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The Impact of Legalization of Marijuana on Opioid Overdose Deaths

by

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Abstract

This masters' thesis aims to examine the impact of the legalization of marijuana for recreational use on the death toll from opioid misuse in the state of Colorado. This investigation was done using the Synthetic Controls Method via data collected primarily from the CDC and IPUMS databases. The results indicate that the 2012 legalization policy in Colorado appears to reduce the number of deaths due to opioid overdoses.

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Introduction

Policy Background

One of the many issues at the forefront of the United States' political landscape presently is the debate over the legalization of marijuana. Cannabis was classified as a Schedule I drug in the United States under the Controlled Substances Act of 1970 because it was considered to have no accepted medical use. In 2009 however, the American Medical Association (AMA) adopted a stance urging the federal government to review the case for rescheduling marijuana, stating that doing so would "facilitate research and development of cannabinoid-based medicine" (AMA, 2009). Oregon was the first state in the country to decriminalize marijuana in 1973; but it wasn't until 1996 that legalization policies were enacted. Between the years 2000 to 2011, twelve states voted for the legalization of medical marijuana. However, as federal laws still classified marijuana as illegal, individuals could be indicted for consuming and possessing the drug. In 2012, Colorado became the first state to legalize recreational marijuana through Amendment 64. Washington state closely followed it, and since then, eight states as well as the District of Colombia have legalized it for recreational use (although some states still prohibit sales for recreational purposes). A vast quantity of literature exists pertaining to the pros and cons of legalizing marijuana usage via analyses conducted in the fields of criminology, sociology, and economics, among others. Several studies show that there are marked differences between medical and recreational marijuana strains, primary of which being that medical marijuana contains a higher Cannabidiol (CBD) content;

whereas the latter, a higher content of Tetrahydrocannabinol (THC)[1]. Is it to be noted that investigation has shown that THC content is the factor that seems to provide pain relief. The second key distinction is that individuals need to have a qualifying condition in order to obtain a medical marijuana recommendation (to be renewed on a regular basis) by a physician; while on the other hand, recreational marijuana can be bought by any adult. Given these factors, this paper focuses on recreational marijuana in order to study the impact of its legalization on the number deaths from opioid misuse.

Motivation

The latest reports by the Centers for Disease Control (CDC) show a substantial proportion of the American population overdosing on opioids in recent times; leading to this misuse (of opioids) being classified as a national crisis. As opioids are drugs that are generally prescribed for chronic pain, their usage, therefore, cannot be entirely stopped. The US Department of Health and Human Services (HHS) claims that over a hundred and thirty people a day die from opioid-related drug overdoses[2]. The Colorado Consortium for Prescription Drug Abuse Prevention also estimates that opioid overdoses result in three hundred deaths per year in Colorado[3]. It has been found that about twenty-nine percent of patients who were prescribed opioids for chronic pain misuse them (Vowles et al., 2015); and that about eighty percent of people who use heroin illegally first misused prescription opioids (Muhuri et al., 2013). A recent paper by Alpert et al., (2018) published in the *American Economic Journal: Economic Policy* focuses on the increase in heroin overdoses across the U.S. The authors believe that, around 2010, there was a sizeable shift from the abuse of

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[1] See: Atakan Z. (2012), Lafaye, G. et al. (2017), https://www.health.harvard.edu/staying-healthy/medical-marijuana-know-the-facts
[2] https://www.hhs.gov/opioids/
[3] http://www.corxconsortium.org/

prescription opioids to heroin abuse due to the reformulation of the drug OxyContin which made it harder to crush and dissolve. They also observed that the states that saw a large volume of existing users switch from the reformulated OxyContin to heroin in the short run, had in fact previously recorded high rates of OxyContin misuse. The paper concludes that such supply-side disruptions may lead to an increase in substitutes across opioid-drug types rather than reductions in overall opioid overdoses. In light of such alarming figures, the National Institutes of Health (NIH), in order to help solve the opioid crisis and prevent opioid misuse, has deemed necessary the determination of innovative and healthier strategies to manage chronic pain[4]. While there are no marijuana-based products for pain relief approved by the United States Food and Drug Administration (FDA) currently, informal evidence exists suggesting that marijuana may in fact help ease certain types of chronic pain; thus making it a good focus for this study.

Evaluation

The analysis in this paper is conducted using the Synthetic Controls Method (SCM), which is one of the latest popular methods[5] used for evaluating public policy. This is because it delivers a quantifiable backing for specific case-studies by generating a "synthetic control region". This hypothetical counterfactual region, generated using statistical software, simulates what the outcome path of the state would look like if it had not undergone a particular policy intervention; i.e. the trend that the opioid-related death rates would have followed in Colorado if not for Amendment 64. This method was carried out by taking the weighted average of pre-legalization opioid-related death rates from a list of "control" states. The states forming the synthetic control

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[4] https://www.nih.gov/research-training/medical-research-initiatives/heal-initiative
[5] Check: Abadie A. et al. (2010), Billmeier A. & Nannicini T. (2013), Abadie A. & Gardeazabal J. (2003)

were selected from the U.S. states that had not legalized marijuana for recreational use during the investigative timeline. The affected state (in this case, Colorado) and its synthetic control counterpart were then used to study the policy's effectiveness i.e. how the legalization of marijuana for recreational use impacts the opioid-related death rate in the state.

Literature Review

There is a strong rhetoric for both the positive and the negative sides of the marijuana legalization debate. Furthermore, there are a large number of articles that seek to examine the effect of the legalization policies and their potential association with opioid use. There is no doubt however, that nearly all of the studies agree on the fact that diminishing the dependence on opioids is an enormous undertaking, and that this reduction in opioid use must be substituted with alternative treatments. The prevailing public opinion in favor of legalizing marijuana, in combination with federal guidelines mandating the limited use of opioids could indeed lead to self as well as prescribed substitutions of marijuana for opioid use (Choo EK et al., 2016). A study by Hill and Saxon published in The Journal of the American Medical Association (JAMA) analyzing more than five years of opioid prescription data discovered that post-legalization, the quantity of prescriptions decreased substantially; establishing that there was a rampant shift away from opioid to marijuana consumption (Hill KP & Saxon AJ, 2018). However, this study could not establish if this move was spearheaded by the patients or by the physicians. There appear to be numerous studies that center on examining the link between medical marijuana legalization and opioid overdose deaths; but fewer that focus on recreational marijuana use due to lack of data and opportunity for research. This has led to emerging concerns that while medical marijuana use may indeed be a good substitute for prescription opioid use, the use of recreational marijuana may in

fact be an accelerant for prescription opioid misuse, making it paramount to understand and look into the impact of recreational marijuana laws on opioid consumption levels. The paper by Yuayn Shi et al. explores this concern. The authors use state-level quarterly prescription drug utilization records for Medicaid enrollees with the aid of difference-in-difference models to conclude that there was no evidence that recreational marijuana legalization increased the number of prescription opioids; but the policy did reduce the consumption of Schedule III[6] opioids in some states following the legalization. A related study focusing on recreational marijuana is by Melvin D. Livingston et al. (2017). The paper makes use of an interrupted time-series design for the time period 2000 to 2015 in order to compare the changes in monthly opioid-related deaths before and after the policy. According to the study, after the legalization of marijuana for recreational use in Colorado, opioid-related deaths decreased by approximately 0.7 deaths per month. However, there have been no studies so far that have employed the SCM to study the effects of this legalization policy; and this analysis, precisely, is what this particular paper endeavors to accomplish.

Data & Implementation

Research Design

The investigative timeline was set from 1999 to 2016, on account of available data. This period of interest for the study ensured that there were seventeen years of data prior to the enactment of the legalization policy. It would have enhanced this study significantly if a larger sample of pre-intervention data were available for analysis, thus ensuring a higher degree of robustness with respect to the results (Abadie et al., 2010). To begin, the appropriate covariates

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[6] Substances that have less potential for abuse than substances classified as Schedules I or II

that would possibly have a significant impact on the opioid overdose death rates were identified. Given the availability of data, the final list of predictors used were per capita income, unemployment rates, the state's expenditure on health as a percent of GDP, age distribution of the population, sex composition of the population, the population's race make-up, and the educational levels of the population. There is scope for the addition of more relevant predictor variables such as state crime rates, industry-composition of the state, and so on which could further enrich the model. This task, however, was limited due to lack of available data. Next, the donor states that would help synthesize the control state were established. The synthetic state is constructed as a weighted average of potential control states, chosen such that the resulting synthetic state best reproduces the values of the predictors before the legalization of marijuana for recreational use. Because the synthetic state is meant to reproduce the opioid overdose death rates that would have been observed for the control state (Colorado) in the absence of this legalization policy, the state of Washington was excluded from the list of donor due to a similar policy being enacted in the considered time frame.

Data Sources & Collection

Primarily, the comprehensive mortality information contained in the CDC database for different opioid classifications was used to collect data on the death rates. CDC data is collected on natural opioids (morphine and codeine), semi-synthetic opioids (oxycodone, hydrocodone, hydromorphone, and oxymorphone), synthetic opioids (methadone, tramadol, and fentanyl), as well as heroin, an illegal opioid synthesized from morphine. Opioid overdose deaths (age-adjusted) were acquired from the 'CDC WONDER' database using the 'Mortality Files'[7] for the time period

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[7] https://wonder.cdc.gov/mcd.html

1999 to 2016. Drug overdose deaths were defined according to the 10th revision of the International Statistical Classification of Diseases i.e. ICD-10 codes (which included the following categories: X40-X44, X60-X64, and Y10-Y14); in addition to specifically opioids (which included the following categories: T40.1-T40.4). Data on state unemployment rates and state health expenditure for the same time period was collected from the Bureau of Labor Statistics (BLS)[8]. Additionally, data on states-wise demographics such as age, sex, marital status, per capita income, and educational level was amassed from the Integrated Public Use Microdata Series (IPUMS)[9].

Results

From Figure 1 below, it can be observed that the trend of opioid-related overdose death rates in Colorado and the rest of the United States appear to progress on a similar path.

And in order to evaluate the effect of the 2012 legalization policy of marijuana for recreational use on the aforementioned death rates in Colorado, the fundamental question that arises is: How to determine what path these opioid-related death rates would have followed in Colorado in the absence of the recreational marijuana legalization policy?

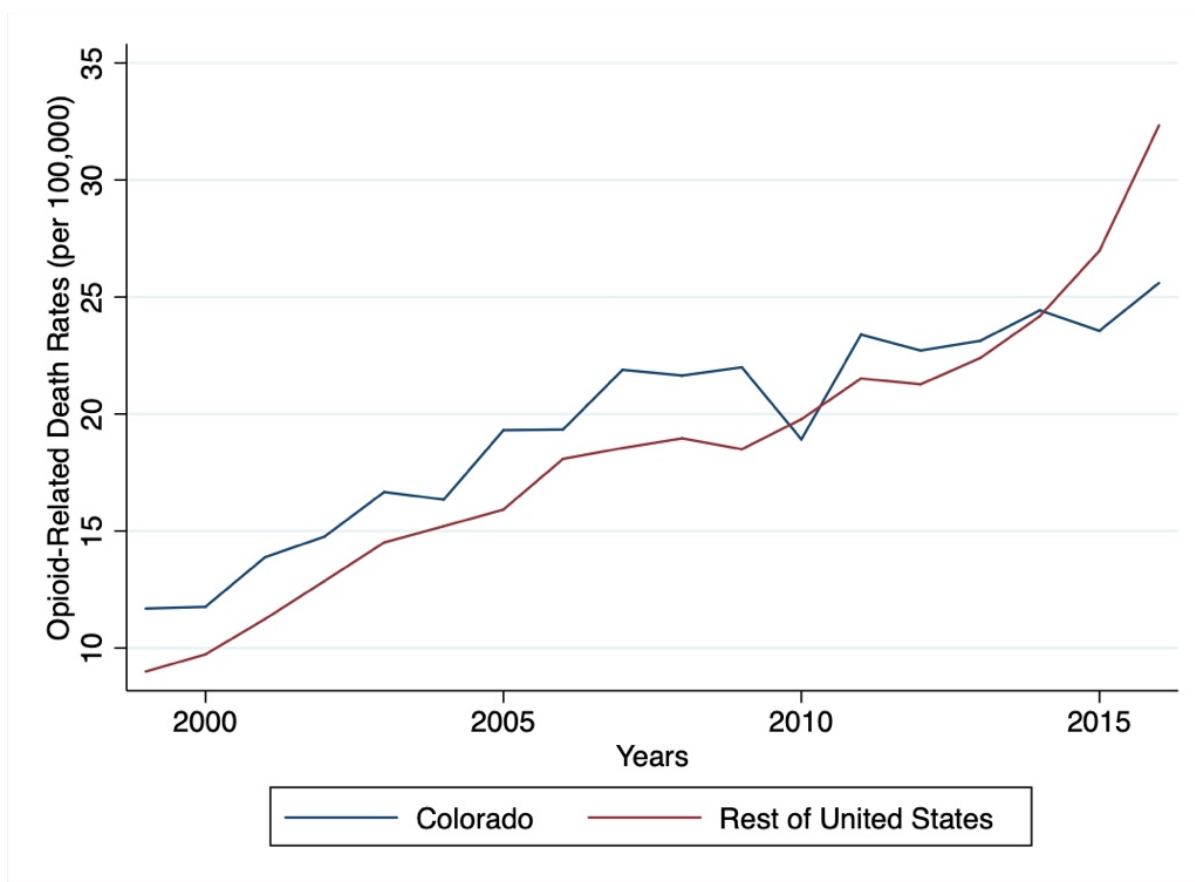[8] https://www.bls.gov/data/
[9] https://usa.ipums.org/usa/

Figure 1

Like discussed above, the synthetic control method provides the best and most systematic way to estimate this counterfactual. Synthetic Colorado was constructed as a "convex combination" of the states in the donor pool that most closely resembled Colorado in terms of pre-legalization values of the relevant predictors. The following table displays the weights of each control state in the synthetic Colorado. The weights reported in Table 1 indicate that the opioid-related death trends in Colorado prior to the legalization of marijuana for recreational use is best reproduced by a combination of the states of Alaska, Arizona, Massachusetts, Nevada, New Hampshire, Utah, and Virginia. All the other states present in the donor pool were assigned zero weights.

Table 1: State Weights in the Synthetic Colorado

State	Weight
Alaska	0.097
Arizona	0.003
Massachusetts	0.081
Nevada	0.158
New Hampshire	0.117
Utah	0.173
Virginia	0.371
Total	1

The ensuing results obtained from conducting this analysis are displayed below. Table 2 compares the pretreatment opioid-related death rates in addition to other characteristics of the actual state of Colorado with that of the generated synthetic Colorado, as well as with the average of the states in the donor pool. It can be noted that the SCM does indeed provide a counterfactual that can be accurately used for comparison with the treated state, Colorado.

On the other hand, the average values of the death rates in the states that did not implement the legalization policy in the investigative time period of 1999 to 2016 do not seem to provide a suitable control group for Colorado when compared to those generated by the formation of the synthetic state. Therefore, it can be said with confidence that synthetic Colorado provides a more accurate reproduction of the average values of the opioid related death rates that are present in actual Colorado. Consequently, the SCM can be used to precisely analyze what path the opioid-related death trends would have taken in Colorado in the absence of the legalization policy of 2012.

Table1: Predictor Means

Variables	Real Colorado	Synthetic Colorado	Average of Control States
Unemployment Rate	5.3	5.030723	5.6213501
Percent of Population Aged:			
15 to 24	0.1237172	0.1288234	0.1245
25 to 34	0.1306196	0.1232939	0.115556
35 to 44	0.1476538	0.1448169	0.138258
45 to 54	0.1579112	0.1506744	0.153121
55 to 64	0.1162098	0.1160114	0.122243
65 to 74	0.0690676	0.0710131	0.081441
Percent of Population that is:			
Unmarried	0.4009644	0.411242	0.398184
Married	0.4558596	0.447872	0.44894
Percent of Population that is:			
Hispanic	0.114054	0.0507353	0.052813
Black	0.0300854	0.0788065	0.091314
White	0.8612794	0.8058996	0.809114
Percent of population that completed:			
College	0.4409718	0.389926	0.363798
High School	0.2537287	0.2805422	0.308211
Percent of Population that is Female	0.5079817	0.5093697	0.615339
Ln(Per Capita Income)	14.51673	14.53484	14.4823
Health Expenditure as a percentage of GDP	0.1080769	0.1071338	0.1391821
Lagged Death Rate (2011)	23.3921	22.95417	21.527614
Lagged Death Rate (2006)	19.3347	19.64065	18.017618
Lagged Death Rate (2000)	11.7631	11.86461	9.6371611

This table emphasizes an important feature of synthetic control, namely, the ability to safeguard against estimation of "extreme counterfactuals that fall far outside the convex hull of the data" (King and Zheng 2006). The pre-intervention root mean squared prediction error for Colorado was found to be 0.7671137 (which is universally accepted as fairly small); indicating that the SCM is able to provide a good fit for the data at hand.

Accordingly, Figure 2 displays the trend of opioid-related death rates for Colorado and its synthetic counterpart during the time period 1999 to 2016. It can be seen that synthetic Colorado closely tracks the path of the opioid-related death rates variable in Colorado for the pre-legalization period suggesting that the synthetic Colorado could indeed provide a reasonable approximation to the number of opioid-related deaths from 2012 onwards in Colorado in the absence of the legalization policy. The two lines begin to diverge noticeably after the legalization went into effect and the real Colorado line seem to show a lower rate of increase when compared to the trajectory of the synthetic Colorado. The discrepancy between the two lines insinuates a negative effect of the legalization of marijuana for recreational use on the number of opioid-related deaths.
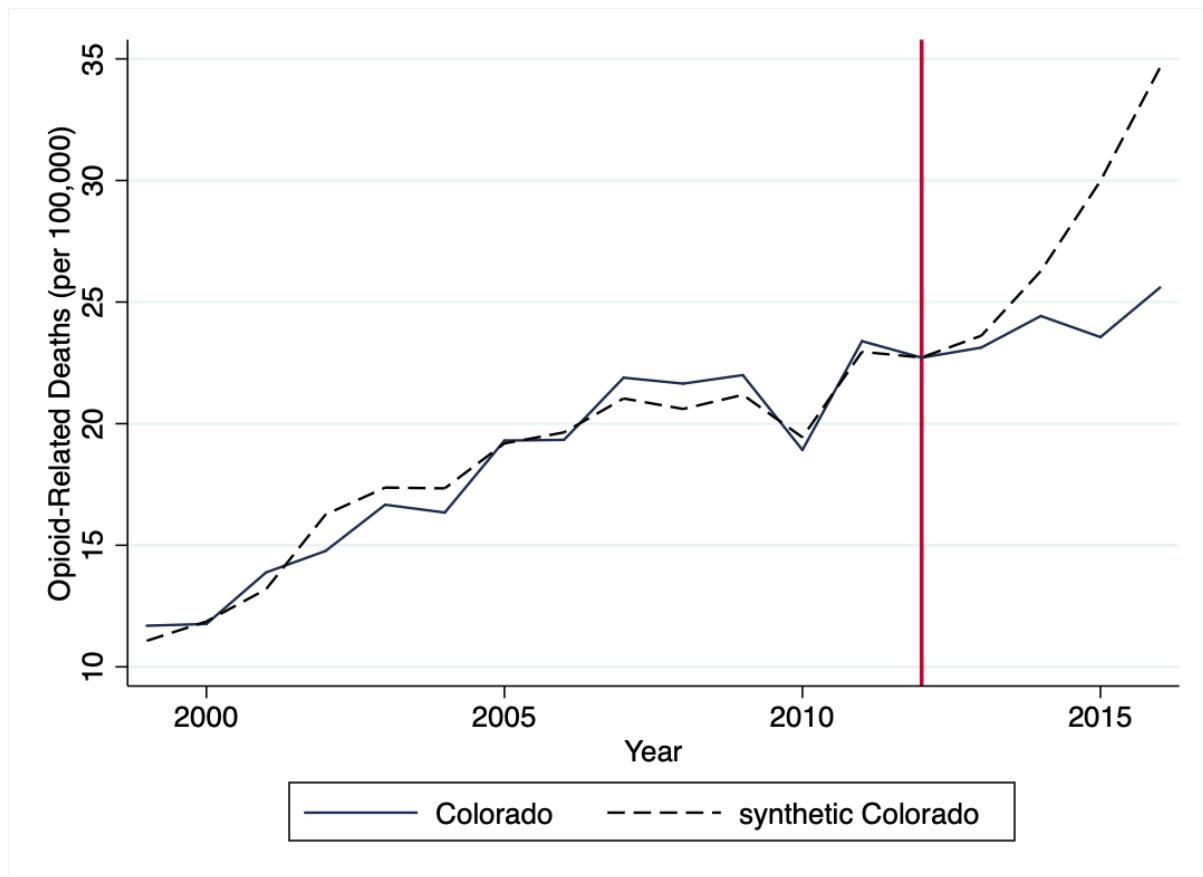

Figure 2

Furthermore, from Figure 3, it can be inferred that the legalization policy did indeed have a large negative effect on the number of opioid-related death rates. It can be observed that for the post 2012 timeframe, i.e., after the recreational legalization policy was enacted, the death rates due to opioid overdoses fell to almost 14 per 100,000 deaths.
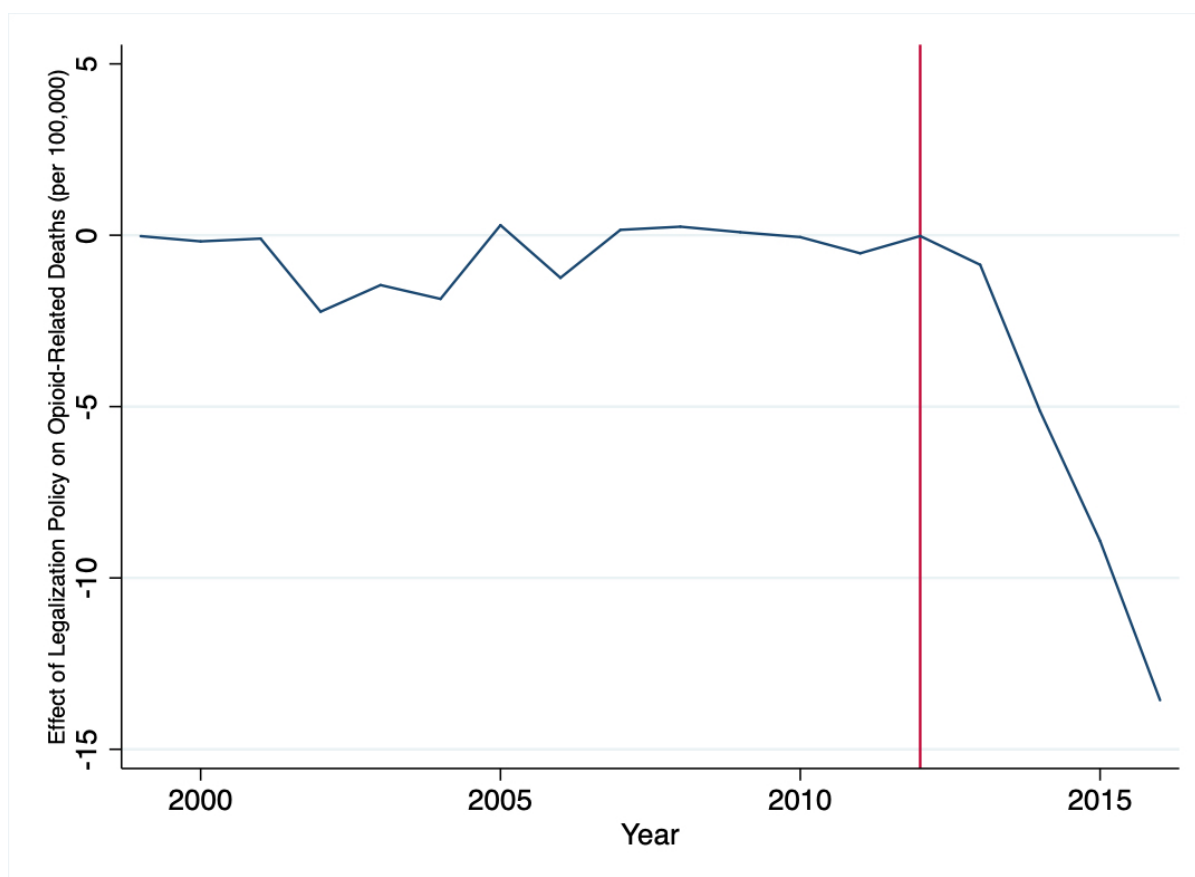

Figure 3

In order to evaluate the significance of the estimates, it is important to check the robustness of the results obtained and rule out the possibility that the resultant outcomes could be driven entirely by chance. Running placebo tests provided one way to answer appropriately the question of chance. The placebo test was run by first applying the SCM to the donor states i.e. those states that did not enact the policy of legalization of marijuana for recreational use during the sample period i.e. 1999 to 2012. If the placebo tests showed that the gap estimated for Colorado is large relative to the gaps

for the states that did not implement any legalization of recreational marijuana policy, then it could be concluded that the analysis provides significant evidence of a negative effect of the 2012 legalization policy on the deaths due to opioid overdose in the state of Colorado (Abadie et al., 2010). The series of placebo studies was constructed by iteratively applying the SCM used to estimate the effect of the 2012 legalization policy in Colorado to every other state in the donor pool. In each iteration, data was reassigned in order to enable investigation as if one of the states in the donor pool would have passed the 2012 legalization policy instead of Colorado. The estimated effect was then computed with each placebo run providing a distribution of estimated gaps for the states where no intervention took place. Figure 4 below displays the results for the placebo test.
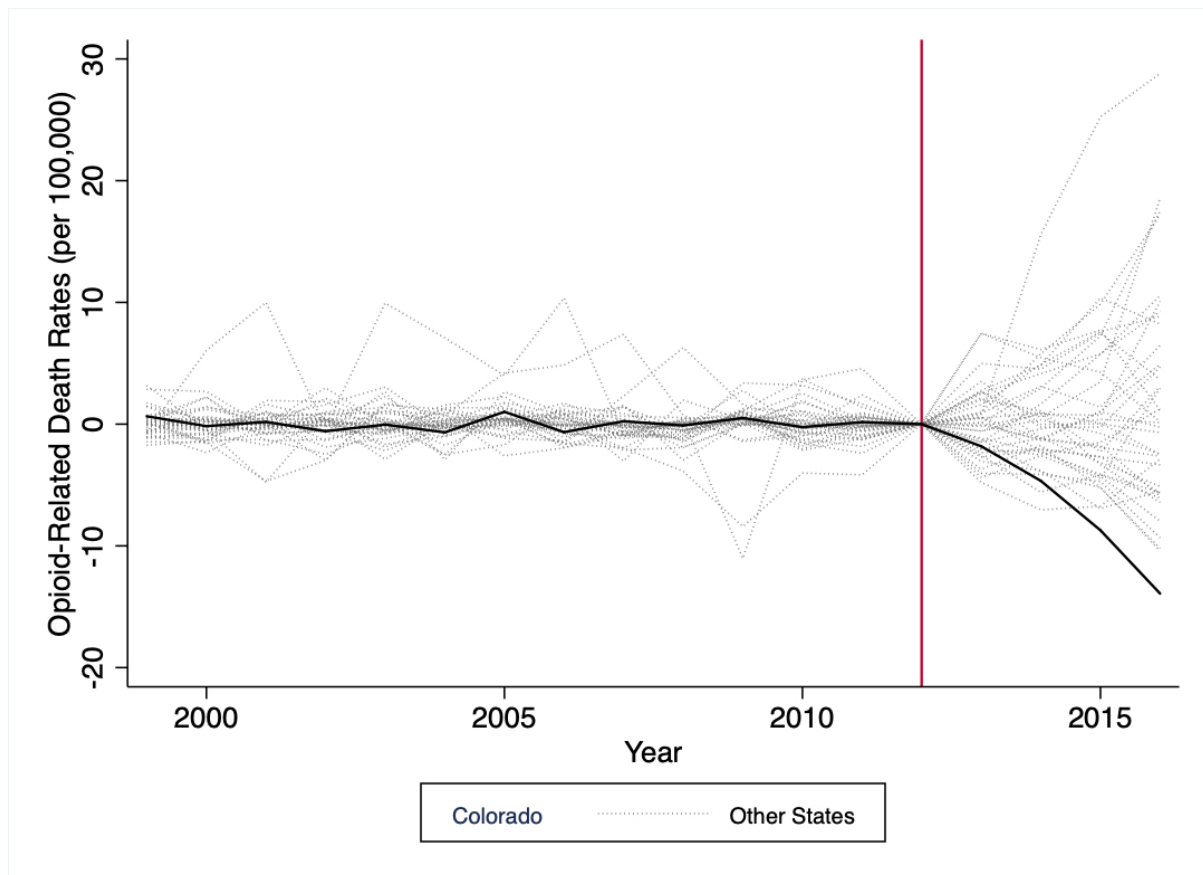

Figure 4

The light-colored lines represent the gap associated with each of the donor state runs of the test and show the difference in death rates between the respective state and its respective synthetic version. As the figure makes apparent, the estimated gap for Colorado after 2012 is large relative to the distribution of the gaps for the states in the donor pool.

Discussion

This report trails the procedure of the SCM described through the paper by Abadie, Diamond, and Hainmueller. As their paper acknowledges, "comparative case study research has broad potential in the social science but its empirical implementation of is plagued by inferential challenges and ambiguity about the choice of valid control groups" (Abadie, A et al., 2010). Hence, using the SCM as a data-driven procedure to select the appropriate comparison units provided a suitable method to analyze the impact of the legalization of marijuana on deaths due to opioid overuse. Using the SCM to analyze the effect of the legalization policy at a county-level analysis rather than a state-level analysis may prove to be a more forceful study. This task, however, was outside the scope of this study. Nevertheless, this report does strongly indicate that the legalization of recreational marijuana would result in a decrease in the number of deaths due to opioid misuse.

Due to the liberal prescribing of opioid drugs during the 1990s, dependency on and the abuse of opioids seems to have grown exponentially in the United States; making the country one of the leading consumer of opioids[10] (UNODC World Drug Report 2018). Thus, there has been a rise in resources and programs being directed toward finding substitutes for chronic-pain treatments that could help bring a reprieve to the opioid crisis. Due to emerging research on its medical benefits,

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[10] https://www.unodc.org/wdr2018/prelaunch/WDR18_Booklet_2_GLOBAL.pdf

marijuana offers to be a good substitute to look into. It has so far, however, proven difficult to study the health impacts of recreational marijuana due to its illegality; causing a hinderance to data collection. There has been an ever-increasing public support for marijuana law reform in the recent years, as well as encouragement from non-profit organizations such as The Drug Policy Alliance (DPA)[11] to regulate marijuana similar to alcohol and tobacco. There is general consensus that allowing the possession, use and sales of marijuana could in fact increase tax revenue, generate commerce and support the agricultural economy. Hence, taking into account all the aforementioned factors, it deems a vital mission to understand the health impacts of marijuana. As there still exist a lot of unknown aspects regarding how the recreational legalization policy could affect marijuana being used as a substitute for opioids, in the treatment of chronic pain, research on it, as carried out by this paper, seems to hold pronounced importance in the present-day.

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[11] http://www.drugpolicy.org/

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