

City University of New York (CUNY)

**CUNY Academic Works**

---

School of Arts & Sciences Theses

Hunter College

---

Fall 12-23-2020

## **Legalization of Marijuana and Its Effect on Alcohol Related Accident Fatalities**

Azamat Sadikov  
*CUNY Hunter College*

[How does access to this work benefit you? Let us know!](#)

More information about this work at: [https://academicworks.cuny.edu/hc\\_sas\\_etds/678](https://academicworks.cuny.edu/hc_sas_etds/678)

Discover additional works at: <https://academicworks.cuny.edu>

---

This work is made publicly available by the City University of New York (CUNY).  
Contact: [AcademicWorks@cuny.edu](mailto:AcademicWorks@cuny.edu)

# Legalization of Marijuana and Its Effect on Alcohol Related Accident Fatalities

by

Azamat Sadikov

Submitted in partial fulfillment  
of the requirements for the degree of  
Master of Arts in Economics  
Hunter College, City University of New York

2020

December 13, 2020

Date:

Randall K. Filer

First Reader

December 13, 2020

Date:

Partha Deb

Second Reader

**Acknowledgment:**

I would like to thank professor Filer and professor Deb for their guidance, feedback and help for this paper and throughout the college years. I would also like to thank my sisters for their spiritual support and for being positive during a pandemic.

## **Table of Contents:**

Acknowledgement	1
Table of Contents	2
Abstract	3
Introduction	
Policy Background	4
Motivation	5
Literature Review	6
Data and Methodology	
Research Design	8
Data	8
Results	9
Conclusion	12
References	13
Tables	15
Figures	18

**Abstract:**

This Masters' Thesis examines the effect of legalization of recreational marijuana on alcohol related car accident fatalities in the state of Colorado. I used the Synthetic Control Method to analyze this effect. Results of my findings indicate that after legalization of marijuana there was no significant increase in the number of drunk driving accident fatalities.

## **Introduction:**

### **Policy Background:**

In 1937, the Marijuana Tax Act was passed which prohibited the recreational use of marijuana at the federal level and passed many regulatory requirements that significantly reduced the use of medical marijuana. In addition to the Marijuana Tax Act, the Controlled Substance Act of 1970 which classified marijuana as a Schedule 1 drug (such as Heroin and Cocaine) defining marijuana to have a high potential for abuse, no acceptance for medical use, and severe safety concerns. However, in recent years, one of the most important issues in the United States is the debate over the legalization of recreational and medical marijuana. The legalization of marijuana has reached a record number of support by the public, but there is still a significant number of people opposing its legalization.

The first step toward the legalization of marijuana was in 1973 when states such as Oregon, Alaska, Ohio, and others decriminalized the use of marijuana. It was no longer a crime to possess a certain amount of marijuana. In 1975 the supreme court of Alaska ruled that the right to privacy included the possession of a small amount of marijuana. California was the first state to legalize the medical use of marijuana in 1996 which was another step towards the legalization of marijuana. Now with a prescription from the doctor people could legally buy marijuana products from drug stores. Between 1996 and 2011 eighteen states have legalized the use of medical marijuana. In 2012 Colorado became the first state to legalize recreational use of marijuana through Amendment 64 (Colorado Official State Web Portal, 2016). Since then multiple states have passed the law to legalize the use of medical and recreational marijuana.

Even when states are legalizing recreational marijuana, it is still illegal at the federal level. Federal law is the “supreme Law of the Land”, and it tops state laws (US Const. Article VI § 2). This means that a person who is using or carrying marijuana can be punished under federal law. However, it is very unlikely that the federal government will get involved because it is not an optimal allocation of limited resources (Cole, 2013). In a memorandum for all U.S attorneys James Cole, who was United

States Deputy Attorney General, says that states and local law enforcement agencies should be responsible to address marijuana activities through the local laws. In addition to the state vs federal government, counties and cities in Colorado also can make their own rules and consequences towards the use of marijuana (Colorado Web Portal, 2016). This means that counties have the power to ban the use and sales of marijuana in their jurisdictions.

Thirty three states and D.C have legalized medical marijuana and eleven states and D.C have legalized recreational marijuana. It is true that there are not many stores that sell marijuana. In the states where the use of recreational marijuana is legal, getting marijuana is as easy as getting alcohol from the stores given that you can get to the dealer easily.

### **Motivation:**

It is illegal to drive when the Blood Alcohol Concentration level in the bloodstream is .08 or higher. However, even a small amount of alcohol can affect driving ability (NHTSA, 2020). Alcohol is a substance that reduces the functioning of the brain, the ability to think, and reason. These are the abilities that are necessary for driving. Drunk driving is the leading cause when it comes to car crashes. In 2018, drunk driving took a life every 50 minutes which was 29 percent of all highway fatalities (NHTSA, 2020). This totaled to 10 thousand lives lost because of drunk driving-related accidents.

Similar to alcohol, driving under influence of marijuana is illegal nationwide too. However, unlike testing that is done in order to check if a person is drunk, checking if a person is under the influence of marijuana is problematic (Bloch, 2020). There are limitations on drug detecting technology and standard procedure in order to detect drivers who used marijuana. In addition, marijuana can stay in blood for a long time while having no effect on cognitive ability. According to NHTSA (2018), in 2006 only eight percent of fatality injured drivers were tested positive for marijuana. In 2016, NHTSA found that 18% of fatally injured drivers were tested positive for marijuana use. This shows that driving under influence of marijuana is becoming more common.

Alcohol and marijuana are the most commonly used drugs in the world. In 2018, 139 million Americans over the age of 12 reported that they have consumed alcohol in the last month and 43 million people have used marijuana in the past year (SAMHSA, 2020). However, it is unclear if individuals who use alcohol together with or separate from marijuana. Since the legalization of marijuana, there have been multiple researchers studying whether marijuana is a complement or substitute for alcohol and there are mixed results from different researches (Subbaraman, 2016). Given that recreational use of alcohol is legal, is the most used recreational drug in the world, and one of the key factors for car accidents and car accident fatalities, does the legalization of recreational marijuana impact the number of drunk driving fatalities.

### **Literature Review:**

There are many reasons for and against the legalization of marijuana, and there are many studies that support or reject these arguments. One of these arguments is whether marijuana is a complement to alcohol. There have been numerous studies and different approaches conducted in support of marijuana being both substitute and complementary to alcohol. One of these approaches was examining price changes where researchers examined the effect of the state-level alcohol tax change on alcohol and marijuana consumption levels (Pacula, 1998). Increasing the beer tax did have a big negative impact on the consumption of marijuana. The study showed a complementary relationship between alcohol and marijuana. Another approach to study the relationship between marijuana and alcohol was a survey that was conducted in Norway on people aged 14-20 that showed that more than 80% of marijuana consumers consumed marijuana together with alcohol (Pape, 2008). Thus, supporting the complementary relationship of marijuana with alcohol.

As stated above, not all studies support the complementary relationship between marijuana and alcohol. In 2001, DiNardo and Lemieux studied alcohol and marijuana consumption level after the

drinking age was changed from 18 to 21 in select states. This policy change decreased alcohol use by a substantial amount but increased the use of cannabis. In addition to this similar study found that in states where the drinking age is 21, the probability of marijuana use at the age of 21 compared to 20 sharply decreased by 20% where the probability of drinking increased from 60 percent to 70 percent (Crost et al, 2012).

There have also been few papers that study the legalization of marijuana on alcohol-related fatalities. Anderson et al., (2013) focus on the legalization of medical marijuana and the effects on traffic fatalities and alcohol consumption across the United States. The article concludes that the legalization of medical marijuana and its impact on prices of high-quality marijuana has resulted in fewer traffic fatalities among young adults even though the majority of medical marijuana was prescribed to people who were 40 years old or older. After the legalization of marijuana in various states, traffic fatalities have dropped by 7.2% for accidents that involved at least one drunk driver for people aged 20-29 in states that legalized recreational marijuana. However, this finding was not statistically significant at a conventional level. For teenagers and for people who are over 40 years old, the study did not find any changes in traffic fatalities.

Another article shows early evidence of recreational marijuana legalization and its effect on traffic fatalities by using synthetic control methods. In this study, the authors find an upward trend in marijuana-related fatalities and a downward trend in alcohol-related fatalities in Colorado and Washington. However, the author finds similar trends in synthetic states with similar effects. Therefore, synthetic control did not find any distinct changes between actual and synthetic states in the short term (Hansen et al., 2018). The article uses only one year period of data post-legalization. This means that Hansen only studied the effect of the legalization of marijuana for only 1 year post-legalization. Unfortunately, there has been no exploration of the effect of the legalization of marijuana on alcohol-related traffic fatalities in longer terms (more than 1 year) by using synthetic control.

## **Data and Methodology:**

### **Research Design:**

The analysis in this paper was conducted by using the Synthetic Control Method. Synthetic Control Method (SCM) is one of the new methods that is used to evaluate the effect of the intervention in a comparative case study. In a comparative case study, we compare multiple cases with a policy change to multiples of other cases without a policy change. For SCM we simplify this by taking only one unit where there was a policy change and analyze that unit to a weighted average of other units with no new policy implementation (Abadie et al, 2010). SCM involves constructing combinations of multiple groups of controlled cases, where this combination very closely resembles the treated case before the policy implementation. Unlike difference in difference approach where policy implementation is a dummy variable and shows by how much effect it has on the dependent variable, SCM models show us how the dependent variable changes over time after the policy in effect. In addition to that, we could not use a case study since there was no other state that would resemble Colorado very closely. Neighbor states of Colorado (Wyoming, Nebraska, New Mexico, and others) also have very different demographics from Colorado. Table 1 below shows different characteristics of Colorado and its neighboring states.

For our study, Colorado is a treatment state and recreational marijuana was legalized in Colorado at the very end of 2012. Therefore, I decided to use 2013 as my treatment time. Synthetic Colorado represents a hypothetical state similar to Colorado where recreational marijuana is not legalized, and it did not affect alcohol-related fatal accidents.

### **Data:**

For this study, I used 10 years of pre recreation marijuana legalization and 6 years of post marijuana legalization. It is possible to use data from further periods in order to enhance this study since more data on the pre-time period increases the robustness of the results (Abadie et al, 2010). Given the

availability of data, predictors used to create synthetic Colorado in this study were unemployment rate, log of GDP per capita, health expenditure, population density, the speed limit in highways, the average number of cars per person, percent of population's sex, age, race demographics and education level in each state. There are other predictors more relevant that can further help the model with predictions (Bharadwaj, 2019). The crime rate, road conditions, state driving laws are a few of the examples that might help this model very much, but I could not use them in my model due to lack of the data availability.

For this study, data on state-level fatal accidents were derived from the Fatality Analysis Report System (FARS). This is individual-level data from every car accident that resulted in at least one fatality. This data has a day of the fatality and whether alcohol was consumed by drivers. Using this data I derived state-level data of alcohol-related fatalities from 2002 to 2018. In addition to this data, the state unemployment rate and GDP per capita were taken from St.Louis' Federal Reserve database. Population demographics were calculated from the Census Bureau of the United States. Health Expenditure per person extracted from the Center for Medicare and Medicare Services. Statewide speed limit from Insurance Institute of Highway Safety. Other additional data was taken from the Integrated Public Use Microdata Series.

## **Results:**

Since the car making industries are getting more and more competitive, manufacturers are making their cars safer to drive every year. In addition to that, road regulation and safety also contributed to reducing fatal car accidents. Mayhew et al found that between 1975 and 1998 alcohol-related fatal accidents “decreased similarly for men and women (about 40%)” drivers accounting for miles driven in the road. From figure 1, we can see that the trend for the United States and Colorado state is going down in general from 2002 to 2018.

The alcohol-related fatal accident rate was dropping in Colorado much faster than in the U.S, however, in 2013 it started trending upwards unlike the U.S's alcohol-related fatal accident rate trend. Since we are comparing one state to the whole country, we cannot conclude that legalization of recreational marijuana caused this break in trend since there are major differences in demographics. In addition to that, the average alcohol-related fatal accident rate for the USA is greater than in Colorado. In order to evaluate how Amendment 64 affected alcohol-related fatal accidents, we need to know what Colorado's alcohol-related fatal accident rate would be if they had not legalized recreational marijuana. In order to do this, we will use the Synthetic Control Method. As stated above, SCM is one of the best methods to evaluate policy change in one place. Synthetic Colorado was created from the combination of donor states that did not legalize recreational marijuana as of 2013 and that best resemble Colorado before the legalization of marijuana. These states are Arizona, Kansas, Michigan, New Hampshire, New Mexico, Texas, Utah, Virginia, and Wyoming. All the other states were assigned zero weight.

In addition, states that were used to make synthetic Colorado, in table 2 you can see states that were used to make synthetic Colorado for Hansen's paper about how legalizing recreational marijuana in Colorado affected alcohol related accident rates. As one can see, Hansen's and this paper's synthetic Colorado differs a lot since different states were used to make it. This is because Hansen used very different predictors to make synthetic Colorado. He used "Fraction Urban, Drug Test Rate, Vehicle Miles Traveled (VMT), and Unemployment Rate". Another reason for this is because Hansen uses alcohol related fatalities per VMT where this paper uses alcohol related fatalities per 100,000 people.

Predictors that were used to create synthetic Colorado are displayed in the table below. Table 3 compares the alcohol-related fatality rate and average values of characteristics of real Colorado to synthetically generated Colorado and all other states in the donor states before 2013 where the Amendment 64 was passed. This table underlines a "very important feature of synthetic control, namely, safeguarding against counterfactuals that fall far outside the convex hull of the data" (King and Zheng 2006, Abadie et al., 2010).

Figure 2 displays the alcohol-related fatality rate of Colorado to the synthetically generated Colorado from 2002 to 2018. Unlike Figure 1, where we compared the average of control states to Colorado, in Figure 2 it can be observed that Synthetic Colorado very closely follows the path of real Colorado's alcohol-related fatal accident rate before the legalization of recreational marijuana. Combined with the balance of predictors (Table 3) and the graph (Figure 2), synthetic control, indeed, provides a very accurate approximation to the alcohol related fatal accident rate of Colorado if it did not legalize marijuana in 2012. In addition to that, RMSPE which is the root mean squared error for our model is .548. This implies that synthetically generated Colorado fits very well in our model to compare to real Colorado.

Notice that after the legalization up until 2015 fatality rate does not differentiate a lot between synthetic and real Colorado. This supports the findings of Hensen et al.'s where he found no difference in alcohol-related fatal accident rates after the legalization of marijuana in the short term. However, based on Figure 2, there is a divergence between synthetic and real Colorado. Synthetic Colorado's fatal accident rate has a sharp downward trend, where actual Colorado's goes up. Differences between these two lines suggest that the effect of the legalization of recreational marijuana increases alcohol related fatal accident rate. In 2013 up until 2015 there was almost no difference between the two Colorados but in 2018 there is a greater than 30% difference in the alcohol-related fatal accident rate.

In order to be sure that my estimates are accurate and not driven by chances, similar to Abadie et al.(2010) and Bharadwaj (2019), I ran a placebo test to other states that were in my donor groups. These donor states are the states that did not legalize recreational marijuana before 2018. In order to run the placebo test, I applied SCM to all the donor states individually and after that, I took the difference between synthetic and actual states. I then plotted these differences in one graph. If the difference in alcohol-related fatal accident rate between actual and synthetic Colorado is greater than other states after 2013, this means that our results are significant and not driven by chance. However, if it is similar to other states and does not have differences between other donor states, this means that our results are actually not significant. Figure 3 displays this graph below.

In this graph, the orange line represents the difference in alcohol-related fatal accident rate between actual and synthetically generated Colorado. Other lines that are colored by light gray is the gap between multiple synthetic and actual donor states. In Figure 3 you can see that there is a lot of wobble before legalization of marijuana. This is due to the volatility or rapid changes between alcohol-related fatal accident rates from one year to another.

The gap between real and synthetic Colorado does not seem very distinct from other states after the legalization of marijuana. Even though the majority of the states had lower or negative differences between real and synthetic states, many states have very similar or greater increases in alcohol related car accident fatalities. This indicates that there is a possibility that my findings were driven by chance and not significant.

## **Conclusion:**

Every year there are fewer and fewer people dying because of car accidents (Mayhew et al., 2003). In addition to that, alcohol related fatalities also have been dropping nationwide. From 2002 to 2018 there was more than a 50 percent drop in alcohol related car accident fatalities in the United States. In 2002 more than 7 people per 100,000 died in alcohol related car accidents where in 2018 this dropped to less than 3.5 people. However, in recent years we see an increase in alcohol related car accident fatalities in the state of Colorado. In just 3 years, from 2015 to 2018, there was more than a 30% increase in alcohol related fatalities.

The result of this study suggests that the legalization of marijuana may increase the number of drunk driving accident fatalities and that marijuana and alcohol are compliments. However, it should be noted that there was almost no effect on alcohol related car accident fatalities in the first two years after the legalization of recreational marijuana. This supports Hansen, Miller, and Weber's finding that legalization of marijuana has little effect on alcohol related accidents in the short term (1-2 years).

## **References:**

Abadie A, Diamond A, and Hainmueller J. “Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California’s Tobacco Control Program.” *Journal of the American Statistical Association* 105 (2010): 493-505

Anderson DM, and Rees DI. Medical marijuana laws, traffic fatalities, and alcohol consumption. Bonn, Germany: Forschungsinstitut zur Zukunft der Arbeit (Institute for the Study of Labor); 2011.

“Alcohol, Tobacco, and Other Drugs.” *SAMHSA*, 2020,

“Article VI Section 2: Constitution Annotated: Congress.gov: Library of Congress.” Web.

Bharadwaj R. “The Impact of Legalization of Marijuana on Opioid Overdose Deaths.” *Academic Works*, 1 February 2019

Bloch S. “Drugged Driving: Marijuana-Impaired Driving.” *Drugged Driving | Marijuana-Impaired Driving*, National Conference of State Legislatures, 2020

Cole JM. “Memorandum For All United States Attorneys.” *Justice*, 29 August 2013

Colorado Official State Web Portal. “Laws about Marijuana Use.” *Colorado Marijuana*, 16 August 2016

Crost B, and S Guerrero. “The Effect of Alcohol Availability on Marijuana Use: Evidence from the Minimum Legal Drinking Age.” *Journal of Health Economics* 31 (2012):112–121

DiNardo J, and Lemieux T. “Alcohol, Marijuana, and American Youth: The Unintended Effects of Government Regulation.” *Nber*, Nov. 1992

Hansen B, Miller K, and Weber C. “Early Evidence on Recreational Marijuana Legalization and Traffic Fatalities.” *Static1 Squarespace*, February 2018

King, G., and Zheng, L. (2006), “The Dangers of Extreme Counterfactuals,” *Political Analysis*, 14 (2), 131–159

National Highway Traffic Safety Administration. “Drunk Driving.” *NHTSA*, 2020

National Highway Traffic Safety Administration. “Drug-Impaired Driving Quick Facts.” NHTSA, 2018

Mayhew DR, Ferguson SA, Desmond KJ, and Simpson HM. “Trends in Fatal Crashes Involving Female Drivers, 1975–1998.” *Accident Analysis & Prevention*, Pergamon, May 2003

Substance Abuse and Mental Health Service Administration. *Find Help: ATOD*. 2020

Pacula RL. “Does Increasing the Beer Tax Reduce Marijuana Consumption?” *Journal of Health Economics*, North-Holland, 25 November 1998

Patrick ME, Schulenberg JE, O’malley PM, Johnston LD, and Bachman JG. “Adolescents' Reported Reasons for Alcohol and Marijuana Use as Predictors of Substance Use and Problems in Adulthood.” *Journal of Studies on Alcohol and Drugs*, Rutgers University, January 2011

Pape H, Rossow I, Storvoll E . “Under Double Influence: Assessment of Simultaneous Alcohol and Cannabis Use in General Youth Populations.” *Drug and Alcohol Dependence* 101 (2009): 69–73.

Subbaraman MS. “Substitution and Complementarity of Alcohol and Cannabis: A Review of the Literature.” *Substance Use & Misuse*, U.S. National Library of Medicine, 18 September 2016

**Tables:**

Table 1: Colorado vs Neighboring States

	Colorado	Arkansas	Kansas	Nebraska	New Mexico	Oklahoma	Utah
White	0.70	0.74	0.78	0.82	0.40	0.68	0.8
Black	0.04	0.15	0.05	0.04	0.02	0.07	0.01
Hispanic	0.21	0.07	0.11	0.1	0.47	0.09	0.13
Female	0.498	0.510	0.504	0.504	0.506	0.505	0.498
Age 0-15	0.219	0.217]	0.226	0.225	0.227	0.221	0.281
Age 16-30	0.214	0.205	0.210	0.211	0.210	0.213	0.256
Age 31-45	0.220	0.197	0.196	0.195	0.193	0.195	0.193
Age 46-60	0.205	0.196	0.198	0.197	0.201	0.197	0.154
Age 60-75	0.100	0.125	0.105	0.108	0.1177	0.118	0.080
College Degree	0.39	0.22	0.32	0.31	0.27	0.25	0.33
Population Density	46.27	53.37	33.94	23.12	16.30	52.09	30.52
Unemployment Rate	6.1	6.4	5.5	3.8	5.9	5.1	5.2
State Speed Limit	65	65	75	70	75	70	65
Car Per Person	0.33	0.28	0.33	0.38	0.32	0.35	0.29
Income per Capita	39820.18	30035.27	36603.54	37947.27	30981.72	33947.91	30852.36
Health Expenditures per Person	5396.63	5673.00	6228.09	6552.45	5506.45	5888.64	4685.27

Table 2: State Weight of Synthetic Colorado

<b>State</b>	<b>Unit Weight</b>	<b>Hansen's</b>
Arizona	.507	.308
Montana	.043	0
Hawaii	.048	0
New Mexico	.050	0
Utah	.073	0
Virginia	.233	0
West Virginia	.045	0
Florida	0	.107
Minnesota	0	.147
New Hampshire	0	.134
Rhode Island	0	.178
South Dakota	0	.127
<b>Total</b>	1	1

Table 3: Predictor Means

	Colorado	Synthetic Colorado	Average of Control States
Percent of population that is:			
White	0.70	0.61	0.78
Black	0.04	0.08	0.11
Hispanic	0.21	0.22	0.10
Female	0.498	0.503	.507
Age 0-15	0.219	0.221	0.215
Age 16-30	0.214	0.21	0.208
Age 31-45	0.220	0.204	0.202
Age 46-60	0.205	0.193	0.203
Age 60-75	0.100	0.117	0.115
College Degree	0.39	0.31	0.30
State Characteristics:			
Population Density	46.27	91.42	166.59
Unemployment Rate	6.1	6.09	6.09
State Speed Limit	65	66.18	66.19
Car Per Person	0.33	0.34	0.36
Ln (Income per Capita)	10.59	10.46	10.51
Ln (Health Expenditures per Person)	8.59	8.59	8.75

**Figures:**

Figure 1: Colorado vs United States on Alcohol Related Fatalities

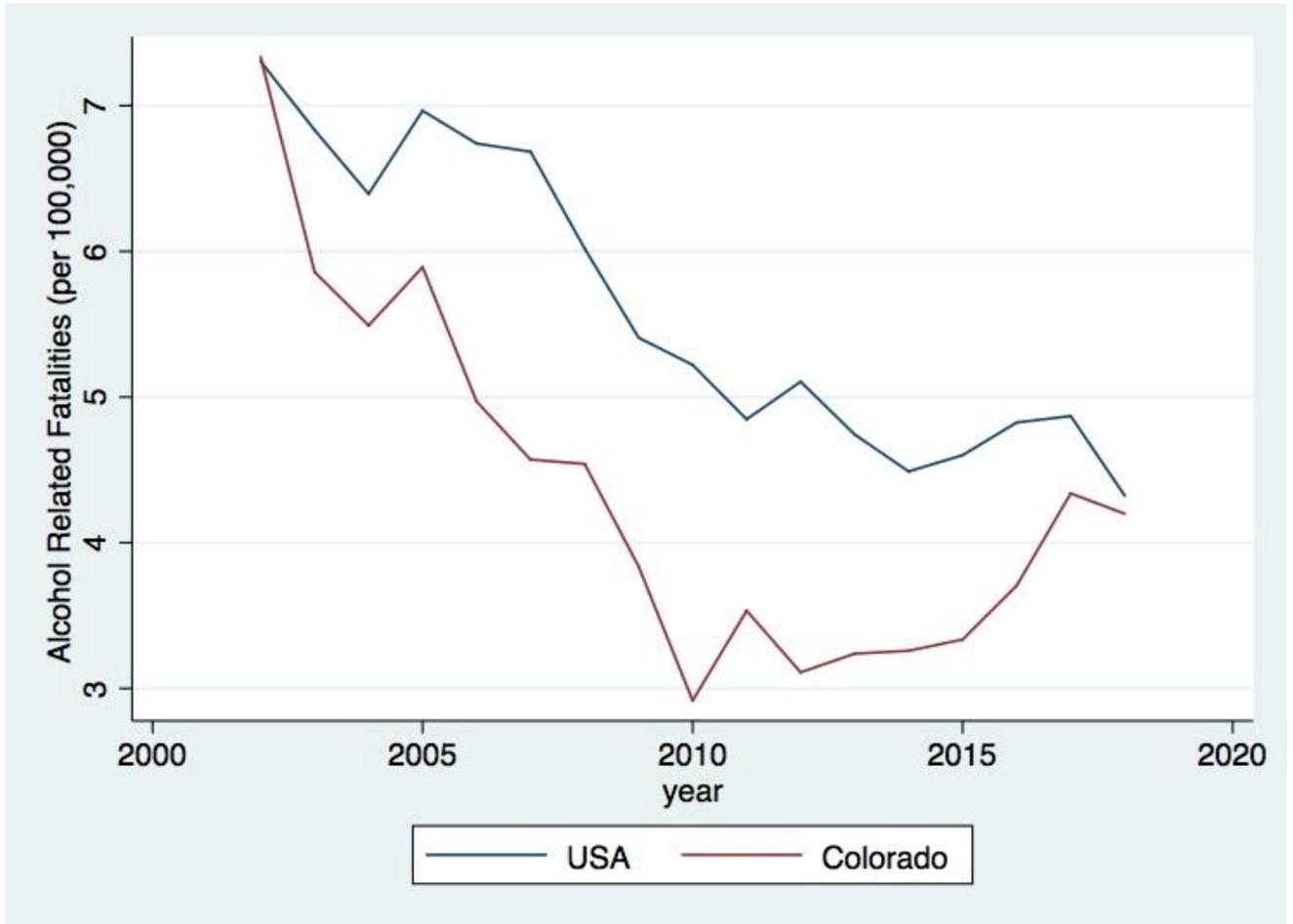


Figure 2: Real vs Synthetic Colorado

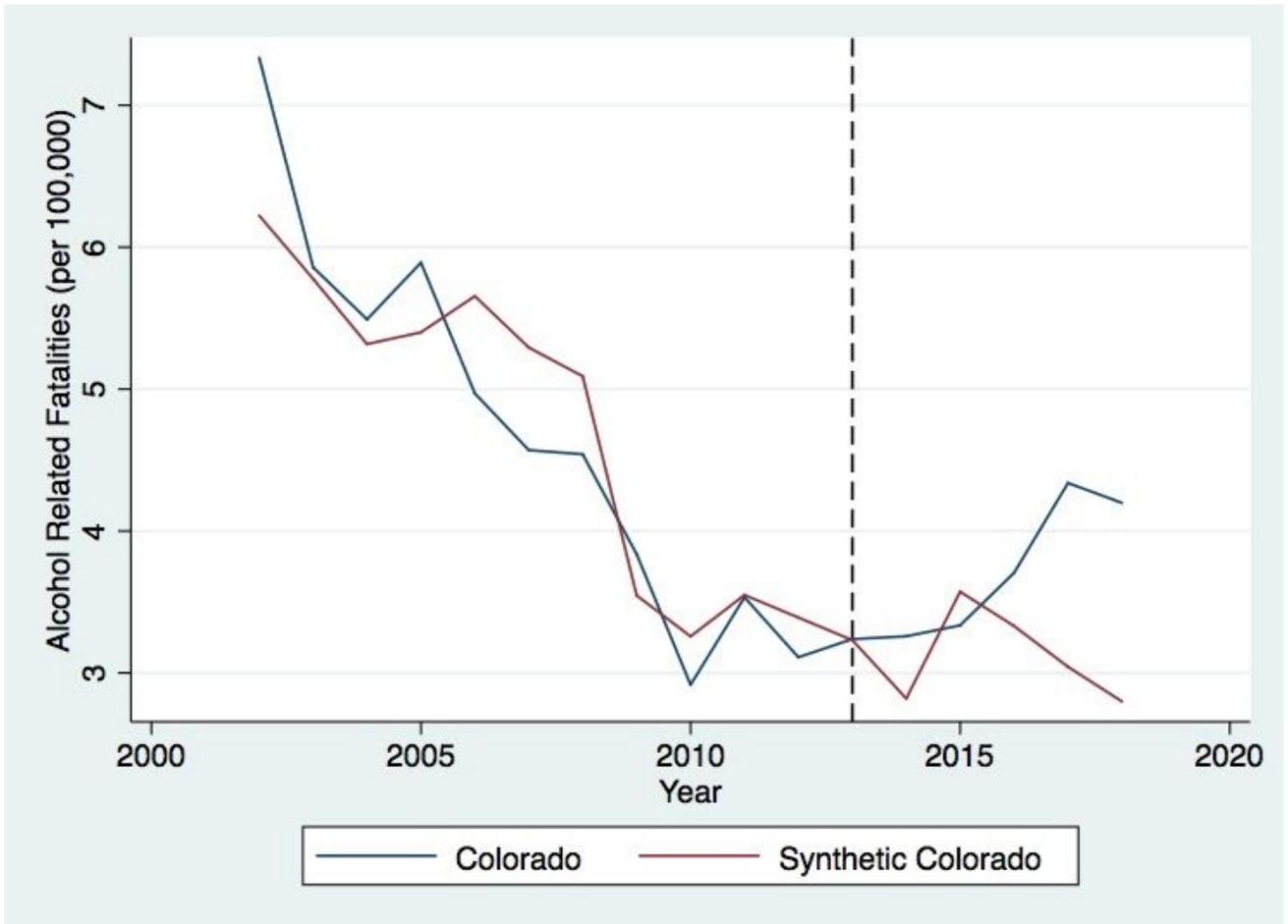


Figure 3: Gap Between Real and Synthetic States, Placebo Effects

