CANNABIS AND CRIME: THE EFFECT OF MEDICAL AND RETAIL CANNABIS LAWS ON CRIME

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Major

Abstract

Few studies have investigated the effects of medical marijuana laws on crime and even fewer have investigated the effects of retail marijuana laws on crime. These studies have mostly employed state-level panel data (Alford, 2014; Morris, TenFyck, Barnes & Kovandzic, 2014; Gavrilova, Kamada & Zoutman, 2014). I aim to study the effects of both medical and retail marijuana laws using city-level panel data. In order to model crime, along with medical and retail marijuana indicator variables, I include socioeconomic and demographic time-varying factors that are known contributors to crime. By using a two-way fixed effects two stage least squares approach, I control for unobserved constant heterogeneity and endogeneity. The results indicate that medical marijuana laws have a decreasing effect on property crime and retail marijuana laws have an increasing effect on property crime. Additionally, they show that the physical dispensaries are the driving factors causing this relationship. However, the results should be interpreted cautiously because there may be unobserved time-varying characteristics that my model does not capture.

KEYWORDS: (Medical, Retail, Marijuana, Law, Crime, City, Dispensary)
JEL CODES: (K14, H10, I18)

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1.Introduction & Literature Review

According to the FBI, over 700,000 people were arrested for marijuana related reasons in the United States in 2014. Of that total, 88.4 percent of arrests were for marijuana possession alone, a rate of about one arrest every 51 seconds (Wing, 2015). On the other hand, 23 states and the District of Columbia have enacted laws that allow for the use, possession, and cultivation of marijuana for qualifying patients. Additionally, four states, Colorado, Washington, Oregon, and Alaska, have enacted laws that legalize the retail use of marijuana for adults 21 years and over (*National Conference of State Legislature*, 2016). For more extensive overview of medical and retail marijuana laws see Appendix A. Not surprisingly this has sparked a heated debate over the social ramifications of medical and retail marijuana laws. This study aims to investigate the effect of these laws on crime rates.

As more states are considering legalization of marijuana in some form, it is becoming more important to study the effects of these laws. There are 12 states with pending medical marijuana legislation (*Procon.org*, 2016). The states pursuing medical marijuana legislation are Florida, Georgia, Indiana, Iowa, Kansas, Mississippi, Missouri, Nebraska, Pennsylvania, South Carolina, Tennessee, and Wisconsin (*Procon.org*, 2016). However, the fact that not all states have medical or retail marijuana laws presents a unique opportunity to study their effects because there are observations available that do not have medical or retail marijuana laws in place and they can be compared to those that do have medical or retail marijuana laws. Additionally, ten states are considering retail marijuana laws of some form. These states include Nevada, California, Arizona, Maine, Massachusetts, Rhode Island, Vermont, Ohio, Michigan and Connecticut (Vigil, 2015).

There are numerous advantages to the legalization of retail marijuana as can be seen in Colorado and Washington. Both states enacted retail marijuana laws in 2012. Colorado has earned 70 million dollars in tax revenue from July1, 2014- June 20, 2015, which was nearly double the tax collected from alcohol sales (Aleem, 2015). Some of this tax money is allocated into school education and construction funds. Much of the rest is spent towards drug abuse education and prevention (Hughes, 2015). Additionally, by creating a legal market for cannabis through dispensaries, the black market for cannabis may be shrinking in these states.

There also could be some disadvantages to medical and retail marijuana laws. One of them being the effect they have on crime. There are numerous mechanisms in which this may occur. First, the supposed increased consumption of marijuana could increase crime (Bushman, 1990; Dembo et al., 1991; Baker, 1998; Niveaue, 2003). Second, the dispensaries themselves could have a negative effect on crime due to the fact that they must operate as a cash business (Hughes, 2015). This indicates the importance of also investigating the effects of different types of medical and retail marijuana laws on crime since not all medical marijuana laws allow for dispensaries.

There have been a few studies investigating the effects of medical marijuana laws on crime rates (Alford, 2014; Morris et al., 2014; Gavrilova et al., 2014). However, they have not reached a consensus on the subject. I add to this limited literature by studying the effects of medical and retail marijuana laws on crime at the city level as opposed to the state level. Using city-level data allows for me to have more observations than at the state level. Additionally, due to the fact that it has been four years since Colorado and Washington approved their retail marijuana laws, I am capable of not only studying the

effects of medical marijuana laws but also retail marijuana laws. It is important to note that I will not be able to capture any lag effects of the retail marijuana laws since crime data is only available up to the year 2014. In this way, if the affect of retail marijuana is anything other than a one period shock, I will not be able to capture the effects.

I use a two way fixed effects two-stage least squares method. I use a one period lagged police variable as an internal instrumental variable for the police level variable in order to control for the endogeneity of police. The fixed effects method includes city fixed effects and time fixed effects, which allows for the model to account for any time-constant unobserved heterogeneity. In order to account for time-varying factors affecting crime, I employ a set of socioeconomic and demographic variables that are known contributors to crime (Alford, 2014; Morris et al., 2014; Gavrilova et al., 2014; Doyle, Ahmed & Horn, 1999).

Next, I will review the current literature. In section 2, I go over the theoretical relationship between medical and retail marijuana laws and crime and introduce my model. Section 3 reviews the data and explains the methodology employed. Section 4 presents the results and goes over the strengths and weaknesses of the analysis. Finally, Section 5 concludes with a summary of the results and the implications of the investigation on local and state policymakers

Literature Review

The debate surrounding the effect of cannabis legalization on crime has raged since the 1970s when 11 states decriminalized cannabis (Alford, 2014). To this day, there is still not a consensus in the literature on the impact of decriminalization of cannabis on crime. One disagreement is whether or not decriminalization affects crime through increased consumption. Two studies were unable to find evidence that decriminalization increases cannabis use (Single, 1989; Thies & Register, 1993). However, another study found that decriminalization increased use by 8% (Saffer & Chaloupka, 1999). Within an economic theoretical framework of crime, decriminalization would increase consumption because the expected cost of the activity would decrease while the expected benefit increases (Becker, 1968).

The decriminalization laws sparked a movement in the 1990s that has resulted in dramatic changes in the legal landscape of cannabis. Since 1996, 23 states and the District of Columbia have passed medical marijuana laws (*National Conference of State Legislatures*, 2016). Although there are some variations to these laws, generally, they make it legal for certain individuals with "debilitating medical conditions" to posses, use, and/or cultivate medical marijuana (*National Conference of State Legislature*, 2016). Colorado and Washington became the first state to legalize the retail use of cannabis in 2012, followed by Alaska (2014), and Oregon (2014) (*National Conference of State Legislature*, 2016). Understanding the effects of these policy changes on crime is becoming more important as more states pursue forms of legalization.

Medical marijuana laws and retail marijuana laws should be treated differently than decriminalization because it creates legal markets for cannabis. In this way, the marijuana

industry is starting to resemble the alcohol industry. The state of Washington changed the state liquor board into the Washington State Liquor and Cannabis Board, which operates as the regulatory authority for both alcohol and cannabis (S. 5052, 2015). Similarly, in Colorado's Retail Marijuana Code, it states that the industry should be run "in a manner similar to alcohol" (C.R.S. 12-43.4-101). Therefore, it is useful to examine the extensive research that explores the relationship between alcohol and crime since marijuana continues to be treated more and more like alcohol in the eyes of the law.

The alcohol literature suggests that there are two main ways alcohol affects crime. The first is through the pharmacological effects of alcohol and the second is through the actual alcohol outlets (Gorman, Spee, Gruenewald & Labouvie, 2001). People have been experiencing the pharmacological effects of cannabis even before medical or retail marijuana laws through black markets. However, now that medical and retail dispensaries exist in certain states, crime could be affected by the legal sales of marijuana for the first time in history.

The pharmacological effects of alcohol could theoretically affect property crime by impairing decision making and/or reducing inhibitions (Lang &
Sibrel, 1989; Sprunt et al, 1994). In this way, if alcohol becomes more available and consumption of alcohol increases then more people would be experiencing pharmacological effects that lead to crime. Although there is no research into the effect of retail marijuana laws on consumption, there is some research into the effect of medical marijuana laws on consumption, but the literature has failed to reach a consensus. Results vary based on data sets used, time period chosen, and methodology employed. Using the National Survey on Drug Use and Health, one study found that medical cannabis

decreases use among youth (Harper, Strumpf & kaufman, 2012). Another study using data from Youth Risk Behavior Surveys, the National Longitudinal Survey of Youth, and the Treatment Episode data set, did not find evidence that medical marijuana laws increase use (Anderson, Hansen, Benjamin & Rees, 2012). However, Chu (2012), Pacula, Powel, Heaton, & Sevigny (2013), and Cerda (2012) found evidence that medical marijuana laws do increase cannabis use. Although there is not a consensus that consumption increases, some evidence supports the claim, and it makes sense within Becker's theoretical framework since medical marijuana laws lower the legal risks and raise the perceived benefits (Becker, 1968). A potential increase in consumption of marijuana may lead to an increase in property crime, similar to alcohol, by impairing decision-making or reducing inhibitions as mentioned before. Additionally, it could lead to and increase in property crime through the need to obtain resources to fund consumption. A group of sociologists argue that alcohol is related to property crime because of the need to use crime to fund the habit (Rush, Gliksman & Brook, 1986). Although little evidence points to cannabis being physically addictive like alcohol, a similar relationship exists because cannabis users can develop a behavioral addiction in which they experience physical and mental withdrawals (*National Institute on Drug Abuse*, 2015).

The pharmacological effects of alcohol have been shown to be correlated with violent crime. Cook and Moore (1993) found that a disproportionately large number of people arrested for violent crimes where under the influence of alcohol. Additionally, violent crime is higher in neighborhoods with high consumption levels compared to neighborhoods with low consumption levels (Parker, 1993). It is important to note that

alcohol and marijuana produce different short-term pharmacological effects. Consumption of cannabis can produce perceptual alterations such as time distortion or changes in emotional moods such as mild euphoria or paranoia (Solowij, 2006). In this way, increased consumption of marijuana could lead to an impact on violent crime. This relationship is more ambiguous, which can be seen by disputes in the literature. Bushman (1990) found more aggression among cannabis smokers than placebo controls in laboratory experiments. Dembo et al. (1991) and Baker (1998) found that cannabis is associated with violent crime in youth. Niveaue (2003) found a relationship between cannabis and violent crime by investigating violent crime cases committed under the influence of cannabis. Additionally, a study conducted in New Zealand found that marijuana dependence in adolescents resulted in a 280% increase in violent behavior (Arseneault, 2000). However, a study investigating the effects of certain drugs found that cannabis does not cause increased aggression but actually inhibits aggression (Miczek, Roth & Reiss, 1994). Whereas, other drugs such as alcohol, cocaine, and crack were found to produce effects that contribute to aggression (Miczek et al., 1994). Another study found that heavy cannabis use in adolescents leads to and increase in property and drug related crime for that individual but found no evidence that cannabis consumption leads to an increase in violent crime (Pederson, 2010). Similarly, a different study using meta-analysis found that cocaine, amphetamines, and opiates were found to have a much stronger association with violent crime than cannabis (Bennett, Holloway & Farrington, 2008). In this way, there is not a consensus in the literature as to the effect of marijuana consumption on violent criminal activity.

There is evidence that medical marijuana laws could cause a substitution effect

where people choose marijuana over other more violent substances. One study finds that medical marijuana laws decrease traffic fatalities involving alcohol. They hypothesize that this result is due to the fact that marijuana and alcohol act as substitutes (Anderson et al., 2013). Another study finds that decriminalization increases cannabis hospitalizations episodes over other drug hospitalizations (Model, 1993). This study also suggests that marijuana and alcohol acts as substitutes. Two other studies support this assertion by finding that marijuana decriminalization was associated with a decrease in alcohol consumption (Saffer & Chaloupka, 1999). Additionally, Crost & Guerrero (2012) and Yörük & Yörük (2011) found that marijuana use decreases at the age of 21, which lends support to the fact that they are substitutes. In this way, medical and retail marijuana laws could decrease violent crime because people are choosing marijuana instead of substances that promote violent activity such as alcohol.

A different type of substitutive effect may be in play in which people choose to participate in the legal market for marijuana through medical or retail dispensaries instead of using the illicit drug market (Gavrilova et al., 2014). Gavrilova et al., (2014) found that violent crime decreases in Mexican border states after the passage of medical marijuana laws. They hypothesize that drug trafficking organizations reliant on marijuana revenue were pushed out resulting in a decrease in drug related violent crime (Gavrilova et al., 2014). Both of these substitutive effects could result in an overall decrease in violent crime in states that have passed medical or retail marijuana laws because people are choosing to participate in the safer legal market. However, it is important to note that some states with medical and/or retail marijuana laws do not allow for dispensaries, which could cause increased participation in the illegal drug market. In this way, it is

important to analyze states that allow for dispensaries versus states that only allow for home cultivation.

Similar to alcohol, medical and retail marijuana laws could increase crime through the physical dispensaries themselves. The alcohol literature suggests that alcohol outlets could affect crime by causing physical and social disorder. The theory being that violent acts are more likely to occur where physical decay is taking place such as broken windows, vacant lots, undesirable commercial establishments, etc. (Gorman et al., 2001). Others argue that it is the environment in which drinking takes places that contributes to violent criminal behavior (Homel, Tomsen, & Thommeny, 1992). One study found that after controlling for neighborhood characteristics, areas with higher alcohol outlet density experienced higher violent crime rates than those with lower alcohol outlet density (Gorman et al., 2001). The relationship between medical or retail dispensaries and crime is most likely different due to a number of factors. One being that marijuana is not allowed to be consumed on the property of the dispensaries (Oregon.gov; Motley Fool). Additionally, since dispensaries are illegal federally, they must operate as a cash only business. Customers are walking into dispensaries with significant amounts of cash making them more susceptible to being a victim of a crime (Alford, 2014). The actual dispensaries are not allowed to use banks resulting in stockpiles of cash on location, which increases the dispensaries' likelihood of being a victim of a crime (Sherman, 1995). States that allow for dispensaries saw an increase in property crime, whereas states that only allowed for home cultivation use experienced a decrease in property crime (Alford, 2014).

However, it could also be the case that the dispensaries decrease property crime

because of the increases in security (i.e, cameras, door men, signs requiring identification) at dispensary locations (Friesthler, 2013). This would result in the opposite effect of alcohol outlets since increase security would strengthen the physical and social order in a community. More research is warranted to discover the impact of dispensary locations on property crime**.**

It is possible that retail marijuana laws could have a larger impact on crime because there is less legal risk and anyone, not just patients, can consume it. Both of these factors would lead to a higher level of consumption and thus a larger impact on crime. Similar to medical marijuana laws, retail marijuana laws are still illegal under federal law, which suggests that a similar dispensary victimization factor will play a role in its impact on crime.

Most of the studies investigating marijuana laws and their effect on crime use state data (Alford, 2014; Morris et al., 2014; Anderson et al., 2013). Due to the recent enactment of retail marijuana laws, these studies were unable to study the effects of retail marijuana laws on crime. I aim to contribute to the literature by using city data to study the affects of not only medical marijuana laws but also retail marijuana laws, which will provide a better understanding of the impact of legal marijuana markets on crime.

Similar to the alcohol industry in which the regulatory authority can enact rules to control certain aspects of operations such as outlet density, advertising, and taxation, the regulatory authorities of each state with medical and/or retail marijuana laws have the power to control certain aspects of the industry (*Alcohol and Tobacco Tax and Trade Bureau*, 2016). For example, the Washington State Liquor and Cannabis Control Board is in charge of regulating the dispensary locations among many other aspects of the industry

(S. 5052, 2015). Also, Colorado House Bill 1284 gives local communities the option to ban medical marijuana operations in their communities (H. 1284, 2010). Unlike the marijuana industry, the leaders in the alcohol industry have ample research to call upon to inform decisions concerning these matters. The leaders of the marijuana industry do not have as much research to draw upon, but as more states legalize marijuana in some form, more people will be impacted by their outcomes. In this way, I hope to provide useful information to policymakers or regulatory decision makers as they decide to enact rules and laws concerning marijuana in their states.

2.Theory

Basic Model

This study builds on the models employed by Alford (2014) and Morris et al., (2014). They used state level data to investigate the effects of medical marijuana laws on crime rates. Their models use social and demographic characteristics to account for time-varying characteristics that contribute to crime. One of the key differences between my model and theirs is that I use city level data.

Dependent Variables

The dependent variable for property crime is the number of offenses per 100,000 inhabitants for burglary, larceny, motor theft, and arson by city. The dependent variable for violent crime is the number of offenses per 100,000 for murder, rape, robbery, and aggravated assaults by city. These crime indexes come from the FBI's Uniform Crime Reporting program (UCR). I have collected crime data for 222 municipalities in 11 states across 5 years. It is important to look at violent crime and property crime differently as the mechanisms that lead to one or the other are different. Additionally, it is important to break up the crime indices and analyze them individually since it is likely that medical and retail marijuana laws impact motor theft differently than larceny, for example.

Socioeconomic and Demographic Variables

Using municipality data from the Census Bureau, I have also included a number of labor and socio-demographic characteristics in order to control for time varying characteristics (Alford, 2014; Morris et al., 2014; Census Bureau; Doyle, 1999). Following the work of Doyle et al. (1999), I include per capita median income and unemployment rate to track labor market conditions. Additionally, I include gender,

percentage of population 19-24 years old, education level, percentage of population who are homeowners, and police officers per 100,000 (Morris et al., 2014; Gyimah-Brempon, 2001; Aflord, 2014; Anderson et al., 2013).

Medical and Retail Marijuana Variables

I include dummy variables that indicate whether the particular city is in a state with complete illegality, medical marijuana laws (MML), or medical and retail marijuana laws (RML). Additionally, in a separate model I will separate out the different types of RML and MML by including dummy variables that indicate the legality of dispensaries and home cultivation in the particular city observation. This variable will help indicate the role that physical dispensaries have on property and violent crime. It is important to note that I am not able to indicate if a particular city has a dispensary, only if the state in which it resides has laws that allow for physical dispensaries. However, I still think that it is a valid indicator variable because the citizens that reside in states with medical and/or retail dispensaries are legally capable of purchasing marijuana. In this way, they at the very least have access to purchasing it through a dispensary.

Table 2.1

Marijuana Laws in Place

State	Medical Marijuana Laws (Year Effective)	Retail Marijuana Laws
California	1996	-----
Washington	1998	2012
Oregon	1998	2015
Nevada	2000	-----
Colorado	2000	2014
New Mexico	2007	-----
Arizona	2010	-----

Sources: ProCon.org, 2016
Article XVIII, Section 16 of the Colorado Constitution
Initiative 502, 2012

Table 2.2

Types of Medical/Retail Marijuana Laws in Place

State	Medical Dispensary	Medical Home Cultivation	Retail Dispensary	Retail Home Cultivation
Arizona	2012	2010	-----	-----
California	1996	1996	-----	-----
Colorado	2001	2000	2012	2014
New Mexico	2007	2007	-----	-----
Washington	1998	2007	2014	-----
Oregon	2014	1998	2015	2015
Nevada	2013	2000	-----	-----

Source: ProCon.org, 2016
Article XVIII, Section 16 of the Colorado Constitution
Initiative 502, 2012

Time Variables

I include time dummy variables in order to control for effects that are caused by time passing (Alford, 2014). These dummy variables control for all time specific fixed effects. This will help ensure that the error terms are independent and that the model does not suffer from autocorrelation.

Model 1

The empirical model used to study the effect of MML and RML on crime is as follows:

$$Property\ Crime/Violent\ Crime = \beta_0 + \beta 1\ Youth + \beta 2\ Education + \beta 3 Per\ capita\ income + \beta 4 Male + \beta 5 Unemployment + \beta 6 Ownership + \beta 7 Police\ level + \beta 8 RML + \beta 9 MML + \beta 12 Time\ effects + Error\ term \quad (2.1)$$

Model 2

The empirical model used to study the effect of different types of MML and RML is as follows:

$$Property\ Crime/Violent\ Crime = \beta o + \beta 1 Youth + \beta 2\ Education + \beta 3 Per\ capita\ income + \beta 4 Male + \beta 5 Unemployment + \beta 6 Ownership + \beta 7 Police\ Level + \beta 10 MML/RML + \beta 11\ Dispensary + \beta 12\ Time\ effects + Error\ term \quad (2.2)$$

βo = constant term

$\beta 1 Youth$ = % of population aged 15-24

$\beta 2 Education$= % of population with a high school degree

$\beta 3 per\ capita\ income$= per capita individual income

$\beta 4 Male$ = % of population male

$\beta 5 Unemployment$ =the unemployment rate

$\beta 6 Ownership$ = % of population who own a their residence**.**

$\beta 7 Police\ Level$ =number of police officers per 100,000

$\beta 8 RML$ =Dummy variable. 1= Medical and retail marijuana laws. 0= No retail marijuana laws

$\beta 9 MML$ =Dummy variable. 1=Medical marijuana laws. 0=No medical marijuana laws

$\beta 10 MML/RML$ = Dummy variable. 1=MML/RML allowed. 0= no RML/MML

$\beta 11 Dispensary$ =Dummy variable. 1=Dispensaries allowed. 0= Dispensaries not allowed.

$\beta 12 Time\ effects$ = a set of time period dummy variables for years 2010-2013.

Hypothesis 1: Medical and retail Marijuana laws will increase property crime.

Property crimes may be impacted for two reasons. One being that marijuana dispensaries must operate as a cash only business since banks are not allowed to accept dispensary money (Maclver, 2015). This results in a situation in which there are more potential victims to a crime since people walking in and out of dispensaries will usually have large amounts of cash. The dispensaries themselves have large amounts of cash on

site. Additionally, the manufacturing of the plant raises more victimization issues. If this hypothesis is supported, I expect the impacts to be largest in the cities that reside in Colorado and Washington as they have passed retail marijuana laws. This assumes that due to the legal environment more people will be consuming and by extension using medical and retail dispensaries than in states that only have medical marijuana laws in place.

The second way in which property crimes may be affected is through increased consumption. As discussed in section 1, the literature indicates that MML causes increased consumption (Anderson et al., 2013; Chu, 2012; Pacula et al., 2013; & Cerda, 2012). However, the literature is less certain on the effect of marijuana consumption on property crime. More people addicted to a substance such as cannabis could cause people to steal to obtain resources to fund their habit (Rush et al. 1986; National Institute on Drug Abuse).

Hypothesis 2: Medical and retail marijuana laws will decrease or have no impact on violent crime.

The mechanism in which this might occur is that through legalization, whether it is medical or retail marijuana laws, consumption of cannabis increases and acts a substitute to other substances such as alcohol. A study investigating the effect of medical marijuana laws on traffic fatalities found that medical marijuana laws cause marijuana to act as a substitute for alcohol (Anderson et al., 2013). Another study found that hospital emergency room drug episodes decreased for drugs other than cannabis under decriminalization laws (Model, 1993). This also suggests a substitutive relationship between alcohol and marijuana when the legal environment changes in the favor of

cannabis. This substitutive effect could cause a decrease in violent crime because alcohol has been shown to be an aggression inducing substance whereas marijuana is not (Miczek et al., 1994). Assuming that this substitutive effect occurs, the cities in states with medical and/or retail marijuana laws will experience less violent crime because more people are consuming marijuana over alcohol, a known contributor to violent crime.

In addition, there may be a different kind of substitutive effect in which the legal cannabis market replaces or diminishes the illegal drug market. In this way, the violence that surrounds the illegal drug trade could be lessened by the presence of legal markets to buy marijuana. However, this theory also suggests that the cities, which only allow for home cultivation, will experience higher levels of violence assuming that only allowing for home cultivation leads to a higher participation in the black market.

Hypothesis 3: Dispensaries will have a positive impact on property crime.

It is important to investigate the difference in marijuana laws because different features of the law could produce different impacts on crime. All of the cities that I am studying that passed retail or medical marijuana laws allow for either medical home cultivation or retail home cultivation or both. However, not all of the cities are in states that allow for medical dispensaries or retail dispensaries. Allowing actual dispensaries to exist could produce different effects on property crime because it creates a legal market and legal industry for the consumption of cannabis, whether it be medical or retail. I assert that the dispensary indicator variable will increase property crime because the actual dispensaries themselves increase the likelihood of being a victim of a crime. The dispensaries must operate in cash due to the fact that RML and MML are still federally illegal, which means there is a lot of cash on location and the people visiting the premises

have cash as well (Sherman, 1995). Additionally, the actual product whether it be in the dispensary or being manufactured off site is very valuable, which also presents victimization issues.

Hypothesis 4: Dispensaries will have a negative impact on violent crime

As discussed in hypothesis 2, I suspect dispensaries will decrease violent crime because they displace the black market. By having a place to purchase cannabis many people will no longer participate in the black market and therefore the violence associated with this black market should decrease. However, this relies on the assumption that people would choose to purchase their cannabis from dispensaries over black markets. This decision could be elastic to the price of illegal cannabis compared to the price of legal cannabis.

3.Methodology

General Approach

In order to investigate the effects of medical marijuana and retail marijuana laws on crime rates, I use unbalanced panel data to employ a two way fixed effects two-stage least squares approach. 2SLS is an extension of the OLS method that is used to analyze structural equations when employing instrumental variables. I track city time varying characteristics for 222 cities across 11 states from 2010-2015. This design allows for the investigation of whether cities and states that passed medical and/or retail marijuana laws experienced different crime trends compared to the cities and states that did not pass such legislation.

Data

The panel consists of a total of 1012 observations. I chose to only investigate states in the southwestern and western region of the United States in order to create a sample set with less variation that is due solely from state differences. The states included in this study are Arizona, California, Colorado, Idaho, New Mexico, Nevada, Oregon, Texas, Utah, Washington, and Wyoming. Additionally, these states represent a good mix and coverage of the major medical and retail marijuana laws, with some states allowing for dispensaries and home cultivation and others only for home cultivation. Within each state, I chose to include every city with a population of over 40,000, except for California since there are a lot more cities in California with populations over 40,000 compared to other states. In California, I took all the cities with a population of 100,000 or more and then from there I took five cities from each 10,000-population range until I reached

40,000. This method resulted in 222 cities across 11 states. The following table shows the chosen states and the number of cities included in the study for that particular state:

Table 3.1

Number of Cities Included in the Study for Each State

State	Number of Cities
Arizona	16
California	50
Colorado	20
Idaho	7
Nevada	5
New Mexico	6
Oregon	11
Utah	16
Washington	19
Wyoming	2
Texas	70

The data covers the time period 2010 -2014. I chose this time period because there was data at the city level for these years. Additionally, this period offers the chance to study not only medical marijuana laws but also retail marijuana laws. This time period also contains years in which there are cities in states with and without dispensaries.

Methods

The literature suggests using a difference in difference estimation method because it works well with policy change panel data by allowing the researcher to investigate the before and after effects of the policy change. (Alford, 2014; Anderson et al., 2013). Additionally, it controls for unobserved effects that vary by state but are constant across time and for unobserved fixed effects that vary across time but are the constant for each state (Wooldridge, 2012). However, the studies done by Alford (2014) and Anderson et al. (2013) used state data and were able to access data in the years before the passing of the marijuana laws. Since I am using city data I did not have access to these dates and thus cannot use the difference in difference method. A different study modeling crime in

North Carolina counties used both the fixed and random affects methods (Baltagi, 2006). Additionally, two other studies investigated the effects of medical marijuana laws and used the fixed effects method because it controlled for unobserved heterogeneity (Morris et al., 2014; Chu, 2012). Heterogeneity is most likely an issue because crime is affected by a vast array of different factors. In this way, it is fair to assume that unobserved factors is an issue that must be addressed. Difference in difference allows you to control for both the unit and time period effects while fixed effects can only control for unit effects (Wooldridge, 2012). However, since my data only covers five years, I can use time period dummy variables to account for time fixed effects. In this way, using a two way fixed effects allows me to control for city unobserved fixed and time fixed effects but not unobserved time varying effects. However, the set of socioeconomic and demographic control variables account for the important time-varying factors.

In order to decide between using a fixed effects or random effects methodology, I performed a Hausman test. When using fixed effects there is the assumption that some factor within the individual, in my case cities, impacts the independent or dependant variable. This is the justification for the assumption of correlation between the cities errors terms and independent variables. A fixed effects model removes this impact in order to discover the effect of the independent variables. However, this only works if the assumption of correlation between the individual cities error terms and independent variables holds. If there is no correlation then fixed effects would produce inefficient estimators and random effects is more suitable. The Hausman test evaluates to see if the city error terms are correlated with the independent variables. The null hypothesis is that they are not correlated. The test scores indicate that I should reject the null hypothesis

that there is no correlation between the error terms and the independent variables for all categories of crime. Therefore, fixed effects method is appropriate.

Although the fixed effects method addresses the problem of heterogeneity, it does not solve the problem endogeneity. Endogeneity is an issue that needs to be addressed because while police levels most likely affect crime, government agencies also probably respond to crime by changing police levels. There has been a long debate over the choice of which instrumental variable to control for the endogeneity of the police variable (Worrall & Kovandzic, 2010). I will follow the work done by Bun (2014) and use an internal instrument to control for the endogeneity of the police variable. Bun (2014) showed that a lagged police variable could be successfully used as an internal instrument to get more accurate estimates than the use of a weak external instrument such as tax per capita or firefighter levels used in other studies (Cornwell and Trumbull 1994). By using two way fixed effects 2SLS methodology, the problems of heterogeneity and endogeneity are accounted for. Thus, I estimate the following fixed effects 2SLS model,

$$CrimeRate_{ct} = A_{c+} \beta 2MLct + \beta 3Zct + \beta 4P_{ct} + \beta 5T_{ct} + E_{ct}, \quad (3.1)$$

$$\beta 4P_{ct} = A_c + CrimeRate_{ct} + \beta 2MLct + \beta 3Zct + \beta 6LPct + \beta 5Tct + E_{ct} \quad (3.2)$$

A_c = unobserved fixed effect

$B2MLct$ = MML and RML indicator variables

$B3Zct$ = Set of socioeconomic and demographic variables

$\beta 4P_{ct}$ =Police Level

$\beta 5T$ = Time dummy variables (time fixed effects)

$\beta 6LP_{ct}$ = One period lagged police level

E_{ct} = Error term

It is important to note that these are the time-demeaned variables. This is achieved through the within transformation in which the original model is subtracted from an average of all variables across time. This results in the unobserved effect being removed and the creation of time-demeaned variables. It is also important to point out that by including the lagged police level variable as an exogenous variable in the second structural equation, the rank order condition is satisfied. Both equations obey the rank order condition because there is at least the same number of excluded exogenous variables as there are right side endogenous variables. In the following section, I will discuss the results of my analysis.

4.Results

Summary Statistics:

Before going over the results from my study, I will provide summary statistics and important characteristics for key variables. Table 4.1 shows the summary statistics for the dependent variables.

Table 4.1

Summary Statistics for Dependent Variables[1]

Variable	Observations	Mean	Std. Deviation	Min	Max
T. Property	1012	3512.782	1393.655	738.091	9323.652
Larceny	1012	2483.595	973.332	577.244	6719.08
Motor theft	1012	323.925	268.704	21.542	1790.357
Arson	1002	19.572	23.732	0	582.116
Burglary	1012	705.262	392.587	577.244	6719.08
T. Violent	1012	386.466	281.489	32.145	2181.495
Murder	1012	3.715	4.08243	0	32.325
Assault	1012	236.27	175.467	7.811	1360.157
Robbery	1012	111.768	114.488	0	1239.764
Rape	1012	34.713	23.291	0	178.187

[1] These crime indices come from the FBI's Uniform Crime Reporting Program (UCR). They are crime offense per 100,000

[2] Everything except police per 100,000 comes from the US census bureau. Police per

Figure 4.1: Violent Crime

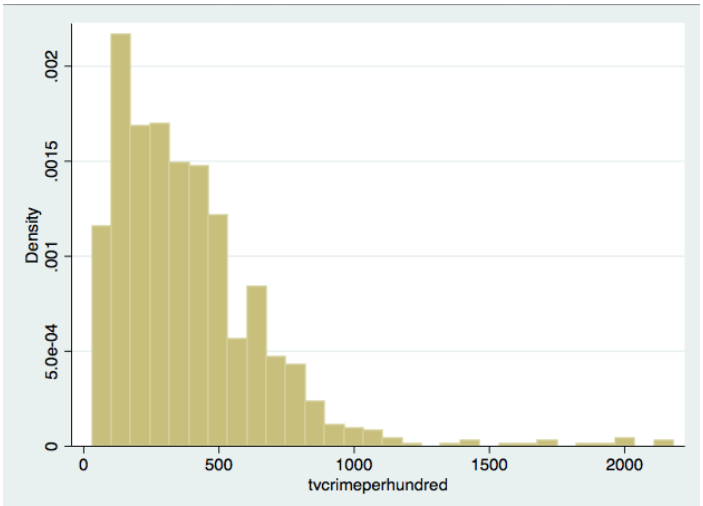
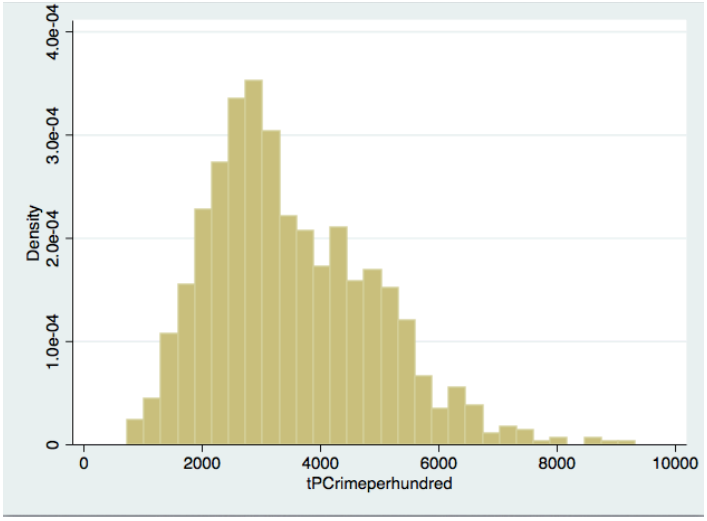


Figure 4.2: Property Crime



Figures 4.1 and 4.2 show the histograms of property and violent crime. These two graphs along with the summary statistics illustrate the necessity to analyze the different crime indices separately. The histogram for violent crime shows how the data is slightly skewed while the data for property crime is more centered around the mean. This most likely results from the fact that property crime is more consistent across cities while violent crime experience more variation. Additionally, the summary statistics suggest the importance of treating the indices within property crime and within violent crime

differently. For instance, arson has a standard deviation of 23.732 while larceny has a standard deviation of 973.332, which indicates that larceny is much more dispersed compared to arson. In this way, it is important to analyze the indices separately because the indices that make up the total property and violent crime could have different relationships with the independent variables that would not be captured if they are all treated as simply property or violent crime. It makes sense logically that the crime indices would have different relationships with the independent variables because different motivations and mechanisms might affect the crime indices differently. See Table 4.2 for summary statistics of the marijuana variables.

Table 4.2

Summary Statistics Marijuana Variables

Variable	Observations	Mean	Std. Deviation	Min	Max
Dispensary	1012	.496	.500	0	1
RML	1012	.072	.259	0	1
MML	1012	.476	.499	0	1

The medical marijuana law dummy variable standard deviation of .499 shows that there is a good mix of states with medical marijuana laws and states where marijuana is illegal. Additionally, the standard deviation of .500 on the dispensary dummy variable shows that there roughly half of the observations included contain a dispensary indicator value and the other half do not. On the other hand the retail marijuana law dummy variable has a standard deviation of .259 and a mean of .072. This illustrates that this variable is not as well dispersed as the other two. This is because the enactment of retail marijuana laws is a fairly recent phenomenon, which results in far fewer observations available to the study. However, this is not necessarily a problem because it is an accurate

representation of reality. In reality, most states and thus cities do not have laws allowing for the adult use of marijuana. In this way, a data set that contained a lopsided number of observations with a retail marijuana laws indicator would be a sample set that misrepresents reality. See Table 4.3 for summary statistics of key control variables.

Table 4.3

Summary Statistics for Key Control Variables[2]

Variable	Observations	Mean	St. Deviation	Min	Max
Male	1012	49.238	1.097	44.3	54
Population	1012	194826	358666	37079	3862210
Youth (15-24)	1012	15.542	5.187	7.3	49.8
Police Level	1012	151.67	60.738	1.772	1404.77
Graduate	1012	10.571	5.675	2.2	37.1
Unemployment	1012	5.709	1.524	2.6	10.6
P. Capita Income	1012	27295.26	9291.944	11860	81198
Ownership	1012	59.152	11.893	25.5	92.1

It is important to note the large standard deviation of 60.738 for the police level variable. This indicates that there is a large difference in the number of police officers in cities. In this way, it is especially important to model the police level since it varies significantly from city to city.

Testing

I tested the data on a number of assumptions in order to see if my results would be unbiased, efficient, and conclusive. First, I investigate to see if there are any multicolinearity problems with my independent variable. I did a simple correlation test. From the test, I found one multicolinearity problem. The variables per capita income and

[2] Everything except police per 100,000 comes from the US census bureau. Police per hundred thousand comes from the FBI's Uniform Crime Reporting Program (UCR).

high school are correlated with a value equal to .68. Multi-colinearity can create problems by causing the standard errors to be larger than normal. Additionally, it can cause type II error in which the research fails to reject the null hypothesis when, in fact, it should. Therefore, I decided to drop the per capita income variable. The model barely lost any explanatory power as measured by the R-squared value. This is most likely due to the fact that the labor market conditions are adequately captured by the unemployment variable.

Next, I tested to make sure that the police level variable was truly endogenous because if it were not then running a 2SLS regression would produce worse estimators than the regular fixed effects regression. In order to test the endogeneity of the police level variable, I regressed it on all the exogenous regressors including the instrument variable, which is the one period lag of the original police variable. Then, I predicted the residuals and ran a regression on the dependent variable and the independent variables along with the predicted residuals. After doing this for all the dependent variables being studied, I looked at the coefficient of the residuals and found that they were statistically significant at the 99.999% confidence level for each different crime dependent variable. These tests provide strong evidence for the presence of endogeneity in the police variable. I then tested to see if the instrumental variable, one period lagged police, was appropriate to use. First, it must be correlated with the original variable. After running a simple correlation test, I found that the lag police variable is correlated with the police variable with a value of .71. Second, it must not suffer the same problem as the original variable and be uncorrelated with the error term. The one period lag police variable was barely correlated with the errors at a value of -0.049. In this way, the one period lagged

police variable is a reasonably strong instrument to take care of the issue of endogeneity. Additionally, the use of the lagged period police variable as an internal instrument was successfully used by Bun (2014).

It is also important to validate the assumption that the errors are independent. Non-dependence of errors could be caused by serial correlation, which can results from the time series nature of the data. However, this problem usually only affects data sets that cover a large span of time such as 20 to 30 years. Additionally, the use of time period dummy variables to control for time period effects helps aid in the problem of serial correlation. In this way, I am confident that serial autocorrelation does not present an issue in my results. However, if it does it could cause the standard errors to be slightly smaller then they should and could report higher t-scores.

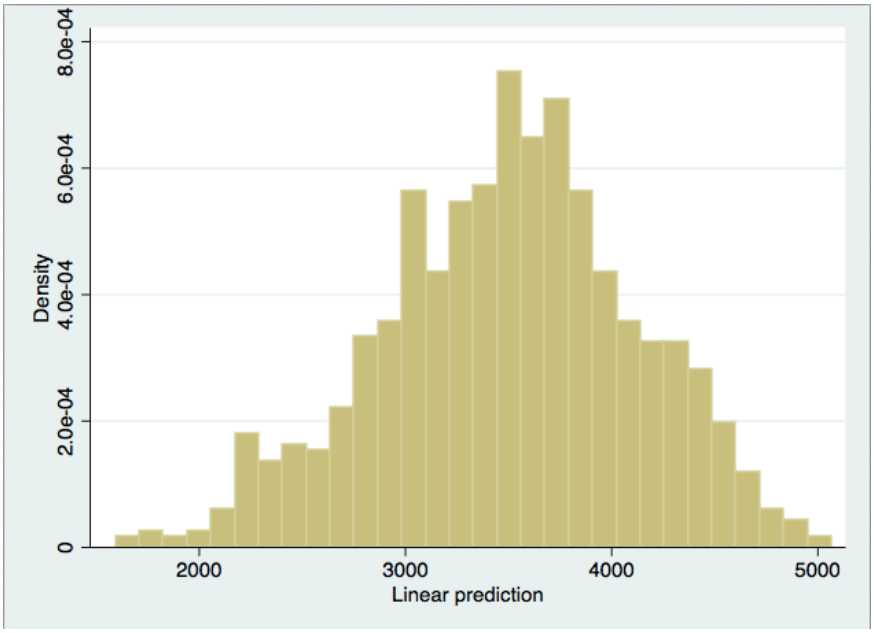
Next, I tested the assumption that the error terms have constant variance. To test for this assumption I computed the Modified Wald test for fixed effects regressions. This tests for heteroscedasticity in which the null hypothesis is homoscedasticity. The test score came back statistically significant at the 99.999% confidence level. This provides evidence for heteroscedasticity in the data set, which can cause the regression to produce unreliable standard errors, t-stats, and p-values. In this way, it is a very important problem to solve. Stata provides a robust command that fixes this by clustering the standard errors at the city level. This approach is also employed by Alford (2014) and Gavrilova et al. (2014).

Due to the fact that I am using a fixed effects 2SLS regression method, I am not able to use the RESET test to test for the assumption that there are no omitted variables. However, the use of the fixed effects method controls for all time-constant factors

affecting the dependent variable. In addition, the time period dummies control for time period effects. The only unobserved factors that could cause violations in this assumption are time-varying characteristics of each city. However, I am confident that the strong R-squared values provide evidence that the inclusion of the socioeconomic and demographic variables accounts for most if not all time varying factors that affect crime. If there omitted variables do exist then it would create bias and inefficiency in the results.

The final key assumption to test for is the assumption that the errors are distributed normally. I used the skewness and kurtosis test to see if the errors are distributed normally. I rejected the null hypothesis of normality of error terms at the 99.9711% level. The test indicates that the problem is skewness and not kurtosis. In an attempt to fix this problem, I logged the dependent variables but failed the to reject the null hypothesis at the 99.999% level. Therefore, I decided not log the dependent variables. See Figure 4.3 for the distribution of the error terms. The figure shows the errors actually appear to be distributed normally when running the regression on the total property crime but not enough for the assumption to completely hold. The failure of the skewness and kurtosis test could be the result of a few outlier observations. The violation of this assumption could result in inefficiency in the model

Figure 4.3: Distribution of Error Terms



Regressions and Analysis

Hypothesis 1. In my first hypothesis, I asserted that medical and retail marijuana laws would have a positive impact on property crime. In order to test this hypothesis, I ran a two way fixed effects 2SLS regressions on Model 1. See Table 4.4 for property crime regression results.

Table 4.4

Model 1 Property Crime Regression Results

VARIABLES	(1) Total Property Crime	(2) Burglary	(3) Larceny	(4) Motor Theft	(5) Arson
PolieLevel	0.454***	0.270***	0.156	0.0282	-0.0203
	(0.161)	(0.0502)	(0.108)	(0.0189)	(0.0152)
Male	-37.78	-22.46	-16.23	0.917	4.149
	(61.09)	(14.77)	(45.21)	(8.590)	(3.913)
Youth	-5.223	0.221	-5.333	-0.111	0.485
	(7.668)	(2.259)	(5.331)	(0.613)	(0.459)
High School	-19.58	-7.339	-10.04	-2.202	1.250
	(27.23)	(7.923)	(20.29)	(4.212)	(1.007)
Unemployment	166.5***	41.02***	117.8***	7.679	-1.264
	(43.39)	(10.95)	(33.27)	(8.101)	(2.226)
Owner	-21.23	8.506	-28.14*	-1.602	-0.725
	(20.04)	(6.010)	(15.15)	(2.842)	(0.906)
RML	199.1**	23.66	149.6**	25.84	0.498
	(82.11)	(22.39)	(58.23)	(18.35)	(1.724)
MML	-230.6***	-80.62***	-152.8**	2.843	1.026
	(83.06)	(21.41)	(67.36)	(16.80)	(2.035)
Dummy2010	631.1***	196.6***	411.2***	23.34	5.453
	(102.6)	(25.64)	(76.59)	(14.48)	(3.938)
Dummy2011	369.8***	150.7***	226.3***	-7.196	2.544
	(76.34)	(21.13)	(56.98)	(10.60)	(2.144)
Dummy2012	276.3***	118.7***	142.0***	15.64*	1.901
	(55.96)	(16.13)	(42.73)	(8.921)	(1.969)
Dummy2013	80.20**	52.98***	20.99	6.233	2.192
	(38.04)	(11.02)	(29.36)	(5.962)	(1.881)
Constant	5,940*	1,125	4,449*	366.7	-170.6
	(3,596)	(763.8)	(2,644)	(487.1)	(165.2)
Observations	987	987	987	987	977
Number of Cities	222	222	222	222	221

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Standard errors are clustered at the city-level

All the categories of the property crime except arson have very strong R^2 values. Additionally, they have strong Wald chi2 (15) scores. The null hypothesis that all of the variables have no relationship with the dependent variable was rejected for all indexes of crime. Both of these test scores suggest that as a whole the model does a good job of explaining the crime in my data set.

Both RML and MML were statistically significant with p-values of 0.015 and 0.006 respectively. The results indicate that cities in states with MML experience a

decrease in property crime of 231 offenses per 100,000. They also indicate that cities in states with RML experience an increase in property crime of 199 offenses per 100,00 people. The fact that RML and MML impact property crime in an almost opposite way is interesting because it suggests that something about marijuana becoming fully legalized causes it to increase property crime. This result could be caused by the increased consumption of marijuana due to the legalized environment, which then leads to property crime.

The results from the individual categories regressions show the importance of modeling the different crime indexes separately. RML was shown to only be statistically significant with larceny while MML was shown to be statistically significant with burglary and larceny. When forming a new combined larceny and burglary variable, slightly stronger p-values of 0.013(RML) and 0.003(MML) are produced. Additionally, the standard errors drop from 82.11 to 69.68 for RML and 83.06 to 78.21 for MML. The MML variable also shows a slightly larger impact on those crimes, which can be seen by its higher coefficient. It increased from -230.594 to -233.47 offenses per 100,000 people.

Hypothesis 2. In my second hypothesis, I asserted that MML and RML laws would either have no effect or decrease violent crime. See the Table 4.5 for regression results on each category of violent crime.

Table 4.5

Model 1 Violent Crime Regression Results

VARIABLES	(1) Total Violent Crime	(2) Homicide	(3) Rape	(4) Robbery	(5) Assault
Police Level	0.0528**	1.35e-05	-0.00280	0.0227	0.0329***
	(0.0223)	(0.000575)	(0.00357)	(0.0166)	(0.0114)
Male	-10.50**	0.156	-1.179	1.728	-11.21***
	(5.311)	(0.198)	(1.502)	(2.072)	(4.162)
Youth	0.469	0.00119	0.718***	0.171	-0.421
	(0.500)	(0.0292)	(0.230)	(0.236)	(0.533)
High School	-0.398	0.195	-0.651	-1.036	1.095
	(3.599)	(0.132)	(0.701)	(1.201)	(2.798)
Unemployment	9.731	0.849***	-1.723*	2.541	8.063
	(6.557)	(0.232)	(1.024)	(2.403)	(5.152)
Owner	-0.772	0.102	-0.225	-0.121	-0.527
	(2.348)	(0.0817)	(0.668)	(0.786)	(1.878)
RML	3.298	-0.400	5.832	-0.825	-1.309
	(10.99)	(0.568)	(4.274)	(3.511)	(7.317)
MML	-6.108	-1.115**	1.369	-0.510	-5.853
	(9.879)	(0.537)	(1.784)	(3.453)	(8.597)
Dummy2010	51.63***	0.869**	-8.526***	18.73***	40.56***
	(11.36)	(0.396)	(2.991)	(3.499)	(9.154)
Dummy2011	21.18**	0.226	-10.25***	7.123**	24.08***
	(8.459)	(0.292)	(2.417)	(2.961)	(6.540)
Dummy2012	19.39***	-0.117	-10.02***	10.06***	19.46***
	(7.337)	(0.284)	(1.851)	(3.018)	(5.508)
Dummy2013	-2.467	-0.711***	-6.040***	5.770**	-1.486
	(5.814)	(0.239)	(1.259)	(2.848)	(4.424)
Constant	869.7***	-18.79	126.0	28.07	734.4***
R^2	97.2	78.7	81.2	96.48	95.61
Observations	987	987	987	987	987
Number of Cities	222	222	222	222	222

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Standard errors are clustered at the city level

Both MML and RML are statistically insignificant. Therefore, I cannot reject the null hypothesis that there is no relationship. This regression provides evidence that supports my hypothesis because there is not a statistically significant relationship between either MML or RML and violent crime.

For the individual categories of violent crime (homicide, rape, assault, robbery) the results were also insignificant for MML and RML except for MML on homicide.

However, the coefficient of -1.115 is so small that it does not provide much insight into the relationship.

Overall, the regressions suggest that there is no relationship between MML or RML and violent crime. However, hypothesis four could provide insight into whether or not there really is no relationship. By controlling for whether or not the particular city is in a state that allows for, Model 2 may provide evidence that there still is a relationship.

Hypothesis 3. In my third hypothesis, I asserted that the dispensary variable would show an increase property crime. See Table 4.6 below for Model 2 property crime regressions.

Table 4.6

Model 2 Property Crime Regression Results

VARIABLES	(1) Total Property Crime	(2) Burglary	(3) Larceny	(4) Motor Theft	(5) Arson
Police Level	0.458**	0.270***	0.159	0.0288	-0.0201
	(0.197)	(0.0586)	(0.132)	(0.0206)	(0.0147)
Male	-8.507	-15.85	3.968	3.379	3.733
	(56.62)	(14.76)	(42.11)	(7.836)	(4.002)
Youth	-6.767	-0.234	-6.411	-0.123	0.480
	(7.626)	(2.253)	(5.302)	(0.599)	(0.452)
High School	-15.96	-7.079	-7.573	-1.311	1.070
	(25.38)	(7.826)	(18.97)	(4.048)	(1.015)
Unemployment	149.9***	37.25***	106.3***	6.349	-1.132
	(43.19)	(10.89)	(33.40)	(8.014)	(2.295)
Owner	-17.74	9.925*	-25.37	-2.297	-0.395
	(20.66)	(5.910)	(15.86)	(2.728)	(0.844)
RMLMML	-309.3**	-80.76*	-203.5**	-25.03*	19.55*
	(141.4)	(45.14)	(98.13)	(15.21)	(9.987)
Dispensary	-417.1**	-69.42	-283.1**	-64.59***	18.19**
	(167.4)	(47.64)	(114.7)	(16.86)	(8.286)
Dummy2010	498.4***	165.6***	317.7***	15.11	5.865*
	(93.23)	(23.64)	(71.40)	(12.50)	(3.391)
Dummy2011	243.5***	121.5***	137.5***	-15.49*	3.185*
	(66.71)	(19.11)	(51.31)	(9.104)	(1.703)
Dummy2012	202.7***	107.1***	88.53**	7.132	2.410
	(51.47)	(14.79)	(40.11)	(8.349)	(1.757)
Dummy2013	83.19**	53.26***	22.77	7.167	1.909
	(39.74)	(10.91)	(30.92)	(5.907)	(1.802)
Constant	4,697	799.4	3,568	329.7	-186.7
	(3,416)	(784.8)	(2,523)	(437.8)	(169.9)
Observations	987	987	987	987	977
Number of Cities	222	222	222	222	221
R^2	94.3	93.5	93.5	95.5	43.3

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Standard errors are clustered at the city level

It is important to note the key difference between Model 1 and Model 2. While Model 1 contains indicator variables for whether the city is in a state with MML or in a state with RML. Model 2 does not differentiate between MML and RML but does contain an indicator variable for whether or not the particular city is in a state that allows for dispensaries. Both the MML/RML variable and the dispensary variable were statistically significant with p-values of 0.029 and 0.013 respectively. The coefficients indicate that cities with MML/RML experience a decrease in total property crime of 309

offenses per 100,000. The fact that the MML/RML combined variable causes a decrease in property crime suggests that it is too early to capture the effects of RML. Thus, the results from hypothesis 1 for RML must be interpreted cautiously. The dispensary variable's coefficient indicates that cities in states that allow for dispensaries experience a decrease in total property crime of 417 offenses per 100,000 people. This result suggests that it is the actual dispensaries driving property crime down. In this way, it seems that the victimization issues theoretically created by dispensaries does not exist. Based on the results, it is more likely that the increase security measures that the dispensaries must employ to operate create a safer environment (ie: doorman, security camera, etc.) (Friesthler, 2013). This is even more important since some researchers argue that most dispensaries operate in lower income districts due to zoning laws. This could be useful to local city policymakers because in many cases they have authority over the zoning laws of dispensaries (*Procon.org*, 2016). By allowing dispensaries to operate in these areas, they could act as a way to clean up the area and make it safer from property crime.

There are a few more interesting results coming from the individual categories of property crime. MML/RML was statistically significant on all indexes except motor theft and arson. The dispensary variable was statistically significant on all indexes except for burglary. The fact that it is even significant on arson provides more evidence that the physical dispensaries are the driving factor. If dispensaries are physical locations that provide an increase in safety then it makes sense that arson, a crime involving the destruction of physical locations, would decrease.

Hypothesis 4. In my fourth hypothesis, I asserted that dispensaries would have a negative impact on violent crime. See Table 4.7 below for Model 2 violent crime regression results.

Table 4.7

Model 2 Violent Crime Regression Results

VARIABLES	(1) Total Violent Crime	(2) Homicide	(3) Rape	(4) Robbery	(5) Assault
Police Level	0.0523**	2.38e-05	-0.00276	0.0225	0.0326***
	(0.0231)	(0.000611)	(0.00328)	(0.0168)	(0.0115)
Male	-10.66**	0.198	-1.030	1.758	-11.59***
	(5.333)	(0.200)	(1.558)	(2.056)	(4.261)
Youth	0.401	-0.00334	0.706***	0.171	-0.472
	(0.511)	(0.0291)	(0.231)	(0.237)	(0.545)
High School	-0.795	0.188	-0.645	-1.034	0.696
	(3.620)	(0.133)	(0.692)	(1.216)	(2.827)
Unemployment	9.726	0.825***	-1.829*	2.524	8.205
	(6.546)	(0.233)	(1.008)	(2.402)	(5.139)
Owner	-0.0453	0.119	-0.0718	-0.199	0.106
	(2.493)	(0.0808)	(0.605)	(0.837)	(1.981)
RMLMML	-21.99**	0.0942	1.262	-15.10***	-8.250
	(8.593)	(0.474)	(3.306)	(3.192)	(7.499)
Dispensary	17.08*	0.0726	-0.481	-3.606	21.09**
	(10.11)	(0.509)	(4.343)	(3.726)	(8.608)
Dummy2010	49.14***	0.684*	-9.962***	18.78***	39.64***
	(11.09)	(0.381)	(2.374)	(3.220)	(8.801)
Dummy2011	19.10**	0.0574	-11.56***	7.103***	23.49***
	(8.482)	(0.275)	(1.819)	(2.678)	(6.600)
Dummy2012	18.79***	-0.0590	-11.45***	10.10***	20.20***
	(6.996)	(0.269)	(1.477)	(2.760)	(5.236)
Dummy2013	-3.163	-0.709***	-6.137***	5.770**	-2.087
	(5.861)	(0.239)	(1.254)	(2.856)	(4.469)
Constant	848.0***	-22.16*	111.8	41.76	716.6***
	(262.9)	(11.97)	(81.84)	(107.9)	(232.0)
Observations	987	987	987	987	987
Number of Cities	222	222	222	222	222
R^2	97.01	78.05	80.93	96.49	95.6

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Standard errors clustered at the city level

The results indicate that RMLMML is statistically significant for total violent crime. The coefficient indicates that it decreases total violent crime by 22 offenses per 100,000 offenses. However, none of the categories of violent crime are statistically significant except robbery is found to be statistically significant with a coefficient of -15.10 at 99.999% confidence. Even though total violent crime and Robbery were found

to be significant the coefficients are so small that they do not provide much insight into the relationship. The dispensary indicator variable is not significant at any category other assault where the coefficient suggests that the indicator variable increases assaults by 22 offenses per 100,000 people at 99.99% confidence. This presents puzzling results since it suggests that physical dispensaries actually make the area less safe and prone to assaults. This result contradicts the regression results that provide evidence for decreasing property crime. One remedy for this contradiction is that the security measures put in place by dispensary owners safeguard against property crime, but the increased consumption of cannabis resulting from the legal markets created by dispensaries could cause an increase in violent behavior. This relies on the assumptions that the population does in fact increase their consumption when legal markets are available and the assumption that the increase consumption leads to increase violence caused by the substance itself.

After interpreting the results from my regression, they indicate that MML has a crime decreasing effect on property crime and no effect on violent crime. They also indicate that RML has a crime increasing effect on property crime and no effect on violent crime. Additionally, they indicate that the medical and retail dispensaries are the driving force behind these effects. However, we must be cautious taking these results to mean that MML and RML caused these increases and decreases. As I pointed out there are possible biases and inefficiencies in the model. First, the model relies on the fact the lagged police level variable is an appropriate instrumental variable. Second, there may be unobserved time varying characteristics. In my case, there could be a time-varying factor that is causing property crime cities in states with MML to trend downwards. In the RML

case, there could be an unobserved time-varying characteristic that causes property crime to trend upwards. Third, there could be autocorrelation caused by the time element of the investigation. I assert that due to the small time period studied and the inclusion of time period dummies it would be unusual to experience autocorrelation but it is possible. Fourth, although the errors appear to be distributed normally (See figure 4.3), it failed the skewness and kurtosis test for normality. In this way, the results are potentially inefficient. These possible violations of the assumptions of the model could be producing biased and inefficient estimators.

5.Conclusion

This study aimed to investigate the effects of retail and medical marijuana laws on crime. The enactment of medical marijuana laws in 23 states and the District of Columbia along with the enactment of retail marijuana laws in four states makes this a topic warranting further research. It is important to understand the social ramifications of laws that are legalizing the use, possession, and cultivation of a substance that has historically been illegal. Additionally, the situation is further complicated by the fact that the federal government still views the situation as illegal. As more states pursue medical and retail marijuana laws, knowing the implications of them will be exceedingly important. In this anaylsis, I used panel data of 222 cities across 11 states to run a two way fixed effects 2SLS methodology. The fixed effects methodology controls for unobserved time constant heterogeneity. Additionally, the inclusion of time fixed effects controls for time period effects. By using a simultaneous equation, I control for the endogeneity of the policy level variable. I employ socioeconomic and demographic variables that are know to contribute to crime in order to account for time-varying factors affecting crime.

The results for property crime indicate that MML cause total property crime to decrease by 231 offenses per 100,000 people. They also indicate that RML causes total property crime to increase by 199. Using Model 2 provides evidence that the dispensaries are the driving factor affecting property crime. Model 2 produces results showing the dispensary variable causing a decrease in total property crime by -309 offenses per 100,000.

The results for violent crime were largely not statistically significant, which are similar to the results found by Morris et al. (2014) and Alford (2014). However, when

using the Model 2 the dispensary indicator variable was found to be statistically significant on the assault crime index with a coefficient of 22.

These results must be interpreted cautiously because of the potential problems with bias and inefficiency. Non-normality of errors, autocorrelation, and unobserved time varying heterogeneity are all potential problems. Although the errors failed the skewness and kurtosis test, the error term distribution graph appears to be normally distributed. The failure of the test is probably due to a few outlier observations. I assert that autocorrelation is most likely not an issue since the time period investigated is small. Also, the inclusion of time fixed effects controls for time period effects. I attempt to control for time varying heterogeneity by including socioeconomic and demographic variables. They do a solid job of explaining crime in the data set as can be seen by the high R^2 values. However, it is still possible that I missed a key unobserved time-varying factor. If any of these assumptions do not hold then the estimates are likely biased and inefficient.

There have been very few studies on the effect of medical marijuana laws on crime. Additionally, these studies have failed to reach a consensus in results (Morris et al., 2014;Alford, 2014;Gavrilova et al., 2014;Anderson et al., 2013). While these studies have used state-wide data, I aimed to contribute to the literature by employing city data. This allowed me to have a greater number of observations. Also, by using city data there were less inherent state differences between the observations. Since, it has been four years since Colorado and Washington passed retail marijuana laws, I was able to study not only the effects of medical marijuana laws but also retail marijuana laws.

As discussed, the estimators presented may be biased and inefficient. However, they suggest that dispensaries have a crime decreasing effect on property crime. This most likely results from the increase security measures employed by dispensary owners. This suggests that policymakers considering the legality of dispensaries in their particular city should not be worried about the crime exacerbating effect they might have.

Future research should focus further on the dispensary element of this relationship. I was only able to indicate whether or not a city was in a state that allowed for dispensaries. In this way, there could have been observations that had a dispensary value equal to one but in reality have no dispensary in that city. By using data that indicates the number of dispensaries in each city or state, I believe that useful information can be found.

Appendix A

Table A.1

Arizona: Medical Marijuana Law

Law Passed	Year Effective	Dispensary,	Age	Possession	Home Cultivation	Main Purpose,
Arizona Medical Marijuana Act	2010	2010	18	2.5 ounces	12 plants (only allowed if patients live 25 miles or more away from a "non profit medical marijuana dispensary"	To legalize the use, possession, and cultivation of medical marijuana for patients qualifying for a "debilitating medical condition."

Source: Arizona Medical Marijuana Act, 2010
ProCon.org

Table A.2

California: Medical Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
The Compassionate Use Act	1996	1996	-----	-----	-----	To legalize the use, possession, and cultivation of medical marijuana for qualifying patients
Senate Bill 420	2004	-----	18	8 ounces	6 mature plants (12 immature plants)	To specify how much medicinal marijuana patients may possess or grow

Source: The Compassionate Use Act, 1996
S. 420, 2004
Note. S. 420 also specifies that counties and municipalities are allowed to impose their own rules concerning possession and cultivation limits.

Table A.3

Colorado: Medical Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Ballot Initiative 20. Medical Use for Persons Suffering from Debilitating Conditions	2001	2001	18	2 ounces	6 plants	To legalize the use, possession, and cultivation of marijuana for medical purposes.
House Bill 1284	2010	-----	-----	-----	------	Allowed for the renewal and application of "Medical Marijuana Centers." Additionally, provided regulations for these centers including allowing local communities to ban or impose their own restriction on the operations of the "Medical Marijuana Centers"

Source: Medical Use for Persons Suffering from Debilitating Conditions, 2001
H. 1284, 2010
Note. Colorado has a Medical Marijuana Code, which is comprised in C.R.S. 12-43.3-101. It provides a regulatory framework for the licensing and operations of the cultivation, manufacturing, and sales of medical marijuana.

Table A.4

Colorado: Retail Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Amendment 64. Personal Use and Regulation of Marijuana	2014	2014	21	1 ounce	6 plants	To legalize "retail marijuana" for the use of adults aged 21 years and older.

Source: Personal Use and Regulation of Marijuana, 2012
Note. Colorado has a Retail Marijuana Code, which is comprised in C.R.S. 12-43.4-10. It provides a regulatory framework for the licensing and operations of the cultivation, manufacturing, and sales of retail marijuana (Retail Marijuana Code).

Table A.5

Nevada: Medical Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Ballot Question 9. A Medical Marijuana Initiative	2000	-----	18	2.5 ounces	12.5 plants	To legalize the use, possession, and cultivation of marijuana for qualifying patients
Senate Bill 374	2014	2014	-----	-----	------	To allow for the registration and creation of "Medical Marijuana Establishments."

Sources: The Nevada Medical Marijuana Act, 2000
S. 374, 2013
Note. Chapter 453A of the Nevada Revised Statutes contains the current regulation and rules for medical marijuana.

Table A.6

New Mexico: Medical Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Senate Bill 523. The Lynn and Erin Compassionate Use Act	2007	2007	18	6 ounces	4 mature plants and 12 seedlings	To allow for the "beneficial use of medical cannabis in a regulated system for alleviated symptoms caused by debilitating medical conditions and their medical treatments."

Source: The Lynn and Erin Compassionate Use Act, 2007

Table A.7

Oregon-Medical Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Ballot Measure 67. The Oregon Medical Marijuana Act	1998	-----	18	24 ounces	6 mature plants	To legalize the use, possession, and cultivation of small amounts of medical marijuana for qualifying patients.
House Bill 3460	2014	2014	-----	------	-----	To charge the Oregon Health Authority to create and regulate "medical marijuana facilities."
Senate Bill 1531	2015	-----	-----	-----	-----	To give local cities and towns the authority to regulate and impose "reasonable" restrictions on medical marijuana facilities.

Source: The Oregon Medical Marijuana Act, 1998
S.1531, 2015
H.3460, 2014
The Control, Regulation, and Taxation of Marijuana and Industrial Hemp Act, 2014
Note. Oregon passed legislation to legalize the retail use of marijuana in 2014 but was not implemented in 2015. Therefore, I do not include an overview of Oregon's retail marijuana laws because my study only covers 2010-2014

Table A.8

Washington-Medical Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Chapter 69.51A RCW. Medical Cannabis	1998	2012	18	60 day supply	illegal	To remove state-level penalties for the use, possession, and cultivation of cannabis for patients that suffer from certain debilitating condition and when the "potential benefits of the medical use of cannabis would likely outweigh the health risks."
Senate Bill 6032	2007	-----	-----	24 ounces	15 plants	To specify the exact amount of cannabis allowed and to allow for home cultivation for registered patients

Source: Chapter 69.51A RCW, 1998
S. 6032, 2007

Table A.9

Washington-Retail Marijuana Law

Law Passed	Year Effective	Dispensary	Age	Possession	Home Cultivation	Main Purpose
Initiative 502	2012	2014	21	1 ounce	illegal	To legalize and regulate the use and possession of small amounts of cannabis for adults ages 21 and over

Source: Initiative 502, 2012

Table A.10

Terminology

State	Term used for Marijuana	Term I will use	Term used for distribution outlets	Term I will use
Arizona	Marijuana	Marijuana	Non profit medical marijuana dispensaries	Medical Dispensary
California	Marijuana	Marijuana	Medical Marijuana Dispensary	Medical Dispensary
Colorado	Marijuana	Marijuana	Medical Marijuana Center and Retail Marijuana Center	Medical Dispensary and Retail Dispensary
New Mexico	Cannabis	Marijuana	-----	-----
Washington	Cannabis	Marijuana	Medical Marijuana Dispensary and State-Licensed Retail Outlet	Medical Dispensary and Retail Dispensary
Oregon	Marijuana	Marijuana	Medical Marijuana Facility	Medical Dispensary
Nevada	Marijuana	Marijuana	Medical Marijuana Establishment	Medical Dispensary

Note: There is no consensus in the way that states refer to the medical versus retail/recreational/adult use laws. I will refer to the former as medical marijuana laws and the latter as retail marijuana laws.

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