2015)).³⁰ Table A.5 in Appendix A gives the results. The results show that relative to control firms in contiguous counties in a neighboring state, treated firms increase (decrease) innovation by an average of 7.6% (12.5%) when their home state lowers (increases) its capital gains tax rates.

²⁹The *BDT* variable is the present discounted value of one dollar of deductions for eligible investment in a given industry for a given year that is obtained from Zwick and Mahon (2017). The *DPAD* variable, which captures the percentage deduction of “Qualified Production Activities Income” (QPAI) (calculated as revenues from the sales of domestically produced goods less the cost of goods sold attributable to domestic production and other expenses related to domestic production including financing costs in a given industry for a given year) is obtained from Ohrn (2018).

³⁰This test assumes that firms in a narrow interval around the state border experience similar local economic conditions (parallel trends absent the tax shock) but are subject to different tax treatments. We limit our sample to 271 county-pair/year clusters in which for each county that experiences a tax change in year t , we match a contiguous county that is not affected by a tax change. We identify a start-up’s county based on its zip code, and use Census data to identify adjacent counties and their zip codes: https://www2.census.gov/geo/docs/reference/county_adjacency.txt.

Next, we add within-state control firms that are headquartered in the treated states but are not affected, or differently affected, by the tax change. We use firms located in an empowerment zone (EZ) as a control sample to firms located in the same treated state, but outside such a zone. The EZ program, which is one of the largest standardized federal interventions in impoverished American neighborhoods, was introduced in 1994 and had a mandate to revitalize distressed urban communities. One of the fiscal benefits introduced by the EZ program was the partial reduction, or a complete exemption, in the treatment of capital gains realized from the sale of EZ assets.³¹ Given that start-ups located in EZs were given partial exemption on paying capital gains taxes, we expect them to be less affected by changes in capital gains tax rates. Table A.6 of Appendix A presents the results. We find that the negative effect of a tax increase on a start-up’s innovation is less pronounced for those located in the same state but in an EZ. These results confirm our hypothesis that start-ups located in EZs react less to changes in the tax rates.

3.5. Capital Gains Tax versus Personal Income Tax

Following the 1987 tax reform, changes in the capital gains tax rates for the majority of US states coincided with changes in the statutory personal income tax rates. This parallel raises the question of whether our results could be driven by personal income taxes. In this subsection, we provide additional evidence and tests that indicate that for VCs, capital gains taxes are likely to be of primary importance. While both personal income taxes and capital gains taxes are likely to matter to entrepreneurs.

The effect of personal income taxes on innovation is less relevant to VC firms for two key reasons. First, the identification of the VC channel in our set-up is driven by start-ups not in the same state as the VC firm. Therefore, channels which can lead to lower innovation through income taxes in the VC firm’s state are unlikely to explain the change in innovation in the start-up’s state.³² Second, the majority of compensation of the GPs of VC firms is carried interest received on the sale of assets, and it is subject to capital gains tax rate rather than the personal income tax rate.

At the entrepreneurial level, personal income taxes and capital gains taxes should be important determinants of innovation. The research has shown the effect of personal income taxes on entrepreneurs’ and firms’ actions. Moretti and Wilson (2017) have shown that star scientists move out of states when personal income taxes change, which can potentially

³¹We obtain the list of EZ regions and the year they were first approved to participate in the EZ program from Busso and Kline (2007).

³²Potential channels are loss of star scientists (Moretti and Wilson (2017)) and firms hiring fewer highly skilled workers (Campello et al. (2019)).

explain the change in innovation. Further, the research has shown that when income tax rates become more progressive, that is, the convexity of the tax rate increases, the entry of new entrepreneurs decreases. This decrease can also explain the decline in innovation growth (Gentry and Hubbard (2000)). First, we test these hypotheses in our setting. Using data from Moretti and Wilson (2017) in our specification, we analyse changes in the number of star scientists after tax changes. We also test whether changes in capital gains taxes affect the number of entrepreneurial firms. We find no evidence in favor of these hypotheses.³³ In summary, our results show that capital gains taxes are an important determinant of innovation, especially innovation by VC-backed start-ups.

In addition, the related literature shows that certain aspects of the US tax code enable VC-backed entrepreneurs to shield their compensation from personal income taxes and defer taxes until they can realize capital gains on sales. Due to unavailability of compensation data, we are unable to directly test these theories. Yet, given their relevance for our set-up, it is worth elaborating on them.

Founders of VC-backed start-ups usually use two classes of stock to capitalize the firm: common and preferred stock. Founders take the low-value common stock in exchange for their efforts, and VC firms take the preferred stock (Fleischer (2011)). The liquidation preference of the preferred stock creates a valuation wedge that permits founders to report a low valuation on their common stock.³⁴ In addition, founders are able to accelerate their recognition of the ordinary income on the stock, even if their ownership is subject to vesting or other restrictions because of electing section 83(b).³⁵ As a result, VC-backed entrepreneurs can shield incentive compensation from the ordinary income rate, defer taxes (until the incentive compensation is sold, or longer), and then pay the capital gains tax rate (Gilson and Schizer (2003)).

³³The results from both tests are reported in Table A.3 of Appendix A.

³⁴On the one hand, the liquidation preference of the preferred stock protects the VC firm's investment in the start-up if things go badly, by giving it all the cash flow rights in the bad state of the world. On the other hand, it reduces the tax bill to founders by allowing them to claim a much lower valuation of their common stock given that in a hypothetical immediate liquidation, the preferred VC stockholders will obtain almost everything.

³⁵Under section 83, enacted in the 1969 amendment to the US tax code, executives of most firms pay tax at ordinary income rates when they receive stock awards; they pay capital gains tax (or recognize capital losses) only on later changes in the stock price. But section 83 also contains an election - the section 83(b) election - which allows executives to accelerate their recognition of ordinary income on restricted stock to the time of the award.

4. Mechanisms

The evidence presented so far demonstrates that firms react to changes in the capital gains taxes for VC firms by changing their patent production. The literature has shown that VC firms provide continuing support and capital to innovative start-up firms. These are the two potential channels through which VC firms' actions can affect the innovative output of firms. We offer evidence for VC support, and evidence related to the investments and the number of start-ups written off by VC firms as well as the size of their portfolios.

4.1. Investments and Size of VC Portfolios

We present key predictions from a double moral hazard model that is applied specifically to the VC-start-up setting (Keushnigg (2004)). The double moral hazard model is set in a market environment, which is similar to that in Inderst and Mueller (2004), and Kueschnigg and Nielsen (2002), (2004). In broad strokes, the model works as follows: Entrepreneurs decide between setting up a start-up firm or working for a wage. The start-up requires investment for which the entrepreneur has to obtain financing from a VC firm. The VC firm provides capital for the investment. Both the entrepreneur and the VC firm provide effort to make the start-up successful. The effort by the entrepreneur is assumed to be critical for success (a similar assumption is used in Cassamatta (2003)). The VC firms choose the number of firms to hold in their portfolio, their shares in the profits of the start-ups, and the prices for those shares.

First, we describe the sequence of events in the model. Next, we focus on the two key predictions based on the model: VC firm's investment, and the size of the VC firm portfolio. First, the government sets tax policy. Then the VC firm decides on the number of firms in her portfolio. She proposes an offer to each entrepreneur to buy a stake in her firm at a price. The entrepreneur chooses between accepting the offer or not. Subject to an agreement, the VC firm and the entrepreneur simultaneously exert effort. Finally, nature rewards effort with success (or failure), and profits are shared, if the start-up is successful.

When the VC firm must pay a higher capital gains tax, the marginal benefit of advice shrinks, and thus, decreases the advice for any given equity share. When the VC firm advises less, the start-up is less likely to succeed which destroys the entrepreneur's return to effort. The entrepreneur then must be compensated with a higher share of the profits to ensure their high level of critical effort. A lower share of profits for the VC firm means that its investment is lower at the outset. So higher capital gains taxes can lead to lower investment by VC firms. This is the first testable, empirical prediction from the model. In the model, lower investment by the VC firm is the result of higher taxes for the VC firm and its lower effort in each start-up. We argue that lower investment leads to fewer innovation outcomes.

A second, related empirical prediction is the following: higher capital gains taxes lead to smaller portfolios. First consider a VC firm with an existing portfolio of start-ups. Adding one more start-up to the portfolio boosts the overall profit of the VC firm. This is similar to the effect of profit creation. When the VC firm expands its portfolio, it cuts back on effort (or advice) to each firm in its portfolio as the VC firm faces a progressively higher cost of effort. Therefore, the VC firm must give up a larger share of its profits to the entrepreneur to ensure critical effort by the entrepreneur. Furthermore, the VC firm must provide higher profit shares to all of its inframarginal firms as the additional advice to the marginal firm comes at the expense of all others in the portfolio. The need to share more generously with entrepreneurs subtracts from the VC firm’s own overall profits. This is the profit destruction effect (Keuschnigg (2004)).

As the capital gains tax increases, the VC firm advises less. This lower advising forces the VC firm to offer each entrepreneur a larger profit share. For a given number of start-ups in the VC firm’s portfolio, a decrease in its profit share decreases the profit creation effect and inflates the profit destruction effect. Consequently, the VC firm consolidates its portfolio. The VC firm reduces the size of its portfolio to neutralize the negative effect of the increase in the capital gains tax. In the model, the smaller portfolio size is the result of higher taxes for the VC firm and its lower effort for each start-up. We argue that investments in fewer firms by the VC lead to fewer innovation outcomes.

We evaluate the effect of changes in the capital gains tax on the size of VC investments and the number of new start-ups in the VC firm’s portfolio. We aggregate variables at the VC-year level. For each VC firm, we count the number of start-ups in which it invests, and the total amount of the investments in these start-ups in the current year. The VentureXpert dataset contains information on the total amount of each transaction, or the total amount invested by all parties in the start-up. As is the norm in the industry, several VC firms can invest simultaneously as a part of the deal. We assume that the total amount is invested, or influenced by, the lead VC firm. This assumption is in line with the literature which has shown that lead VCs are responsible for providing a large part of the capital and the significant effort towards the success of the start-up (Bernstein et al. (2016)).

INSERT Table 9 ABOUT HERE

Table 9, presents the results. Columns (1) and (2) show the effect of taxes on the level of investment of the lead VC firm in the first year after the current year, $\Delta \ln(Investment)$. The coefficient of the net-of-tax rate for the VC firm, $\Delta \ln(1 - VC\tau)$ is positive and significant at the 1% level. The positive coefficient indicates that the effect of an increase in the

capital gains tax has a significant and negative effect on the investments made by the VC firm. In column (2), we add the control variables. We find similar results. These results provide evidence in favor of the hypothesis of lower investment by the VC firm and indicate less effort in response to higher taxes. Columns (3) and (4) show the effect of changes in taxes on the size of the VC firm’s portfolio. The dependent variable is the natural logarithm of the number of investments in start-ups made by the VC firm in the first year after the current year, $\Delta \ln(Firms)$. Using similar regression specifications, we show that an increase in the capital gains tax for the VC firm leads to a decrease in the number of start-ups it invests in. In summary, we find evidence to support the hypothesis that VC firms reduce the amount of investment, and the size of their portfolios in response to increases in the capital gains tax.

4.2. VC Firms’ Support

To test the effect of the capital gains tax on a VC firm’s effort, we examine whether this tax affects the amount of innovation exchanges between the start-ups included in its portfolio. Gonzalez-Uribe (2020) shows that after start-ups are added to the VC firm’s portfolio, several proxies of exchanges between them and other, existing portfolio start-ups increase by an average of 60%. Our argument is the following: Innovation exchanges occur between the start-ups in the VC firm’s portfolio because the VC firm acts as an arbiter. Absent the VC firm or its arbitration efforts, such exchanges would not occur. As successful inventions are typically facilitated by such exchanges, we argue that an increase in the capital gains tax at the VC firm can result in fewer innovation exchanges that thereby, lead to fewer innovation outcomes for start-ups.

We focus on several proxies of innovation exchanges between start-ups within the same portfolio: citations given, citations received, patents bought, and patents sold. Citations given is the number of citations given by the start-up to the patents of other portfolio start-ups over time. Citations received is the number of citations received by the patents of the start-up from other portfolio start-ups over time. Patent re-assignments are transfers of intellectual property between patent assignees and third parties. Studies have used them as measures of the transfers of innovation ownership between firms (Akcigit et al. (2019), Galasso et al. (2016) among others). We focus on these re-assignments within the VC portfolio as in Gonzalez-Uribe (2020). Based on bulk download of the data from USPTO, we construct proxies for patents that are bought or sold. Patents bought are the number of patents bought by the start-up from other portfolio start-ups over time. Patents sold are the number of patents sold by the start-up to other portfolio start-ups over time.

INSERT Table 10 ABOUT HERE

Table 10 presents the results. Columns (1) and (2) show that the coefficient of the net-of-tax rate for the VC firms is positive and significant at the 10% level. This coefficient means that the elasticity of citations given due to the capital gains tax rate on VC firms ranges from -0.77 to -0.84. In columns (3) and (4), we focus on citations received. The coefficient of the net-of-tax rate for the VC firms is positive and significant at the 1% level. The elasticity of citations received ranges from -2.43 to -2.50. Taken together, these results show that the capital gains tax on the VC firm has a significant and negative effect on the level of innovation exchanges between start-up firms within the same VC firm’s portfolio.

In columns (5) and (6), we focus on patents bought. In these tests too, we observe a qualitatively similar result. A change in the net-of-tax rate for the VC firm has a significant effect on the number of patents bought by the start-up from other firms within the same VC firm’s portfolio. In columns (7) and (8), we focus on patents sold. The coefficient of interest is positive but not statistically significant. This lack of significance may be due to the fact that there are fewer observations of patent sales within portfolio firms at the firm-year level within our sample.³⁶ We note that the coefficient for the VC firms’ capital gains taxes is positive, while the coefficient for the start-ups’ is negative. These are qualitatively similar to the results for citations given and received.

The coefficient for the start-ups’ net-of-tax rate is statistically insignificant in each column of Table 10. The fact that we find that innovation exchanges between the start-ups of the same VC firm’s portfolio respond to changes in the tax rates of VC firms and not to changes in those of the start-ups provides further support for our hypothesis. We expect these innovation exchanges to be facilitated by the venture capitalists (and less by the entrepreneurs). As the VC firms’ incentives change with increases in taxes, they are less likely to act as arbiters that enable innovation exchanges. This lack of arbitration in turn affects the level of innovation within their portfolio firms.

4.3. *Lock-in*

As a last test related to the VC firms’ incentives, we examine whether GPs are timing the realization of capital gains or losses by strategically timing their exits from portfolio start-ups. The partnership agreements of VC firms typically require funds to be returned to LPs within 10 to 12 years of the initial commitment. This requirement makes it difficult for GPs to time their realization decisions when tax rates are favorable. They also cannot

³⁶We aggregate patent transactions at the start-up-year level. It turns out that in some years, there are fewer start-ups selling patents and more start-ups buying them. As a result, we end up with fewer observations for patents sold at the start-up-year level when compared to patents bought at the start-up-year level.

defer gains indefinitely, in contrast to shareholders of a corporate stock (Sarin et al. (2021)). Yet, tax changes may be able to influence the exit decision of GPs to a certain extent. An increase in the capital gains tax could incentivise GPs to hold on to their investments and delay the sales of start-ups with gains by waiting for initial public offerings (IPOs).³⁷ Tax increases may influence GPs’ exits from unsuccessful start-ups as well by accelerating their write-offs.

INSERT Table 11 ABOUT HERE

In Table 11, we test the above hypotheses and report the results. The dependent variable in the first two columns is the change in the natural logarithm of the number of firms which have completed a successful IPO, $\Delta \text{Ln}(\text{IPO start-ups})$, in the first year after the current year. Column (1), shows the results without control variables, while column (2) incorporates the control variables. In both specifications, we find that the coefficient estimate for the net-of-tax rate of the VC firm, $\Delta \text{Ln}(1 - VC\tau)$, is not statistically significant.

In columns (3) and (4) of Table 11, we test whether firms are more likely to be written off by the VC firms after a tax change. The dependent variable used is change in the natural logarithm of the number of firms written-off from the VC portfolio, $\Delta \text{Ln}(\text{Write-off start-ups})$. VC firms can become more “impatient” and accelerate the liquidation of non-star firms when taxes increase. Based on Tian and Wang (2014), we classify a firm as written off by its VC firm if 10 years have passed since the last investment by the VC firm. We find that the coefficient of interest is negative and significant at the 1% level. With an increase in the capital gains tax, there are more firms being written-off by the VC firm. Overall, the results fail to provide evidence in favour of the lock-in effect. Yet, VC firms’ accelerated liquidation of relatively poorly performing firms indicates that increases in the capital gains tax result in a decrease in the VC firm’s effort.

4.4. *Alternative Mechanisms*

Above we have shown that our results are overall consistent with the predictions of our main hypothesis on the changes in the incentives of VC firms. Different potential explanations for the response of innovation to changes in the capital gains tax can arise if the effect of the tax on VC partners’ behavior leads to other general equilibrium effects. For instance, when the capital gains tax increases, VC partners can potentially “lock in” their investments

³⁷Jin (2006) provides evidence that tax sensitive investors defer selling stocks that incurred large capital gains, although this pattern is not observed for institutions with predominantly tax-exempt clients.

in public stock (Holt and Shelton (1961)). This behavior can lead to a less active public equity market, and more patient investors (Feldstein et al. (1980)). Such changes can increase the allocation of capital to high-growth, innovative, public firms that potentially also changes the financial constraints on public firms. Both of these effects can drive a change in the innovation of public firms as well as in the innovation of their private counterparts. We estimate two specifications to evaluate whether these alternative mechanisms may be at work behind the tax-innovation relationship. However, we do not find any support. The results and more details can be found in Table A.7 of the Appendix A.

5. Discussion

Studies have found mixed empirical findings on the VC channel. Poterba (1989a) argues against a VC channel because most LPs are tax-exempt in the US. However, most GPs do pay capital gains taxes and are therefore affected by changes in the tax policy. We show a strong effect through the VC channel that includes the VC firms' effort.

Nevertheless, there is a possibility that our tests on the effort channel are an overestimation of the actual effect. There is a potential interaction between two channels: the VC firms' effort and entrepreneurs' effort. An increase in the capital gains tax rates in the state where the headquarters of the lead VC firm is located can lead to less effort by that firm in supporting start-ups, which could lead to more shirking by entrepreneurs. In other words, the effect of changes in the capital gains tax on innovation that we find may be in fact lower and our results may be capturing the upper bound of the effect (as they may reflect both less effort by both the VC firms and the entrepreneurs).

On a similar note, when the capital gains tax rate increases in the state where the headquarters of the start-up is located and entrepreneurs reduce their effort, VC firms may increase their support. Before the increase in taxes, the net marginal benefit of advising by the VC firm was low but after the tax increases, there is a higher marginal benefit to support. If VC firms are able to counterbalance the effect of higher taxes on start-ups, then our results on the entrepreneur's channel capture the lower bound of the effect. Overall, while we may not be able to clearly distinguish the exact magnitude of the effect coming from the two channels, our results show that both VC firms' and entrepreneurs' effort matter and that capital gains taxes affect innovation via the two channels.

6. Conclusion

The role of entrepreneurial firms, especially those backed by VC firms, in innovation is well-documented. VC-backed start-ups represent some of the most innovative and high-growth firms in the world. The question of whether and how tax policy can encourage

innovation through these firms is the focus of attention across several nations including the US. President Biden's Fiscal Year 2022 Revenue Proposals include a proposition to tax carried interest as ordinary income.³⁸ The potential enactment of this provision will affect GPs in both VC firms and private equity firms. Typically, securities held in these firms exceed the three-year holding period, and the compensation to GPs in the form of a partnership interest (carried interest, performance allocation or promote) is generally taxed at preferential, long-term capital gain rates.

Other studies have examined the effect of capital gains taxes on entrepreneurial entry and investment (Gentry and Hubbard (2000), Poterba (1989b)). In contrast, we examine the relative responsiveness of VC firms and their GPs versus entrepreneurs to capital gains taxes. A common view is that capital gains taxes are less important for VC partners, as the largest share of LPs in the US are tax-exempt (Poterba (1989a)). This study shows that capital gains taxes matter for GPs' decisions and this affects start-ups' innovation. The VC firms' response to capital gains taxes is statistically and economically larger than that of entrepreneurs'. Higher taxes change the incentives of GPs who are taxed as individuals. They decrease their level of support to start-up firms by facilitating less innovation exchanges within their portfolios and by writing-off more start-ups.

These findings have implications for the design of policies for the capital gains tax. The results show that it is important to consider not only entrepreneurs but also investors in start-ups as this consideration can improve investment and the distribution of this investment across start-up firms.

³⁸The proposal is to increase the long-term capital gains rate and qualified dividend income rate to 39.6% from 20% to the extent the taxpayer's income exceeds \$1 million and is indexed for inflation. This proposal is proposed to be effective retroactively for gains and income recognized after April 28, 2021 (<https://home.treasury.gov/system/files/131/General-Explanations-FY2022.pdf>).

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Figure 1: Ownership Structure of Venture Capital Firms

The figure below shows the legal ownership structure of an average venture capital firm in the US. The oval shapes represent either corporations or individuals. The rectangular boxes represent firms or corporations. The Management Co. is related to the General Partner. Usually, the Management Co. receives the management fee and the General Partner receives a share of the profits, or the carried interest.

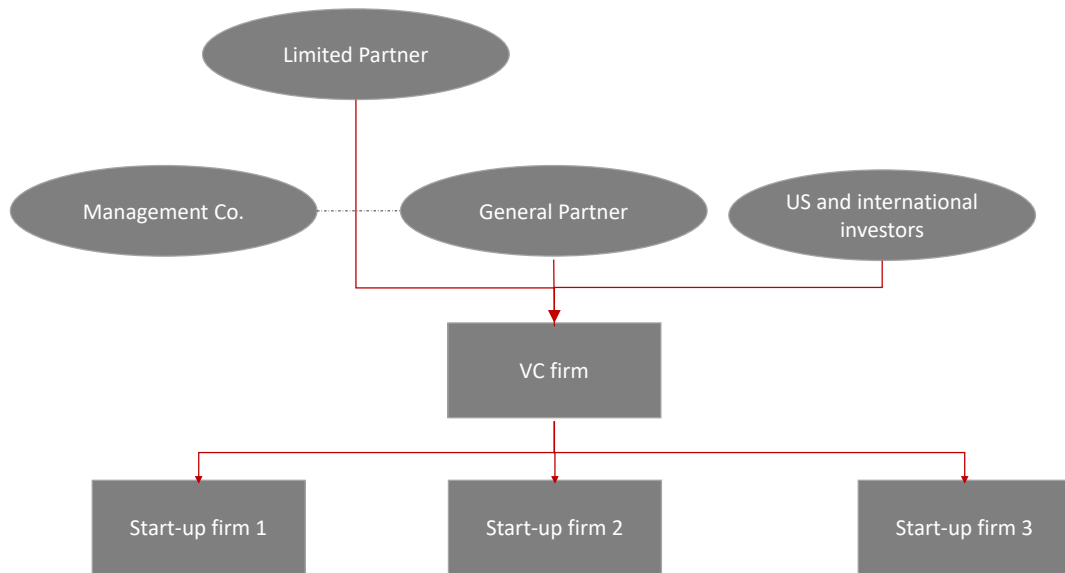


Figure 2: Timing of State-level Changes in Capital Gains Tax Rate

The figure below plots the number of changes in the capital gains tax rate in US states over the period from 1992 to 2014. A change in the capital gains tax constitutes a change in the maximum state-level tax on long-term capital gains (NBER TAXSIM, Feenberg and Coutts (1993)).

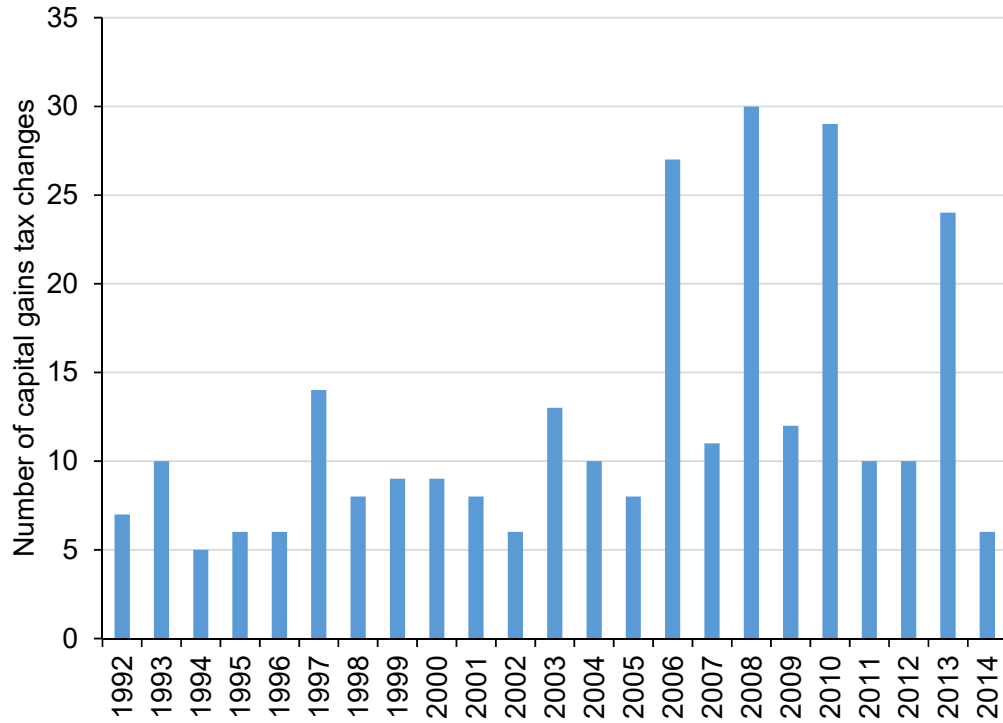


Figure 3: Effect of VC Firm Tax Changes on Innovation

The figures below plot the change in the number of successful patents filed by a firm that is measured in the log scale in response to changes in the VC-level capital gains tax rate. Start-up firms with lead VC partners located outside their state, or out-of-state firms, are included in the sample. The specification is the same as in Equation 1 except that the variable $\Delta^{-(+)}$ *Tax rate VC* is replaced by a series of variables *Rate VC(k)*, where *Rate VC(k)* is a variable which equals $\Delta^{-(+)}$ *Tax rate VC* exactly *k* years after (or before if *k* is negative) the state implements the change in capital gains tax. The blue markers plot the point estimates for $k = -3, \dots, 3$ that use the year of tax change as $k = 0$. The dashed lines show the 95% confidence intervals. Standard errors are clustered at the state-level. The top panel comprises decreases in state-level capital gains tax rates on VC firms, and the bottom panel comprises the increases.

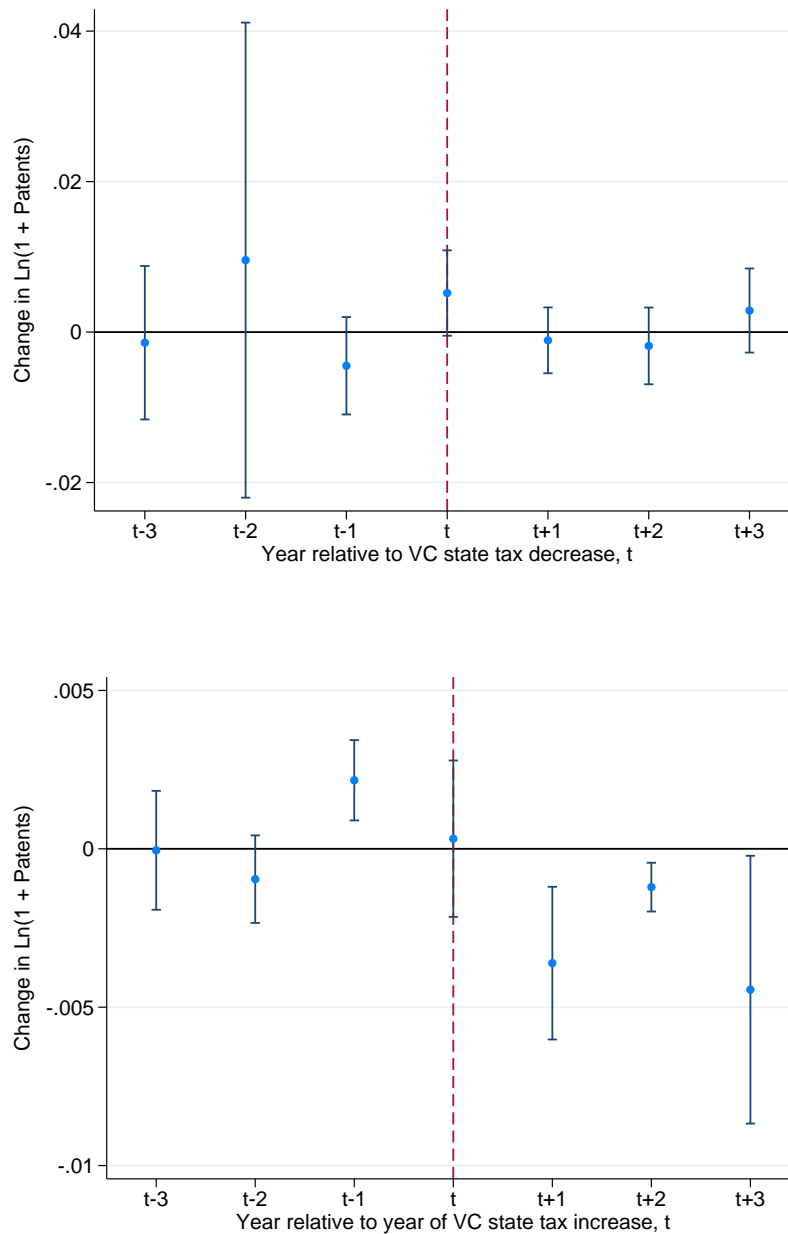


Figure 4: Effect of VC Firm Tax Changes on Innovation: Alternative Specification

The figures below plot the change in the number of successful patents filed by a firm that is measured in the log scale in response to changes in the VC-level capital gains tax rate. The specification used is $\Delta Y_{i,s,t} = \sum_{h=-3}^{h=3} \beta_h \cdot \Delta \text{Ln}(1 - VC\tau_{s,t-h}) + \lambda_{j,t} + \epsilon_{i,s,t}$ (where Δ indicates a one-period change). The blue markers plot the point estimates for $\beta_{-3}, \beta_{-2}, \dots, \beta_3$. The dashed lines show the 95% confidence intervals. Standard errors are clustered at the state level. The top panel plots the point estimates for all VC-level tax changes, and the bottom panel plots the point estimates for large VC-level tax changes that are defined as those which are larger or equal in magnitude to one percentage point.

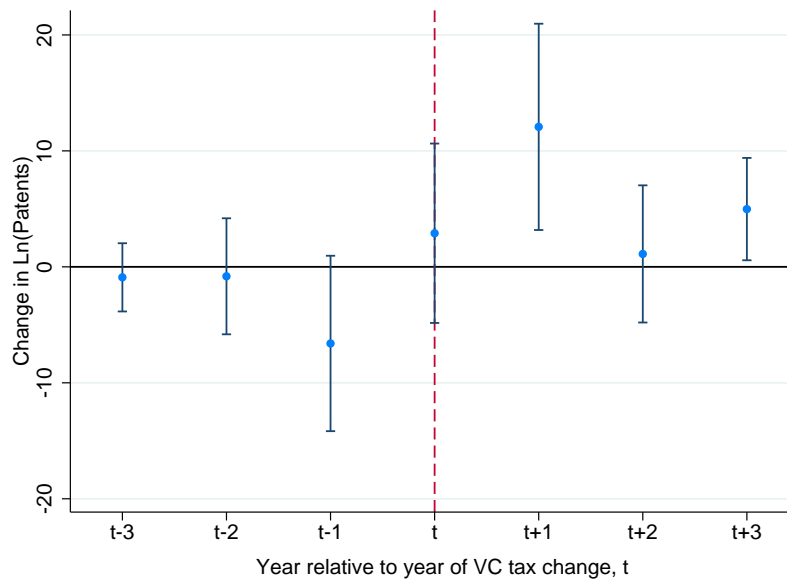
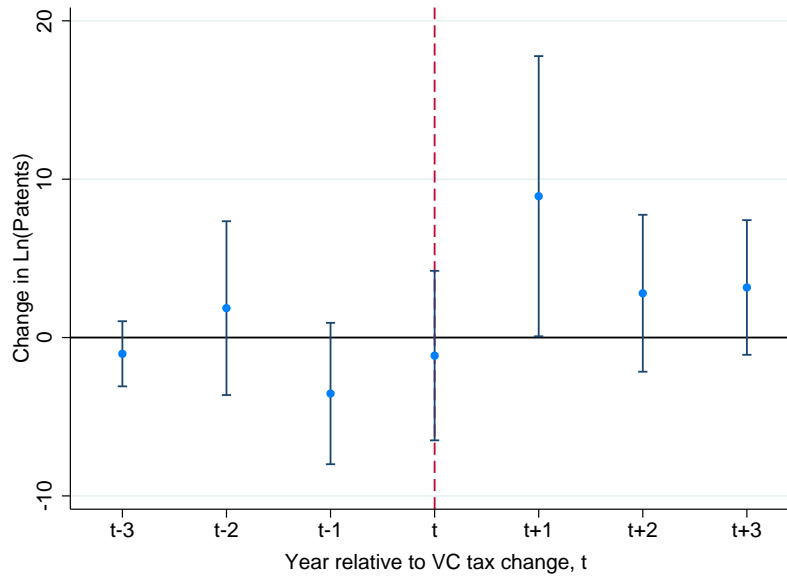


Table 1. Definitions of Variables

This table shows a summary of all explanatory variables used in the analysis.

Variable name	Variable description
Firm characteristics and innovation measures:	
LnPat_{it}	The natural logarithm of (1 + number of newly granted patents filed) by firm i in year t (Source: DWPI).
LnPatYoung_{it} [LnPatOld_{it}]	The natural logarithm of (1 + number of newly granted patents filed) by firm i in year t , if the firm was founded within the last three years [more than three years before the current year] and zero otherwise (Source: DWPI).
$\text{Ln}(\text{Patents})_{it}$	The natural logarithm of the number of newly granted patents filed by firm i in year t (Source: DWPI).
$\text{Ln}(\text{PYoung})_{it}$ [$\text{Ln}(\text{POld})_{it}$]	The natural logarithm of the number of newly granted patents filed by firm i in year t , if the firm was founded within the last three years [more than three years before the current year] and zero otherwise (Source: DWPI).
$\text{Ln}(\text{Patents bought})_{it}$ [$\text{Ln}(\text{Patents sold})_{it}$]	The natural logarithm of the number of patents bought [sold] by or re-assigned to firm i in year t from other firms which are included in the portfolio of its lead VC firm (Source: USPTO).
CwPat_{it}	The natural logarithm of (1 + number of cite-weighted patents received) by firm i in year t (Source: DWPI).
Cit_{it}	The natural logarithm of (1 + number of citations received) by firm i in year t (Source: DWPI).
$\text{Ln}(\text{Cite-wt patents})_{it}$	The natural logarithm of the number of cite-weighted patents of firm i in year t (Source: DWPI).
$\text{Ln}(\text{Citations})_{it}$	The natural logarithm of the number of citations received by firm i in year t (Source: DWPI).
$\text{Ln}(\text{Cites given})_{it}$	The natural logarithm of the number of citations given by patents filed by firm i in year t to patents of other firms which are included in the portfolio of its lead VC firm (Source: DWPI).
$\text{Ln}(\text{Cites received})_{it}$	The natural logarithm of the number of citations received by all existing patents of firm i by patents filed in year t by other firms which are included in the portfolio of its lead VC firm (Source: DWPI).
Inventor_{it}	An indicator variable equal to one if firm i has at least one newly granted patent filed in year t .
Age_{it}	Age of firm i in year t based on the number of years since the firm's founding (Source: VentureXpert).
HHI_{it} [HHI_{it}^2]	Herfindahl-Hirschman index. Equal to the sum of the squared share of firm i in total industry sales at the 3-digit SIC code in year t [HHI squared].
Tax policies measures:	
$\Delta^{-[+]}$ Tax rate $_{st}$	The decrease [increase] in state-level capital gains tax rate in year t for a start-up firm headquartered in state s .
$\Delta^{-[+]}$ Tax rate VC $_{st}$	The decrease [increase] in state-level capital gains tax rate in year t for a lead VC firm headquartered in state s .
Tax decrease high [Tax increase high] $_{st}$	An indicator variable equal to one if there is a tax decrease [increase] in the state-level capital gains tax rate in year t , which is more than one percentage point, for a start-up firm headquartered in state s .
Tax decrease VC high $_{st}$ [Tax increase VC high] $_{st}$	An indicator variable equal to one if there is a tax decrease [increase] in the state-level capital gains tax rate in year t , which is more than one percentage point, for a lead VC firm headquartered in state s .
$\text{Ln}(1 - \tau_{st})$	The natural logarithm of $(1 - \tau) = 1 - \tau^{fed} - \tau^{st}$, where τ^{fed} is the federal capital gains tax rate, and τ^{st} is the state-level capital gains tax rate in year t for a start-up firm headquartered in state s .

Table 1 – Continued

Variable name	Variable description
$\text{Ln}(1 - VC\tau_{st})$	The natural logarithm of $(1 - VC\tau) = 1 - \tau^{fed} - \tau^{state}$, where τ^{fed} is the federal capital gains tax rate and τ^{state} is the state-level capital gains tax rate in year t for a lead VC firm headquartered in state s .
$\text{Ln}(1 - VC\tau\ corr_{.st})$	The natural logarithm of $(1 - VC\tau\ corr.) = 1 - \tau^{fed} - \tau^{state}$, where τ^{fed} is the federal capital gains tax rate and τ^{state} is the state-level capital gains tax rate in the state of the lead VC firm s in year t if the start-up is in a state which exempts non-resident partners of partnership firms from paying taxes on investment activities. Alternatively, the natural logarithm of $(1 - VC\tau\ corr.) = 1 - \tau^{fed} - \tau^{st}$, where τ^{st} is the state-level capital gains tax rate in the state of the start-up s in year t if the start-up is in a state which does not exempt non-resident partners of firms from paying taxes on investment activities.
Large start-up tax _{st}	An indicator variable equal to one if there is a decrease or increase in the capital gains tax in year t of more than one percentage point in magnitude for a start-up firm headquartered in state s .
Large VC tax _{st}	An indicator variable equal to one if there is a decrease or increase in the capital gains tax in year t of more than one percentage point in magnitude for a lead VC firm headquartered in state s .
Δ Carryback _{st} [Δ Carryover _{st}]	An indicator variable equal to one if there is an increase in the length of the statutory net operating loss (NOL) carryback [carryover] in year t for firms headquartered in state s , minus one if there is a decrease, and zero otherwise.
Δ Corporate tax _{st}	An indicator variable equal to one if there is an increase in the state-level corporate income tax rate in year t for firms headquartered in state s , minus one if there is a decrease, and zero otherwise.
Δ RD tax credit _{st}	An indicator variable equal to one if there is an increase in the R&D tax credit rate in year t for firms headquartered in state s , minus one if there is a decrease, and zero otherwise.
BDT_{it}	The present discounted value of one dollar of deductions for eligible investment under the Bonus Depreciation Tax in year t for firm i (Source: Zwick and Mahon (2017)).
$DPAD_{it}$	The percentage deduction of “Qualified Production Activities Income” (QPAI) under the Domestic Production Activities Deduction in year t for firm i (Source: Ohn (2018)).
Additional variables:	
$\text{Ln}(\text{GDP})_{st}$	The natural logarithm of real gross domestic product in state s and year t (Source: Bureau of Economic Analysis).
Per capita income _{st}	The real gross domestic product divided by total population in state s and year t (Source: Bureau of Economic Analysis).
Unemployment _{st}	The unemployment rate in state s and year t (Source: Cleveland Federal Reserve).
$\text{Ln}(\text{Investment})_{it}$	The natural logarithm of the dollar amount invested by the lead VC firm i in year t (Source: VentureXpert).
$\text{Ln}(\text{Firms})_{it}$	The natural logarithm of the number of investments made by the lead VC firm i in year t (Source: VentureXpert).
$\text{Ln}(\text{IPO start-ups})_{it}$	The natural logarithm of the number of start-ups, backed by the lead VC firm i , which successfully complete an IPO in year t (Source: VentureXpert).
$\text{Ln}(\text{Write-off start-ups})_{it}$	The natural logarithm of the number of start-ups written-off by the lead VC firm i in year t (Source: VentureXpert, Tian and Wang (2014)).

Table 2. Summary Statistics

This table presents the summary statistics for the key variables used in the analysis. The sample period is from 1992 to 2014. Panel A comprises the firm-level variables and Panel B comprises the state-level tax policy variables. Patent information is from the Derwent World Patents Index (DWPI) database. See Table 1 for variables' definitions.

	N	Mean	St. Dev.	p25	Median	p75
Panel A: Firm-level and state-level variables						
Patents	83,943	35.013	335.436	0.000	0.000	1.000
LnPat	83,943	0.675	1.369	0.000	0.000	0.693
Cite-weighted patents	83,943	34.016	362.063	0.000	0.000	0.038
CwPat	83,943	0.473	1.337	0.000	0.000	0.037
Citations	83,943	211.823	2162.614	0.000	0.000	1.000
Cit	83,943	0.778	1.855	0.000	0.000	0.693
Inventor	83,943	0.328	0.469	0.000	0.000	1.000
Ln(GDP)	83,943	3.837	0.225	3.759	3.902	3.986
Per capita income	83,943	38.153	9.239	31.062	38.025	44.162
Age	83,943	15.710	15.467	6.000	12.000	20.000
Δ Corporate tax	83,943	-0.019	0.252	0.000	0.000	0.000
Δ RD tax credit	83,943	0.058	0.266	0.000	0.000	0.000
Unemployment	83,943	6.534	2.208	4.942	6.058	7.558
Panel B: Tax policy variables						
State capital gains tax rate (in %)	1,224	5.017	2.989	3.400	5.200	6.960
Δ^- Tax rate (in %, non-zero)	210	0.414	0.820	0.060	0.100	0.400
Δ^+ Tax rate (in %, non-zero)	98	0.685	0.936	0.120	0.265	0.880
Δ Carryback	1,224	0.041	0.200	0.000	0.000	0.000
Δ Carryover	1,224	0.014	0.117	0.000	0.000	0.000

Table 3. Capital Gains Tax and Innovation

This table presents the effect of the capital gains tax on patent production from an OLS regression. Panel A presents the results for the dependent variable ΔLnPat ; while in Panel B, the dependent variables are $\Delta \text{LnPatYoung}$, $\Delta \text{LnPatOld}$, ΔCwPat , ΔCit , and $\Delta \text{Inventor}$ that represent different proxies for firm innovation measured one year after the current time period, t . See Table 1 for variables' definitions. $\Delta^{-(+)}$ *Tax rate* captures the decrease (increase) in state-level capital gains tax rate in the state where the start-up is headquartered. $\Delta^{-(+)}$ *Tax rate VC* captures the decrease (increase) in state-level capital gains tax rate in the state where the lead VC firm is headquartered. Controls are $\Delta \text{Carryback}$, $\Delta \text{Carryover}$, $\Delta \text{Ln(GDP)}$, $\Delta \text{Per capita income}$, $\Delta \text{Ln(Age)}$, $\Delta \text{Corporate tax}$, $\Delta \text{RD tax credit}$, and $\Delta \text{Unemployment}$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

Panel A:	ΔLnPat				
	(1)	(2)	(3)	(4)	(5)
Δ^- Tax rate	0.004** (0.002)	0.016** (0.006)	0.017*** (0.006)	0.014** (0.006)	
Δ^+ Tax rate	-0.003** (0.001)	-0.004 (0.003)	-0.004 (0.003)	-0.003 (0.003)	
Δ^- Tax rate VC	-0.002 (0.001)	-0.014** (0.006)	-0.012** (0.006)	-0.013 (0.008)	
Δ^+ Tax rate VC	-0.004*** (0.001)	-0.013*** (0.004)	-0.013*** (0.004)	-0.013*** (0.004)	
Tax decrease high					0.014** (0.007)
Tax increase high					-0.002 (0.003)
Tax decrease VC high					-0.014* (0.008)
Tax increase VC high					-0.013*** (0.004)
Δ Carryback	-0.003 (0.003)		-0.010 (0.012)	-0.008 (0.013)	-0.008 (0.013)
Δ Carryover	0.008** (0.004)		0.012 (0.008)	0.009 (0.008)	0.009 (0.008)
$\Delta \text{Ln(GDP)}$	0.041 (0.042)		0.065 (0.099)	0.016 (0.109)	0.017 (0.109)
Δ Per capita income	-0.001* (0.001)		-0.006* (0.003)	-0.005 (0.004)	-0.005 (0.004)
$\Delta \text{Ln(Age)}$	0.050*** (0.004)		0.226*** (0.019)	0.233*** (0.016)	0.233*** (0.016)
Δ Corporate tax	-0.004** (0.002)		-0.023*** (0.004)	-0.023*** (0.007)	-0.023*** (0.007)
Δ RD tax credit	0.006*** (0.002)		0.023*** (0.007)	0.027*** (0.008)	0.027*** (0.008)
Δ Unemployment	-0.001 (0.002)		-0.004 (0.005)	-0.001 (0.006)	-0.001 (0.006)
Industry-Year FE	Yes	No	No	Yes	Yes
Observations	189,520	73,386	73,386	73,386	73,386
R-squared	0.030	0.009	0.012	0.061	0.061

Table 3 – Continued

Panel B:	$\Delta \text{LnPatYoung}$	$\Delta \text{LnPatOld}$	ΔCwPat	ΔCit	$\Delta \text{Inventor}$
	(1)	(2)	(3)	(4)	(5)
Δ^- Tax rate	0.008 (0.005)	0.007 (0.008)	0.022** (0.010)	0.027* (0.015)	0.000 (0.008)
Δ^+ Tax rate	0.001 (0.002)	-0.005** (0.002)	-0.006 (0.004)	-0.010* (0.005)	-0.006** (0.003)
Δ^- Tax rate VC	-0.008 (0.005)	-0.005 (0.007)	-0.006 (0.010)	-0.014 (0.014)	-0.005 (0.006)
Δ^+ Tax rate VC	-0.000 (0.001)	-0.012*** (0.004)	-0.012*** (0.004)	-0.019** (0.007)	-0.004 (0.003)
Δ Carryback	-0.001 (0.003)	-0.010 (0.013)	0.010 (0.009)	-0.006 (0.015)	0.009* (0.005)
Δ Carryover	-0.004 (0.004)	0.013* (0.007)	0.009 (0.009)	0.021 (0.015)	0.003 (0.006)
$\Delta \text{Ln}(\text{GDP})$	0.036 (0.094)	-0.052 (0.128)	-0.005 (0.173)	-0.060 (0.360)	0.136 (0.111)
Δ Per capita income	-0.002 (0.002)	-0.002 (0.005)	-0.004 (0.006)	-0.006 (0.010)	-0.004* (0.002)
$\Delta \text{Ln}(\text{Age})$	-0.175*** (0.011)	0.407*** (0.016)	0.129*** (0.024)	0.299*** (0.039)	0.152*** (0.013)
Δ Corporate tax	-0.008** (0.003)	-0.013** (0.005)	-0.003 (0.011)	-0.016 (0.021)	-0.017** (0.008)
Δ RD tax credit	0.000 (0.006)	0.028*** (0.010)	0.007 (0.007)	0.019* (0.010)	0.015** (0.007)
Δ Unemployment	0.003 (0.002)	-0.004 (0.006)	0.006 (0.006)	0.009 (0.012)	-0.001 (0.004)
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	73,386	73,386	73,386	73,386	73,386
R-squared	0.009	0.065	0.041	0.053	0.064

Table 4. Capital Gains Tax and Innovation: Alternative Variables' Construction

This table presents the effect of the capital gains tax on patent production from an OLS regression. Panel A presents the results for the dependent variable $\Delta \text{Ln}(\text{Patents})$; while in Panel B, the dependent variables are $\Delta \text{Ln}(\text{PYoung})$, $\Delta \text{Ln}(\text{POld})$, $\Delta \text{Ln}(\text{Cite-wt patents})$, $\Delta \text{Ln}(\text{Citations})$, and $\Delta \text{Ln}(\text{Inventor})$ that represent the different proxies of firm innovation measured one year after the current time period, t . See Table 1 for variables' definitions. $\Delta \text{Ln}(1 - \tau)$ captures the change in the natural logarithm of $(1 - \tau)$ where τ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the start-up is headquartered. $\Delta \text{Ln}(1 - VC\tau)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the lead VC firm is headquartered. Controls are $\Delta \text{Carryback}$, $\Delta \text{Carryover}$, $\Delta \text{Ln}(\text{GDP})$, $\Delta \text{Per capita income}$, $\Delta \text{Ln}(\text{Age})$, $\Delta \text{Corporate tax}$, $\Delta \text{RD tax credit}$, and $\Delta \text{Unemployment}$. Additional controls are the one-year and two-year leads and lags of the main tax variables: $\Delta \text{Ln}(1 - \tau)$, and $\Delta \text{Ln}(1 - VC\tau)$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

Panel A:	$\Delta \text{Ln}(\text{Patents})$			
	(1)	(2)	(3)	(4)
$\Delta \text{Ln}(1 - \tau)$	-1.550** (0.598)	-1.364 (0.963)	-0.540 (1.465)	
$\Delta \text{Ln}(1 - VC\tau)$	1.589** (0.622)	0.936 (1.033)	2.653*** (0.861)	
$\Delta \text{Ln}(1 - \tau)$ * Large start-up tax				-0.564 (1.545)
$\Delta \text{Ln}(1 - VC\tau)$ * Large VC tax				2.593*** (0.806)
$\Delta \text{Carryback}$		-0.057 (0.064)	-0.120 (0.073)	-0.119 (0.072)
$\Delta \text{Carryover}$		0.069** (0.026)	-0.006 (0.045)	-0.002 (0.043)
$\Delta \text{Ln}(\text{GDP})$		0.051 (0.145)	0.004 (0.657)	-0.003 (0.653)
$\Delta \text{Per capita income}$		0.032*** (0.008)	-0.011 (0.017)	-0.010 (0.016)
$\Delta \text{Ln}(\text{Age})$		-0.056 (0.051)	-0.030 (0.064)	-0.030 (0.064)
$\Delta \text{Corporate tax}$		-0.039** (0.018)	0.000 (0.024)	0.006 (0.025)
$\Delta \text{RD tax credit}$		0.100*** (0.017)	0.033 (0.024)	0.027 (0.027)
$\Delta \text{Unemployment}$		0.001 (0.010)	-0.023 (0.023)	-0.023 (0.023)
p-value for test of diff. in coeff.s of $\Delta \text{Ln}(1 - \tau)$ and $\Delta \text{Ln}(1 - VC\tau)$	0.012**	0.251	0.026**	0.061*
Additional controls	Yes	Yes	Yes	Yes
Industry-Year FE	No	No	Yes	Yes
Observations	16,780	16,780	16,780	16,780
R-squared	0.003	0.006	0.137	0.137

Table 4 – Continued

Panel B:	$\Delta \text{Ln(PYoung)}$	$\Delta \text{Ln(POld)}$	$\Delta \text{Ln(Cite-wt patents)}$	$\Delta \text{Ln(Citations)}$	$\Delta \text{Inventor}$
	(1)	(2)	(3)	(4)	(5)
$\Delta \text{Ln}(1 - \tau)$	-1.343 (13.033)	-0.037 (1.223)	4.249 (2.605)	4.125 (2.595)	0.446 (0.292)
$\Delta \text{Ln}(1 - \text{VC}\tau)$	-10.172 (16.686)	1.749** (0.702)	5.268** (2.523)	5.423** (2.609)	0.240 (0.246)
$\Delta \text{Carryback}$			-0.084 (0.129)	-0.086 (0.129)	0.011 (0.012)
$\Delta \text{Carryover}$			0.067 (0.076)	0.053 (0.074)	0.002 (0.006)
$\Delta \text{Ln(GDP)}$			-0.261 (1.135)	-0.412 (1.129)	0.142 (0.117)
$\Delta \text{Per capita income}$			-0.015 (0.046)	-0.014 (0.047)	-0.005** (0.002)
$\Delta \text{Ln(Age)}$			0.009 (0.171)	-0.028 (0.169)	0.050*** (0.012)
$\Delta \text{Corporate tax}$			0.020 (0.045)	0.019 (0.043)	-0.021** (0.009)
$\Delta \text{RD tax credit}$			-0.017 (0.050)	-0.016 (0.050)	0.015* (0.008)
$\Delta \text{Unemployment}$			-0.033 (0.037)	-0.038 (0.037)	0.002 (0.006)
Additional controls	No	No	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	1,008	18,348	12,606	12,606	65,704
R-squared	0.328	0.142	0.155	0.171	0.065

Table 5. State-level Tax Rules and Regulations

This table presents the state-level taxation rules and regulations for out-of-state investment partnerships. In the first column, we identify the names of the top states in our sample based on the number of firm-year observations of start-up firms. In the second column, we provide information on whether out-of-state investment partnerships are exempt from state taxes. “NA” means that the state does not tax income or capital gains and the issue of state taxation is not relevant. In the third column, we provide the name of the tax regulation relevant for taxing investment partnerships.

State	Out-of-state VC firms exempt from state taxes	Regulation
California	Yes	California: Cal. Rev. & Tax. Code § 17955
Colorado	No	C.R.S. § 39-22-601
Connecticut	Yes	CT Gen Stat § 12-711
District of Columbia	No	D.C. Subchapter VIII, § 47
Florida	NA	
Georgia	Yes	Ga. Code Ann. § 48-7-24 (c)
Illinois	Yes/No	IITA Section 1501(a)(11.5) & IITA Section 100.3500(d)
Maryland	Yes	Md. Code Ann. § 10-102.1(f)(2)(ii)
Masachusetts	Yes	Mass. G.L. Ch. 62, § 17(b)
Michigan	No	Mich. Comp. Laws § 206.703
Minnesota	Yes	Minn. Stat. § 290.92. Subd.4b.
Missouri	No	Mo. Rev. Stat. § 143.411.5
New Jersey	Yes	N.J. Rev. Stat. § 54:10A-15.11.a.(1)
New York	Yes	N.Y. Tax Law § 631(b)(2)
North Carolina	Yes	N.C. Gen. Stat. § 105-154(d)
Ohio	Yes	Oh. Rev. Code Sec. [§ 5733.40.1] § 5733.401
Pennsylvania	No	72 P.S. § 7324.1
Texas	NA	Tex. Tax Code Ann. § 171.0002(b)(3) & § 171.0003(a)(2)
Virginia	Yes	Va. Code. Ann. § 58.1-486.2.C
Washington	NA	

Table 6. Accounting for State-level Variations in VC Firm Taxation

This table presents the effect of the capital gains tax on patent production from an OLS regression. The dependent variables are $\Delta LnPat$ and $\Delta Ln(Patents)$ that represent different proxies of firm innovation measured one year after the current time period, t . See Table 1 for variables' definitions. $\Delta^{-(+)} Tax rate [\Delta^{-(+)} Tax rate VC]$ captures the decrease (increase) in state-level capital gains tax rate in the state where the start-up [the lead VC firm] is headquartered. $\Delta^{-(+)} Tax rate VC corr.$ captures the decrease (increase) in state-level capital gains tax rate accounting for corrections of VC-level taxes. $\Delta Ln(1 - \tau)$ captures the change in the natural logarithm of $(1 - \tau)$ where τ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the start-up is headquartered. $\Delta Ln(1 - VC\tau)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the lead VC firm is headquartered. $\Delta Ln(1 - VC\tau corr.)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal and state-level capital gains tax accounting for corrections of VC-level taxes. Controls are $\Delta Carryback$, $\Delta Carryover$, $\Delta Ln(GDP)$, $\Delta Per capita income$, $\Delta Ln(Age)$, $\Delta Corporate tax$, $\Delta RD tax credit$, and $\Delta Unemployment$. Additional controls are the one-year and two-year leads and lags of the main tax variables: $\Delta Ln(1 - \tau)$ and $\Delta Ln(1 - VC\tau)$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\Delta LnPat$				$\Delta Ln(Patents)$			
$\Delta^- Tax rate$	0.011 (0.007)	0.014** (0.006)	0.008 (0.007)	0.011* (0.006)				
$\Delta^+ Tax rate$	-0.003 (0.003)	-0.003 (0.003)	-0.005* (0.003)	-0.005** (0.002)				
$\Delta^- Tax rate VC$	-0.013 (0.009)		-0.015 (0.011)					
$\Delta^+ Tax rate VC$	-0.011*** (0.004)		-0.010** (0.004)					
$\Delta^- Tax rate VC corr.$		-0.011 (0.008)		-0.013 (0.009)				
$\Delta^+ Tax rate VC corr.$		-0.011*** (0.004)		-0.010** (0.004)				
$\Delta Ln(1 - \tau)$					-0.827 (1.484)	-0.578 (1.426)	-1.112 (1.470)	-0.866 (1.418)
$\Delta Ln(1 - VC\tau)$					2.576*** (0.914)		2.204** (0.849)	
$\Delta Ln(1 - VC\tau corr.)$						2.764** (1.027)		2.443** (0.963)
Additional controls	No	No	No	No	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	66,187	73,386	63,791	70,712	15,358	16,780	14,949	16,315
R-squared	0.065	0.061	0.066	0.063	0.140	0.136	0.139	0.136

Table 7. Capital Gains Tax and Innovation: Robustness Tests

This table presents the effect of the capital gains tax on the patent production from an OLS regression. Panel A presents the results for patents; while in Panel B, the results are for citations that represent different proxies of firm innovation measured one year after the current time period, t . See Table 1 for variables' definitions. $\Delta^{-(+)}$ *Tax rate VC* captures the decrease (increase) in state-level capital gains tax rate in the state where the lead VC firm is headquartered. $\Delta \ln(1 - VC\tau)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the lead VC firm is headquartered. All specifications include industry-year fixed effects and the controls for Δ *Carryback*, Δ *Carryover*, $\Delta \ln(GDP)$, Δ *Per capita income*, $\Delta \ln(Age)$, Δ *Corporate tax*, Δ *RD tax credit*, and Δ *Unemployment*. Specifications reported in columns (4) and (5) include the one-year and two-year leads and lags of the main tax variables: $\Delta \ln(1 - \tau)$ and $\Delta \ln(1 - VC\tau)$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

Panel A:	$\Delta \ln Pat$			$\Delta \ln(\text{Patents})$	
	Δ^- Tax rate VC	Δ^+ Tax rate VC	N	$\Delta \ln(1 - VC\tau)$	N
	(1)	(2)	(3)	(4)	(5)
Clustering by year	-0.013 (0.008)	-0.013*** (0.004)	73,386	2.653*** (0.914)	16,780
Clustering by industry	-0.013** (0.005)	-0.013*** (0.003)	73,386	2.653* (1.337)	16,780
Clustering by firm	-0.013 (0.008)	-0.013*** (0.005)	73,386	2.653** (1.294)	16,780
With firm fixed effects	-0.015* (0.009)	-0.014*** (0.004)	73,386	3.289*** (0.846)	16,780
Excluding firms which move HQ across states	-0.013 (0.008)	-0.013*** (0.004)	72,513	2.647*** (0.831)	16,553
Excluding firms located in CA and MA	0.000 (0.010)	-0.013* (0.007)	29,328	5.028** (1.970)	7,865
Firms in industries with short patent lags	0.016** (0.007)	-0.010** (0.005)	54,073	2.292* (1.325)	13,817
Excluding states with no tax changes	-0.016 (0.010)	-0.017*** (0.004)	64,031	2.707*** (0.752)	14,586
Using R&D tax credits until 2014	-0.013 (0.008)	-0.013*** (0.004)	73,386	2.650*** (0.863)	16,780

Table 7 – Continued

Panel B:	Δ CwPat			Δ Ln(Cite-wt patents)	
	Δ^- Tax rate VC (1)	Δ^+ Tax rate VC (2)	N (3)	Δ Ln(1 - VC τ) (4)	N (5)
Clustering by year	-0.006 (0.007)	-0.012*** (0.003)	73,386	5.268*** (1.539)	12,606
Clustering by industry	-0.006 (0.016)	-0.012*** (0.005)	73,386	5.268*** (1.242)	12,606
Clustering by firm	-0.006 (0.010)	-0.012** (0.005)	73,386	5.268* (2.737)	12,606
With firm fixed effects	-0.006 (0.012)	-0.013*** (0.005)	73,386	6.091** (2.489)	12,606
Excluding firms which move HQ across states	-0.008 (0.011)	-0.013*** (0.005)	72,513	5.001* (2.890)	12,441
Excluding firms located in CA and MA	0.002 (0.020)	-0.010** (0.005)	29,328	8.213** (3.877)	5,705
Firms in industries with short patent lags	0.013** (0.006)	-0.011*** (0.003)	54,073	6.048 (4.218)	10,310
Excluding states with no tax rate changes	-0.007 (0.011)	-0.015*** (0.005)	64,031	4.365* (2.413)	11,005
Using R&D tax credits until 2014	-0.006 (0.010)	-0.012*** (0.004)	73,386	5.268** (2.521)	12,606

Table 8. Capital Gains Tax and Innovation: Additional Control Variables

This table presents the effect of the capital gains tax on patent production from an OLS regression. The dependent variables are ΔLnPat , $\Delta \text{Ln}(\text{Patents})$, ΔCwPat , and $\Delta \text{Ln}(\text{Cite-wt patents})$ that represent different proxies of firm innovation measured one year after the current time period, t . See Table 1 for variables' definitions. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

	ΔLnPat	$\Delta \text{Ln}(\text{Patents})$	ΔCwPat	$\Delta \text{Ln}(\text{Cite-wt patents})$
	(1)	(2)	(3)	(4)
Δ^- Tax rate	0.018*** (0.006)		0.027*** (0.010)	
Δ^+ Tax rate	-0.004 (0.003)		-0.005 (0.003)	
Δ^- Tax rate VC	-0.009 (0.006)		-0.004 (0.009)	
Δ^+ Tax rate VC	-0.013*** (0.004)		-0.010*** (0.004)	
$\Delta \text{Ln}(1 - \tau)$		-0.811 (1.028)		3.696 (2.555)
$\Delta \text{Ln}(1 - \text{VC}\tau)$		1.811* (0.908)		3.670* (1.937)
Δ Carryback	-0.007 (0.012)	-0.109 (0.068)	0.007 (0.008)	-0.131 (0.097)
Δ Carryover	0.012 (0.008)	0.011 (0.038)	0.009 (0.008)	0.029 (0.058)
$\Delta \text{Ln}(\text{GDP})$	0.078 (0.098)	0.250 (0.440)	0.045 (0.146)	0.287 (0.616)
Δ Per capita income	-0.005* (0.003)	-0.011 (0.013)	-0.004 (0.005)	-0.011 (0.030)
$\Delta \text{Ln}(\text{Age})$	0.233*** (0.017)	-0.062 (0.058)	0.126*** (0.024)	-0.029 (0.135)
Δ Corporate tax	-0.022*** (0.004)	-0.007 (0.021)	-0.005 (0.010)	0.000 (0.051)
Δ RD tax credit	0.024*** (0.007)	0.032* (0.019)	0.003 (0.006)	0.008 (0.037)
Δ Unemployment	-0.003 (0.005)	-0.019 (0.020)	0.006 (0.005)	-0.025 (0.027)
Δ HHI	-0.280** (0.121)	-1.220*** (0.368)	0.146 (0.164)	-1.283 (0.894)
ΔHHI^2	0.290* (0.151)	1.043** (0.459)	-0.141 (0.171)	0.926 (1.168)
Δ BDT	-2.984*** (0.829)	-2.627 (2.169)	-2.441* (1.224)	-6.888* (3.598)
Δ DPAD	0.054 (0.043)	0.523*** (0.110)	0.134*** (0.050)	0.964*** (0.171)
Additional controls	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	72,089	16,504	72,089	12,422
R-squared	0.013	0.024	0.006	0.028

Table 9. Capital Gains Taxes and Innovation: VC Firm Investments, and VC Firm Portfolio

This table presents the effect of the capital gains tax on the investments and the size of the portfolio of VC firms from an OLS regression. The dependent variables are $\Delta \text{Ln}(\text{Investment})$ and $\Delta \text{Ln}(\text{Firms})$ that represent the aggregate investment by the VC firm and the aggregate number of firms in its portfolio respectively. See Table 1 for variables' definitions. $\Delta \text{Ln}(1 - VC\tau)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the lead VC firm is headquartered. Controls are $\Delta \text{Carryback}$, $\Delta \text{Carryover}$, $\Delta \text{Ln}(\text{GDP})$, $\Delta \text{Per capita income}$, $\Delta \text{Corporate tax}$, $\Delta \text{RD tax credit}$, and $\Delta \text{Unemployment}$. Additional controls are the one-year and two-year leads and lags of the main tax variable: $\Delta \text{Ln}(1 - VC\tau)$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

	$\Delta \text{Ln}(\text{Investment})$		$\Delta \text{Ln}(\text{Firms})$	
	(1)	(2)	(3)	(4)
$\Delta \text{Ln}(1 - VC\tau)$	19.446*** (6.982)	20.171*** (6.896)	7.180*** (1.977)	8.355*** (2.676)
$\Delta \text{Carryback}$		0.071 (0.081)		-0.014 (0.084)
$\Delta \text{Carryover}$		0.013 (0.126)		0.016 (0.037)
$\Delta \text{Ln}(\text{GDP})$		0.458 (1.517)		-0.515 (0.446)
$\Delta \text{Per capita income}$		-0.026 (0.066)		-0.040* (0.022)
$\Delta \text{Corporate tax}$		0.179 (0.111)		0.104** (0.040)
$\Delta \text{RD tax credit}$		0.106 (0.074)		-0.028 (0.046)
$\Delta \text{Unemployment}$		0.033 (0.093)		-0.018 (0.035)
Additional controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	2,033	2,033	2,191	2,191
R-squared	0.039	0.040	0.040	0.044

Table 10. Capital Gains Taxes and Innovation: Innovation Exchanges within VC Firm Portfolios

This table presents the effect of the capital gains tax on innovation exchanges between the start-ups in a VC firm portfolio from an OLS regression. The dependent variables are measures of citations between start-up firms within the same VC firm portfolio, $\Delta \text{Ln}(\text{Cites given})$ and $\Delta \text{Ln}(\text{Cites received})$ and measures of patent transactions between start-up firms within the same VC portfolio: $\Delta \text{Ln}(\text{Patents bought})$ and $\Delta \text{Ln}(\text{Patents sold})$. See Table 1 for variables' definitions. $\Delta \text{Ln}(1 - \tau)$ captures the change in the natural logarithm of $(1 - \tau)$ where τ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the start-up is headquartered. $\Delta \text{Ln}(1 - VC\tau)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the lead VC firm is headquartered. Controls are $\Delta \text{Carryback}$, $\Delta \text{Carryover}$, $\Delta \text{Ln}(GDP)$, $\Delta \text{Per capita income}$, $\Delta \text{Ln}(Age)$, $\Delta \text{Corporate tax}$, $\Delta \text{RD tax credit}$, and $\Delta \text{Unemployment}$. Additional controls are one-year and two-year leads and lags of the main tax variables: $\Delta \text{Ln}(1 - \tau)$ and $\Delta \text{Ln}(1 - VC\tau)$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state level. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

	$\Delta \text{Ln}(\text{Cites given})$	$\Delta \text{Ln}(\text{Cites received})$	$\Delta \text{Ln}(\text{Patents bought})$	$\Delta \text{Ln}(\text{Patents sold})$				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta \text{Ln}(1 - \tau)$	-1.697 (3.646)	-2.746 (3.831)	-0.593 (3.082)	-0.420 (3.046)	2.399 (2.013)	2.314 (1.890)	-0.417 (4.537)	-0.359 (4.154)
$\Delta \text{Ln}(1 - VC\tau)$	2.979* (1.557)	2.745* (1.504)	8.872*** (2.590)	8.609*** (2.573)	2.717** (1.279)	2.882** (1.307)	0.024 (4.082)	0.920 (4.551)
$\Delta \text{Carryback}$		-0.270*** (0.096)		0.466 (0.278)		0.031 (0.072)		0.110 (0.163)
$\Delta \text{Carryover}$		0.036 (0.059)		-0.029 (0.096)		-0.032 (0.068)		0.150 (0.149)
$\Delta \text{Ln}(GDP)$		-0.870 (1.270)		3.456* (1.995)		0.887 (0.938)		2.234 (3.299)
$\Delta \text{Per capita income}$		-0.013 (0.028)		-0.106** (0.043)		-0.022 (0.026)		0.019 (0.057)
$\Delta \text{Ln}(Age)$		-0.065 (0.117)		0.210 (0.305)		-0.056 (0.074)		0.064 (0.275)
$\Delta \text{Corporate tax}$		-0.037 (0.084)		-0.105** (0.039)		-0.070** (0.033)		0.150 (0.129)
$\Delta \text{RD tax credit}$		0.101* (0.053)		0.026 (0.122)		-0.017 (0.060)		0.059 (0.131)
$\Delta \text{Unemployment}$		0.018 (0.022)		0.019 (0.044)		-0.011 (0.034)		-0.038 (0.072)
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,440	10,440	2,339	2,339	7,464	7,464	1,700	1,700
R-squared	0.269	0.270	0.256	0.259	0.177	0.177	0.284	0.287

Table 11. Capital Gains Tax and Innovation: IPOs and Write-offs

This table presents the effect of the capital gains tax on the number of firms that complete an IPO and the number of firms being written-off from an OLS regression. The dependent variable $\Delta \text{Ln}(IPO \text{ start-ups})$ is the natural logarithm of the number of start-ups in the VC firm portfolio which successfully complete an IPO; $\Delta \text{Ln}(Write-off \text{ start-ups})$ is the natural logarithm of the number of start-ups in the VC firm portfolio which are written-off. See Table 1 for variables' definitions. $\Delta \text{Ln}(1 - VC\tau)$ captures the change in the natural logarithm of $(1 - VC\tau)$ where $VC\tau$ is the combined federal capital gains tax rate and the state-level capital gains tax rate in the state where the lead VC firm is headquartered. Controls are $\Delta \text{Carryback}$, $\Delta \text{Carryover}$, $\Delta \text{Ln}(GDP)$, $\Delta \text{Per capita income}$, $\Delta \text{Corporate tax}$, $\Delta \text{RD tax credit}$, and $\Delta \text{Unemployment}$. Additional controls are the one-year and two-year leads and lags of the main tax variable: $\Delta \text{Ln}(1 - VC\tau)$. The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5% and 10% levels respectively.

	$\Delta \text{Ln}(IPO \text{ start-ups})$		$\Delta \text{Ln}(Write-off \text{ start-ups})$	
	(1)	(2)	(3)	(4)
$\Delta \text{Ln}(1 - VC\tau)$	0.046 (0.178)	-0.116 (0.257)	-0.874*** (0.240)	-1.167*** (0.250)
$\Delta \text{Carryback}$		0.014*** (0.003)		0.012 (0.011)
$\Delta \text{Carryover}$		-0.011*** (0.004)		0.006 (0.014)
$\Delta \text{Ln}(GDP)$		-0.071 (0.122)		0.247 (0.240)
$\Delta \text{Per capita income}$		0.004** (0.002)		0.005 (0.006)
$\Delta \text{Corporate tax}$		0.002 (0.005)		-0.003 (0.013)
$\Delta \text{RD tax credit}$		0.003 (0.006)		0.005 (0.011)
$\Delta \text{Unemployment}$		0.007* (0.003)		0.012* (0.007)
Additional controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	6,815	6,815	4,982	4,982
R-squared	0.044	0.046	0.027	0.029



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