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

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Abstract

We examine the effect of staggered changes in the state-level capital gains tax on venture capital (VC)-backed start-ups and show that an increase in the tax rate of VC firms reduces the quantity and quality of patents by the start-ups. The results are consistent with a reduction in VC firms' incentives to provide effort: increases in the capital gains tax for VC firms lead to incrementally lower innovation exchanges between start-ups in the VC firm's portfolio. VC firms also decrease the level of investment in start-ups and the size of their portfolio as well as increase the number of start-ups that they write off.

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

JEL classification: G24, H25, L26, O31

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1. Introduction

Entrepreneurial firms supported by venture capital (VC) investors play an important role in innovation and productivity growth. VCs are associated with some of the most influential

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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 VC before their initial public offerings (IPOs): Alphabet, Apple, Amazon, Facebook, and Microsoft in the USA, 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 (Hellmann and Puri, 2000; Kortum and Lerner, 2000; Bernstein, Giroud, and Townsend, 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), while the outside investors are limited partners (LPs). LPs 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 USA. 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, 2003, 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 the 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 USA, 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 USA (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, 2003, 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 article 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 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 facilitate the interpretation of the results as elasticities (Agersnap and Zidar, 2021; Gravelle, 2020). For our second approach, we focus on large changes in the state-level tax rates on capital gains, that is, changes that are more than one percentage point (Agersnap and Zidar, 2021).

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

1 The magnitude of the effect of changes in the capital gains tax compares well with the effect of changes in the 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 are lower than the elasticity of patents to changes in the personal income tax at the state level (–2 to –3.4) (Akcigit *et al.*, 2022). 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. 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.*, 2022).

concentration, and two control variables to account for other contemporaneous changes in tax policy which can potentially affect innovation: the Bonus Depreciation Tax (BDT) policy and the Domestic Production Activities Deduction (DPAD) 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 the 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 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 firms can lead to fewer innovation outcomes. We find strong, empirical evidence in favor of taxes having a negative effect on the investments and the size of the portfolios of VC firms.

For 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, leading 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 portfolios. 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. We provide strong evidence that the changes in taxes affect the VC firms' incentives which changes 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, Spatt, and Zhang, 2001; Chari, Golosov, and Tsyvinski, 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 change 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 cause investors in public firms to become more patient (Holt and Shelton, 1961; Feldstein, Slemrod, and Yitzhaki, 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 article makes three contributions. First, by studying VC-backed start-up firms, our article 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 article 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, 2003, 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 VC being raised, and less entries and exits by firms.[2]

Second, by focusing on one aspect of growth, innovation, this article 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 article 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]

2 For a reference, see Gompers and Lerner (1999), Bock and Watzinger (2017), Bruce (2000, 2002), and Cullen and Gordon (2007). Similarly, Da Rin, Nicodano, and Sembenelli (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.

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

4 See Graham (2006); Blouin, Core, and Guay (2010); Asker, Farre-Mensa, and Ljungqvist (2015); Heider and Ljungqvist (2015); and Faulkender and Smith (2016).

5 In addition to the papers mentioned in footnote 2, refer to Gentry and Hubbard (2005) and Gentry (2016).

6 Cornaggia *et al.* (2015); Amore, Schneider, and Zaldokas (2013); Chava *et al.* (2013); Acharya and Subramanian (2009); Acharya, Baghai, and Subramanian (2013, 2014); Aghion *et al.* (2005); Hsu, Tian, and Xu (2014); Hombert and Matray (2016); and Blanco and Wehrheim (2017).

2. 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 GPs and the outside investors are called LPs.[7] A typical business arrangement for the GPs would comprise (1) 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 fund in the USA.

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 USA, 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 (or more) than one year and then sells it for a profit, the tax authority classifies it as a short-term (or long-term) capital gain and taxes it as ordinary income (capital gain). The top federal tax rate on long-term capital gains in the USA for the 2019 tax year was 23.8%. In addition to federal taxes on capital gains, most states in the USA 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, which are tax-exempt in the USA, 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; Keuschnigg and Nielsen, 2003, 2004). In line with this argument, we test whether the capital gains tax affects firm

7 LPs 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 GPs 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).

8 To 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.

9 Poterba (1989a) argues against any effect because most LPs are tax-exempt in the USA. Some authors find a negative effect of the capital gains tax on funding raised by VC firms (Cumming, 2005; Da Rin, Nicodano, and Sembenelli, 2006; Bock and Watzinger, 2017). Others show the lack of an effect of the capital gains tax on investments by VC firms (Jeng and Wells, 2000).

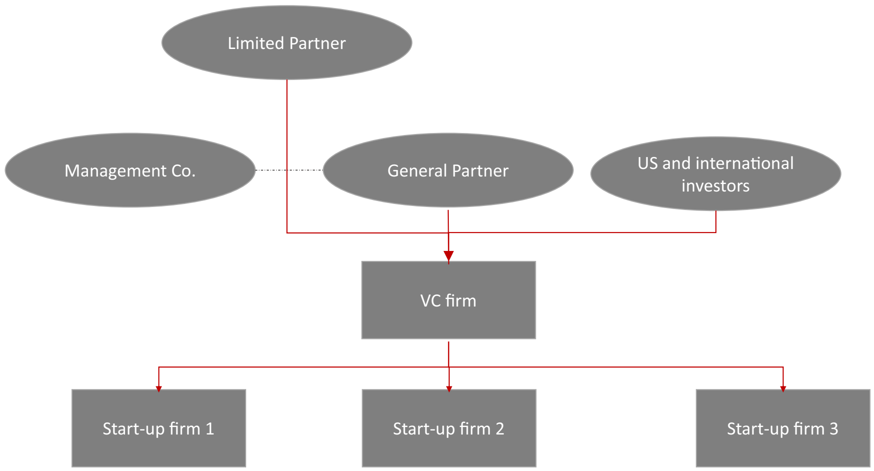

Figure 1. Ownership structure of VC firms. The figure shows the legal ownership structure of an average VC firm in the USA. The oval shapes represent either corporations or individuals. The rectangular boxes represent firms or corporations. The Management Co. is related to the GP. Usually, the Management Co. receives the management fee and the GP receives a share of the profits, or the carried interest.

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 with 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. Specifically, 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.

3. 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 come from Thomson Reuters' Derwent World Patents Index (DWPI) database. DWPI is a value-added worldwide patents database that contains patent applications and grants from forty-eight patent issuing authorities worldwide on more than 23 million unique inventions for over

50 million patent documents.[10] We match 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.

3.1 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, Jaffe, and Trajtenberg, 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.

3.2 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 have the potential to be a valid instrument (Feenberg and Coutts, 1993). The key explanatory variables in our analysis are Δ^- Tax rate (VC) and Δ^+ Tax rate (VC). These variables capture the decrease and increase in the capital gains tax for a given year in the headquarters state of the start-up (the lead VC firm).

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 is

10 To ensure the completeness of the DWPI database, we compare the US patents data from DWPI to the data obtained from the USPTO as made available publicly by Google 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 available from the corresponding author on request.

11 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.

12 The 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

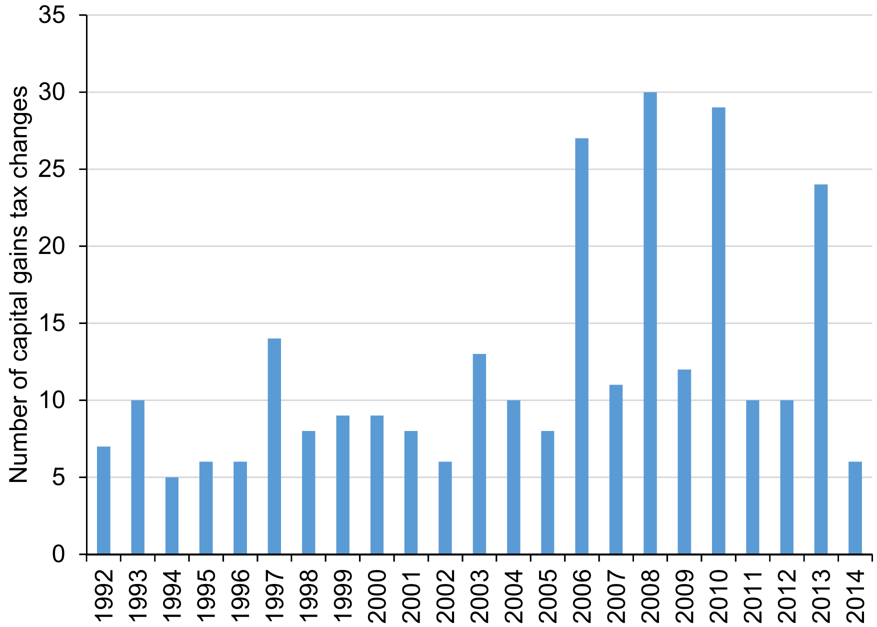

Figure 2. Timing of state-level changes in capital gains tax rate. The figure plots the number of changes in the capital gains tax rate in US states over the period from 1992 to 2014. A change in the capital gains tax constitutes a change in the maximum state-level tax on long-term capital gains (NBER TAXSIM, Feenberg and Coutts, 1993).

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 carried the 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 (Lerner, 1995; Gompers and Lerner, 1999). 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 losses, 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

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.

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

14 The 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.

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 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, Singh, and Zaldokas, 2017; Atanassov and Liu, 2020). We use corporate income tax data from Heider and Ljungqvist (2015) and Atanassov and Liu (2020).

3.3 Control Variables

In this section, 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

15 Losses 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.

16 The 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, 2018). 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).

17 Wilson (2009) shows that these tax incentives are effective in increasing R&D investment within the state. He shows that thirty-two 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.

in determining the relevant state tax rate for both start-ups and VC firms. The definitions of the variables are summarized in Table I.

3.4 Summary Statistics

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

Panel A of Table II 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. 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. The average year is characterized with 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.

4. 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 ordinary least squares (OLS) specification:

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

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, forty states experience repeated treatments, that is, a sequence of tax increases or tax cuts; thirty-two states experience tax reversals, that is, a tax increase followed by a tax cut or vice versa.

Table I. 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).
Ln(Patents)_{it}	The natural logarithm of the number of newly granted patents filed by firm *i* in year *t* (*source*: DWPI).
$\text{Ln(Patents bought)}_{it}$ [$\text{Ln(Patents sold)}_{it}$]	The natural logarithm of the number of patents bought [or 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).
$\text{Ln(Cite-wt patents)}_{it}$	The natural logarithm of the number of cite-weighted patents of firm *i* in year *t* (*source*: DWPI).
$\text{Ln(Citations)}_{it}$	The natural logarithm of the number of citations received by firm *i* in year *t* (*source*: DWPI).
$\text{Ln(Cites given)}_{it}$	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).
$\text{Ln(Cites received)}_{it}$	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^2_{it}]	HHI. 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	
$\Delta^{-[+]}$ $\text{Tax rate}_{\text{st}}$	The decrease [or increase] in state-level capital gains tax rate in year *t* for a start-up firm headquartered in state *s*.
$\Delta^{-[+]}$ $\text{Tax rate VC}_{\text{st}}$	The decrease [or increase] in state-level capital gains tax rate in year *t* for the lead VC firm headquartered in state *s*.

(continued)

Table I. Continued

Variable name	Variable description
Tax decrease high [Tax increase $high_{st}$]	An indicator variable equal to one if there is a tax decrease [or 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 [or increase] in the state-level capital gains tax rate in year t, which is more than one percentage point, for the 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 in the state where the start-up s is headquartered.
$\text{Ln}(1-\text{VC}\tau_{st})$	The natural logarithm of $(1-\text{VC}\tau) = 1-\tau^{fed}-\tau^{state}$, where τ^{fed} is the federal capital gains tax rate and τ^{state} is the state-level capital gains tax rate in year t in the state the lead VC firm s is headquartered in.
$\text{Ln}(1-\text{VC}\tau\ \text{corr.}_{st})$	The natural logarithm of $(1-\text{VC}\tau\ \text{corr.}) = 1-\tau^{fed}-\tau^{state}$, 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 $(1-\text{VC}\tau\ \text{corr.}) = 1-\tau^{fed}-\tau^{st}$, 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 [Small 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 [or less] than one percentage point in magnitude in the state in which start-up firm s is located.
Large VC tax [Small 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 [or less] than one percentage point in magnitude in the state in which the lead VC firm s is located.
$\Delta\ \text{Carryback}_{st}$ [$\Delta\ \text{Carryover}_{st}$]	An indicator variable equal to one if there is an increase in the length of the statutory NOL carryback [or carryover] in year t for firms headquartered in state s, minus one if there is a decrease, and zero otherwise.

(continued)

Table I. Continued

Variable name	Variable description
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 BDT in year *t* for firm *i* (*source*: Zwick and Mahon, 2017).
DPAD$_{it}$	The percentage deduction of "QPAI" under the DPAD in year *t* for firm *i* (*source*: Ohrn, 2018).
Additional variables	
Ln(GDP)$_{st}$	The natural logarithm of real GDP in state *s* and year *t* (*source*: BEA).
Per capita income$_{st}$	The real GDP divided by total population in state *s* and year *t* (*source*: BEA).
Unemployment$_{st}$	The unemployment rate in state *s* and year *t* (*source*: Cleveland Federal Reserve).
Ln(Investment)$_{it}$	The natural logarithm of the dollar amount invested by the lead VC firm *i* in year *t* (*source*: VentureXpert).
Ln(Firms)$_{it}$	The natural logarithm of the number of investments made by the lead VC firm *i* in year *t* (*source*: VentureXpert).
Ln(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).
Ln(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).

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 USA 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

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

Table II. 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 DWPI database. See Table I 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
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
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

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; Bertrand, Duflo, and Mullainathan, 2004). As we show in Table VII, 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 three potential concerns with such an analysis. The first concern is related to the form of the main dependent variable. In our specification (as shown in Equation (1)), the dependent variable takes the form, $\text{Ln}(1+x)$. The economic interpretation of the coefficients from such regressions and the econometric properties of the resulting estimators are unclear (Cohn, Liu, and Wardlaw, 2022). In addition, in order to obtain consistent estimators, the error structure needs to exhibit a particular form of heteroskedasticity. The combination of nonlinearities in the relationship between the dependent variable and the covariates, and among the different covariates can bias the estimates of the average effects. To address these concerns, we use the log transformation, that is, $\mathrm{Ln}(x)$ as our main dependent variable in our alternative specification (Equation (2)).

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

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

where $(1-\tau) = 1-\tau^{\mathrm{fed}}-\tau^{\mathrm{st}}$ 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; $(1-\mathrm{VC}\tau) = 1-\tau^{\mathrm{fed}}-\tau^{\mathrm{state}}$ 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 and allows us to interpret the results as elasticities (Agersnap and Zidar, 2021; Gravelle, 2020). For our second approach, we focus on large changes in state capital gains taxes: changes which are more than one percentage point (Agersnap and Zidar, 2021). This approach also helps address the issue of the economic magnitude of our main effect.

The third 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 (Holt and Shelton, 1961; Feldstein, Slemrod, and Yitzhaki, 1980). We conduct a direct test for this alternative mechanism to address the concern.

4.1 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 III.

4.1.a. VC channel

The dependent variable in Panel A of Table III is $\Delta\ \mathrm{LnPat}_{t+1}$. 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 Δ^{+} 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

Table III. 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 Δ LnPat; while in Panel B, the dependent variables are Δ LnPat, Δ CwPat, Δ Cit, and Δ Inventor that represent different proxies for firm innovation measured one year after the current time period, *t*. See Table I 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 located. $\Delta^{-(+)}$ Tax rate VC captures the decrease (increase) in state-level capital gains tax rate in the state where the lead VC firm is located. Controls are Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ Ln(Age), Δ Corporate tax, Δ RD tax credit, and Δ 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:	Δ LnPat				
	(1)	(2)	(3)	(4)	(5)
Δ^{-} Tax rate	0.004**	0.016**	0.017***	0.014**	
	(0.002)	(0.006)	(0.006)	(0.006)	
Δ^{+} Tax rate	–0.003**	–0.004	–0.004	–0.003	
	(0.001)	(0.003)	(0.003)	(0.003)	
Δ^{-} Tax rate VC	–0.002	–0.014**	–0.012**	–0.013	
	(0.001)	(0.006)	(0.006)	(0.008)	
Δ^{+} Tax rate VC	–0.004***	–0.013***	–0.013***	–0.013***	
	(0.001)	(0.004)	(0.004)	(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		–0.010	–0.008	–0.008
	(0.003)		(0.012)	(0.013)	(0.013)
Δ Carryover	0.008**		0.012	0.009	0.009
	(0.004)		(0.008)	(0.008)	(0.008)
Δ Ln(GDP)	0.041		0.065	0.016	0.017
	(0.042)		(0.099)	(0.109)	(0.109)
Δ Per capita income	–0.001*		–0.006*	–0.005	–0.005
	(0.001)		(0.003)	(0.004)	(0.004)
Δ Ln(Age)	0.050***		0.226***	0.233***	0.233***
	(0.004)		(0.019)	(0.016)	(0.016)
Δ Corporate tax	–0.004**		–0.023***	–0.023***	–0.023***
	(0.002)		(0.004)	(0.007)	(0.007)
Δ RD tax credit	0.006***		0.023***	0.027***	0.027***
	(0.002)		(0.007)	(0.008)	(0.008)
Δ Unemployment	–0.001		–0.004	–0.001	–0.001
	(0.002)		(0.005)	(0.006)	(0.006)

(continued)

Table III. Continued

Panel A:	Δ LnPat				
	(1)	(2)	(3)	(4)	(5)
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

Panel B:	Δ LnPat	Δ LnPat	Δ CwPat	Δ Cit	Δ Inventor
	(1)	(2)	(3)	(4)	(5)
Δ^- Tax rate	0.091	0.011	0.022**	0.027*	0.000
	(0.057)	(0.007)	(0.010)	(0.015)	(0.008)
Δ^+ Tax rate	0.050	−0.003	−0.006	−0.010*	−0.006**
	(0.059)	(0.003)	(0.004)	(0.005)	(0.003)
Δ^- Tax rate VC	−0.090	−0.010	−0.006	−0.014	−0.005
	(0.074)	(0.007)	(0.010)	(0.014)	(0.006)
Δ^+ Tax rate VC	−0.067**	−0.012***	−0.012***	−0.019**	−0.004
	(0.027)	(0.004)	(0.004)	(0.007)	(0.003)
Δ Carryback	0.057	−0.009	0.010	−0.006	0.009*
	(0.052)	(0.012)	(0.009)	(0.015)	(0.005)
Δ Carryover	0.115**	−0.000	0.009	0.021	0.003
	(0.047)	(0.008)	(0.009)	(0.015)	(0.006)
Δ Ln(GDP)	−0.837	0.070	−0.005	−0.060	0.136
	(0.745)	(0.138)	(0.173)	(0.360)	(0.111)
Δ Per capita income	0.023	−0.005	−0.004	−0.006	−0.004*
	(0.023)	(0.005)	(0.006)	(0.010)	(0.002)
Δ Ln(Age)	0.437***	−0.041	0.129***	0.299***	0.152***
	(0.043)	(0.027)	(0.024)	(0.039)	(0.013)
Δ Corporate tax	0.020	−0.028***	−0.003	−0.016	−0.017**
	(0.026)	(0.009)	(0.011)	(0.021)	(0.008)
Δ RD tax credit	0.069***	0.024***	0.007	0.019*	0.015**
	(0.021)	(0.009)	(0.007)	(0.010)	(0.007)
Δ Unemployment	0.029	0.001	0.006	0.009	−0.001
	(0.023)	(0.007)	(0.006)	(0.012)	(0.004)
Industry-year FE	Yes	Yes	Yes	Yes	Yes
Observations	6,341	67,045	73,386	73,386	73,386
R-squared	0.153	0.064	0.041	0.053	0.064

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 with 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

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

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, Singh, and Zaldokas (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 III 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 presents 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 statistically significant. Further, in Table IV, 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 VC firms' tax increases 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 with 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.

In Panel A of Table IV, 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 (Zidar, 2019; Agersnap and Zidar, 2021).

20 A 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.

21 As Mukherjee, Singh, and Zaldokas (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.

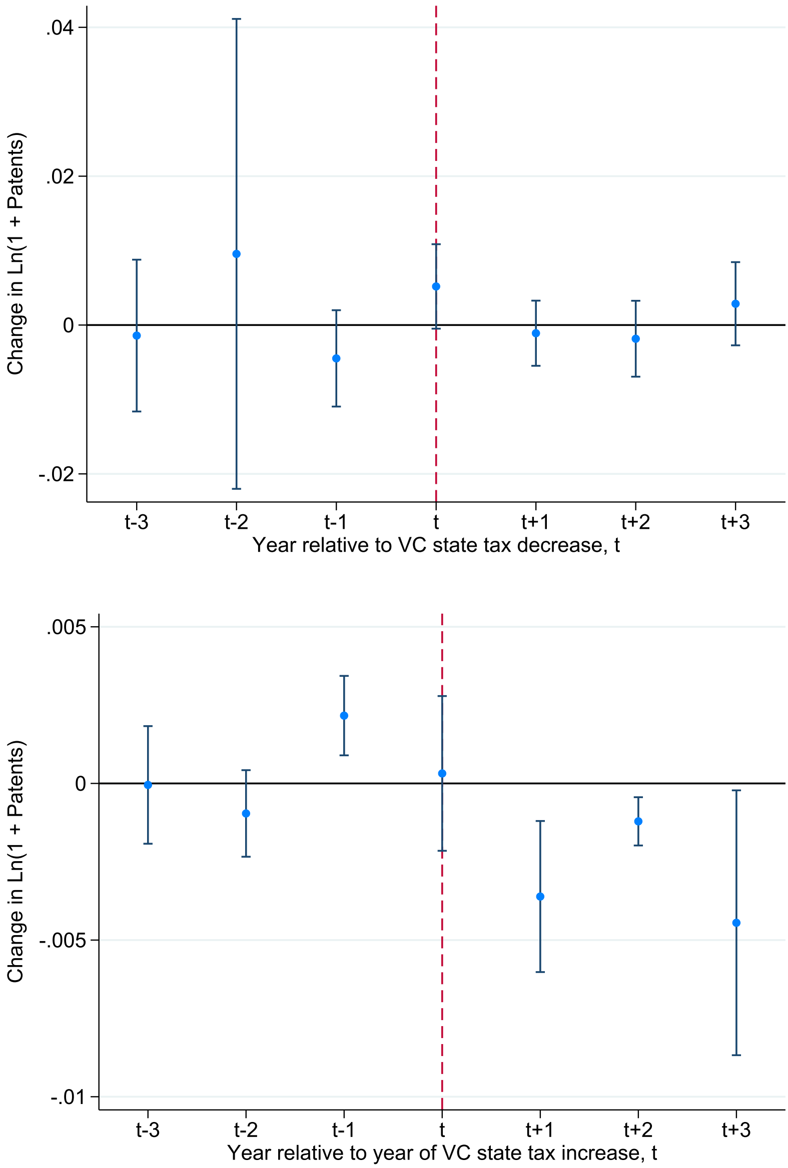

Figure 3. Effect of VC-level tax changes on innovation. The figures plot the change in the number of successful patents filed by a firm that is measured in the log scale in response to changes in the VC-level capital gains tax rate. Start-up firms with lead VC partners located outside their state, or 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 equal $\Delta^{-(+)}$ 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 $k = -3, .., 3$ 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.

Table IV. 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 Δ Ln(Patents); while in Panel B, the dependent variables are Δ Ln(Patents), Δ Ln(Cite-wt patents), Δ Ln(Citations), and Δ Inventor that represent the different proxies of firm innovation measured one year after the current time period, *t*. See Table I for variables' definitions. Δ Ln(1 − τ) captures the change in the natural logarithm of (1 − τ), 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 located. Δ Ln(1 − VCτ) captures the change in the natural logarithm of (1 − VCτ), where VCτ 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 located. Controls are Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ Ln(Age), Δ Corporate tax, Δ RD tax credit, and Δ Unemployment. Additional controls are the one-year and two-year leads and lags of the main tax variables: Δ Ln(1 − τ), and Δ Ln(1 − VCτ). 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:	Δ Ln(Patents)			
	(1)	(2)	(3)	(4)
Δ Ln(1 − τ)	−1.550**	−1.364	−0.540	
	(0.598)	(0.963)	(1.465)	
Δ Ln(1 − VCτ)	1.589**	0.936	2.653***	
	(0.622)	(1.033)	(0.861)	
Δ Ln(1 − τ) * Large start-up tax				−0.564
				(1.545)
Δ Ln(1 − VCτ) * Large VC tax				2.593***
				(0.806)
Δ Ln(1 − τ) * Small start-up tax				−0.064
				(1.344)
Δ Ln(1 − VCτ) * Small VC tax				4.601***
				(1.006)
Δ Carryback		−0.057	−0.120	−0.119
		(0.064)	(0.073)	(0.072)
Δ Carryover		0.069**	−0.006	−0.002
		(0.026)	(0.045)	(0.043)
Δ Ln(GDP)		0.051	0.004	−0.003
		(0.145)	(0.657)	(0.653)
Δ Per capita income		0.032***	−0.011	−0.010
		(0.008)	(0.017)	(0.016)
Δ Ln(Age)		−0.056	−0.030	−0.030
		(0.051)	(0.064)	(0.064)
Δ Corporate tax		−0.039**	0.000	0.006
		(0.018)	(0.024)	(0.025)
Δ RD tax credit		0.100***	0.033	0.027
		(0.017)	(0.024)	(0.027)
Δ Unemployment		0.001	−0.023	−0.023
		(0.010)	(0.023)	(0.023)
P-value for test of diff. in coeff.s of Δ Ln(1 − τ) and Δ Ln(1 − VCτ)	0.012**	0.251	0.026**	0.061*

(continued)

Table IV. Continued

Panel A:		Δ Ln(Patents)			
		(1)	(2)	(3)	(4)
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

Panel B:	Δ Ln(Patents)	Δ Ln(Patents)	Δ Ln(Cite-wt patents)	Δ Ln(Citations)	Δ Inventor
	(1)	(2)	(3)	(4)	(5)
Δ Ln(1 − τ)	−1.343	−0.037	4.249	4.125	0.446
	(13.033)	(1.223)	(2.605)	(2.595)	(0.292)
Δ Ln(1 − VCτ)	−10.172	1.749**	5.268**	5.423**	0.240
	(16.686)	(0.702)	(2.523)	(2.609)	(0.246)
Δ Carryback			−0.084	−0.086	0.011
			(0.129)	(0.129)	(0.012)
Δ Carryover			0.067	0.053	0.002
			(0.076)	(0.074)	(0.006)
Δ Ln(GDP)			−0.261	−0.412	0.142
			(1.135)	(1.129)	(0.117)
Δ Per capita income			−0.015	−0.014	−0.005**
			(0.046)	(0.047)	(0.002)
Δ Ln(Age)			0.009	−0.028	0.050***
			(0.171)	(0.169)	(0.012)
Δ Corporate tax			0.020	0.019	−0.021**
			(0.045)	(0.043)	(0.009)
Δ RD tax credit			−0.017	−0.016	0.015*
			(0.050)	(0.050)	(0.008)
Δ Unemployment			−0.033	−0.038	0.002
			(0.037)	(0.037)	(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

Column (1) of Panel A shows the results. The coefficient for the net-of-tax rate at the VC firm-level, $\text{Ln}(1 - \text{VC}\tau)$, 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 for the VC firm is 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 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 is 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.*, 2022). 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 levels 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.*, 2022).[23] To summarize, the elasticity of patents to the capital gains tax of VC firms is significantly negative and lower than the elasticity of patents to the personal income tax.

In Column (4), we interact the net-of-tax rates with an indicator variable for tax changes at the state level which are larger than one percentage point, and an indicator variable for tax changes at the state level which are smaller than one percentage point. 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. The coefficient of the interaction between the tax change for VC firms and the small tax change indicator is also positive and significant at the 1% level. The *F*-test for the equality of the coefficients of this interaction and the interaction between the start-up's tax rate and small tax changes rejects the null at the 5% level. VC firms react to large and small changes in the capital gains tax rate. Small tax changes can lead to good control groups (compare taxpayers who are very similar yet face different prospects in marginal tax rates) but also can lead to less meaningful estimates (taxpayers may not be aware of the minute details of the tax code). In our case of VC firms, it is likely that these firms are more aware of the tax code than the average individual or entrepreneur. And therefore, we argue that both small and large tax changes are likely to provide meaningful estimates of the effect of capital gains tax changes on innovation.

Our main results are robust when we use the alternative specification. One limitation of this specification is that we can retain only the subset of firms which have consecutive years with non-zero patent grants. The number of such observations (as shown in Table IV) is 16,780, or 22.8% of the total number of observations as reported in Table III. However,

22 The coefficient for $\text{Ln}(1 - \text{VC}\tau)$ measures the elasticity of patents with respect to the net-of-tax rate. In Column (3) of Table IV, 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 (Agersnap and Zidar, 2021; Gravelle, 2020).

23 The elasticity of patents at the individual level is the result of responses of individual investors such as an inventor changing his work effort, or investment in resources, or shifting between corporate and personal tax bases. At the state level, the elasticity of patents is the sum of responses of both firms and inventors. In addition, they also capture movements across states, and cross-state spillovers. Therefore, the elasticities at the state level and at the inventor level can be quite varied.

our results are not limited to this sub-sample. We use the inverse hyperbolic sine transformation both with first-differences, Δ $A\sinh(x)$, and in levels, $A\sinh(x)$, and a $\mathrm{Ln}(x)$ specification to confirm that our results are indeed affirmed within the entire sample.[24]

Nevertheless, the sample used in our Δ $\mathrm{Ln}(x)$ specification restricts our analysis to a special kind of observation. In this sample, firms are older, and are located in states with lower GDP, lower per capita income, lower state corporate tax rates, and higher R&D tax credits. These firms are in states which do not have different levels of unemployment compared with the average state in our entire dataset. Given that these firms are different on some firm-level and state-level characteristics, this influences the external validity of our results. Our sample includes VC-backed start-ups, which are different from the average start-up in the USA. In addition, we focus on young firms with consecutive non-zero patent years. Therefore, the effect of VC firms' capital gains tax on the start-ups' innovation, which we identify in our sample, may be different for older firms and/or for non-VC backed start-ups.

To summarize, 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 USA which makes it unlikely that they will respond to changes in capital gains taxes (Poterba, 1989a).[25] GPs, however, are subject to the capital gains tax; our results show that the involvement and support of GPs can be an important channel through which that tax on VC firms affects innovation.

4.1.b. Entrepreneur channel

In this section, we address the entrepreneur channel and discuss the coefficients for the variables Δ^{+} Tax rate and Δ^{-} Tax rate. Column (1) in Panel A of Table III shows the result for the main specification for all firms (as in Equation (1)). The coefficient for Δ^{-} Tax rate is positive while the coefficient for Δ^{+} Tax rate is negative, and both are statistically significant at the 5% level. These results indicate that capital gains tax has an effect on patenting. In Column (2), we focus on the sample of firms which have at least one patent. We find

24 The inverse hyperbolic sine transformation retains observations with zero patents, and it is more representative of the effect on patents in the entire dataset (see Clemens and Tiongson, 2017; Mckenzie, 2017; Bahar and Rapoport, 2018, among others). We report our robust results in Table A.3 of Online Appendix A.

25 Furthermore, 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 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.*, 2022). 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.

that both coefficients of interest are larger in magnitude but only one is statistically significant: the coefficient for Δ^- 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 Δ^- 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 IV, we report the results from our alternative specification. The coefficient for the net-of-tax rate at the start-up level, $\mathrm{Ln}(1-\tau)$, 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 III shows that the decreases in taxes matter for entrepreneurs, while tax 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; Kaplan and Stromberg, 2003; Schmidt, 2003).[26] 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 IV 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.

4.2 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.[27]

26 This compensation structure means that the fraction of the 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.

27 Recent 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

In Column (1) of Panel B in Table III, we estimate the effect on patents of "young" start-ups. We include observations if the start-up firm was founded within the last three years. Analogously in Column (2) of Panel B in Table III, we estimate the effect on patents of "old" start-ups. We include observations if the start-up firm was founded more than three years before the current year. In both Columns (1) and (2), we report that the coefficients for Δ^- Tax rate are not statistically significant. These results are inconclusive in determining a differential impact of capital gains tax on entrepreneurs of early-stage start-ups versus older start-ups.

In Columns (1) and (2) of Panel B in Table IV, we estimate the effect on patents of young and old start-ups, using our alternative specification. We find similar results to those reported in Panel B of Table III. In both Columns (1) and (2), the coefficient for the net-of-tax rate at the start-up level, $\text{Ln}(1-\tau)$, is statistically insignificant. In Section 4.5, we examine further the effect of the capital gains tax on entrepreneurs relative to that of the personal income tax.

In Columns (3) and (4) of Panel B in Table III, we test our main specification using measures of innovation quality, Δ CwPat_{t+1} and Δ Cit_{t+1}, as the dependent variables. The coefficient for Δ^- Tax rate is positive and statistically significant in each of the two columns, which indicates that 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, Δ^+ 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 Δ^+ 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 IV, 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, which indicates that 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.

4.3 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:

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

The specification is similar to Equation (1) except that the variable Δ^- Tax rate VC (Δ^+ Tax rate VC) is replaced by a series of variables $\text{Rate}(k)$ that is a variable which equals Δ^- Tax rate VC (Δ^+ Tax rate VC) exactly k years from the year of the decrease (increase)

that discourage entrepreneurship (Thawani, 2019). The same survey shows that a few years after creation firms are less concerned with taxes.

in the capital gains tax for the VC firm. We add the tax changes for start-ups to the set of control variables, $X_{i,s,t}$.

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 $\text{LnPat}_{i,s,t}$. 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:

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

The specification is similar to Equation (2) except that the variable $\Delta\ \text{Ln}(1 - \text{VC}\tau)$ is replaced by a series of variables $\Delta\ \text{Ln}(1 - \text{VC}\tau_{s,t-h})$, where $\text{VC}\tau_{s,t-h}$ 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, $X_{i,s,t}$.

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 $\text{Ln(Patents)}_{i,s,t}$. 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 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 $\Delta\ \text{Ln}(1 - \text{VC}\tau_{s,t-h})$ 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 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

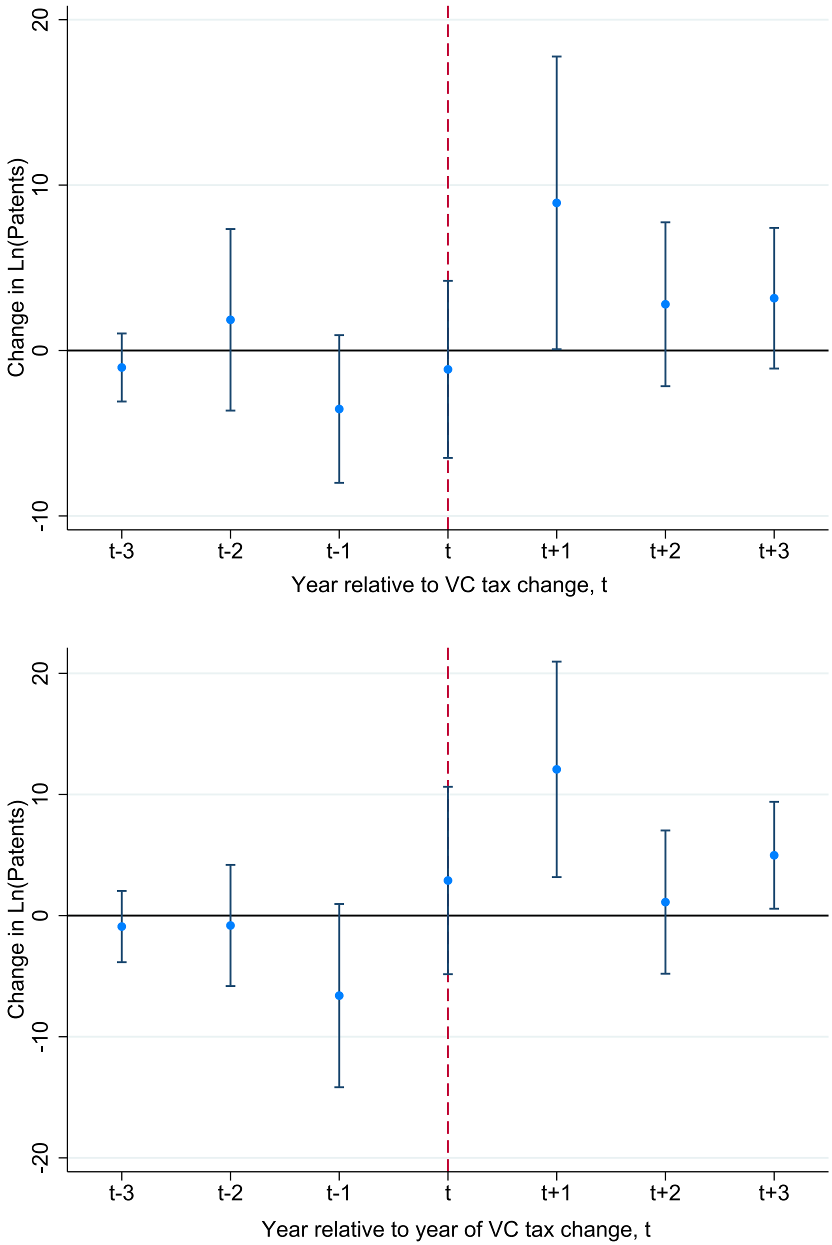

Figure 4. Effect of VC-level tax changes on innovation: alternative specification. The figures plot the change in the number of successful patents filed by a firm that is measured in the log scale and are in response to changes in the VC-level capital gains tax rate. The specification used is $\Delta Y_{i,s,t} = \sum_{h=-3}^{h=3} \beta_h \cdot \Delta \text{Ln}(1 - \text{VC}\tau_{s,t-h}) + \lambda_{j,t} + \epsilon_{i,s,t}$ (where Δ indicates a one-period change). The blue markers plot the point estimates for $\beta_{-3}, \beta_{-2}, \ldots, \beta_3$. 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.

future.[28] 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 the changes in 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 tax treatment. Other studies have shown an immediate effect on patents (Mukherjee, Singh, and Zaldokas, 2017; Chu, Tian, and Wang, 2019). On this aspect, our results agree with the literature.

4.4 Other Robustness Tests

4.4. a. 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 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 taxation rules for the top twenty states in our sample, which account for 96% of the start-ups in the sample. Table V presents the details.

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

Among the top twenty states in our sample, Colorado, Michigan, Missouri, Pennsylvania, and Illinois before the year 2005, as well as the District of Columbia did not

28 Hall, Jaffe, and Trajtenberg (2001) show that the average patent and investment lag is two years for US firms.

Table V. 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. and 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) and IITA Section 100.3500(d)
Maryland	Yes	Md. Code Ann. §10-102.1(f)(2)(ii)
Massachusetts	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) and §171.0003(a)(2)
Virginia	Yes	Va. Code. Ann. §58.1-486.2.C
Washington	NA	

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: $\text{Ln}(1 - \text{VC}\tau\ \text{corr.})$. 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 VI shows these new updated results.

Table VI. Accounting for state-level variations in VC taxation

This table presents the effect of the capital gains tax on patent production from an OLS regression. The dependent variables are Δ LnPat and Δ Ln(Patents) that represent different proxies of firm innovation measured one year after the current time period, *t*. See Table I 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 is located [the lead VC firm]. $\Delta^{-(+)}$ Tax rate VC corr. captures the decrease (increase) in state-level capital gains tax rate accounting for corrections of VC-level taxes. Δ 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 located. Δ Ln(1 – VCτ) captures the change in the natural logarithm of (1 – VCτ), where VCτ 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 located. Δ Ln(1 – VCτ corr.) captures the change in the natural logarithm of (1 – VCτ), where VCτ is the combined federal and state-level capital gains tax accounting for corrections of VC-level taxes. Controls are Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ Ln(Age), Δ Corporate tax, Δ RD tax credit, and Δ Unemployment. Additional controls are the one-year and two-year leads and lags of the main tax variables: Δ Ln$(1-\tau)$ and Δ Ln(1 – VCτ). The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Δ LnPat				Δ Ln(Patents)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ^{-} Tax rate	0.011	0.014**	0.008	0.011*				
	(0.007)	(0.006)	(0.007)	(0.006)				
Δ^{+} Tax rate	–0.003	–0.003	–0.005*	–0.005**				
	(0.003)	(0.003)	(0.003)	(0.002)				
Δ^{-} Tax rate VC	–0.013		–0.015					
	(0.009)		(0.011)					
Δ^{+} Tax rate VC	–0.011***		–0.010**					
	(0.004)		(0.004)					
Δ^{-} Tax rate VC corr.		–0.011		–0.013				
		(0.008)		(0.009)				
Δ^{+} Tax rate VC corr.		–0.011***		–0.010**				
		(0.004)		(0.004)				
Δ Ln$(1-\tau)$					–0.827	–0.578	–1.112	–0.866
					(1.484)	(1.426)	(1.470)	(1.418)
Δ Ln(1 – VCτ)					2.576***		2.204**	
					(0.914)		(0.849)	
Δ Ln(1 – VCτ corr.)						2.764**		2.443**
						(1.027)		(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

In Column (1) of Table VI, 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

Table VII. 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 I 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 located. Δ Ln(1 – VCτ) captures the change in the natural logarithm of (1 – VCτ), where VCτ 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 located. All specifications include industry-year fixed effects and the controls for Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ 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: Δ Ln(1 – τ) and Δ Ln(1 – VCτ). 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:	Δ LnPat			Δ Ln(Patents)	
	Δ^- Tax rate VC (1)	Δ^+ Tax rate VC (2)	N (3)	Δ Ln(1 – VCτ) (4)	*N* (5)
Clustering by year	–0.013	–0.013***	73,386	2.653***	16,780
	(0.008)	(0.004)		(0.914)	
Clustering by industry	–0.013**	–0.013***	73,386	2.653*	16,780
	(0.005)	(0.003)		(1.337)	
Clustering by firm	–0.013	–0.013***	73,386	2.653**	16,780
	(0.008)	(0.005)		(1.294)	
With firm fixed effects	–0.015*	–0.014***	73,386	3.289***	16,780
	(0.009)	(0.004)		(0.846)	
Excluding firms which move	–0.013	–0.013***	72,513	2.647***	16,553
HQ across states	(0.008)	(0.004)		(0.831)	
Excluding firms located	0.000	–0.013*	29,328	5.028**	7,865
in CA and MA	(0.010)	(0.007)		(1.970)	
Firms in industries with short	0.016**	–0.010**	54,073	2.292*	13,817
patent lags	(0.007)	(0.005)		(1.325)	
Excluding states with no	–0.016	–0.017***	64,031	2.707***	14,586
tax changes	(0.010)	(0.004)		(0.752)	
Using R&D tax credits	–0.013	–0.013***	73,386	2.650***	16,780
until 2014	(0.008)	(0.004)		(0.863)	
Using changes in Carryback years	–0.013	–0.013***	73,386	2.637***	16,780
and Carryover years	(0.008)	(0.004)		(0.845)	
Panel B:	**Δ CwPat**			**Δ Ln(Cite-wt patents)**	
	Δ^- Tax rate VC (1)	Δ^+ Tax rate VC (2)	N (3)	Δ Ln(1 – VCτ) (4)	*N* (5)
Clustering by year	–0.006	–0.012***	73,386	5.268***	12,606
	(0.007)	(0.003)		(1.539)	
Clustering by industry	–0.006	–0.012***	73,386	5.268***	12,606
	(0.016)	(0.005)		(1.242)	
Clustering by firm	–0.006	–0.012**	73,386	5.268*	12,606

(continued)

Table VII. 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 – VCτ) (4)	*N* (5)
	(0.010)	(0.005)		(2.737)	
With firm fixed effects	–0.006	–0.013***	73,386	6.091**	12,606
	(0.012)	(0.005)		(2.489)	
Excluding firms which move HQ across states	–0.008	–0.013***	72,513	5.001*	12,441
	(0.011)	(0.005)		(2.890)	
Excluding firms located in CA and MA	0.002	–0.010**	29,328	8.213**	5,705
	(0.020)	(0.005)		(3.877)	
Firms in industries with short patent lags	0.013**	–0.011***	54,073	6.048	10,310
	(0.006)	(0.003)		(4.218)	
Excluding states with no tax rate changes	–0.007	–0.015***	64,031	4.365*	11,005
	(0.011)	(0.005)		(2.413)	
Using R&D tax credits until 2014	–0.006	–0.012***	73,386	5.268**	12,606
	(0.010)	(0.004)		(2.521)	
Using changes in Carryback years and Carryover years	–0.006	–0.012***	73,386	5.275**	12,606
	(0.010)	(0.004)		(2.500)	

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 tax variables with the corrected VC tax variables, that is, Δ^- Tax rate VC corr. and Δ^+ Tax rate VC corr. In this specification, we see a very similar result. We repeat these specifications and limit our sample to the top twenty 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)–(8), we use our alternative specification of Ln(Patents) as our dependent variable and Δ Ln(1 – τ) and Δ Ln(1 – VCτ) 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.

4.4. b. Different subsample analyses

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

Panel A of Table VII 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 that 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).[29] Further, we exclude firms located in the

29 In Table A.4 of Online 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

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, Jaffe, and Trajtenberg, 2001).[30] Focusing only on industries with short investment-patent lags, we find that the coefficient for Δ^{+} 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. In the last row, instead of indicator variables for Carryback and Carryover, we include the changes in the number of years of tax carryback and tax carryover allowed at the state level.

In Table VIII, we re-estimate our main analysis by including additional control variables. HHI controls for industry competition using the HHI, while HHI^2 accounts for nonlinearities 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 BDT policy and the DPAD scheme. These tax incentive policies both affect firm-level investment (Zwick and Mahon, 2017; Ohrn, 2018). Given 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.[31] Our findings are robust to those additional control variables. In the additional robustness tests reported in Table A.5 of Online Appendix A, we also show that our results are not significantly affected by truncation bias, time trends, and technological class trends.

4.4. c. Potential confound: local economic conditions

In this section, 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 neighboring 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

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.

30 We 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).

31 The 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).

Table VIII. 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 Δ LnPat, Δ Ln(Patents), Δ CwPat, and Δ Ln(Cite-wt patents) that represent different proxies of firm innovation measured one year after the current time period, *t*. See Table I 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.

	Δ LnPat	Δ Ln(Patents)	Δ CwPat	Δ Ln(Cite-wt patents)
	(1)	(2)	(3)	(4)
Δ^- Tax rate	0.018***		0.027***	
	(0.006)		(0.010)	
Δ^+ Tax rate	–0.004		–0.005	
	(0.003)		(0.003)	
Δ^- Tax rate VC	–0.009		–0.004	
	(0.006)		(0.009)	
Δ^+ Tax rate VC	–0.013***		–0.010***	
	(0.004)		(0.004)	
Δ Ln(1 − τ)		–0.811		3.696
		(1.028)		(2.555)
Δ Ln(1 − VCτ)		1.811*		3.670*
		(0.908)		(1.937)
Δ Carryback	–0.007	–0.109	0.007	–0.131
	(0.012)	(0.068)	(0.008)	(0.097)
Δ Carryover	0.012	0.011	0.009	0.029
	(0.008)	(0.038)	(0.008)	(0.058)
Δ Ln(GDP)	0.078	0.250	0.045	0.287
	(0.098)	(0.440)	(0.146)	(0.616)
Δ Per capita income	–0.005*	–0.011	–0.004	–0.011
	(0.003)	(0.013)	(0.005)	(0.030)
Δ Ln(Age)	0.233***	–0.062	0.126***	–0.029
	(0.017)	(0.058)	(0.024)	(0.135)
Δ Corporate tax	–0.022***	–0.007	–0.005	0.000
	(0.004)	(0.021)	(0.010)	(0.051)
Δ RD tax credit	0.024***	0.032*	0.003	0.008
	(0.007)	(0.019)	(0.006)	(0.037)
Δ Unemployment	–0.003	–0.019	0.006	–0.025
	(0.005)	(0.020)	(0.005)	(0.027)
Δ HHI	–0.280**	–1.220***	0.146	–1.283
	(0.121)	(0.368)	(0.164)	(0.894)
Δ HHI^2	0.290*	1.043**	–0.141	0.926
	(0.151)	(0.459)	(0.171)	(1.168)
Δ BDT	–2.984***	–2.627	–2.441*	–6.888*
	(0.829)	(2.169)	(1.224)	(3.598)
Δ DPAD	0.054	0.523***	0.134***	0.964***
	(0.043)	(0.110)	(0.050)	(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

unemployment rates), then these economic conditions should have a similar effect on start-ups that are located on either side of a neighboring border. Therefore, we should not find any difference between start-ups in treated states and their neighbors in untreated states just across the state border. Table A.5 in Online Appendix A presents the results. We find no evidence that the innovation of start-ups reacts to tax changes in neighboring 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).[32] Table A.6 in Online 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.

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.[33] 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.7 of Online 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.

4.5 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 section, 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 that can lead to lower innovation through income taxes in the VC firm's state are unlikely to explain the change in innovation

32 This 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

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

in the start-up's state.[34] 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 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). We test these hypotheses in our setting. Using data from Moretti and Wilson (2017) in our specification, we analyze 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.[35] 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.[36] 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).[37] 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).

34 Potential channels are loss of star scientists (Moretti and Wilson, 2017) and firms hiring fewer highly skilled workers (Campello, Gao, and Xu, 2019).

35 The results from both tests are reported in Table A.4 of Online Appendix A.

36 On 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.

37 Under 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.

5. 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, the number of start-ups written off by VC firms, as well as the size of their portfolios.

5.1 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 Keuschnigg and Nielsen (2003, 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 Casamatta, 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 investment and the size of the VC portfolio. First, the government sets tax policy. Then, the VC 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 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 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 toward the success of the start-up (Bernstein, Giroud, and Townsend, 2016).

Table IX 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, Δ Ln(Investment). The coefficient of the net-of-tax rate for the VC firm, Δ 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, Δ 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.

5.2 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

Table IX. Capital gains taxes and innovation: VC investments, and VC 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 Δ Ln(Investment) and Δ Ln(Firms) that represent the aggregate investment by the VC firm and the aggregate number of firms in its portfolio, respectively. See Table I for variables' definitions. Δ Ln(1 – VCτ) captures the change in the natural logarithm of (1 – VCτ), where VCτ 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 located. Controls are Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ Corporate tax, Δ RD tax credit, and Δ Unemployment. Additional controls are the one-year and two-year leads and lags of the main tax variable: Δ Ln(1 – VCτ). The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Δ Ln(Investment)		Δ Ln(Firms)	
	(1)	(2)	(3)	(4)
Δ Ln(1 – VCτ)	19.446***	20.171***	7.180***	8.355***
	(6.982)	(6.896)	(1.977)	(2.676)
Δ Carryback		0.071		–0.014
		(0.081)		(0.084)
Δ Carryover		0.013		0.016
		(0.126)		(0.037)
Δ Ln(GDP)		0.458		–0.515
		(1.517)		(0.446)
Δ Per capita income		–0.026		–0.040*
		(0.066)		(0.022)
Δ Corporate tax		0.179		0.104**
		(0.111)		(0.040)
Δ RD tax credit		0.106		–0.028
		(0.074)		(0.046)
Δ Unemployment		0.033		–0.018
		(0.093)		(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

tax at the VC level 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 (Galasso *et al.*, 2013; Akcigit *et al.*, 2022, 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 US Patent and Trademark Office (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.

Table X 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.[38] 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 X. 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.

5.3 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 firms. The partnership agreements of VC firms typically require funds to be returned to LPs within 10–12 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 defer gains indefinitely, in contrast to shareholders of corporate stocks (Sarin *et al.*, 2021). Yet, tax changes may influence the exit decision of GPs to a certain extent. An increase in the capital gains tax could incentivize GPs to hold on to their investments and delay the sales of start-ups with gains by waiting for IPOs.[39] Tax changes may influence GPs' exits from unsuccessful start-ups as well by accelerating their write-offs.

38 We aggregate patents sold and bought at the firm-year level. In the case of patent sales at the firm-year level, there are multiple transactions within the same firm-year observation. As a result, we end up with fewer observations for patents sold at the firm-year level when compared with patents bought at the firm-year level.

39 Jin (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.

Table X. Capital gains taxes and innovation: innovation exchanges within VC portfolios

This table presents the effect of the capital gains tax on innovation exchanges between the start-ups in a VC portfolio from an OLS regression. The dependent variables are measures of citations between start-up firms within the same VC portfolio, Δ Ln(Cites given) and Δ Ln(Cites received) and measures of patent transactions between start-up firms within the same VC portfolio: Δ Ln(Patents bought) and Δ Ln(Patents sold). See Table I for variables' definitions. Δ Ln(1 – τ) captures the change in the natural logarithm of (1 – τ), 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 located. Δ Ln(1 – VCτ) captures the change in the natural logarithm of (1 – VCτ), where VCτ 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 located. Controls are Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ Ln(Age), Δ Corporate tax, Δ RD tax credit, and Δ Unemployment. Additional controls are one-year and two-year leads and lags of the main tax variables: Δ Ln(1 – τ) and Δ Ln(1 – VCτ). 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.

	Δ Ln(Cites given)		Δ Ln(Cites received)		Δ Ln(Patents bought)		Δ Ln(Patents sold)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Ln(1 – τ)	–1.697	–2.746	–0.593	–0.420	2.399	2.314	–0.417	–0.359
	(3.646)	(3.831)	(3.082)	(3.046)	(2.013)	(1.890)	(4.537)	(4.154)
Δ Ln(1 – VCτ)	2.979*	2.745*	8.872***	8.609***	2.717**	2.882**	0.024	0.920
	(1.557)	(1.504)	(2.590)	(2.573)	(1.279)	(1.307)	(4.082)	(4.551)
Δ Carryback		–0.270***		0.466		0.031		0.110
		(0.096)		(0.278)		(0.072)		(0.163)
Δ Carryover		0.036		–0.029		–0.032		0.150
		(0.059)		(0.096)		(0.068)		(0.149)
Δ Ln(GDP)		–0.870		3.456*		0.887		2.234
		(1.270)		(1.995)		(0.938)		(3.299)
Δ Per capital income		–0.013		–0.106**		–0.022		0.019
		(0.028)		(0.043)		(0.026)		(0.057)
Δ Ln(Age)		–0.065		0.210		–0.056		0.064
		(0.117)		(0.305)		(0.074)		(0.275)
Δ Corporate tax		–0.037		–0.105**		–0.070**		0.150
		(0.084)		(0.039)		(0.033)		(0.129)
Δ RD tax credit		0.101*		0.026		–0.017		0.059
		(0.053)		(0.122)		(0.060)		(0.131)
Δ Unemployment		0.018		0.019		–0.011		–0.038
		(0.022)		(0.044)		(0.034)		(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

In Table XI, 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 in the first year after the current year, Δ Ln(IPO start-ups). Column (1) shows the results without control variables, while Column (2) incorporates the

Table XI. 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 Δ Ln(IPO start-ups) is the natural logarithm of the number of start-ups in the VC portfolio which successfully complete an IPO; Δ Ln(Write-off start-ups) is the natural logarithm of the number of start-ups in the VC portfolio which are written-off. See Table I for variables' definitions. Δ Ln(1 – VCτ) captures the change in the natural logarithm of (1 – VCτ), where VCτ 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 located. Controls are Δ Carryback, Δ Carryover, Δ Ln(GDP), Δ Per capita income, Δ Corporate tax, Δ RD tax credit, and Δ Unemployment. Additional controls are the one-year and two-year leads and lags of the main tax variable: Δ Ln(1 – VCτ). The standard errors, reported in parentheses, are heteroskedasticity consistent and clustered by state. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Δ Ln(IPO start-ups)		Δ Ln(Write-off start-ups)	
	(1)	(2)	(3)	(4)
Δ Ln(1 – VCτ)	0.046	–0.116	–0.874***	–1.167***
	(0.178)	(0.257)	(0.240)	(0.250)
Δ Carryback		0.014***		0.012
		(0.003)		(0.011)
Δ Carryover		–0.011***		0.006
		(0.004)		(0.014)
Δ Ln(GDP)		–0.071		0.247
		(0.122)		(0.240)
Δ Per capita income		0.004**		0.005
		(0.002)		(0.006)
Δ Corporate tax		0.002		–0.003
		(0.005)		(0.013)
Δ RD tax credit		0.003		0.005
		(0.006)		(0.011)
Δ Unemployment		0.007*		0.012*
		(0.003)		(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

control variables. In both specifications, we find that the coefficient estimate for the net-of-tax rate of the VC firm, Δ Ln(1 – VCτ), is not statistically significant.

In Columns (3) and (4) of Table XI, 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 in the first year after the current year, Δ Ln(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 favor 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.

5.4 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 in public stock (Holt and Shelton, 1961). This behavior can lead to a less active public equity market, and more patient investors (Feldstein, Slemrod, and Yitzhaki, 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.8 of Online Appendix A.

6. 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 USA. 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.

7. 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 USA. President Biden's Fiscal Year 2022 Revenue Proposals include a proposition to tax carried interest as ordinary income.[40] The potential enactment of this provision will affect GPs in both VC firms and private equity funds. Typically, securities held in these funds 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 (Poterba, 1989b; Gentry and Hubbard, 2000). 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 USA is 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.

Data Availability Statement

Part of the data underlying this article were provided by the following proprietary databases: Thomson Reuters VentureXpert and Clarivate Analytics. Data will be shared on request to the corresponding author conditional on permission from the third parties listed above.

Supplementary Material

Supplementary data are available at *Review of Finance* online.

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40 The 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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