Investing in Innovation and CEO Termination

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ABSTRACT: I examine how investing in innovation affects CEO termination. Theory argues that firms investing in innovation will reduce their propensity to terminate their CEOs to encourage risk taking and long-term thinking. Consistent with these arguments, I find that firms affected by the plausibly exogenous passage of research and development tax credits invest more in innovation, produce more innovative output, and decrease their propensity to terminate their CEO. Firms appear to commit *ex ante* to reduced termination by decreasing their board independence. I also find evidence that CEO termination decreases more when innovative projects are longer-horizon, but no evidence that CEO termination decreases more when innovative projects are riskier.

Keywords: CEO termination, innovation

JEL classification: J41, O31, O32

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All errors are my own.

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1. Introduction

The production of new knowledge, or innovation, is arguably the central driver of economic growth in developed economies (e.g., Solow, 1957). Economic actors responding to market incentives are responsible for the majority of innovation (e.g., Romer, 1990; Porter, 1992). Consequently, private investments in innovation have received a great deal of academic attention. However, motivating agents to invest in innovation is theoretically challenging, and different from incentivizing other types of investments (e.g., Holmstrom, 1989; Manso, 2011). Innovative projects have a high risk of failure and long-term payoffs, and agents may be unwilling to invest in these projects as a result. In this paper, I examine how firms investing in innovation change their propensity to terminate the CEO in light of these challenges.

There are several theoretical arguments for why firms investing in innovation might change their propensity to terminate their CEO. Manso (2011) argues that a key challenge facing innovative firms is potential horizon mismatches between shareholders and CEOs. He models innovation as an investment with long-term payoffs, consistent with the evidence in Lev and Souigiannis (1996) that research and development (R&D) expenditures affect firm performance with a significant delay. He argues that shareholders are more willing to accept projects with long-term payoffs than are CEOs, who have a relatively shorter horizon because of their career concerns (e.g., Gopalan, Millbourn, Song, and Thakor, 2014). Manso's (2011) model suggests that firms investing in innovation will reduce their propensity to terminate their CEO to encourage them to think long-term.

While Manso (2011) assumes away differences in risk preferences between shareholders and CEOs to focus on potential horizon problems, Holmstrom (1989) takes the opposite approach. He models innovation as a single period investment with a high risk of failure, consistent with the evidence in Kothari, Laguerre, and Leone (2002) that investments in R&D increase earnings volatility. He argues that CEOs whose compensation, wealth, and/or career outcomes are sensitive to their firm’s performance are willing to reject risky, but positive net present value, projects. His model suggests that firms investing in innovation will reduce their propensity to terminate their CEO to encourage them to take risk.

Despite the arguments of Holmstrom (1989) and Manso (2011), there are several reasons why investing in innovation might not affect CEO termination. If boards or shareholders can observe investments in innovation and identify the optimal investment, they would not need to delegate decision rights to CEOs. Relatedly, CEOs might not make the decision to invest in innovation or be responsible for the outcomes of the innovative process. In these cases, firms would not have to rely on costly incentive mechanisms, such as reduced termination, to motivate CEOs to make optimal decisions.

Similarly, there are several reasons why firms investing in innovation might *increase* their propensity to terminate their CEOs. Both Holmstrom (1989) and Manso (2011) suggest firms investing in innovation will reduce CEO termination via an *ex ante* commitment. If firms lack a credible mechanism to commit to reduced termination, their models suggest investing in innovation will increase CEO termination. Relatedly, reduced termination might increase the scope for CEOs to shirk or invest in “pet” projects. Consequently, firms investing in innovation might view reduced termination as too costly and instead rely on other incentive mechanisms, such as convex or long-term compensation schemes. In this case, firms might increase CEO termination if investing in innovation increases the scope for shirking. Finally, firms investing in innovation might also fire incumbent CEOs if these CEOs are not a good fit for overseeing innovation, again resulting in a positive relation between investing in innovation and CEO termination.

Therefore, the relation between investing in innovation and CEO termination is theoretically ambiguous and ultimately an empirical question. However, despite the economic importance of innovation and the ambiguous relation between investing in innovation and CEO termination, prior work has not investigated this relation. There are two likely reasons for this gap in the literature. First, it is difficult to measure CEO termination. To overcome this challenge, I classify CEO turnover into forced and unforced turnover using the press announcement based classification introduced by Peters and Wagner (2014) and Jenter and Kanaan (2015). Second, the relation between termination and innovation is likely endogenous, making it difficult to draw credible inferences. For example, reduced risk of termination likely also affects innovation, resulting in a potential reverse causality problem.

To address the endogenous relation between investing in innovation and termination, I use the staggered passage of research and development (R&D) tax credits by different states at different times as shocks to investments in innovation (e.g., Bloom, Schankerman, and Van Reenen, 2013).[1] Many of these R&D tax credit changes were significant, ranging from effective increases of 20% to decreases of 15% during my sample period. I find that firms whose scientists work in states that implemented R&D tax credits significantly increased their investments in innovation, as measured by R&D expenditures. I also find that these firms produced relatively more innovative output, as measured by patent filings, citations on those patents, and the equity market announcement returns to patent approvals (Hall, Jaffe, and Trajtenberg, 2005; Kogan, Papanikolaou, Seru, and Stoffman, 2017). These latter results suggests that these firms substantially increased their relative innovative activity, and did not merely shift their classification or reporting of R&D expenditures.

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[1] Bloom et al. (2013) provide a discussion of the exogeneity of state R&D tax credits, available at https://www.econometricsociety.org/sites/default/files/9466_extensions_0.pdf.

Consistent with the predictions of Holmstrom (1989) and Manso (2011), I find that firms investing in innovation significantly reduce their propensity to terminate their CEOs. I also find that the sensitivity of CEO termination to stock market performance decreases when firms invest in innovation. My results suggest that a 10% increase in investments in innovation results in a 0.3 to 3.7 percentage point decrease in the likelihood of CEO termination. Therefore, my results not only show that investing in innovation decreases CEO termination, but also show that investing in innovation is an economically important determinant of CEO termination.

I extend my main results in two important ways. First, I examine whether firms investing in innovation commit to reduced CEO termination. Theory argues that firms investing in innovation will reduce CEO termination via an *ex ante* commitment, as boards may otherwise find it optimal to terminate the CEO *ex post* (e.g., Hermalin and Weisbach, 1998; Manso, 2011). I hypothesize that boards can make such a commitment by decreasing their independence, as evidence suggests that independent directors more aggressively monitor CEOs.[2] Consistent with this hypothesis, I find that a 10% increase in investments in innovation results in a 0.3 to 3.2 percentage point decrease in board independence.

Second, I examine the mechanism through which innovation causes a decline in CEO termination. Although Holmstrom (1989) and Manso (2011) make the same prediction regarding the relation between investing in innovation and CEO termination, their predictions arrive via the influence of different forces. While Holmstrom (1989) suggests that firms investing in innovation will reduce CEO termination to encourage risk-taking, Manso (2011) suggests that firms investing

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[2] E.g., Weisbach (1988), Hermalin and Weisbach (1998), and Knyazeva, Knyazeva, and Masulis (2013). Similarly, stock exchanges and governance committees have justified minimum board independence requirements and recommendations by arguing that non-independent directors are ineffective monitors of the CEO (see, e.g., section 303A.01 of the NYSE listing manual, or similar justifications and recommendations by the NASDAQ, the U.K.'s Cadbury Committee, and the Korean Stock Exchange).

in innovation will reduce CEO termination to encourage long-term thinking. Although prior work on innovation frequently cites both horizon and risk concerns for motivation, the two are distinctly different concepts. For example, a 30-year Treasury bond is a long-horizon and low-risk investment, while a CCC rated one-year corporate bond is a short-horizon and high-risk investment. Therefore, I examine the relative contribution of the expected risk and horizon of R&D investments to changes in CEO termination.

To measure the expected risk and horizon of R&D investments, I use inter-industry differences in the historical relation between R&D investments, subsequent risk, and the delay until performance realization. The intuition for this approach is that that the results of innovative investments are impossible to describe at the investment stage (e.g., Aghion and Tirole, 1994; Tirole, 1999). Consequently, CEOs and boards likely face considerable uncertainty about the expected risk and horizon of R&D investments and may rely heavily on the "typical" such relation in their industry to form their expectations. Therefore, I use the historical risk and horizon of R&D investments in the firm's industry as proxies for the expectations of CEOs and boards.

Consistent with Manso (2011), I find that the relation between investing in innovation and CEO termination is stronger when the expected delay between investments in innovation and subsequent patenting activity is longer. Inconsistent with Holmstrom (1989), I find no evidence that the relation between investing in innovation and CEO termination varies with the expected relation between investments in innovation and changes in return volatility. This asymmetry may occur because boards can use many alternative mechanisms other than reduced termination to encourage CEOs to take risk (e.g., options and bonus schemes). In contrast, boards may have few mechanisms other than reduced termination to encourage CEOs to think long-term because of the difficulty and cost of contracting around post-employment outcomes. Regardless, in total the results are consistent with firms investing in innovation reducing their propensity to terminate their CEOs to encourage long-term thinking.

My results contribute to the literature on innovation by documenting how investing in innovation affects CEO termination.[3] In addition, I separately examine the effect of the expected horizon and risk of innovative investments. Prior work on the determinants and consequences of innovation typically cites one or both of horizon and risk problems for motivation, without considering the separate contribution of each (e.g., Holthausen et al., 1995). As my findings demonstrate, the horizon and risk of innovative investments may result in different effects.

I also contribute to the literature on corporate governance by documenting evidence that firms investing innovation decrease their board independence. Critics have argued that decreased board independence protects the CEO from the consequences of poor performance, and is therefore inefficient (e.g., Bebchuk and Fried, 2004). However, my results suggest that firms investing in innovation decrease their board independence, consistent with the Manso's (2011) argument that boards can use decreased board independence to encourage innovation.

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[3] Among the literature on innovation most closely related to my work, authors have found innovation shares a U-shaped relation with product market competition (Aghion, Bloom, Blundell, Griffith, and Howitt (2005); is increased by leveraged buyouts (Lerner, Sorenson, and Stromberg, 2011); is increased by CEO overconfidence (Hirshleifer, Low, and Teoh, 2012); decreased by institutional investors (Aghion, Van Reenen, and Zingales, 2013); related to antitakeover provisions for IPO firms; decreased by analysts (He and Tian, 2013); increased by wrongful discharge laws (Acharya, Baghai, and Subramanian, 2013); increased by corporate venture capitalists, relative to independent venture capitalists (Chemmanur, Loutskina, and Tian, 2014); decreased by stock liquidity (Fang, Tian, and Tice, 2014); increased by financial market development (Hsu, Tian, and Xu, 2014); decreased by conglomeration (Seru, 2014); increased by failure tolerant venture capitalists (Tian and Wang, 2014); increased by interstate banking deregulation (Cornaggia, Mao, Tian, and Wolfe, 2015); decreased by dependence on external financing (Acharya and Xu, 2017); decreased by unionization (Bradley, Kim, and Tian, 2016); increased by hedge fund activism (Brav, Jiang, Hsu, and Xi, 2016); decreased by policy uncertainty (Bhattacharya, Hsu, and Xu, 2017); increased by foreign institutional ownership (Luong, Moshirian, Nguyen, Tian, and Zhang, 2017); hindered by corporate taxes (Mukherjee, Singh, and Zaldokas, 2017); and reduced by mutual fund manager myopia Agarwal, Vashishtha, and Venkatachalam (2017). Atanassov, (2013); Chemmanur and Tian, (2014); Baranchuk, Kieschnick, and Moussawi (2014); Sapra, Subramanian, and Subramanian (2014) and Karpoff and Wittry (2016) find conflicting evidence on the relation between innovation and antitakeover provisions.

Finally, I contribute to the literature on CEO termination. The vast majority of studies in this literature document how stock or accounting performance, corporate governance, or industry conditions relate to CEO termination.[4] I add to this literature by documenting a novel determinant of CEO termination and by documenting evidence consistent with boards intentionally adjusting CEO termination to accomplish incentive goals. Shielding CEOs from termination is arguably both an extremely powerful and an extremely costly incentive mechanism, relative to compensation incentives.[5] My results are consistent with boards and CEOs implicitly contracting on termination, in addition to explicitly contracting on compensation. Consequently, my results also suggest a potential explanation for why boards appear to terminate CEOs too infrequently (e.g., Taylor, 2010). As Hermalin and Weisbach (1998) and Manso (2011) argue, a termination rule that is *ex post* inefficiently lenient may be optimal because it provide benefits *ex ante*. My results suggest that such an *ex ante* commitment could explain the low rate of CEO termination.

I organize the remainder of the paper as follows. I discuss the theoretical motivation for my study and provide background information in Section 2. I discuss my sample, data sources, and variable measurement in Section 3. I present my results in Section 4 and provide concluding remarks in Section 5.

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[4] For examples of studies in the first group see Coughlan and Schmidt (1985), Kang and Shivdasani (1995), Engel, Hayes, and Wang (2003), Farrell and Whidbee (2003), Lehn and Zhao (2006), Bushman, Dai, and Wang (2010); for examples in the second group see Weisbach (1988), Mikkelson and Partch (1997), Huson, Parrino, and Starks (2001), Parrino, Sias, and Starks (2003), DeFond and Hung (2004), Huson, Malatesta, and Parrino (2004), Taylor (2010), Coles, Daniel, and Naveen (2014); for examples in the third group see DeFond and Park (1999), Eisfeldt and Kuhnen (2013), Peters and Wagner (2014), Jenter and Kanaan (2015). Campbell, Gallmeye, Johnson, Rutherford, and Stanley (2011) are an exception, they find CEO optimism decreases CEO turnover.

[5] Peters and Wagner (2014) find that a one percentage point increase in termination risk is associated with a 7% greater subjective value of compensation, suggesting a substantial compensating wage differential for termination risk. Taylor (2010) finds that shareholder value would rise 3% if firms eliminated perceived CEO termination costs, suggesting forgoing optimal *ex post* termination policies is extremely costly.

2. Theoretical Motivation and Background

2.1. Innovation and termination

The innovation literature suggests that successfully innovating requires long-term thinking and a tolerance for risk. However, the governance literature suggests that CEOs have a shorter time horizon and greater risk aversion than shareholders. Therefore, motivating innovation likely entails addressing an agency conflict between CEOs, who are averse to investing innovation, and shareholders, who would like CEOs to take all positive NPV projects. Even if the CEO were to invest in innovation, he or she still might invest only in safe or short-horizon innovative projects, and avoid risky or long-horizon projects.

Manso (2011) examines one such agency conflict in a two period model in which all parties are risk neutral. In the first period, the agent chooses between innovating, which is modeled as the exploration of an untested idea, or continuing business as usual. Innovating endows the agent with valuable information about the attractiveness of the untested idea. If the innovative project is a failure, the agent can return to business as usual in the second period. Conversely, if the innovative project is a success, the agent can continue to pursue the project in the second period. However, innovating also entails a high chance of initial failure. The agent is averse to innovating because he is concerned about the effect of initial failure on his subsequent compensation and employment. If forgoing innovation is sufficiently attractive to the agent, the principal must incentivize him to pursue innovation. She can do so by committing to a threshold for termination that is below the *ex post* efficient threshold ("excessive continuation"). Therefore, Manso (2011) suggests that firms investing in innovation may reduce their propensity to terminate their CEO to encourage investment in long-term innovative projects, resulting in a negative relation between investing in innovation and CEO termination.

While Manso (2011) assumes away differences in risk preferences between agents and principals to focus on horizon problems, Holmstrom (1989) takes the opposite approach. In his model, there is only one period, preventing any horizon problems. However, the agent is risk-averse and the principal is risk neutral. As a result, the agent is more averse to investing in risky innovative projects. To mitigate the agent's risk concerns, the principal can commit to reduced termination, effectively shielding the agent from some negative outcomes. Therefore, Holmstrom (1989) suggests that firms investing in innovation may reduce their propensity to terminate the CEO to encourage investment in risky innovative projects, resulting in a negative relation between investing in innovation and CEO termination.

Prior work indirectly supports the arguments of Holmstrom (1989). For example, Aghion et al. (2013) and Luong et al. (2017) find that institutional investor ownership increases firm innovation, and argue that this effect occurs because institutional investors shield CEOs from the consequences of poor performance. Tian and Wang (2014) find that failure tolerant venture capitalists are associated with higher levels of innovation. Acharya et al. (2014) find that wrongful discharge laws increase firm innovation. Together, these studies suggest that aspects of the corporate environment that increase the tolerance for failure can increase firm innovation.

Prior work also indirectly supports the arguments of Manso (2011). For example, He and Tian (2013) find that analyst following reduces innovation, and argue that this effect occurs because analyst following causes CEOs to focus on the short term. Similarly, Agarwal et al. (2017) find that shocks to mutual fund managers' focus on the short term reduces innovation, and argue that this effect occurs because mutual fund manager's focus on the short term causes corporations to focus on the short term. Together, these studies suggest that aspects of the corporate environment that increase CEOs' focus on the short term can decrease firm innovation.

However, these studies provide only indirect evidence on the relation between investing in innovation and CEO termination. While institutional ownership, failure tolerant venture capitalists, analyst following, and myopic mutual fund managers likely affect innovation, the mechanism through which they affect innovation might not be changes in CEO termination risk. Similarly, while wrongful discharge laws affect employee termination, there is no evidence they affect CEO termination.[6] Even if termination risk affects CEOs' incentives to invest in innovation, investing in innovation might not necessarily affect CEO termination. For example, any effect of termination risk on investing in innovation might be driven by the termination risk of scientists or R&D executives, and unrelated to the termination of CEOs. Furthermore, firms seeking to incentivize CEOs to invest in innovation might rely on alternative incentive mechanisms, such as convexity in CEOs' compensation. Therefore, the relation between investing in innovation and CEO termination is ultimately an open question.

2.2. Identification

While Holmstrom (1989) and Manso (2011) suggest that investing in innovation can affect CEO termination, their arguments are predicated on the converse being true (i.e., their arguments are based on the notion that CEO termination risk affects CEOs' incentives to invest in innovation). Therefore, any correlation between investing in innovation and CEO termination might partially reflect the effect of CEO termination risk on investing in innovation. To address this potential issue, I use a shock to investments in innovation that is otherwise exogenous with respect to CEO termination.

Following Bloom et al. (2013), I use changes in R&D tax credits by different states at different times as an instrument for investing in innovation. The intuition for the instrument is that

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[6] I find that employee wrongful discharges laws are unrelated to, or even positively related to, CEO termination.

tax credits reduce the user-cost of R&D, encouraging affected firms to increase their investment in R&D. Prior literature also highlights a large degree of randomness in the passage of state R&D credits, suggesting that R&D tax credits are otherwise exogenous with respect to CEO termination. For example, Chirinko and Wilson (2008) find that aggregate variables, such as federal tax credits, have some explanatory power for the evolution of state R&D tax credits, but that local economic conditions and political conditions have little explanatory power. Similarly, Kim (2010) finds that states did not adopt R&D tax credits in response to organized private interests and Bloom et al. (2013) find that state-level R&D expenditures and GDP do not have any explanatory power for the evolution of state R&D tax credits.

However, prior work suggests that states enacted R&D tax credits in response to declining state tax revenues (Kim, 2010; Miller and Richard, 2010). To the extent that these declining state revenues were also correlated with changes in the performance of firms headquartered in the state, these changes in state economics could drive my results. To address this potential issue, I include controls for state economic conditions (e.g., state budget balances, changes in state gross domestic balances) and controls for firm performance (e.g., return on assets, equity market returns). Prior work also suggests that changes in R&D tax credits were often part of a larger tax reform (Miller and Richard, 2010) and that state corporate and personal income taxes may affect the R&D spending of firms headquartered there (Ljungqvist, Zhang, and Zuo, 2016 and Armstrong, Glaeser, Huang, and Taylor, 2017, respectively). Consequently, concurrent changes in state taxes may represent potential correlated omitted variables. To address this issue, I include controls for taxes at the state level (e.g., personal income taxes on top managers, corporate income taxes, and non-R&D tax credits) and for firms' effective tax rates.

In total, prior literature suggests that states may have enacted R&D tax credits in response to declining tax revenues and as part of larger tax reforms. Therefore, I include several controls for firm and state economic performance and taxation. Nonetheless, even in the absence of these controls, declining tax revenues or changes in taxation are unlikely to drive my results. For example, if declining tax revenues are correlated with declining firm performance, this should, if anything, increase CEO termination.

3. Measurement and sample

3.1. Innovative activity

I measure investments in innovation using innovative input and output based measures. I measure innovative inputs using R&D expenditures as reported in the Compustat database (*R&D*). Following Koh and Reeb (2015), I replace missing values of R&D with zeroes and include an indicator for missing R&D (*Missing R&D Indicator*). A potential issue with using R&D expenditures to measure investments in innovation is that prior work suggests that R&D tax credits affect the measurement of innovative inputs by more than they affect real investments in innovation.

In particular, prior work argues that R&D tax credits encourage firms to reclassify non-R&D expenses as R&D and increases the demand for R&D (e.g., Berger, 1993; Hall, 1993). Consequently, the relation between changes in R&D tax credits and reported R&D may partially reflect the reclassification of non-R&D expenditures into R&D and changes in the price of R&D driven by increased demand for R&D. For example, increased demand for innovative inputs might increase the demand for scientists' labor, raising scientists' wages for the same labor level. Consequently, R&D tax credits may increase R&D by more than they increase real investments in innovation because they effect the price of innovative inputs. This effect should be limited in my setting because the effect of *state*-level changes in R&D tax credits on the total demand for R&D should be proportional to the share of total demand concentrated in the credit state.

Nonetheless, I address any interpretational issues due to using R&D to measure investments in innovation by also using measures of innovative output (e.g., reclassification of non-R&D expenses should not affect the rate of innovative output). Specifically, I complement my innovative input measure with innovative output measures derived from patenting activity. I measure innovative output using the count of patents filed by the firm in a given year (*Patents Filed*), the count of forward-citations those patents received (*Patent Citations*), and the Kogan et al. (2016) measure of patent values, which is based on the equity market reaction to patent approvals (*Total Patent Value*). I obtain my output-based measures of innovative activity from Kogan et al. (2016).[7] The authors download the entire history of U.S. patent documents from the Google Patents database and match patent assignees to CRSP firms. Following prior work, I use the patent's file date instead of its grant date, as there is typically at least a year's lag between file date and grant date.

3.2. State R&D tax credits

I measure state R&D credits using the *effective* credit rate, as states frequently design credits so that the effective rate is substantially different from the statutory rate. For example, some states recapture (tax) R&D credits, reducing the effective credit rate by the state corporate income tax rate. Furthermore, some states calculate the credit base on a rolling basis, so that a credit applied today reduces future opportunities to claim a credit. Therefore, I use Wilson's (2009) measures of the highest tier R&D effective tax credit rates to account for these differences in the application of

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[7] I thank the authors for generously providing their data upon request.

R&D credits across states and within states over time.[8] I list all changes in effective credit rates greater than 0.1% in magnitude in Appendix B, by state and year.

I measure firms' exposure to state R&D tax credits using the location of firms' R&D activities. Following prior work, I use the location of a firm's inventors, identified from the NBER patent database, to determine the distribution of the firm's R&D activities across states (e.g., Griffith, Harrison, and Van Reenen, 2006; Bloom et al., 2013). To ensure my results are not driven by inventor relocation, I lag investors' locations by one year. The resulting measure, *R&D Credit Rate*, measures the firm's effective R&D credit rate, weighted by the location(s) of its inventors:

$$R\&D\ Credit\ Rate_{i,t} = \sum\nolimits_{s=1}^{n} \frac{Scientists\ in\ State\ s_{i,t-1}}{Total\ \#\ Scientists_{i,t-1}} \times Effective\ Credit\ Rate_{s,t-1}$$

where *s* indexes states, *t* indexes years, and *i* indexes firms.

3.3. CEO termination

I follow Peters and Wagner (2014) and Jenter and Kanaan (2015) to identify CEO termination.[9] The authors identify CEO turnover for all years in which the CEO identified in Execucomp changes. They then search Factiva news for the turnover announcement date and the description of the turnover. To identify the reason for CEO turnover, the authors follow Parrino (1997) and classify all departures for which the press reports that the CEO is fired, forced out, or retires or resigns due to policy differences or pressure as forced. Otherwise, the authors classify the departure as unforced if the CEO is older than 59. If the CEO is younger than 60 the authors further review the departure and classify it as forced if either the press does not report the reason

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[8] I thank the author for generously providing their data upon request. I use the state effective credit rate without attempting to estimate firms' eligibility for claiming the credit (e.g., whether the firm has a taxable gain it can offset with a credit). I do so because firm performance is endogenously determined, while state credit rates are arguably exogenous. Consequently, using information about firm performance to calculate firm-specific eligibility makes the resulting instrument endogenous.

[9] I thank the authors for generously providing their data on CEO turnover upon request.

as death, poor health, or the acceptance of another position (including chairmanship of the board), or the press reports that the CEO is retiring but does not announce the retirement at least six months before the succession. Finally, the authors reclassify cases classified as forced if the reports convincingly explain the departure as due to reasons unrelated to the firm's activities.

3.4. Sample and controls

I require non-missing data for control variables from the Compustat, CRSP, Thomson Reuters 13-F filing, and I/B/E/S databases, and the various databases of state characteristics. I include several controls for state and firm performance because prior work suggests the passage of R&D tax credits was often a response to declining state tax revenues (e.g., Kim, 2010; Miller and Richard, 2010). In particular, I include the percentage change in state domestic product, or *Gross State Product*; the state budget balance, or *Budget Balance*; the state unemployment rate, or *Unemployment Rate*; the firm's income before extraordinary items scaled by assets, or *Return on Assets*; the firm's buy and hold returns over the fiscal year, or *Returns*; an indicator equal to one if the firm's net income was negative, or *Loss Indicator*; and the natural logarithm of the firm's market value of equity, or *ln(Market Value)*.

I also include several controls for state and firm tax positions because prior work suggests the passage of R&D tax credits was often part of larger tax reforms. In particular, I include the state's top statutory tax rate on corporate income, or *Corporate Tax Rate*; the effective marginal tax rate on individuals in the top-bracket that live in the state identified as in Armstrong et al. (2018), or *Manager Tax Rate*; the number of years which a firm can carry back a net operating loss in the state, or *Carryback*; the number of years which a firm can carry forward a net operating loss in the state, or *Carryforward*; an indicator for whether the state offers a tax credit for job creation, or *Job Credit Indicator*; an indicator for whether the state offers a grant for job creation, or *Job Grant Indicato*r; the state investment tax credit rate, or *Investment Tax Credit*; the firm's cash taxes paid scaled by pre-tax income, or *Cash Effective Tax Rate*; and the firm's GAAP reported income taxes, scaled by pre-tax income, or *GAAP Effective Tax Rate*.

I also include controls for the percentage of equity held by institutions, or *Institutional Ownership %,* and the natural logarithm of one plus the number of investors who hold 5% or more of the firm's shares, or *ln(Blockholders)*, because prior work suggest institutional ownership affects firm innovation (Aghion et al., 2013). I also include the natural logarithm of one plus the number of analysts who follow the firm, or *ln(Analysts)*, because prior work suggests analysts affect firm innovation (He and Tian, 2013). Finally, I include the ratio of the firm's book value of debt to the book value assets, or *Leverage*; the standard deviation of the firm's monthly returns, or *sigma(Returns)*; an indicator if R&D was missing, or *Missing R&D Indicator*; and the ratio of plant, property, and equipment, to assets, or *Capital Intensity*.

I also include an indicator for whether the state has passed the Uniform Trade Secret Act, or *UTSA*, as prior work suggests the UTSA increased firms' investments in innovation and decreased their patenting rates (e.g., Png, 2017; Glaeser, 2018). Similarly, I include indicators for wrongful discharge laws, or *Good Faith Exception*, *Implied Contract Doctrine*, and *Public Policy Exception* (Acharya et al., 2014); an indicator for state antitakeover laws, or *Business Combination Law* (Atanassov, 2013); indicators for the political party makeup of the state's government, or *Republican Governor* and *Republican Legislature*; and an indicator for whether the state has enacted the inevitable disclosure doctrine, or *Inevitable Disclosure Doctrine*.

I control for the above state characteristics because prior suggests they may affect firm innovation, and could be correlated with the passage of R&D tax credits or CEO termination. Although these state characteristics affect firms based on their headquarters location or state of incorporation, and not based on the locations of their R&D activity, public firms conduct the majority of their R&D activities at or near the firm's headquarters (e.g., Lund, 1986; Howells, 1990; Breschi, 2008). Many firms are also incorporated in the same state they are headquartered. Therefore, the effects of these state characteristics may be correlated with the effect of R&D credits. Including these state characteristics can also explain variation in innovation or CEO termination that is unrelated to R&D credits, increasing the precision of my empirical estimates.

A concern with these variables is that Compustat backfills firms' headquarters state and state of incorporation, leading to errors when firms move their headquarters or change their state of incorporation. To address this concern, I use the headquarters and incorporation data first used in Dyreng, Lindsey, and Thornock (2013) and Jennings, Lee, and Matsumoto (2017). Dyreng et al. (2013) use Exhibit 21 header data collected from the SEC EDGAR database to identify firms' headquarter location and state of incorporation, while Jennings et al. (2017) use a text search of all 10-Ks on the SEC EDGAR database. In cases where the two disagree, I use the Jennings et al. (2017) data because the header data is frequently updated well after a location or incorporation change and not retroactively corrected.[10]

The sample begins in 1995 because of data availability for state government political party membership and state economic growth. The sample ends in 2007 because the patent database ends in 2010 and I exclude the last three years of the database to address potential truncation bias in patent filings and citations. Patent data involves truncation bias because citations are a forward-looking measure, and because patents do not appear in the database until they are granted (e.g., a patent granted in the last year of the database will have received very few citations and some filed

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[10] The Dyreng et al. (2013) data is available on Scott Dyreng's website: https://sites.google.com/site/scottdyreng/Home/data-and-code/EX21-Dataset. The Jennings et al. (2017) data was provided upon request. I thank the authors of both studies for generously making the data publicly available.

patents that are in process in the year the database ends will not yet appear because they have yet to be granted). Hall, Jaffe, and Trajtenberg (2001) find that more than 95% of all citations are received in the first three years of the patent life and suggest that researchers can include only observations that occur prior to the last three years of the patent database to address potential truncation bias. In addition to following their suggestion, I also include year fixed effects in all tests to further address any truncation bias.

4. Results

4.1. R&D tax incentives and innovation

To measure the effect of R&D tax incentives on firms' innovative activity, I estimate the following differences-in-differences regression:

$$ln(Innovative\ Activity_{i,t+1} + 1) = \beta_0 + \beta_1 ln(1 - R\&D\ Credit\ Rate_{i,t}) + \gamma' X_{i,t} + FirmFE + Industry\text{-}YearFE + \varepsilon_{i,t+1} \quad (1)$$

where *Innovation* is each of my measures of innovative activity (e.g., R&D spending, patent filings, etc.). I include *1 – R&D Credit Rate* instead of *R&D Credit Rate* so that I can take the natural logarithm of the variable without transformation, and because the resulting measure corresponds to the tax cost of R&D. I take the natural logarithm of *Innovation* and *1 – R&D Credit Rate* so that the β_1 coefficient has the interpretation of an elasticity (i.e., so that the interpretation is that a 1% change in the tax cost of R&D results in a β_1% change in *Innovation*).

I include firm fixed effects to control for time invariant aspects of the firm. I include fixed effects for each Fama-French 48 industry in each year to control for common macroeconomic shocks and industry cycles in CEO turnover (e.g., Eisfeldt and Kuhnen, 2013; Guay, Taylor, and Xiao, 2013; Jenter and Kanaan, 2015). I also include a large number of time-varying state and firm characteristics that prior work argues are correlated with innovation and/or CEO termination. I include these characteristics to assuage any remaining concerns that my results are due to correlated omitted variables. I also include these characteristics to explain variation in innovation and CEO termination that is unrelated to changes in R&D tax credits, increasing the precision of the model's estimates. In all specifications, I report standard errors clustered by headquarters state and year.

I report the results of estimating Eq. (1) in Table 2. I find that the elasticity of innovation with respect to the tax cost of R&D is large. The results suggest that a 1% decrease in the tax cost of R&D results in an increase in innovative activity of 0.44% to a 5.16% (*t*-statistics of -3.31 to -5.06).[11] In total, the results suggest that changes in R&D tax credits have an economically and statistically significant effect on firms' investments in innovation. Therefore, *ln(1-R&D Credit Rate)* is likely a valid instrument for investing in innovation.

4.2. Investing in innovation and CEO termination

To measure the effect of investing in innovation on CEO termination, I first estimate a reduced form differences-in-differences regression:

$$Termination_{i,t+1} = \beta_0 + \beta_1 ln(1\text{- } R\&D\ Credit\ Rate_{i,}) + \gamma' X_{i,t} + FirmFE + Industry\text{-}YearFE + \varepsilon_{i,t+1} \quad (2)$$

where *Termination* is the press announcement based classification of CEO termination introduced by Peters and Wagner (2014) and Jenter and Kanaan (2015). The other variables are defined as in Eq. (1). I also estimate combined differences-in-differences and instrumental variables specifications (IV-DiD). The first stage regression is represented by Eq. (1) and the results are reported in Table 2. I use the fitted values of *Innovation* from the first stage in second stage differences-in-differences specifications:

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[11] This result is similar to those in prior studies on the elasticity of innovative investments with respect to tax incentives (e.g., Hall and Van Reenen, 2000).

$$Termination_{i,t+1} = \beta_0 + \beta_1 \widehat{Innovation} + \gamma' X_{i,t} + FirmFE + Industry\text{-}YearFE + \varepsilon_{i,t+1} \quad (3)$$

I report the results of estimating Eqs. (2) and (3) in Table 3. I report the *F*-statistics for *ln(1-R&D Credit Rate)* as an instrument for *Innovation* below the second stage regression results reported in Columns (2) – (5). Each of the reported *F*-statistics is above the recommended minimum value of ten from Stock and Yogo (2005).[12]

The results of the reduced form regression reported in column (1) suggest that a 10% decrease in the tax cost of R&D results in a 1.8 percentage point decrease in CEO termination (*t*-statistic of 2.77). In columns (2) – (5) I report the second stage results of a regression of *Termination* on the fitted values of *Innovation*. The results reported in columns (2) – (5) suggest that a 10% increase in innovative activity results in a 0.3 to a 3.7 percentage point decrease in CEO termination (*t*-statistics of -1.97 to -2.91). In total, the results suggests that firms investing in innovation reduce their propensity to terminate their CEOs.

4.3. Investing in innovation and board independence

To measure whether boards appear to commit to reduced CEO termination *ex ante*, I modify Eqs. (2) and (3) by replacing *Termination* as the dependent variable with *Board Independence*. I report the results in Table 4. The results of the reduced form regression reported in Column (1) suggest that a 10% decrease in the tax cost of R&D results in a 1.5 percentage point decrease in *Board Independence*, equivalent to 7.5% of the sample standard deviation of *Board Independence* (*t*-statistic of 2.76). The results of the IV-DiD regressions reported in columns (2) – (5) suggest that a 10% increase in innovative activity results in a 0.3 to 3.2 percentage point

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[12] More precisely, Stock and Yogo (2005) show that if the first-stage *F*-statistic for all instruments is greater than ten, the maximum bias of the instrumental variables estimator will be less than 10%. Subsequent work has adopted the "rule of thumb" that first-stage *F*-statistics greater than ten are acceptable (Roberts and Whited, 2010, 516).

decrease in *Board Independence*, equivalent to 1.5% to 18.5% of the sample standard deviation of *Board Independence* (*t*-statistics of -1.96 to -3.11).

4.4. Moderating effects of expected horizon and risk of innovative investments

4.4.1. Measuring the expected risk of innovative investments

I extend my main results by examining the relative contribution of the expected risk and horizon of innovative investments to the relation between investing in innovation and CEO termination. I estimate the expected risk of innovative investments using the historical relation between changes in innovative investments and changes in risk within the firm's industry. In particular, I estimate the following regression by Fama-French 12 Industry and year (i.e., 156 separate regressions):[13]

$$\Delta sigma(Returns_{i,t}) = \beta_0 + \beta_1 \Delta R\&D_{i,t-1} + \varepsilon_{i,t} \qquad (4)$$

The β_1 coefficient from estimating Eq. (4) captures how changes in R&D spending in the prior year contribute to changes in risk in the current year for firms in industry *j* and year *t*. Therefore, I use the β_1 coefficient multiplied by 1,000 to ease interpretation, or *Risk of Innovation*, to measure the expected risk of investments in innovation.

Consistent with Kothari et al. (2002) I find that increased investment in innovation is associated with increased firm risk. The results suggest that, on average, a one standard deviation increase in *R&D* is associated with a 0.006 unit increase in *sigma(Returns)*, equivalent to 8.6% of a standard deviation. However, this average relation belies significant heterogeneity. At the 75th percentile of *Risk of Innovation*, a one standard deviation increase in R&D spending is associated with a 0.02 unit increase in *sigma(Returns)*, equivalent to 28.6% of a standard deviation. At the

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[13] I use Fama-French 12 industries to ensure there are enough observations to estimate Eq. (4).

25th percentile of *Risk of Innovation,* changes in R&D spending are *negatively* related to changes in risk.

In total, *Risk of Innovation* suggests that investing in innovation increases firm risk on average, but that the relation varies significantly across time and industries. For example, the results suggest that investments in innovation in the manufacturing industry (Fama-French 12 Industry #3) are more than twice as risky as investments in innovation in the healthcare industry (Fama-French 12 Industry #10). The results also suggest that the risk of investing in innovation in the healthcare industry has declined by almost half over the sample period.

4.4.2. Measuring the expected horizon of innovative investments

I estimate the expected horizon of innovative investments using the historical relation between changes in innovative investments and subsequent changes in patenting activity. In particular, I estimate the following regression by Fama-French 12 Industry and year:

$$\begin{aligned} \Delta \mathit{Patents\ Filed}_{i,t-1} &= \beta_0 + \beta_1 \Delta \mathit{R\&D}_{i,t-1} + \beta_2 \Delta \mathit{R\&D}_{i,t-2} + \beta_3 \Delta \mathit{R\&D}_{i,t-3} + \beta_4 \Delta \mathit{R\&D}_{i,t-4} + \\ &+ \beta_4 \Delta \mathit{R\&D}_{i,t-4} + \beta_5 \Delta \mathit{R\&D}_{i,t-5} + \varepsilon_{i,t-1} \end{aligned} \tag{5}$$

Eq. (5) estimates how changes in R&D spending in each of the last five years contribute to changes in patent filings in the prior year, for firms in the same industry. I use patent filings to measure the horizon of innovative investments because patent filings likely credibly reveal the results of innovative investments. In particular, patent applications must be sufficiently detailed such that a person skilled in the relevant area could recreate the invention independently of the inventor. Because the patent office reviews and publicly discloses patent filings, patent filings credibly and publicly reveal the results of innovative investments.[14]

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[14] The patent office publishes patent applications even if it denies the patent. The patent office discloses patent applications filed on or after November 29, 2000 18 months post-filing, although there are exceptions. Prior to November 29, 2000, the patent office disclosed patent applications after the decision date. Patent application decisions typically take 36 months. Any fixed delay between patent filings and patent application publication should not affect my inferences.

I use the β coefficients from estimating Eq. (5) to develop a measure of the delay between innovative investments and performance outcomes that is analogous to the duration measure in bond-pricing and executive compensation (e.g., Gopalan et al., 2014):

$$Horizon\ of\ Innovation_{i,t} = \frac{\sum_{i=1}^{5} \beta_i \times i}{\sum_{i=1}^{5} \beta_i}$$

Consistent with Lev and Souigiannis (1995) I find that the results of investments in innovation are revealed with a significant delay. The results suggest that, on average, the expected delay between investments in innovation and patent filings is 3.09 years. Again, this average relation belies significant heterogeneity. At the 75th percentile of *Horizon of Innovation* the expected delay is 4.20 years, at the 25th percentile the expected delay is only 2.06 years.

Horizon of Innovation also varies significantly across industries and within industries over time. It is almost half again as large in the healthcare industry (Fama-French 12 Industry #10) as in the chemicals industry (Fama-French 12 Industry #5). *Horizon of Innovation* grew by almost 22% in the healthcare industry between the first half and the second half of the sample period. Comparing the change in *Horizon of Innovation* to the change in *Risk of Innovation* in the healthcare industry over time also highlights that the two measures capture distinctly different concepts. While the expected horizon of innovative investments in the healthcare industry increased significantly, the expected risk declined. Similarly, the correlation between *Horizon of Innovation* and *Risk of Innovation* is only 0.014. Therefore, the risk and horizon of innovative investments are distinct concepts that may contribute differently to the relation between investing in innovation and CEO termination.

4.4.3. Relative contributions of risk and horizon

To examine the relative contributions of the expected risk and horizon of investments in innovation to changes in CEO termination, I re-estimate Eq. (2) after splitting the sample on the median of *Risk of Innovation* and of *Horizon of Innovation*. I then test whether the positive relation between *ln(1-R&D Credit Rate)* and *Termination* is more pronounced in settings where the expected risk or horizon of innovative investments is higher. The advantage of this research design (i.e., estimating separate treatment effects for each setting) is that it does not constrain the coefficients on the control variables or fixed effects to be the same across the various settings.[15]

I report the results of estimating Eq. (2) after splitting the sample on the median of *Risk of Innovation* in Table 5, column (1). Column (1a) reports the results for firm-years where investments in innovation are expected to be relatively less risky. The results suggest that a 10% decrease in the tax cost of R&D results in a 1.3 percentage point decrease in CEO termination. Column (1b) reports the results for firm-years where investments in innovation are expected to be relatively more risky. The results suggest that a 10% decrease in the tax cost of R&D results in a 1.3 percentage point decrease in CEO termination. Unsurprisingly, the difference between the coefficients on *ln(1-R&D Credit Rate)* in column (1a) and (1b) is not statistically significant (*F*-statistic of 0.09, p-value of 0.979). In total, there is no evidence in Table 5 that the expected risk of investments in innovation affects CEO termination.

I report the results of estimating Eq. (2) after splitting the sample on the median of *Horizon of Innovation* in Table 5, column (2). Column (2a) reports the results for firm-years where investments in innovation are expected to be relatively shorter horizon. The results suggest that a 10% decrease in the tax cost of R&D results in a 1.3 percentage point *increase* in CEO termination. Column (2b) reports the results for firm-years where investments in innovation are expected to be relatively longer horizon. The results suggest that a 10% decrease in the tax cost of R&D results

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[15] I use the median to partition the sample to ensure that the two resulting sub-samples are of similar size and, in turn, that the tests have similar power. Note that this design is equivalent to fully interacting an indicator for whether the observation is above or below the median with all of the control variables and fixed effects, and testing whether the interaction with *ln(1-R&D Credit Rate)* is different from zero.

in a 3.4 percentage point decrease in CEO termination. The difference between the coefficients on *ln(1-R&D Credit Rate)* in column (2a) and (2b) is statistically significant (*F*-statistic of 9.12, p-value of 0.011). In total, the results suggest that investments in innovation only affect CEO termination when they are expected to be longer horizon, consistent with Manso (2011).

4.5. Investing in innovation and the sensitivity of CEO termination to performance

I also document how investing in innovation affects the sensitivity of CEO termination to firm performance. Although the theory is silent on how investing in innovation affects the sensitivity of CEO termination to firm performance, it is common in the literature to examine the sensitivity of termination to performance. Therefore, I estimate the following reduced form differences-in-differences regression:

$$\begin{aligned} Termination_{i,t+1} = {} & \beta_0 + \beta_1 ln(1\text{- } R\&D\ Credit\ Rate_{i,t-1}) + \beta_2 Performance\ Measure_{i,t+1} \\ & + \beta_3 ln(1\text{- } R\&D\ Credit\ Rate_{i,t-1}) * Performance\ Measure_{i,t+1} \\ & + \gamma' X_{i,t} + FirmFE + Industry\text{-}YearFE + \varepsilon_{i,t+1} \qquad (6) \end{aligned}$$

Eq. (6) is identical to Eq. (2), except that I include one of several measures of firm performance and interact the measure with $ln(1\text{- } R\&D\ Credit\ Rate_{i,t-1})$. The β_3 coefficient captures whether investing in innovation affects the sensitivity of CEO termination to firm performance. I examine several measures of firm performance. First, I examine buy and hold returns over the fiscal year (*Return*). Second, I examine *Return* minus the CRSP value weighted index return over the same period (*Market Adjusted Return*). Third, I examine *Return* minus the median industry return over the same period (*Industry Adjusted Return*). Fourth, I examine the residuals from regressions of monthly excess returns on the market, size, value, and momentum factors, estimated over rolling twelve-month windows (*Idiosyncratic Return*).

I report the results of estimating Eq. (6) separately for each of the four measures of performance in Table 6. The results suggest that investing in innovation reduces the sensitivity of termination to performance, in addition to reducing the baseline level of termination. In particular, the interaction of $ln(1-R\&D\ Credit\ Rate_{i,t-1})$ and $Performance\ Measure_{i,t+1}$ is negative and statistically significant for each of the four measures of performance (*t*-statistics of -2.12 to -3.87).

5. Conclusion

I examine the effect of investing in innovation on CEO termination. I find that firms affected by the plausibly exogenous passage of state R&D tax credits invest more in innovation and reduce their propensity to terminate their CEOs. Firms investing in innovation also reduce the sensitivity of CEO termination to firm performance. Firms appear to commit to reduced CEO termination *ex ante* by reducing the independence of the board. The effect of investing in innovation on CEO termination is greater when the expected horizon of innovative investments is longer, consistent with Manso's (2011) argument that firms can use reduced termination to encourage CEOs to think long term and invest in innovation. However, the effect of investing in innovation on CEO termination does not vary with the expected risk of innovative investments, inconsistent with Holmstrom's (1989) argument that firms can use reduced termination to encourage CEOs to take risks and invest in innovation.

I contribute to the literature on innovation by documenting how investing in innovation affects CEO termination. Innovation is arguably the central driver of economic growth and economic actors responding to market incentives are responsible for the majority of innovation (e.g., Solow, 1957; Romer, 1990; Porter, 1992). Consequently, understanding how and when investing in innovation affects CEO termination is important for understanding an important share of the economy. I also contribute to this literature by developing and implementing a method to separate the relative contributions of the expected risk and expected horizon of innovative investments. Prior work on innovation frequently cites both horizon and risk concerns for motivation, but does not examine the separate effects of each. As my results demonstrate, horizon and risk concerns do not always lead to the same results.

I also contribute to the literature on corporate governance by documenting evidence consistent with firms using “weak” governance structures to commit to reduced CEO termination for incentive reasons. Therefore, my results contribute to the debate about the optimality of observed governance structures by suggesting a rationale for why some firms might select governance structures that shield CEOs from the consequences of poor performance. As Hermalin and Weisbach (1998) argue, a governance structure that is *ex post* inefficiently lenient may be optimal because it provide benefits *ex ante*.

Finally, I contribute to the literature on CEO termination by documenting an important and novel determinant of CEO termination. My results are consistent with boards and CEOs implicitly contracting on termination, in addition to explicitly contracting on compensation. Consequently, my results suggest that boards may appear to terminate CEO s too infrequently because of *ex ante* commitments to reduced CEO termination *ex post* (e.g., Hermalin and Weisbach, 1998; Taylor, 2010; Manso, 2011).

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Appendix A. Variable Definitions

Panel A, Dependent variables:

Board Independence	The percentage of the board that is independent, identified using BoardEx. In cases where BoardEx data is missing, identified using RiskMetrics.
Termination	Identified by Peters and Wagner (2014) and Jenter and Kanaan (2015), as any change in the CEO listed in the Execucomp database for which the press identifies that the CEO is fired, forced out, or retires or resigns due to policy differences; if the CEO is younger than 60 and the press does not report the reason as death, poor health, or the acceptance of another position (including chairmanship of the board), or the press reports that the CEO is retiring but does not announce the retirement at least six months before the succession.
ln(Patent Citations)	The natural logarithm of one plus the count of forward citations of the firm's filed patents. Identified by Kogan et al. (2016) using the Google Patents database and CRSP.
ln(Patents Filed)	The natural logarithm of one plus the count of patents filed by the firm in a given year. Identified by Kogan et al. (2016) using the Google Patents database and CRSP.
ln(R&D)	The natural logarithm of one plus the firm's R&D expenditures identified using Compustat. Missing values of R&D are replaced with zeroes.
ln(Total Patent Value)	The natural logarithm of one plus the value of all patents filed by the firm in a given year. Identified by Kogan et al. (2016) from the equity market reaction to patent approvals using the Google Patents database and CRSP.

Appendix A. Variable Definitions

Panel B, Firm variables:

Capital Intensity	The ratio of plant, property, and equipment, to assets identified using Compustat.
Cash Effective Tax Rate	The firm’s cash taxes paid scaled by pre-tax income identified using Compustat. I truncate the resulting measure at 0 and 1.
GAAP Effective Tax Rate	The firm’s GAAP reported income taxes, scaled by pre-tax income identified using Compustat. I truncate the resulting measure at 0 and 1.
Idiosyncratic Return	The residuals from regressions of monthly excess returns on the market, size, value, and momentum factors, estimated over rolling twelve month windows.
Industry Adjusted Return	Firm buy and hold returns over the fiscal year, less the median return for firms in the same industry.
Institutional Ownership %	The percentage of the firm’s shares held by institutions, identified using Thomson Reuters.
Horizon of Innovation	The duration of R&D spending, calculated using the coefficients from separate industry-year regressions of the change in patents filed on the change in R&D spending over each of the last five years: $\Delta Patents\ Filed_{i,t-1} = \beta_0 + \beta_1 \Delta R\&D_{i,t-1} + \beta_2 \Delta R\&D_{i,t-2} + \beta_3 \Delta R\&D_{i,t-3} + \beta_4 \Delta R\&D_{i,t-4} + \beta_5 \Delta R\&D_{i,t-5} + \varepsilon_{i,t-1} \quad (5)$ $Horizon\ of\ Innovation_{i,t} = \frac{\sum_{i=1}^{5} \beta_i \times i}{\sum_{i=1}^{5} \beta_i}$
Leverage	The ratio of the firm’s book value of debt to the book value assets, identified using Compustat.
ln(Analysts)	The natural logarithm of one plus the number of analysts with one-year ahead earnings forecasts, identified using I/B/E/S.
ln(Blockholders)	The natural logarithm of one plus the number of investors who hold 5% or more of the firm's shares, identified using Thomson Reuters.
ln(Market Value)	The natural logarithm of the firm's market value of equity, identified using Compustat.
Loss Indicator	An indicator equal to one if the firm's net income was negative, identified using Compustat.
Market Adjusted Return	Firm buy and hold returns over the fiscal year, less the return on the CRSP value weighted index over the same period.
Missing R&D Indicator	An indicator equal to one if a missing value of R&D was replaced with zero.
Return	Buy and hold returns over the fiscal year, identified using CRSP.
Return on Assets	Income before extraordinary items, scaled by assets, identified using Compustat.

Risk of Innovation	The β_1 coefficient from separate industry-year regressions of the change in return volatility on the change in prior year R&D spending, multiplied by 1,000 to ease interpretation: $\Delta sigma(Returns_{i,t}) = \beta_0 + \beta_1 \Delta R\&D_{i,t-1} + \varepsilon_{i,t}$ (4)
sigma(Returns)	The standard deviation of the firm's monthly returns, identified using CRSP.

Appendix A. Variable Definitions

Panel C, State variables:

Budget Balance	The state budget balance.
Business Combination Law	An indicator equal to one if the firm's state of incorporation has enacted a business combination law.
Carryback	The number of years which a firm can carry back a net operating loss in the state.
Carryforward	The number of years which a firm can carry forward a net operating loss in the state.
Corporate Tax Rate	The state’s top statutory tax rate on corporate income.
Good Faith Exception	An indicator equal to one if the state courts apply the good faith exception.
Gross State Product Growth	The percentage change in state domestic product.
Implied Contract Doctrine	An indicator equal to one if the state courts apply the implied contract doctrine.
Inevitable Disclosure Doctrine	An indicator equal to one if the state courts apply the inevitable disclosure doctrine.
Investment Tax Credit	The state investment tax credit rate.
Job Credit Indicator	An indicator equal to one if the state offers a tax credit for job creation.
Job Grant Indicator	An indicator equal to one if the state offers a grant for job creation.
ln(1-R&D Credit Rate)	The natural logarithm of one minus the R&D credit rate. The credit rate is calculated as the effective rate, following Wilson (2009). Firms exposure to state R&D credits is based off the location of their R&D activities, calculated using the location of their investors in the NBER patent database in the prior year (Griffith et al., 2006; Bloom et al., 2013): $R\&D\ Credit\ Rate_{i,t} = \sum_{s=1}^{n} \frac{Scientists\ in\ State\ s_{i,t-1}}{Total\ \#\ Scientists_{i,t-1}} \times Effective\ Credit\ Rate_{s,t-1}$
Manager Tax Rate	The effective marginal tax rate on individuals in the top-bracket that live in the state, identified as in Armstrong et al. (2018).
Public Policy Exception	An indicator equal to one if the state courts apply the public policy exception.
Republican Governor	An indicator equal to one if the state's governor identifies as a Republican.
Republican Legislature	An indicator equal to one if all houses of the state's legislature have a majority of members who identify as Republican.
Unemployment Rate	The state unemployment rate.
UTSA	An indicator equal to one if the state has enacted the Uniform Trade Secrets Act. Identified as in Glaeser (2018).

Appendix B. R&D Effective Tax Credit Rate Changes

I list all changes in the highest tier R&D effective tax credit rate greater than 0.1% in magnitude between 1994 and 2007, by state and year (Wilson, 2009).

State	Year	Effective Credit Rate Change
Arizona	1994	20.00%
Arizona	2001	-9.00%
California	1997	2.77%
California	1999	0.91%
California	2000	2.73%
Delaware	2000	0.83%
Georgia	1998	10.00%
Hawaii	2000	20.00%
Idaho	2001	5.00%
Illinois	2003	-0.49%
Illinois	2004	0.49%
Indiana	2003	5.00%
Louisiana	2003	8.00%
Maine	1996	0.43%
Maryland	2000	0.83%
Missouri	1994	0.62%
Montana	1999	5.00%
Nebraska	2006	0.17%
New Hampshire	1994	7.50%
New Hampshire	1995	-15.00%
New Jersey	1994	10.00%
North Carolina	1997	5.00%
North Carolina	2006	-2.00%
North Dakota	2007	3.50%
Ohio	2004	0.53%
Pennsylvania	1997	0.96%
Rhode Island	1994	5.00%
Rhode Island	1998	11.90%
South Carolina	2001	2.50%
South Carolina	2002	2.50%
Texas	2001	4.00%
Texas	2002	1.00%
Utah	1999	6.00%
Vermont	2003	0.95%
West Virginia	2003	-7.00%

Table 1

Descriptive statistics

This Table presents descriptive statistics for my sample. My main sample is constructed from the intersection of CRSP and Compustat (accounting and stock price data) for the time period 1995 to 2007. I exclude utilities (SIC codes 4900–4942) and financial firms (SIC codes 6000–6999) due to the unique nature of innovation in those industries.

Panel A: Dependent variables and firm controls

Variable	Observations	Mean	Std	25th	Median	75th
Dependent variables:						
Board Independence	14,691	0.77	0.20	0.64	0.81	1.00
Termination	14,691	0.03	0.17	0.00	0.00	0.00
ln(Patent Citations)	14,691	1.41	1.85	0.00	0.00	2.81
ln(Patents Filed)	14,691	1.11	1.52	0.00	0.00	2.08
ln(R&D)	14,691	2.01	2.19	0.00	1.25	3.88
ln(Total Patent Value)	14,691	1.82	2.37	0.00	0.00	3.70
Firm variables:						
Capital Intensity	14,691	0.29	0.21	0.12	0.23	0.41
Cash Effective Tax Rate	14,691	0.28	0.24	0.09	0.26	0.37
GAAP Effective Tax Rate	14,691	0.32	0.16	0.28	0.35	0.39
Horizon of Innovation	14,691	3.02	4.03	2.06	3.09	4.20
Idiosyncratic Return	14,691	-0.04	0.11	-0.05	-0.03	-0.01
Industry Adjusted Return	14,691	0.15	0.50	-0.15	0.06	0.32
Institutional Ownership %	14,691	0.6	0.31	0.46	0.68	0.83
Leverage	14,691	0.21	0.18	0.05	0.20	0.33
ln(Analysts)	14,691	1.85	1.02	1.39	2.08	2.64
ln(Blockholders)	14,691	0.90	0.61	0.69	1.10	1.39
ln(Market Value)	14,691	7.34	1.50	6.28	7.20	8.32
Loss Indicator	14,691	0.16	0.36	0.00	0.00	0.00
Market Adjusted Return	14,691	0.04	0.49	-0.26	-0.02	0.24
Missing R&D Indicator	14,691	0.36	0.48	0.00	0.00	1.00
Return	14,691	0.18	0.54	-0.14	0.10	0.38
Return on Assets	14,691	0.04	0.11	0.02	0.05	0.09
Risk of Innovation	14,691	0.05	0.46	-0.02	0.09	0.16
sigma(Returns)	14,691	0.12	0.07	0.07	0.10	0.14

Table 1, continued

Descriptive statistics

This Table presents descriptive statistics for my sample. My main sample is constructed from the intersection of CRSP and Compustat (accounting and stock price data) for the time period 1995 to 2007. I exclude utilities (SIC codes 4900–4942) and financial firms (SIC codes 6000–6999) due to the unique nature of innovation in those industries.

Panel B: State variables

Variable	Observations	Mean	Std	25th	Median	75th
State variables:						
Budget Balance	14,691	0.01	0.05	-0.02	0.01	0.04
Business Combination Law	14,691	0.19	0.05	0.00	0.00	0.00
Carryback	14,691	0.70	1.12	0.00	0.00	2.00
Carryforward	14,691	12.67	6.25	5.00	15.00	20.00
Corporate Tax Rate	14,691	0.07	0.02	0.06	0.08	0.09
Good Faith Exception	14,691	0.28	0.45	0.00	0.00	1.00
Gross State Product Growth	14,691	0.03	0.02	0.02	0.03	0.04
Implied Contract Doctrine	14,691	0.84	0.37	1.00	1.00	1.00
Inevitable Disclosure Doctrine	14,691	0.57	0.49	0.00	1.00	1.00
Investment Tax Credit	14,691	0.02	0.03	0.00	0.00	0.04
Job Credit Indicator	14,691	0.67	0.47	0.00	1.00	1.00
Job Grant Indicator	14,691	0.29	0.45	0.00	0.00	1.00
ln(1-R&D Credit Rate)	14,691	-0.01	0.03	0.00	0.00	0.00
Manager Tax Rate	14,691	0.42	0.03	0.40	0.42	0.44
Public Policy Exception	14,691	0.85	0.36	1.00	1.00	1.00
Republican Governor	14,691	0.59	0.49	0.00	1.00	1.00
Republican Legislature	14,691	0.31	0.46	0.00	0.00	1.00
Unemployment Rate	14,691	5.03	1.04	4.40	5.00	5.70
UTSA	14,691	0.71	0.45	0.00	1.00	1.00

Table 2

R&D tax incentives and innovation

This Table presents results from estimating OLS regressions of innovative activity as a function of firms' exposure to R&D tax credits. All variables are as defined in Appendix A. *t*–statistics appear in parentheses and are based on standard errors clustered by headquarters state and year. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail), respectively. Sample descriptive characteristics are found in Table 1.

Variable:	*ln(R&D)* (1)	*ln(Patents Filed)* (2)	*ln(Patents Citations)* (3)	*ln(Total Patent Value)* (4)
ln(1-R&D Credit Rate)	-0.438***	-3.285***	-5.161***	-4.035***
	(-3.31)	(-5.06)	(-4.82)	(-4.86)
Firm Controls	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Industry - Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	14,691	14,691	14,691	14,691
Adjusted R^2	0.977	0.927	0.908	0.919

Table 3

Investing in innovation and CEO termination

This Table presents results from estimating OLS regressions of CEO termination as a function of investments in innovation. Column (1) presents results from a reduced form regression of forced termination as a function of firms' exposure to R&D tax credits. Columns (2) – (5) present the second stage results of an instrumental variables regression of innovative activity variables instrumented for by firms' exposure to R&D tax credits. Corresponding first stage results are reported in Table 2. All variables are as defined in Appendix A. *t*–statistics appear in parentheses and are based on standard errors clustered by headquarters state and year. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail), respectively. Sample descriptive characteristics are found in Table 1.

Variable:	*Termination*				
	(1)	(2)	(3)	(4)	(5)
ln(1-R&D Credit Rate)	0.172**	.	.	.	.
	(2.77)	.	.	.	.
Instrumented Innovation Measure:					
ln(R&D)	.	-0.392*	.	.	.
	.	(-1.97)	.	.	.
ln(Patents Filed)	.	.	-0.052**	.	.
	.	.	(-2.91)	.	.
ln(Patents Citations)	.	.	.	-0.033**	.
	.	.	.	(-2.65)	.
ln(Total Patent Value)	.	.	.	.	-0.043**
	.	.	.	.	(-2.55)
Kleibergen-Paap First Stage F-Statistic:	N/A	13.47	25.63	23.27	23.59
Firm Controls	Yes	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry - Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	14,691	14,691	14,691	14,691	14,691
Adjusted R^2	0.977	0.977	0.927	0.908	0.919

Table 4

Investing in innovation and board independence

This Table presents results from estimating OLS regressions of board independence as a function of investments in innovation. Column (1) presents results from a reduced form regression of board independence as a function of firms' exposure to R&D tax credits. Columns (2) – (5) present the second stage results of an instrumental variables regression of innovative activity variables instrumented for by firms' exposure to R&D tax credits. Corresponding first stage results are reported in Table 2. All variables are as defined in Appendix A. *t*–statistics appear in parentheses and are based on standard errors clustered by headquarters state and year. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail), respectively. Sample descriptive characteristics are found in Table 1.

Variable:	*Board Independence*				
	(1)	(2)	(3)	(4)	(5)
ln(1-R&D Credit Rate)	0.145**	.	.	.	.
	(2.76)	.	.	.	.
Instrumented Innovation Measure:					
ln(R&D)	.	-0.331*	.	.	.
	.	(-1.96)	.	.	.
ln(Patents Filed)	.	.	-0.044***	.	.
	.	.	(-3.11)	.	.
ln(Patents Citations)	.	.	.	-0.028**	.
	.	.	.	(-2.83)	.
ln(Total Patent Value)	.	.	.	.	-0.036**
	.	.	.	.	(-2.82)
Kleibergen-Paap First Stage F-Statistic:	N/A	13.47	25.63	23.27	23.59
Firm Controls	Yes	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry - Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	14,691	14,691	14,691	14,691	14,691
Adjusted R^2	0.977	0.977	0.927	0.908	0.919

Table 5

Moderating effects of expected horizon and risk of innovative investments

This Table presents results from estimating OLS regressions of forced CEO termination as a function of firms' exposure to R&D tax credits. Column (1) presents results after splitting the sample on the median of the expected risk of innovative investments. Column (2) presents results after splitting the sample on the median of the expected duration of innovative investments. All variables are as defined in Appendix A. *t*–statistics appear in parentheses and are based on standard errors clustered by headquarters state and year. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail), respectively. Sample descriptive characteristics are found in Table 1.

Variable:	*Termination*			
	(1a)	(1a)	(2a)	(2b)
Innovation Characteristic:	Less Risky	More Risky	Shorter Horizon	Longer Horizon
ln(1-R&D Credit Rate)	0.126	0.121	-0.125	0.318***
	(0.96)	(1.54)	(-1.52)	(3.69)
F-statistic of the difference:	0.09		9.12**	
F-statistic p-value:	0.979		0.011	
Firm Controls	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Industry - Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	14,691	14,691	14,691	14,691
Adjusted R^2	0.977	0.977	0.927	0.908

Table 6

Investing in innovation and the sensitivity of CEO termination to performance

This Table presents results from estimating OLS regressions of CEO termination as a function of investments in innovation, performance, and the interaction of investments in innovation and performance. All variables are as defined in Appendix A. *t*–statistics appear in parentheses and are based on standard errors clustered by headquarters state and year. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail), respectively. Sample descriptive characteristics are found in Table 1.

Variable:	*Termination*			
	(1)	(2)	(3)	(4)
ln(1-R&D Credit Rate)	0.184**	0.181**	0.198**	0.082
	(2.51)	(2.66)	(2.62)	(1.31)
Performance Measure:				
Return	-0.047***	.	.	.
	(-6.16)	.	.	.
Market Adjusted Return	.	-0.049***	.	.
	.	(-5.90)	.	.
Industry Adjusted Return	.	.	-0.047***	.
	.	.	(-6.07)	.
Idiosyncratic Return	.	.	.	-0.036
	.	.	.	(-0.65)
Performance Measure * *ln(1-R&D Credit Rate)*	-0.168*	-0.246***	-0.245***	-1.449**
	(-2.12)	(-3.56)	(-3.87)	(-2.93)
Firm Controls	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Industry - Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	14,691	14,691	14,691	14,691
Adjusted R^2	0.203	0.203	0.203	0.194