Employee Health and Corporate Innovation: Evidence from Medical Cannabis Legalization

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Abstract

We study the effects of employee health on corporate innovation by exploiting staggered medical cannabis legalization across states from 1995 to 2020. Medical cannabis legalization increases medical access, thereby significantly influences employee health. Using a difference-in-differences empirical design, we find that firms became more innovative after their states legalized medical cannabis use. In particular, we show that firms produced more patents, generated more patents with significant impacts, and attained higher patent values following the passages of the bills. We identify a possible mechanism through which employee health spurs innovation: lower worker turnover. Collectively, our findings support the hypotheses that medical cannabis legalization improves employee health, overall well-being and their innovative capacities.

Keywords: **Government Policy and Regulation, Corporate Innovation, Corporate Finance, Labor Economics**
JEL Classification: G30, G38, G41, J01

1 Introduction

There is general consensus that employee health and well-being are important to corporate outcomes and economic growth (Strauss and Thomas (1998), Bhargava, Jamison, Lau, and Murray (2001), and Schultz (2002)). However, empirical evidence is limited due to difficulties in disentangling the simultaneity issue. One strand of literature shows the relation between employee health risk factors and productivity (Burton, Conti, Chen, Schultz, and Edington (1999) and Boles, Pelletier, and Lynch (2004)) while other studies attribute worker health to their occupations and work environments (Llena-Nozal, Lindeboom, and Portrait (2004) and Schneider and Harknett (2019)). It is unclear whether healthy labor force leads to superior corporate outcomes or outstanding firms are able to attract healthier workers and provide better care to their employees (Frijters, Johnston, and Shields, 2014).

In this paper, we propose a novel identification strategy to study the effects of employee health on corporate innovation. In particular, we exploit staggered variations in medical cannabis legalization across different states as a quasi-natural experiment. We show that increasing access to medical cannabis improves employee health and spurs corporate innovation. The topic is of great interest to many stakeholders because innovation enhances competitiveness at both firm and national levels (Fang, Tian, and Tice, 2014).

Given the significance of innovation, the literature provides a plethora of factors driving innovation. However, it is empirically challenging to establish a causal relationship. The challenge lies in identifying exogenous variations. Our empirical identification strategy relying on the staggered legalization of cannabis medical use allows for such analyses. Specifically, increasing cannabis access across states represents a reduction in medical frictions for employees. Medical cannabis legalization provides a unique setting for our study because medical cannabis access

affects employee health and their abilities to work and innovate, and it is likely shielded from corporate influences.

Our empirical design benefits from the merits of prior cannabis research. Extensive medical literature documents cannabis's non-invasive superiority in treating many chronic physical diseases and physiological disorders of various degrees. Cannabis is shown to be effective for people with Alzheimer's disease, arthritis, asthma, autism, bi-polar disorder, brain tumors, cancer, chronic pains, dementia, depression, diabetes, epilepsy, glaucoma, headaches and migraine attacks, Huntington's disease, multiple sclerosis (MS), Parkinson's disease, and post-traumatic stress disorder (PTSD), among others (Musty and Rossi (2001), Rosenberg, Tsien, Whalley, and Devinsky (2015), Ware, Wang, Shapiro, Robinson, Ducruet, Huynh, Gamsa, Bennett, and Collet (2010), Greco, Gasperi, Maccarrone, and Tassorelli (2010). Richardson, Pearson, Kurian, Latif, Garle, Barrett, Kendall, Scammell, Reeve, and Chapman (2008), Sieradzan, Fox, Hill, Dick, Crossman, and Brotchie (2001), Azuara-Blanco, Tomida, and Perlwee (2004), Fraser (2009), Elbaz, Nasser, Ravi, Wani, Ahirwar, Zhao, Oghumu, Satoskar, Shilo, Carson III, et al. (2015), Aviello, Romano, Borrelli, Capasso, Gallo, Piscitelli, Di Marzo, and Izzo (2012)). Given cannabis's medicinal values in both physical and psychological domains, cannabis medical access is of great importance to many employees and inventors.

There are various reasons why employee health may impact corporate innovation. First, health economics research documents reasonable links between worker health and their performance/productivity (Burton, Conti, Chen, Schultz, and Edington (1999) and Boles, Pelletier, and Lynch (2004)). Second, healthy people are generally longer-term oriented and have higher tolerance to early failures, which are crucial for innovation (Tian and Wang (2014), Chemmanur, Loutskina, and Tian (2014)) (Flammer and Bansal, 2017). Third, healthier and happier workers are more likely

to work well with others and generate positive teamwork results. Forth, healthier workers spending less time on personal health care and costs have more spare time on mastering skills and building their human capital. All of these factors create a feedback loop generating compounding effects on innovation activities at the corporate level.

Our difference-in-differences (DiD) tests use staggered cannabis legalization over the period between 1995 and 2020. We show that improved access to medical cannabis in a given state spurs corporate innovation. In terms of economic significance, we find that the passage of medical cannabis legalization led to increases of about 8% to 10% in the numbers of patents, citations, patent values and impact patents. We also find that the effects of increased employee health on firm innovation were concentrated in states with lower health ratings. This finding suggests decreasing marginal effects of medical cannabis legalization on innovation success for states with healthier employees.

In order to interpret our results as the causal effect of cannabis legalization on firm innovation, we need to address the parallel assumption that in the absence of the shock, the average change in innovation would have been the same for both treatment and control groups. We show that our results are robust to a number of econometric concerns, which could potentially jeopardize this assumption. First, cannabis legalization and innovation could be spuriously correlated with underlying economic factors. We show that our results are robust to local macro-economic factors and state fixed effects. Second, we find that the treatment effect of medical cannabis on innovation only occurred in the years following the passages of the bills, but not before.

We further investigate the underlying channels through which employee health may impact innovation activities. Prior literature suggests that long-term orientation

and its derivative traits such as tolerance to failures are crucial for innovation success (Tian and Wang (2014), Chemmanur, Loutskina, and Tian (2014) and Flammer and Bansal (2017)). We hypothesize that healthier long-term oriented workers are more likely to invest in firm-specific human capital and enjoy reciprocal relationships with their colleagues. Empirically, we expect to observe lower worker turnover following the passage of the law. We indeed find that worker turnover dropped by approximately 8.5% relative to the mean after their states legalized cannabis medical use.

Although the staggered adoption of medical cannabis across states enables us to employ a DiD design to study the relationship between employee health and corporate innovation, we admit that the passage of medical cannabis legalization may not be random. We conduct a battery of tests to alleviate the non-random assignment concern. In particular, we do not find evidence that innovation activities are related to the timing of medical cannabis legalization. We also do not find any support that innovation reversely trigger the passages of the bills. Our analyses are robust to the inclusion of various firm attributes, regional characteristics, time-invariant factors, and state clustering standard errors.

Our paper's main contribution lies on addressing the question as to what extent and through which channels employee health affects corporate innovation. Extensive health economics literature suggests that employee health affects labor productivity and imposes significant costs on employers. Health risk factors are linked to significant constraints on worker abilities to obtain a job and maintain their productivity (Burton, Conti, Chen, Schultz, and Edington (1999) and Boles, Pelletier, and Lynch (2004)). Kapur (2004) shows that employment-based health insurance costs dampen employment at small firms. Our study provides causal evidences of employee health on innovation. In addition, we show that firms exhibit lower worker turnover as a result of medical cannabis legalization.

Our study relates to the literature of labor market regulations and frictions on corporate outcomes (Acharya, Baghai, and Subramanian (2013), Acharya, Baghai, and Subramanian (2014), Bradley, Kim, and Tian (2017), Bai, Fairhurst, and Serfling (2020)). Their studies show that employment protection, labor law and unionization negatively affect R&D and corporate innovation. Lim (2021) shows that paid family leave acts promoting participation of female inventors in the labor force spurs innovation. Our paper highlights the significance of policy-making decisions on general public and private sector.

Our paper also relates to prior research examining the impact of liberal ideologies. Vakili and Zhang (2018) find that liberal policies such as same-sex marriage and marijuana legalization increase state-level patents while anti-liberal policies such as abortion restrictions reduce patenting. They propose that adoptions of liberal policies facilitates openness to diversity, thereby improves innovation. Zandberg (2021) shows that access to abortion clinics and other reproductive services increases female entrepreneurship. In our paper, we show that access to medical cannabis, an alternative non-invasive treatment, significantly improves the relational and professional life quality of inventors, and ultimately, corporate innovation. However, we do not find significant differences in innovation with respect to recreational cannabis access.

The paper proceeds as follows. Section 2 describes our data, sample construction and key variables. Section 3 describes our empirical design. Section 4 presents validity tests. Section 5 provides the empirical results, and section 6 concludes the paper.

2 Data and Sample Construction

2.1 Innovation Data

We obtain data on firm innovation activities for the period between 1995 and 2020 from the Kogan, Papanikolaou, Seru, and Stoffman (KPSS) database (Kogan, Papanikolaou, Seru, and Stoffman, 2017). Each patent is given a unique identification number issued by the United States Patent and Trademark Office (USPTO). The data provides information on patent number, issue date, filing date, economic value and citations associated with each patent. Following the innovation literature, we use filing date as the time variable for our sample due to the variations in patent processing time lengths.

2.2 Cannabis Legalization

We hand collect data on cannabis legal status across 50 states to study the effects of cannabis legalization on corporate innovation. We identify the years that medical and recreational cannabis use was legalized in each state. Table 1 summarizes cannabis legal status by jurisdiction.

[Insert Table 1]

2.3 Sample Construction

Our sample spans between 1995 and 2020. Our data starts in 1995 when state health data is available. We match Compustat firm characteristics with KPSS innovation data. Following prior research, we exclude utility (SIC codes 4900–4999) and financial firms (SIC codes 6000–6999). These restrictions result in a sample size of 23,962 firm-year observations from 1995 to 2020. Table 2 presents summary statistics of the sample.

[Insert Table 2]

We use several measures of firm innovation activities. *Patents* is the total number of patents filed by a firm in a given year. *Citations* is the sum of citations across all patents filed by a firm in a given year. *Patent Value* is the sum of patent economic values across all patents filed by a firm in a given year, scaled by the firm's market value. On average, firm filed 33 patents and received 424 citations per year. These patents were valued at roughly 7% of firm market value. Given the high skewness of the innovation measures, we use their natural logarithms in our regression analysis. Specifically, *Ln(Patents)* is the natural logarithm of the number of patents filed during the year, *Ln(Citations)* is the natural logarithm of the citations across all patents filed by a firm during the year and *Ln(Patent Value)* is the natural logarithm of the economic values across all patents filed by a firm in a given year, scaled by the firm's market value.

3 Identification Strategy

In order to examine the effects of employee health on corporate innovation, we exploit the variations in legal status of cannabis medical use across different states. Our DiD specification is as follows:

$$Innovation_{i,t} = \alpha + \beta * mLegalized_{i,t} + \gamma X_{i,t} + \theta_i + \delta_{i,t} + \omega S_{s,t} + \epsilon_{i,t}$$

Where $Innovation_{i,t}$ are different innovation measures proxied by firm patents, citations and economic values. Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. Ln(Citations) is the natural logarithm of the citations across all patents filed by a firm in a given year. Ln(Patent Value) is the natural logarithm of the economic values across all patents filed by a firm in a given

year, scaled by the firm's market value. Ln(Top10) is the natural logarithm of one plus the numbers of patents in the top ten percentile (decile) of citations in a given year.

$mLegalized_{i,t}$ is an indicator equals 1 if the firm's state legalized cannabis use. β is the main coefficient of interest for examining the effects of medical cannabis legalization on corporate innovation. θ_i captures the firm-level time-invariant characteristics. $\delta_{i,t}$ represents the industry and year fixed effects that pick up sector and economic trends that could potentially drive our results.

$X_{i,t}$ denotes firm characteristics used as control variables, including firm size, leverage, age, cash holdings, market-to-book, net working capital, capital expenditure and R&D. *Size* is the natural logarithm of the book value of assets (log (AT_t)). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *Leverage* is the ratio of long-term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *Net working capital (NWC)* is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPEX/TA* is Capital expenditure (CAPEX) scaled by the book value of assets (AT). *R&D/TA* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *MB* (market-to-book) is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). Continuous variables are winsorized at 1% level to reduce the effects of outliers.

$S_{s,t}$ denotes state attributes used as additional control variables, including state GDP and number of firms. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. *Ln(Nfirms)* is the natural logarithm of the number of

firms headquartered in a state in a given year. We also correct estimated standard errors in all regressions by clustering at the state level.

4 Validity Tests

The DiD design relies on the parallel trend assumption and the exogeneity of the shock. In this section, we will present evidence for the validity of our identification strategy. We first use a timing test in which the dependent variable is the natural logarithm of the time till the passage of the laws. The sample is at the headquarter state-year level and spans from 1995 to 2020. The independent variables are innovation measures aggregated at the headquarter state level. For example, *m_XRD/AT* is the average (mean) of Research and Development expenditures (XRD) scaled by the book value of assets (AT) for firms headquartered in a state in a given year. Other variables are similarly defined. We include state control variables to pick up regional effects. Results are reported in Table 3. The coefficients are statistically insignificant, suggesting that firms are not likely to engage in lobbying for the passage of the law. This finding helps to reduce endogeneity concern of the shock.

[Insert Table 3]

We next verify that medical cannabis legalization indeed helps to improve general health. We collect state health data from the Centers for Disease Control and Prevention (CDC) website. We construct a measure of state health based on survey data. Participants were asked to rate their general health from 1(poor) to 5(excellent), with 5 being the best[1]. *Health* is calculated as the weighted average of the ratings where the weights are the percentages of participants with the ratings in the state in a given year. The sample is from 1995 to 2020, and at the headquarter state-year

[1]Participants were asked: "How is your general health?"

level. Results are reported in Table 4. In Panel A, we show that there are significant differences in the health ratings with respect to state medical cannabis legalization status. In Panel B, we run a DiD regression at the headquarter state level. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. We find that medical cannabis legalization improves approximately 6.36% in the health ratings. Collectively, these findings confirm that medical cannabis indeed helps to improve health conditions.

[Insert Table 4]

5 Empirical Results

5.1 Medical Cannabis Legalization and Firm Innovation

In this section, we will present our findings of medical cannabis legalization on firm innovation. We will look at multiple aspects of innovation activities including the number of patents, the number of citations, patent economic values and impact patents.

Table 5 reports the estimates of medical cannabis legalization on firm innovation outputs. The two measures of innovation outputs are Ln(Patents) and Ln(Citations). Model (1) of Table 5 is an ordinary least squares (OLS) model with firm and industry-year fixed effects without any control variables. Model (2) includes firm attributes as control variables. Model (3) adds several state control variables. Standard errors are clustered at the state level. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. The coefficient is statistically significant across different models.

In terms of economic significance, Models (1) and (4) of Table 5 suggest that the treatment effect is about 10%. Following the passage of medical cannabis legalization,

the number of patents and citations increased by 10.3% and 10.5%, respectively. In Models (2) and (5) of Table 5, we include firm size, leverage ratio, firm age, cash holdings, market-to-book ratio, net working capital, capital expenditure, and R&D expenditure. In Models (3) and (6) of Table 5, we include state GDP and the number of firms in the state to pick up regional effects. The results are robust to the inclusion of all these control variables[2].

[Insert Table 5]

Innovation outputs do not always translate into shareholder wealth. Thus, we next examine patent economic value. We use real dollar economic patent values to facilitate comparisons across time and industry. Patent Value is the sum of patent economic values across all patents filed by a firm in a given year, scaled by the firm's market value. Patents economic values are in dollars adjusted by the consumer price index (CPI). In our regressions, we use the natural logarithm of Patent Value (Ln(Patent Value)) due to the high skewness of the measure. The results are reported in Table 6. The coefficients of the treatment effect are both statistically and economically significant. In particular, Model (3) of Table 6 suggests that patents generated post medical cannabis legalization increased approximately 9.72% in economic value.

[Insert Table 6]

Our findings indicate that medical cannabis legalization improves innovation outputs as measured by the numbers of patents and citations. However, innovation outputs do not fully capture the extent to which employee health spurs innovation. We next investigate whether firms actually generate meaningful innovations. We classify patents as "high-impact" if they are in the top 10 percentile (decile) of the

[2]In separate regressions, we analyze the effect of recreational cannabis use legalization on corporate innovation, and do not find significant differences in corporate innovation outcomes. The results are reported in Appendix Table A.1.

citation distribution. Table 7 reports the estimates of medical cannabis legalization on impact patents. As shown in Table 7, the treatment effect is significant across all models. The results are robust to the inclusion of firm characteristics and state control variables. Model (3) of Table 7 suggests that medical cannabis legalization led to an increase of approximately 7.19% in high-impact patents.

[Insert Table 7]

In Table 8, we show that the relationship between medical cannabis legalization and firm innovation is stronger for states with worse health ratings. Health data is collected from the Centers for Disease Control and Prevention (CDC) website. *Health* is calculated as the weighted average of the ratings where the weights are the percentages of participants with the ratings in the state in a given year. The variable of interest is the interaction between cannabis legalization status and health. We find that the positive relationship between cannabis legalization and corporate innovation decreases with the level of health ratings. This finding indicates that the relationship exhibits decreasing marginal effects of medical cannabis legalization on innovation.

[Insert Table 8]

5.2 Reverse Causality

The parallel trend assumption is essential to the DiD design. We are only able to observe the treatment effect of the treated and non-treatment effect of the control. The treatment effect of the control and non-treatment effect of the treated are not observable. Thus, the treatment effect observed on the treated would only be valid if the response of the treated and the control groups followed a parallel trend. This motivates us to conduct a pretrend check in innovation activities in the years prior to medical cannabis legalization.

Another concern for our identification strategy is the non-randomization of law enactments. Firms are known to influence legislation through lobbying. In Table 9, we study the timing of changes in corporate innovation relative to the timing of medical cannabis legal status. If reverse causality drives our results, we should observe an increasing trend in firm innovation in the treatment states before the actual cannabis legalization. Such evidence would also violate the parallel trend assumption and invalidate our causal interpretation of the empirical results.

We consider a model specification with treatment dummies for three year prior to three years post the passage of cannabis legalization bills. More specifically, we estimate the following model:

$$Innovation_{i,t} = \alpha + \sum_{k=-3}^{k=+3} \beta^k MCL^k + \gamma X_{it} + \theta_i + \delta_{i,t} + +\omega S_{s,t} + \epsilon_{i,t}$$

Where MCL^k is an indicator equal to one for the k^{th} year relative to the actual medical cannabis legalization (MCL) year. More specifically, MCL^{-3}, MCL^{-2}, MCL^{-1}, MCL^0, MCL^{+1}, MCL^{+2} and MCL^{+3} are indicators equal to one for the years following medical cannabis legalization if the state was to legalize cannabis three years earlier, two years earlier, one year earlier, same year, one year later, two years later, and three years later respectively. $Innovation_{i,t}$ denote firm innovation measures proxied by firm patents.

We find that the coefficients on MCL^{-3}, MCL^{-2}, MCL^{-1} and MCL^0 are close to zero and statistically insignificant. This finding suggests that there are no significant differences in innovation between the treated and the control groups prior to the enactment of the law. The coefficients are only statistically significant for the years following the passages of the law. Overall, these results indicate that innovation measures of firms in states legalizing medical cannabis use increase relative to those of the control firms only after the effective year of cannabis legalization, but not

before.

[Insert Table 9]

5.3 Possible Mechanisms

We next explore possible mechanisms through which employee health may affect corporate innovation. We hypothesize that healthier workers are more long-term oriented, are often in better moods, thereby work well with others. Their long-term orientation motivates investments in firm-specific human capital and resilience characteristics, both of which are important for innovation (Bai, Fairhurst, and Serfling (2020), Tian and Wang (2014), Chemmanur, Loutskina, and Tian (2014) and Flammer and Bansal (2017)). We empirically test these predictions by examining the rate at which firms replace their employees.

We collect turnover data from the U.S. Census Bureau. *Turnover* represents the employee turnover rate, which is calculated as the total of this quarter's stable hires and the next quarter's stable separations divided by the average quarter employment. The data is at the state-quarter level. Results are reported in Table 10. Panel A shows the differences in employee turnover with respect to the state's medical cannabis legal status. Panel B employs a DiD model to show the effects of medical cannabis legalization on employee turnover. In general, the results are consistent with our predictions. Following the passage of medical cannabis bills, worker turnover dropped by 0.85%. Relative to the mean of approximately 10%, this represents a 8.5% reduction relative to the mean.

[Insert Table 10]

5.4 Robustness Tests

In this section, we present findings of robustness tests. In Models (1) and (2) of Table 11, we we use Altman Z-score (Altman, 1968) and KZ-Index (Kaplan and Zingales, 1995) as additional control variables to capture the extent to which firm financial strength affects innovation. Altman Z-score measures firm financial strength and likelihood of bankruptcy while KZ-Index captures firm reliance on external financing.

In Models (3) and (4) of Table 11, we consider two measures of corporate governance to control for the effects of governance on innovation activities. More specifically, we use GIM governance index (Gompers, Ishii, and Metrick, 2003) and entrenchment index (Bebchuk, Cohen, and Ferrell, 2008) as proxies for corporate governance. GIM index captures the extent of managerial entrenchment by tracking 24 anti-takeover provisions. Entrenchment E-Index uses a similar approach, but only tracks 6 provisions. The sample size in Models (5) and (6) significantly dropped due to data unavailability beyond the year 2006. In general, our results remain robust to the inclusion of various controls of financial constraints and corporate governance. Following Petersen (2009), we also show that our results are robust to standard errors clustered at the state and year level (reported in Appendix Table A.2.).

[Insert Table 11]

Truncation problems are well-documented in the innovation literature. One of the truncation problems is the lag in granting patents to applications. We address this problem by using filing dates. Another truncation problem is due to outdated citation tracks in the NBER database. We address this issue by updating citations till 2020. In addition, we check that our results are robust to a truncated sample from 1995 to 2015 to ensure that newer patents are allowed adequate time to accumulate their citations. The results are reported in Appendix Table A.3.

6 Conclusions

Employee health is naturally assumed to improve firm performance and innovation. However, it is empirically challenging to establish a causal relationship. In this study, we evaluate the effects of employee health on corporate innovation by using a novel identification strategy. More specifically, we explore the staggered passages of bills legalizing cannabis medical use from 1995 to 2020. Medical cannabis legalization is a shock to employee medical access. Using a DiD design, we show that firms in states that legalized cannabis medical use increased their innovation outcomes. We find that firms produced approximately 8% more patents and these patents generated higher economic values and were of higher impact.

Our findings are robust to several endogeneity concerns that could potentially threaten our causal interpretation of the relationship. In particular, we show that the results are not driven by underlying local economic factors. Our results are robust to the inclusion of various firm and state control variables. We also show that the changes in innovation outcomes only occurred in the years following the passages of the laws, but not before. Collectively, our robustness tests alleviate some of the omitted variables and reverse causality concerns.

Variable Definitions

Patents: Patents is the total number of patents filed by a firm in a given year.

Citations: Citations is the sum of citations across all patents filed by a firm in a given year.

Patent Value: Patent Value is the sum of patent economic values across all patents filed by a firm in a given year, scaled by the firm's market value.

Ln(Patents): the natural logarithm of the number of patents filed during a given year.

Ln(Citations): the natural logarithm of the citations across all patents filed by a firm during a given year.

Ln(Patent Value): the natural logarithm of the economic values across all patents filed by a firm in a given year, scaled by the firm's market value.

Ln(Top10): the natural logarithm of one plus the numbers of patents in the top ten percentile (decile) of citations in a given year.

Size: the natural logarithm of the book value of assets (log (AT_t)).

Age: the number of years since the firm first appears in Compustat.

Ln(Age): the natural logarithm of the number of years since the firm first appears in Compustat.

Leverage: the ratio of long-term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). Leverage= (DLTT + DLC)/AT

CashHoldings: the ratio of cash and short-term investments (CHE) to the book value of assets (AT). Cash holdings= CHE/AT

Net working capital (NWC): the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). NWC= (WCAP- CHE)/AT

CAPX/TA: Capital expenditure (CAPX) scaled by the book value of assets (AT)

R&D/TA: Research and development expenditures (XRD) scaled by the book value

of assets (AT). If XRD is missing, it is set to zero.

MB (market-to-book): *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). MB=(AT-CEQ + CSHO*PRCC_F)/AT

Ln(GDP) is the natural logarithm of the headquarter state GDP in a given year.

Ln(Nfirms) is the natural logarithm of the number of firms headquartered in a state in a given year.

mLegalized is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year.

rLegalized is an indicator which equals 1 if recreational cannabis use is legalized in the state in a given year.

Turnover represents the employee turnover rate, which is calculated as the total of this quarter's stable hires and the next quarter's stable separations divided by the average quarter employment.

Z-score: the Altman Z-score measuring a company's underlying financial strength (Altman, 1968)

Z= 1.2*(WCAP/AT)+1.4*(RE/AT)+3.3*(EBIT/AT)+0.6*(CEQ/LT)+0.9

KZ-Index: the Kaplan-Zingales measure of a firm's reliance on external financing (Kaplan and Zingales, 1995).

KZ=-1.001909*[(IB+DP)/Lag_PPENT]+0.2826389*[(AT+(PRCC_F×CSHO)-CEQ-TXDB)/AT]+3.139193*[(DLTT+DLC)/(DLTT+DLC+SEQ)]-39.3678*[(DVC+DVP)/Lag_PPENT]-1.314759*(CHE/Lag_PPENT)

GIM-Index: is the corporate governance index from Gompers, Ishii, and Metrick (2003). GIM index captures the extent of managerial entrenchment by tracking the number of anti-takeover provisions. There are 24 governance provisions that the GIM index tracks. GIM index ranges from 0 to 24.

E-Index: Entrenchment E-Index uses a similar approach as the GIM governance index. However, it only tracks 6 provisions. E-index ranges from 0 to 6 (Bebchuk, Cohen, and Ferrell, 2008).

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Table 1: Legality of Cannabis by jurisdiction

This table provides a summary of cannabis legality across 50 states along with the years medical and recreational cannabis use legalized.

State	State abbreviation	Medical use	Recreational use
Alabama	AL	2021	illegal
Alaska	AK	1998	2014
Arizona	AZ	2011	2020
Arkansas	AR	2016	illegal
California	CA	1996	2018
Colorado	CO	2000	2012
Connecticut	CT	2012	2022
Delaware	DE	2011	illegal
Florida	FL	2017	illegal
Georgia	GA	2015	illegal
Hawaii	HI	2000	illegal
Idaho	ID	illegal	illegal
Illinois	IL	2014	2020
Indiana	IN	illegal	illegal
Iowa	IA	illegal	illegal
Kansas	KS	illegal	illegal
Kentucky	KY	illegal	illegal
Louisiana	LA	2015	illegal
Maine	ME	1999	2016
Maryland	MD	2017	illegal
Massachusetts	MA	2012	2017
Michigan	MI	2008	2018
Minnesota	MN	2014	illegal
Mississippi	MS	2020	illegal
Missouri	MO	2018	illegal
Montana	MT	2004	2021
Nebraska	NE	illegal	illegal
Nevada	NV	2000	2016
New Hampshire	NH	2013	illegal
New Jersey	NJ	2010	2020
New Mexico	NM	2007	2021
New York	NY	2014	2019
North Carolina	NC	illegal	illegal
North Dakota	ND	2016	illegal
Ohio	OH	2016	illegal
Oklahoma	OK	2018	illegal
Oregon	OR	1998	2014
Pennsylvania	PA	2016	illegal
Rhode Island	RI	2006	illegal
South Carolina	SC	illegal	illegal
South Dakota	SD	2021	2021
Tennessee	TN	illegal	illegal
Texas	TX	illegal	illegal
Utah	UT	2018	illegal
Vermont	VT	2004	2018
Virginia	VA	2020	2021
Washington	WA	1998	2012
West Virginia	WV	2017	illegal
Wisconsin	WI	illegal	illegal
Wyoming	WY	illegal	illegal

Table 2: Summary Statistics

This table reports summary statistics for the main variables in the regression models. The sample consists of 23,962 firm-year observations (excluding financial and utility firms) over the period from 1995 to 2020. *Patents* is the total number of patents filed by a firm in a given year. *Citations* is the sum of citations across all patents filed by a firm in a given year. Citations are updated till 2020. *Patent Value* is the total economic patent value over the market value of equity in a given year. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long-term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Age* is the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. Continuous variables are winsorized at 1%.

Variable	**N**	**Mean**	**Std Dev**	**25th Pctl**	**Median**	**75th Pctl**
Patents	23,962	33.92	98.24	2.00	5.00	18.00
Citations	23,962	424.27	1,301.56	12.00	49.00	213.00
Patent Value	23,368	0.07	0.12	0.01	0.03	0.08
Size	23,959	6.12	2.27	4.43	5.94	7.68
Leverage	23,856	0.18	0.19	0.00	0.13	0.29
Age	23,961	19.36	16.61	6.00	13.00	28.00
CashHoldings	23,955	0.29	0.27	0.06	0.20	0.46
MB	23,367	2.70	2.27	1.35	1.91	3.12
NWC	23,674	0.06	0.17	-0.04	0.06	0.17
CAPX/AT	23,793	0.05	0.05	0.02	0.03	0.06
XRD/AT	23,959	0.12	0.16	0.02	0.06	0.15

Table 3: Validity tests: Timing of Medical Cannabis Legalization

This table reports the results of the validity tests for the experiment. The sample includes headquarter state-year observations from 1995 to 2020. The dependent variable is the natural logarithm of the expected time till the passage of medical cannabis legalization in a given state. The independent variables are measures of firm innovation aggregated at the state level. In particular, *m_XRD/AT* is the average (mean) of Research and Development expenditures (XRD) scaled by the book value of assets (AT) for firms headquartered in a state in a given year. *m_Ln(Patents)* is the average (mean) of the natural logarithms of the patents filed by firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. Standard errors are clustered at the headquarter state level, and reported in parentheses.

	(1) Ln(Time)	(2) Ln(Time)	(3) Ln(Time)
m_XRD/AT	0.809		0.849
	(0.96)		(1.03)
m_Ln(Patents)		-0.00930	-0.0190
		(-0.18)	(-0.40)
Ln(GDP)	1.138*	1.114*	1.114*
	(1.95)	(1.84)	(1.88)
Ln(Nfirms)	0.0526	0.0420	0.0459
	(0.57)	(0.39)	(0.45)
N	500	500	500
Adjusted R^2	0.8801	0.8792	0.8800
Year FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes

Table 4: Validity tests: Medical Cannabis Legalization and Health

This table reports the results of the validity tests for the experiment. The sample includes headquarter state-year observations from 1995 to 2020.

Panel A.
This panel reports the differences in state health status with and without medical cannabis legalization. State health data is collected from the Centers for Disease Control and Prevention (CDC) website. We construct a measure of state health based on survey data. Participants were asked to rate their general health from 1(poor) to 5(excellent), with 5 being the best. *Health* is calculated as the weighted average of the ratings where the weights are the percentages of participants with the ratings in the state in a given year.

Medical Cannabis Legalization Status	N	Mean
Not Legalized	948	3.5527
Legalized	375	3.5549
Difference		0.0022***

Panel B.
This panel reports the results from the ordinary least squares (OLS) regressions relating medical cannabis legalization to health for the sample from 1995 to 2020. The main dependent variable is Health. *Health* is calculated as the weighted average of the health ratings where the weights are the percentages of participants with the ratings in the state in a given year. The independent variable is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year.

	Health
mLegalized	0.0636***
	(2.69)
N	1,323
Adjusted R^2	0.2755
Year FE	Yes
State Clustering	Yes

Table 5: Medical Cannabis Legalization and Patent Outputs

This table reports the results from the ordinary least squares (OLS) regressions relating medical cannabis legalization to innovation outputs for the sample from 1995 to 2020. All regressions include firm and industry-year fixed effects. The dependent variables are Ln(Patents) and Ln(Citations). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. Ln(Citations) is the natural logarithm of the citations across all patents filed by a firm in a given year. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. Some of the models include control variables. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patents)	(2) Ln(Patents)	(3) Ln(Patents)	(4) Ln(Citations)	(5) Ln(Citations)	(6) Ln(Citations)
mLegalized	0.103*** (2.78)	0.0832** (2.58)	0.0888*** (2.80)	0.105** (2.36)	0.104** (2.34)	0.104** (2.36)
Size		0.422*** (29.22)	0.421*** (29.30)		0.406*** (23.84)	0.407*** (24.14)
Leverage		-0.170* (-1.84)	-0.168* (-1.83)		-0.173* (-1.86)	-0.173* (-1.87)
Ln(Age)		0.0266 (0.65)	0.0263 (0.61)		-0.0780 (-1.08)	-0.0755 (-1.00)
CashHoldings		0.125 (1.54)	0.126 (1.55)		0.134 (1.25)	0.134 (1.25)
MB		0.0197*** (4.15)	0.0198*** (4.09)		0.0383*** (4.96)	0.0384*** (4.89)
NWC		-0.0724 (-0.88)	-0.0737 (-0.90)		0.142 (1.52)	0.141 (1.52)
CAPX/AT		0.674*** (3.11)	0.670*** (3.09)		0.585* (1.81)	0.582* (1.81)
XRD/AT		0.969*** (10.23)	0.968*** (10.26)		0.916*** (7.82)	0.917*** (7.92)
LN(Nfirms)			-0.0679 (-0.95)			-0.0368 (-0.30)
Ln(GDP)			0.207 (0.69)			-0.0650 (-0.13)
N	19,062	18,130	18,130	19,062	18,130	18,130
Adjusted R^2	0.8033	0.8188	0.8188	0.7405	0.7486	0.7485
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Medical Cannabis Legalization and Patent Economic Value

This table reports the results from the ordinary least squares (OLS) regressions relating medical cannabis legalization to patent economic values for the sample from 1995 to 2020. All regressions include firm and industry-year fixed effects. The dependent variable is Ln(Patent Value). Ln(Patent Value) is the natural logarithm of the economic values across all patents filed by a firm in a given year, scaled by the firm's market value. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. Some of the models include control variables. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patent Value)	(2) Ln(Patent Value)	(3) Ln(Patent Value)
mLegalized	0.0844** (2.30)	0.0983** (2.61)	0.0972** (2.43)
Size		-0.317*** (-19.94)	-0.315*** (-19.70)
Leverage		0.338*** (4.95)	0.340*** (4.91)
Ln(Age)		0.0219 (0.63)	0.0308 (0.89)
CashHoldings		-0.298*** (-4.41)	-0.298*** (-4.46)
MB		-0.141*** (-19.40)	-0.140*** (-19.48)
NWC		-0.370*** (-4.13)	-0.373*** (-4.14)
CAPX/AT		0.250 (0.57)	0.239 (0.55)
XRD/AT		1.161*** (11.33)	1.166*** (11.34)
Ln(Nfirms)			-0.140** (-2.11)
Ln(GDP)			-0.208 (-0.71)
N	18,545	18,130	18,130
Adjusted R^2	0.5622	0.6057	0.6059
Firm FE	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes

Table 7: Medical Cannabis Legalization and Impact Patents

This table reports the results from the ordinary least squares (OLS) regressions relating medical cannabis legalization to impact patents for the sample from 1995 to 2020. All regressions include firm and industry-year fixed effects. The dependent variable is Ln(Top10). Ln(Top10) is the natural logarithm of one plus the numbers of patents in the top ten percentile (decile) of citations in a given year. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. Some of the models include control variables. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Top10)	(2) Ln(Top10)	(3) Ln(Top10)
mLegalized	0.0877*** (2.77)	0.0668** (2.44)	0.0719** (2.72)
Size		0.380*** (24.36)	0.379*** (24.43)
Leverage		-0.155* (-1.83)	-0.154* (-1.83)
Ln(Age)		0.0177 (0.47)	0.0163 (0.41)
CashHoldings		0.0746 (1.04)	0.0748 (1.05)
MB		0.0154*** (4.01)	0.0153*** (3.94)
NWC		-0.0695 (-0.94)	-0.0703 (-0.95)
CAPX/AT		0.626*** (3.44)	0.624*** (3.43)
XRD/AT		0.861*** (11.15)	0.859*** (11.17)
Ln(Nfirms)			-0.0409 (-0.66)
Ln(GDP)			0.206 (0.77)
N	19,062	18,130	18,130
Adjusted R^2	0.8249	0.8411	0.8411
Firm FE	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes

Table 8: Medical Cannabis Legalization, Health and Corporate Innovation

This table reports results from the ordinary least squares (OLS) regressions relating medical cannabis legalization and health to corporate innovation. The sample is from 1995 to 2020. All regressions include firm and industry-year fixed effects. The dependent variable is Ln(Patents). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. Firm control variables are Size, Leverage, Ln(Age), CashHoldings, MB, NWC, CAPX/AT, XRD/AT. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. State control variables are Ln(Nfirms) and Ln(GDP). *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patents)	(2) Ln(Patents)	(3) Ln(Patents)
mLegalized	2.118** (2.58)	2.008*** (3.18)	2.359*** (3.81)
Health	0.127 (0.56)	0.265 (1.17)	0.283 (1.26)
mLegalized*Health	**-0.560**** **(-2.48)**	**-0.535***** **(-3.04)**	**-0.631***** **(-3.62)**
N	19,058	18,126	18,126
Adjusted R^2	0.8034	0.8189	0.8189
Firm Controls	No	Yes	Yes
State Controls	No	No	Yes
Firm FE	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes

Table 9: Cannabis Legalization Timing and Corporate Innovation

This table reports results from the ordinary least squares (OLS) regressions of corporate innovation on indicators for different years of medical cannabis legalization. The sample is from 1995 to 2020. All regressions include firm and industry-year fixed effects. The dependent variable is Ln(Patents). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. MCL^{-3}, MCL^{-2}, MCL^{-1}, MCL^{0}, MCL^{+1}, MCL^{+2} and MCL^{+3} are equal to one for the years following medical cannabis legalization if the headquarter state was to legalize medical cannabis use three years earlier, two years earlier, one year earlier, same year, one year later, two years later, and three years later, respectively. Control variables include Size, Leverage, Age, CashHoldings, MB, NWC, CAPEX/TA, XRD/TA, Ln(Nfirms) and Ln(GDP). *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patents)	(2) Ln(Patents)
MCL^{-3}	-0.0150	-0.0215
	(-0.33)	(-0.51)
MCL^{-2}	0.0540	0.0855
	(0.97)	(1.64)
MCL^{-1}	0.00610	-0.00738
	(0.14)	(-0.14)
MCL^{0}	-0.00848	-0.0127
	(-0.15)	(-0.22)
MCL^{+1}	0.0592**	0.0649**
	(2.08)	(2.47)
MCL^{+2}	-0.0331	-0.0449
	(-0.75)	(-1.12)
MCL^{+3}	0.173***	0.130***
	(4.62)	(4.16)
N	22,143	21,070
Adjusted R^2	0.8062	0.8209
Controls	No	Yes
Firm FE	Yes	Yes
Industry x Year FE	Yes	Yes
State Clustering	Yes	Yes

Table 10: Medical Cannabis Legalization and Employee Turnover

This table reports the results of analyses relating medical cannabis legalization and employee turnover. The sample includes headquarter state-quarter observations from 1995 to 2020.

Panel A.
This panel reports the differences in employee turnover with and without medical cannabis legalization. Employee turnover data is collected from the U.S. Census Bureau. *Turnover* represents the employee turnover rate, which is calculated as the total of this quarter's stable hires and the next quarter's stable separations divided by the average quarter employment.

Medical Cannabis Legalization Status	N	Mean
Not Legalized	2,001	0.1021
Legalized	1,370	0.0995
Difference		-0.00252***

Panel B.
This panel reports the results from the ordinary least squares (OLS) regressions relating medical cannabis legalization to employee turnover for the sample from 1995 to 2020. The data is at the state-quarter level. The main dependent variable is Turnover. *Turnover* represents the employee turnover rate, which is calculated as the total of this quarter's stable hires and the next quarter's stable separations divided by the average quarter employment. The independent variable is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year.

	Turnover
mLegalized	-0.00848***
	(-5.08)
N	3,371
Adj R-squared	0.4575
State FE	Yes
State Clustering	Yes

Table 11: Robustness Tests

This table reports the results from the ordinary least squares (OLS) regressions relating medical cannabis legalization to innovation outputs. All regressions include firm and industry-year fixed effects. The dependent variable is Ln(Patents). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. The main independent variable is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. Control variables include Size, Leverage, Age, CashHoldings, MB, NWC, CAPEX/TA, XRD/TA, Ln(Nfirms) and Ln(GDP). *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Additional control variables are Z-score, KZ- Index, G-Index, and E-Index. Z-score is the Altman Z-score measuring a company's underlying financial strength (Altman, 1968). KZ-Index is the Kaplan-Zingales measure of a firm's reliance on external financing (Kaplan and Zingales, 1995). GIM-Index is the governance index (Gompers, Ishii, and Metrick, 2003). E-Index is the entrenchment index (Bebchuk, Cohen, and Ferrell, 2008). Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	Capital Constraints		Corporate Governance	
	(1) Ln(Patents)	(2) Ln(Patents)	(3) Ln(Patents)	(4) Ln(Patents)
mLegalized	0.0890*** (2.82)	0.0690** (2.10)	0.296** (2.18)	0.288** (2.12)
Z-Score	-0.00424** (-2.49)			
KZ-Index		0.00000219 (0.03)		
GIM-Index			-0.0119 (-0.43)	
E-Index				-0.0636 (-1.03)
N	18,104	16,707	1,385	1,385
Adjusted R^2	0.8192	0.8166	0.8463	0.8466
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes	Yes

Employee Health and Corporate Innovation: Evidence from Medical Cannabis Legalization

Internet Appendix

Table A.1. Recreational Cannabis Legalization and Corporate Innovation

This table reports the results from the ordinary least squares (OLS) regressions relating recreational cannabis legalization to corporate innovation for the sample from 1995 to 2020. All regressions include firm and industry-year fixed effects. The dependent variables are Ln(Patents), Ln(Citations), Ln(Patent Value) and Ln(Top10). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. Ln(Citations) is the natural logarithm of the citations across all patents filed by a firm in a given year. Ln(Patent Value) is the natural logarithm of the economic values across all patents filed by a firm in a given year, scaled by the firm's market value. Ln(Top10) is the natural logarithm of one plus the numbers of patents in the top ten percentile (decile) of citations in a given year. The main variable of interest is *rLegalized*. *rLegalized* is an indicator which equals 1 if recreational cannabis use is legalized in the state in a given year. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patents)	(2) Ln(Citations)	(3) Ln(Patent Value)	(4) Ln(Top10)
rLegalized	0.0155	0.166	0.00119	0.0390
	(0.23)	(0.92)	(0.01)	(0.82)
Size	0.426***	0.413***	-0.316***	0.384***
	(26.53)	(29.26)	(-17.16)	(22.13)
Leverage	-0.141	-0.207*	0.286***	-0.125
	(-1.46)	(-1.89)	(4.18)	(-1.43)
Ln(Age)	0.00538	-0.0996	0.0375	-0.00734
	(0.12)	(-1.27)	(0.95)	(-0.19)
CashHoldings	0.148	0.168	-0.299***	0.0965
	(1.60)	(1.43)	(-4.17)	(1.20)
MB	0.0180***	0.0358***	-0.142***	0.0138***
	(3.65)	(4.41)	(-18.67)	(3.50)
NWC	-0.107	-0.0139	-0.464***	-0.0909
	(-1.04)	(-0.17)	(-4.39)	(-1.03)
CAPX/AT	0.492**	0.274	0.129	0.485**
	(2.24)	(0.74)	(0.22)	(2.84)
XRD/AT	0.991***	0.906***	1.172***	0.880***
	(9.90)	(7.49)	(13.61)	(10.87)
Ln(Nfirms)	0.0271	0.179	-0.136**	0.0486
	(0.37)	(1.53)	(-2.17)	(0.76)
Ln(GDP)	-0.284	-1.007*	-0.344	-0.218
	(-0.74)	(-1.89)	(-0.94)	(-0.59)
N	13,828	13,828	13,828	13,828
Adjusted R^2	0.8230	0.7559	0.6041	0.8466
Firm FE	Yes	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes	Yes

Table A.2. Robustness Check: Two-way Clustering

This table reports the results from ordinary least squares (OLS) regressions relating medical cannabis legalization to corporate innovation for the sample from 1995 to 2020. All regressions include firm and industry-year fixed effects. Standard errors are clustered by state and year. The dependent variables are Ln(Patents), Ln(Citations), Ln(Patent Value) and Ln(Top10). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. Ln(Citations) is the natural logarithm of the citations across all patents filed by a firm in a given year. Ln(Patent Value) is the natural logarithm of the economic values across all patents filed by a firm in a given year, scaled by the firm's market value. Ln(Top10) is the natural logarithm of one plus the numbers of patents in the top ten percentile (decile) of citations in a given year. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patents)	(2) Ln(Citations)	(3) Ln(Patent Value)	(4) Ln(Top10)
mLegalized	**0.0888***** **(2.73)**	**0.104**** **(2.44)**	**0.0972**** **(2.52)**	**0.0719***** **(2.62)**
Size	0.421*** (29.69)	0.407*** (21.69)	-0.315*** (-16.74)	0.379*** (31.87)
Leverage	-0.168*** (-3.40)	-0.173** (-2.27)	0.340*** (5.39)	-0.154*** (-3.67)
Ln(Age)	0.0263 (1.08)	-0.0755** (-1.99)	0.0308 (0.87)	0.0163 (0.80)
CashHoldings	0.126** (2.34)	0.134* (1.71)	-0.298*** (-4.14)	0.0748* (1.72)
MB	0.0198*** (5.04)	0.0384*** (6.11)	-0.140*** (-19.10)	0.0153*** (4.81)
NWC	-0.0737 (-0.92)	0.141 (1.33)	-0.373*** (-3.71)	-0.0703 (-1.09)
CAPX/AT	0.670*** (3.26)	0.582* (1.74)	0.239 (0.83)	0.624*** (3.63)
XRD/AT	0.968*** (12.60)	0.917*** (7.66)	1.166*** (9.70)	0.859*** (14.11)
Ln(Nfirms)	-0.0679 (-1.23)	-0.0368 (-0.49)	-0.140** (-2.09)	-0.0409 (-0.87)
Ln(GDP)	0.207 (1.00)	-0.0650 (-0.21)	-0.208 (-0.84)	0.206 (1.19)
N	18,130	18,130	18,130	18,130
Adjusted R^2	0.8193	0.7492	0.6069	0.8415
Firm FE	Yes	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes
State x Year Clustering	Yes	Yes	Yes	Yes

Table A.3. Truncated Sample: Medical Cannabis Legalization and Corporate Innovation

This table reports the results from ordinary least squares (OLS) regressions relating medical cannabis legalization to corporate innovation for the sample from 1995 to 2015. All regressions include firm and industry-year fixed effects. The dependent variables are Ln(Patents), Ln(Citations), Ln(Patent Value) and Ln(Top10). Ln(Patents) is the natural logarithm of the number of patents filed by a firm in a given year. Ln(Citations) is the natural logarithm of the citations across all patents filed by a firm in a given year. Ln(Patent Value) is the natural logarithm of the economic values across all patents filed by a firm in a given year, scaled by the firm's market value. Ln(Top10) is the natural logarithm of one plus the numbers of patents in the top ten percentile (decile) of citations in a given year. The main variable of interest is *mLegalized*. *mLegalized* is an indicator which equals 1 if medical cannabis use is legalized in the state in a given year. *Size* is the natural logarithm of the book value of asset. *Leverage* is the ratio of long term debt (DLTT) plus debt in current liabilities (DLC) to the book value of assets (AT). *Ln(Age)* is the natural logarithm of the number of years since the firm first appears in Compustat. *CashHoldings* is the ratio of cash and short-term investments (CHE) to the book value of assets (AT). *MB* is the market value of assets (market value of equity (PRCC_F×CSHO) plus book value of assets (AT) minus book value of equity (CEQ)) divided by the book value of assets (AT). *Net working capital* (NWC) is the ratio of net working capital (WCAP) minus cash and short-term investments (CHE) to total assets (AT). *CAPX/AT* is capital expenditure (CAPX) scaled by the book value of assets (AT). *XRD/AT* is Research and development expenditures (XRD) scaled by the book value of assets (AT). If XRD is missing, it is set to zero. *Ln(Nfirms)* is the natural logarithm of the number of firms headquartered in a state in a given year. *Ln(GDP)* is the natural logarithm of the headquarter state GDP in a given year. Standard errors in parentheses are clustered by state. ***, **, * indicate significance of the coefficient at the 1%, 5% and 10% levels, respectively.

	(1) Ln(Patents)	(2) Ln(Citations)	(3) Ln(Patent Value)	(4) Ln(Top10)
mLegalized	**0.0995**** **(2.60)**	**0.117**** **(2.46)**	**0.111**** **(2.46)**	**0.0837**** **(2.60)**
Size	0.419*** (20.01)	0.408*** (21.81)	-0.341*** (-21.60)	0.374*** (17.26)
Leverage	-0.152 (-1.45)	-0.115 (-0.97)	0.349*** (4.18)	-0.143 (-1.52)
Ln(Age)	0.0194 (0.43)	-0.0928 (-1.17)	0.0297 (0.87)	0.00747 (0.18)
CashHoldings	0.136 (1.66)	0.164 (1.58)	-0.295*** (-4.30)	0.0816 (1.16)
MB	0.0199*** (3.45)	0.0370*** (4.46)	-0.147*** (-16.08)	0.0152*** (3.30)
NWC	-0.0427 (-0.52)	0.182* (1.94)	-0.371*** (-4.18)	-0.0480 (-0.67)
CAPX/AT	0.568** (2.56)	0.422 (1.28)	0.179 (0.41)	0.525*** (2.77)
XRD/AT	0.985*** (8.25)	0.905*** (7.46)	1.120*** (11.03)	0.863*** (8.94)
Ln(Nfirms)	-0.0641 (-0.80)	-0.0762 (-0.53)	-0.170** (-2.15)	-0.0352 (-0.50)
Ln(GDP)	0.132 (0.45)	0.0363 (0.07)	-0.352 (-1.09)	0.136 (0.52)
N	17,089	17,089	17,089	17,089
Adjusted R^2	0.8142	0.7389	0.6099	0.8369
Firm FE	Yes	Yes	Yes	Yes
Industry x Year FE	Yes	Yes	Yes	Yes
State Clustering	Yes	Yes	Yes	Yes