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# Marijuana Liberalization and Public Finance: A Capital Market Perspective on a Public Health Policy

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## ABSTRACT

The staggered passage of state medical marijuana laws increases state bonds' offering and trading spreads by 7-11 basis points. Consistent with medical marijuana laws causing an increase in states' credit risk, states incur higher safety and public welfare expenditures and experience greater deficits following the law's passage. Additional analyses show that the increase in spreads is stronger for states with greater corruption, more vulnerable demographics, and better cultivation environments. Overall, these results support economic theory on substance use, which suggests that legalizing marijuana for medical purposes expands the availability, reduces the perceived risks, and increases the local consumption of marijuana.

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# 1. Introduction

Marijuana is the most widely used controlled substance in the United States. In 2018, sixteen percent of Americans reported marijuana use, and forty-five percent reported marijuana use at some point during their lives (SAMHSA, 2018). Liberalizing marijuana has generated debates among legislators, voters, social activists, researchers, and the popular press. Although marijuana use remains illegal under federal laws, marijuana legalization at the state level has grown in popularity. Since 1996, thirty-three states and the District of Columbia have legalized the use of medical marijuana. States' legal approval of medical use has reshaped public opinions on marijuana's health and legal risks and altered residents' acceptance of casual marijuana use (Kilmer and MacCoun, 2017). The passage of medical marijuana laws (MML) also facilitated the emergence of a visible and active marijuana industry and led to greater marijuana use for both medical and non-medical purposes. From 2002 to 2018, total marijuana consumption increased by 45% and intensive users more than doubled (see figure 1).

While extant evidence (e.g., Carliner et al. (2017) and Baggio et al. (2020)) exists on the health and social consequences of increased marijuana use induced by MML, research on MML's public finance impact is scarce. In this study, we examine how medical marijuana liberalization affects local state governments' borrowing costs. Our analysis of municipal borrowing costs adopts a capital market perspective and offers unique insights about MML's public finance effect. Capital market investors condition their pricing decisions on the effects related to bond issuers' economic prospects and financial conditions. In the municipal bond market, bondholders and underwriters closely track a series of factors that affect state and local governments' fiscal health. The bondholders evaluate the aggregate economic benefits and costs. Prior studies have used the municipal bond market to investigate state policies for distressed municipalities (Gao et al., 2019b), as well as controversial social issues such as racial discrimination (Dougal et al., 2019) and climate change (Painter, 2019). In this sense, the pricing of municipal bonds can serve as a useful tool to gauge the expected impact of MML on local governments' near- and long-term fiscal health.

According to economic theory on substance use (Becker and Murphy, 1988; Grossman, 2005), a drug liberalization reform, even one for medical purpose, promotes illicit drug use because legalization reduces the perceived health and legal risks associated with the drug, and because increased drug availability reduces the search costs born by illicit drug consumers.[1] Consistent with these predictions, our analyses show that the increased marijuana use following the passage of MML occurs due to lower perceived risks associated with marijuana and greater marijuana availability. Cerdá et al. (2012), Wen et al. (2015), and Hasin et al. (2017) also report greater marijuana use by adults for both medical and illicit purposes after MML.

Default risk is the primary determinant that explains municipal bond spreads (Schwert, 2017; Novy-Marx and Rauh, 2012). Higher marijuana use induced by MML can alter a local government's probability of default by affecting its fiscal strength. On the one hand, state governments that have passed MML likely incur higher expenditures to enforce such laws and mitigate potential negative social and economic consequences of increased marijuana use. These states could also suffer from lower revenues in the long run due to the worsened health conditions and reduced productivity of marijuana users (Volkow et al.,

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1. Illicit use refers to the use of illegal drugs and the non-medical use of prescription psychoactive medications.

2014). These adverse impacts strain states' debt service capacity, increasing their probability of default. On the other hand, legalization of medical marijuana can cultivate a new industry, create more jobs, and attract new residents. Thus, MML may expand states' tax base and lower their default risks. The capital market consequences of MML in the municipal bond market hence remain an empirical question.

Our analyses exploit the staggered approval of MML in state legislatures between 1996 and 2018 as a source of exogenous variation to identify the effect of marijuana liberalization. We start our analyses by examining how MML affects the offering spreads of state bonds in the primary municipal bond market. Using a baseline model with state and time fixed effects, and after controlling for differences in bonds' contractual features and changes in states' economic conditions, we find that states' offering spreads increase by 7 bps after the passage of MML relative to those that do not pass MML. In dollar terms, MML increases a state's interest cost by $7.35 million for the average total issuance amount per year. Using a sample of state bonds with available marijuana use data, we further specify that a one-percent increase in a state's marijuana use rate induced by MML is associated with a 7-bps increase in state offering spreads. We find similar effects when we use raw yields and tax- adjusted offering spreads, and we find an 11-bps increase in the secondary market trading spreads for state bonds. In addition to interest costs, MML also leads to a 4-bps increase in the underwriter's gross spreads, consistent with the idea that underwriters charge higher fees because they assume inventories of riskier bonds. In dollar terms, this increase adds another annual $420,000 to the cost of MML. These findings indicate that bondholders and underwriters impose higher borrowing costs on states with MML, likely due to the greater marijuana use observed in these states.

We employ two additional identification strategies to address the possibility that our findings may be driven by unmeasurable time-variant state-level factors (e.g., Atanasov and Black 2016; Karpoff and Wittry 2018). We first explore the abrupt changes in state policies around state borders by comparing adjacent counties across state borders, whose economic, social, and cultural characteristics are likely to be very similar in the absence of the policy change. We find that these border counties located in MML states face higher borrowing costs relative to their neighboring counties in non-MML states. Next, we rely on Arizona's 2010 ballot (approved with 50.1%) and Arkansas's 2012 ballot (defeated with 48.6%) to isolate a random change in marijuana liberalization. Since the vote outcomes for both ballots are within narrow margins of the decision rule (i.e., 50%), the residents' voting preference towards medical marijuana is similar across the two states. The borrowing cost of Arizona increases after the passage of MML in the ballot relative to Arkansas. These results provide more confidence that the relation between MML and local governments' borrowing costs is causal.

We conduct several analyses to support the mechanisms underlying the relation between MML and states' borrowing costs. First, MML's effect on states' borrowing costs is stronger for states with higher corruption (likely exhibiting poorer monitoring and enforcement of non-medical use), for states with social-demographics associated with higher marijuana use (leading to higher demand), and for states with more optimal temperatures for marijuana cultivation (resulting in higher supply). This evidence reveals that bondholders impose higher borrowing costs on states in which MML likely induces a greater increase in marijuana use.

Second, the increase in states' borrowing costs is greater for general obligation (GO) bonds than for revenue (RV) bonds,[2] for bonds with lower credit ratings, and for bonds with longer maturity terms.

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2. GO bonds are backed by the state's ultimate taxing ability whereas RV bonds are repaid restrictedly by project-specific revenues.

These findings indicate that bondholders bearing states' ultimate financial burdens (i.e., GO bonds) and those facing substantial credit risks (i.e., lower-rated bonds and longer-term bonds) are more concerned about the potential adverse impacts of higher marijuana use induced by MML.

Consistent with MML resulting in more financial obligations and deteriorating credit quality, MML leads to higher expenditures on police, correction, health, and public welfare, which correspond to areas discussed by prior research as related to marijuana use, such as enforcement and intervention. In contrast, MML does not affect states' spending on highway, natural resources, and parks and recreation, which are areas unrelated to marijuana use. We observe the greatest increase in states' public welfare spending, which is driven by states' expanded provisions of public housing, energy subsidies, and food stamps to support low- income families after MML. This increase in public welfare spending could be the result of adverse impacts of increased marijuana use on individuals' school attainment and career prospects, as suggested by prior studies (e.g., Volkow et al., 2014; Bray et al., 2000; Lynskey and Hall, 2000a; Brook et al., 2013; Schmidt et al., 1998). Consistent with this idea, we conduct a test to show that states with MML have lower high-school graduation rates, smaller populations with college degrees, and more drug-induced deaths subsequent to the passage of MML. This collective evidence is consistent with the earlier evidence that MML increased marijuana use and suggests that such an increase created additional financial burdens, raised state expenditures, and adversely affected their credit quality.

We conduct additional analyses to explore three alternative explanations. First, we examine another staggered shock of marijuana liberalization—the opening of the first medical marijuana dispensary stores. We find states incur higher borrowing costs after opening their first dispensary stores. This finding further alleviates the concern that other confounding events unrelated to MML explain our results. Second, the passage of MML creates a conflict between marijuana's federal ban and state legalization, which can pose additional risks to local residents and businesses who must navigate federal laws. Thus, it's possible that the observed increase in bond spreads reflects heightened future political uncertainty (e.g., Pástor and Veronesi, 2013). Inconsistent with this explanation, the MML effect becomes stronger after issuance of the Cole memorandum, which partially alleviates the federal-state conflict. Third, we address an alternative explanation based on investors' preference to avoid 'sin' securities (e.g., Hong and Kacperczyk, 2009). That is, rather than assessing MML states as higher credit risks, bond investors may simply prefer not to invest in bonds issued by 'marijuana' states (i.e., states that pass MML) because marijuana use contradicts social norms. We believe, however, that our setting is *ex ante* unlikely subject to investors' preference to avoid sin bonds because the passage of MML reflects the societal acceptance of marijuana. Nonetheless, we test our belief by examining how the relation between MML and states' borrowing costs varies by the U.S. public acceptance level of marijuana. Inconsistent with the sin explanation, we find that the effect of MML on increased municipal borrowing costs is more pronounced when marijuana is more accepted by the general public.

Our tests primarily focus on marijuana legalization for medical use rather than for recreational use because the initial liberalization of medical marijuana is the first event that initiates a series of economic and social changes that could affect local governments' fiscal health. Further, only ten states and the District of Columbia subsequently allowed recreational use after legalizing marijuana for medical use in the recent years (i.e., between 2012 and 2018). Thus, a very limited number of states and time periods are available to study recreational legalization. With this caveat in mind, we provide modest evidence consistent with the idea that legalizing marijuana for recreational purposes further increases marijuana use due to greater recreational consumption, which further increases states' borrowing costs.

This study contributes to public policymaking and academic research in several ways. First, we contribute to the public health debate on marijuana liberalization by identifying and quantifying a cost that state and local governments bear when legalizing marijuana for medical use. We emphasize that this increase in states' borrowing costs translates into additional financing costs of $7.35 million for an average state's total issuance in a year. Our results imply that municipal bond investors perceive MML as creating a net economic cost rather than benefit. We contribute to the most recent marijuana debates about legalizing marijuana for recreational consumption. In addition to the ten states mentioned above that have passed recreational marijuana laws, Illinois overwhelmingly voted to legalize recreational marijuana on May 31, 2019. Other states, such as New York and New Jersey, are also considering similar laws (Angell, 2018).[3]

Second, we add to the emerging research on public health issues in the finance literature. As municipal bond prices slumped amidst the Covid-19 outbreak, the financial burden caused by public health issues on local governments has become apparent. Recent concurrent studies investigate the impact of the opioid epidemic on firm value (Ouimet et al., 2019), auto loan default and loan costs (Jansen, 2019), and municipal financing (Cornaggia et al., 2019; Li and Zhu, 2019). Our study provides evidence of a public health issue—marijuana liberalization—leading to a public finance effect. A related paper by Ellis et al. (2019) investigates the impact of medical marijuana legalization on auto insurance premiums.

Third and more broadly, we contribute to the literature that studies the determinants of municipal borrowing costs. Researchers have examined states' fiscal policies for distressed municipalities (Gao et al., 2019b), political integrity (Butler et al., 2009), newspaper information environment (Gao et al., 2019a), climate risk (Painter, 2019), racial discrimination (Dougal et al., 2019), and population demographics (Butler and Yi, 2018). We provide unique evidence that a public health policy also affects municipal borrowing costs.

The next section details the institutional background. Section 3 describes the data. Section 4 presents summary statistics. Section 5 describes the research design and presents the results for medical marijuana liberalization. Section 6 provides robustness tests and additional analyses. Section 7 concludes.

## 2. Background on Marijuana Liberalization

### 2.1. Federal Prohibition of Marijuana

The cultivation, consumption, and distribution of marijuana by residents is prohibited under federal laws. During the Great Depression of the 1930s, growing and smoking marijuana became popular among new settlers in the west coast.[4] Pressure from western state governments to address this issue led Congress to pass the Marihuana Tax Act of 1937, which placed an implicit prohibition of marijuana through the federal government's taxing power. The act established a marijuana transfer tax for which no stamps or licenses to use or distribute marijuana were available to residents. Despite such regulatory efforts, however, marijuana remained popular and became widespread in the 1960s.

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3. MML plays an essential role in smoothing the transition to non-medical (i.e., recreational) legalization by facilitating the emergence of industrial and regulatory frameworks for the marijuana industry and altering residents' perception towards marijuana. For more details, see Kilmer and MacCoun (2017), Lane (2009), and Passik and Tickoo (2011).

4. See Musto (1991) for the history of Marijuana laws.

To deter the growing popularity of marijuana among residents, Congress passed the Comprehensive Drug Abuse Prevention and Control Act of 1970, which listed marijuana as a controlled substance, along with other abusive drugs such as heroin and cocaine. The act divided the controlled substances into five schedules. Substances in Schedule I (Schedule V) have the highest (lowest) abusive potential and lowest (highest) medical value. Marijuana is listed in Schedule I to indicate its highest abusive potential and lowest medical value.[5]

Title II of the 1970s Act, known as the Controlled Substances Act (CSA), laid down the legal foundation of the federal government's legislation for controlled substances. The CSA explicitly banned the manufacture, importation, possession, use, and distribution of marijuana. Violations can result in criminal and civil charges (e.g., drug trafficking offenses). In 1973, the Drug Enforcement Administration (DEA) was established to manage the administration, supervision, and enforcement of federal laws related to controlled substances along with the Food and Drug Administration (FDA). The schedule in which a substance is listed also determines how the substance is controlled by the DEA. For example, drugs in Schedule I are prohibited, while those in Schedule V may not even require prescriptions from licensed physicians. As a Schedule I drug, marijuana is prohibited by federal laws for use by residents regardless of the intended purpose (Mikos, 2011).

### 2.2. State Marijuana Liberalization

The past two decades have witnessed a tremendous shift in state policies towards marijuana liberalization. In the late 1980s, liberalizing marijuana for medical use (MML) gathered support in select states, partly in tandem with the rising public empathy towards patients living in pain with cancer and AIDS (Kilmer and MacCoun, 2017). For instance, patients with AIDS suffer from loss of appetite (which by itself is a life-threatening condition), nausea, and pain. Although the effect of marijuana was not medically tested, the patients reported that marijuana mitigated these symptoms (Treaster, 1993).

The enthusiasm for allowing patients to seek relief for medical ailments by using marijuana is especially strong in the west coast. In 1996, California passed Proposition 215—the first state law that liberalized marijuana for medical use. This Proposition legalized the use of marijuana for medical purposes, "where that medical use is deemed appropriate and has been recommended by a physician who has determined that the person's health would benefit from the use of marijuana in the treatment of cancer, anorexia, AIDS, chronic pain, spasticity, glaucoma, arthritis, migraine, or any other illness for which marijuana provides relief."[6]

Following California, different states passed similar laws at different times over the following two decades. For example, seven states legalized medical marijuana by 2000. Seven more states and the District of Columbia passed comparable laws in the next decade. Eighteen states passed MML between 2011 and 2018. Appendix A provides the passage date for each state. States that have legalized the medical use of marijuana generally allow residents to possess, consume, and grow marijuana after obtaining a qualifying diagnosis from a board-licensed physician.[7]

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5. https://www.dea.gov/drug-scheduling.

6. https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=11362.5.&lawCode=HSC.

7. Doctors in these states can only recommend (but cannot prescribe) marijuana to patients with an appropriate diagnosis because marijuana is prohibited under federal laws.

The economic theory on substance use advocated by Becker and Murphy (1988) and Grossman (2005) suggests that consumers maximize their utility of consuming intoxicating substances subject to their own cost constraints. According to this theory, illicit users face additional costs—the health risk, the legal risk, and the search cost for finding the substance—in addition to the monetary price (Grossman, 2005; Pacula et al., 2010; Galenianos et al., 2012). Although MML appears to only liberalize marijuana for 'medical' use, the passage of MML reduces these additional costs born by illicit users, and hence, induces a broader initiation of illicit marijuana consumption. First, following states' legal approval, marijuana can be viewed as a medicine rather than an intoxicating substance. Thus, MML reduces the perceived health risk associated with using marijuana and favorably alters the public attitudes towards marijuana. Figure 2 shows that the national acceptance rate towards marijuana has been trending up over time since the 1990s.[8] Second, MML reduces the perceived legal risk because law enforcement's ability to separate illicit marijuana users from medical users tends to be low (Lofton, 2019). Third, MML initiates the development of a legal marijuana industry, and greatly expands production and supply of marijuana in the marketplace. Marijuana products can be diverted to non-medical use through either straw purchases or drug trafficking. As such, legalization of medical marijuana can increase marijuana availability to local residents and reduce potential search costs born by illicit users.[9] For these three reasons, MML reduces the perceived health and legal risks as well as search costs associated with marijuana, leading to higher illicit marijuana consumption.

To validate these predictions about MML, in Appendix B, we directly investigate MML's empirical relation with states' marijuana use rates and residents' perceptions towards marijuana's health risk, legal risk, and availability.[10] Consistent with the economic theory of substance use mentioned above, our tests reveal that following the passage of MML, residents in states with MML perceive lower health and legal risks associated with marijuana use and greater marijuana availability. States with MML also have significantly higher marijuana use rates after MML relative to non-MML states. Importantly, our tests further show that this increase in marijuana use is at least partially explained by the lower health and legal risks and greater drug availability induced by MML. Our findings are also supported by several prior studies (Cerdá et al., 2012; Wen et al., 2015; Pacula et al., 2015; Hasin et al., 2017) that document greater illicit marijuana consumption by both adults and youths following the passage of medical marijuana.[11]

Higher marijuana use induced by MML may also negatively affect residents' health and living. According to a review article by Volkow et al. (2014), marijuana use is associated with substantial adverse

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8. Data are from the General Social Survey by the National Opinion Research Center at the University of Chicago.

9. A straw purchase refers to a purchase in which an agent purchases a good or a service on behalf of the ultimate end user, who may or may not be able to legally purchase the good or service.

10. We collect data from the National Survey on Drug Use and Health (NSDUH), which conducts household face-to-face interviews to approximately 70,000 respondents over age 12 across different states about their tobacco, alcohol, and drug use every year. Individual level data are aggregated at the state-year level, using weights based on the poststratification to population estimates from the Census Bureau. Because marijuana use data are first available from 2002, we present the results only for states that passed MML after 2002 to allow for the establishment of pre-trends.

11. Cerdá et al. (2012) report that in 2004 the average annual prevalence of marijuana use among adults above 18 years old is 7.13% in MML states, while it is only 3.57% in non-MML states, using the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). Wen et al. (2015) find that MML leads to a 14-percent increase in current marijuana use, a 15-percent increase in regular (daily) marijuana use, and a 10-percent increase in marijuana abuse by adults aged 21 or above in the ten states that passed MML between 2004 and 2012. Hasin et al. (2017) report that MML increases illicit marijuana use from 5.55% to 9.15% and marijuana use disorders from 1.48% to 3.10% from 1991/92 to 2012/13.

effects, such as addiction to marijuana or other substances, motor vehicle accidents, abnormal brain development, and diminished lifetime achievement. They further suggest that these public adverse effects are expected to be pronounced in states with marijuana liberalization because of marijuana's increasing "availability and social acceptability." Moreover, medical marijuana policies have been expanded to include provisions for the retail sale of marijuana for medical purposes in many states. In cities such as Los Angeles, medical marijuana dispensaries are popularly thought to outnumber Starbucks coffee shops (Barco, 2009). Appendix C summarizes the health and social benefits and costs of MML discussed in news articles and the existing literature.

### 2.3. Current Debate

Figure 3 visually presents the marijuana policy for each state in 2018. State laws for MML conflict with federal laws—making marijuana a controversial issue for both public policies and private businesses. For example, medical marijuana users residing in a state that has legalized marijuana can be denied federal benefits. Also, marijuana dispensaries can be sued by pharmaceutical companies for committing civil RICO actions.[12]

Since 1972, marijuana liberalization advocates have filed multiple descheduling petitions to remove marijuana from Schedule I, but have met with very limited success. For the most part, the DEA has repeatedly denied the petitions. In 2016, for example, the DEA stated that the denial decision was based on the conclusion that marijuana still had a high potential for abuse, no accepted medical use in treatment, and no FDA-approved marijuana products available (DEA, 2016). Federal prohibition of marijuana has recently changed. In June 2018, the FDA approved Epidiolex (cannabidiol) as the first drug that contains a purified drug substance derived from marijuana.[13] The Hemp Farming Act of 2018 removed hemp (a strain of the cannabis sativa plant species with less than 0.3% THC) from the the list of Schedule I controlled substances.[14]

Notwithstanding the current movement towards descheduling marijuana, the use of marijuana for both medical and non-medical purposes (other than the medical use of cannabidiol) remains illegal at the federal level. Given the potential of federal descheduling and the trend towards state liberalization, a better understanding of the impact of marijuana liberalization should help develop coherent policies pertaining to marijuana legalization (Kilmer and MacCoun, 2017).

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12. RICO actions refer to the Racketeer Influenced and Corrupt Organizations Act, which allows an organization to be trialed for the crimes that it assists others to commit.

13. This drug treats seizures associated with two rare and severe forms of epilepsy (i.e., Lennox-Gastaut and Dravet syndrome) for patients above two years old (FDA, 2018; Adams, 2018). The FDA further states that while cannabidiol (CBD) and tetrahydrocannabinol (THC) are both chemical components of the cannabis- sativa plant (commonly known as marijuana), unlike THC, CBD does not cause intoxication (the "high") and is not a primary psychoactive component of marijuana.

14. The 2018 United States Farm Bill incorporated provisions of the Hemp Farming Act and made hemp an ordinary agricultural commodity for the first time on December 20, 2018 (Finn et al., 2018). Further, in May 2019, a federal appeals court reinstated a 2017 case (i.e., Washington et. al v. Sessions et. al) against the heads of the DEA and Justice Department over the Schedule I status of marijuana (Hasse, 2019). This lawsuit was initially dismissed by the judge based on the grounds that the plaintiffs were required to exhaust administrative remedies including petitioning the DEA to reschedule marijuana (Somerset, 2018). (See https://www.congress.gov/bill/115th-congress/senate-bill/2667/text.)

## 3. Data

Our main sample consists of state bond offerings from 1990 to 2018. Our analysis starts in 1990 to allow time to establish pre-MML trends before California passed the first MML in 1996. We focus on state bonds because MML is passed and enacted at the state level. We use the dates that state marijuana legislatures are approved in the state legislative process as the passage dates of state marijuana laws in our tests. Appendix D presents an example to illustrate the timeline of MML. We collect data on states' marijuana laws from ProCon.org. This organization is a non-profit nonpartisan public charity that provides the pros, cons, and related research on more than 80 controversial issues, including the propositions or bills of states' marijuana laws. Researchers have used data from this organization to study the impact of marijuana laws (e.g., Chu and Townsend 2019). We validate the accuracy of the approval dates by reconciling them against those reported on state legislature websites and existing literature (Wen et al., 2015; Williams et al., 2019).

In an initial offering, an underwriter organizes bonds into packages. Bonds and packages are referred to as facilities and issues, respectively. We obtain facility-level data on state bonds' offerings from Bloomberg. The average issue in our sample includes 16.6 facilities. We download monthly treasury yield curve rates from the Federal Reserve of St. Louis, and interpolate the treasury rates for bonds with the same maturity terms to calculate treasury-adjusted bond spreads. Moreover, we collect states' total population, population by age, ethnicity, and education categories, income per capita, and unemployment rates from the U.S. Census Bureau, Bureau of Labor Statistics, Bureau of Economic Analysis, and Federal Reserve of Philadelphia. The final sample consists of 113,723 state-bond facility- level observations after requiring non-missing values for test and control variables. Table 1 shows that California, Florida, Ohio, Oregon, Texas, Washington, and Wisconsin are the top seven issuers.

We collect data on secondary market trading transactions for the bonds in our main sample from the Municipal Securities Rulemaking Board (MSRB). This self-regulatory organization collects and releases secondary market trading data, including a trade's price, yield, par value, and type (customer purchase from a dealer, customer sale to a dealer, or inter-dealer trade). MSRB provides trading data for research purposes starting in 2005, which limits our trading yield analysis to the years from 2005 to 2018.

## 4. Summary Statistics

Table 2 reports summary statistics for state-bond offerings in our sample. Panel A provides statistics for the overall sample. The mean state-bond offering yield is 3.99%. State bonds typically have lower yields than the corresponding treasuries due to municipal bonds' tax-exemption benefit for investors, so the mean treasury-adjusted spread is negative (–0.40%). Standard & Poor's rates 85% of the bonds. We convert the bond ratings into numerical values by assigning a value of 21 to the highest credit rating (AAA), a value of 20 to the next-highest rating (AA+), and so forth. The mean rating for the rated bonds is between AA and AA+ (19.36). These statistics for bond contractual features are generally comparable to those reported in Butler et al. (2009) and Painter (2019). Panel B provides detailed facility-level characteristics by state as contractual features at the facility level vary significantly by state.

# 5. Empirical Results

## 5.1. Baseline Results

We use the staggered passage of MML that affects different states at different points in time as our main identification strategy. Relative to a single-shock design, staggered shocks reduce the likelihood of having a confounding factor that explains the treatment effect because such a confounding factor has to be correlated with the staggered passage of MML.

Our research design is similar to Gao et al. (2019a), who study the impact of newspaper closures on public finance, in that we exploit staggered shocks and employ long-window tests of local governments' borrowing costs. In our setting, the legislation of MML is not a single event, rather, it embodies a series of involvements (e.g., the voting, formation of a regulatory system, and establishment of a monitoring channel). Also, the potential impact of marijuana use may emerge over a longer period. This design allows us to evaluate both the near-term and longer-term impact following the passage of MML. We further follow Gao et al. (2019a) to evaluate a state's borrowing cost using primary-market offering spreads as our main measure and secondary-market trading spreads as a robustness check.

We estimate the effect of MML on offering spreads, using an ordinary least squares (OLS) regression with the following model:

$$y_{ijt} = \alpha + \beta MML_{jt} + \gamma' X_{it} + \delta' Z_{jt} + \eta_j + \mu_t + \varepsilon_{ijt} \qquad (1)$$

where $i$ denotes bond, $j$ denotes state, and $t$ denotes year month. $y_{ijt}$ is the offering spread of bond $i$ issued by state $j$ during year month $t$, measured as the offering yield adjusted by the treasury rate for corresponding maturity terms. $MML_{jt}$ is an indicator that equals one for bonds issued after the corresponding state $j$'s passage of medical marijuana laws, zero otherwise. We control for bond contractual features and state economic factors that could affect bond spreads documented in prior literature (e.g., Butler et al. 2009; Gao et al. 2019a; Painter 2019). $X_{it}$ is a vector of bond-level characteristics. $Z_{jt}$ is a vector of state-year-level economic factors. We include state fixed effects ($\eta_j$) to account for state-specific and time- invariant characteristics, and time (year-month) fixed effects ($\mu_t$) to absorb time-varying economy-wide trends. Because bonds contained in the same issue tend to have the same intended purpose, such as funding a highway or an airport (Painter, 2019; Ang and Green, 2011), the residuals are likely to be correlated at the issue level due to project-specific features or risks. The residuals may also be correlated over time due to macroeconomic factors or changes in market conditions (e.g., bond demand and supply). Hence, we double cluster standard errors by bond issue and year-month of issuance. The coefficient on $MML_{jt}$ gauges the effect of changes in the level of marijuana liberalization on a state issuer's borrowing cost relative to the issuers of the unaffected states.

Table 3, Panel A presents the estimates of the impact of MML on state bonds' offering spreads. We report specifications with different sets of control variables, as some of these variables could be endogenous to the passage of MML and bias our estimate. As a benchmark, Column (1) shows the results when only the *MML* indicator, and state and year-month fixed effects are included in the regression. The coefficient of *MML* is positive (0.11) at the 1% level, indicating that MML leads to a 11-bps increase in states' offering spreads.

In Column (2), we control for bond contractual features in the offering agreement. We find that the offering spread decreases in size and increases in time to maturity. The offering spread is lower for GO bonds, insured and tax-exempt bonds, and bonds issued through competitive bids, while it is higher for bonds with sinking or callable provisions. These coefficients are largely consistent with those reported in

Butler et al. (2009), Gao et al. (2019a), and Painter (2019). Notably, while accounting for these bond contractual features greatly improves the fit of our model ($R^2$ increases from 70% to 82%), the coefficient on *MML* remains at a similar level (Coefficient=10 bps; *t*-statistic=5.31). In Column (3), we further control for local economic conditions, including state's unemployment rate, income per capita, and population. To the extent that local economic conditions changed as a result of MML, we obtain a more conservative estimate of the borrowing cost increase (Coefficient=9 bps; *t*-statistic=4.75). In Column (4), we augment the regression specification with rating fixed effects. Consistent with credit rating agencies incorporating some of the effects of MML, we find a lower estimate of the MML effect (Coefficient=7 bps; *t*-statistic=4.01).

Next, we provide more direct evidence on how MML affects local governments' borrowing costs through an increase in local residents' marijuana use. We perform two-stage regressions to quantify the impact of increased marijuana use on state bonds' spreads using available marijuana use rates data from 2002 and 2016. Table 3, Panel B presents the results. In the first stage, we use MML and the other controls to predict the state-year marijuana use rates (yearly users). In the second stage, we take the predicted value of marijuana use rates as an independent variable that explains bond spreads. We include bond contractual terms as control variables in Columns (1) and (2), and add state economic conditions and bond rating fixed effects in Column (3) and (4). Results from Columns (1) and (3) confirm a significant increase in marijuana consumption after MML. Columns (2) and (4) suggest that a one-percent increase in the state population that uses marijuana after MML is associated with a bond yield increase of 11 and 7 basis points, respectively. The results provide more direct evidence on the positive relationship between the increased marijuana use induced by MML and local governments' borrowing costs.

Last, we examine the parallel trends assumption by evaluating the effects of MML by year relative to the approval dates. Figure 4 plots the coefficients. We observe no significant changes in states' borrowing costs between MML and non-MML states in the pre period. MML states incur higher borrowing costs on average in the post period starting from year 1. Unlike the other post period years, the *MML* coefficients observed in years 2 and 3 are not significantly different from zero. While we are not able to identify any systematic reason for these weaker effects, anecdotally we know that the specific rules and requirements of the law are enacted following approval of MML laws. It is possible that this implementation may have differed from what investors initially anticipated. Based on the average coefficient estimates prior to and following our MML approval date, we believe our assumption of parallel trends is reasonable.

Taken together, the results in Table 3 indicate that MML leads to higher marijuana use and a subsequent increase in state-bond borrowing costs in the range of 7 to 11 bps. The economic significance is comparable to that of the newspaper-closure effect (i.e., 5 to 11 basis points) documented by Gao et al. (2019a). MML increases states' borrowing costs by $1.59 million per average state-bond issue, or by $7.35 million per average state annual issuance.[15]

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15. We interpret the economic impact of MML using the most conservative estimate from Column (4) of Table 3, Panel A in which we control for both changes in economic conditions and credit ratings. The average state issue size is $227 million, and the mean maturity term is ten years in our sample. We obtain $1.59 million estimate by multiplying $227 million by 7 bps and then by 10 years. The average annual issuance amount is $1.05 billion (with 4.6 issues per year). We obtain $7.35 million estimate by multiplying 1.05 billion by 7 bps and then by 10 years.

### 5.2. Identification Strategy I: Bordering Counties in Different States

Although we adopt a staggered shock design, we cannot fully rule out the possibility that the main results are driven by unmeasurable time-variant state-level factors that correlate with the staggered passage of MML. For example, changes in the composition of local residents and expectations of a gloomy local economy can lead to the passage of MML and thus confound our main findings. To mitigate such concerns, we examine adjacent counties residing in different states as an alternative identification strategy. Without a random assignment of MML to regions, one way to identify the causal effect of MML on borrowing costs is to select a counterfactual region that is similar to the treated one and then compare the differences in the pair's borrowing costs around MML. We examine two adjacent counties across the state border, whose characteristics are very likely to be similar in the absence of the policy change (Holmes, 1998). This approach relies on the abrupt changes in state policies (i.e., policy discontinuity) around the state borders for identification—any difference in changes of the borrowing cost that we observe between the two border counties around the passage of MML can be more confidently attributed to MML. Table 4 presents the results for the bordering counties tests. We obtain a list of border counties from the U.S. Census and county-bond offerings from Bloomberg. We estimate the effects of MML on bordering counties with equation (1) using two samples. Panels A and B of Figure 5 illustrate the samples, respectively, on a map.

For our first test, we follow Dube et al. (2010) to construct a sample of adjacent counties residing on the state borders, where the treatment counties are paired with the control counties with replacement. Specifically, we retain all adjacent county pairs across state borders in the U.S. Census list, as long as one county resides in a state where MML is legal and another county is located in a state where MML is illegal, for at least one year during our sample period. This procedure produces a sample of 146,088 county-bond offerings, corresponding to 495 pairs of bordering counties. Column (1) reveals that bordering counties located in MML states experience a 6-bps increase in their cost of borrowing relative to the control counties ($t$-statistic=2.43).

A long estimation window in our first sample allows us to capture the effect of MML over time, but is also more susceptible to confounding factors. To mitigate such a concern, we construct a sample for a strict difference-in-differences test following Huang (2008). We compare the changes in the treated county's borrowing cost from the four years before to four years after the passage of MML, relative to a control county residing in a bordering state that does not pass MML. We further require adjacent county pairs to have at least one bond issuance in both the pre- and post-MML periods. If multiple control counties are available for one treated county, we keep the closest one in population. These procedures limit the sample to 30 pairs of one-to-one matched treatment and control counties with available bond-issuance data around MML. Column (2) shows that treated counties incur a significant 21-bps increase ($t$-statistic=3.06) in the borrowing cost relative to the control counties. The estimated coefficient is larger than that in Column (1), likely due to the difference in how the samples are constructed. Our second sample consists of counties with at least one bond issuance around the passage of MML. As these counties continue to issue bonds despite higher borrowing costs, they likely have worse access to credit and higher financial and spending constraints relative to those counties that are dropped out of our sample.[16] Thus,

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16. Consistent with the idea that issuers trade off different financing venues, Baber and Gore (2008) report local governments use more public debt financing when the borrowing cost is lowered by adopting mandatory GAAP reporting. In our case, local governments are likely to use less public debt financing if the borrwoing cost increases with the passage of MML.

we observe a more pronounced increase in the borrowing cost among the more constrained issuers. Collectively, the bordering county tests reduce the possibility that states' cultural, social, and economic differences explain the treatment effect, and thus strengthen the causal link between MML and local governments' borrowing costs.

## 5.3. Identification Strategy II: Discontinuity in Voting Outcome

Our second identification strategy relies on an arguably random change in marijuana liberalization by focusing on two states, in which one passed MML by a small margin and the other rejected MML by a small margin. As Lee (2008) points out, the inherent uncertainty in the U.S. election vote count makes winning or losing a close election essentially "as good as random." In a similar sense, for our setting, the final decision of passing or rejecting MML determined in ballots within a small margin at the decision threshold (e.g., 50%) likely approximates a random change. The state with a close margin below the approval threshold can thus serve as a valid counterfactual for the treated state, which passes MML with a narrow margin above the threshold. Since the two states are similar in the residents' voting preferences towards medical marijuana, a difference between changes in the two states' borrowing costs around MML is likely due to the passage of MML rather than changes in the institutional and political factors that could have initiated the regulation.

Appendix E provides details about U.S. medical marijuana ballots, including the year, percentage voted for yes, and final outcome, collected from ballotpedia.org. We choose Arizona's 2010 ballot (approved with 50.1%) and Arkansas's 2012 ballot (defeated with 48.6%), because i) they were passed or rejected with the closest margins, and ii) they were voted within a shorter time period (which mitigates concerns over confounding effects due to time-variant factors). Because Arizona and Arkansas were not active in new bond issuance around the ballots, we use trading spreads to proxy for their borrowing costs. We compare changes in the borrowing costs between Arizona and Arkansas during the five years around the Arizona ballot (i.e., between 2005 and 2015), as the earliest trading data start in 2005. Following Gao et al. (2019a), we collect bond transactions associated with investor purchases from dealers and calculate the value-weighted average of trading yields for each bond in a given month. Then, we subtract the corresponding treasury rates from the aggregated trading yields to calculate trading spreads.

Table 5 presents the results. In Column (1), we use a base model with rating, state, and time (year-month) fixed effects, and we control for facility characteristics and local economic conditions. We find that the passage of MML by Arizona leads to a 36-bps increase in state-bond trading spreads relative to Arkansas ($t$-statistic=3.22). In Column (2), we examine the within-bond variation in trading spreads by replacing state fixed effects with facility fixed effects. Arizona's passage of MML leads to a 25-bps increase relative to Arkansas in this test ($t$-statistic=2.65). These results mitigate the concern that our inference could be driven by changes in the underlying institutional and political factors that lead to MML, rather than MML itself.

## 5.4. Underlying Mechanisms

### *5.4.1. State Contextual Factors*

We investigate whether the MML effect on bond spreads varies by state contextual features that have been shown by previous studies to be associated with the degree of marijuana use increases after MML. Table 6, Panel A presents the results. First, as part of MML, adequate regulation and enforcement are required

for administrative processes, such as packaging, industry licensing, and local control (Kilmer and MacCoun, 2017). States with more corruption tend to have lower law enforcement quality, and hence may fail to adequately regulate and enforce the MML processes to prevent potential negative spillover effects (e.g., drug trafficking). To capture the cross-sectional variation in states' level of corruption, we use the state-level corruption index from Saiz and Simonsohn (2013), which is based on corruption-related social phenomena exposed on the Internet.[17] Consistent with our expectation, Column (1) shows that the increase in offering spreads after MML is concentrated among states with higher levels of corruption.

Second, certain groups of population are found to be more vulnerable to the spillover effect of MML. Hasin et al. (2015) report that the increased prevalence of marijuana use from 2001/02 to 2012/03 is more concentrated among younger peole, African Americans, and urban residents. Columns (2) to (4) indicate that the increase in offering spreads after MML is more pronounced for states with younger populations, states with more African Americans, and states with more urban residents.

Third, states' natural environments affect the production costs of growing marijuana and hence its market supply. For instance, the ideal temperature of growing marijuana plants falls in a narrow range between 24 and 30 °C (75 to 86 °F) (Green, 2010). We use this narrow temperature range to separate states into two groups—those with more favorable versus less favorable environments for growing marijuana plants. We obtain data on states' average monthly temperatures from the National Centers for Environmental Information.[18] Column (5) shows that the increase in states' borrowing costs is greater for states whose average monthly temperatures tend to fall into the ideal temperature range more often. This finding suggests that bondholders are more concerned when the supply of marijuana is likely higher due to the cultivating environments. Overall, these cross-sectional results collectively lend credence to the mechanism that the increased marijuana use induced by MML leads to higher borrowing costs.

### *5.4.2. State Credit Risks*

Schwert (2017) and Novy-Marx and Rauh (2012) document that credit risk is the primary factor that drives municipal bond spreads. The increased bond spreads we observe in both the offering and secondary markets are likely a manifestation of bondholders' pricing of states' heightened credit risks. We further specify how the passage of MML alters states' credit risks and ultimately leads to higher municipal borrowing costs using two analyses.

First, we provide evidence with cross-sectional tests using bond-level characteristics. Table 6, Panel B, provides the cross-sectional results of the main effect by bond types (i.e., GO versus RV bonds), credit ratings, and bonds' maturity terms. Column (1) shows that the effect of MML on bond spreads is concentrated on GO bonds, which are directly backed by states' public budgets. Column (2) suggest that MML effect is significantly larger for lower-rated bonds, supporting the idea that MML affects bond yields through the default channel (Novy-Marx and Rauh 2012). Last, Column (3) finds that the increase in the bond spreads is concentrated among bonds with longer maturity terms, which is consistent with the stronger long-term social and health impacts arising from marijuana use, as argued by a synthesis of marijuana medical research (Volkow et al., 2014). These cross-sectional results indicate that MML affects

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17. Saiz and Simonsohn (2013) measure the degree of corruption of a state by calculating the ratio of the number of internet documents containing "corruption" and the state (using text proximity algorithms) over the total number of documents containing only the state. The logic is that a state with higher corruption receives more exposure online.

18. https://www.ncdc.noaa.gov/cag/national/time-series.

bond spreads especially for bondholders bearing states' ultimate financial burdens (i.e., GO bonds) and for those facing substantial credit risks (i.e., lower- rated bonds and longer-term bonds). The evidence suggests that states' credit risks likely are an important mechanism underlying the relation between MML and bond spreads.

Second, we directly investigate the impact of MML on state governments' spending in areas that are likely associated with the social consequences of increased marijuana use. As we have a relatively long sample period, spanning from 1990 to 2018, some of the increased credit risk priced in municipal bonds as a result of MML could manifest itself in states' public budgets. We collect state expenditures data from the U.S. Census Bureau's Annual Survey of State and Local Government Finances.[19] Appendix C, mentioned previously, shows that prior studies tend to argue MML affects residents' safety (e.g., crime rate), health (e.g., drug use disorder), and potentially social welfare (e.g., school attainment and unprotected sex). Columns (1) to (4) of Table 7, Panel A indicate that MML states spend more on residents' police, correctional facilities, health, and public welfare. As placebo tests, Columns (5) to (7) report that the expenditures on MML-unrelated activities (i.e., highways, natural resources, and park and recreation, respectively) do not change significantly. Column (8) suggests that MML increases states' deficits per capita by $237. These findings are consistent with the idea that MML states incur more expenditures on police, correctional facilities, and public welfare, likely to prevent and mitigate the negative social consequences of increased marijuana use. The evidence suggests that states' debt service capacity becomes more constrained by greater expenditures after MML, likely to prevent and mitigate the negative social consequences of increased marijuana use, resulting in higher credit risks and thus borrowing costs.

We highlight that public welfare expenditures that fund a collection of categorical programs, including low-income public housing and energy assistance, and food stamp administration, experience the greatest increase in Column (4) of Panel A. To supplement this finding, we investigate the change of population who received these three types of public welfare programs, using data from the Current Population Survey (CPS) March Supplements. We present results in Panel B of Table 7. Columns (1) to (3) indicate that a significantly larger percentage of MML state residents are provided with public housing, energy subsidies, and food stamps after MML. The expanded provisions of these services add more credence to the observed increase in state governments' public welfare spending. As for the reasons behind the increased needs for public welfare services, Columns (4) and (5) provide suggestive evidence that MML leads to a lower level of education attainment among local residents. Column (6) documents an increased number of drug-induced deaths in MML states, pointing to a potentially higher use of addictive drugs among MML state residents. These findings imply a potential reduction in labor productivity in MML states. A stream of literature documents the significantly negative impacts of regular marijuana use on individuals' school attainment and lifetime achievements (Volkow et al., 2014). For example, increased marijuana use is found to be associated with worsened school performance and an increased probability of school dropouts (Bray et al., 2000; Marie and Zölitz, 2017; Lynskey and Hall, 2000b). Marijuana use is also linked to poor career opportunities, lower income, and greater levels of welfare dependency (Fergusson and Boden, 2008; Brook et al., 2013; Schmidt et al., 1998).

Given that marijuana liberalization is a multifaceted issue, it is challenging to enumerate all the possible MML outcomes that affect governments' financial health and bondholders' pricing decisions. That said, we believe that the findings of higher government expenditures (in expected areas)

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19. https://www.census.gov/programs-surveys/state.html.

complemented with greater use of social welfare programs presented above provide more persuasive support for our proposed mechanism—MML drives up states' expenditures, increases states' financial burdens, and thus adversely affects states' debt servicing capacities and credit risks.

## 6. Robustness Tests and Additional Analyses

### 6.1. Robustness Tests

Table 8 shows that our main results are robust to the use of raw offering yields, tax- adjusted offering spreads, trading spreads, and gross spreads. Column (1) presents the estimates using raw offering yields. Column (2) examines tax-adjusted offering spreads. We collect state income tax rates from the National Bureau of Economic Research and follow Schwert (2017) to adjust the offering spreads of federal- and state-exempt bonds. The magnitude of the coefficients from both columns is at a similar level to those reported in Table 3. Columns (3) and (4) employ trading spreads from secondary market transactions as an alternative measure. We use a baseline model in Column (3), and in Column (4) we replace state fixed effects with facility fixed effects to control for differences in bond features. The findings indicate that the passage of MML leads to a 11-bps increase in trading spreads after accounting for changes in bond features. Moreover, we conduct a robustness check to address the concern that the main effect may be driven by specific states. Untabulated analysis shows that the main findings are robust to exclusion of any U.S. census region (i.e., West, Midwest, Northeast, and South) one at a time.

Next, we explore the micro-structure of the primary bond issuance market to examine the impact of MML on underwriter fees. In a municipal bond offering deal, the underwriter assumes the risk and responsibility to sell the bonds (O'Hara, 2012). The underwriter is compensated by the issuer with a fee (referred to as the gross spread), which is the difference between the purchase price from the issuer and the issue price (at which the bond is set to be offered to investors). The underwriter can make additional profits by selling the bond to investors at a higher price than the issue price, given that the sale price does not exceed a predetermined price set by the issuer in the offering deal. Thus, the gross spread is an underwriting fee paid by the issuer. If MML increases the state's credit risk, we expect the underwriter to demand a higher fee from the issuer to compensate for holding riskier bonds in inventory. Column (5) shows that MML states experience a 4-bps increase in the gross spread relative to non-MML states. That is, out of every $100 raised, four cents flow to underwriters. In dollar terms, this increase adds $420,000 to the annual cost of MML. This fee paid to the underwriter is in addition to the interest cost paid to investors (i.e., the offering spread).[20]

In sum, the collective evidence of the staggered shock of MML presented in Sections 5.1 to 5.4 above—using a sample of state bonds, a sample of neighboring-county bonds, and a discontinuity approach in state ballot votes, supplemented with a battery of robustness checks using alternative measures of borrowing costs—provides strong support of a causal inference that MML increases local governments' borrowing costs.

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20. Note that the offering yield excludes the expenses incurred in the bond issuance process, such as fees paid to underwriters and lawyers.

### 6.2. Alternative Explanations

In this section, we investigate three tests to examine alternative explanations. First, since our research design relies on the staggered adoption of MML, any alternative events that could confound our results must coincide with the staggered passage of MML across different states. Nonetheless, we further bolster our identification by employing another staggered change during the MML implementation—the opening of the first medical marijuana dispensary stores in MML states. This second shock is not perfectly correlated with MML's passage dates. Out of the thirty-two states and D.C. with MML, twenty-four states set up operational medical cannabis dispensaries before 2018. For example, Alaska passed MML but did not allow the establishment of state-licensed dispensaries. For states that both passed MML and allowed dispensary stores, the lag between MML's passage date and dispensaries' opening date varies significantly by states. Previous studies (Pacula et al., 2015; Baggio et al., 2020) provide evidence that the impact of MML magnifies after the opening of dispensary stores. As seen from Column (1) of Table 9, we also obtain consistent evidence that MML further increases bond spreads after states opened the first marijuana dispensary store. This intertemporal change in bond spreads with respect to staggered dispensary openings further reduces the possibility of other unrelated events driving our results.

Second, the passage of MML creates a conflict between the federal ban on marijuana and state legalization, posing additional risks on local residents and businesses that need to comply with federal laws. Thus, it's possible that the observed increase in bond spreads reflects heightened future political uncertainty (Pástor and Veronesi, 2013). To navigate the possibility of such a pricing factor, we compare the MML effect around an event that loosened the federal enforcement on marijuana prohibition. On August 29, 2013, the U.S. Deputy Attorney General, James Cole, issued a memorandum to deprioritize the use of funds to enforce cannabis prohibition under the Controlled Substances Act. The issuance of this memorandum greatly reduces the likelihood of federal intervention with local states' marijuana legalization, which should lower the degree of political uncertainty and hence the bond spreads. However, the reduced level of federal effort on marijuana prohibition can further encourage local residents' use of marijuana, intensifying the spillover effect of MML. Column (2) of Table 9 shows that the MML effect becomes stronger after the Cole memorandum, supporting the increased use of marijuana as the primary pricing factor, rather than the heightened political uncertainty resulting from the legal conflict.

Third, Hong and Kacperczyk (2009) argue that some investors prefer not to invest in sin stocks that involve producing alcohol, tobacco, and gaming, and as a result these stocks exhibit higher expected returns. If state bondholders simply prefer not to invest in 'marijuana' states that pass MML, the capital supply for their bonds would decrease, and the borrowing cost of MML states can increase. While this explanation is certainly plausible, the impact of MML on borrowing costs is ex-ante less likely driven by investors' preference to avoid sin states because the passage of MML laws is primarily determined by residents in ballot votes. In other words, when residents' preference to avoid sinful behavior is strong, we would not be able to see the passage of MML. Given that a large portion of state bondholders are local residents (due to the tax exemption benefits) who can participate in voting of MML, the effect of MML should less likely come from the sin effect. Nonetheless, to test this sin explanation, we examine how the impact of MML varies by public acceptance of marijuana. The sin story implies that marijuana is more likely to be associated with sin when its acceptance rate is lower. This suggests that an increase in borrowing costs due to sin would be stronger when marijuana is less publicly accepted. However, if MML instead increases the state's credit risk, we would expect the main effect to be stronger when the public acceptance of marijuana is higher, which likely induces higher use. We collect data on the national

acceptance rate for marijuana from the General Social Survey conducted by the National Opinion Research Center at the University of Chicago.[21] Column (3) of Table 9 shows that the effect of MML is increasing in marijuana's public acceptance, which is more consistent with the idea of increased marijuana use as opposed to the sin story.

### 6.3. Recent Recreational Marijuana Liberalization

Our main analysis estimates the overall effect of marijuana liberalization using the initial liberalization of marijuana (i.e., for medical purpose). Following this initial liberalization, several states took steps to further liberalize marijuana by actively advocating for the legalization of marijuana for recreational use. These recreational marijuana policies generally allow for the commercial production, processing and sale of marijuana, similar to alcohol and tobacco.[22] Between 2012 and 2018, a total of ten states (i.e., Alaska, California, Colorado, Maine, Massachusetts, Michigan, Nevada, Oregon, Vermont, and Washington) and the District of Columbia further allowed the recreational use of marijuana. Other states, such as New York and New Jersey, are considering similar legislation (Angell, 2018). As recreational marijuana was only recently liberalized in a few states, the time series data following passage is extremely limited, and hence public policy evidence on the outcomes of recreational marijuana liberalization is likely inconclusive.[23] With this caveat in mind, we conduct an additional analysis with the aim of providing preliminary evidence on recreational marijuana liberalization.

The impact of subsequent liberalization of recreational marijuana is ex-ante unclear. On the one hand, state officials and media argue that allowing marijuana for recreational use yields several economic benefits, such as reduced law enforcement costs, increased tax revenues, and the creation of jobs by boosting the size of marijuana industry (McGinty et al., 2016, 2017; Jacobi and Sovinsky, 2016). Compared with medical marijuana, local governments can collect higher tax revenues on recreational marijuana, which should at least to some extent mitigate states' increased government expenditures and borrowing costs. On the other hand, the reasons for higher borrowing costs that we document with medical marijuana laws are likely to be exacerbated with recreational marijuana legalization because of even greater expected use of marijuana. For instance, Colorado and Washington legalized possession of marijuana for recreational use in the amount of one ounce or less by adults 21 and older. Thus, recreational marijuana liberalization likely results in even greater marijuana use and thus an additional increase in states' borrowing costs.

Table 10 presents the results of our analyses. We augment the regression specification used in Column 4 of Table 3, Panel A. For states with both medical and recreational marijuana laws, we separately estimate the effects of marijuana liberalization for two consecutive time periods—the initial passage of medical marijuana *(Med_year)* and the subsequent liberalization of recreational marijuana *(Rec_year )*. *Med_year* is an indicator that equals one for bonds issued after the bond issuing state legalizes medical marijuana and before the state further legalizes recreational marijuana, zero otherwise. *Rec_year* is an indicator that equals one for bonds issued after the bond issuing state further allows recreational marijuana, zero

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21. See https://www.norc.org/Research/Projects/Pages/general-social-survey.aspx.

22. For more details, see Table 1 of McGinty et al. (2017).

23. Kerr et al. (2017) find that college students in Oregon increase marijuana use after recreational marijuana legalization in 2014. Dragone et al. (2019) find a reduced incidence of rape and property crime in the District of Columbia after recreational marijuana legalization in 2014.

otherwise. For the states that have only legalized medical marijuana, *Rec_year* is defined as zero. Column (1) shows that relative to the pre-liberalization period, states' borrowing costs increases after medical marijuana liberalization and climbs slightly higher after recreational marijuana liberalization. Column (2) shows that the effect of *Med_year* on GO bonds' offering spreads is particularly strong (0.01+0.09=0.10), and similarly, the effect of *Rec_year* for GO bonds is pronounced (-0.04+0.20=0.16), consistent with the result reported in Column (1) of Table 6, Panel B. Further, although the difference between *Med_year* and *Rec_year* in Column (1) is not statistically significant at conventional levels, Column (2) shows that this difference is statistically significant among GO bonds. These findings suggest that states' borrowing costs may have even climbed higher after the recreational marijuana liberalization.[24]

Overall, this evidence provides modest support that states continue bearing higher borrowing costs associated with marijuana legalization after the legalization of recreational marijuana despite the potentially higher revenue collected from recreational marijuana consumption. We caution however that our evidence is far from conclusive, as only ten states and the District of Columbia recently legalized recreational marijuana. We leave the comprehensive investigation of recreational marijuana laws for future research.

## 7. Conclusion

We provide the first evidence on an unmentioned cost of U.S. medical marijuana liberalization imposed by investors in the capital market. We show that the passage of medical marijuana laws increases state bonds' offering spreads by 7 bps, trading spreads by 11 bps, and underwriter gross spreads by 4 bps. In addition, counties residing in states that pass medical marijuana laws also experience higher bond spreads of 6 bps. These findings indicate that municipal bond investors impose higher borrowing costs on local governments with medical marijuana laws. Cross-sectional results reveal that this increase in the borrowing costs is stronger for GO bonds, longer-term bonds, and riskier bonds, as well as for states expected to suffer higher marijuana use (i.e., states with more corruption, socio-demographics associated with more use, and better cultivation conditions for marijuana). States incur greater expenditures related to marijuana after the passage of MML, suggesting that MML laws hinder states' debt servicing capacity and thus adversely affect their credit quality.

The findings from our paper are particularly relevant to policy makers and residents interested in evaluating the overall cost of liberalizing marijuana. We add to the debate by showing that municipal bondholders perceive medical marijuana liberalization to induce a net economic cost to the state. We also contribute to the emerging literature on public health issues in finance and the growing literature that studies the determinants of municipal bond yields by documenting the public finance effect of a public health policy.

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24. As a robustness check, we exclude the states that legalized both medical and recreational marijuana from the main tests and continue to find inferences unchanged (untabulated).

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## APPENDIX A: DATES OF MML'S APPROVAL AND FIRST DISPENSARY STORES' OPENING

This table lists the approval dates of medical marijuana liberalization (MML) and the dates of opening of the first dispensary store between 1996 and 2018. We use Arizona's 2010 ballot (approved with 50.10%) and Arkansas's 2012 ballot (defeated with 48.56%) in our second identification strategy.

| State | MML | First Dispensary Store |
|---|---|---|
| California | 11/05/1996 | 11/10/1996 |
| Alaska | 11/03/1998 | |
| Oregon | 11/03/1998 | 10/11/2009 |
| Washington | 11/03/1998 | 11/13/2009 |
| Maine | 11/02/1999 | 03/31/2011 |
| Hawaii | 04/25/2000 | 08/08/2017 |
| Colorado | 11/07/2000 | 10/01/2005 |
| Nevada | 11/07/2000 | 10/30/2009 |
| Vermont | 05/19/2004 | 06/21/2013 |
| Montana | 11/02/2004 | 03/01/2009 |
| Rhode Island | 01/03/2006 | 04/19/2013 |
| New Mexico | 03/13/2007 | 07/01/2009 |
| Michigan | 11/04/2008 | 06/15/2009 |
| New Jersey | 01/11/2010 | 12/06/2012 |
| District of Columbia | 05/04/2010 | 07/29/2013 |
| Arizona | 11/02/2010 | 12/06/2012 |
| Delaware | 05/11/2011 | 06/26/2015 |
| Connecticut | 05/04/2012 | 08/20/2014 |
| Massachusetts | 11/06/2012 | 06/24/2015 |
| Illinois | 05/17/2013 | 11/09/2015 |
| New Hampshire | 06/26/2013 | 04/30/2016 |
| Maryland | 04/07/2014 | 07/06/2017 |
| Minnesota | 05/16/2014 | 07/01/2015 |
| New York | 06/20/2014 | 01/07/2016 |
| Pennsylvania | 04/13/2016 | |
| Louisiana | 05/16/2016 | |
| Ohio | 05/25/2016 | |
| Arkansas | 11/08/2016 | |
| Florida | 11/08/2016 | 7/26/2016 |
| North Dakota | 11/08/2016 | |
| West Virginia | 04/06/2017 | |
| Oklahoma | 06/26/2018 | 9/16/2018 |
| Missouri | 11/06/2018 | |
| Utah | 11/06/2018 | |

## APPENDIX B: MARIJUANA USE AND PERCEPTIONS TOWARDS MARIJUANA

The economic theory of substance use (Becker and Murphy, 1988; Grossman, 2005) suggests that passage of MML increases perceived health and legal risks associated with marijuana use, expands marijuana availability, and thus induces greater local marijuana consumption. To validate these predictions, we examine the impacts of MML on states' marijuana use rates and residents' perceptions towards marijuana. First, we estimate the effect on marijuana consumption by regressing the staggered passage of MML on a state's percentage of population who use marijuana. Next, we show the effects on resident' s perceptions towards marijuana's health risk, legal risk, and availability, by regressing MML on perceived harm, legal risk, and availability, respectively. Finally, we include both states' marijuana use rates and residents' perception variables in the regression. We obtain the outcome measures from the National Survey on Drug Use and Health (NSDUH), which first become available in 2002.

We estimate these effects, using an ordinary least squares (OLS) regression with the following model:

$$y_{jt} = \alpha + \beta MML_{jt} + \delta' Z_{jt} + \eta_j + \mu_t + \varepsilon_{jt} \qquad (2)$$

where $j$ denotes state, and $t$ denotes year month. $y_{jt}$ is the outcome variables described above for state $j$ during year $t$. $MML_{jt}$ is an indicator that equals one if state $j$'s passes medical marijuana laws, zero otherwise. $Z_{jt}$ is a vector of state-year-level economic factors. We include state fixed effects ($\eta_j$ ) to account for state-specific and time-invariant characteristics, and year fixed effects ($\mu_t$) to absorb time-varying economy-wide trends. We cluster standard errors by state. The coefficient on $MML_{jt}$ gauges the effect of MML on states' marijuana use rates and residents' perceptions relative to the unaffected states.

We present the results of this analysis below. First, Columns (1) and (2) investigate MML's impact on states' marijuana consumption. Column (1) uses a state's percentage of population who use marijuana in the year before the survey as an outcome variable. Column (2) employs a state's percentage of population who use marijuana every day in the month before the survey as a dependent variable. The coefficients on $MML_{jt}$ indicate that MML increases marijuana yearly users by 0.95 percent of states' population, and regular daily users by 0.70 percent. Given that the state average rate is 11.15% and 2.35%, these increases represent 9% above the average of yearly users (0.95% / 11.15%), and 30% above the average of daily users (0.70% / 2.35%), respectively, suggesting that MML significantly increases both the number of users and the frequency of use.

Next, Columns (3) to (5) examine whether MML alters residents' perceptions towards marijuana's health risk, legal risk, and availability. Column (3) uses a state's percentage of population who agree that smoking marijuana once or twice a week might cause harm as an outcome variable. Column (4) employs a state's percentage of population who report that their perception of the maximum legal penalty in their state of residence for the first offense possession of an ounce or less of marijuana for their own use is a prison sentence, as a dependent variable. The coefficients on $MML_{jt}$ indicate that MML is associated with a 1.03-percent reduction in the population who believe smoking marijuana once or twice a week might cause harm, and a 2.69-percent reduction in the population who report that possessing marijuana for

their own use could put them in jail. Column (5) uses a state's percentage of population who report that it would be fairly easy or very easy for them to obtain marijuana if they want some, as an outcome variable. The coefficient on $MML_{jt}$ indicates that MML is associated with as a 2.54-percent increase in residents' who report easier access to marijuana, suggesting improved marijuana availability and lower search costs faced by potential users.

Finally, Column (6) presents the effect of MML on marijuana consumption after controlling for residents' perception variables. The significant coefficients on $PerceivedHarm_{jt}$, $PerceivedLegalRisk_{jt}$, and $PerceivedAvailability_{jt}$ indicate that these three perceptions explain the increase in marijuana users induced by MML. Further, the lower coefficient on $MML_{jt}$ confirms that the effect of MML is at least partially subsumed by residents' perception variables.

The collective evidence in this table suggests that MML has increased local marijuana consumption by lowering health and legal risks and expanding marijuana availability. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively.

Appendix B (Continued)

| | (1) Yearly User | (2) Daily User | (3) Perceived Harm | (4) Perceived Legal Risk | (5) Perceived Availability | (6) Yearly User |
|---|---|---|---|---|---|---|
| MML | 0.95** | 0.70*** | -1.03*** | -2.69*** | 2.54*** | 0.36 |
| | (2.42) | (5.17) | (-3.29) | (-3.17) | (3.63) | (1.23) |
| Perceived Harm | | | | | | -0.31*** |
| | | | | | | (-6.63) |
| Perceived Legal Risk | | | | | | -0.05*** |
| | | | | | | (-3.45) |
| Perceived Availability | | | | | | 0.14*** |
| | | | | | | (5.30) |
| Economic Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 645 | 516 | 516 | 516 | 516 | 516 |
| Adj. $R^2$ | 0.88 | 0.77 | 0.92 | 0.83 | 0.76 | 0.90 |

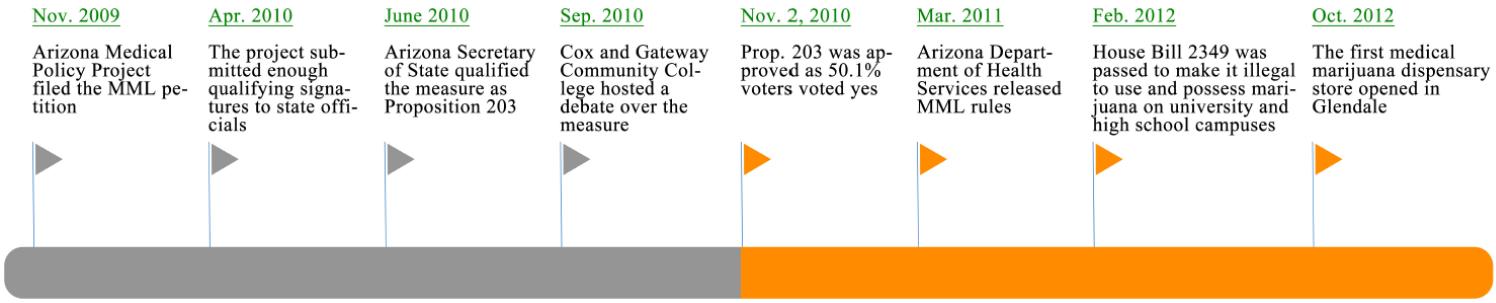
## APPENDIX C: SUMMARY OF MML'S EXPECTED OUTCOMES

This table summarizes the benefits and costs of medical marijuana liberalization (MML) discussed in the news articles and the existing literature.

| Pros | | Examples |
|---|---|---|
| 1 | Give patients in needs access to a quality and safe product | Schlinkmann (2010) |
| 2 | Provide a safer choice than traditional opioid drugs, or narcotics, with less severe side effects | Worden (2015) |
| 3 | Develop the marijuana industry and create jobs | Wollan (2010) |
| 4 | Increase government revenue by charging permit fees and sales taxes | Wollan (2010) |
| 5 | Attract more residents and visitors to the counties with dispensary stores | Brooks (2013) |
| **Cons** | | **Examples** |
| 1 | Lead to more illicit use | Schlinkmann (2010) |
| 2 | Lead to more use of other hard drugs (e.g., Opioid overdose) | Schlinkmann (2010)<br>Shover et al. (2019) |
| 3 | Adversely change the perception and culture | Schlinkmann (2010) |
| 4 | Slippery slope to full legalization | Holden (2012) |
| 5 | Encourage adolescent use | Goyena (2014)<br>Pacula et al. (2015)<br>Wen et al. (2015) |
| 6 | Increase crime rates | Goyena (2014) |
| 7 | Increase the potency of marijuana products in the market | Goyena (2014) |
| 8 | Ineffective controls and regulations | Gershman (2012) |
| 9 | Limited knowledge about the dosage and the risk | Worden (2015) |
| 10 | Unprotected sex | Baggio et al. (2020) |
| 11 | Traffic fatality | Li et al. (2013) |

## APPENDIX D: TIMELINE OF MEDICAL MARIJUANA LEGALIZATION IN ARIZONA

We use Arizona as an example to demonstrate the timeline of medical marijuana legalization below.



## APPENDIX E: LIST OF MEDICAL MARIJUANA BALLOTS IN THE U.S.

This table lists the ballot dates and outcomes (both approvals and defeats) for the eighteen states that have passed medical marijuana in ballots. We compare the two states with the closest margin to the decision rule (50%)—Arizona's 2010 ballot (approved with 50.10%) and Arkansas's 2012 ballot (defeated with 48.56%).

| State | Name of Measure | Year | Outcome | Yes% |
|---|---|---|---|---|
| California | Marijuana Legalization, Proposition 19 | 1972 | Defeated | 33.5% |
| California | Proposition 215, the Medical Marijuana Initiative | 1996 | Approved | 55.6% |
| Alaska | Medical Marijuana Act, Measure 8 | 1998 | Approved | 58.7% |
| Nevada | Medical Marijuana Act, Question 9 | 1998 | Approved | 58.7% |
| Oregon | Medical Marijuana, Measure 67 | 1998 | Approved | 54.6% |
| Washington | Medical Marijuana, Initiative 692 | 1998 | Approved | 59.0% |
| Maine | Medical Marijuana for Specific Illnesses, Question 2 | 1999 | Approved | 61.4% |
| Colorado | Medical Use of Marijuana, Initiative 20 | 2000 | Approved | 53.5% |
| Nevada* | Medical Marijuana Act, Question 9 | 2000 | Approved | 65.4% |
| Arizona | Marijuana Legalization, Proposition 203 | 2002 | Defeated | 42.7% |
| Montana | Medical Marijuana Allowance, Measure I-148 | 2004 | Approved | 61.8% |
| South Dakota | Measure 4, Medical Marijuana | 2006 | Defeated | 47.7% |
| Michigan | Medical Marijuana Initiative, Proposal 1 | 2008 | Approved | 63.0% |
| Arizona | Medical Marijuana Question, Proposition 203 | 2010 | Approved | 50.1% |
| South Dakota | Medical Marijuana Act, Initiated Measure 13 | 2010 | Defeated | 36.7% |
| Arkansas | Medical Marijuana Question, Issue 5 | 2012 | Defeated | 48.6% |
| Massachusetts | Medical Marijuana Initiative, Question 3 | 2012 | Approved | 63.3% |
| Florida† | Right to Medical Marijuana Initiative, Amendment 2 | 2014 | Defeated | 57.6% |
| Arkansas | Medical Marijuana Amendment, Issue 6 | 2016 | Approved | 53.1% |
| Florida | Medical Marijuana Legalization, Amendment 2 | 2016 | Approved | 71.3% |
| North Dakota | Medical Marijuana Legalization, Initiated Statutory Measure 5 | 2016 | Approved | 63.8% |
| Missouri | Proposition C, Medical Marijuana and Veterans Healthcare Services, Education, Drug Treatment, and Public Safety Initiative | 2018 | Defeated | 43.6% |
| Missouri | Amendment 2, Medical Marijuana and Veteran Healthcare Services Initiative | 2018 | Approved | 65.6% |
| Missouri‡ | Amendment 3, Medical Marijuana and Biomedical Research and Drug Development Institute Initiative | 2018 | Defeated | 31.5% |
| Oklahoma | Question 788, Medical Marijuana Legalization Initiative | 2018 | Approved | 56.9% |
| Utah | Proposition 2, Medical Marijuana Initiative | 2018 | Approved | 52.8% |

*In Nevada, it requires approval in consecutive elections for a constitutional amendment to be enacted.
†In Florida, it takes a supermajority vote (60%) for a constitutional amendment to be enacted.
‡Missouri had three parallel medical marijuana initiatives with differences in tax collection and spending in the ballots of 2018.

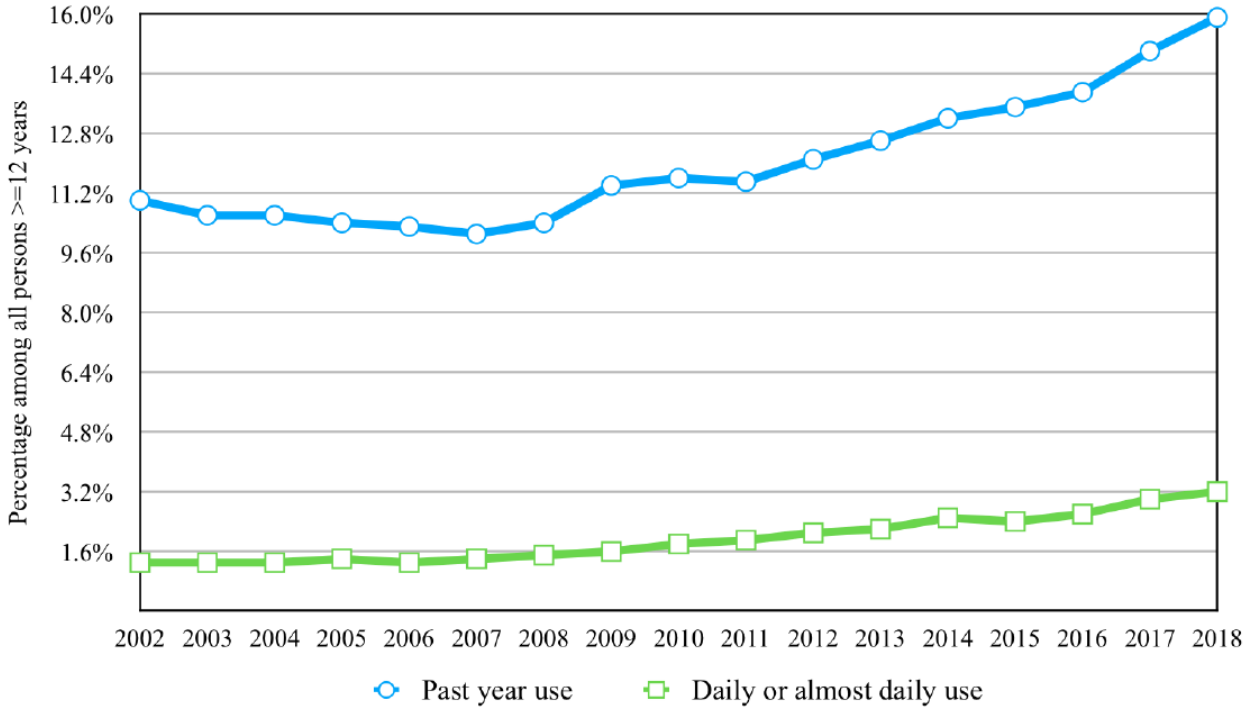
## APPENDIX F: VARIABLE DEFINITIONS

| Variable | Definition |
|---|---|
| Acceptance rate | Acceptance rate towards marijuana legalization in the bond's issuance year, obtained from General Social Survey conducted by the National Opinion Research Center at the University of Chicago. |
| Ad Valorem | Indicator that equals one if the bond is repaid by ad valorem taxes, and zero otherwise |
| AMT | Indicator that equals one if the bond's interest is subject to alternative minimum tax (AMT), and zero otherwise |
| BQ | Indicator that equals one if the bond is a bank qualified bond, and zero otherwise |
| Callable | Indicator that equals one if the bond has an embedded call option, and zero otherwise |
| Competitive Bid | Indicator that equals one if the bond is sold to underwriters through competitive bidding, and zero otherwise |
| Corrupt | Indicator that equals one if the bond is issued by a state with above-median corruption index obtained from Saiz and Simonsohn (2013), and zero otherwise |
| Fed Exempt | Indicator that equals one if the bond's interest is not subject to federal income tax, and zero otherwise |
| GO Bond | Indicator that equals one if the bond is a general obligation bond, and zero otherwise |
| Gross Spread | Bond's issuance underwriter discount cost disclosed by the underwriter in an official statement, measured as a percentage of the total issued amount; an official statement is a document prepared by or on behalf of a state or local government for a new issue of municipal securities |
| Income | Log transformation of annual income per capita in the state or the county for a given year |
| Insurance | Indicator that equals one if the bond is insured, and zero otherwise |
| Long Term | Indicator that equals one if the bond's time to maturity is above sample median, and zero otherwise |
| Low College | Indicator that equals one if the bond is issued by a state with a below-median percentage of population that have some college, Associate, Bachelor, Graduate or professional degrees in the last census, and zero otherwise |
| Majority | Indicator that equals one if the surveyed acceptance rates toward marijuana legalization in the bond issuance year are over 50 percent, and zero otherwise |
| African American | Indicator that equals one if the bond is issued by a state with an above-median percentage of African Americans over the total population in the last census, and zero otherwise |
| MML | Indicator that equals one if the bond is issued after the corresponding state's approval date of medical marijuana law, and zero otherwise |
| Offering Yield | Discount rate that makes the proceed amount the expected coupons and principal repayments equal to the price at issuance |

| Appendix F (Continued) | |
|---|---|
| Variable | Definition |
| Offering Spread | Offering yield adjusted by the interpolated treasury rates for corresponding maturity terms |
| Optimal Growing | Indicator that equals one if the bond is issued by a state with above-median percentage of months with average temperature ideal for marijuana cultivation (between 75°F to 86 °F) in 1990-2018 |
| Population | Log transformation of population in the state or the county for a given year |
| Puttable | Indicator that equals one if the bond has an embedded put option, and zero otherwise |
| Refunding | Indicator that equals one if the bond is refunded after the issuance, and zero otherwise |
| Sinkable | Indicator that equals one if the bond is backed by a sinking fund, and zero otherwise |
| Size | Bond's issue amount. We use the log transformation of issue amount in the regressions |
| State Exempt | Indicator that equals one if the bond's interest is not subject to the state income tax, and zero otherwise |
| Tax-Adjusted Offering Spread | Offering yield adjusted based on the bond's tax exempt status under the assumption of the highest federal and state income tax rates, and then less the interpolated treasury rates for corresponding maturity terms, following Schwert (2017) |
| Time to Maturity | Number of years between the bond's issue date and its maturity date |
| Trading Yield | Value-weighted average of trading yields in the secondary market for the bond's customer-buy transactions in a given month |
| Trading Spread | Secondary market trading yield adjusted by the interpolated treasury rates for corresponding maturity terms |
| Unemployment | Unemployment rate in the state or the county for a given year |
| Young | Indicator that equals one if the bond is issued by a state with an above-median percentage of population that's aged 30 and below in the last census, and zero otherwise |

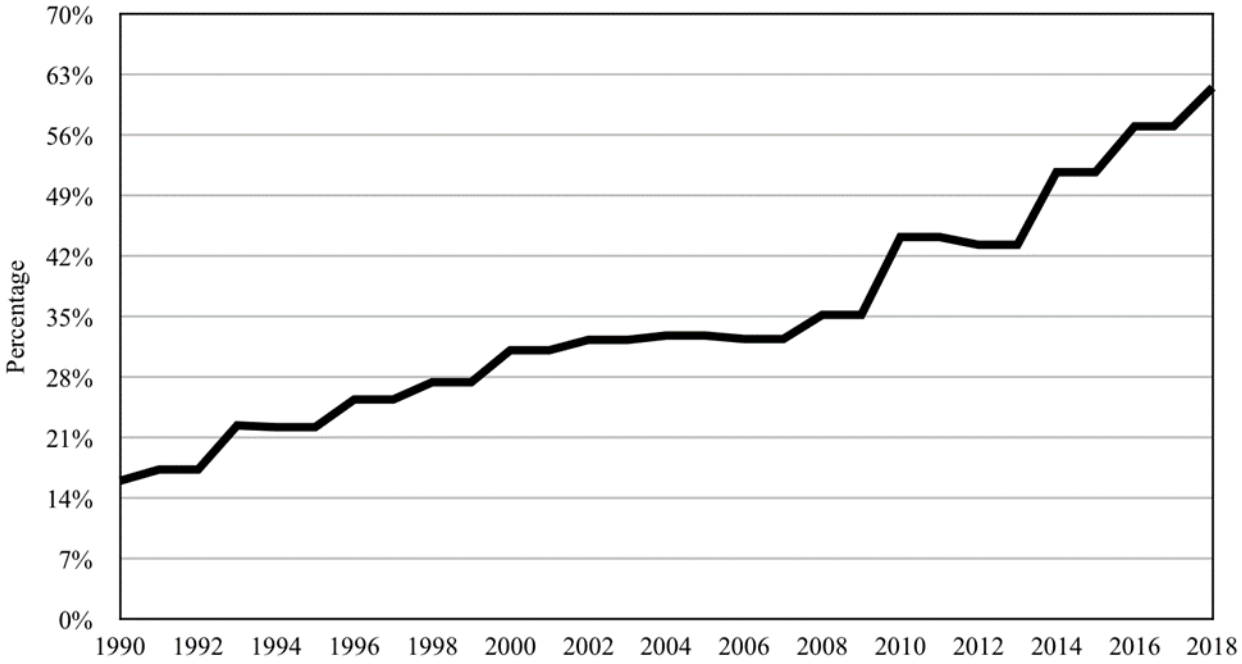
## FIGURE 1: MARIJUANA USER RATES OVER TIME

This table shows the percentage of marijuana users among all persons aged 12 and above from 2002 to 2018, according to the National Survey on Drug Use and Health conducted by the Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality.



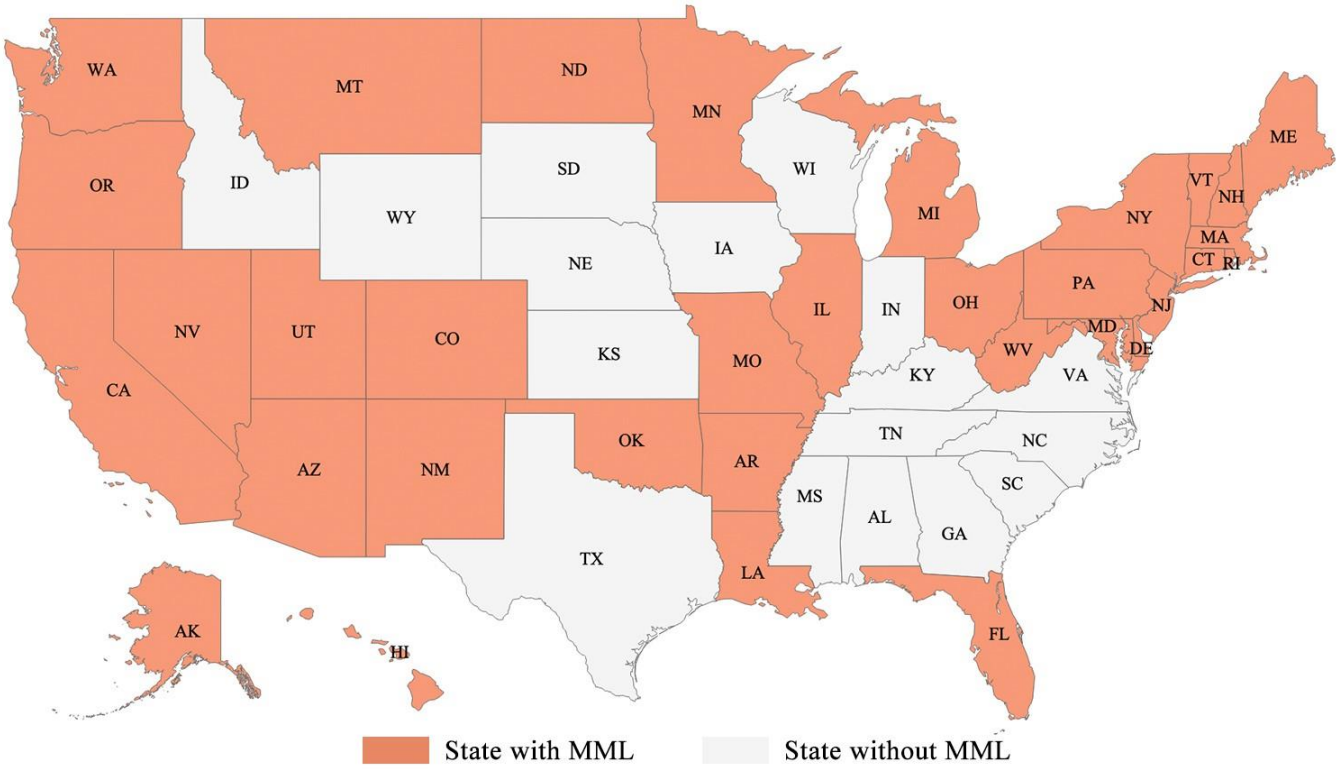
## FIGURE 2: MARIJUANA ACCEPTANCE RATES OVER TIME

This table shows the national acceptance rate towards marijuana legalization from 1990 to 2018, according to the General Social Survey conducted by the National Opinion Research Center at the University of Chicago.



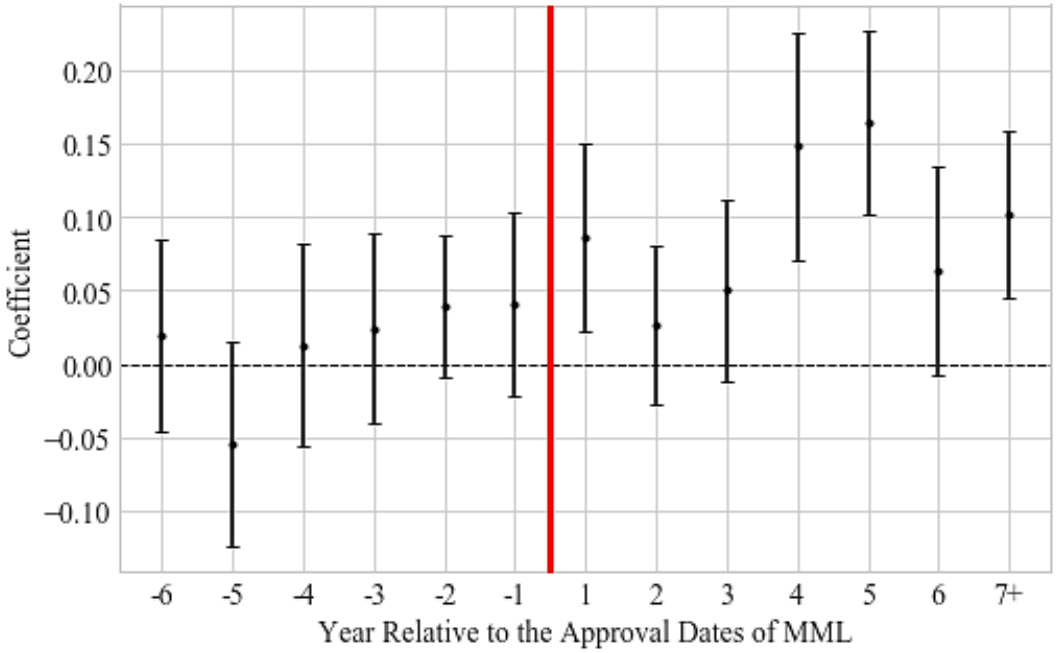
## FIGURE 3: MML STATES

This map labels states with medical marijuana liberalization (MML) as of the sample period end (i.e., 2018).



## FIGURE 4: PARALLEL TRENDS ASSUMPTION

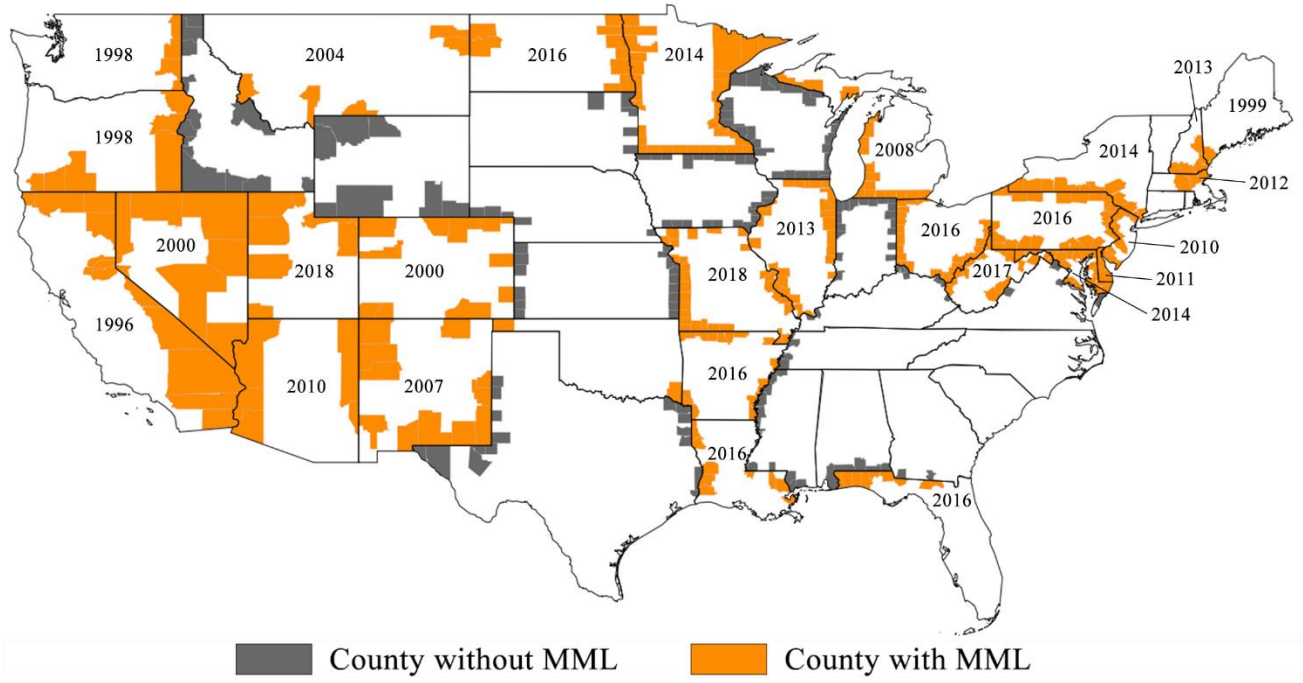
This graph examines the parallel trends assumption. We plot the incremental effects of MML on the state-bond offering spreads by the number of years relative to the states' MML approval dates. The x-axis denotes the year relative to the states' MML approval dates. The y-axis plots the coefficient for each event-year estimated using the regression specification in column 4 of Table 3. The dots represent coefficient estimates, and the lines represent 95% confidence intervals.



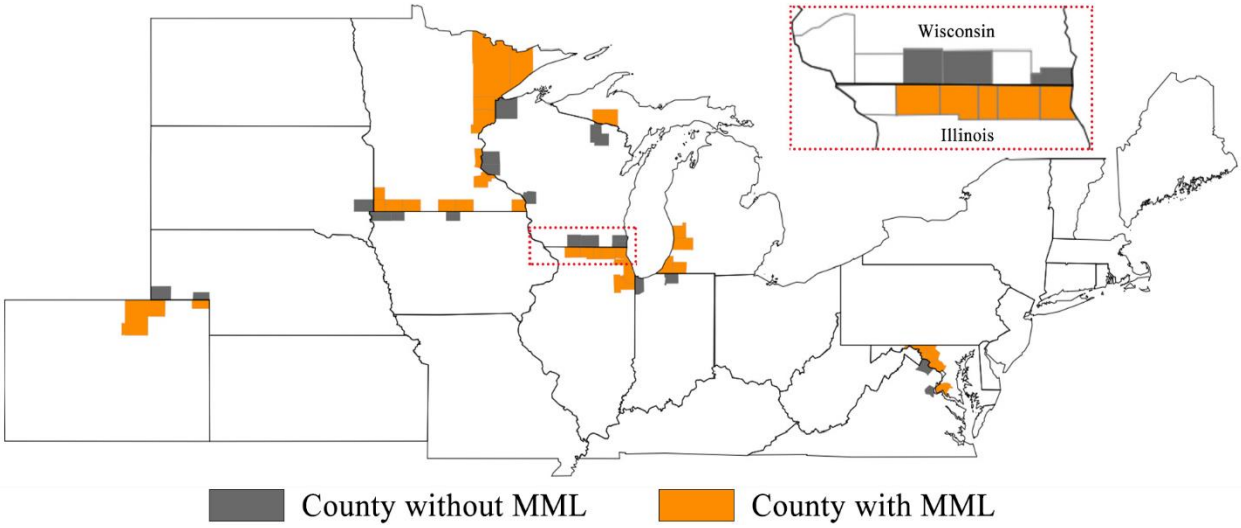
## FIGURE 5: IDENTIFICATION STRATEGY I: BORDERING COUNTIES

These figures demonstrate the samples used for the bordering county tests in Table 4. *Panel A* graphs the paired county sample (with replacement) used for column 1. We label the approval years of MML for treated counties. Due to the staggered passage of MML, a county with MML (which has not passed MML) can serve as the control county for another treated county that is passing MML in the year. For instance, California passed MML in 1996, and Arizona passed MML in 2010. A county residing in Arizona and along the California-Arizona border can be the control county for a California county that receives the MML treatment in 1996. *Panel B* illustrates the difference-in-differences sample (matched on population with replacement) used for column 2.

Panel A



Panel B



## TABLE 1: SAMPLE COMPOSITION

This table presents the number of bonds and its percentage in our main test sample by state. MML is the percentage of bonds issued after the passage of medical marijuana laws in each state relative to all bonds issued by the state during the sample period.

| State | Obs. | Percentage | MML | State | Obs. | Percentage | MML |
|---|---|---|---|---|---|---|---|
| AK | 640 | 0.6% | 80% | MT | 1,365 | 1.2% | 31% |
| AL | 491 | 0.4% | 0% | NC | 1,310 | 1.2% | 0% |
| AR | 1,355 | 1.2% | 2% | ND | 137 | 0.1% | 0% |
| AZ | 420 | 0.4% | 15% | NE | 603 | 0.5% | 0% |
| CA | 8,196 | 7.2% | 83% | NH | 847 | 0.7% | 15% |
| CO | 585 | 0.5% | 87% | NJ | 952 | 0.8% | 12% |
| CT | 3,566 | 3.1% | 22% | NM | 210 | 0.2% | 32% |
| DC | 2,535 | 2.2% | 36% | NV | 3,017 | 2.7% | 58% |
| DE | 1,058 | 0.9% | 26% | NY | 2,445 | 2.1% | 8% |
| FL | 5,736 | 5.0% | 5% | OH | 5,985 | 5.3% | 10% |
| GA | 2,228 | 2.0% | 0% | OK | 188 | 0.2% | 0% |
| HI | 2,177 | 1.9% | 72% | OR | 7,321 | 6.4% | 69% |
| IA | 231 | 0.2% | 0% | PA | 2,444 | 2.1% | 6% |
| ID | 29 | 0.0% | 0% | RI | 1,507 | 1.3% | 49% |
| IL | 5,170 | 4.5% | 9% | SC | 2,269 | 2.0% | 0% |
| IN | 2,840 | 2.5% | 0% | SD | 100 | 0.1% | 0% |
| KS | 39 | 0.0% | 0% | TN | 790 | 0.7% | 0% |
| KY | 125 | 0.1% | 0% | TX | 6,949 | 6.1% | 0% |
| LA | 851 | 0.7% | 9% | UT | 342 | 0.3% | 0% |
| MA | 4,920 | 4.3% | 20% | VA | 1,091 | 1.0% | 0% |
| MD | 2,578 | 2.3% | 11% | VT | 1,132 | 1.0% | 54% |
| ME | 821 | 0.7% | 56% | WA | 7,699 | 6.8% | 75% |
| MI | 3,875 | 3.4% | 10% | WI | 6,632 | 5.8% | 0% |
| MN | 2,063 | 1.8% | 18% | WV | 435 | 0.4% | 16% |
| MO | 753 | 0.7% | 0% | WY | 13 | 0.0% | 0% |
| MS | 4,658 | 4.1% | 0% | Total | 113,723 | 100% | |

## TABLE 2: SUMMARY STATISTICS

This table summarizes state bonds' contractual features at the facility level. Panel A provides summary statistics of facility-level characteristics for the full sample. Panel B provides summary statistics of facility-level characteristics by state.

Panel A

| State | Yield (%) | Spread (%) | Size (millions) | Rating | Non-Rated | Maturity | GO Bond | Insurance | Refunding | Ad Valorem | Fed Exempt | State Exempt | AMT | BQ | Sinkable | Callable | Puttable | Competitive |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 3.99 | -0.40 | 8.68 | 19.36 | 15% | 9.97 | 62% | 18% | 22% | 31% | 87% | 69% | 5% | 3% | 6% | 42% | 0% | 43% |
| SD | 1.54 | 0.87 | 15.58 | 1.74 | 0.35 | 6.45 | 0.49 | 0.38 | 0.42 | 0.46 | 0.34 | 0.46 | 0.22 | 0.16 | 0.23 | 0.49 | 0.01 | 0.50 |
| Min | 0.43 | -2.10 | 0.02 | 6 | 0 | 0.59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| p25 | 3.00 | -1.00 | 0.62 | 19 | 0 | 4.93 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 4.15 | -0.46 | 2.86 | 20 | 0 | 9.00 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| p75 | 5.05 | 0.14 | 10.00 | 21 | 0 | 14.03 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| Max | 7.25 | 2.08 | 101.62 | 21 | 1 | 29.92 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Panel B | | | | | | | | | | | | | | | | | | |
| AK | 3.64 | -0.32 | 5.27 | 20.45 | 12% | 9.25 | 25% | 54% | 14% | 18% | 74% | 45% | 24% | 0% | 3% | 40% | 0% | 31% |
| AL | 3.33 | -0.38 | 8.74 | 19.36 | 2% | 9.18 | 80% | 6% | 15% | 36% | 98% | 94% | 0% | 0% | 1% | 40% | 0% | 76% |
| AR | 4.10 | -0.63 | 2.47 | 19.15 | 1% | 10.44 | 100% | 5% | 24% | 31% | 90% | 99% | 0% | 0% | 6% | 39% | 0% | 74% |
| AZ | 4.16 | -0.35 | 6.08 | 19.97 | 5% | 8.22 | 0% | 69% | 14% | 0% | 98% | 91% | 2% | 0% | 4% | 34% | 0% | 0% |
| CA | 4.20 | -0.35 | 20.22 | 17.70 | 24% | 12.89 | 65% | 18% | 32% | 14% | 95% | 95% | 2% | 1% | 11% | 53% | 0% | 31% |
| CO | 3.05 | -0.13 | 15.72 | 19.12 | 18% | 7.41 | 4% | 30% | 15% | 3% | 90% | 94% | 0% | 3% | 4% | 27% | 0% | 25% |
| CT | 3.84 | -0.43 | 12.66 | 18.92 | 1% | 9.32 | 86% | 11% | 23% | 56% | 91% | 95% | 2% | 0% | 1% | you | 0% | 12% |
| DC | 4.10 | -0.10 | 10.84 | 19.11 | 8% | 11.50 | 35% | 43% | 27% | 33% | 96% | 91% | 0% | 0% | 13% | 42% | 0% | 10% |
| DE | 3.58 | -0.54 | 6.49 | 20.72 | 4% | 10.04 | 98% | 2% | 39% | 32% | 97% | 96% | 0% | 0% | 0% | 48% | 0% | 58% |
| FL | 3.99 | -0.51 | 8.33 | 20.28 | 9% | 11.42 | 73% | 24% | 27% | 9% | 99% | 73% | 0% | 0% | 6% | 51% | 0% | 87% |
| GA | 3.64 | -0.48 | 13.54 | 20.70 | 6% | 9.26 | 87% | 7% | 19% | 52% | 83% | 97% | 0% | 5% | 2% | 28% | 0% | 76% |
| HI | 3.94 | -0.22 | 11.28 | 19.61 | 12% | 11.06 | 89% | 35% | 43% | 16% | 90% | 92% | 3% | 0% | 1% | 46% | 0% | 1% |
| IA | 3.51 | -0.19 | 12.14 | 19.84 | 6% | 8.61 | 0% | 37% | 15% | 0% | 93% | 77% | 0% | 0% | 2% | 26% | 0% | 4% |
| ID | 2.34 | -0.83 | 101.56 | - | 100% | 0.99 | 83% | 0% | 0% | 28% | 100% | 76% | 0% | 0% | 0% | 0% | 0% | 3% |
| IL | 4.76 | -0.39 | 11.00 | 19.13 | 13% | 10.66 | 41% | 35% | 24% | 10% | 95% | 3% | 0% | 0% | 11% | 40% | 0% | 28% |
| IN | 3.35 | 0.35 | 6.12 | 18.76 | 25% | 10.30 | 1% | 14% | 17% | 1% | 82% | 97% | 2% | 13% | 14% | 43% | 0% | 4% |
| KS | 5.37 | -0.81 | 0.63 | 16.64 | 72% | 6.13 | 0% | 0% | 0% | 0% | 100% | 23% | 0% | 0% | 0% | 62% | 0% | 28% |
| KY | 3.59 | 0.28 | 1.72 | - | 100% | 10.50 | 0% | 0% | 12% | 0% | 45% | 100% | 0% | 54% | 11% | 44% | 0% | 68% |
| LA | 3.34 | -0.27 | 12.98 | 19.47 | 6% | 9.76 | 88% | 42% | 30% | 29% | 97% | 91% | 0% | 0% | 0% | 43% | 0% | 56% |
| MA | 4.04 | -0.46 | 18.71 | 19.45 | 3% | 11.79 | 49% | 24% | 34% | 23% | 93% | 95% | 6% | 0% | 7% | 43% | 0% | 22% |
| MD | 3.67 | -0.56 | 10.11 | 20.87 | 52% | 9.28 | 43% | 0% | 11% | 29% | 88% | 96% | 10% | 0% | 9% | 37% | 0% | 37% |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | 3.99 | -0.61 | 5.29 | 19.63 | 8% | 5.03 | 90% | 4% | 0% | 36% | 74% | 67% | 0% | 0% | 0% | 0% | 0% | 10% |
| MI | 4.52 | -0.72 | 5.42 | 19.48 | 11% | 9.13 | 15% | 34% | 21% | 3% | 93% | 86% | 0% | 1% | 6% | 36% | 0% | 6% |
| MN | 3.42 | -0.36 | 11.54 | 20.38 | 10% | 9.86 | 86% | 1% | 31% | 81% | 91% | 88% | 2% | 0% | 1% | 49% | 0% | 80% |
| MO | 4.41 | -1.03 | 3.63 | 20.86 | 0% | 10.87 | 89% | 4% | 38% | 89% | 100% | 100% | 0% | 0% | 2% | 47% | 0% | 91% |
| MS | 4.55 | -0.59 | 2.96 | 18.84 | 4% | 8.00 | 86% | 11% | 10% | 34% | 43% | 80% | 44% | 0% | 3% | 51% | 0% | 77% |
| MT | 4.02 | -0.57 | 0.89 | 18.22 | 3% | 8.64 | 79% | 1% | 13% | 48% | 80% | 98% | 2% | 0% | 2% | 44% | 0% | 55% |
| NC | 3.33 | -0.52 | 14.83 | 20.68 | 3% | 9.00 | 67% | 8% | 22% | 45% | 98% | 98% | 0% | 0% | 1% | 37% | 0% | 76% |
| ND | 6.78 | -1.15 | 0.58 | 19.16 | 9% | 6.48 | 1% | 91% | 3% | 0% | 91% | 8% | 7% | 1% | 6% | 30% | 4% | 0% |
| NE | 3.22 | -0.77 | 0.40 | - | 100% | 3.64 | 0% | 0% | 1% | 0% | 96% | 20% | 0% | 4% | 1% | 51% | 0% | 0% |
| NH | 3.91 | -0.42 | 4.00 | 19.48 | 1% | 10.19 | 98% | 3% | 28% | 49% | 92% | 98% | 0% | 0% | 1% | 39% | 0% | 55% |
| NJ | 4.51 | -0.35 | 15.82 | 19.36 | 3% | 9.46 | 71% | 15% | 36% | 53% | 82% | 91% | 4% | 0% | 1% | 34% | 0% | 57% |
| NM | 3.08 | -0.57 | 18.25 | 19.65 | 24% | 4.76 | 70% | 0% | 7% | 61% | 91% | 79% | 0% | 6% | 5% | 19% | 0% | 86% |
| NV | 4.14 | -0.58 | 2.80 | 19.49 | 1% | 9.91 | 96% | 23% | 32% | 94% | 98% | 68% | 0% | 0% | 3% | 45% | 0% | 81% |
| NY | 4.48 | -0.58 | 11.26 | 17.36 | 5% | 10.63 | 62% | 7% | 25% | 7% | 87% | 78% | 3% | 0% | 6% | 42% | 0% | 56% |
| OH | 3.36 | -0.19 | 6.32 | 19.38 | 3% | 8.15 | 55% | 6% | 17% | 22% | 84% | 96% | 9% | 0% | 5% | 27% | 0% | 22% |
| OK | 4.52 | -0.09 | 5.06 | 18.66 | 30% | 8.66 | 46% | 22% | 18% | 25% | 81% | 47% | 2% | 9% | 13% | 35% | 0% | 12% |
| OR | 3.93 | -0.37 | 1.58 | 19.12 | 28% | 9.47 | 74% | 1% | 13% | 59% | 58% | 91% | 8% | 26% | 6% | 53% | 0% | 19% |
| PA | 4.14 | -0.45 | 15.93 | 19.15 | 12% | 9.62 | 57% | 34% | 24% | 37% | 90% | 95% | 1% | 5% | 5% | 40% | 0% | 57% |
| RI | 3.63 | -0.33 | 4.45 | 19.65 | 4% | 8.39 | 69% | 47% | 28% | 31% | 93% | 93% | 2% | 0% | 1% | 32% | 0% | 28% |
| SC | 3.50 | -0.66 | 3.04 | 20.45 | 2% | 8.64 | 100% | 0% | 14% | 90% | 96% | 98% | 0% | 0% | 0% | 35% | 0% | 99% |
| SD | 5.46 | 0.36 | 1.52 | 21.00 | 46% | 8.51 | 25% | 54% | 5% | 11% | 54% | 0% | 0% | 30% | 26% | 12% | 0% | 0% |
| TN | 3.63 | -0.50 | 7.66 | 20.13 | 2% | 9.97 | 100% | 4% | 32% | 34% | 86% | 96% | 0% | 0% | 1% | 45% | 0% | 61% |
| TX | 4.00 | -0.32 | 5.70 | 19.69 | 5% | 10.61 | 64% | 17% | 20% | 12% | 78% | 0% | 12% | 1% | 5% | 46% | 0% | 33% |
| UT | 3.10 | -0.54 | 19.79 | 20.76 | 1% | 6.93 | 88% | 0% | 16% | 88% | 92% | 90% | 4% | 0% | 1% | 20% | 0% | 46% |
| VA | 3.96 | -0.62 | 5.29 | 20.75 | 3% | 10.86 | 95% | 0% | 36% | 25% | 96% | 98% | 0% | 0% | 2% | 49% | 0% | 89% |
| VT | 3.52 | -0.57 | 2.32 | 19.48 | 1% | 8.85 | 91% | 4% | 19% | 88% | 97% | 95% | 0% | 0% | 0% | 35% | 0% | 53% |
| WA | 3.86 | -0.43 | 6.74 | 19.90 | 43% | 9.59 | 55% | 26% | 19% | 39% | 96% | 0% | 0% | 1% | 2% | 35% | 0% | 83% |
| WI | 4.37 | -0.10 | 6.44 | 18.75 | 27% | 10.17 | 34% | 23% | 21% | 20% | 92% | 2% | 3% | 1% | 13% | 45% | 0% | 24% |
| WV | 4.19 | -0.48 | 5.75 | 19.12 | 0% | 10.83 | 100% | 55% | 15% | 3% | 73% | 100% | 13% | 0% | 4% | 40% | 0% | 69% |
| WY | 2.68 | -1.12 | 70.36 | - | 100% | 0.98 | 0% | 0% | 0% | 8% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |

## TABLE 3: STATE BOND OFFERING SPREADS AND MML

The tables provide the main results. *Panel A* presents the results for the effect of MML on state bond offering spreads. Column 1 uses a base model with state and time (year-month) fixed effects. Column 2 adds bond characteristics as control variables. Column 3 further controls for state economic factors. Column 4 includes credit-rating fixed effects. *Panel B* provides the results that specifies the effect of MML on state bond offering spreads through an increase in marijuana use. We first predict the the yearly marijuana use rates using MML and then examine the relationship between state bond offering spreads and the predicted marijuana use rates. In columns 1 and 2, we include bond characteristics, and state and year-month fixed effects. In columns 3 and 4, we further include state economic factors and bond rating fixed effects. We cluster standard errors by issue and time (year-month). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

Panel A: Effect of MML on Offering Spreads

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Off. Spread | Off. Spread | Off. Spread | Off. Spread |
| MML | 0.11*** | 0.10*** | 0.09*** | 0.07*** |
| | (5.02) | (5.31) | (4.75) | (4.01) |
| Size | | -0.01*** | -0.02*** | -0.01** |
| | | (-4.96) | (-5.27) | (-2.53) |
| Time to Maturity | | 0.13*** | 0.13*** | 0.14*** |
| | | (10.31) | (10.41) | (10.84) |
| GO Bond | | -0.19*** | -0.19*** | -0.10*** |
| | | (-13.37) | (-13.51) | (-7.01) |
| Insurance | | -0.15*** | -0.15*** | -0.05*** |
| | | (-12.99) | (-13.54) | (-4.24) |
| Refunding | | -0.05*** | -0.05*** | -0.06*** |
| | | (-4.34) | (-4.65) | (-5.06) |
| Ad Valorem | | -0.02 | -0.01 | -0.01 |
| | | (-1.28) | (-1.06) | (-0.86) |
| Fed Exempt | | -1.11*** | -1.10*** | -1.12*** |
| | | (-25.99) | (-26.04) | (-26.69) |
| State Exempt | | -0.11*** | -0.12*** | -0.07*** |
| | | (-5.49) | (-6.02) | (-4.06) |
| AMT | | -0.92*** | -0.91*** | -0.92*** |
| | | (-17.75) | (-17.39) | (-18.17) |
| BQ | | -0.93*** | -0.93*** | -1.04*** |
| | | (-16.68) | (-16.91) | (-19.21) |
| Sinkable | | 0.21*** | 0.21*** | 0.16*** |
| | | (13.71) | (13.55) | (11.71) |
| Callable | | 0.20*** | 0.20*** | 0.19*** |
| | | (21.37) | (21.63) | (20.40) |
| Puttable | | -0.62** | -0.62** | -0.59** |
| | | (-2.39) | (-2.41) | (-2.38) |
| Competitive Bid | | -0.09*** | -0.09*** | -0.09*** |
| | | (-8.51) | (-8.25) | (-8.09) |
| Unemployment | | | 0.03*** | 0.03*** |
| | | | (4.72) | (4.17) |
| Income | | | -0.74*** | -0.52*** |
| | | | (-3.79) | (-3.00) |
| Population | | | -0.10 | -0.16** |
| | | | (-1.06) | (-2.11) |
| Rating FE | No | No | No | Yes |
| State FE | Yes | Yes | Yes | Yes |
| YM FE | Yes | Yes | Yes | Yes |
| Obs. | 113,723 | 113,723 | 113,723 | 113,723 |
| Adj. $R^2$ | 0.70 | 0.82 | 0.83 | 0.84 |

Table 3 (Continued)

Panel B: Effect of MML on Offering Spreads through Marijuana Use

| | (1) Marijuana Use | (2) Off. Spread | (3) Marijuana Use | (4) Off. Spread |
|---|---|---|---|---|
| MML | 1.23*** | | 1.23*** | |
| | (8.77) | | (8.80) | |
| Predicted Marijuana Use | | 0.11*** | | 0.07** |
| | | (3.49) | | (2.45) |
| Size | -0.02 | -0.01*** | -0.01 | -0.00 |
| | (-1.50) | (-2.84) | (-1.44) | (-0.26) |
| Time to Maturity | -0.01 | 0.10*** | -0.01 | 0.10*** |
| | (-0.41) | (5.98) | (-0.38) | (6.26) |
| GO Bond | -0.01 | -0.24*** | -0.01 | -0.14*** |
| | (-0.11) | (-9.09) | (-0.12) | (-5.98) |
| Insurance | -0.09 | -0.13*** | -0.06 | -0.03 |
| | (-1.26) | (-6.05) | (-0.74) | (-1.63) |
| Refunding | -0.10*** | -0.06*** | -0.10*** | -0.08*** |
| | (-2.73) | (-3.60) | (-2.78) | (-4.74) |
| Ad Valorem | 0.07 | -0.03 | 0.07 | -0.03 |
| | (0.87) | (-1.27) | (0.86) | (-1.46) |
| Fed Exempt | 0.03 | -0.86*** | 0.02 | -0.87*** |
| | (0.57) | (-18.58) | (0.51) | (-21.83) |
| State Exempt | 0.04 | -0.14* | 0.08 | -0.05 |
| | (0.51) | (-1.70) | (0.89) | (-0.58) |
| AMT | 0.14 | -0.42*** | 0.14 | -0.44*** |
| | (1.36) | (-6.38) | (1.34) | (-6.75) |
| BQ | -0.15 | -0.71*** | -0.14 | -0.78*** |
| | (-1.02) | (-7.17) | (-0.93) | (-9.54) |
| Sinkable | 0.01 | 0.26*** | -0.00 | 0.16*** |
| | (0.13) | (9.47) | (-0.06) | (6.78) |
| Callable | 0.08*** | 0.19*** | 0.08*** | 0.19*** |
| | (3.57) | (13.11) | (3.57) | (13.95) |
| Puttable | 1.53 | -0.57 | 1.49 | -0.44 |
| | (1.40) | (-1.26) | (1.38) | (-0.94) |
| Competitive Bid | 0.02 | -0.06*** | 0.03 | -0.02 |
| | (0.35) | (-3.54) | (0.48) | (-1.07) |
| Unemployment | | | 0.00 | 0.03*** |
| | | | (0.04) | (2.71) |
| Income | | | -0.24 | -0.67* |
| | | | (-0.17) | (-1.86) |
| Population | | | -0.12 | -0.46** |
| | | | (-0.10) | (-1.98) |
| Rating FE | No | No | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes |
| YM FE | Yes | Yes | Yes | Yes |
| Obs. | 43,240 | 43,240 | 43,240 | 43,240 |
| Adj. $R^2$ | 0.92 | 0.75 | 0.92 | 0.79 |

## TABLE 4: IDENTIFICATION STRATEGY I: BORDERING COUNTIES IN DIFFERENT STATES

This table provides the results of the first identification strategy test, using the bordering county samples. Column 1 uses a sample consisting of adjacent counties across the state borders paired with control counties (with replacement). Column 2 uses a difference-in-differences sample consisting of county pairs on the state borders, matched based on population. Figure 5 illustrates the samples. We cluster standard errors by issue and time (year-month). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

| | (1) Off. Spread | (2) Off. Spread |
|---|---|---|
| MML | 0.06** | 0.21*** |
| | (2.48) | (3.06) |
| Size | -0.02*** | -0.03*** |
| | (-3.72) | (-2.98) |
| Time to Maturity | 0.11*** | 0.14*** |
| | (7.85) | (7.11) |
| GO Bond | -0.19*** | -0.50*** |
| | (-5.53) | (-2.88) |
| Insurance | -0.12*** | -0.34*** |
| | (-7.64) | (-3.17) |
| Refunding | -0.02* | 0.01 |
| | (-1.81) | (0.13) |
| Ad Valorem | -0.05 | 0.29 |
| | (-1.42) | (1.63) |
| Fed Exempt | -1.00*** | -0.70*** |
| | (-22.75) | (-7.59) |
| State Exempt | -0.02 | 0.12 |
| | (-0.77) | (1.22) |
| AMT | -0.84*** | 0.00 |
| | (-14.31) | (0.00) |
| BQ | -1.16*** | -0.90*** |
| | (-26.87) | (-11.11) |
| Sinkable | 0.15*** | 0.17*** |
| | (9.67) | (3.49) |
| Callable | 0.20*** | 0.26*** |
| | (15.24) | (11.44) |
| Puttable | -0.57*** | 1.16*** |
| | (-3.05) | (6.49) |
| Competitive Bid | -0.17*** | -0.05 |
| | (-9.22) | (-0.91) |
| Unemployment | 0.03*** | 0.01 |
| | (5.72) | (0.36) |
| Income | -0.14 | 0.54 |
| | (-1.62) | (1.08) |
| Population | -0.12*** | 1.78* |
| | (-2.66) | (1.81) |
| Rating FE | Yes | Yes |
| State FE | Yes | Yes |
| YM FE | Yes | Yes |
| Obs. | 146,005 | 6,344 |
| Adj. $R^2$ | 0.86 | 0.84 |

## TABLE 5: IDENTIFICATION STRATEGY II: DISCONTINUITY IN BALLOT OUTCOME

This table presents the results for the second identification strategy test, employing a discontinuity in ballot voting outcomes. We compare Arizona's 2010 ballot (approved with 50.10%) and Arkansas's 2012 ballot (defeated with 48.56%). Column 1 uses a model with state, rating, and time (year-month) fixed effects, with standard errors clustered by issue and time (year-month). Column 2 includes facility fixed effects, with standard errors clustered by facility and time (year-month). We use trading spreads to proxy for borrowing costs because Arizona and Arkansas were not active in new bond issuance around the ballots. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

| | (1) Trading Spread | (2) Trading Spread |
|---|---|---|
| MML | 0.36*** | 0.25*** |
| | (3.22) | (2.65) |
| Size | -0.08*** | |
| | (-4.52) | |
| Time to Maturity | -0.02 | -0.40*** |
| | (-0.65) | (-12.36) |
| GO Bond | 0.00 | |
| | (0.00) | |
| Insurance | -0.04 | |
| | (-0.28) | |
| Refunding | -0.08 | |
| | (-1.44) | |
| Ad Valorem | 0.05 | |
| | (0.65) | |
| Fed Exempt | -0.67*** | |
| | (-5.82) | |
| State Exempt | -0.13 | |
| | (-0.36) | |
| AMT | -0.54 | |
| | (-1.37) | |
| BQ | 0.00 | |
| | (0.00) | |
| Sinkable | 0.16 | |
| | (1.47) | |
| Callable | -0.08 | |
| | (-1.21) | |
| Puttable | 0.00 | |
| | (0.00) | |
| Competitive Bid | -0.17 | |
| | (-1.49) | |
| Unemployment | 0.17*** | 0.08** |

| | | |
|---|---|---|
| | (3.95) | (2.36) |
| Income | -5.66*** | -5.45*** |
| | (-3.56) | (-4.19) |
| Population | -15.51*** | -13.76*** |
| | (-3.41) | (-6.37) |
| Rating FE | Yes | No |
| State FE | Yes | No |
| Facility FE | No | Yes |
| YM FE | Yes | Yes |
| Obs. | 6,587 | 6,577 |
| Adj. $R^2$ | 0.67 | 0.78 |

## TABLE 6: CROSS-SECTIONAL TESTS

This table presents the results for the cross-sectional analyses of the main test results. *Panel A* presents the cross-sectional analyses using state contextual factors. Column 1 presents the effect of MML on state bonds for states with a higher perceived corruption index. Columns 2 to 4 present results of cross-sectional variations in state socio-demographics. Column 2 shows the effect for states with lower-median-age population. Column 3 shows the effect for states with more African Americans. Column 4 shows the effect for states with greater urban population. Column 5 shows the effect for states with temperatures that are more optimal for marijuana cultivation. We cluster standard errors by issue and time (year-month). *Panel B* presents the cross-sectional analyses using using bond facility characteristics. Column 1 presents the main effect for general obligation (GO) bonds relative to revenue (RV) bonds. Column 2 presents the effect for state bonds by bonds' credit ratings. Column 3 shows the effect of MML on the offering spreads of state bonds with longer terms to maturity. We cluster standard errors by issue and time (year-month). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

Panel A: State Contextual Factors

| Indicator = | Corrupt | Young | African American | Urban | Optimal Growing |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| | Off. Spread | Off. Spread | Off. Spread | Off. Spread | Off. Spread |
| MML | 0.01 | 0.04** | 0.04** | -0.02 | 0.05*** |
| | (0.66) | (1.98) | (2.40) | (-0.57) | (2.63) |
| MML x Indicator | 0.12*** | 0.07** | 0.05* | 0.10*** | 0.06* |
| | (4.70) | (2.25) | (1.83) | (3.19) | (1.69) |
| Indicator | - | 0.00 | -0.10** | 0.00 | - |
| | | (0.17) | (-2.47) | (0.13) | |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Rating FE | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes |
| YM FE | Yes | Yes | Yes | Yes | Yes |
| Obs. | 111,188 | 113,723 | 113,723 | 113,723 | 113,546 |
| Adj. $R^2$ | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |

Panel B: Bond Contractual Features

| Indicator = | GO | Below AA | Long Term |
|---|---|---|---|
| | (1) | (2) | (3) |
| | Off. Spread | Off. Spread | Off. Spread |
| MML | 0.00 | 0.05*** | 0.02 |
| | (0.17) | (3.12) | (0.91) |
| MML x Indicator | 0.10*** | 0.07** | 0.11*** |
| | (4.06) | (2.40) | (6.90) |
| Indicator | -0.13*** | - | 0.08*** |
| | (-8.69) | | (9.40) |
| Controls | Yes | Yes | Yes |
| Rating FE | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes |
| YM FE | Yes | Yes | Yes |
| Obs. | 113,723 | 97,113 | 113,723 |
| Adj. $R^2$ | 0.84 | 0.87 | 0.84 |

## TABLE 7: STATE GOVERNMENT'S EXPENDITURES AND PROGRAMS

The tables below provide the results for the effect of MML on states' expenditures and programs. *Panel A* presents the effect of MML on states' expenditures. Columns 1 to 4 show the effect of MML on states' MML-related expenditures on correction, police, health, and public welfare (per capita), respectively. Columns 5 to 7 present the effect of MML on a MML-unrelated expenditures on highway, natural resources, and park and recreational expenditures (per capita), respectively. Columns 8 present the effect of MML on variables related to states' deficit (per capita). *Panel B* provides more support for Column 4 of Panel A with states' various social welfare programs. Column 1 presents the effect of MML on states' percent of population who live in public housing. Column 2 presents the effect of MML on states' percent of population who receive energy subsidies. Column 3 presents the effect of MML on states' percent of population who receive food stamps. Column 4 presents the effect of MML on states' percent of ninth-grade cohort that graduates in four years. Column 5 presents the effect of MML on states' percent of population aged between 25 and 64 who have college degrees. Column 6 presents the effect of MML on states' number of drug-induced deaths per 100,000 people. We obtain the measures of public housing, energy subsidy, food stamp, and college rate from Current Population Survey (CPS) March Supplements. We obtain high school graduation rates from America's Health Rankings from United Health Foundation, and drug-induced death rates from the Centers for Disease Control and Prevention (CDC) We control for the impact of state economic conditions and cluster standard errors by state. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

Panel A: States' Expenditures and Financial Strength

| | MML Related Expenditures | | | | MML Unrelated Expenditures | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Police Exp. | Correction Exp. | Health Exp. | Public Welfare Exp. | Highway Exp. | Natural Resource Exp. | Parks & Recreation Exp. | Deficit |
| MML | 9.040** | 9.210* | 22.84 | 169.1*** | 7.770 | -0.7900 | -2.120 | 237.54** |
| | (2.48) | (1.87) | (1.48) | (3.55) | (0.45) | (-0.15) | (-1.35) | (2.18) |
| Unemployment | -0.2400 | 0.4100 | -3.390 | -5.140 | 6.020 | 1.630 | -0.4500 | 52.37 |
| | (-0.42) | (0.33) | (-1.03) | (-0.46) | (0.61) | (0.86) | (-0.95) | (1.62) |
| Income | 64.95*** | 159.6*** | 260.879* | 101.1 | 997.7** | 465.2*** | 60.75*** | 302.20 |
| | (2.89) | (3.17) | (1.79) | (0.28) | (2.23) | (3.11) | (5.01) | (0.22) |
| Population | -25.71* | -51.94* | 33.01 | -1,139*** | -70.02 | 3.340 | 4.610 | -2,113*** |
| | (-1.97) | (-1.72) | (0.39) | (-5.17) | (-0.67) | (0.09) | (0.51) | (-3.73) |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 |
| Adj. $R^2$ | 0.87 | 0.89 | 0.74 | 0.92 | 0.86 | 0.91 | 0.77 | 0.91 |

Table 7 (Continued)

Panel B: Social Welfare Programs

| | (1) Public Housing | (2) Energy Subsidy | (3) Food Stamp | (4) High-School Graduation | (5) College Degree | (6) Drug-Induced Death |
|---|---|---|---|---|---|---|
| MML | 1.29** | 0.30* | 0.37 | -2.38** | -1.09*** | 2.72*** |
| | (2.61) | (1.69) | (1.42) | (-2.64) | (-2.88) | (2.85) |
| Unemployment | -0.20 | 0.09* | 0.67*** | -0.56* | 0.07 | -0.44* |
| | (-1.01) | (1.82) | (6.69) | (-1.83) | (0.54) | (-1.81) |
| Income | 2.09 | 0.04 | -6.36*** | -16.34** | -2.97 | -19.41*** |
| | (0.38) | (0.02) | (-3.49) | (-2.11) | (-0.74) | (-2.99) |
| Population | -3.70 | -2.35* | -1.20 | -6.39 | -8.81*** | -28.03*** |
| | (-1.47) | (-2.00) | (-0.83) | (-0.89) | (-4.55) | (-3.70) |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 1,479 | 1,479 | 1,479 | 1,450 | 1,479 | 1,020 |
| Adj. $R^2$ | 0.47 | 0.71 | 0.79 | 0.83 | 0.93 | 0.80 |

## TABLE 8: ROBUSTNESS

This table presents the results for the robustness checks of alternative measures of states' borrowing costs. Columns 1 and 2 present results using raw offering yields and tax-adjusted offering spreads as the dependent variable, respectively. Columns 3 and 4 present the results using secondary market trading spreads as an alternative measure. Column 5 uses gross spreads as the outcome variable. We cluster standard errors by issue and time (year-month) in columns 1, 2, 3 and 5 and by facility and time (year-month) in column 4. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

| | (1) Raw Off. Yield | (2) Tax-Adjusted Off. Spread | (3) Trading Spread | (4) Trading Spread | (5) Gross Spread |
|---|---|---|---|---|---|
| MML | 0.06*** | 0.09*** | 0.14*** | 0.11*** | 0.04** |
| | (3.20) | (3.05) | (6.99) | (11.08) | (2.20) |
| Controls | Yes | Yes | Yes | No | Yes |
| Rating FE | Yes | Yes | Yes | No | Yes |
| State FE | Yes | Yes | Yes | No | Yes |
| Facility FE | No | No | No | Yes | No |
| YM FE | Yes | Yes | Yes | Yes | Yes |
| Obs. | 113,723 | 113,723 | 1,097,097 | 1,097,097 | 37,043 |
| Adj. $R^2$ | 0.92 | 0.76 | 0.52 | 0.74 | 0.52 |

## TABLE 9: ALTERNATIVE EXPLANATIONS

This table presents the results for the intertemporal analyses of the main test results. Column 1 shows the incremental effect for states that open dispensary stores after MML. Column 2 provides the results for the incremental effect of MML on state-bonds' offering spreads after Deputy Attorney General, James Cole, issued a memorandum to deprioritize the use of funds to enforce marijuana prohibition under the Controlled Substances Act on August 29, 2013. Columns 3 provides the results for the effect of MML on state-bonds' offering spreads, by public acceptance rate of marijuana. We obtain annual national acceptance rates for marijuana legalization from the General Social Survey conducted by the National Opinion Research Center at the University of Chicago. We cluster standard errors by issue and time (year-month). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All variables are defined in Appendix F.

| | (1)<br>Off. Spread | (2)<br>Off. Spread | (3)<br>Off. Spread |
|---|---|---|---|
| MML | 0.05*** | 0.06*** | -0.03 |
| | (2.91) | (2.94) | (-0.53) |
| MML×Dispensary Opening | 0.05** | | |
| | (2.14) | | |
| MML×Cole Memo | | 0.05* | |
| | | (1.70) | |
| MML×Acceptance Rate | | | 0.24** |
| | | | (2.08) |
| Controls | Yes | Yes | Yes |
| Rating FE | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes |
| YM FE | Yes | Yes | Yes |
| Obs. | 113,723 | 113,723 | 113,723 |
| Adj. $R^2$ | 0.84 | 0.84 | 0.84 |

## TABLE 10: MEDICAL VERSUS RECREATIONAL MARIJUANA LIBERALIZATION

This table presents the results for the impact of recreational marijuana liberalization on state-bond offering spreads. We augment the regression specification used in Column 4 of Table 3, Panel A. For states with both medical and recreational marijuana laws, we define two indicators, Med_year and Rec_year, based on the their corresponding legalization periods, separately. Med_year is an indicator that equals one for a bond issued after the corresponding state's passage of medical marijuana law and before subsequent passage of recreational marijuana law (if any), and zero otherwise. Rec_year is an indicator that equals one for a bond issued after the corresponding state's passage of recreational marijuana law (if any), and zero otherwise. Column 1 examines the average effect of recreational marijuana liberalization. Column 2 presents the recreational marijuana liberalization's effect for general obligation (GO) bonds relative to non- general-obligation bonds. We cluster standard errors by issue and time (year-month). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level using two-tailed tests, respectively. All other variables are defined in Appendix F.

| | (1) Off. Spread | (2) Off. Spread |
|---|---|---|
| Med_year | 0.07*** | 0.01 |
| | (4.03) | (0.51) |
| Rec_year | 0.09** | -0.04 |
| | (2.93) | (-1.09) |
| Med_year×GO Bond | | 0.09*** |
| | | (3.42) |
| Rec_year×GO Bond | | 0.20*** |
| | | (4.74) |
| Controls | Yes | Yes |
| Rating FE | Yes | Yes |
| State FE | Yes | Yes |
| YM FE | Yes | Yes |
| Obs. | 113,723 | 113,723 |
| Adj. $R^2$ | 0.84 | 0.84 |

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