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## The Effect upon State Crime Rates of the Legalization of Recreational Marijuana in California

Robert Boxerman

*University of Missouri-St. Louis*, [rdb359@umsystem.edu](mailto:rdb359@umsystem.edu)

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# **The Effect upon State Crime Rates of the Legalization of Recreational Marijuana in California**

Robert D. Boxerman

B.S. Chemical Engineering, Missouri University of Science and Technology, 2018

A Thesis Submitted to The Graduate School at the University of Missouri-St. Louis  
in partial fulfillment of the requirements for the degree  
Master of Arts in Criminology and Criminal Justice

May  
2020

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## **ABSTRACT**

This work examines criminal effects of the legalization of recreational marijuana in the state of California in 2016. While multiple states have legalized marijuana for recreational purposes, there is little empirical evidence to determine the criminal effect, if any, of introducing marijuana products into the legal market. The research analyzes crime rates pre and post legalization. Crime rates from the years 1990-2018 are taken from the California Attorney General Office “Crime in California” annual report, and consist of FBI Part I offenses: murder and nonnegligent homicide, rape, robbery, aggravated assault, burglary, motor vehicle theft, larceny-theft, and arson. Misdemeanor drug arrests, marijuana felony arrests, and non-marijuana felony drug arrests are also included. DUI arrests are sourced from the California Department of Motor Vehicles DUI management information annual report. Interrupted time-series analysis is the primary analytic strategy, in conjunction with descriptive statistics. Results suggest that legalization has had a non-trivial impact on arson, felony marijuana arrests, and non-marijuana felony drug arrests, although there are some data limitations which are discussed.

## INTRODUCTION

In 2018, The U.S. Census Bureau reported that California had a population of 39.56 million. Roughly 75% of the population is at least twenty-one years old (U.S. Census Bureau, 2018), and following a narrowly approved 2016 state ballot measure, able to legally purchase marijuana -- a federally illegal substance -- for recreational use. There are a variety of arguments both in favor of and against the legalization of marijuana for recreational use: medical, moral, political, and ideological. However, the criminal effects of legalizing marijuana remain relatively unstudied. In order to provide a complete picture of the effects of legalization of marijuana, criminal repercussions of legalizing a drug for public consumption should be taken into account. As the national trend towards decriminalization and legalization of marijuana continues, research and data informing upon how these laws and changes affect crime become more valuable.

There exists some research regarding the effects of marijuana upon individual criminality (Pacula & Kilmer, 2003; Bennet and Hollway, 2008) and the effect of marijuana upon the adolescent (Brook et. al, 2003; Philips, 2012; Reingle et. al, 2012; Aalen, 2013). Other works explore the criminal effects of medical marijuana laws on a national scale (Morris et. al, 2014), as well as the effect of legalization laws upon drug crime in multiple states such as Colorado and Washington (Lu et. al, 2019). This work examines what effect (if any) the legalization of recreational marijuana has had on crime in the state of California, and will contribute to the growing literature regarding marijuana and crime by examining the relationship between marijuana legalization and multiple varieties of crime, both violent and nonviolent, as well as drug-related and DUI arrests. By restricting the analysis to the state of California, an in-depth examination may reveal trends and relationships to inform future research and policy. Following

a brief discussion of the history of marijuana legislation in both the United States and California, as well as the present-day status of the substance, I will review the extant empirical literature on the effects of marijuana use and legislation on crime, followed by a discussion of the data used and the analytic strategy employed. Results of descriptive and visual analyses are followed by model construction results from time-series analysis. A conclusion section Then summarizes this work and discusses future direction.

### **HISTORY OF MARIJUANA IN THE UNITED STATES**

In California, marijuana production is seen in agricultural records as early as 1795, where the plant was cultivated in order to harvest hemp, a valuable fiber source used for textile production (Clarke, 2013). Outside of California, marijuana was being grown in North America many years prior. Colonial America produced vast quantities of hemp for everyday usage, including canvas, rope, sails, paper, and clothing (Robinson, 1995). Records dating back to 1611 detail significant amounts of hemp production in Jamestown, Virginia (Deitch, 2003). Several centuries later, hemp played a significant role in World War II, as the U.S. government subsidized American farmers to increase domestic hemp production for wartime use (Higdon, 2018). The federal government even produced a wartime film entitled *Hemp for Victory* espousing the value of hemp to the Allied war effort (Robinson, 1995). In the present-day, outside of the United States, hemp is a regulated and commercially produced material with a variety of modern applications (Johnson, 2018). However, hemp production ceased in the United States when a complete ban on cultivation of the marijuana plant was put into effect post-World War II.

The use of marijuana as an intoxicant was first prominently seen in the States following an expanding population of Mexican laborers in the early 20th century (Mann, 2001). The dominant white population was apprehensive of the steadily growing Mexican community, and beginning in the 1920's, many Western states including California began enacting laws prohibiting the usage of marijuana (Gieringer 1999). The Federal Bureau of Narcotics was formed by Congress in response to concerns over marijuana usage in 1930, and by 1935, the majority of states had enacted anti-marijuana legislation. The Marijuana Tax Act of 1937 placed a severe tax on marijuana distribution and signaled the first significant piece of anti-marijuana federal legislation (the act was later repealed in 1970 following the 1969 case *Leary vs. The United States*<sup>1</sup>.) Anti-marijuana legislation quickly became a method of controlling the growing number of Mexicans and other minority populations, such as Blacks in the South and White immigrant classes in the East. One Texas lawmaker was on record as saying "All Mexicans are crazy and this stuff (marijuana) is what makes them crazy" (Schlosser, 23).

While state and federal laws prohibited all use of marijuana, they were unsuccessful at eradicating illicit marijuana consumption. The 1960's signaled a resurgence of the drug as the younger, college-aged generation increasingly consumed marijuana in its various forms. Correspondingly, marijuana arrests skyrocketed to more than 100,00 yearly arrests by 1970 (Gettman, 2005). In response to public opinion and a series of Congressional hearings regarding the significant number of citizens who often faced severe sentences at the time (from several years to several decades), Congress passed the Controlled Substances Act of 1970, which (temporarily) reduced the strictness of marijuana sentencing law. While sentencing guidelines

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<sup>1</sup> Timothy Leary was arrested for possession of marijuana in violation of the Tax Act of 1937. Leary made a case that the Act required self-incrimination and was in violation of the Fifth Amendment. The court unanimously declared the Marihuana Tax Act unconstitutional as a result.

generally became less severe, under this new legislation, marijuana was categorized as a Schedule I drug, alongside narcotics such as heroin and psychedelics (LSD, mushrooms, etc.) Drugs in this category were defined as having a high potential for abuse, no currently accepted medical use in treatment in the United States, and a lack of accepted safety for use of the drug under medical supervision.<sup>2</sup> Following a lengthy period of study, a Congressional Commission recommended that marijuana be removed from this categorization and studied further to better understand its recreational and medicinal properties. The Nixon administration and the soon-to-follow “War on Drugs,” however, largely ignored the Commission's findings and took a hard stance against marijuana. By the time Nixon resigned, annual marijuana-related arrests had risen from 119,000 in 1970, to 445,000 in 1974 (Gettman, 2005).

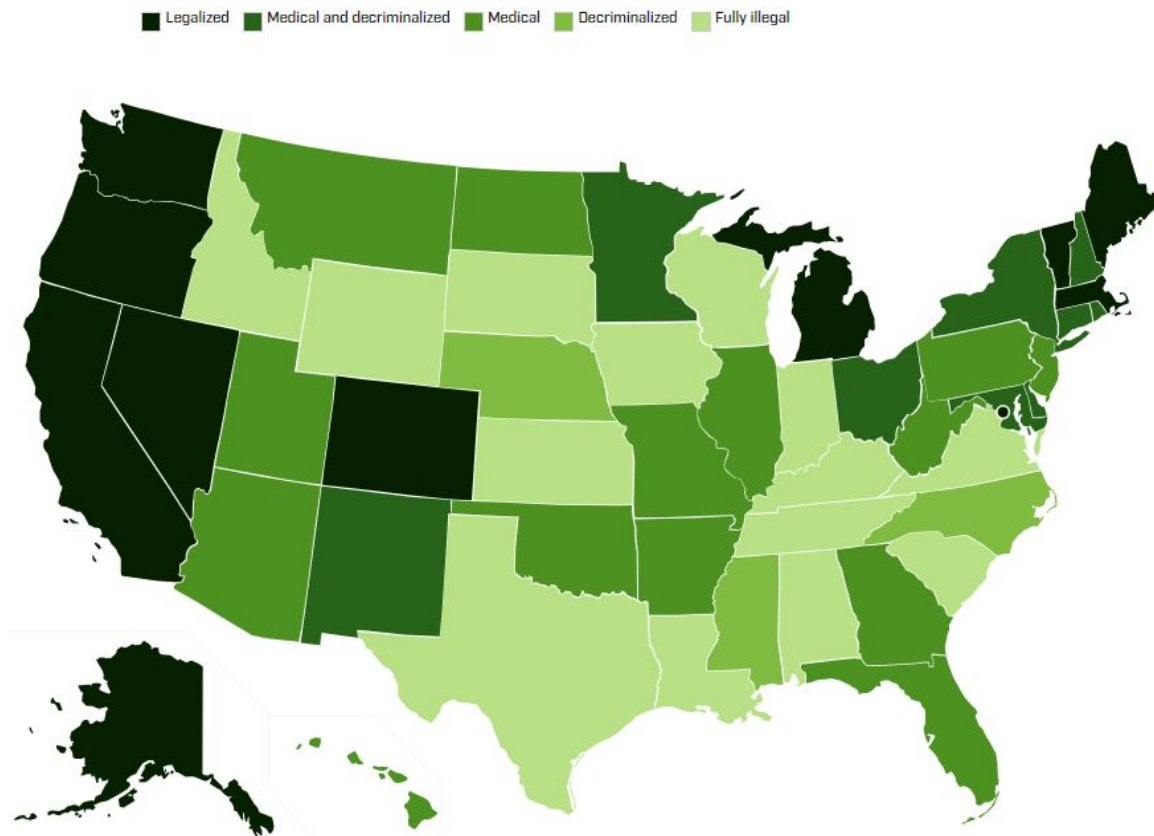
Beginning with Oregon in 1973, a variety of states began decriminalizing small amounts of marijuana. The state of California decriminalized marijuana several years later in 1975 (Anderson, 1981), and several decades later, was the first state to legalize medical marijuana with the passage of Proposition 215 (Balzar, 1996). Oregon, Alaska, Washington, and several other mostly Western states began to follow suit (NORML, 2019). In 2012, Colorado and Washington passed legislation legalizing recreational marijuana at the state level; a massive departure from the Nixon-era classification of marijuana as a Schedule I drug. Most recently, in 2019, Illinois legalized recreational marijuana.

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<sup>2</sup> State laws sometimes categorize marijuana differently. For example, North Carolina recognizes marijuana as a Schedule VI drug, which is defined as having "no currently accepted medical use in the United States, or a relatively low potential for abuse in terms of risk to public health and potential to produce psychic or physiological dependence liability based upon present medical knowledge, or a need for further and continuing study to develop scientific evidence of its pharmacological effects." The federal categorization of marijuana as a Schedule I drug remains a controversial topic. For more information, see <https://norml.org>.

## THE CURRENT “STATE” OF MARIJUANA

Today, marijuana occupies ambiguous territory regarding its legality. Federally, marijuana is still classified as a Schedule I drug, as originally designated in 1970. However, its legal status varies within the states. Currently there are thirteen states (including Washington D.C.) in which marijuana is fully legalized, both medically and recreationally<sup>3</sup>. Figure 1 shows the legal status of marijuana by state (note that the figure has not been updated since Illinois passed recreational marijuana law into effect in 2019. At the time of writing, Illinois allows for the recreational use of marijuana.)



**Figure 1. Map of Marijuana Legality by State. DISA Global Solutions. [2019]. Retrieved from [disa.com/map-of-marijuana-legality-by-state](http://disa.com/map-of-marijuana-legality-by-state).**

<sup>3</sup> While each state has differing laws and regulations, marijuana use is typically restricted to individuals who are at least twenty-one years of age. Use, possession, distribution and cultivation is regulated and subject to the discretion of state agencies, lawmakers, and licensing entities. For more information regarding marijuana laws by state, visit <http://disa.com/map-of-marijuana-legality-by-state>.



Some states, such as New York, have not allowed for the recreational use of marijuana but have decriminalized possession of small amounts of marijuana. For example, New York Article 221 states “Unlawful possession of marihuana is a violation punishable only by a fine of not more than one hundred dollars” (New York, 221.05) There are stipulations surrounding the decriminalization of marijuana, however; in New York, possession of marijuana in a public place is a Class B misdemeanor. Possession of a marijuana product (including edible marijuana products) in excess of twenty-five grams is also a Class B misdemeanor. Most states have also established their own laws regarding the sale and distribution of marijuana. In New York, punishments for violations of the state’s marijuana laws vary from a Class B misdemeanor to a Class C felony, with permissible sentence lengths from fifteen days to one year (Class B misdemeanor) to greater than one year (Class C felony) (New York, 10.00)

States also have discretion regarding the legal status of *medical* marijuana. For example, in Missouri, a citizen may apply for a medical marijuana license through the Missouri Department of Health and Senior Services. Citizens are able to apply under a broad range of medical conditions, many of which are explicitly listed on the Department’s website:<sup>4</sup> cancer, epilepsy, and glaucoma (Missouri DHSS, 2019), to list a few. While some permissible medical conditions are explicitly defined, the state allows for an individual to apply if “in the professional judgment of a physician, any other chronic, debilitating or other medical condition, including, but not limited to, hepatitis C” (Missouri DHSS, 2019), marijuana may provide medical benefit. Essentially, the Department allows a physician discretion to prescribe medical marijuana in

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<sup>4</sup> <https://health.mo.gov/safety/medical-marijuana/how-to-apply-pi.php>

virtually any circumstance in which it may provide benefit or relief to a patient. In addition to providing medical marijuana licenses to citizens for personal medical use, the Department also issues cultivation and distribution licenses to qualified entities and individuals.

Clearly, there is no national legal consensus on the status of marijuana. While marijuana may be legal medically and recreationally in certain states, such as California, the fact that marijuana is still federally illegal has caused conflict in the past and continues to provide a barrier to proponents of legal marijuana and legal marijuana providers/distributors. To name but one example, the Rohrabacher–Farr amendment, introduced first in 2001 and passed in late 2014, was a legislative attempt to prohibit the United States Department of Justice to utilize funds in order to interfere with the enactment of state medical marijuana laws (113th Congress, Rec. 160 No. 82, 2014). Signaling significant progress for medical marijuana advocates, the amendment was contested by federal officials, who argued that it protected state officials but not private entities or individuals. The Department of Justice proceeded to prosecute businesses and private citizens under their interpretation of the amendment, until U.S. District Judge Charles Breyer confirmed the original meaning and intent of the amendment, and ruled the DOJ's actions "counterintuitive and opportunistic", claiming it "defies language and logic" and "tortures the plain meaning of the statute" (Ingraham, 2015).

An individual from one state may cross a state line and find that they are in violation of state marijuana laws. For example, if an adult over the age of twenty-one were to step from Oregon (where marijuana is legal recreationally and medically) into Idaho, they could be subject to a year in jail, a \$1,000 fine, or both, for possession of less than two ounces of marijuana. Greater amounts could lead to a felony conviction and longer sentence lengths. This discrepancy

between state and federal law, as well as state-to-state law, is representative of the unclear position of marijuana and its legal standing in the United States.

## **MARIJUANA AND CALIFORNIA**

Some of the earliest reports of marijuana usage by Mexican, Arab, and Hindu immigrants originate from California (Duvall, 2014) in the late 1800's. Legislation enacted in 1915 restricted the sale and possession of marijuana products without a prescription, and by 1925, possession and sale sentencing were made much stricter, with sentences reaching up to 6 years in prison--climbing to up to 10 years in 1929. By the mid 1950's, sentences of up to 15 years for sale, and a minimum of 1-10 years for possession were in effect (Gieringer, 1999).

California has been known for a liberal and progressive population and culture, typically associated with drug usage--marijuana in particular (Cerdá et. al, 2019). In 1964, Lowell Eggemeier publicly protested California's ban on marijuana by smoking a marijuana joint on the steps of the San Francisco Hall of Justice (NORML, 2014). Eggemeier would go on to serve nearly a year in jail, but had started the movement towards marijuana reform in California. Eggemeier's attorney, James R. White III, initiated a series of legal contests under the argument that prohibition of marijuana violated both the 8th and the 14th amendments. White also founded the LeMar (Legalize Marijuana) advocacy group which would launch a failed ballot initiative in 1972 to legalize marijuana. Marijuana became more popular and prevalent throughout the 70's, until California decriminalized the substance in 1975, and eventually legalized medical marijuana in 1996 and recreational marijuana in 2016.

In 2018, California produced roughly 15.5 million pounds of marijuana, and about \$2.5 billion of legal marijuana products were sold in the state according to a report published by the

California Department of Food and Agriculture (MacEwan et. al, 2017). The legalization of both medical and recreational marijuana has had significant impacts on the state, with ramifications for its economy and polity. A California Department of Tax and Fee Administration memo states that as of January 1st, 2018, the purchase of marijuana products is taxed at a rate of 15% in California, while producers, distributors, and cultivators pay an additional “\$9.25 per dry-weight ounce of cannabis flowers, and \$2.75 per dry-weight ounce of cannabis leaves” with additional taxes and fees potentially to come--in addition to local, city, and municipal taxes (CDTFA, 2019). Revenue from these taxes goes to a variety of sources: general services, education, public health, and others. The 2016 legalization initiative stated that “the revenues will provide funds to invest in public health programs that educate youth to prevent and treat serious substance abuse, train local law enforcement to enforce the new law with a focus on DUI enforcement, invest in communities to reduce the illicit market and create job opportunities, and provide for environmental cleanup and restoration of public lands damaged by illegal marijuana cultivation” (Adult Use of Marijuana Act, 2016).

Currently, California is struggling to curb illegal marijuana sales and growth for a variety of reasons. Lack of funding for enforcement, staffing issues within regulatory agencies, discrepancy between state and local regulations, unclear enforcement/agency responsibilities, and the sheer scale of the marijuana market have proven significant obstacles for creation of an efficient and regulatable legal market. Governor Gavin Newsom recently stated that illegal growing operations in California are worsening (Fuller, 2019), and tax revenue from legal marijuana sales have been far below projections. Consequently, California has created a variety of agencies to cope with the injection of marijuana into the state economy. The 2015 passage of

the Medical Cannabis Regulation and Safety Act (MCRSA) was an attempt to create a statewide framework to effectively regulate and tax the sale and distribution of medical marijuana (CAC, 2018). Several years later, through Senate Bill 94, MCRSA was merged with existing legislation in order to manage both medical and recreational marijuana regulation throughout the state (CAC, 2018). The Bureau of Cannabis Control (known as the Bureau) is the primary regulatory agency, but other agencies such as the Manufactured Cannabis Safety Branch, CalCannabis Cultivation Licensing (CalCan), and the Cannabis Advisory Committee (CAC) provide important services in the regulation of marijuana. A CAC report released in 2018 details the difficulties the state has had in the enforcement of effective marijuana regulation. The federal classification of marijuana as an illegal substance, the relative youth of legal marijuana in the United States, and the task of integrating an established industry into a new regulatory framework have proven to be serious obstacles to effective marijuana policy (CAC, 2018).

### **LITERATURE REVIEW: MARIJUANA AND CRIME**

The relationship between marijuana and crime is one that is often fueled by anecdotal evidence or no evidence at all (Lu et. al, 2019). Marijuana was first “discussed” from a criminal perspective in the early to mid 1900’s by opponents of its use. At the time of expanding sanctions for marijuana use and possession, opponents of marijuana employed fearmongering and exaggeration to push their prohibitive agenda. Wichita police officer L.E. Bowery asserted in 1933 that marijuana gave criminals inhuman strength, endurance, sexual aggression and immunity to pain (Artamento et. al, 2009). Many lawmakers and law enforcement agents alike insisted that marijuana trafficking was a significant concern within the U.S., echoing the bold claims of Bowery on the effects of marijuana on the criminal individual and the implications for

public safety. Dr. William C. Woodward addressed Congress to refute these claims, asserting that the Bureau of Prisons had yet to provide any evidence that any of their prisoners were marijuana addicts (Artamento et. al, 2009), but his arguments fell largely upon deaf ears. Leading the charge into marijuana prohibition was Henry Anslinger, the appointed head of the Federal Bureau of Narcotics. Anslinger utilized inflammatory and factually unevidenced statements regarding the criminal potential of marijuana to persuade federal lawmakers to continue the crusade against marijuana in the States.

What empirical evidence is there to inform on the effect of marijuana upon crime? On an individual level, marijuana has been subject to a moderate amount of research to determine its violent or criminal effects. Pacula and Kilmer (2003) explored the link between marijuana use and individual crime by analyzing arrest data from the Arrestee Drug Abuse Monitoring (ADAM) Program and the FBI's Uniform Crime Reports (UCR). The authors cite Taylor and Bennett (1999) and Makkai et al.'s (2000) findings that "reports from the United States, England, and Australia...all show that approximately 60% of arrestees test positive for marijuana use and that marijuana is the drug whose metabolites are most frequently found in arrestees' urine" (Pacula & Kilmer, 2003) as a basis for further exploration of the link between marijuana and crime, as they argue no inferences can be drawn from this finding as most arrestees are not using marijuana exclusively, but are frequently under the influence of other substances and narcotics as well. They also argue that urine tests for THC are indicative of THC use anytime in the preceding month, and that the short-term influence of marijuana on criminal activity can not be established from this method of testing.

Results show that of all arrestees in the sample, marijuana users are more likely to be charged with a drug-related crime. The authors acknowledge that due to the sample being comprised of only those who have been arrested, the finding is not surprising, agrees with previous research, and likely not generalizable to the greater population. Results also indicated that individuals who had been arrested for a violent crime were more likely to have used marijuana in the past 30 days, but that this relationship can not be inferred to be causal in nature. In other words, it is plausible that individuals who commit violent crimes are also likely to engage in marijuana use, but the violent act can not be attributed to using marijuana. Pacula and Kilmer do find, however, that within the sample, marijuana users (regardless of time of use or method of measurement of use) are more likely to commit property crime than non-marijuana users. The authors acknowledge that their sample is limited (only individuals arrested and processed through law enforcement entities participating in the ADAM program are included) and may not be generalizable to the overall arrestee population. Pacula and Kilmer also propose that they are unable to confirm how the individuals *arrested* for crime are behaviorally similar to individuals who *commit* crime, and that the associations between marijuana use and arrest may merely point to the fact that using marijuana decreases the likelihood of successfully committing a crime, and increases the likelihood of apprehension and arrest. When re-running the model using crime rates rather than arrest rates, there was no causal link between violent crime and marijuana use. The relationship between property crime and marijuana use was less obvious, as results were only statistically significant when endogenous measures of enforcement were used. The authors claim that their work supports a causal link between proximal marijuana use and property crime, although whether marijuana use increases the individuals likelihood of

participation in crime is unclear. Overall, Pacula and Kilmer's study suggests that arrestees for property crime are more likely to be marijuana users, although a causal link is difficult to establish.

Another examination of the link between individual marijuana use and crime is seen in Bennet and Hollway's (2008) meta-analysis of drug use and offending. Of all the studies reviewed, 10 examined the link between marijuana use and crime within the United States. Overall, the authors find that marijuana users are about 1.5 times more likely to offend than non-marijuana users (Bennet & Holloway, 2008; Lu et. al, 2019)<sup>5</sup>. Does this establish causality or does it merely suggest association? In order to answer this question, research examining marijuana use among adolescents may provide some insight. Similar to prior research suggesting that early marijuana use in juveniles may adversely affect cognitive development, Brook et. al (2003) determined that adolescent marijuana use is related to problem behavior later in adolescence in Colombian youth, and Philips (2012) determined that marijuana use among high-risk youth was a predictor of violent behavior. Reingle et. al (2012) examined the relationship between marijuana use and intimate partner violence, finding that marijuana use during adolescence is related to intimate partner violence later in life. These studies present evidence of, at the very least, an association between marijuana use and crime, particularly when use occurs among adolescents. Some studies, however, such as Aalen (2013) suggest that marijuana use may act as a substitute among adolescents for more criminal or dangerous acts. I am concerned that these studies typically examine youth in lower SES contexts or youth who are relatively at greater risk to become involved in offending. Weis (1974) described this issue,

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<sup>5</sup> Lu et. al make the important point that this study is not sensitive to the legal status of marijuana.



writing that beyond measuring prevalence, most studies regarding adolescent drug use focus on low-income, African-American children. Just as Philips (2012) and Reingle et. al (2012) focused on Colombian and at-risk American youth (respectively), these studies often neglect to examine adolescent marijuana use from a broader perspective, across greater swathes of populations. Patrick et. al (2012) determined that adolescent marijuana use is related to higher family SES when compared to alcohol or tobacco use, and yet in the course of research, I found that very few researchers examined marijuana use among middle-class adolescents, and focused rather on minority adolescents in urban environments. This represents a serious and concerning deficit in the effort to establish the relationship between adolescent marijuana use and offending later in life. Further research examining the effect of marijuana use in adolescence among a greater diversity of samples (such as middle or upper class Caucasian youth in higher SES areas) would help increase the confidence of stating that adolescent marijuana use does indeed have a causal effect upon crime.

In recent years, literature regarding marijuana laws and crime on a state or national scale has become more prevalent. Most recently, a 2019 JRSA report analyzed the impact of marijuana legalization and decriminalization upon state criminal justice resources. Farley and Orchowsky (2019) used state-level data to assess three measures: impacts of marijuana legalization and decriminalization on criminal justice resources in Colorado, Washington, and Oregon; the impacts on criminal justice resources in states that border those states that have legalized marijuana (Nebraska, Nevada, Oklahoma, Utah, and Kansas), and the impacts of marijuana legalization and decriminalization on drug trafficking through northern and southwest border states (Arizona, California, Idaho, Oregon, and Washington.) The authors note that there are

serious data limitations in that state agencies do not adhere to a uniform, standardized measure of reporting regarding marijuana arrests and seizures, as well as difficulty obtaining required data from state/local agencies in interpretable or manageable ways. The authors also note that many of their analyses examine a pre- and post- trend with a short timeframe being used for post-analyses, given that legalization of marijuana is a recent phenomenon, and that a greater amount of time may be required to draw conclusions on causality and/or associations regarding the legalization of marijuana.

While keeping these limitations in mind, the authors offer some tentative findings. Legalization of marijuana for recreational purposes lowered the number of marijuana-related arrests and court cases. When arrests and court case filings were quantified in Oregon and Washington (two states with legal recreational marijuana), a decrease was observed in the years following legalization. Secondly, although subject to significant data limitations, no observable increase in drug crime-related indicators was observed in the states bordering states with legal marijuana.<sup>6</sup> Third, no indicators of increased drug trafficking were observed in border states, although the authors point to qualitative interviews conducted which suggest that in some states trafficking may be increasing while it may be decreasing in other states, and that longer time periods are potentially required to address this particular topic.

Morris, TenEyck, Barnes, and Kovandzic (2014) examined state *medical* marijuana laws across the country and whether they had an effect upon crime between 1990-2016. FBI Part I offenses (homicide, rape, robbery, assault, burglary, larceny, and auto theft) were used as the dependent variables). When examining unconditioned crime trend data, the authors found that

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<sup>6</sup> The authors state that their efforts to address this research question were severely hampered by data limitations, and that this finding should be interpreted with caution.

states that enacted medical marijuana laws saw a reduction in crimes in general. Given that the nation as a whole was experiencing declining crime rates, the authors compared these states to states without medical marijuana laws and found that the rate of reduction in crimes for states with medical marijuana laws was greater than those states without. Using a fixed-effects panel design in conjunction with ordinary least-squares regression, findings suggested that states with medical marijuana laws experienced a 2.4% yearly reduction in homicide and assault, with effects compounding annually for each year that medical marijuana laws were in effect.

Lu et. al (2019) performed a quasi-experimental study that is most similar to my proposed work. The authors used UCR Part I Offense data in Washington and Colorado in conjunction with an interrupted time-series analysis and found that the legal status of marijuana in these states had little to no effect on major indicators of offending for both violent and property crime.

### **THEORETICAL LINKS BETWEEN MARIJUANA AND OFFENDING**

Regarding theoretical explanations as to *why* marijuana (and by extension laws regarding its legality) may affect offending, Goldstein (1985) suggests that drugs contribute to crime in three possible ways: psychopharmacologically (an individual commits crime as a direct result of the drugs effects upon the body and mind), economic compulsively (committing crime for material/monetary gain in order to acquire more drugs), and/or systemically (violence as a result of the drug market or drug-related interactions with others such as sales and distribution.) My propositions for the causes of marijuana-related crime align well with Goldstein's framework and are presented as follows.

**Marijuana may inhibit an individual's cognitive abilities and lead him/her to make poor decisions or engage in criminal activity (psychopharmacological)**<sup>7</sup>. Literature regarding how marijuana directly engenders crime is sparse at best. Association between marijuana use and crime has been established, but causality remains difficult to confirm or deny. Most research regarding marijuana pertains to its medical effects, and “hard” drugs such as crack-cocaine and heroin are more prevalent in the literature due to their more visible health and criminal impacts.

As has been documented, marijuana impacts an individual’s decision-making ability and other mental functions. A person under the influence of marijuana may do things they otherwise would not do--engaging in vandalism/petty crime, violent behavior, etc. Laboratory research typically shows that marijuana use inhibits violent behavior. Mizcek et. al (1994) as well as White & Gorman (2000) both show this to be the case. However, a study by Baker (1998) found that juveniles who engage in marijuana use are significantly more likely to engage in violent acts and vandalism. Bushman (1990) performed laboratory trials in which marijuana users were seen to be more aggressive when compared to the placebo group, and the U.S. National Research Council (1993) suggests that prolonged marijuana usage may engender changes in the nervous system, leading to increased aggression.

Increases in driving while under the influence of marijuana may lead to more accidents, injuries, and deaths. Driving under the influence of marijuana is illegal in California, although difficult to test, as traces of marijuana remain in the body for weeks after use, and is not as easily testable in the same way as alcohol (Farley and Orchowsky, 2019). An interviewee in the JRSA 2019 report claimed an increase of 55-60% in drugged driving in the state of Oregon (Farley and

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<sup>7</sup> For a discussion of the physical effects of marijuana, see Appendix I.

Orchowsky, 2019). Some research shows that driving while under the influence of marijuana increases risky or dangerous driving behaviors (Hartman et. al, 2015; Lenné et. al, 2010).

**Marijuana users may turn to criminal activity to fund their purchasing of the drug (economic compulsive).** It is logical to extrapolate that an individual who is willing to commit a crime for economic purposes such as purchasing marijuana is likely to attempt to acquire marijuana regardless of its legal status<sup>8</sup>--thus, the legalization of marijuana may have a negligible effect on this variety of crime, especially given that illegal marijuana is often significantly cheaper in California when compared to legal marijuana (McGreevy, 2019). However, the legality of recreational marijuana may increase the ease and availability of purchase (purchasing from a legal dispensary may be easier than purchasing through illicit channels) leading to an increased demand and higher counts of property or violent crime.

**Drug-market violence and crime may be affected by the legalization of marijuana (systemic).** It is doubtful that marijuana fuels drug violence to the same extent that other drugs such as cocaine and methamphetamines do; Goldstein et. al (1998) found that of 414 New York City drug-related homicides, only 6 were related to marijuana use. There is some evidence that legalization of marijuana has even reduced Mexican drug-trafficking organization activity (CBC, 2017). However, in a 2019 JRSA report, some law enforcement officials expressed concern that illegal marijuana home-grow operations have led to violence as individuals attempt to establish turf (Farley and Orchowsky, 2019), and that individuals from out-of-state commute into states with legal marijuana and create illegal growing and distributing operations. Law enforcement officials also express frustration over the difficulty of differentiating between legal and illegal

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<sup>8</sup> By this, I mean that the illegality of marijuana would not be a barrier to purchase.

marijuana, as illegal distributors are able to slip under the radar in states with legal marijuana now that the substance is not scrutinized as heavily. For example, the smell of marijuana is no longer as useful to law enforcement officers as an indicator of criminal activity (Farley and Orchowsky, 2019) and in some cases can not be used as probable cause to lead to searching a vehicle or for an arrest. This could prevent officers from removing criminal or dangerous individuals from the street, and may be expressed in greater crime rates.

If marijuana is legal, buyers may turn to legal outlets to acquire the drug and may avoid contributing to the illicit drug market, which could decrease violence and illicit drug sales. Conversely, drug dealers may find that they are struggling to sell as much illegal marijuana and may attempt to increase sales of other more dangerous narcotics such as methamphetamines or heroin. They may also make bolder and more dangerous efforts to sell marijuana to a greater market, and may infringe upon the turf of rival drug dealers, which may incite greater levels of violence.

**Marijuana dispensaries typically deal only in cash and offer potential targets for crime.** Felson and Cohen's 1979 routine activity theory proposes that there are three necessary elements for crime to occur: a motivated offender, a suitable target, and the absence of a capable guardian. Revenue from legal marijuana sales is recognized under federal law as drug trafficking, and many dispensaries are unable to establish accounts with banking institutions (Chemerinsky et. al, 2015). As a result, most dispensaries operate solely in cash transactions and have significant amounts of cash on hand, as well as a steady influx of customers who have both cash and marijuana on their person; hence, a suitable target for motivated offenders (which are generally accepted to be present in virtually all situations). As law enforcement agents or other

capable guardians<sup>9</sup> are not always present or effective, there may be greater rates of property and/or violent crime in areas immediately surrounding marijuana dispensaries<sup>10</sup> which may also be reflected in greater counts of state crime.

## HYPOTHESES

This work seeks to determine whether legalizing recreational marijuana in the state of California has had an appreciable effect on crime at the state level. My hypotheses are as follows:

- **There will be little or no effect of legislation on violent crime or property crime.**

There is not enough research affirming the causal role of marijuana in crime to believe that legalization will engender a significant amount of new criminal activity. Existing state-level research such as Lu et. al (2019) has found that legal marijuana has not yet produced a noticeable change in crime, and Orchowsky & Farley (2019) were unable to find noticeable state-level effects as a result of legalization.

- **There will be fewer marijuana related arrests, particularly felony-level arrests, following legalization.** Currently, California marijuana laws contain only two marijuana violations which are classified as felonies: sale or delivery to individuals under 14 years, or between 14-17 years.<sup>11</sup> While it is possible that there will be more arrests for these two specific felony violations, there are no possession, cultivation, or paraphernalia felony charges for marijuana--charges which are likely the most applicable to the general

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<sup>9</sup> A capable guardian need not be a law enforcement agent or even a human being but may be a safe, a locked door, a security camera, etc. The “capability” of the guardian reflects their ability to effectively deter or prevent crime.

<sup>10</sup> Lu et. al (2019) propose the same mechanism.

<sup>11</sup> <https://norml.org/laws/item/california-penalties>

population. Orchowsky & Farley (2019) also found a decrease in marijuana-related court cases in states that legalized marijuana.

- **There may be an increase in misdemeanor-level drug arrests.** I believe that marijuana will be more readily available and that the general individuals attitude about the substance will be more relaxed and may lead them to consume the product inappropriately (in excess, in public spaces, etc.) or they may inadvertently violate laws such as transportation of marijuana or may be in possession of a greater amount of marijuana than is legally permissible, although these minor legal transgressions may not be visible on a state scale, or may not occur frequently.
- **There may be an increase in DUI arrests.** As the DUI arrest count incorporates marijuana *and* alcohol, it may be difficult to disentangle arrests for the two, and as Orchowsky et. al (2019) pointed out, testing drivers for marijuana use is difficult and costly. For this reason, while it is possible more drivers are under the influence of marijuana, this may not be reflected in a greater number of arrests.

## DATA

The California Attorney General’s Office publishes an annual “Crime in California” report, which the state Department of Justice purports to be the most comprehensive report on crime in the state. Reports from the years 1990-2018 include the following crimes, which will be the primary dependent variables: homicide, rape, robbery, aggravated assault, burglary, vehicle theft, larceny, and arson, all measured as the total number of reported crimes for each year. The reports are available on the Department of Justice website.<sup>12</sup> The reports also provide annual

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<sup>12</sup> <https://oag.ca.gov/>



counts of felony marijuana arrests, felony non-marijuana drug arrests, and misdemeanor drug arrests.

The California Department of Motor Vehicles releases an annual DUI management information report which is publicly available on the Department website<sup>13</sup>. The report is the state's attempt to compile a comprehensive DUI data reference and monitoring system, and contains information such as total number of annual DUI arrests and convictions, drug or alcohol related license violations, and recidivism estimates for DUI offenders.

As the population of California has increased steadily since 1990, I controlled for the annual population as measured by the U.S. Census Bureau's Decennial Census, as well as the American Community Survey. For the years 1991-1999 and 2001-2009, there is no survey data available for counts of the state population. In order to provide control values for these years, linear interpolation was performed. For the year 2018, linear extrapolation was performed to provide an estimate for the state population.<sup>14</sup>

### **Dependent Variables**

<i>Property Crime (burglary, vehicle theft, larceny, and arson)</i>	Source: CA DOJ Report
<i>Violent Crime (homicide, rape, robbery, aggravated assault)</i>	Source: CA DOJ Report
<i>Drug Arrests (marijuana and nonmarijuana felony, misdemeanor)</i>	Source: CA DOJ Report
<i>DUI Arrests</i>	Source: CA DMV Report

### **Independent Variables**

<i>Post-Legalization (dichotomous dummy variable)</i>
<i>Post-SB 1449 (dichotomous dummy variable)</i>
<i>Post-47 (dichotomous dummy variable)</i>

### **Control Variables**

<i>State Population</i>	Source: U.S. Census Bureau
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## **METHODS**

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<sup>13</sup> <https://www.dmv.ca.gov/portal/dmv>

<sup>14</sup> At the time of writing, ACS surveys are only available up until the year 2017.

Descriptive statistics for crime rates (*property, violent*) and arrests (*DUI, drug*) in the periods before and following legalization laws were calculated, as well as t-tests for pre- and post- periods. Underlying trends are taken into account in order to isolate potential causality between marijuana policy changes and resulting changes in indicators of offending. There are three independent variables. A dichotomous variable “Post-Legalization” is coded 0 for the years 1990-2016<sup>15</sup>, and coded 1 for the years 2017-2018. In 2010, California passed SB 1449, in which possession of less than one ounce of marijuana was reclassified as a misdemeanor rather than a felony. This represents a stringent piece of legislation, and may have effects upon crime (particularly drug-related arrests.) For this reason, the second dichotomous independent variable, “Post-1449,” is given a value of 0 for the years 1990-2010<sup>16</sup>, and a value of 1 for the years 2011-2018. Similarly, Proposition 47, passed in 2014, reduced the classification of some drug and nonviolent crimes from felonies to misdemeanors. This may have a non-trivial effect on arrest data for drug offenses. “Post-47” will be coded 0 for the years 1990-2014<sup>17</sup>, and 1 for the years 2015-2018.

Limitations to a purely descriptive and pre- post- analysis are two-fold. There is no comparative case with which to compare results, in that this comparison is limited to the state of California. While there have been other states such as Colorado and Washington that have legalized marijuana recreationally, California has a vastly different social, economic, and population landscape, and as previously mentioned, has greater marijuana production and a larger marijuana economy than other states. However, existing literature has performed similar

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<sup>15</sup> Prop 64 did not pass until November 2016, and for this reason, 2016 is being included in the pre-legalization period and will receive a 0 value for the Post-Legalization variable.

<sup>16</sup> SB 1449 was passed in Congress in September 2010. 2010 will be coded as a 0 for “Post-1449” as a result.

<sup>17</sup> Prop 47 was not passed until November 2014.

analyses in these states (Lu et. al, 2019; Farley & Orchowsky, 2018) and the results of their analyses may be used for comparative purposes. Additionally, descriptive and pre- post- post-analysis do little to determine causality and make inferences about the effect of legalization discretely from underlying, pre-existing trends in crime and arrest data. Crime rates have generally been declining in the United States in recent decades (UCR, 2017) and by relying on descriptive analysis, it would be incorrect to assign the observed decreasing trend in crime and arrests to marijuana legalization. In order to address this concern, time-series analysis was performed.

According to Corsaro (2018) time-series analysis is a method of analysis used to ascertain whether an intervention at a known point and time had an effect upon an outcome, where the effect of the intervention is greater than a pre-existing underlying trend. This allows researchers to determine with greater certainty that changes in the outcome are in fact due to the intervention rather than the existing trend. In order for time-series analysis to be performed, there are several requirements that must be met. The first is that the intervention must occur at a known point in time; as Bernal et. al (2017) state, there must be clear differentiation. In this case, the first requirement is met in that the date of legalization legislation is known, and effective immediately statewide. Next, the outcome must change immediately following the intervention. Given that all data is provided in yearly counts, it is likely a reasonable assumption that changes in crime and arrest data should be “instantaneous” at an annual level and immediately visible (to some degree) in the yearly aggregation of crime and arrests. If data were provided weekly or monthly, however, or should the previous assumption be found to be incorrect, there are more complicated time-series models that allow for a delay between the intervention and changes in

the outcome. Another requirement for time-series analysis is that there is a clear pre-intervention function. A cursory visual inspection of the data shows that pre-2016 data follow fairly clear trends and a functional relationship can be found. There must also be an acceptable amount of pre-intervention observations; here, by beginning analysis in 1990, there is a reasonable amount of pre-intervention points available<sup>18</sup>. Lastly, there must be no alternative factor causing changes in the outcome. By taking non-legalization legislation (such as SB 1449 and Prop 47) into account, as well as controlling for population in California, spuriousness can be minimized. There is also no other known legislation or extraneous event occurring in 2016 (the year that the intervention takes place) that would affect crime and arrest data.

A typical time-series analysis uses the following model:

$$Y_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 T X_t$$

Here, T = the time that has passed since the beginning of the study, coded in the same frequency with which observations are taken.  $\beta_0$  represents the independent variable at T= 0,  $\beta_1$  shows the increase associated with a unit increase in T (the underlying pre-intervention trend),  $\beta_2$  represents a level or “step” change following the intervention, and  $\beta_3$  represents a slope change following the intervention (Bernal et. al, 2017). As mentioned previously in this section, the model may be simplified according to the predicted outcome.

For this analysis, a negative binomial regression was used. Time series analysis requires the use of maximum likelihood estimation when outcomes are not normal. Preliminary analysis of the data shows that, similar to much count data (Bernal et. al, 2017), normality is absent. Corsaro recommends use of a Poisson or negative binomial regression in these instances. In this

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<sup>18</sup> Corsaro states that a “rule of thumb” is 40-60 total observations.

case, a negative binomial regression is preferable to address an issue commonly occurring in count data in that the current data does not fit a Poisson distribution; the variance is not equal to the mean (Ford, 2016), and use of a Poisson regression would result in a poorly fitted model.

When performing time-series analysis, both seasonality and stationarity of the data must be addressed. Seasonality refers to seasonal variations in data; for example, crime rates increasing in warmer summer months and decreasing during the winter (Lauritsen, 2014). Given that the data is available in yearly counts, seasonality is not an issue; visual inspection of the data confirms this, and additional statistical verification can be performed if deemed necessary<sup>19</sup>. Stationarity refers to mean and variance stability. A visual inspection of the data clearly shows that stationarity must be accounted for, which was addressed through the addition of a trend variable in the later stages of model development (Corsaro, 2018).

The Huber-White sandwich estimator is a method of adjusting the standard errors for lack of consistent variance across observations (non-normality among the residuals) leading to heteroscedastic-consistent errors. This estimator was used in the present analysis as well; Slocum et. al (2019) utilized the Huber-White sandwich estimator when analyzing police count data over time, a similar analysis to the one at hand.

The use of time-series design for this research question is potentially problematic, as there are only 2 observations for the post-intervention period, although Corsaro states that typically there are far fewer observations available for the post-period in a time-series analysis, and Bernal et. al (2017) believe it is rarely practical for pre- and post-intervention observations to be equal in number. As with most statistical analysis, exogenous variables remain potentially

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<sup>19</sup> Accounting for seasonality by adding a “seasonal” variable into the model had no effect when analysis was performed, verifying that the data does not display seasonal variation.

problematic in time-series analysis. These may be identified and included within the model; population has been accounted for in the proposed model, as well as exogenous interventions (Prop 47, SB 1449). Other variables which are frequently included in criminological models include SES and racial composition. I omitted these variables from the model for the reason that the entire state is the unit of analysis, and inclusion of an SES variable across time would require adjustment for multiple extraneous factors such as inflation and the dynamics of the California economy. Also, as the state is the sole “case” and data is taken not across different groups but across different points in time, SES seems unnecessary to include.<sup>20</sup> Racial composition was excluded for the same reason; analysis of racial composition of California (as reported in the ACS and Census surveys) shows that the state has experienced relative racial proportion stability.

## RESULTS

The first step of analysis was visual examination of the time-series crime data. Underlying trends in national offending have been consistently moving downwards in the past several decades. Figures 2 through 13 present a series of graphs which show national arrest data sourced from the FBI UCR juxtaposed with arrests in California. There is no nationally available data for marijuana-specific arrests or misdemeanor drug arrests, therefore marijuana felony arrests, non-marijuana felony drug arrests, and misdemeanor drug arrests are not included.<sup>21</sup> DUI

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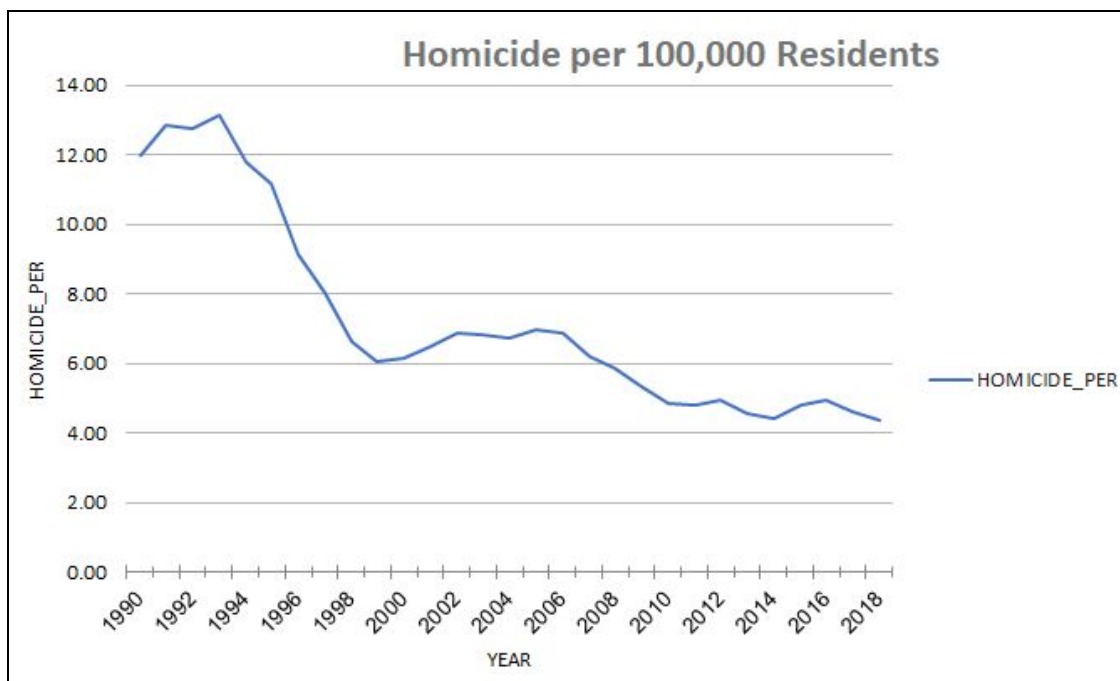
<sup>20</sup> If the state of California as a whole were to experience SES changes on a macroscopic scale across the periods of observation, SES would likely need to be included. A cursory visual analysis of California median income in the period of observation shows that this is not the case (Data USA, 2019). Alternately, if crime and arrest data was being examined county-to-county or city-to-city, SES would vary, and would likely contribute to variance in the dependent variables, and would thus require inclusion in the model. As this is not the case, neither SES nor racial composition are included in the model.

<sup>21</sup> There is information regarding marijuana arrests and other drug arrests by year but they are not separable by felony or misdemeanor.

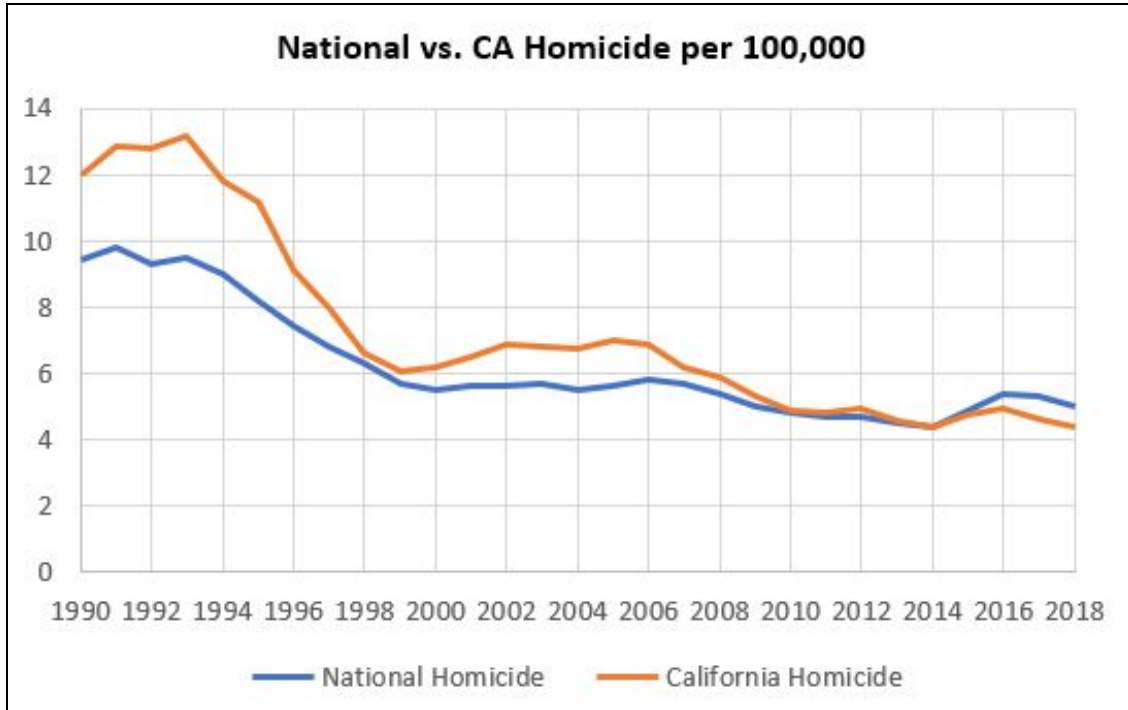
arrest data is only available from 1995 onwards. Juxtaposition of the California and national offense data helps to determine whether changes in offending in California are unique to the state and attributable to changes in legislation, or whether they follow national patterns.

Homicide (Figure 2) counts are seen to decrease greatly since the beginning of the observation period, with some variation throughout. Homicide is on an incline from the year 2015 through 2016, and declines in 2017 and 2018, the years in which recreational marijuana is legal. As mentioned prior, crime has generally been decreasing in the United States during the period of observation. Figure 2a displays homicide in California juxtaposed with homicide counts for the entire United States. National homicide counts are seen to follow a very similar trend to that of California. In 2014. National counts increase at a rate even greater than that of California. Similar to California, they also decline in 2017 and 2018, at a lower rate than in California.

**Figure 2. Homicide per 100,000 Residents, California**



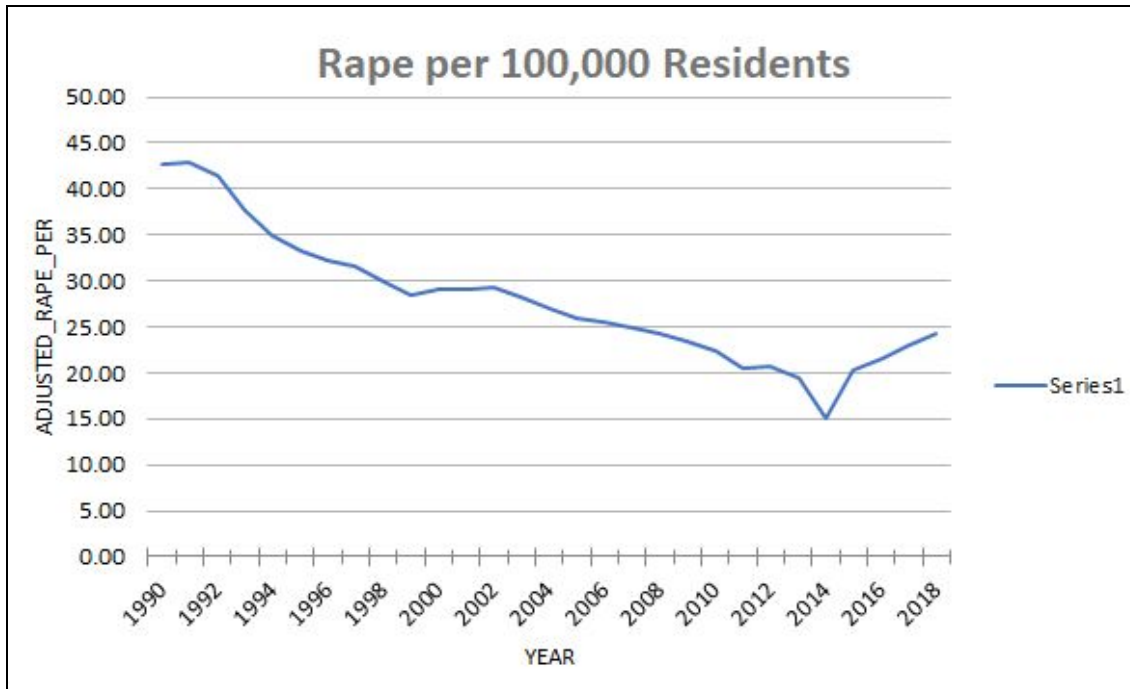
**Figure 2a. National vs CA Homicide**



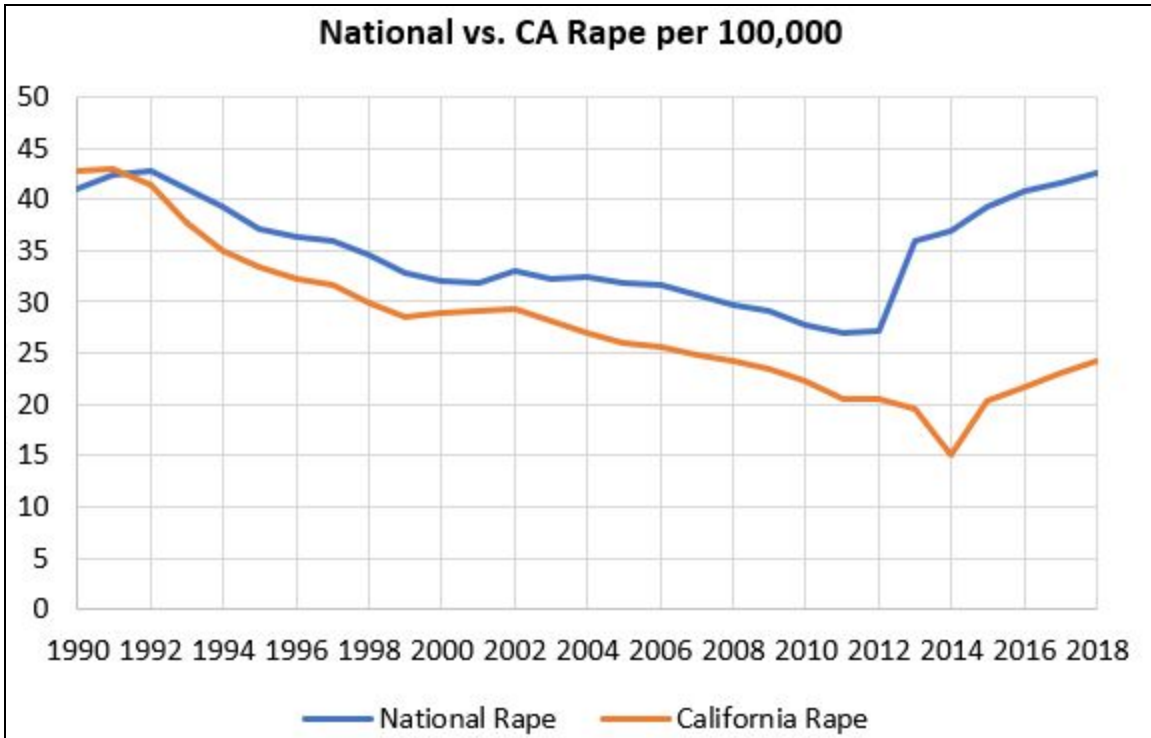
Rape (Figure 3) declines until the year 2015, after which counts increase through 2018. The slope of the increase is virtually unchanged in 2017 and 2018 compared to 2016, and is a less steep slope than from 2015-2016. In Figure 3a, it is evident that national and California patterns are similar. There is a large jump in national counts from 2012-2013 due to the FBI revising their definition of rape to include more circumstances. National rape counts follow the California trend of increasing in 2014 through 2018.



**Figure 3. Rape per 100,000 Residents, California**

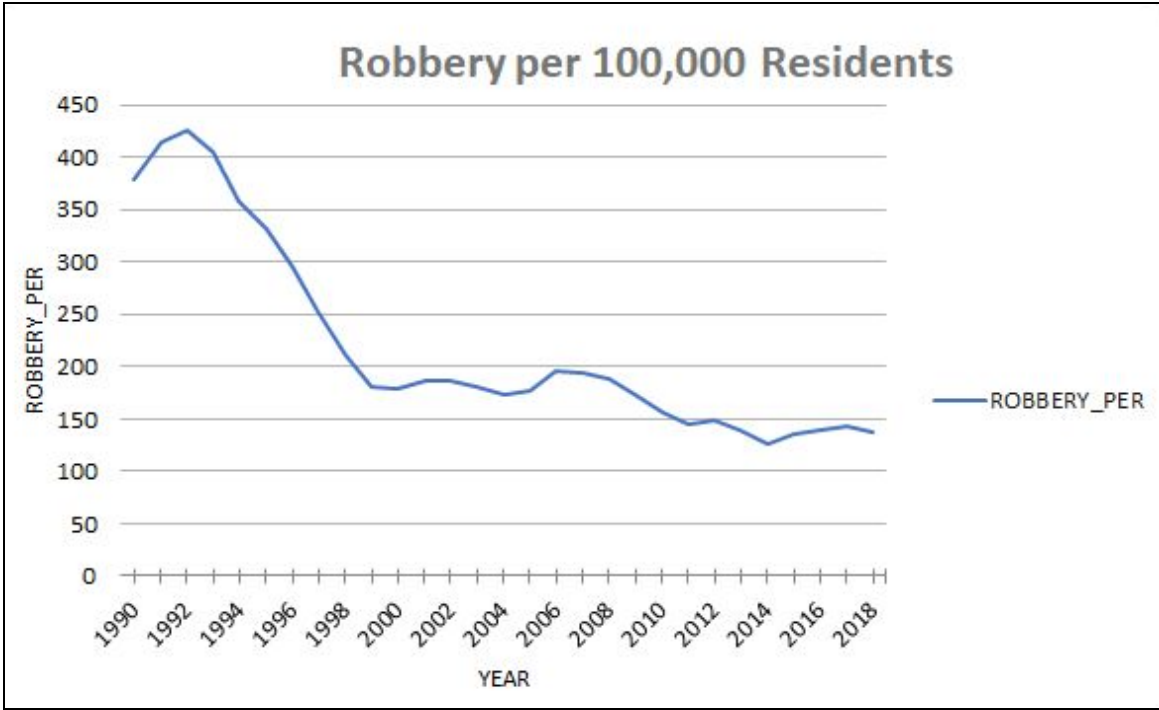


**Figure 3a. National vs CA Rape**

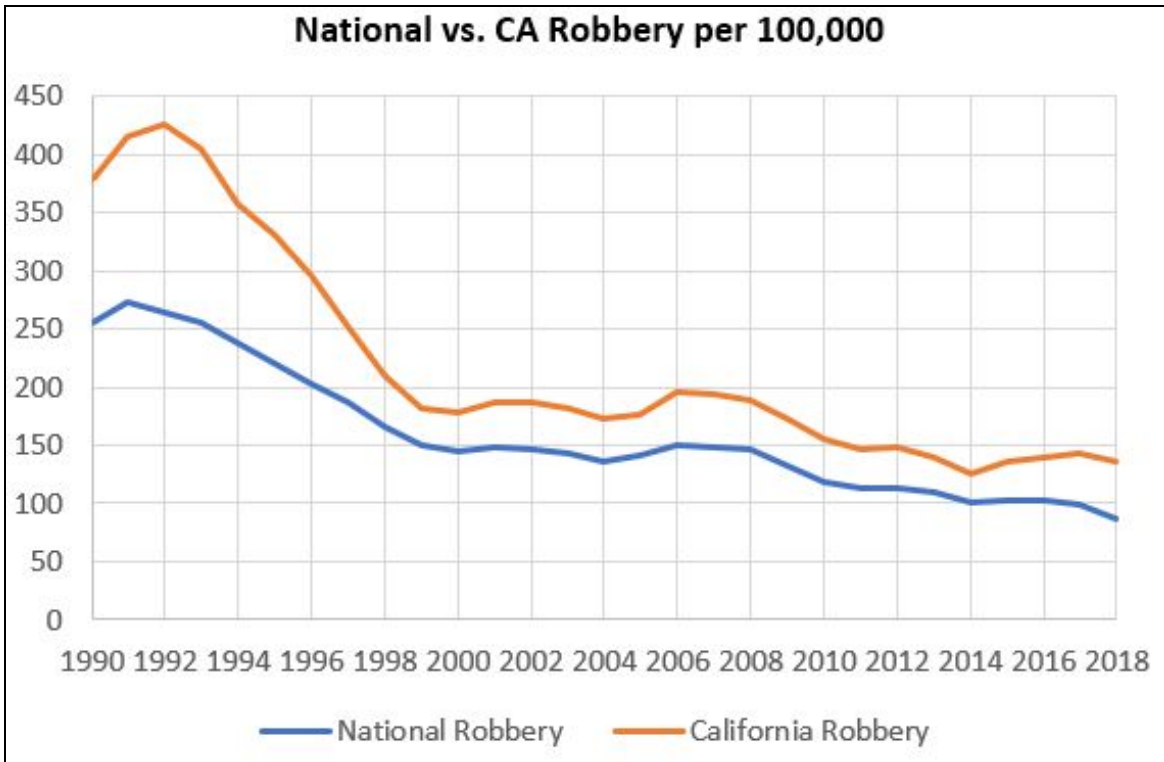


Robbery (Figure 4) also faces a general decline from 1990. The data levels out between 2013-2018 and is roughly at the same level during these years. There is a slight decline from 2017-2018. The national robbery trends are similar to those in California, although the curve is flattened somewhat and changes in robbery show less rapid increases and decreases. It is worth noting that California consistently displays higher levels of robbery per capita.

**Figure 4. Robbery per 100,000 Residents, California**

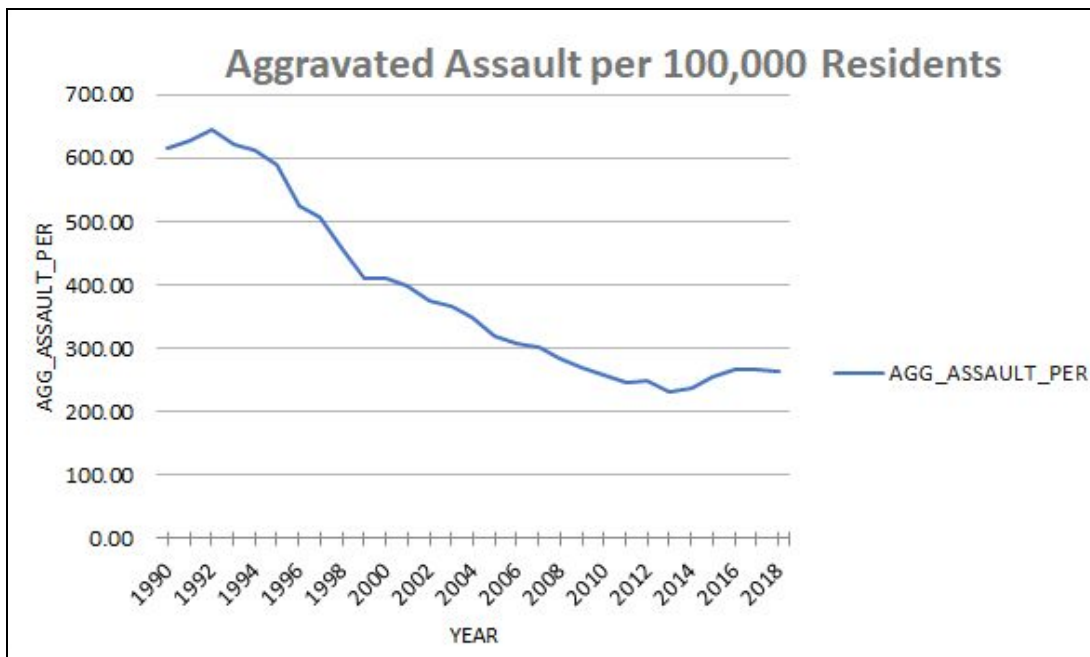


**Figure 4a. National vs California Robbery**

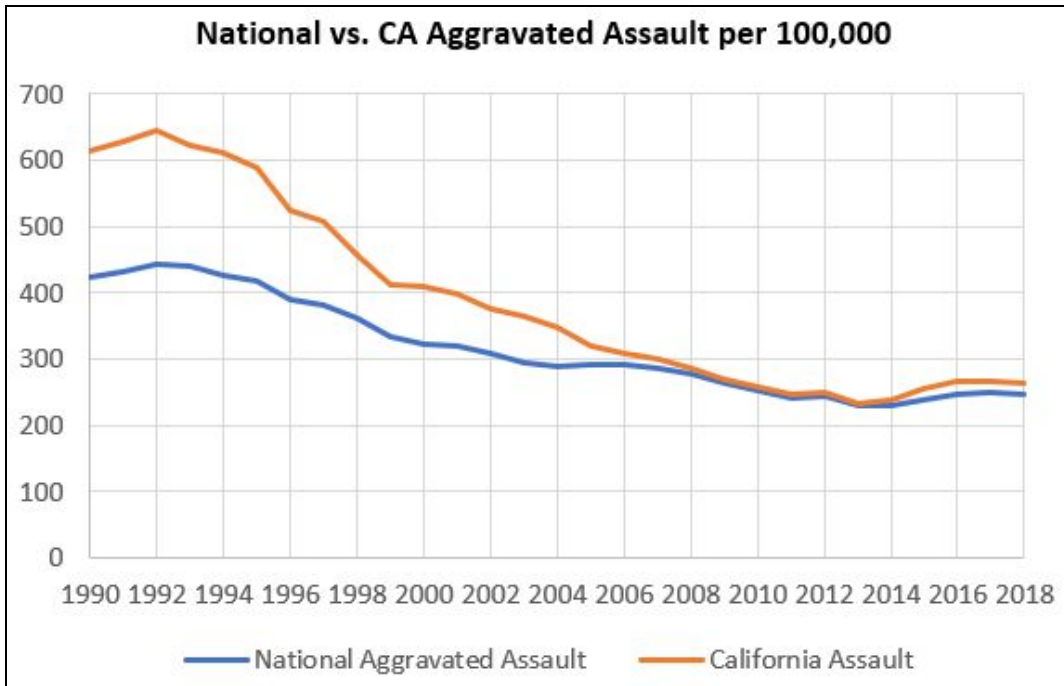


Aggravated assault (Figure 5) consistently decreases until 2013, after which it gradually increases until leveling out from 2016-2018. National aggravated assault trends mirror those of California almost exactly.

**Figure 5. Aggravated Assault per 100,000 Residents**



**Figure 5a. National vs CA Aggravated Assault**



Burglary (Figure 6) declines fairly consistently throughout the entire period of observation. The slope of the data is virtually unchanged from the years 2014-2018. The California trend is extremely similar to national burglary counts.

**Figure 6. Burglary per 100,000 Residents, California**

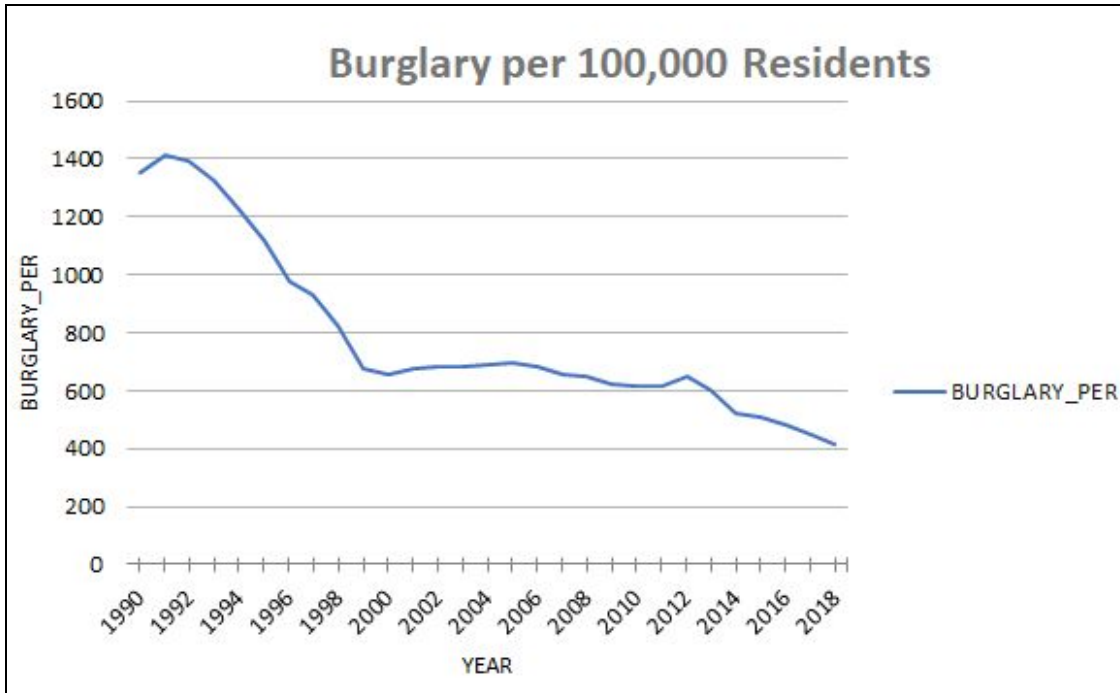
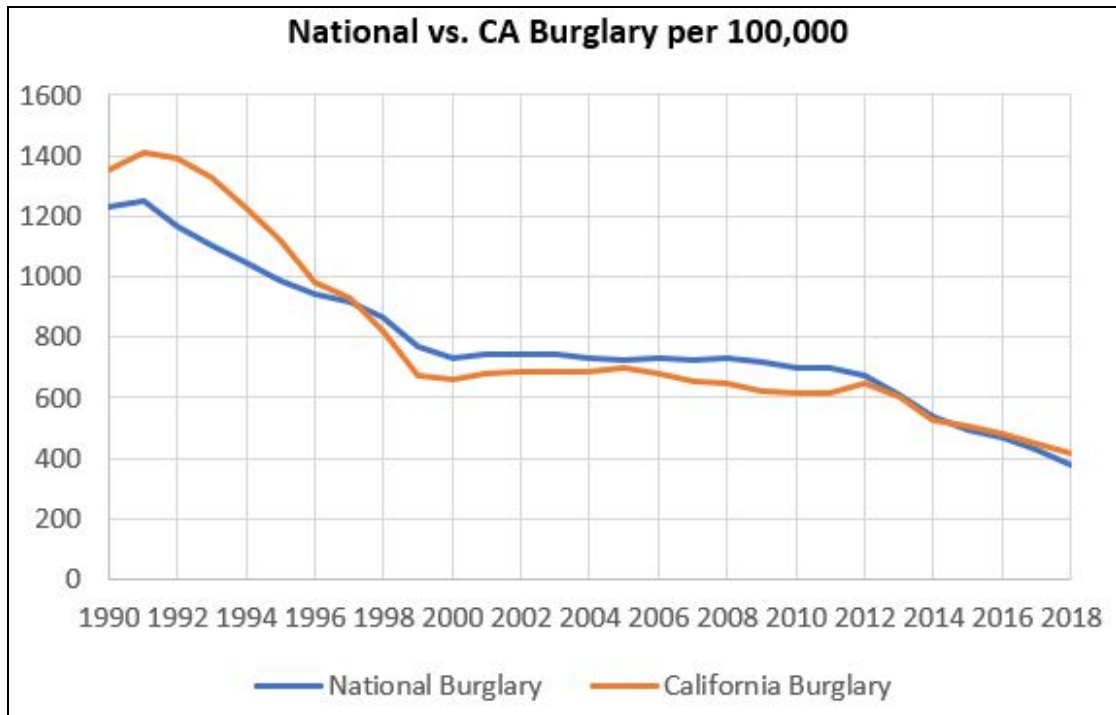


Figure 6a. National vs CA Burglary

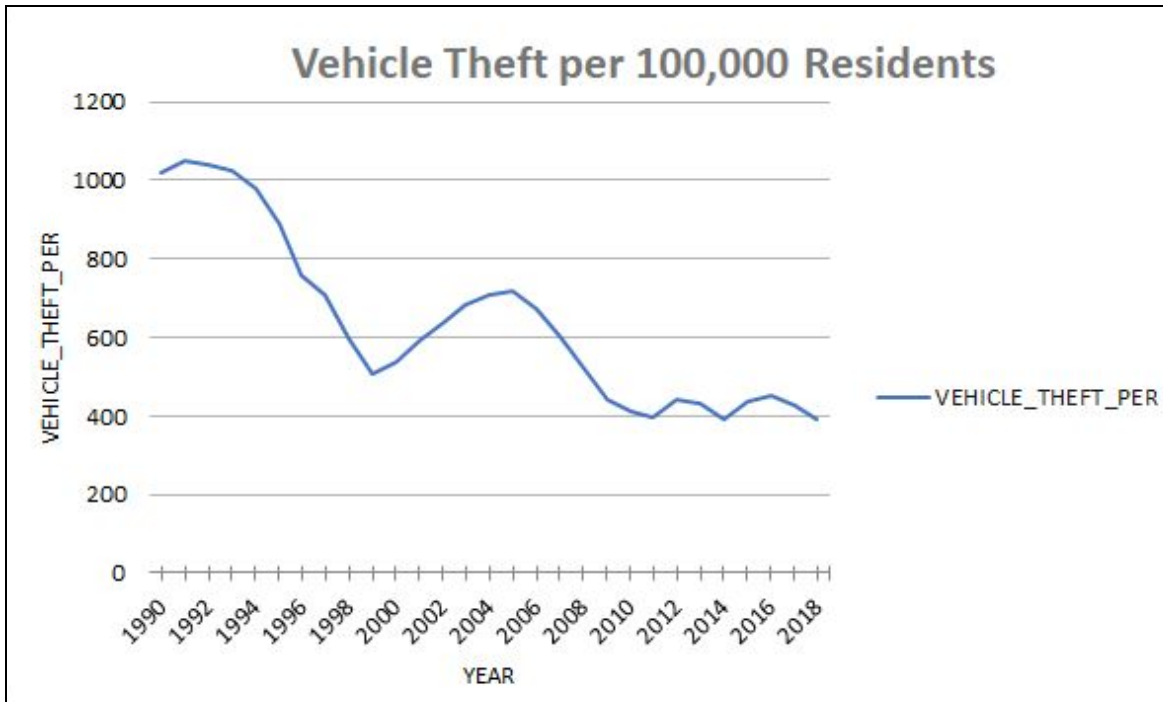


Vehicle thefts (Figure 7) declined overall from 1990, but with much greater variation.

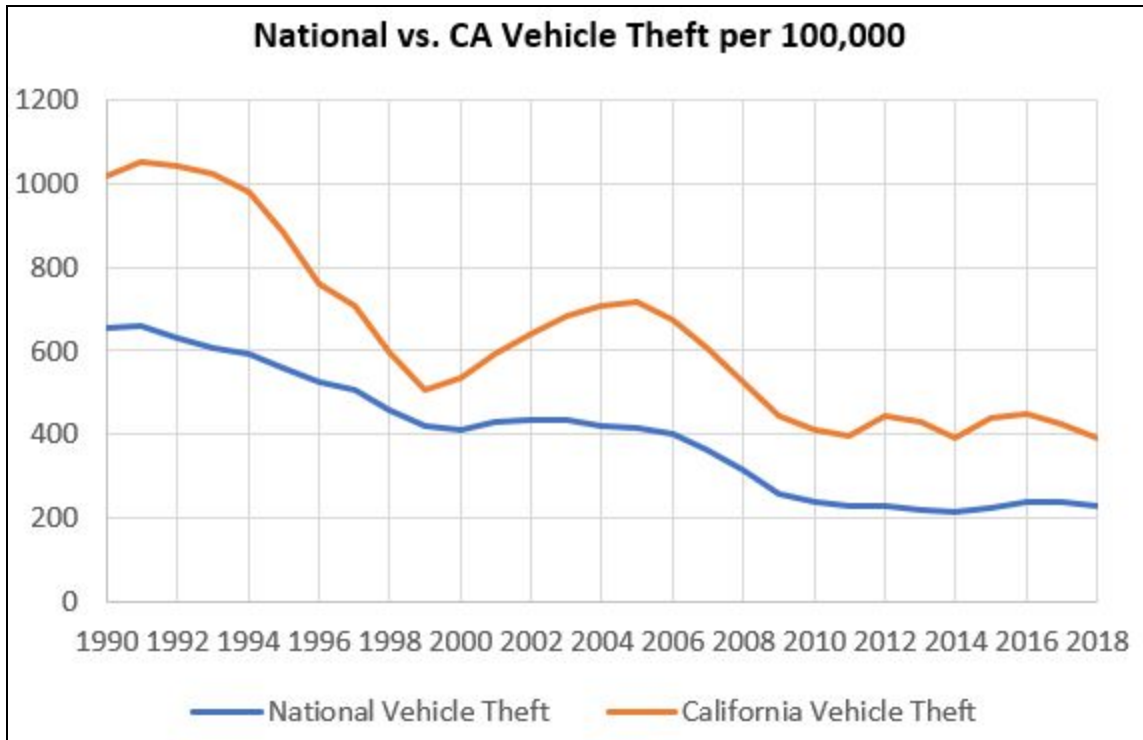
There is a peak in the year 2005, after which a decline occurs until 2011. From 2011-2018, the

data oscillates slightly, with declines occurring from 2016-2018. National vehicle theft counts display less oscillation overall. National counts also show an uptick in 2014, and similar to California, decrease gradually from 2016-2018.

**Figure 7. Vehicle Theft per 100,000 Residents, California**



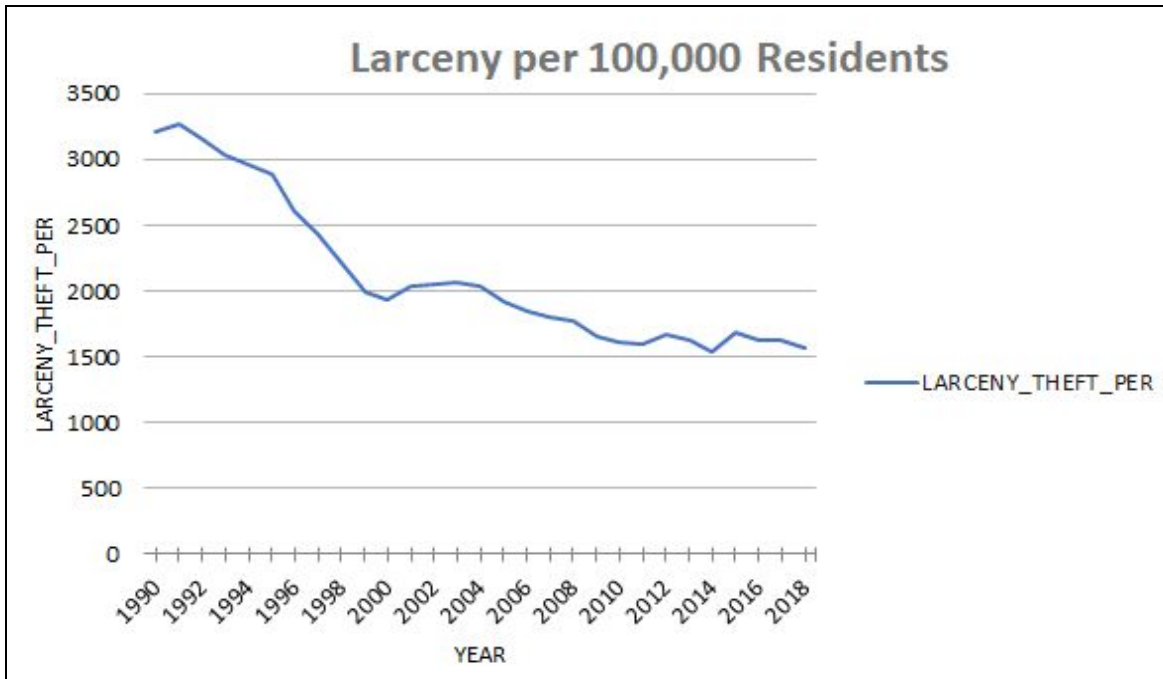
**Figure 7a. National vs California Vehicle Theft**



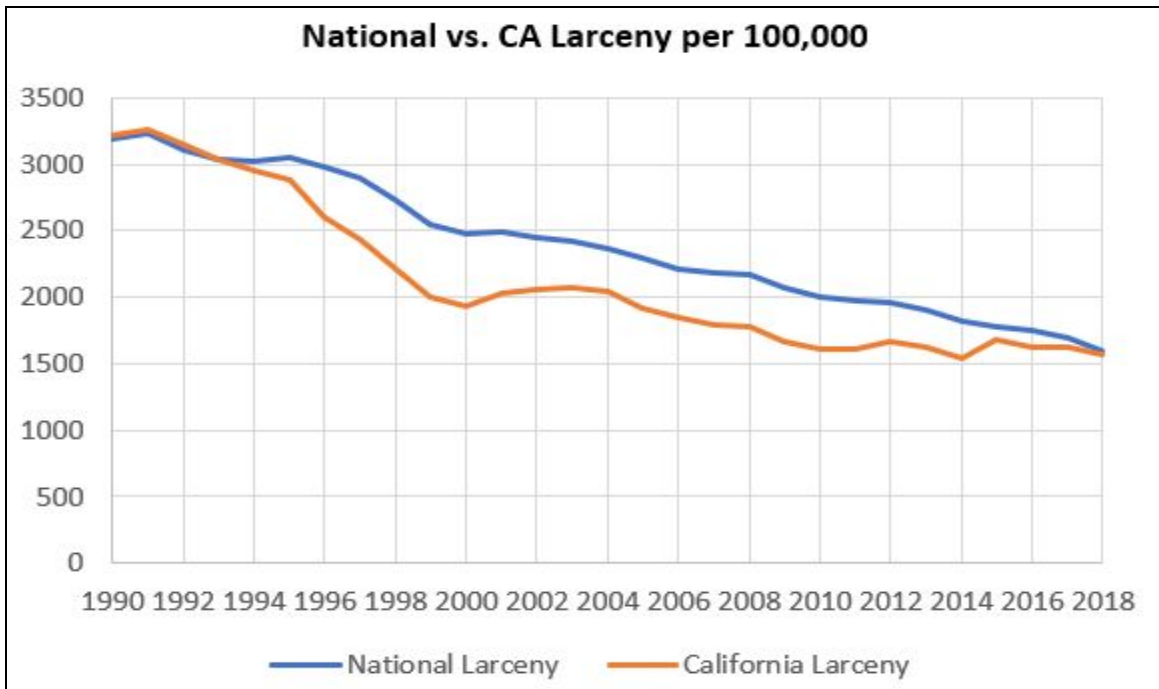
Larceny (Figure 8) decreases overall. There is a slight increase from 2014-2015, followed by a gradual decline through 2018. Unlike California, national larceny counts do not increase from 2014-2015, but decline consistently from 1990-2018.



**Figure 8. Larceny per 100,000 Residents, California**

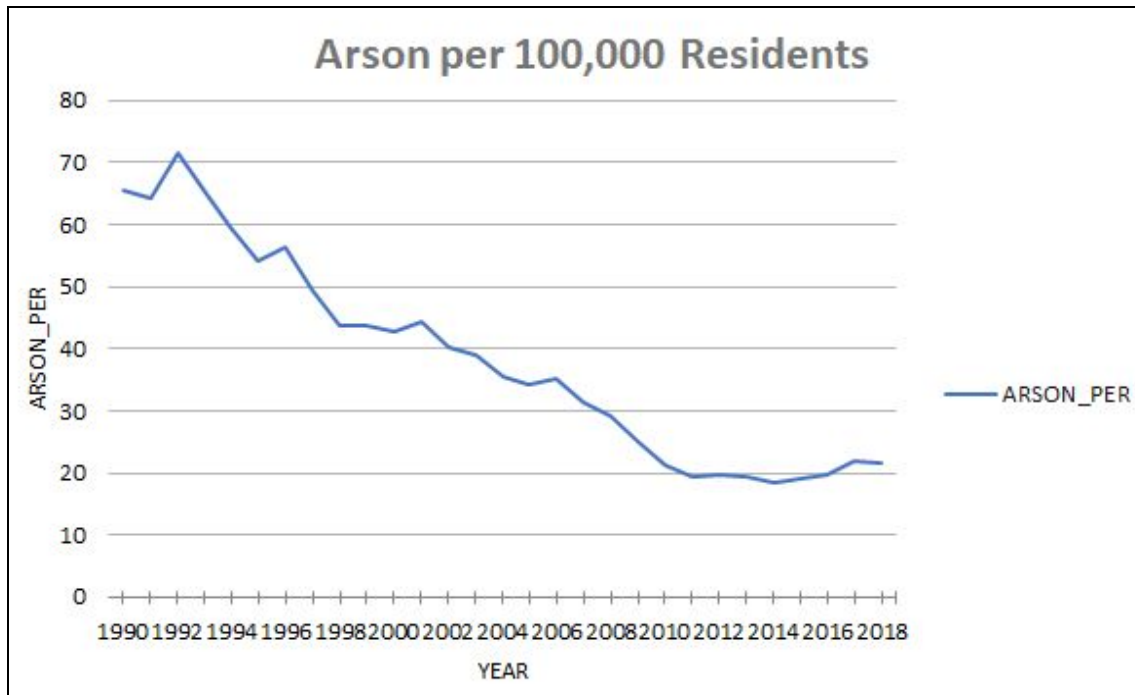


**Figure 8a. National vs CA Larcen**

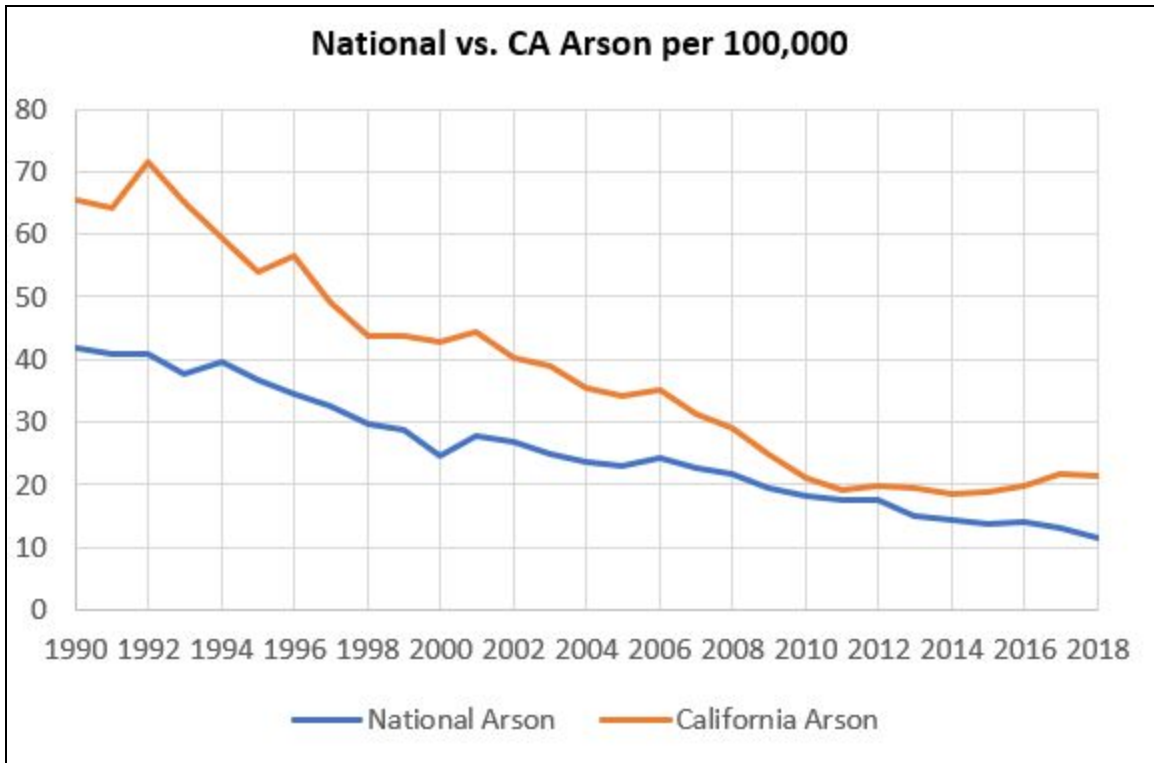


Arson (Figure 9) trends downwards until beginning a shallow incline from 2014 through 2018. Arson counts in California gradually decrease 2017-2018. National arson counts have a slight uptick from 2014-2015, but contrary to California, decrease from 2016-2018.

**Figure 9. Arson per 100,000 Residents, California**

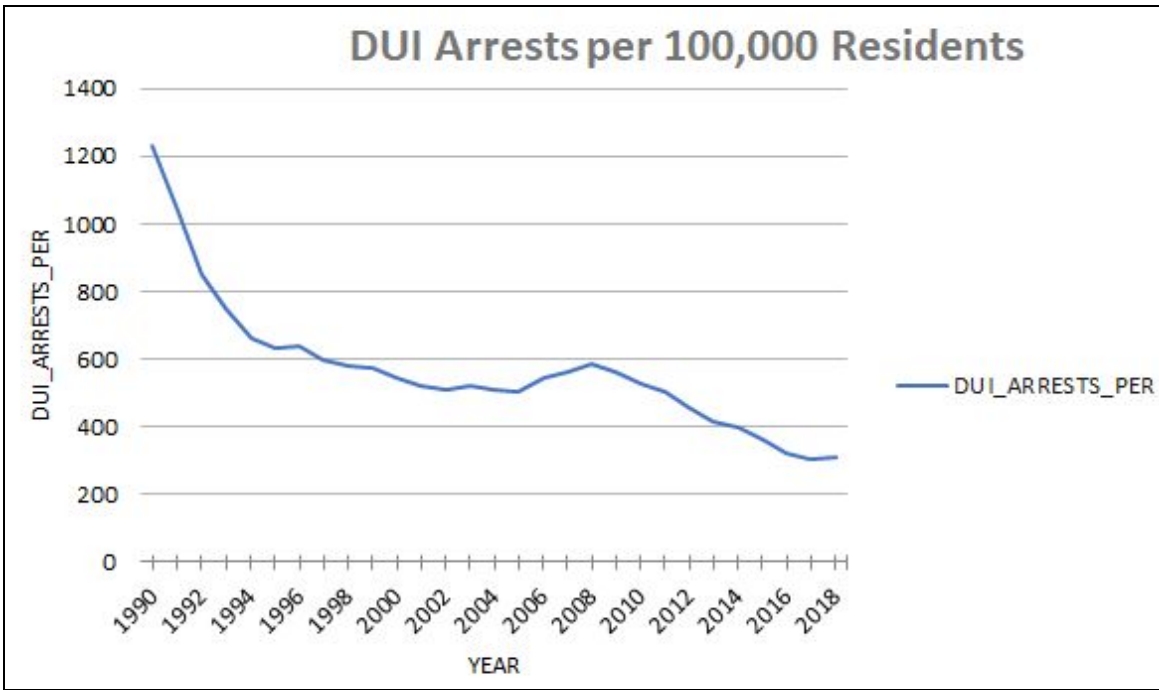


**Figure 9a. National vs CA Arson**

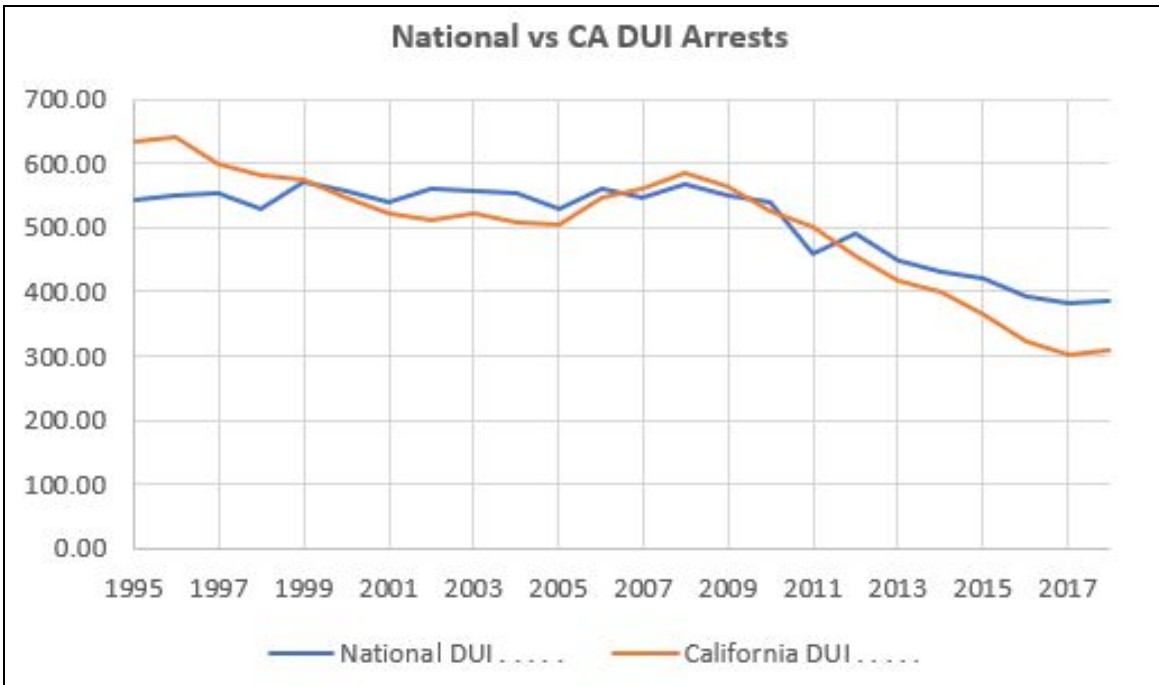


Similar to the UCR offenses, DUI (Figure 10) arrests drop considerably throughout the observation period. There is a slight increase from 2005 to 2008, followed by a decrease until 2017. There is a very slight increase from 2017 to 2018 (roughly 9 more DUI arrests per 100,000 residents.) National trends also reflect a decrease from 2012-2017, until a slight uptick in 2018.

**Figure 10. DUI Arrests per 100,000 Residents, California**

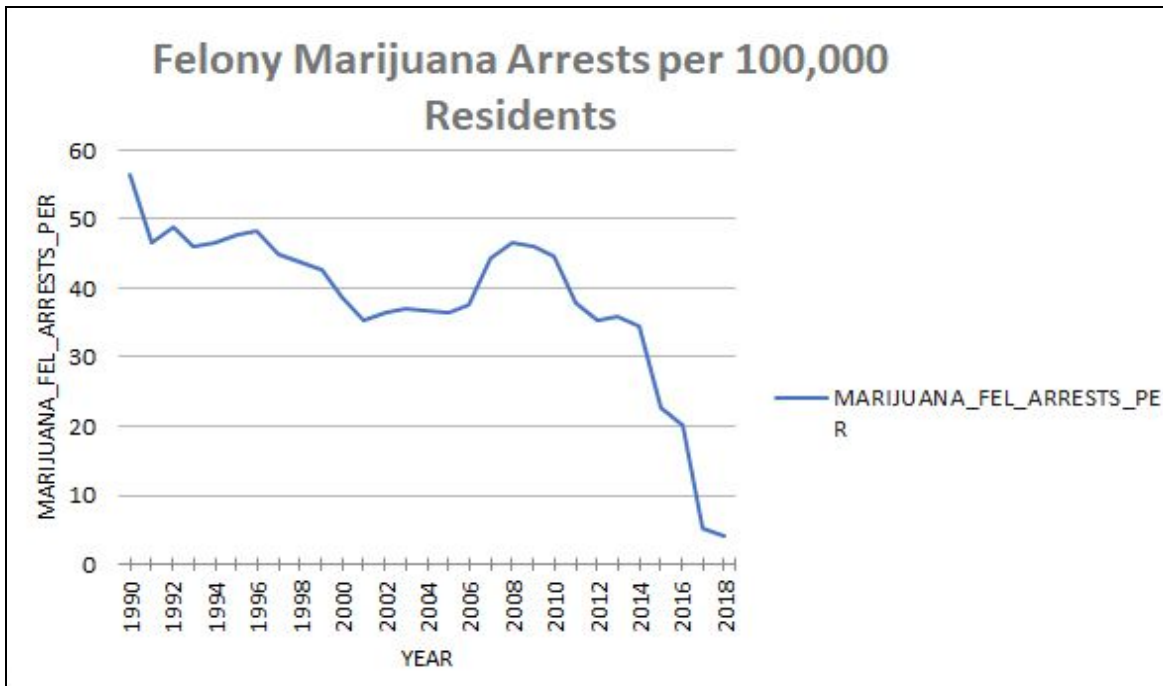


**Figure 10a. National vs California DUI Arrests**



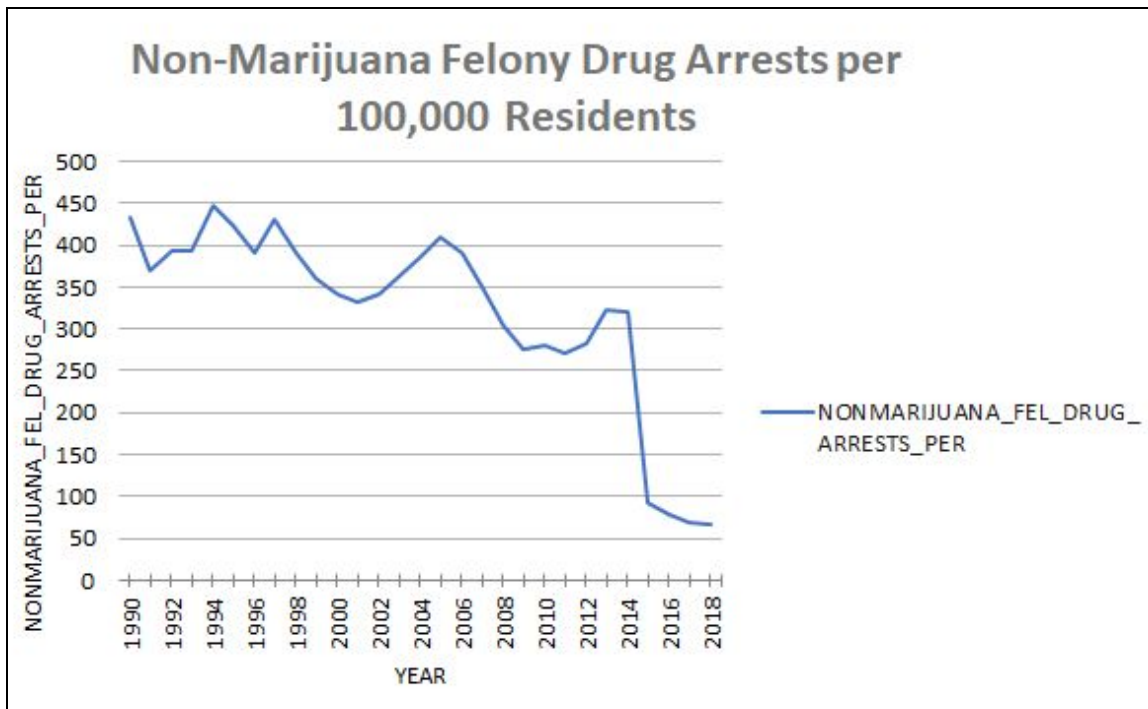
Felony marijuana arrests (Figure 10) declined greatly from 1990 to 2001 until peaking in 2008. Between 2008-2018, arrests go from 48 per 100,000 to 4 in 2018. This is consistent with the passing of SB-1449 and Prop 47, which both reduced many marijuana offenses from felonies to misdemeanors.

**Figure 11. Felony Marijuana Arrests per 100,000 Residents, California**



Non-marijuana felony arrests (Figure 12) gradually declined from 1990 to 2011, with significant oscillation throughout. Arrests were at a local peak in 2013 before steeply declining from 2014-2016 with the passing of Prop 47. Declines continued gradually through 2018. Passage of SB 1449 in 2010 does not immediately appear to affect non-marijuana felony drug arrests.

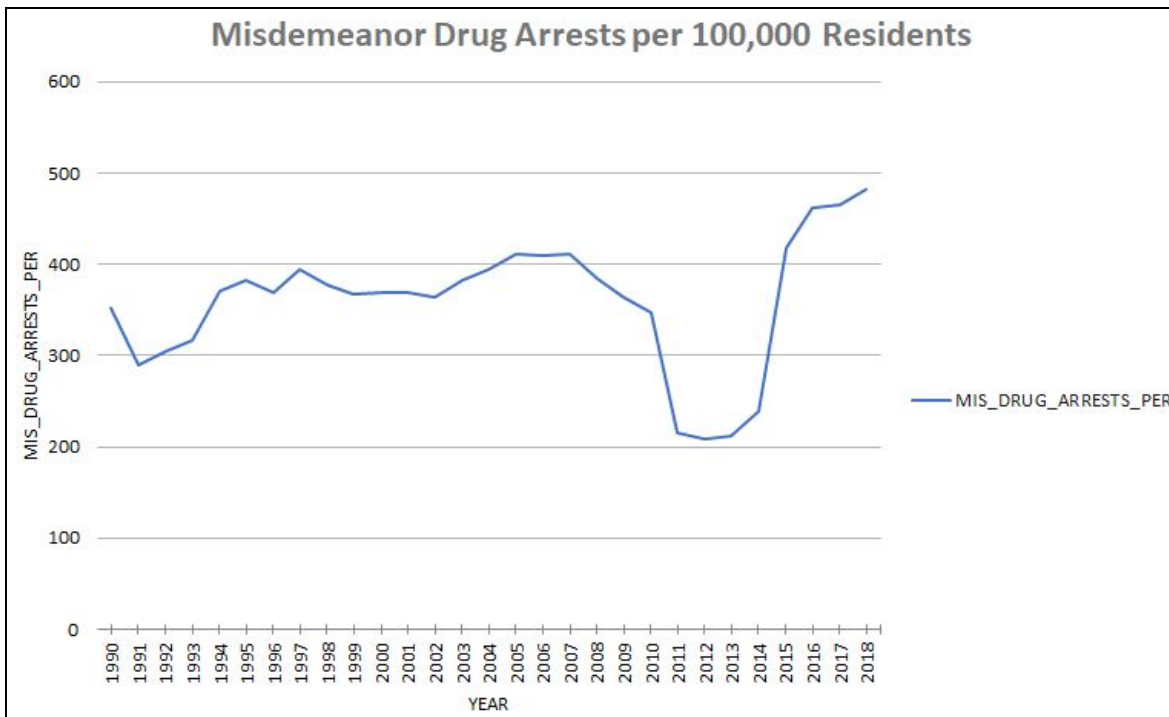
**Figure 12. Non-Marijuana Felony Drug Arrests per 100,000 Residents**



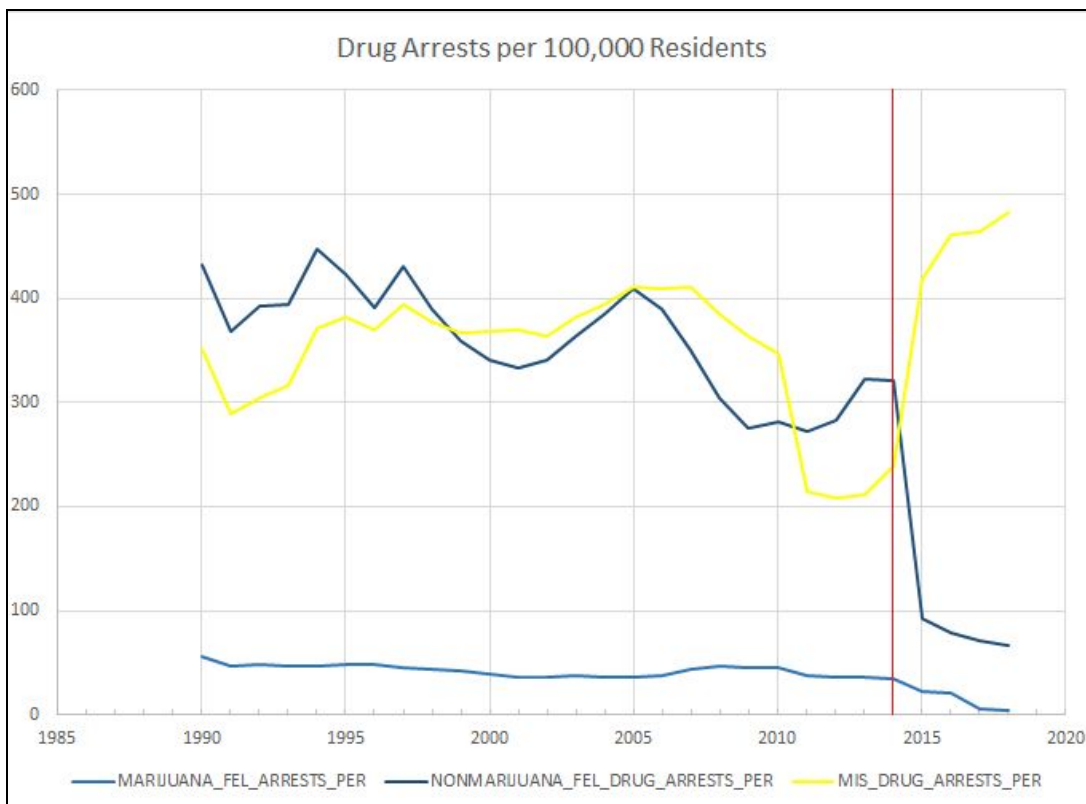
Misdemeanor drug arrests (Figure 13) contrary to other offense data, gradually increased from the years 1990-2007, before sharply dropping 2007-2012 to the lowest levels throughout the entire period of observation. Arrests then sharply rose through 2018. This is consistent with my hypothesis that misdemeanor drug arrests, relatively minor offenses, would likely increase. The sharpest increase occurs between 2014-2016--the years in which Prop 47 took effect. I

hypothesize that the arrests which had previously been classified as felonies were recategorized as misdemeanors, which is reflected by sharp decreases in felony arrests and corresponding increases in misdemeanor arrests. This is displayed for clarity in Figure 13. The vertical red line represents the passage of Prop 47.

**Figure 13. Misdemeanor Drug Arrests per 100,000 Residents, California**



**Figure 14. Drug Arrests per 100,000 Residents**



Descriptive statistics (Table 1) were calculated, as well as t-scores for pre- and post-legalization. For all comparisons other than misdemeanor drug arrests, the mean number of yearly offenses was significantly lower after legalization. The descriptive statistics suggest that the legalization of marijuana correlated to fewer offenses, with the exception of misdemeanor drug offenses. Visual examination of homicide, robbery, aggravated assault, burglary, vehicle theft, larceny, arson, marijuana felony arrests and non-marijuana felony drug arrests also appear to decrease post-legalization, while rape and misdemeanor drug arrests appear to increase post-legalization.



**Table 1. Comparison of Crime Count Data Before and After Legalization**

	Pre-Legalization		Post-Legalization		t- score
	Mean	SD	Mean	SD	
Homicide	7.45	2.86	4.5	0.18	5.22***
Rape	28.24	7.24	23.64	0.77	3.07***
Robbery	225.15	95.25	139.92	4.61	4.58***
Aggravated Assault	397.61	143.91	265.79	1.1	4.76***
Burglarly	811.99	292.23	430.4	23.15	6.51***
Vehicle Theft	654.23	218.76	408.1	24.95	5.39***
Larceny	2156.21	566.58	1593.34	42.39	4.98***
Arson	39.51	16.74	21.66	0.31	5.52***
DUI Arrests	589.41	193.11	306.01	5.84	7.58***
Marijuana Felony Arrests	40.7	7.82	4.67	0.85	22.22***
Non-Marijuana Felony Drug Arrests	339.74	88.65	68.91	2.23	15.81***
Misdemeanor Drug Arrests	351.19	66.51	473.45	12.65	-7.83***

Abbreviations: SD = Standard Deviation

Note: \*\*\* $p \leq .001$ . Two-sample t-test with unequal variances comparing crime counts per year before and after legalization,  $df = 8$

Changes in offending have been drastic since the start of the period of observation. Table 2 displays the percent change in offending from 1990 to 2016, the year before legalization occurred in California. It is evident that on a national scale, offending has dropped significantly since 1990. Figure 2a shows changes in offending for California. California also displays significant decreases in offending from 1990-2016.

**Figure 2. Percent Change in Offenses, National 1990-2016**

	National									
	Homicide	Rape	Robbery	Agg. Assault	Burglary	Vehicle Theft	Larceny	Arson	DUI	
1990	9.4	41.1	256.3	422.9	1232.2	655.8	3185.1	41.7	541.8	
2016	5.4	40.9	102.9	248.3	468.9	237.3	1745.4	14.2	391.4	
Percent Change	-42.6%	-0.5%	-59.9%	-41.3%	-61.9%	-63.8%	-45.2%	-65.9%	-27.8%	

**Figure 2a. Percent Change in Offenses, California 1990-2016**

		California												
		Homicide	Rape	Robbery	Agg. Assault	Burglary	Vehicle Theft	Larceny	Arson	DUI	Marijuana Fel.	NonMar. Fel. Drug	Mis. Drug	
1990		12.0	42.7	377.9	615.6	1352.7	1018.9	3209.8	65.4	1233.0	57.0	433.0	352.0	
2016		4.9	21.7	139.7	266.0	479.8	450.5	1623.2	19.8	321.0	20.0	79.0	462.0	
Percent Change		-58.9%	-49.3%	-63.0%	-56.8%	-64.5%	-55.8%	-49.4%	-69.7%	-74.0%	-64.9%	-81.8%	31.3%	

In order to detangle changes in offending from pre to post marijuana legalization, percent change in offending from 2016 to 2018 is presented for national (Table 3) and California (Table 3a) counts. A comparison of percent changes shows that for all FBI Part I offenses with the exception of arson, both California and national offenses have decreased from a range of -.4% to -19.8%. California-specific offense data (drug arrest information) shows that felony drug arrests have decreased significantly, while misdemeanor drug arrests have increased by more than 80%. Compared to drug arrest differences from 2016-2018, the majority of the decrease in non-marijuana felony drug arrests occurred from 1990 as opposed to 2016 (-81.8% to -15.2%). Similarly, the increase in misdemeanor drug arrests (31.3%) from 1990 is far less from 2016 to 2018 (4.3%).

**Table 3. Percent Change in Offenses, National 2016-2018**

	National								
	Homicide	Rape	Robbery	Agg. Assault	Burglary	Vehicle Theft	Larceny	Arson	DUI
2016	5.4	40.9	102.9	248.3	468.9	237.3	1745.4	14.2	391.4
2018	5.0	42.6	86.2	246.8	376.0	228.9	1594.6	11.6	384.7
Percent Change	-7.4%	4.2%	-16.2%	-0.6%	-19.8%	-3.5%	-8.6%	-18.3%	-1.7%

**Figure 3a. Percent Change in Offenses, California 2016-2018**

		California											
		Homicide	Rape	Robbery	Agg. Assault	Burglary	Vehicle Theft	Larceny	Arson	DUI	Marijuana Fel.	NonMar. Fel. Drug	Mis. Drug
2016		4.9	21.7	139.7	266.0	479.8	450.5	1623.2	19.8	321.0	20.0	79.0	462.0
2018		4.4	24.2	136.7	265.0	414.0	390.5	1563.4	21.4	310.0	4.0	67.0	482.0
Percent Change		-11.1%	11.7%	-2.1%	-0.4%	-13.7%	-13.3%	-3.7%	8.3%	-3.4%	-80.0%	-15.2%	4.3%

National and California offense data shows frequent increases in offending post-2014. In order to assess this, Table 4 and Table 4a present percent changes in offenses of the mean value between 2012-2016 compared to the mean value for 2017-2018. Results show that national counts for homicide and vehicle theft have increased, while California counts have gone down. National robbery and arson counts have decreased, while California counts have increased. For all other FBI offenses, California and national levels have trended in parallel, with some variation in slope, ranging from most variation (difference of 9.7%) to least (2.9%).

**Table 4. Percent Change in Offenses, National 2012-2016 and 2017-2018**

	National								
	Homicide	Rape	Robbery	Agg. Assault	Burglary	Vehicle Theft	Larceny	Arson	DUI
Mean (2012-2016)	4.8	36.0	105.7	237.6	556.7	225.3	1843.6	15.0	435.9
Mean (2017-2018)	5.2	42.2	92.4	248.0	402.9	233.3	1645.1	12.4	383.0
Percent Change	7.7%	17.0%	-12.6%	4.4%	-27.6%	3.5%	-10.8%	-17.2%	-12.1%

**Table 4a. Percent Change in Offenses, California 2012-2016 and 2017-2018**

		California												
		Homicide	Rape	Robbery	Agg. Assault	Burglary	Vehicle Theft	Larceny	Arson	DUI	Marijuana Fel.	NonMar. Fel. Drug	Mis. Drug	
Mean (2012-2016)		4.7	19.4	138.0	247.7	552.5	431.4	1626.6	19.3	391.7	29.8	219.3	307.9	
Mean (2017-2018)		4.5	23.6	139.9	265.8	430.4	408.1	1593.3	21.7	306.0	4.5	68.9	473.4	
Percent Change		-4.6%	21.6%	1.4%	7.3%	-22.1%	-5.4%	-2.0%	12.3%	-21.9%	-84.9%	-68.6%	53.8%	

Further t-tests were performed between 2012-2016 and 2017-2018 in order to detangle changes in offending from underlying trends. Table 5 and 5a show the results for t-tests performed on the 5-year period preceding legalization to the 2 year post-legalization. Results suggest that changes in offending for national offenses were only significant for robbery and larceny. For California, only arson and marijuana felony arrest changes were significant. Other changes in offending are possibly only attributable to random variation or oscillation.

**Table 5. T-tests, 2012-2016 and 2017-2018, National**

	National				
	Pre-Legalization		Post-Legalization		t-score
	Mean	SD	Mean	SD	
Homicide	4.78	0.4	5.15	0.21	-1.21
Rape	36	5.4	42.4	0.64	-1.52
Robbery	105.7	5.1	92.4	8.8	2.64*
Aggravated Assault	237.6	3.717	248	1.7	-1.66
Burglary	556.7	83.9	402.9	38	2.39
Vehicle Theft	225.3	8.6	233.3	6.2	-1.17
Larceny	1843.6	89.4	1645.1	71.3	2.76*
Arson	15	1.5	12.4	1.1	2.12
DUI arrests	3589.5	312.4	3150.1	23.8	1.88

Note: \* =  $p \leq .05$ . \*\* =  $p \leq .01$ . \*\*\* =  $p \leq .001$ .

**Table 5a. T-tests, 2012-2016 and 2017-2018, California**

	California				
	Pre-Legalization		Post-Legalization		t-score
	Mean	SD	Mean	SD	
Homicide	4.72	0.24	4.5	0.18	1.14
Rape	19.4	2.6	23.6	0.77	-2.17
Robbery	138	8.3	140	4.61	-0.3
Aggravated Assault	247.7	13.6	265.8	1.1	-1.77
Burglary	552.5	70.5	430.4	23.15	2.28
Vehicle Theft	431.4	22.6	408.1	25	1.21
Larceny	1626.6	59.1	1593.3	42.4	0.71
Arson	19.3	0.58	21.7	0.31	-5.32*
DUI arrests	391.7	51.6	306	5.8	2.22
Marijuana Felony	29.8	7.6	4.7	0.85	4.41**
Non-marijuana Felony Drug	219.3	123.2	68.9	2.2	1.63
Misdemeanor Drug Arrests	307.9	122.3	473.4	12.7	-1.81

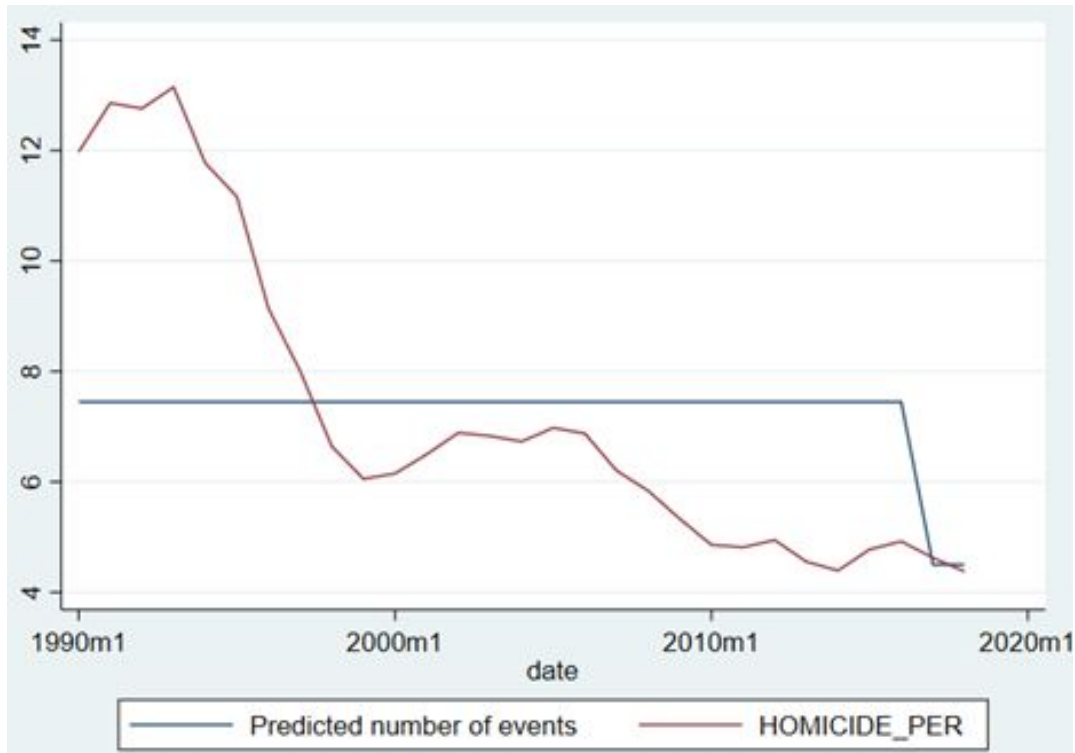
Note: \* =  $p \leq .05$ . \*\* =  $p \leq .01$ . \*\*\* =  $p \leq .001$ .

Interrupted time-series analysis was also performed in order to determine whether changes in offending were attributable to legalization, or merely due to existing trends. Initial model construction, where all change in homicide is attributed to legalization, is presented as an example<sup>22</sup> in figure 15. This negative binomial model displays the issue with disregarding underlying trends as well as external disruptions (Prop 47, SB-1449). Clearly, this is not an accurate model (pseudo  $R^2 = .018$ ). This model suggests that legalization of marijuana is strongly significant ( $p \leq 0.000$ ) and has a negative effect on homicide (coef. =  $-.504$  or roughly 60% impact).

<sup>22</sup>Stages of model construction are shown here in order to display the utility of time series analysis for count data such as this; full models only are provided for other dependent variables. Partial models are available in the supplementary data file that accompanies this document.



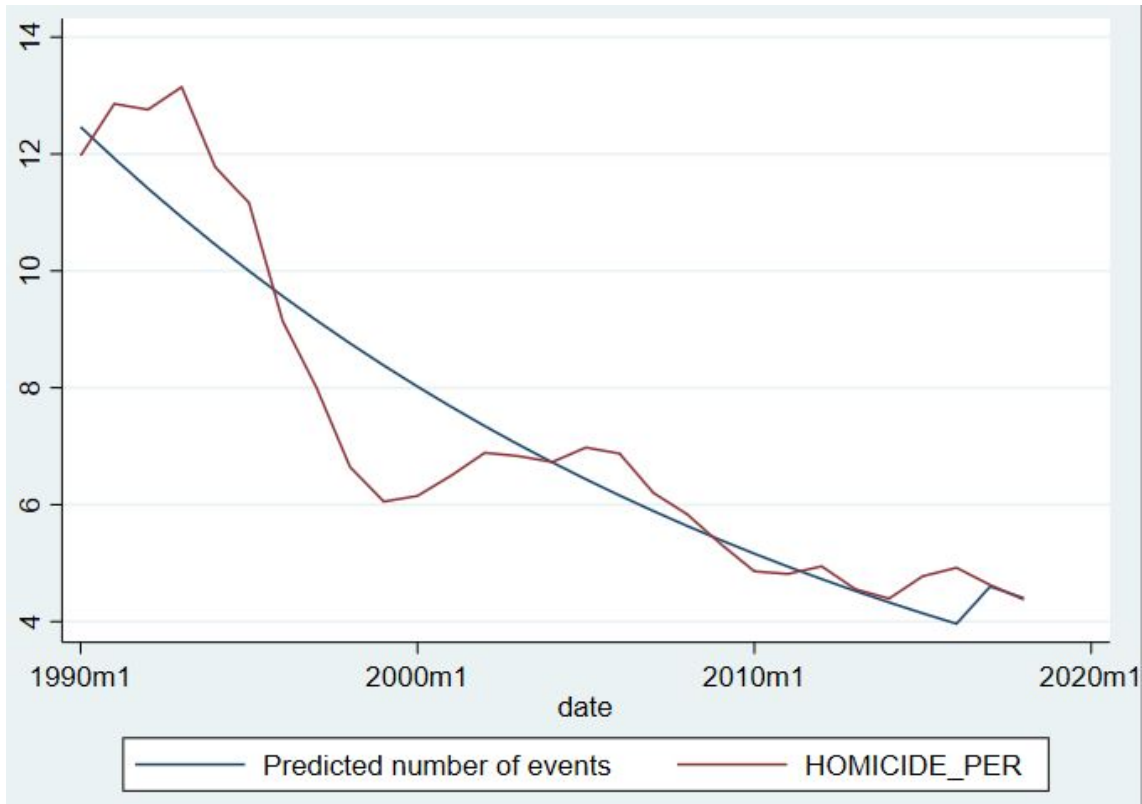
**Figure 15. Homicide Attributed only to Legalization**



	Coef.	Robust SE	$p \leq$
Legalization	-0.504	0.076	0
Pseudo-R <sup>2</sup>	0.0178		

Inclusion of a trend variable improves the model (Figure 16.) The trend variable is negative and strongly significant (coef. = -.044,  $p \leq 0.000$ ) while the effect of legalization is less powerful, positive, and still significant (coef. = .193,  $p \leq 0.000$ ). The model accuracy is also improved significantly (pseudo  $R^2 = .183$ ).

**Figure 16. Homicide Attributed to Legalization and the Existing Trend**

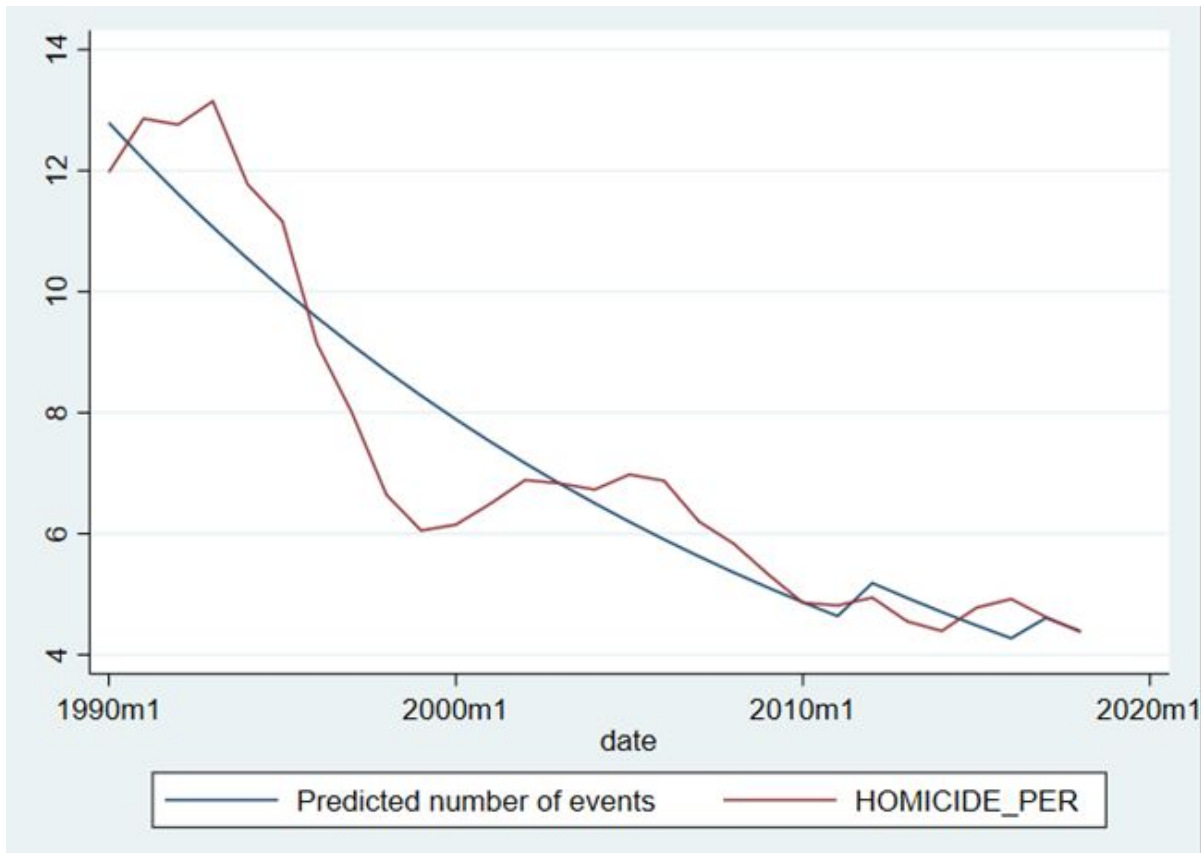


	Coef.	Robust SE	$p \leq$
Legalization	0.193	0.045	0
Trend	-0.044	0.003	0
Pseudo R <sup>2</sup>	0.183		

External disruptions should also be included whenever possible in order to increase the accuracy of the model, and to avoid attributing too much change in the dependent variable to the intervention. In this case, SB-1449 and Prop-47 were both considered to be important outside influences. Including these had significant impacts upon the model; legalization of marijuana was no longer seen to be significant (coef. = .023,  $p \leq .435$ ). The trend variable was still significant and negatively related to homicide (coef. = -.049,  $p \leq 0.000$ ) and SB-1449 (coef. = .099,  $p \leq 0.042$ ) as well as Prop-47 were both significant and positively related to homicide. The

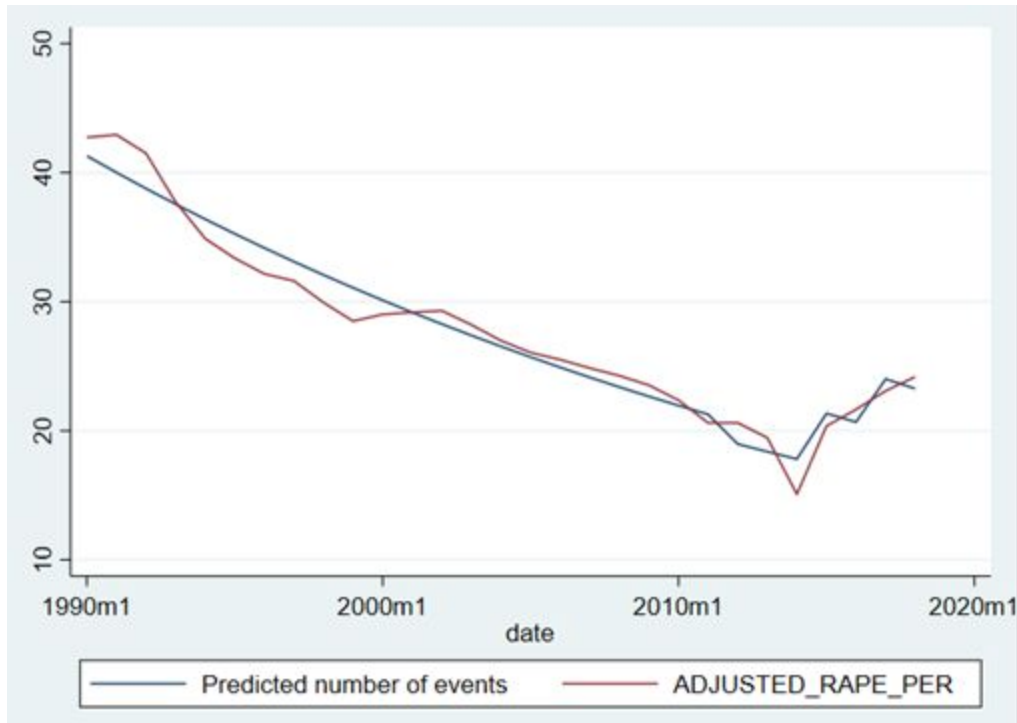
trend variable is responsible for roughly 4.75% of the variance, while SB-1449 and Prop 47 were 9.45% and 18.32%, respectively. The intervention (legalization of marijuana), SB-1449, and Prop-47 explain about 32.5% of all variance, and is an improvement upon previous models with a pseudo  $R^2$  value of .186. For this and all following models, a squared trend term was initially added, but was not found to be significant in any of the models, and was dropped. The same is true for inclusion of a slope-change term ( $\beta_3 TX_t$ ) and neither term was included.

**Figure 17. Homicide, Full MLE Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.023	0.029	0.435
Trend	-0.047	0.003	0
SB1449	0.099	0.049	0.042
Prop47	0.168	0.031	0
Pseudo $R^2$	0.186		

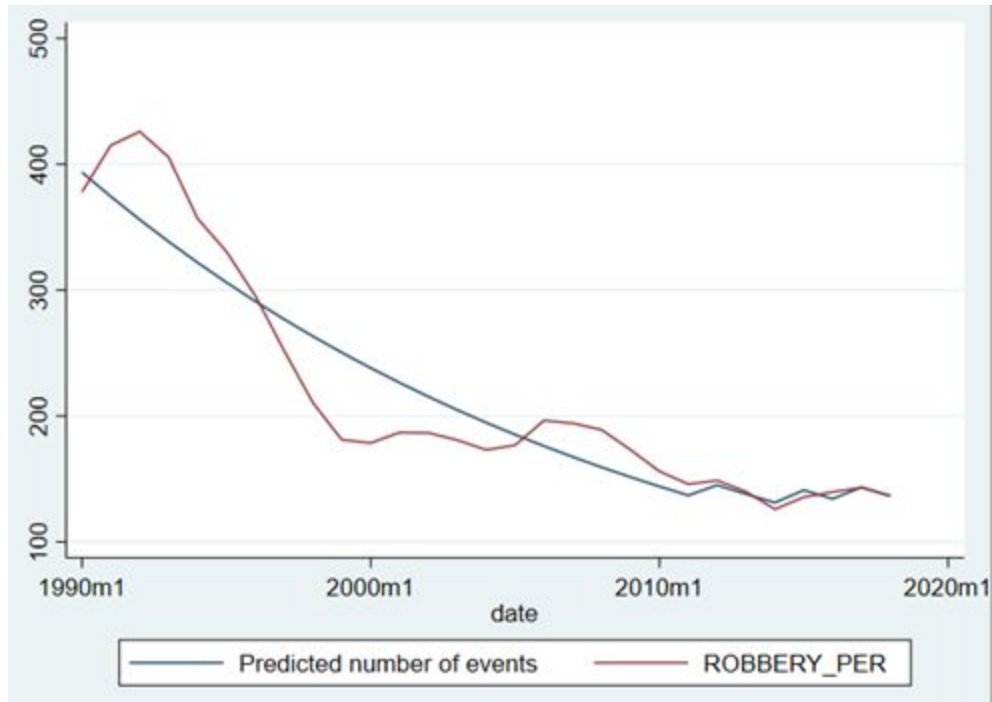
**Figure 18. Rape, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.181	0.044	0
Trend	-0.032	0.002	0
SB1449	-0.083	0.064	0.194
Prop47	0.212	0.071	0.003
Pseudo R <sup>2</sup>	0.216		

Using the MLE model to examine rape data shows legalization to be strongly significant ( $p \leq 0.000$ ) and positively related (coef. = .181). Prop-47 (coef. = .212,  $p \leq .003$ ) is also significant, and positively related to rape counts. SB1449 ( $p \leq .194$ ) is not significant. This model has a pseudo R<sup>2</sup> value of .216, and is reasonably close-fitting to the count data for the region of interest (2010-2018).

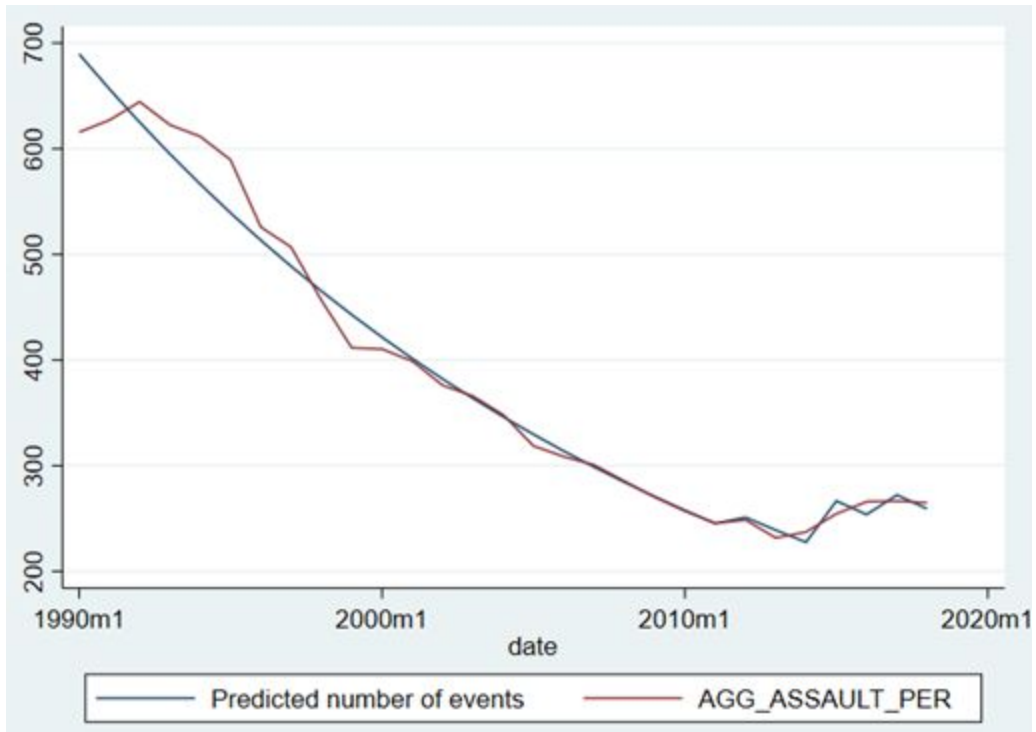
**Figure 19. Robbery, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.117	0.03	0
Trend	-0.05	0.004	0
SB1449	0.108	0.06	0.071
Prop47	0.123	0.035	0
Pseudo R <sup>2</sup>	0.184		

The model for robbery shows that legalization is positively correlated to robbery counts (coef. = .117,  $p \leq 0.000$ ). The same is true for Prop-47 (coef. = .123,  $p \leq 0.000$ ), although SB1449 is not significant at alpha = .05 ( $p \leq .071$ ). The trend variable is significant ( $p \leq 0.000$ ) and negatively related to robbery (coef. = -.05).

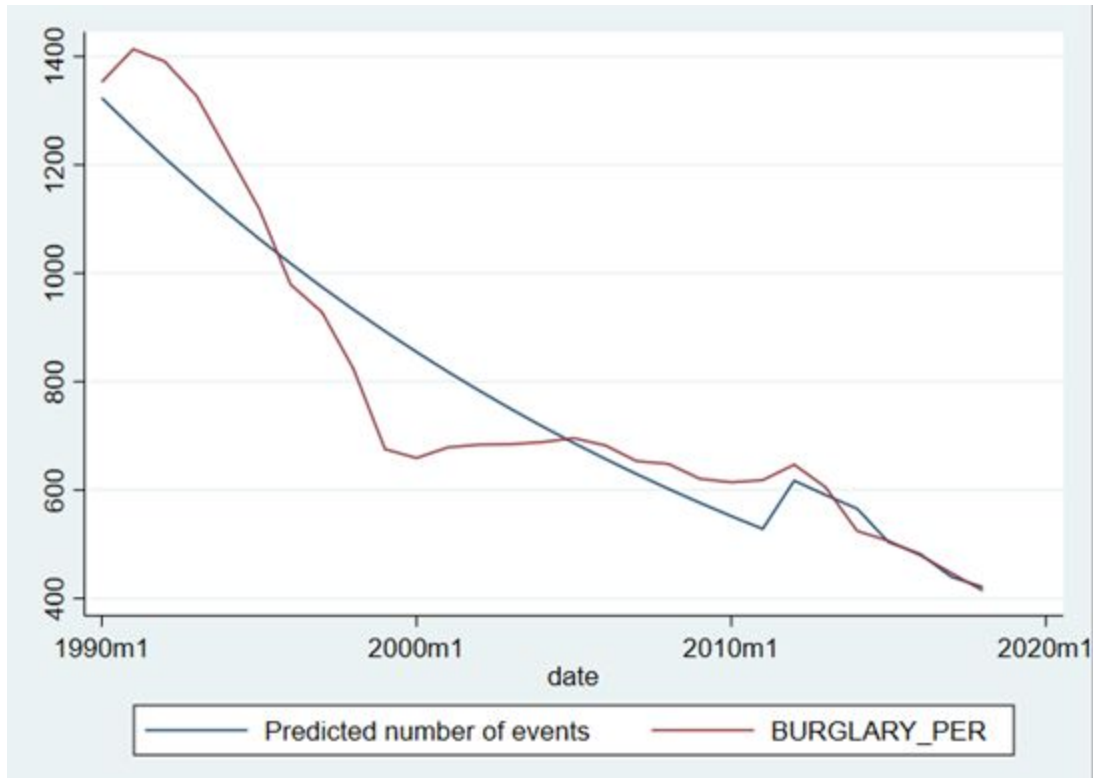
**Figure 20. Aggravated Assault, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.119	0.037	0.001
Trend	-0.049	0.002	0
SB1449	0.072	0.026	0.005
Prop47	0.208	0.038	0
Pseudo R <sup>2</sup>	0.315		

The model for aggravated assault shows that legalization is significant ( $p \leq .001$ ) and positively related to aggravated assault (coef. = .119). SB1449 (coef. = .072,  $p \leq .005$ ) and Prop-47 (coef. = .208,  $p \leq 0.000$ ) are also both significant and positively related to counts for aggravated assault.

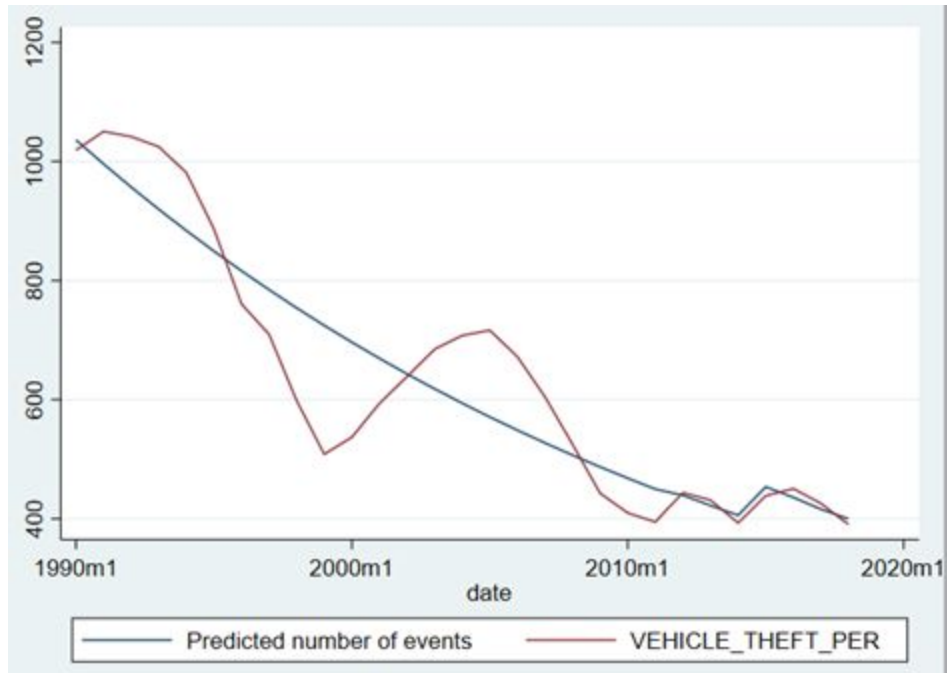
**Figure 21. Burglary, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	-0.049	0.014	0
Trend	-0.044	0.003	0
SB1449	0.199	0.056	0
Prop47	-0.072	0.032	0.024
Pseudo R <sup>2</sup>		0.169	

The model for burglary suggests that all variables are significant. Legalization is negatively related (coef. = -0.049,  $p \leq 0.000$ ), as is the trend variable (coef. = -0.044,  $p \leq 0.000$ ) and Prop-47 (coef. = -0.072,  $p \leq .024$ ). SB1449 is positively related to burglaries (coef. = .199,  $p \leq 0.000$ )

**Figure 22. Vehicle Theft, Full Model**

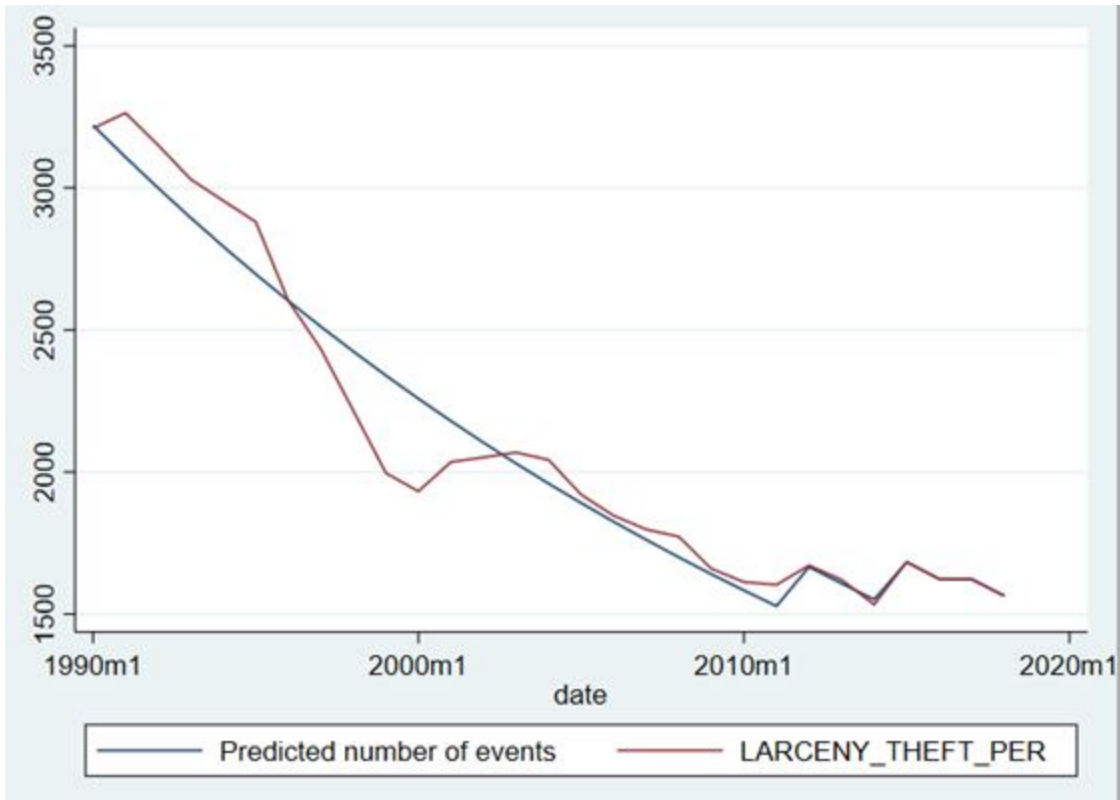


	Coef.	Robust SE	$p \leq$
Legalization	-0.007	0.03	0.819
Trend	-0.04	0.004	0
SB1449	0.016	0.065	0.803
Prop47	0.151	0.029	0
Pseudo R <sup>2</sup>	0.138		

The model for vehicle theft shows that legalization ( $p \leq .819$ ) and SB1449 ( $p \leq .803$ ) are both not significant. The trend variable (coef. =  $-0.04$ ,  $p \leq 0.000$ ) and Prop-47 (coef =  $.151$ ,  $p \leq 0.000$ ) are both significant. The trend variable is negatively related, while Prop-47 is positively related.



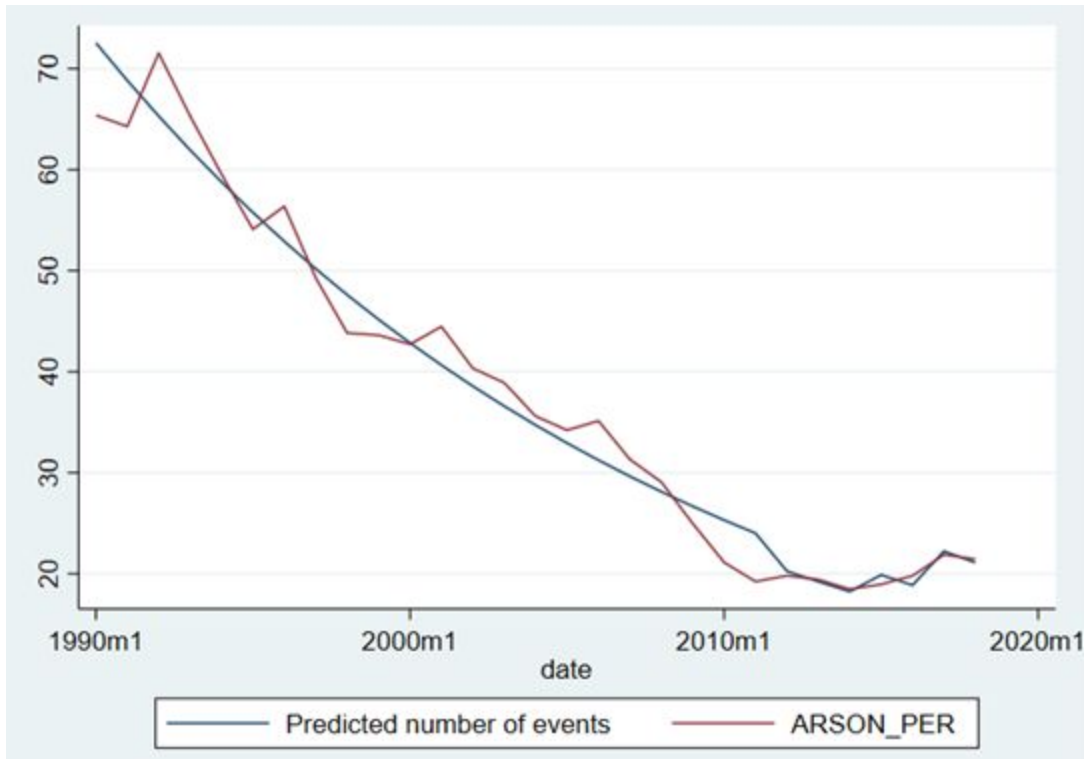
**Figure 23. Larceny, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.034	0.003	0
Trend	-0.035	0.001	0
SB1449	0.122	0.018	0
Prop47	0.117	0.006	0
Pseudo R <sup>2</sup>	0.2		

The model for larceny fits very well for the years 2010-2018. All variables are significant, with  $p \leq 0.000$ . Legalization (coef. = .034), SB1449 (coef. = .122), and Prop-47 (coef. = .117) are all positively related to larceny counts. The trend variable (coef. = -.035) is negatively related.

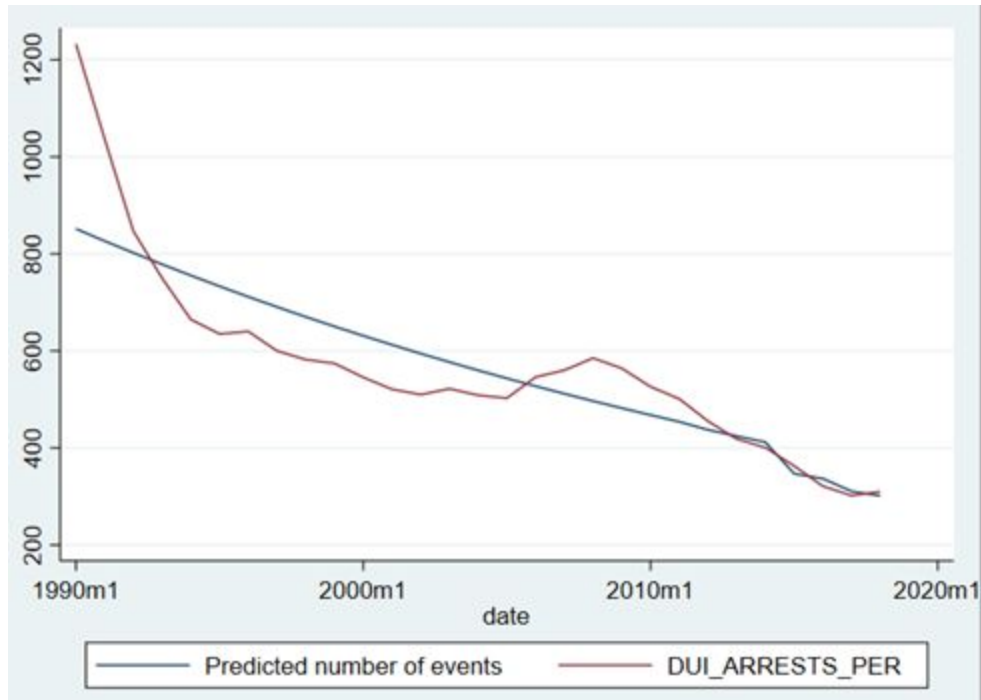
**Figure 24. Arson, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.217	0.037	0
Trend	-0.053	0.003	0
SB1449	-0.117	0.051	0.021
Prop47	0.139	0.037	0
Pseudo R <sup>2</sup>	0.329		

All variables are significant in the model for arson. Legalization (coef. = .217,  $p \leq 0.000$ ) and Prop-47 (coef. = .139,  $p \leq 0.000$ ) are both positively related to arson. The trend variable (coef. = -.053,  $p \leq 0.000$ ) and SB1449 (coef. = -.117,  $p \leq 0.021$ ) are both negatively related.

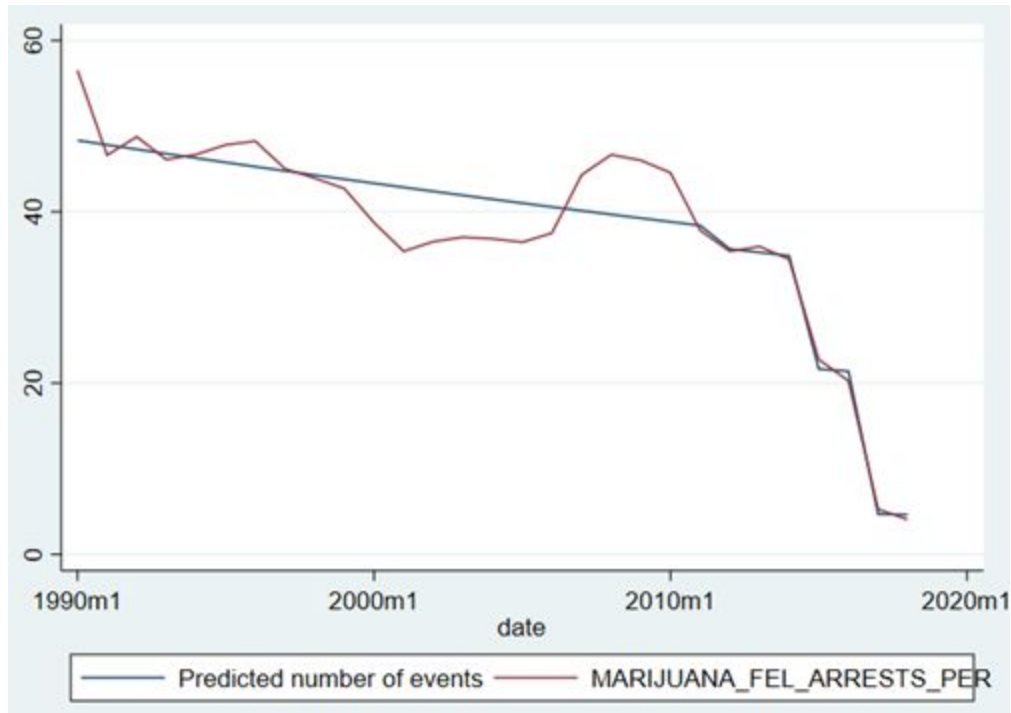
**Figure 25. DUI Arrests, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	-0.051	0.041	0.218
Trend	-0.03	0.006	0
SB1449	-0.008	0.071	0.915
Prop47	-0.142	0.041	0
Pseudo R <sup>2</sup>	0.134		

The model for DUI arrests shows that legalization ( $p \leq .218$ ) and SB1449 ( $p \leq .915$ ) are not significant. The trend variable (coef. = -.03,  $p \leq 0.000$ ) and Prop-47 (coef. = -.142,  $p \leq 0.000$ ) are both significant and negatively related to DUI arrests.

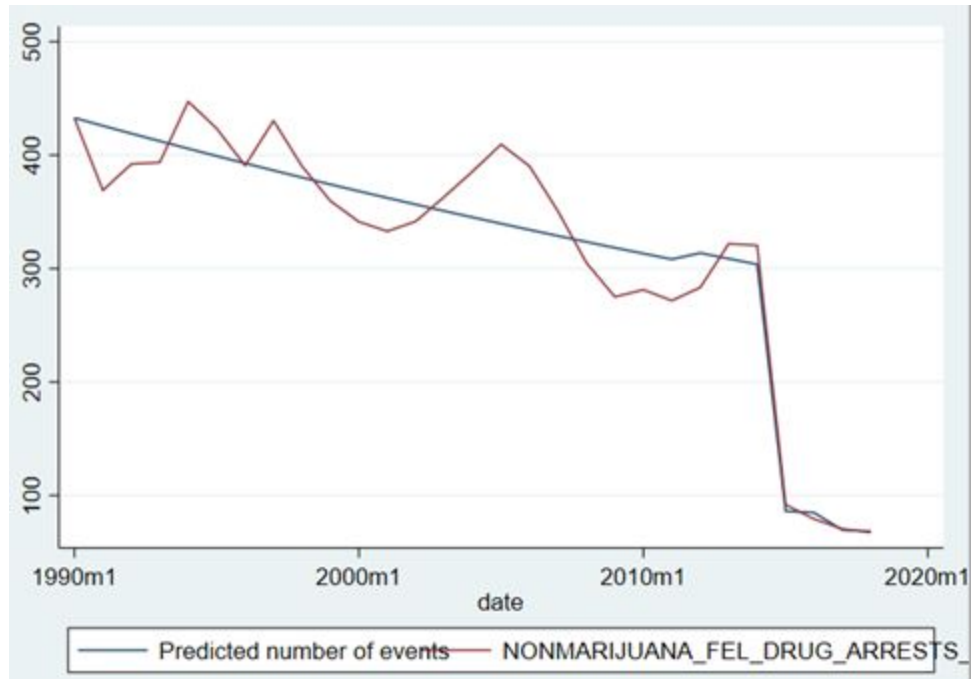
**Figure 26. Marijuana Felony Arrests**



	Coef.	Robust SE	$p \leq$
Legalization	-1.505	0.1	0
Trend	-0.011	0.004	0.003
SB1449	-0.064	0.06	0.286
Prop47	-0.466	0.04	0
Pseudo R <sup>2</sup>	0.309		

Marijuana felony arrests are seen to be negatively related to legalization (coef. = -1.505,  $p \leq 0.000$ ), as is the case with the trend variable (coef. = -.011,  $p \leq .003$ ) and Prop-47 (coef. = -.466,  $p \leq 0.000$ ). SB1449 is not significant in this model ( $p \leq .286$ ).

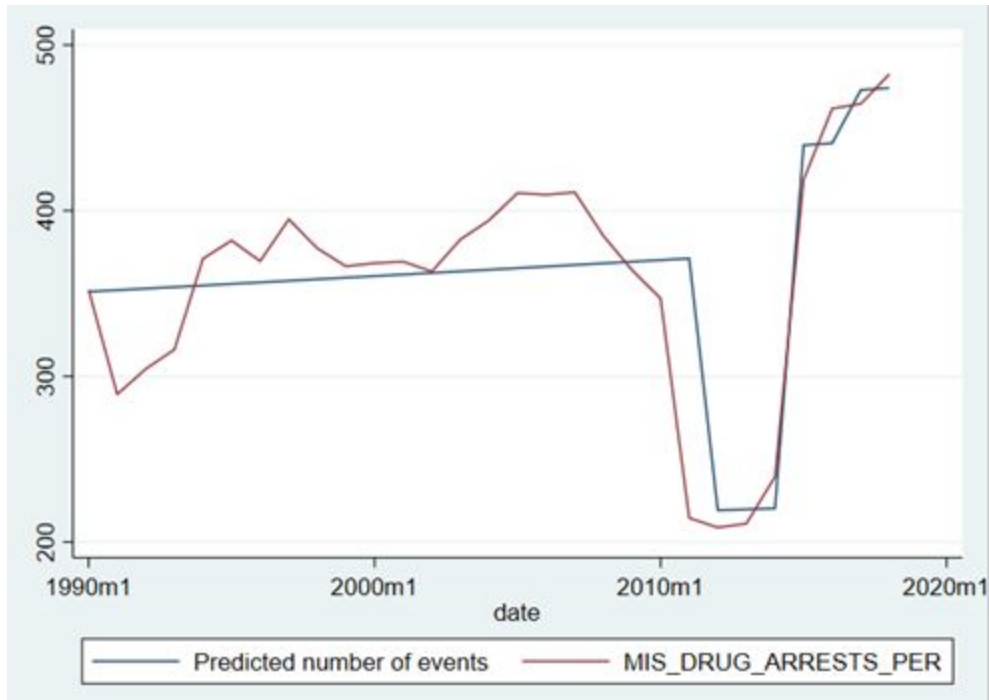
**Figure 27. Non-Marijuana Felony Drug Arrests, Full Model**



	Coef.	Robust SE	<i>p</i> ≤
Legalization	-0.183	0.049	0
Trend	-0.016	0.003	0
SB1449	0.034	0.069	0.621
Prop47	-1.244	0.063	0
Pseudo R <sup>2</sup>	0.258		

The model for non-marijuana felony drug arrests shows that SB1449 is not significant ( $p \leq .621$ ). All other variables are significant and negatively related to non-marijuana felony drug arrests. Legalization (coef. =  $-0.183$ ,  $p \leq 0.000$ ), trend variable (coef. =  $-0.016$ ,  $p \leq 0.000$ ), and Prop-47 (coef. =  $-1.244$ ,  $p \leq 0.000$ ).

**Figure 28. Misdemeanor Drug Arrests, Full Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.068	0.039	0.079
Trend	0.003	0.006	0.674
SB1449	-0.529	0.102	0
Prop47	0.688	0.52	0
Pseudo R <sup>2</sup>	0.1		

The last model, for misdemeanor drug arrests, shows that legalization ( $p \leq .079$ ) and the trend variable ( $p \leq .674$ ) are not significant. SB1449 (coef. =  $-.529$ ,  $p \leq 0.000$ ) is negatively related to misdemeanor drug arrests, and Prop-47 (coef. =  $.688$ ,  $p \leq 0.000$ ) is positively related.

**Table 6. Summary of Model Parameters by Crime Type**

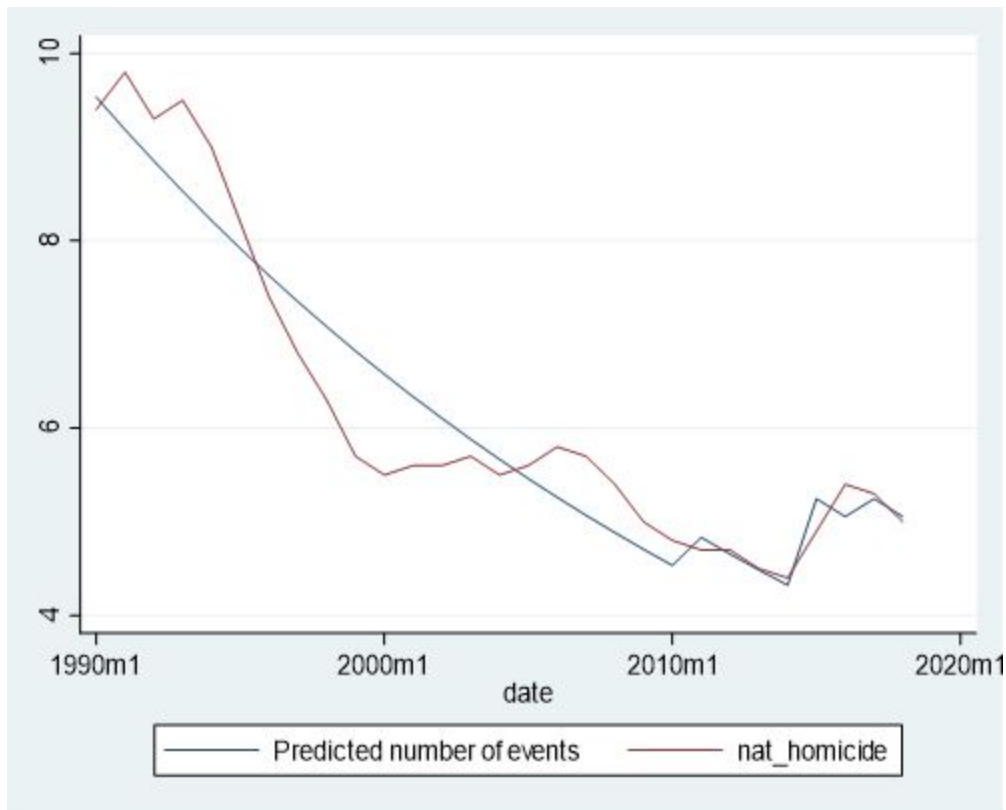
	Homicide		Rape		Robbery		Agg. Assault		Burglary		Vehicle Theft	
	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE
Legalization	0.023	0.029	.181***	0.044	.117***	0.03	.119***	0.037	.049***	0.014	-0.007	0.03
Trend	.047***	0.003	-.032***	0.002	-.05***	0.004	-.049***	0.002	-.044***	0.003	-.04***	0.004
SB1449	0.099*	0.049	-0.083	0.064	0.108	0.06	.072*	0.026	.199***	0.0056	0.016	0.065
Prop47	0.168***	0.031	.212*	0.071	.035***	0.035	.208***	0.038	-.072*	0.032	.151***	0.029
Pseudo R <sup>2</sup>	0.186		0.216		0.184		0.315		0.169		0.138	
	Larceny		Arson		DUI Arrests		Mar. Fel. Arrests		Non-Mar. Fel. Arrests		Mis. Drug Arrests	
	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE
Legalization	.034***	0.003	.217***	0.037	-0.051	0.041	-1.505***	0.1	-.183***	0.049	0.068	0.039
Trend	-.035***	0.001	-.053***	0.003	-.03***	0.006	-.011*	0.004	-.016***	0.003	0.003	0.006
SB1449	.122***	0.018	-.117*	0.051	-0.008	0.071	-0.064	0.06	0.034	0.069	-.529***	0.102
Prop47	.117***	0.006	.139***	0.037	-.142***	0.041	-.466***	0.04	-1.244***	0.063	.688***	0.052
Pseudo R <sup>2</sup>	0.2		0.329		0.134		0.309		0.258		0.1	

Abbreviations: Coef. = Coefficient; RSE = Robust Standard Error; Agg. = Aggravated; Mar. = Marijuana; Fel. = Felony; Mis. = Misdemeanor

Note: \*\*\*p<.001, \*\*p<.05

National offense data for FBI offenses and DUI arrests were also submitted into the time-series model for the reason that changes in offending in California captured by the model may reflect national trends and may not be due to legislative changes. These models are presented in Figures 29-37 and summarized in Table 7.

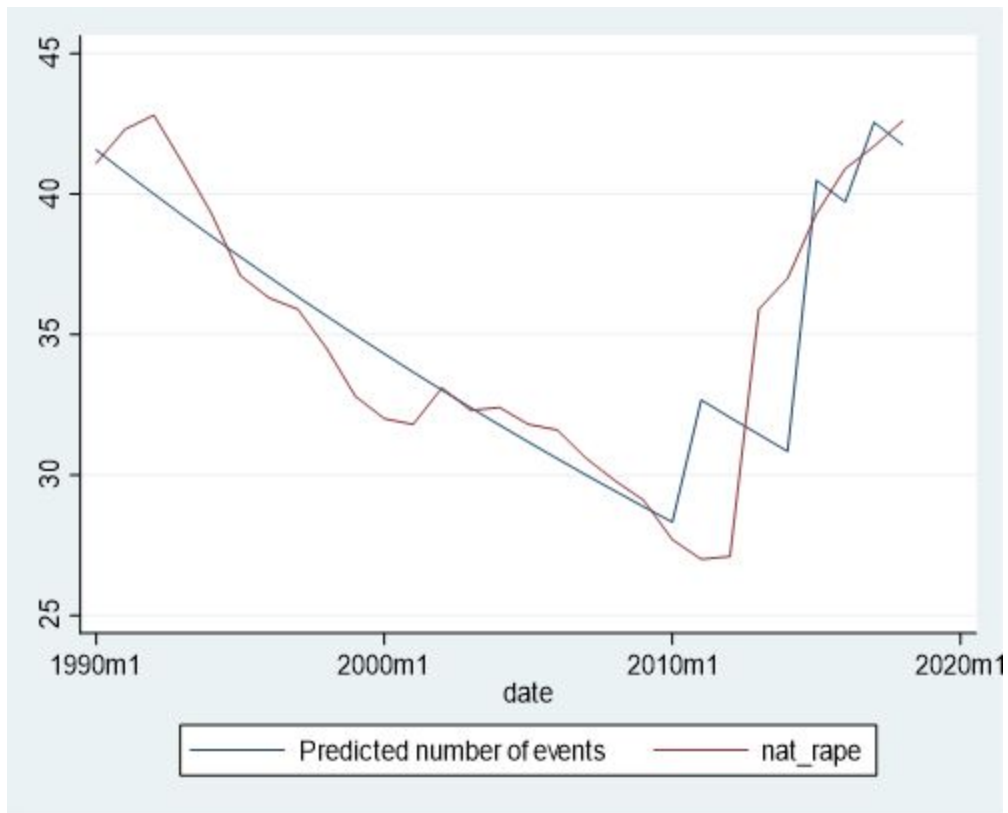
**Figure 29. Homicide, National Model**



	Coef.	Robust SE	$p \leq$
Legalization	0.074	0.049	0.131
Trend	-0.037	0.002	0.000
SB1449	0.101	0.043	0.018
Prop47	0.231	0.05	0.000
Pseudo R <sup>2</sup>	0.091		

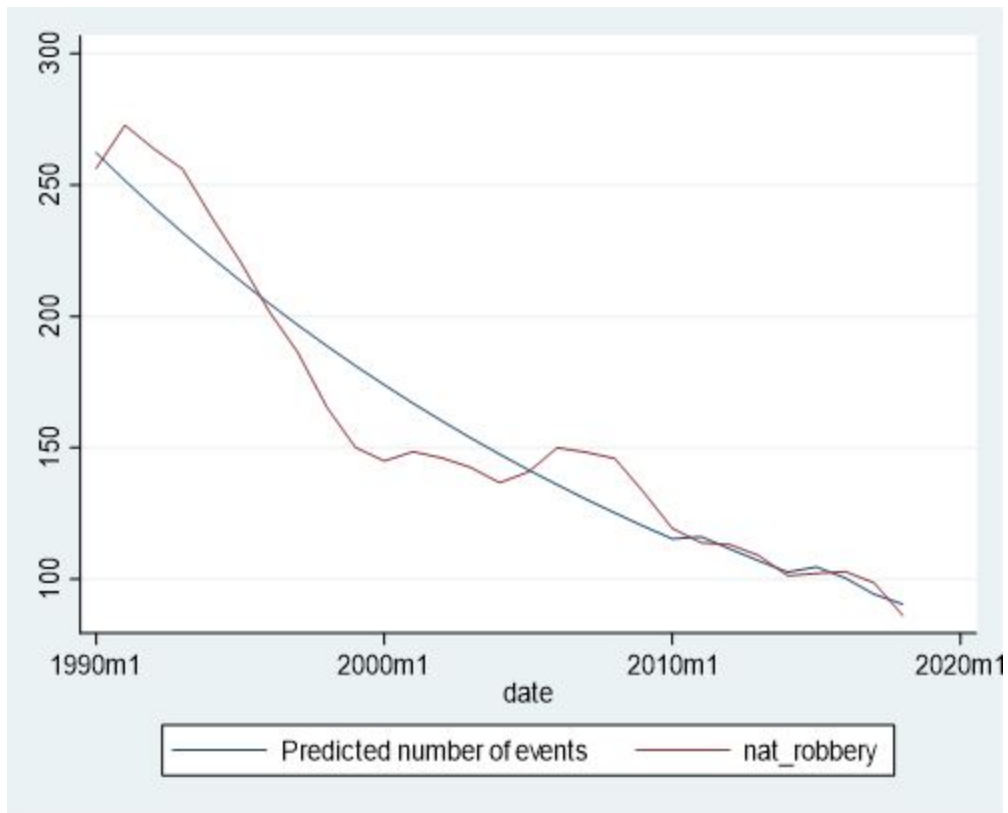


**Figure 30. Rape, National Model**



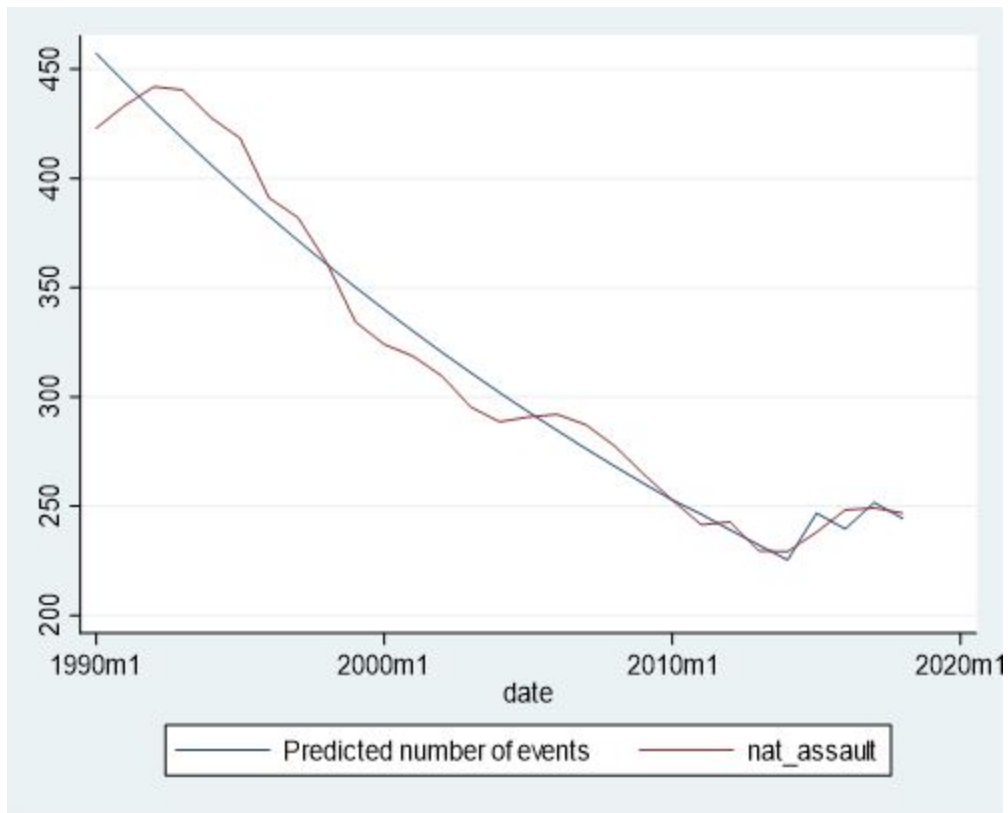
	Coef.	Robust SE	$p \leq$
Legalization	0.088	0.026	0.001
Trend	-0.02	0.001	0.000
SB1449	0.162	0.087	0.062
Prop47	0.291	0.088	0.001
Pseudo R <sup>2</sup>	0.087		

**Figure 31. Robbery, National Model**



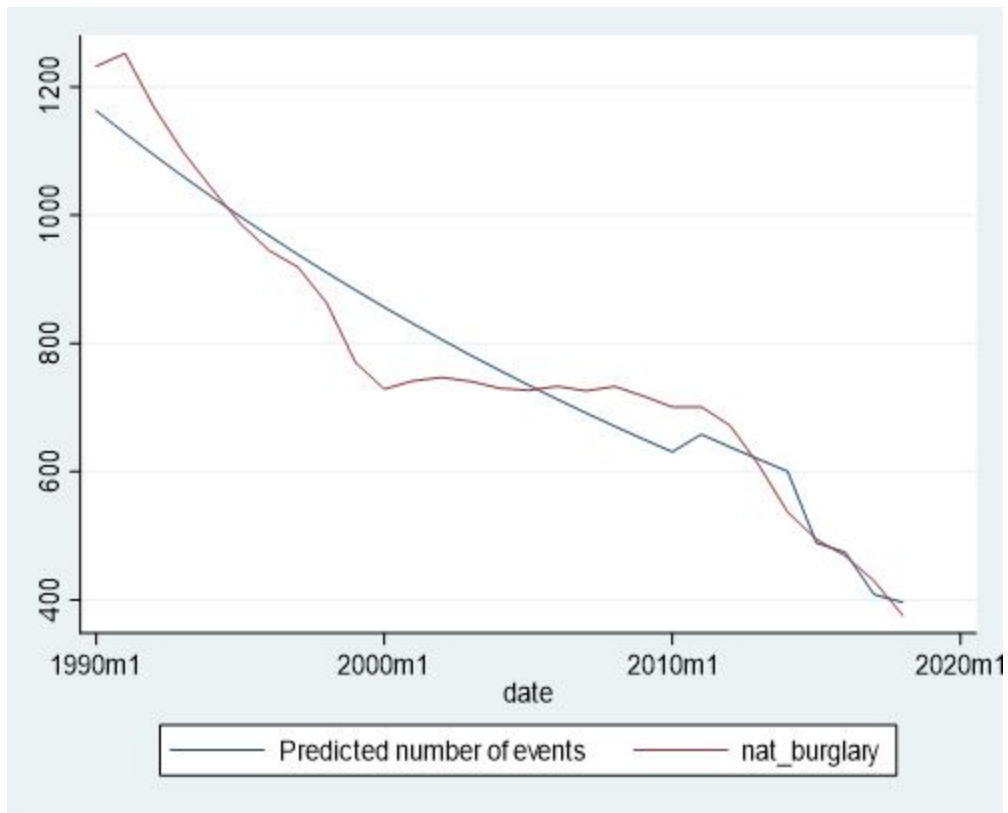
	Coef.	Robust SE	$p \leq$
Legalization	-0.022	0.038	0.559
Trend	-0.041	0.003	0.000
SB1449	0.048	0.052	0.353
Prop47	0.06	0.022	0.006
Pseudo R <sup>2</sup>	0.244		

**Figure 32. Aggravated Assault, National Model**



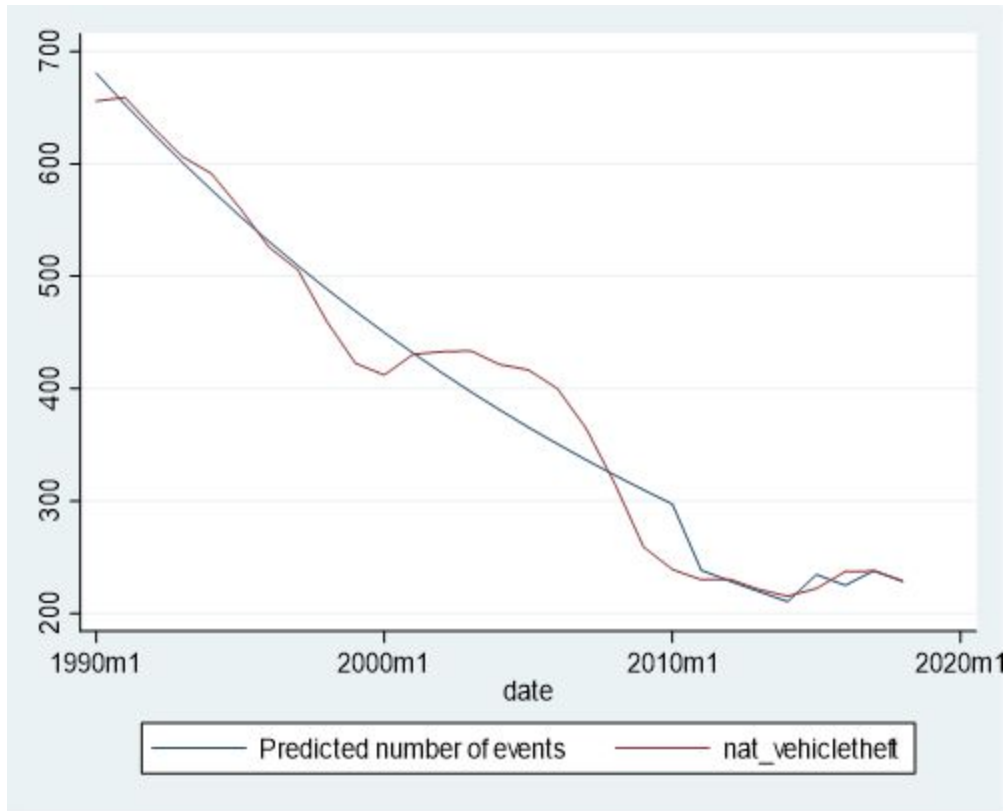
	Coef.	Robust SE	$p \leq$
Legalization	0.079	0.027	0.003
Trend	-0.03	0.002	0.000
SB1449	0.004	0.021	0.858
Prop47	0.121	0.027	0.000
Pseudo R <sup>2</sup>	0.291		

**Figure 33. Burglary, National Model**



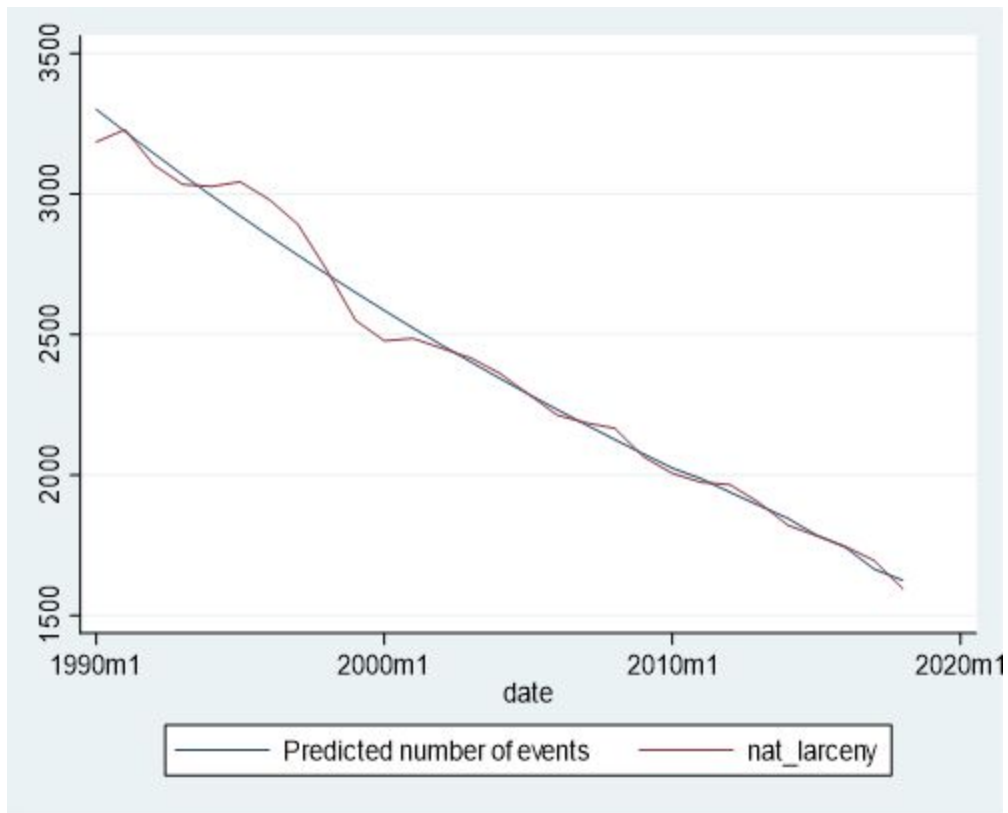
	Coef.	Robust SE	$p \leq$
Legalization	-0.118	0.038	0.002
Trend	-0.031	0.003	0.000
SB1449	0.073	0.052	0.16
Prop47	-0.175	0.036	0.000
Pseudo R <sup>2</sup>	0.207		

**Figure 34. Vehicle Theft, National Model**



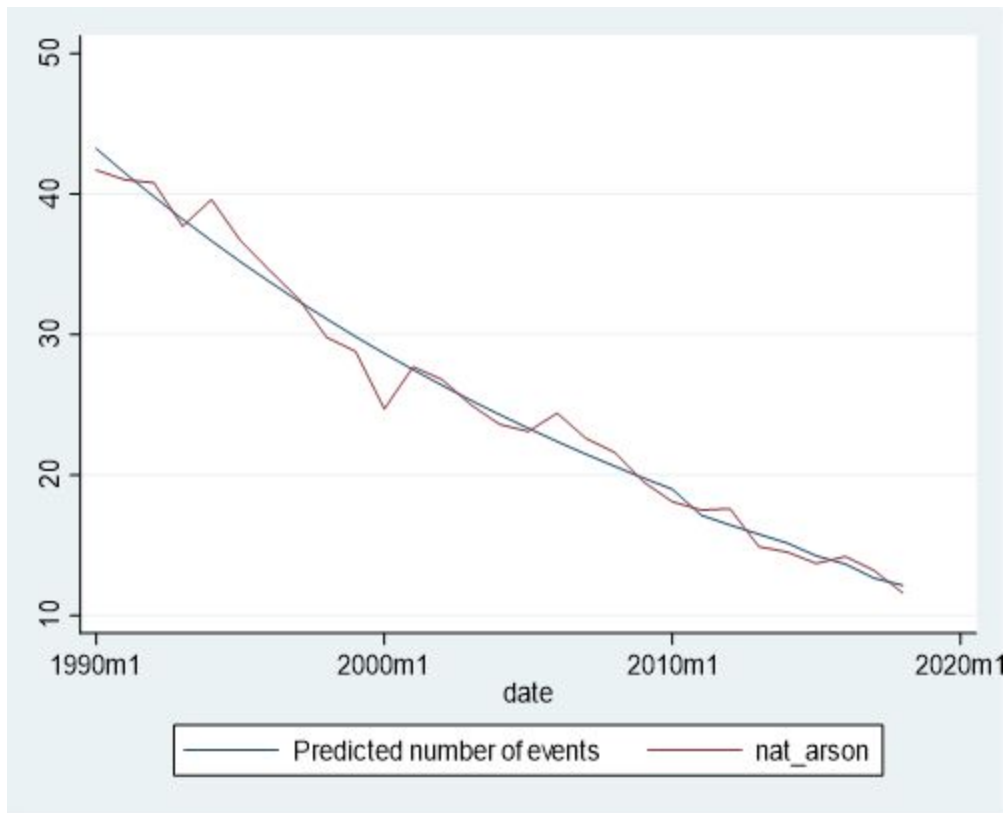
	Coef.	Robust SE	$p \leq$
Legalization	0.098	0.039	0.013
Trend	-0.041	0.004	0.000
SB1449	-0.179	0.062	0.004
Prop47	0.149	0.042	0.000
Pseudo R <sup>2</sup>	0.254		

**Figure 35. Larceny, National Model**



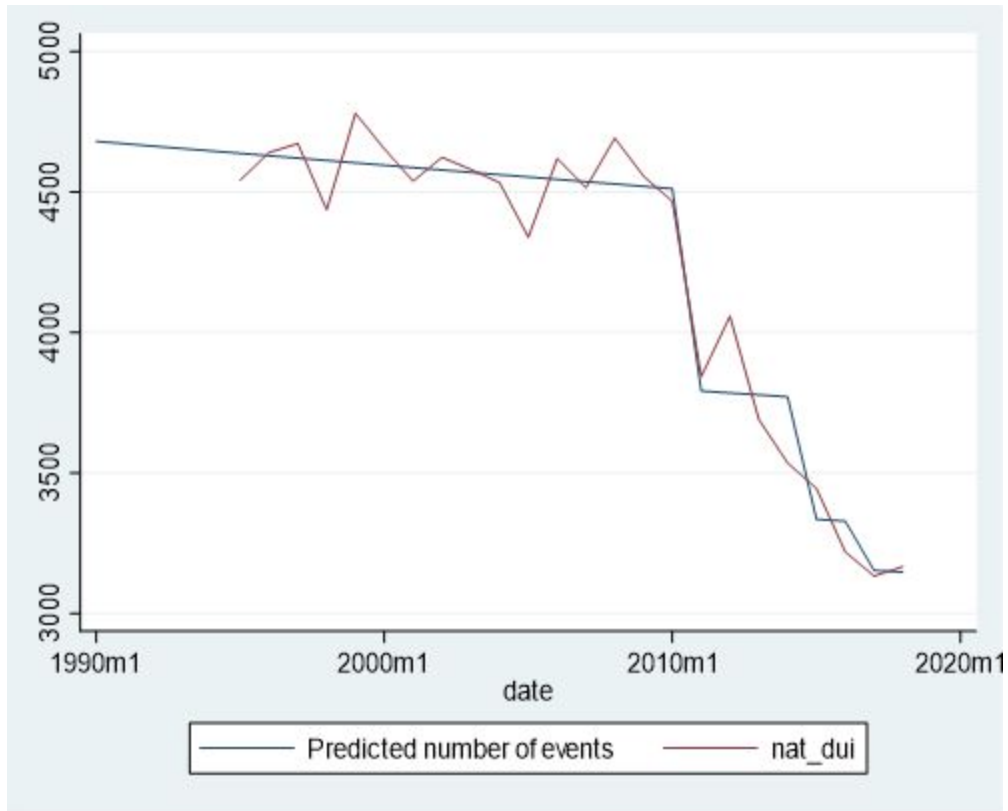
	Coef.	Robust SE	$p \leq$
Legalization	-0.021	0.013	0.113
Trend	-0.024	0.001	0.000
SB1449	0.005	0.009	0.548
Prop47	-0.009	0.006	0.141
Pseudo R <sup>2</sup>	0.297		

**Figure 36. Arson, National Model**



	Coef.	Robust SE	$p \leq$
Legalization	-0.035	0.042	0.4
Trend	-0.041	0.001	0.000
SB1449	-0.061	0.035	0.078
Prop47	-0.021	0.038	0.588
Pseudo R <sup>2</sup>	0.298		

**Figure 37. DUI Arrests, National Model**



	Coef.	Robust SE	$p \leq$
Legalization	-0.052	0.024	0.031
Trend	-0.002	0.001	0.113
SB1449	-0.172	0.027	0
Prop47	-0.121	0.035	0.001
Pseudo R <sup>2</sup>	0.199		



**Table 7. Summary of Model Parameters, National Model**

	Homicide		Rape		Robbery		Assault		Burglary		Vehicle Theft		Larceny		Arson		DUI	
	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE
Legalization	0.074	0.049	0.088**	0.026	-0.022	0.038	0.079**	0.027	-0.118**	0.038	0.098*	0.039	-0.021	0.013	-0.035	0.042	-0.052*	0.024
Trend	-0.037***	0.002	-0.02***	0.001	-0.041***	0.003	-0.03***	0.002	-0.031***	0.003	-0.041***	0.004	-0.024***	0.001	-0.041***	0.001	-0.002	0.001
SB1449	0.101*	0.043	0.162	0.087	0.048	0.052	0.004	0.021	0.073	0.052	-0.179**	0.062	0.005	0.009	-0.061	0.035	-0.172***	0.027
Prop47	0.231*	0.05	0.291***	0.088	0.06**	0.022	0.121***	0.027	-0.175***	0.036	0.149***	0.042	-0.009	0.006	-0.021	0.038	-0.121***	0.035
Pseudo R <sup>2</sup>	0.091		0.087		0.244		0.291		0.207		0.254		0.297		0.298		0.199	

Abbreviations: RSE = Robust Standard Error. Coef = Coefficient. \* =  $p \leq .05$ . \*\* =  $p \leq .01$ . \*\*\* =  $p \leq .001$ .

## DISCUSSION

Overall, results suggest that legalization of marijuana has had a mostly impact on crime in California. Model impacts for rape, robbery, aggravated assault, burglary, larceny, arson, felony marijuana arrests, and felony non-marijuana arrests were all significant at  $p \leq .05$  for all cases and  $p \leq .001$  for some cases, while homicide, vehicle theft, DUI arrests, and misdemeanor drug arrests were not significant at the  $p \leq .05$  level. These findings should be interpreted with caution, for several reasons. First, an examination of impact sizes shows that there is variability in the estimated impact of each crime type. Table 7 displays the percent change in expected counts for each significant variable. This percentage change is calculated by the following formula:

$$\textit{Percentage Change in Expected Counts} = 100 * [\exp(b) - 1]$$

Where 'b' is the coefficient from the negative binomial regression model. This approach takes advantage of the multiplicative nature of the relationship between the predictor and outcome variables; regression coefficients represent the expected change in the outcome variable when a one-unit change occurs in the predictor variable (holding other variables constant.) The logarithmic nature of the relationship requires exponentiating the coefficient in order to produce an estimate for the percentage change in the expected outcome as a result of a change in the predictor.

**Table 7. Percentage Change in Expected Counts, Time-series Analysis**

	<b>Coef.</b>	<b>% Change in Expected Counts</b>
Rape	0.181	19.84
Robbery	0.117	12.41
Agg. Assault	0.119	12.64
Burglary	0.049	5.02
Larceny	0.034	3.46
Arson	0.217	24.23
Fel. Mar. Arrests	-1.505	-77.80
Fel. Non-Mar. Arrests	-0.183	-16.72

The model suggests that legalization of marijuana increased counts for arson by 24.23%. Rape (19.84%), robbery (12.41%), aggravated assault (12.64%), burglary (5.02%), and larceny (3.46%) all increased as a result of legalization. Felony marijuana arrests (-77.8%) and felony non-marijuana arrests (-16.72%) both decreased as a result of legalization.

These percentage changes should be interpreted with extreme caution. The reliability of the time-series models in this work are questionable largely for the reason that there are very few observations for the post-legalization period. Corsaro recommends that this type of time-series analysis be performed on a total of 40-60 observations, roughly split across the pre and post periods; these models utilize a total of 29 observations total, with only 2 observations occurring in the post-legalization period. This makes it difficult to examine any true trend that may be occurring, and changes in counts may merely reflect fluctuations in data. The models included in this analysis attempt to measure whether there is an immediate step-change increase in crime counts--an upward or downward spike as a result of fluctuation would be reported by the model as an indicator of a step-change occurring, resulting in a "false-positive" although no true change has taken place.

Time-series analysis also allows for inclusion of a slope-change measurement in the outcome variable as a result of the intervention. This can be determined by inclusion of another time variable; in this case, as data is taken yearly, this variable would increase by 1 for every year that legalization has been in place. This variable was initially included in the model, however, inclusion of this variable had virtually no effect upon the model whatsoever and was consequently excluded. This is likely again due to the short post- period, in which 2 data points (2017 and 2018) are insufficient to determine a slope change.

Visual analysis of the graphed data can serve to reiterate the above limitations, and to strengthen conclusions. All of the Part I and Part II UCR offenses show trends which do not change drastically in either slope or step change in 2017 or 2018, but tend to follow trends which were established in previous years, or have spikes and drops which are consistent with fluctuation in data for the previous period of observation. Counts for misdemeanor drug arrests show a slightly more significant increase in the post period, although the model suggests that legalization was not significant. Examination of national data shows that most changes in offending in California appear to mirror national trends.

Inclusion of national offense data in the time-series model is useful in order to determine whether changes in offending as a result of legalization are due to legislation or are merely in-line with national trends. When examining offenses that were significant in the California-only time-series analysis model in conjunction with the national model, it is revealed that rape, aggravated assault, and burglary are likely due to national trends and are independent of legislative changes in offending. This was determined by comparing coefficients and significance levels for significant California offenses to offenses in the national model. Robbery,

larceny, and arson still appear to be significant in the California model when compared to the national model. Robbery and larceny are unlikely to have changed as a result of legalization when their t-tests and percent changes are examined. Their t-test values are not consistently significant, suggesting that changes in mean offending levels are likely due to random variation. Examination of their percent change values also shows that it is highly likely that changes in these offenses are reflective of national trends.

However, when analyzing percent changes and t-test values for these “significant” offenses, only arson appears to be affected as a result of legalization. Arson was significant in both national and California time-series models. The national percent change in arson counts between 2016 and 2018 was negative, and it was also negative between the 5-year period before legalization and the mean value post-legalization. This is in contrast to positive changes in both percent change models for California. Finally, changes in arson counts were significant in the pre- and post- legalization t-tests for both the entire period of observation and the 5-year period prior to legalization. This suggests that legalization of recreational marijuana may have contributed to an increase in arson in the state of California post-legalization. There is little to no existing literature to inform as to why this may be. Jayaraman & Frazer (2006) examined a sample of convicted arsonists in the United Kingdom and found that roughly half of the sample had cannabinoids in their system at the time of arrest; however, causality is nearly impossible to establish, and mere correlation may be responsible. All of the individuals were under the influence of alcohol, and a third had opioids in their system as well. Some arson investigators and fire department officials believe that arson is on a rise since legalization, although there is no peer-reviewed or academic literature to support this (Pitawanich, 2016).

Regarding the validity of time-series models in this work, Lu et al. (2019) performed a similar time-series analysis to the methods in this study using FBI data in the Offenses Known and Clearances by Arrest dataset which is offered monthly; however, this dataset has not yet been released for the years 2017 and 2018. By using a dataset which offers monthly counts, a more reliable model can be created, however the timeliness of recreational legalization in California limits the available data that can be analyzed. State-wide datasets offering crime information in monthly or weekly increments do not seem to be available at this time. The Los Angeles Police Department has recorded every reported crime in the city for the years 2010-2019; San Francisco offers COMPSTAT reports for monthly crime data in the city as well. Other large cities in the state have similar datasets available for public access. Future actions could increase the reliability of the models in this work by including new UCR state-wide data once the datasets are released; they may also use city-wide data which is often available in monthly or weekly increments.

## **CONCLUSION**

A combination of visual, descriptive, and time-series analysis suggests that legalization of recreational marijuana in California has had a significant and non-trivial impact on several types of offending: arson, felony marijuana arrests, and felony non-marijuana arrests. Arson appears to have increased post-legalization, while felony marijuana arrests and felony non-marijuana drug arrests have decreased. Theoretical links between legalization and arson are difficult to establish. Future directions for this may include an aggregate analysis of all states in which marijuana has been legalized in order to determine whether these results are generalizable outside of California. Qualitative interviews with officials in these states such as investigators,

retail distributors, and fire department officials may also expose the potential link between legalization and arson.

It is not surprising that felony marijuana arrests have decreased greatly; as mentioned in the literature review of this study, California has reduced penalties for marijuana possession, to the point where felony marijuana charges are relatively unlikely to occur (compared to previous years and other violations) and are largely only allocated in the case of illicit distribution of marijuana to minors. It is not necessarily the case that fewer individuals are committing the acts formerly defined as felony marijuana violations, but rather that the state has reclassified these actions as misdemeanors, ordinance violations, or entirely legal acts. It is also possible that law enforcement officers exercise discretion and no longer or ticket arrest individuals in California for marijuana violations, given the changing social environment regarding marijuana use. This also brings to mind the continuing debate between positivistic and theological crime, or the clash between “immoral” and criminal acts.

The summary of marijuana legislation in this work outlined how marijuana prohibition began as a form of social control directed at specific populations. The act itself was not seen as abhorrent in the same way that a crime such as murder or rape is universally immoral. This clash between legal and moral crime is explored by Fuller in his 1942 publication, “Morals and the Criminal Law.” Fuller writes that some practitioners of the time believed that the law was determined by custom and public opinion. Fuller suggests that society enacts new criminal legislation in order to cater to the moral standards of certain groups, and that criminal legislation does not always reflect a universal moral standard, but rather the moral standard of whichever group is able to enact their agenda. Perhaps most expressive of his sentiment in his work is his

statement: “Criminal and Immoral are not always synonymous.” Mewett (1962) argues that criminal law is socially constructed, and that the law should only be concerned with acts that have demonstrable negative effects on society. Mewett believes that all laws should seek to minimize societal harm, and that morality and law are essentially separate. He describes the relationship between criminality and morality as complex, “an immoral person can not be equated with a criminal person. Even if one accepts that all criminals are immoral, one can not suggest that all criminal acts are immoral. In any case, it is doubtful whether all criminal acts are immoral acts” (Mewett, 214). Cohen (1940) echoes this sentiment, arguing that some define an action as a crime only when those with legislative power determine it to be a crime, while others argue that an action is a crime when it is so in nature, or goes against the nature of society. Cohen describes the former view of crime as positivistic, and the latter as a theological viewpoint. Cohen inserts his own thoughts on the subject, saying “Laws must often be changed if our rules of conduct are to facilitate the good life under changing conditions. How this is to be brought about in any given determinate social situation is not something known in advance, but must be determined in the processes of adjustment of our economic and political life” (Cohen, 997). Cohen clearly takes a more positivistic view on crime, arguing that laws must change in order to adjust to evolving social and political environments and norms. This debate still rages on more than half a century later, as the overall lack of credible evidence suggesting that marijuana incites violent or property crime points to the positivistic rather than theological nature of marijuana violations.

A decrease in non-felony marijuana arrests is less easily explained. It is plausible that users of other drugs such as opiates or amphetamines have increased their marijuana



consumption and reduced usage of these other non-marijuana substances, leading to a decrease in arrests for these drugs. It is also possible that enforcement has changed in California, and while there are fewer arrests, the actual level of drug violations has not changed as a result of legalization. This tentative hypothesis is based on the history of California in decriminalizing and reducing penalties for many non-violent and drug offenses, and would require further investigation to verify. Mixed-methods consisting of qualitative interviewing with law enforcement and judicial officials in conjunction with analysis of more detailed drug-arrest data would likely reveal the veritability of this hypothesis.

Proposition 47, which both reduced penalties for non-violent drug offenses (and some low-level property offenses), has been the subject of a significant amount of empirical attention. Prop-47 was seen to be significant in many of the time-series models. While not the focal point of this work, Prop-47 has been seen to have no effect on violent crime and a minor increase in larceny--roughly 9% (Bird et. al, 2018). The results of this analysis reinforce the findings of Bird et al., 2018. The ramifications of reducing penalties for these kinds of offenders may include a focus on treatment alternatives rather than incarceration. Proponents of labeling theory would also likely argue that by keeping individuals out of the penal system, they are less likely to reoffend. In the context of marijuana and marijuana users in California, Proposition 47 should theoretically reduce crime according to this ideological perspective. SB-1449 (2011) set the tone for future legalization in California. The time-series models in this work suggest that SB-1149 may have had a non-trivial impact on larceny, arson, aggravated assault, and burglary. However, when combined with visual analysis of offense data, it seems likely that construction of a more complex time-series model would be necessary to verify this. This line of inquiry was considered

to be out of the scope of this work and was not pursued, but has potential for future research.

Given, however, that the results of this work suggest that (other than arson) legalizing marijuana did not affect offending, it seems fairly unlikely that reducing penalties for marijuana possession would have significantly affected offending.

Lu et. al (2019) determined that legalizing marijuana did not have any significant effects upon crime in Washington in Colorado; Farley and Orchowsky (2019) then interviewed law enforcement and government officials in these states. These interviewees believed that legalization had attracted crime from out of state, increased violence in drug markets, and increased DUI rates, although the “hard” data suggests otherwise. Reliance merely on quantitative methods and large datasets likely does not tell the whole story. Conversely, interviews, even with qualified respondents, have limited utility if they can not be backed with reliable data. Future research in this vein which integrates and encourages cooperation between practitioners and academics could utilize the experience and specific knowledge of both groups in order to construct new and improved datasets which may lend themselves to future research.

Policy implications for future iterations of this work may include focused policing on varieties of crime which increase post-legalization. For example, should burglary be found to increase post-legalization, law enforcement agencies may wish to concentrate efforts on anti-burglary enforcement. These results could be strengthened by geospatial analysis of the relationship between dispensary location and crime, or other analyses which are performed in order to determine how marijuana-related crime occurs geographically, so that law enforcement is better able to plan for how to allocate their resources to most efficiently combat increases in

crime post-legalization. This work also suggests that enforcement and policy may change as some variants of crime may decrease, such as felony marijuana arrests.

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## APPENDIX I

### THE EFFECT OF MARIJUANA UPON THE INDIVIDUAL

The word “marijuana” is Mexican in origin, and refers to the entire plant as a whole. There are three species of marijuana: *cannabis sativa*, *cannabis indica*, and *cannabis ruderalis*. The plant can be grown both indoors and outdoors, and under optimal conditions, can reach maturity within sixty days (Armentano et. al, 2009). The stalks of the plant (which can grow up to twenty feet tall), are the source of hemp. The psychoactive components of the plant are found in the flowers of a female plant, also known as buds, and the leaves of plants of both genders. While marijuana plants contain a variety of psychoactive and non-psychoactive (but still active) chemicals, the plant is best known for the psychoactive compound delta-9-tetrahydrocannabinol (THC). Other non-psychoactive but still active compounds include cannabigerol (CBG), cannabinol (CBN), and cannabidiol (CBD), which provide a variety of effects when ingested, but do not provide an intoxicant effect (Armentano et. al, 2009). Similar to the alcohol content of liquor or beer, the concentration of THC within the product determines the strength of the intoxicant effect. Ingesting a product with a high concentration (10-15% THC) will induce the effects faster and more intensely than a low concentration product (most domestic marijuana products contain a THC concentration of around 5%).

The intended effects of marijuana ingestion can vary by individual and by product but most often include pleasant mental and/or physical sensations such as relaxation. Some marijuana users report decreased anxiety and an increased ability to interact with others in social situations. Users also often report that marijuana heightens some of their body’s senses such as touch, sound, or hunger and taste (hence the term “munchies.”) (Armentano et. al, 2009; NIH,

2019). Negative side-effects of marijuana ingestion include rapid heart beat, paranoia, and dry-mouth. These effects are typically felt by a first-time user or when too much marijuana product is ingested in a short period of time. While unpleasant, these effects pose minimal physiological risk.

Marijuana can be ingested in a variety of ways. Inhalation and oral consumption are the primary methods. Other products include topical applications such as lotions (although these products are not typically used for intoxicant purposes) (DPA, 2019). Physical effects are felt when the active compounds in marijuana pass into the user's bloodstream, whether ingestion occurs through consumption, inhalation, or other means. Inhalation produces the fastest response, one that is almost instantaneous (DPA, 2019).

### **BENEFITS OF MARIJUANA USAGE**

A 1988 DEA hearing concluded that marijuana usage “in strict medical terms” is safer than many commonly consumed food in America, and is “one of the safest” therapeutically active substances available (Young, 1988). Marijuana is frequently used for medical purposes, with an estimated three million *legal* medical marijuana users in the nation--and an unknown number of citizens using *illegal* marijuana for medical purposes (MPP, 2019). Marijuana is used to treat symptoms corresponding to a variety of conditions including mild to moderate pain, nausea, and eating disorders (Grinspoon, 2018), and has been seen in clinical studies to significantly improve the negative effects of glaucoma (Mack & Joy, 2000). One study found that marijuana has the potential to reduce inflammation in individuals suffering from HIV (Rizzo et. al, 2018). Non-THC marijuana products such as CBD oils have been applauded in the past for their ability to provide relief in cases of severe epilepsy (FDA, 2018) anxiety, neural

degeneration (Artamento et. al, 2009), and pain (Grinspoon, 2018). The American Kennel Club even acknowledges anecdotal evidence of CBD oil providing medical benefits for dogs (Burke, 2018).

The medical effects of marijuana may be corroborated by significant amounts of anecdotal evidence and some clinical research, but compared to other recognized forms of therapy and medication such as prescription opiates, the quantity of empirical research and clinical study is fairly sparse. As a result, the medical potential of marijuana is relatively uncertain in the scientific domain. Medical marijuana clinical research typically is not funded at the federal level due to the classification of marijuana as a Schedule I drug (MAPS, 2019). In order to remove marijuana from this classification, it would be necessary to provide evidence that it does indeed have definitive and proven medical benefits<sup>23</sup> This creates a situation in which it is difficult to provide compelling clinical evidence in favor of the medical benefits of marijuana.

### **RISKS OF MARIJUANA USAGE**

Marijuana has some established medical and recreational benefits, both anecdotal and clinical. However, there are proven as well as potentially unknown risks to marijuana users. Marijuana can temporarily impair an individual's cognitive and motor abilities (Crean et. al, 2011). Individuals should not drive or operate heavy machinery while under the influence of marijuana. Decision-making may also be adversely affected by marijuana use (Kauert et. al, 2006), as well as short-term memory impairment (Cherek et. al, 2005). The CDC acknowledges that more research is necessary to make concrete conclusions, but advises pregnant women not to

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<sup>23</sup> I am not suggesting that marijuana does not have potential medical benefits, but rather that the present categorization of marijuana as a Schedule I drug in the view of the federal government does.



consume marijuana (ACOG, 2017), and that doing so may be related to low infant birth-weight (Heard et. al, 2013) and developmental issues (Gunn et. al, 2016). There is some evidence as well that men may lower their sperm count as a result of marijuana ingestion (Whan et. al, 2006).

Inhalation of marijuana can lead to serious negative health risks, including damage to the airway and potential predisposition to infections and cancer (Tashkin, 2001). The American Lung Association states that “smoke from marijuana combustion has been shown to contain many of the same toxins, irritants and carcinogens as tobacco smoke” (ALA, 2019). There are also concerns that cannabis may increase blood pressure (Harvard Medical School, 2017) and contribute to fatty buildup in the liver<sup>24</sup> (Chhabra et. al, 2018).

Perhaps one of the most significant dangers of marijuana is the dearth of literature on its potential long-term effects<sup>25</sup>. For a substance that enjoys such widespread use, there is a relatively small amount of literature on potential complications. A National Institute of Health-supported evidence-based review of the effects of marijuana use delivered a variety of concerning conclusions. “Research on the effects of cannabis on cognition has generally lagged behind studies on the cognitive effects of alcohol, cocaine, methamphetamine and heroin...few controlled studies have investigated the effects of acute doses of cannabis on impulsive behavior...this area of the literature has been fraught with inconsistencies in findings and is complicated by discrepant definitions of what constitutes “long-term effects”” (Crean et. al, 2011). The lack of reliable literature and academic consensus has proven to be a persistent

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<sup>24</sup> Like much of the medical information surrounding marijuana use, this is a contested point, and some research points to the opposite (Chhabra et. al, 2018).

<sup>25</sup> A point that bears repeating again and again in this argument is not that literature is entirely absent regarding the potential negative effects of marijuana, but that compared to other substances such as alcohol and opiates, the existing knowledge base is insufficient to draw a consensus in the medical and scientific community.

obstacle for advocates of medical and recreational marijuana, and a roadblock to effective policy creation.