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The Impact of the Legalization of Marijuana in Colorado on Education Funding and Car Crash
Fatality Rates

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Senior Honors Project

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Abstract

The objective of this thesis is to investigate and report the impact of the legalization of marijuana on the funding of education and car crash fatality rates in the state of Colorado. Legalization has been a controversial topic, and marijuana has already been legalized for recreational use in 11 states, and medically in 22 states across the United States. The tax revenues from marijuana are used in school funding, though the allocations of these funds have varied in different years. As we approach the impact that legalization has had on Colorado, it will be interesting to see if the newly allocated funds are supplementary or a replacement.

For this investigation we will need data on the following: marijuana tax revenue, marijuana tax allocation, state education funding (non-marijuana), and crash fatality data. The increased funding for education should lead to lower crime rates; the legalization of a schedule V drug for recreational and medical use should also lead to a decrease in drug incidents at schools and lower dropout rates. Looking at the data, we will be able to see if that holds true for Colorado since legalization in November of 2012.

Using statistics and regression analysis, I will examine the effect that legalization has had in Colorado on the funding of education and on car crash fatality rates. Examining the process and effects that legalization and the tax revenue from marijuana sales has had on the state of Colorado, is important in further decisions of legalization in other states and on a federal level. After I have completed my study, I will report my findings and analyze the results and their potential impact on future policy decisions.

INTRODUCTION

The legalization of marijuana has been a controversial subject in recent years. On a federal level marijuana has not been legalized, but many states have already legalized marijuana for medical and/or recreational use. Table 1 shows the states that as of February 2020 have legalized use of marijuana containing THC or are going to vote on legalization this year.

Table 1: Marijuana Legalization USA

<u>Legalized Medical Marijuana (22 States)</u>	<u>Legalized Medical and Recreational Marijuana (11 States)</u>	<u>Voting on Legalization in 2020 (9 States)</u>
<ul style="list-style-type: none"> ● Arizona ● Arkansas ● Connecticut ● Delaware ● Florida ● Hawaii ● Louisiana ● Maryland ● Minnesota ● Missouri ● Montana ● New Hampshire ● New Jersey ● New Mexico ● New York ● North Dakota ● Ohio ● Oklahoma ● Pennsylvania ● Rhode Island ● Utah ● West Virginia 	<ul style="list-style-type: none"> ● Alaska ● California ● Colorado ● Illinois ● Maine ● Massachusetts ● Michigan ● Nevada ● Oregon ● Vermont ● Washington ● Washington D.C.* <p style="text-align: center; font-size: small;">*Washington D.C. is a federal district</p>	<ul style="list-style-type: none"> ● Idaho ● Arizona ● North Dakota ● South Dakota ● Nebraska ● Missouri ● Arkansas ● Mississippi ● New Jersey

Source: Money Morning, Kyle Anderson

There has been some form of legalization passed in 33 states, with 11 legalizing recreational use. In 2020, there are 9 states that will be voting on legalization. Federal legalization of marijuana is an ongoing debate that will benefit from examining the effects that legalization has had in different states. Studying trends of legalization in states, such as Colorado, will be beneficial in future legalization in other states and on a federal level.

Colorado has legalized medical and recreational marijuana since it was passed in 2012 and in effect since 2014. The idea that legalization will increase education spending is imperative to investigate because in the past there have been discrepancies between what was promised, and the actual allocation of tax revenues. When gambling was legalized it was promised that the revenues would add to education funds, when they were instead used to replace the original funding. It is important to investigate and make sure that marijuana revenues are supplementary to education funds, and not a replacement.

I will add to the current discussion of the effects of legalizing marijuana on the school system of the state by examining the taxation, the allocation of the tax revenue, and the impact of legalization of marijuana on school funds and car crash fatality rates in the state of Colorado. Understanding the impact of legalization is vital in future decisions regarding legalization and regulation in other states and on a federal level.

I. BACKGROUND

As the state level legalization of marijuana is relatively new, there is a need for more research on the impact that legalization has on the state of Colorado. The legalization of medical or recreational marijuana use was passed in Colorado on November 6th of 2012, and implemented in 2014 (Hickenlooper, p.243).

Governor Hickenlooper of Colorado released his commentary on legalization, *Experimenting with Pot*, to discuss public health, budget, revenue, and the approach they will take to regulate marijuana. Amendment 64 was implemented to help with efforts to regulate marijuana, and to do so in a similar way to the regulation of alcohol. Similarly, to alcohol, marijuana has licensing processes, established use limitations for drivers, restricted use to persons 21 years and over, is subject to excise taxes, and subject to rules for public consumption as well as advertisements (Hickenlooper, p.245-246). The regulation of marijuana is a major concern for the health of the state, especially for minors. The age limit of 21 is in place, as with alcohol, and there is consideration for restrictions of outlet locations in proximity to schools and neighborhoods. Hickenlooper discusses the regulations that are being put on marijuana and their parallels to the regulation of alcohol and tobacco, as well as the resources in place to protect public health and the safety of minors. He also discusses the budgeting of revenues, and that by using pre-existing programs they can reduce cost and work to ensure that the revenues are used responsibly. The measures taken in Amendment 64 are vital in the responsible regulation of marijuana, and it is important to understand the laws that are put in place.

Underage use of marijuana has been a concern when it comes to regulation and lawmaking. In response to anti-marijuana ads in Arizona, Colorado lawmakers claimed that the ads were spreading false information to sway voters against future legalizations. In 2015, the Colorado Department of Public Health and Environment found through the Healthy Kids Colorado Survey that since 2009 teen use of marijuana has remained relatively unchanged, and in fact was slightly lower than in 2009 (Ferner, 2016). Ferner also discusses his findings in September of 2016 that legalization has not increased youth access to marijuana and that, “Although more adults in general are using marijuana nationwide, according to the study, the

percentage of teens who use, abuse or depend upon the drug actually decreased between 2002 and 2014,” (Ferner, 2016). This is valuable because the natural assumption would be that legalization would increase youth access and use, however, it is evident that this is not the case.

Reflecting on legalization five years later, Healy discusses both positive and negative impacts; though teen use has fallen, violent crime is on the rise. Following an increase in illegal cultivation arrests, the US attorney in Denver, Jason Dunn, said that Colorado has become the “epicenter of black-market marijuana in the United States,” (Healy, 2019). This rise in black market growth appears to have come with an increase in violent crimes. From 2012 to 2017, after legalization, there has been a 20 percent rise in violent crime, however, marijuana arrests have dropped by almost 50 percent (Healy, 2019). Police in Denver say that since 2014, marijuana offenses have fallen by 25 percent and make up less than 1 percent of overall crimes (Healy, 2019). The number of students expelled for drugs has also dropped since legalization. This is due to lower teen use rates as well as getting rid of the zero-tolerance policy at schools. Post legalization, schools are now catching fewer students drinking and more students using marijuana; however, according to school disciplinary numbers, marijuana is a leading reason that students are handed over to the police or punished at school (Healy, 2019). According to state surveys, teen marijuana use has slightly decreased since 2009 and though many teens may have tried marijuana, ‘80 percent are not current marijuana users.’ In addition to decreased teen use, ‘teen marijuana arrests have fallen by 20 percent since legalization,’ (Healy, 2019). Though there has been a national trend of more conservative teenage behavior, the decrease in teen use is surprising since the assumption would be that increased access due to legalization would exacerbate teen use. Illegal cultivation and home growing have become a major issue in the regulation of marijuana. It is unsurprising that with increased black-market activities, Colorado

is also experiencing increased violent crime rates. The regulation of illegal growth and trafficking across state lines is a major issue that needs to be studied and reconciled in Colorado, which will also aid in future acts of legalization in creating laws and regulations that will halt black-market activities.

In a study at Harvard University in Boston, Massachusetts, Dr. Chadi and Dr. Levy published a review of adolescent marijuana use from a pediatrics perspective. The National Survey on Drug Use and Health supports that between 2015 and 2016, Marijuana use has dropped among 12 to 17-year-olds by 0.5 percent (Bose, 2017). This suggests that legalization did not in fact increase national youth consumption of marijuana. In 1983, 2.9 percent of students reported no lifetime use of alcohol, tobacco, or marijuana, this has increased since 2013 to 25 percent (Chadi, et al. 2017).

A rising concern for marijuana policies is the concentration of tetrahydrocannabinol in cannabis which has increased in the past three decades. Increased potency in cannabis products is linked to the rising presence of use disorders, like the once rare cannabis hyperemesis syndrome (CHS). CHS occurs in heavy users and effects the digestive tract; it is common for people with CHS to experience severe vomiting and can impact how long it takes to empty the stomach as it effects the esophageal sphincter. CHS symptoms can also include dehydration, stomach pain, weight loss, and nausea (Cedars). Possible long term effects include: muscle spasms, muscle weakness, seizures, kidney failure, shock, heart rhythm abnormalities, and in rare cases it can cause brain swelling (Cedars). Though the newly legal drug is slowly becoming perceived as healthy due to it being natural, psychiatric symptoms from the drug include hallucinations, paranoia, and delusions and is also known to be detrimental to the developing brain (Chadi, et al). This is a growing concern in the medical industry as youth exposure to

marijuana can be harmful to the adolescent brain and its development. It is important to consider the damage that adolescent use can have on the brain as well as harm due to abuse and marijuana addiction when it comes to lawmaking and regulation of the newly legal drug.

The debate of legalizing recreational marijuana is an on-going process and its use is still illegal on a federal level. To consider both sides, ProCon, a Santa Monica nonprofit, has compiled a list of pro and anti-marijuana arguments to be reviewed when considering the legalization of marijuana. The most daunting arguments against legalization are: the steep costs, risk of dependence and addiction, increased black market opportunities as seen with increased illegal cultivation in Colorado, potential health risks, environmental effects from growing marijuana, and the influence of 'Big Marijuana' to children as seen with 'Big Tobacco,' (ProCon). In Colorado, the increase in black market opportunities for growth and distribution of marijuana has coincided with an increase in violent crime. The review of the possible consequences of legalization is important in future regulation and reducing the harm to our environment. Legalization has also come with many positive side effects: marijuana boosts the economy, teen usage is dropping, traffic deaths dropped 11 percent on average in legalized states, the content of legal marijuana will be regulated for safety, decreased revenues for drug cartels and gangs, decreased alcohol consumption results in fewer crimes associated with alcohol such as domestic violence and assault, tax revenues support public programs, and creating new jobs that are estimated to reach a quarter million in 2020 (ProCon). The former deputy director for the National Cannabis Industry Association, Taylor West, says that we are seeing lower crime rates because the criminal market is being crippled by legalization; organized crime can no longer function in the same way due to the end of marijuana prohibition. This is interesting because it contradicts other research that in Colorado violent crime has increased post

legalization. There seems to be different results for legalization in different areas, however, many of the positive effects remain the same. Creating jobs and boosting the economy are some of the more common positive side effects to legalization. Understanding the negative consequences to legalizing marijuana is important in future regulation and law-making decisions.

In March 2016, Congress published a report on early findings post marijuana legalization in Colorado. Revenue from taxes, licenses, and fees associated with legalization increased 77 percent and excise tax revenue for the public school capital construction assistance fund increased 163 percent, respectively, from 2014 to 2015 (Reed, p76). The National Incident-Based Reporting System records the locations where offenses took place into 57 categories. While all other categories have remained relatively flat during 2012 to 2014, elementary and secondary schools have increased 34 percent (Reed, p63). Colorado adolescent marijuana use is above the national average and though there was only a 2 percent increase in arrests for marijuana-related offenses in juvenile cases, there was a substantial increase in the arrest rate for females and offenses on school property (Reed, p65). There is concern that with legalization, there would be more adolescent use, the most concerning being the 34 percent increase in marijuana related offences at elementary and secondary schools. The adolescent brain is especially at risk to harm when using marijuana as the brain is not fully developed until the age of 25. This risky behavior needs to be regulated and addressed in Colorado and in other legalized states to ensure the safety of the youth. However, 80 percent of teens are not current users of marijuana and teen arrests have fallen 20 percent since legalization (Healy, 2019). There has also been a slight decrease in the perception of the risks of marijuana among the youth in Colorado post legalization, probably due to the idea that legality infers safety. It is important to educate the youth about the risks of marijuana consumption. The report contains information

on the impact of legalization on public safety, youth, public health, and information on revenues and arrests.

A study on the traffic fatality trends in Colorado by Dr. Sakai and colleagues, dives into the changes in marijuana and alcohol use of drivers in fatal motor vehicle crashes. They examined the proportions of drivers who were marijuana-positive, and who were alcohol-impaired. The study was done using data from the Fatality Analysis Reporting System from 1994-2011, and compared to 34 states that were non-medical marijuana states. They found that since medical legalization in 2009, marijuana-positive crashes rose and in contrast there were no changes in non-medical states; in the same period, there were no significant changes in alcohol-impaired fatal crashes in either group. The study is important as there were expectations that marijuana legalization would lead to an increase in fatal motor vehicle crashes, which it appears that after medical legalization there was an increase. They concluded that there needs to be more education in place to inform the public on the risks of marijuana-positive driving. It will be important to test if there is an increase after legalization of recreational use as well, which was implemented after this study was conducted.

Another study used the data from the Fatality Analysis Reporting System (FARS), conducted in 2017. Jayson Aydelotte studied total crashes instead of using the marijuana-impaired numbers, because of the issues with testing for marijuana use. The limitations of marijuana testing make it difficult to have a uniform basis for what is classified as ‘marijuana-impaired.’ They found that there was no association between recreational legalization and total crash rates after the first 3 years of legalization in both Colorado and Washington (Aydelotte, 2017).

A simulation study done in 1969, does a comparison of driving performance between marijuana and alcohol users. Crancer, et. al., do a great job of looking at the effects of tetrahydrocannabinol on driving, and reflexes to driving situations. They took 36 subjects, and tested their skills at different levels of ‘treatment,’ or use of either alcohol or marijuana. They were spread out at different times of day, and their simulation scores were recorded to see the differences between social, control, and high use to compare between the levels of consumption. They found that marijuana users' sense of speed led to them driving at slower speeds during the simulations. They also re-tested four of the subjects after they had consumed three times the amount in the main experiment and found no significant difference in their performance. They also added four additional subjects who had never smoked marijuana before; these subjects were pre-tested and then they smoked to reach the levels of the experiment and were tested to see if there was a significant difference in their skills. These subjects show either no change, or insignificant improvements in their results. Their study suggests that marijuana impairment had little to no significant impact on driving errors in the simulation, compared to the control conditions for any level of marijuana dosage or experience level.

II. MODEL DEVELOPMENT

The following equation will be used in investigating the impact of the legalization of marijuana on education funds:

$$\text{Education Expenditures for Public Schools} = \beta_0 + \beta_1 * \text{Personal Income Per Capita} + \beta_2 * \text{Unemployment Rate} + \beta_3 * \text{Resident Population} + \beta_4 * \text{High school Dropout Rate} + \beta_5 * \text{Total Marijuana Sales} + \beta_6 * \text{Total Marijuana Sales Tax Collected}.$$

For each beta there is a null and alternate hypothesis. For β_0 , we assume the base of educational spending is positive. For Beta 1, the null is β_1 equals 0 and the alternate hypothesis β_1 is greater than 0, and the projected sign is positive. We expect that as personal income per capita increases, that education spending will increase as areas with higher income tend to have

more educational funding. For Beta 2, the null is β_2 equals 0 and the alternate hypothesis is β_2 is less than 0, as the projected sign is negative. As the unemployment rate increases, we should expect less funding for education as much of that funding is tax revenue based. For Beta 3, the null is β_3 equals 0 and the alternate hypothesis is β_3 is greater than 0, and the projected sign is positive. As the resident population grows, we expect there to be more educational spending as the population will provide more students and tax revenue. For Beta 4, the null is β_4 equals 0 and the alternate hypothesis is β_4 is less than 0, and the projected sign is negative. As the high school dropout rate increases, we expect there to be less money spent on education, with fewer students and likely future lower income averages. For Beta 5, the null is β_5 equals 0 and the alternate hypothesis is β_5 is greater than 0, and the projected sign is positive. For Beta 6, the null is β_6 equals 0 and the alternate hypothesis is β_6 is greater than 0, and the projected sign is positive. β_5 and β_6 are projected to be positive as they will lead to a growth in education funding due to the allocation of tax revenue to schools. Before and after legalization, it will be interesting to see the changes and impact on these variables as well as on the funds for education.

For the analysis of car crash fatality rates we will examine the percent changes before and after legalization. It is important to see the changes in fatal crashes particularly those involving persons 21 and over, as they are legal to use recreational marijuana as well as alcohol and compare this with the changes in crashes involving someone who was intoxicated. My hypothesis is that overall, post legalization there will be a decrease in fatal car crashes. Since marijuana and alcohol can be considered substitutes, there is likely to also be a decrease in alcohol related accidents now that marijuana has been legalized. Legalization should lead to a decrease in speeding related accidents because of the nature of the drug. The prior research indicated no change, or a slight decrease in alcohol related accidents. However, I estimate that

there will be a decrease in alcohol related fatalities, as well as a slight increase in accidents for those 21 and older due to the legal age to use marijuana. The population growth of Colorado post-legalization could also contribute to any changes after 2014; Colorado's population increase of 1.89% was more than double the 0.79% increase of the entire US population (Svaldi). Over two thirds of the population gain was from net migration (Svaldi). Looking at the composition of fatal crashes before and after legalization we can determine if there was an impact, and what the impact was of marijuana legalization in Colorado.

III. DESCRIPTION OF DATA

The data for this study is primarily gathered from government resources. The data for total school system expenditures, high school dropout rates, and drug and alcohol related incident information is all from the Colorado Department of Education. The data for marijuana sales, marijuana sales taxes, the allocation of the marijuana taxes, and the marijuana license and application fees are from the Colorado Department of Revenue. The data for unemployment, personal income per capita, and population are from the Federal Reserve Bank of St. Louis, or FRED. All data was collected from 2010-2017, however, marijuana data was not available prior to 2014, the year of legalization. All marijuana data has been modified to include years prior to legalization with zero values, as tax revenue, and legal sales of marijuana would indeed be zero before legalization. The drug related incident data for school actions taken was also modified because in 2014 the school systems began to separate drug incidents and marijuana incidents into separate categories, so I combined them after 2014 to be consistent in what the data included each year. Total state taxes were also recoded, as I had to combine the quarters for yearly data, but otherwise left alone. The Public School Fund did not begin to receive the excess excise taxes until 2016, so the years prior to 2016 have been given a zero value. I combined the total medical and retail marijuana sales into one variable. The car crash fatality data was collected from The

National Highway Traffic Safety Administration, from 2009 to 2018. The CDE, CDOR, NHTSA and FRED are all reliable sources for the data gathered.

I would have liked to include data on the standardized testing scores before and after legalization, as well as GPA, for high school students to show any effects on education levels. The total expenditures for schools before and after the legalization of marijuana will be the dependent variable, while all other data will be the independent variables in this study. It would have been beneficial to find a more detailed data set for consumption, in regards to users age, gender, profession, and education for both recreational and medical consumers. It would also be interesting to do another study focused on crime levels and types of crime, and whether they have significantly changed or not post legalization. One major limitation for this study was the availability of certain variables, and their consistency; I would like to have gone back further in time for more data, however, some of the variables were not accessible before 2010. Another change for future research would be to use SPSS, or another program to analyze the data. I would like to be able to include more variables, however, some data had to be left out or modified to work in the study.

IV. METHODOLOGY

An ordinary least squares regression will be used in this study to test the relationship between legalization and the money spent on the education system. The total expenditures for public schools will be used as the dependent, with the other data as the independent variables. The data has been collected from 2010 to 2017, which is a smaller time frame than anticipated, however, much of the data was only consistent or available during this period. I will examine the connection between the variables and the impact that their multicollinearity will have on the regression results; an OLS regression minimizes the sum of squares in the difference between

actual and predicted values of the dependent. The regression will give the estimated Beta values, standard error, t-stat, p-values, and the r-squared value. I will use these statistics to check the significance of the variables. There will be multiple regressions run to determine the most influential variables to see the impact that legalization has had on educational spending; with the r-squared indicating the accuracy of the results.

This OLS model has an issue with multicollinearity; multicollinearity can inflate standard errors and increase the p-values which will make us less likely to reject the null when we should. We will test for multicollinearity in the model. Another possible issue in a regression is serial correlation; residuals are not independent and are actually correlated. Testing the time series for serial correlation is important in fixing the error. Using a Durbin-Watson test we will test for serial correlation. Based on findings, I may have to adjust the model to include variables that are not so correlated, so as not to skew test statistics, to increase the accuracy of the model. One way that this may be achieved is to adjust some of the data into percent changes year-by-year, instead of having totals for each variable.

Looking at the data from the NHTSA and comparing changes in fatality statistics before and after legalization, we can chart the actual impact that legalization has had on Colorado car crashes. It is important to see how and if legalization has had an impact on the car crash fatality rates in Colorado, or if there is little change. I have calculated the changes by year for each variable and will compare the trends before and after legalization to see what the overall effect of legalization has been.

V. RESULTS

Serial correlation is an issue with OLS regressions when the data is time series, we first look to the Durbin Watson test to identify first order serial correlation. The critical Durbin

Watson values are $dL=0.203$ and $dU=3.004$, as $K=6$. The Durbin Watson test requires the lagging of residuals, used to test for serial correlation. Testing against the null hypothesis is that there is serial correlation, which would be indicated by the d-value being less than the dL table value. If the d-value is greater than the dU value, then we fail to reject the null, indicative of no serial correlation. If the d-value is between the upper and lower table values, the test is inconclusive. The result for this test was $d=2.3$, so it is inconclusive; the result was very close to 2 which signals we fail to reject the hypothesis. There is no evidence of strong positive or negative first order serial correlation, however, this does not mean that the data is not correlated.

The regression resulted in large coefficients which were to be expected dealing with public spending. We have significant multicollinearity between some of the variables, which has consequently led to lower t-stats and a high adjusted r-squared of .946. Theory tells us that it is better to do nothing for this than to drop variables and have omitted variable bias. The regression coefficients are as follows: $\beta_0=583.12$ million, $\beta_1=244.76k$, $\beta_2=66.04$ billion, $\beta_3=-953.15$, $\beta_4=-56.098$ billion, $\beta_5=-2.736$, and $\beta_6=189.26$. Each beta represents the amount of increase or decrease in educational spending for every 1 unit of increase in its corresponding variable. To test the significance of each variable in this study, we will be using p-values; anything over .05 being insignificant and anything under .05 being statistically significant. The variables with statistically significant p-values are highlighted in table 2:

Table 2: Betas, P-values, and Coefficients

<u>Variable</u>	<u>Coefficient Value</u>	<u>P-value</u>
β_0 Intercept	583143415.625	0.990209056
β_1 Personal Income Per Capita	244762.469	0.0382189133
β_2 Unemployment Rate	66037953069	0.0259875725
β_3 Resident Population	-953.1498888	0.0913214388
β_4 High school Dropout Rate	-56,098,309,288	0.0800531341
β_5 Total Marijuana Sales	-2.736693019	0.046305664
β_6 Total Marijuana Sales Tax Collected	189.2616217	0.0317453456

These variables are the most statistically significant based on the information available. Prior to the regression, we had hypothesized the beta and its projected sign, in the following table we can see the results, and if they were in line with the pre-study expectations:

Table 3: Beta Hypothesis and Outcome

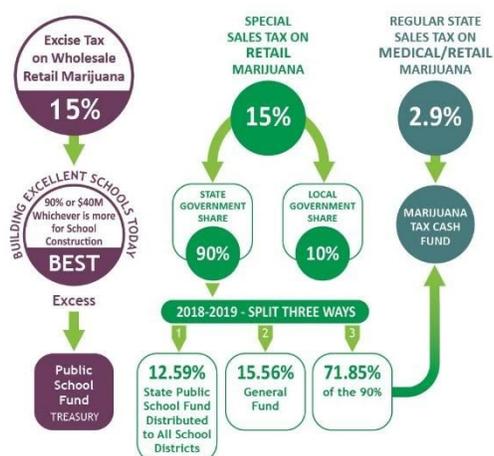
<u>β</u>	<u>Ho/Ha</u>	<u>Reject or Fail to Reject the Null</u>	<u>Projected Sign</u>	<u>Actual Sign</u>
β_0	$H_0:\beta_0=0; H_a:\beta_0>0$	Fail to Reject	+	+
β_1	$H_0:\beta_0=0; H_a:\beta_0>0$	Reject	+	+
β_2	$H_0:\beta_0=0; H_a:\beta_0<0$	Reject	+	+
β_3	$H_0:\beta_0=0; H_a:\beta_0>0$	Fail to Reject	+	-
β_4	$H_0:\beta_0=0; H_a:\beta_0<0$	Fail to Reject	-	-
β_5	$H_0:\beta_0=0; H_a:\beta_0>0$	Reject	+	-
β_6	$H_0:\beta_0=0; H_a:\beta_0>0$	Reject	+	+

β_1 Personal Income Per Capita, β_2 Unemployment Rate, β_3 Resident Population,
 β_4 Highschool Dropout Rate, β_5 Total Marijuana Sales, β_6 Total Marijuana Sales Tax Collected

Both β_3 , the resident population of Colorado, and β_4 , high school dropout rate failed to reject the null and β_3 had the opposite of the anticipated sign. The expectation was that as the population grows in Colorado, education spending would grow as well. As with total marijuana sales, however, the data rejects the null. This could be due to issues with multicollinearity as well as possible omitted variable bias. The limitations on the available data and the limitations on OLS regressions in Excel themselves have led to an inaccurate adjusted R-squared as well as skewed t-statistics; which may also be responsible for the unexpected signs of the betas 3 and 5. Overall, the connection between the statistically significant personal income per capita, unemployment rate, tax revenue from marijuana, total marijuana sales and educational spending confirms that Colorado's legalization of marijuana has impacted the amount spent on education.

Looking at the tax revenue distribution in Colorado, we can see how the marijuana taxation will contribute to education spending. However, this allocation did not go into effect until 2018 and will need to be studied further.

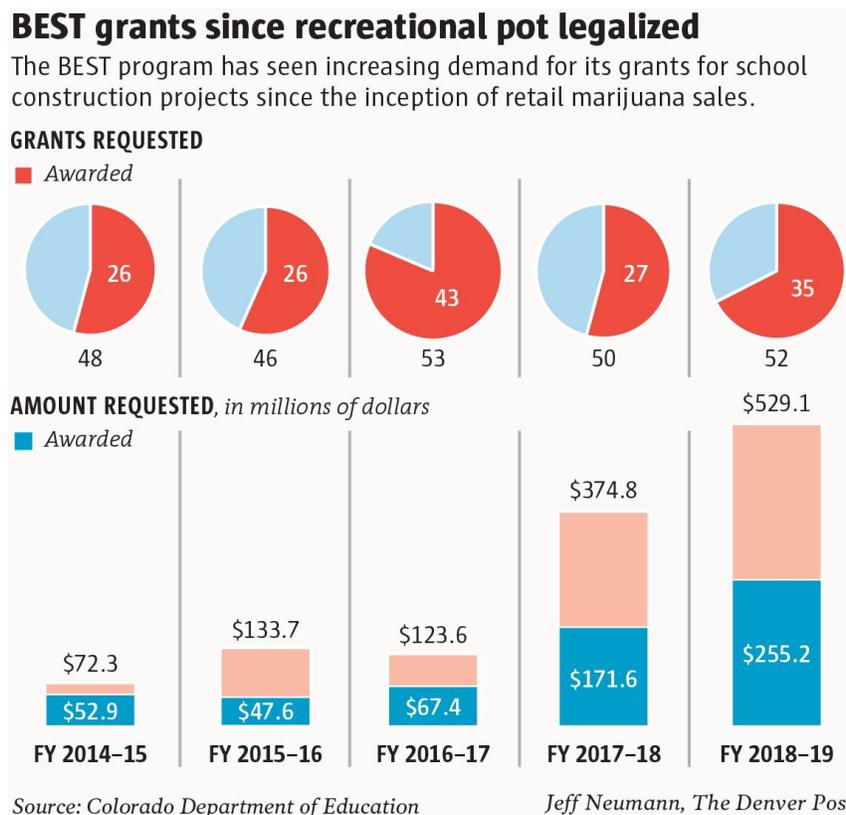
Figure 1: Marijuana Tax Allocation 2018-2019



Source: CDE

The BEST program gets about a third of its funding from marijuana tax; BEST is the Building Excellent Schools Today program, they work to fix and build new schools. Other funding was also given to school programs, though legislation is continually changing. The first \$40 million of excise tax goes towards BEST, and the rest is spread between other programs and funds. In 2018, legislation changed this to either the first \$40 million or 90% of excise taxes, whichever is greater (Migoya, 2018). There are requirements with the BEST program, as school have to match the funds from 2% up to 80% for repairs and building facilities.

Figure 2: BEST grants by fiscal year

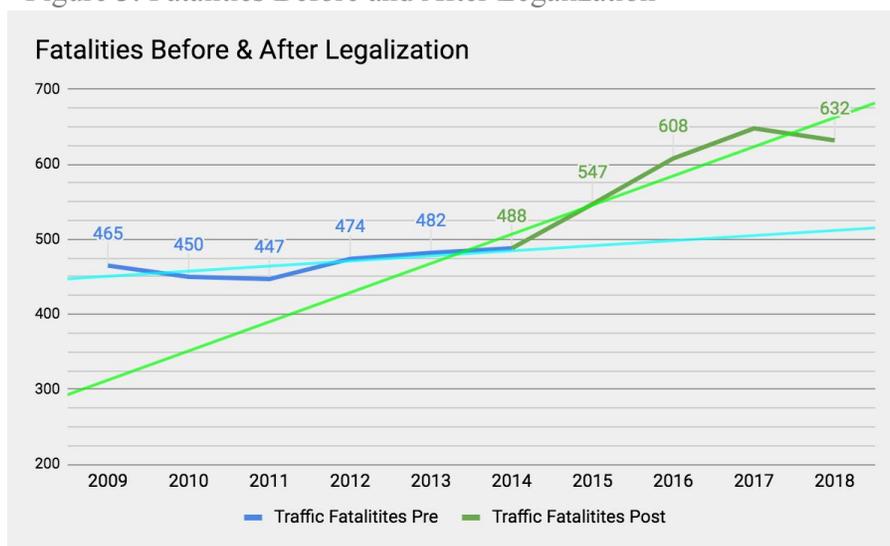


In figure 2 the BEST grants requested and awarded are shown by fiscal year. When recreational marijuana was legalized in 2014, and the BEST program saw an increase in the amount of grant requests. In fiscal year 2014-2015 there were \$72.3 million in requests and in fiscal year

2018-2019 there were \$529.1 million in requests (Migoya, 2018). The growth in BEST grants distributed since legalization was implemented is evident in the demand and awarding of grants. This smaller portion of marijuana tax allocation has already made an impact on education spending through the BEST program, and the other taxes put toward education, such as the marijuana tax cash fund and the state public school fund, make an impact as well. We see that through legalization there has been an increase in spending on education, and the goal is for it to continue to increase as legislation continues to change in the coming years.

Legalization has also impacted car crash fatalities. Though I had expected a drop in fatal crashes after legalization, the data indicates an increase. When looking at the raw data and the percent changes by year in fatal crashes by attributes, we can see a clear indication that marijuana legalization has not led to a significant decrease in the number of fatal crashes in Colorado.

Figure 3: Fatalities Before and After Legalization

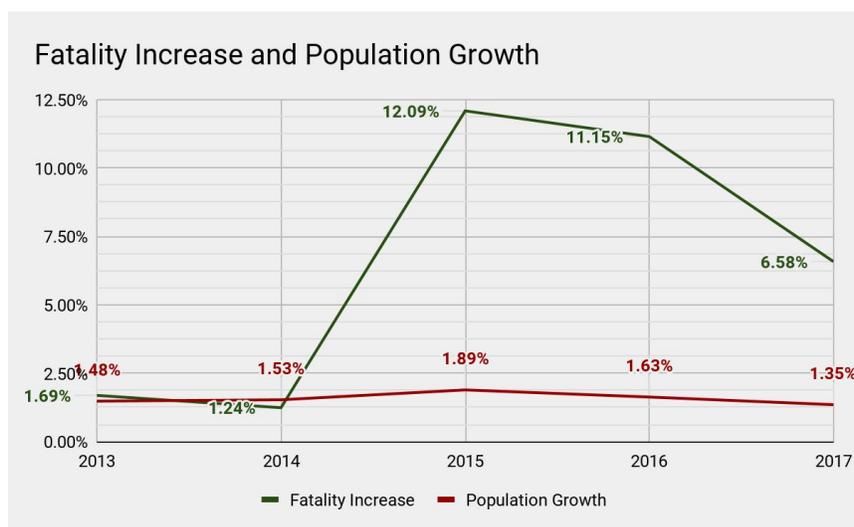


Source: NHTSA

Though I had anticipated a drop in fatal car accidents following legalization, the data shows us otherwise. Prior to legalization (2009 to 2014), the rate of fatal accidents in Colorado

was relatively unchanged; the state averaged 468 fatal car crashes per year up to 2014. After legalization, Colorado has seen a clear increase in fatal car crashes, as indicated by the trend lines in the figure 1 above (neon blue indicates pre-legalization trends, and neon green indicates post-legalization trends). From 2014-2018, there was an average of 585 fatal car accidents per year. This is a huge change in fatal crashes, as the average level has increased 25%. This is contradicting the research I have seen regarding legalization and car accidents. However, this increase could be partially due to the growing population in Colorado, as many people moved to the state after legalization (Svaldi).

Figure 4: Fatality Increase and Population Growth

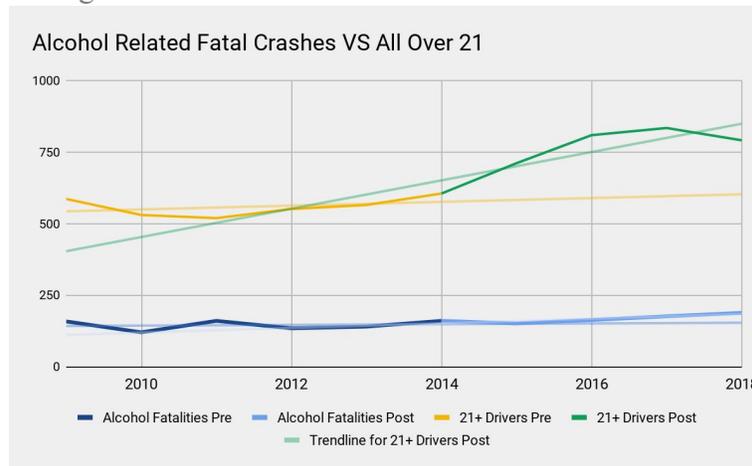


Source: NHTSA

Looking at population growth data in figure 4, there was an increase between 2014 and 2015. Colorado averaged a 1.47% population growth every year up to 2014, but in 2015 they saw a 1.89% growth rate; they went from a population of 5.35 million to 5.45 million, a growth of 100,889 people which was approximately 23% more new residents than they saw the year prior. Legalization brought an increase in population growth in Colorado, which likely is a contributing factor to the increase in fatal car crashes. Though the population increase still

leaves a gap between population growth and fatal crash increases. However, 2015 brought a 7.2% increase in traffic deaths across the United States, which was the biggest increase since 1966. Past research indicates that the major causes of car crash fatalities are speeding, alcohol, and distracted driving. It would be interesting to compare the increase with distracted driving/cell phone usage however I could not find the data for this specifically. Seeing how car accidents have increased is an indication that there needs to be more attention and research dedicated to uncovering the best way to combat this issue.

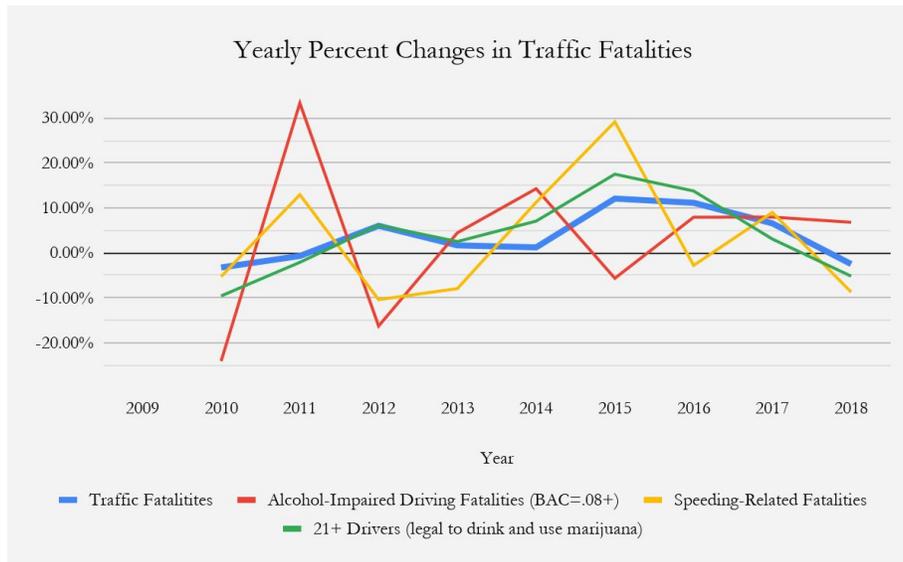
Figure 5: Alcohol Related Fatal Crashes Verses All over 21



Source: NHTSA

As shown in figure 5, the fatal crashes attributed to alcohol impairment are less than half of the total crashes involving persons over 21 years of age. To legally use recreational marijuana, the citizen has to be 21 and older. Though there is a large gap between the number of accidents with alcohol use and with persons over 21, not all of this can be explained with marijuana only. Though it is logical that some of the increase post legalization has been due to either marijuana use, or more likely due to the population increase that followed its legalization.

Figure 6: Yearly % Changes in Traffic Fatalities



Source: NHTSA

As shown in figure 6 above, overall changes in traffic fatalities rose directly after legalization in 2014, but then declined back to pre-legalization trends. It is interesting to note that alcohol impaired driving fatalities took a steep drop the year after legalization, decreasing 5% from 2014 to 2015. However, in 2016, the levels were back to pre-legalization. The year after legalization, alcohol impaired fatalities decreasing makes sense as more people likely moved to experimenting with recreational marijuana instead of alcohol. There was a spike in speeding related traffic fatalities in 2015, but this decreased back to prior levels in 2016. Though there was an increase in traffic fatalities after legalization, this could be largely attributed to the growing population of Colorado that came with recreational marijuana. Though it appears much of the increase in fatal car crashes is likely due to the growing population, further studies could be done to better determine the correlation between legalization and fatal car crashes.

VI. CONCLUSION AND DISCUSSION

Colorado has experienced an increase in public education spending since the legalization of marijuana in 2014. The partial allocation of marijuana tax revenue to public schools seems to

have contributed to an increase in spending for education. The state has also seen a decrease in high school dropout rates, and in drug violations in schools since legalization. Though the perception of risk associated with the use of marijuana has decreased in recent years, the state has not experienced an increase in adolescent use, it has in fact seen a substantial decrease. The results indicate that as marijuana sales increase, therefore increasing tax revenue from marijuana, the amount spent on education also increases.

The analysis of education spending was limited by different factors. The data was changing every year; legislation is continually changing with different allocation specifications making uniform analysis more difficult. The changes in tax distributions will make a huge impact in the coming years with more excise tax being allocated to the BEST programs and as overall marijuana taxes increase. The growing population could also be contributing to the growth in education spending, but it is clear that the growing funds from the marijuana excise taxes given to the BEST program have made a substantial impact on the school system. It would be imperative to do a more detailed analysis of the specific uses of funds that have benefited from the taxation of marijuana. It would be beneficial to do state by state comparisons of the use of marijuana taxes to see how different states have benefited from the added tax revenue. Seeing the different uses of the new taxes would give a wider perspective on what the best way to implement tax allocation would be on a national scale.

Though legalization was expected to come with a decrease in car crash fatalities, the results we have seen so far are inconclusive. I had expected the decrease in alcohol related fatal crashes that came directly after legalization, as they can be considered substitutes. Directly after legalization there was a spike in accidents, however, there was also population growth due to people moving to be in a legal state. The trend lines show that there are more accidents in

Colorado now, but the reason behind them may not solely be marijuana use. The population growth following recreational legalization could be a major player in the increase of fatal car accidents; however, until better testing is developed it will be hard to know if the increase was substantially due to a growing population or if there has been a large increase in marijuana use while driving. With legalized recreational marijuana still being relatively new, there is much more to be analyzed after more time has passed.

Studies in the future would benefit from finding more extensive data sources, as marijuana has only been legal in Colorado since 2014, it would be prudent to study the effects of legalization in a state that has had marijuana legalized for a longer period of time. It would be beneficial to do more surveys and studies in each city with dispensaries and examine more closely the local impacts. Localized studies can also shed light on more specific impacts, especially in dense areas that have experienced substantial population growth after legalization. It is also important that there are future studies on a more national level; investigating legalization impacts across different states, such as those in table 1, would give a more representative perspective on how legalization could impact the US as a whole.

There were some limitations to the study that could be remedied by using an alternate program to run the regression, such as SPSS, and by using more extensive sources over a larger time-frame. It would be interesting to investigate the connection between legalization and crime rates; has legalization led to a drop in drug related crime and violent crime, or has it created a new set of issues? As Colorado has seen a rise in black market crime, future studies could pinpoint more specifically what has changed in the state. It would also be interesting to look at opioid use, and whether or not marijuana legalization has led to a decline in prescription drug

use. Since alcohol and marijuana are substitutes, it would also be interesting to see if legalization has led to a decrease in domestic violence.

Legislation and regulation should increase focus on traffic safety and continue to target underage use prevention. Keeping the youth safe and providing education about the newly legalized drug will be key in the success of marijuana legalization. Future studies on illegal cultivation, drug crime, and violent crime and their relationship to marijuana legalization would be beneficial in creating targeted and effective regulations and laws to combat the issues. Careful examination of the effects of legalization in Colorado are crucial in future legalization in other states and on a federal level.

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