

The Effects of Recreational Cannabis Legalization

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Introduction

The push for cannabis legalization has been going on for many years on both the state and national level in the United States. Over time, more and more states have voted to decriminalize or fully legalize medicinal and recreational cannabis which brings the number of fully legalized states to 16 as of April 2021. Polls in 2020 found that 68% of Americans now believe cannabis should be fully legalized, with the highest support coming from the young, the college-educated, and the upper-class.

The stage is being set for legalization to continue in states throughout the country, and the move towards federal legalization could be on the horizon. So the question must be asked, how does recreational cannabis affect society? Does legal recreational cannabis have a positive or negative impact? As with all things, the answer is most likely both. There are 9 statistics studied in this project, from higher-order statistics like GDP growth and unemployment, to more focused statistics including drug deaths and alcohol consumption. This paper aims to derive meaning from the differences in annual rates of multiple statistics between Colorado and the United States. The goal is to explain how recreational cannabis legalization will affect states individually, and the United States as a whole, if and when they decide to legalize recreational cannabis.

Data, Methods, and Model Design

The data for this paper was gathered from a variety of sources, primarily with web scraping. Websites and databases for healthcare centers and independent medical agencies were scraped for data, as these were the most reliable sources on the web. Cross-checking the mined data with different sources and data matching was used to obtain the most precise and thorough information. The data focuses on the time range of 1999-2018, but some statistics lacked accessible data for the entirety of this time period, which will be discussed further under the Limitations and Challenges section. Specifically, some variables had missing data from the earlier years of that time period. To handle this issue, yearly entries with missing data were simply removed from that dataset *for that variable only*. For example, data about suicide rates was only accessible after 2004, so in the dataframe for suicide rates, the years 1999-2003 (years without data) were simply omitted. In terms of data organization, all data was placed in one csv file, and for simplicity, the data was also organized in separate csv files for each variable.

Data for both Colorado and the United States was necessary to show the comparison between trends in the two focus areas. Colorado legalized recreational cannabis in December 2012, so 2012 will be used as the benchmark between pre and post recreational legalization. Each model will contain two graphs: the left highlights the difference in Colorado before and after legalization, and the right illustrates the comparison between Colorado and the United States before and after legalization. The statistics studied in this paper are GDP per Capita, Unemployment, Suicide Rates, Tax Revenue per Capita, Cigarette Sales per Capita, Alcohol

Consumption per Capita, Alcohol-Related Driving Deaths per Capita, Drug Deaths per Capita, and Rehabilitation Admissions per Capita.

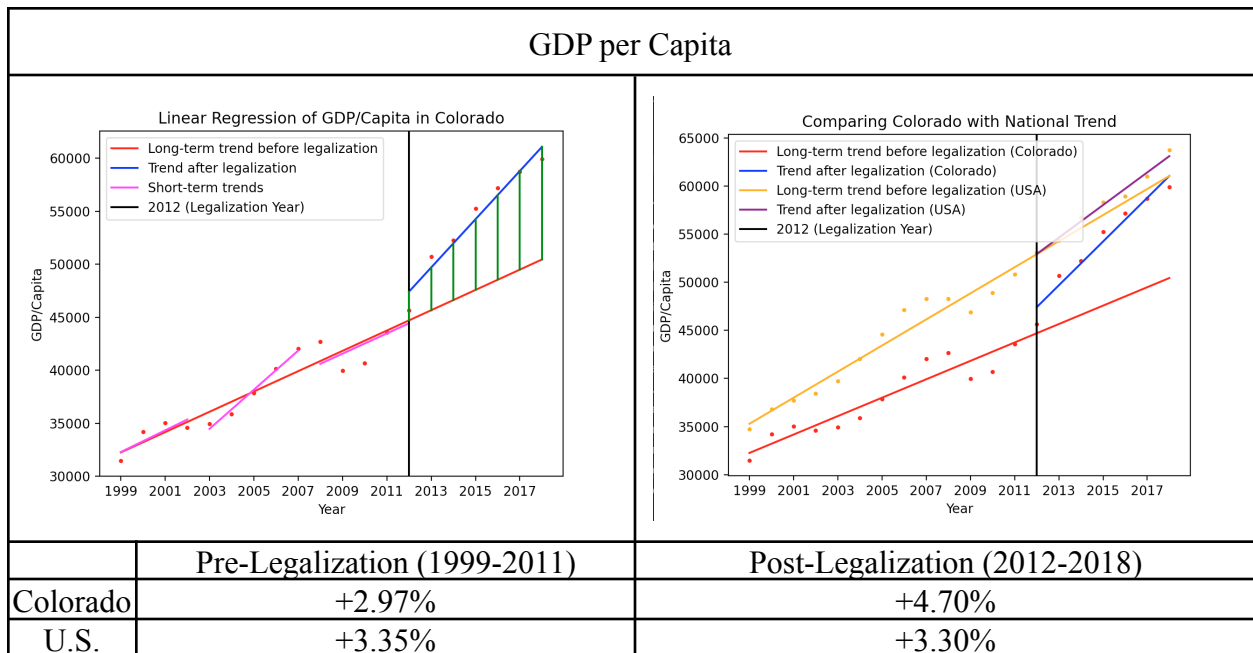
Using Python's Pandas package, the data (in the form of .csv files) was parsed, processed, and ultimately placed into different Pandas dataframes for each trend explored. Each dataframe contained information about the year, the data points for Colorado, the national data points, the year-over-year percent change for the Colorado data, and the year-over-year percent change for the national data. The first step in model selection was to plot the data and gain intuition about the trends, what kind of data is present, if there are outliers or any externalities, etc.

Using Python's Matplotlib package, the Colorado data was plotted against the national data to observe the trends and perform a basic visual analysis of the difference between the two before and after legalization in 2012. This initial visualization helped determine which trends were potentially affected by the legalization of cannabis. Since the data is temporal and therefore continuous, linear regression models were selected to be the catalyst in performing a more quantitative analysis of the data.

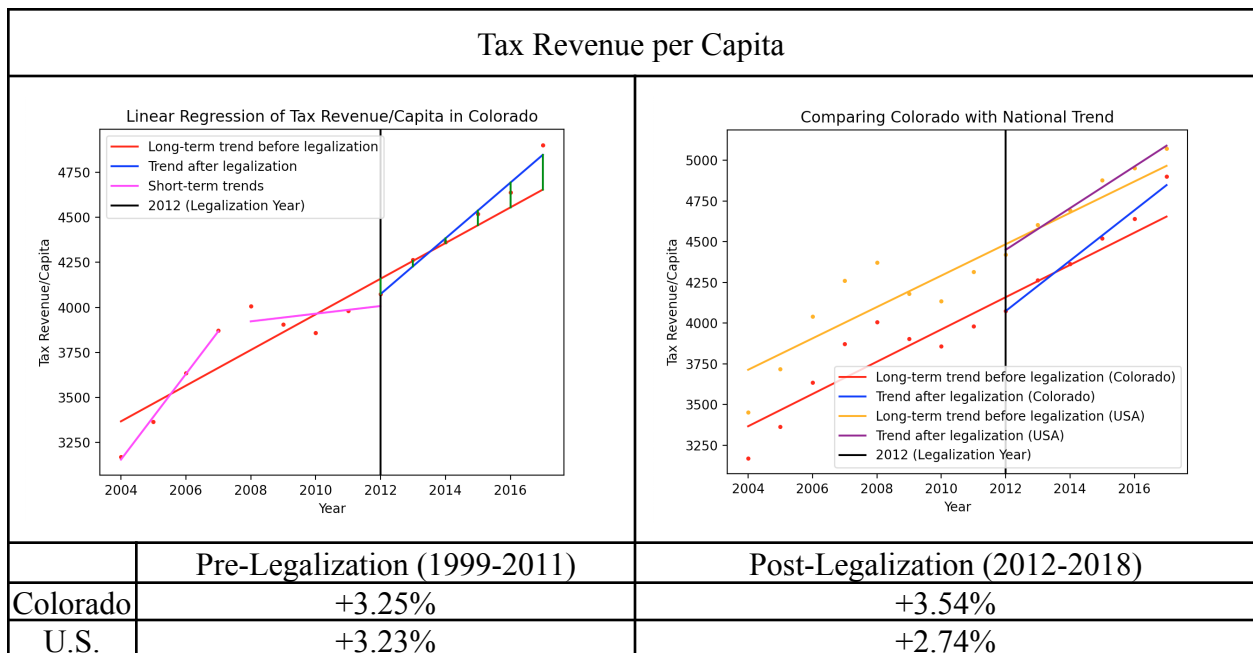
Using Scikit-Learn's Linear Regression, several different linear regression models were run in order to derive the maximum amount of insights possible from the given data. These models included a long-term regression model before legalization, a regression model after legalization, and several short-term models throughout the entire time frame. The long-term model serves to represent what one could hypothetically expect to see, should the trend (without legalization) continue.

The post-legalization model shows the overall trend of the data after 2012, representing what happened after the legalization of cannabis. The short-term regression models give an idea of how the data looked in shorter intervals of time, which can be helpful in evaluating whether changes in trends are simply due to changes over time, or whether they are actually significant. The short-term trends are often able to capture more information that may be lost in long-term trends. For each linear regression model, the slope and intercept of the least-squares regression line are reported. Another significant calculation used was the percentage change of slopes of the regression lines before and after 2012. This metric gauges the extent of the impact of legalization in 2012.

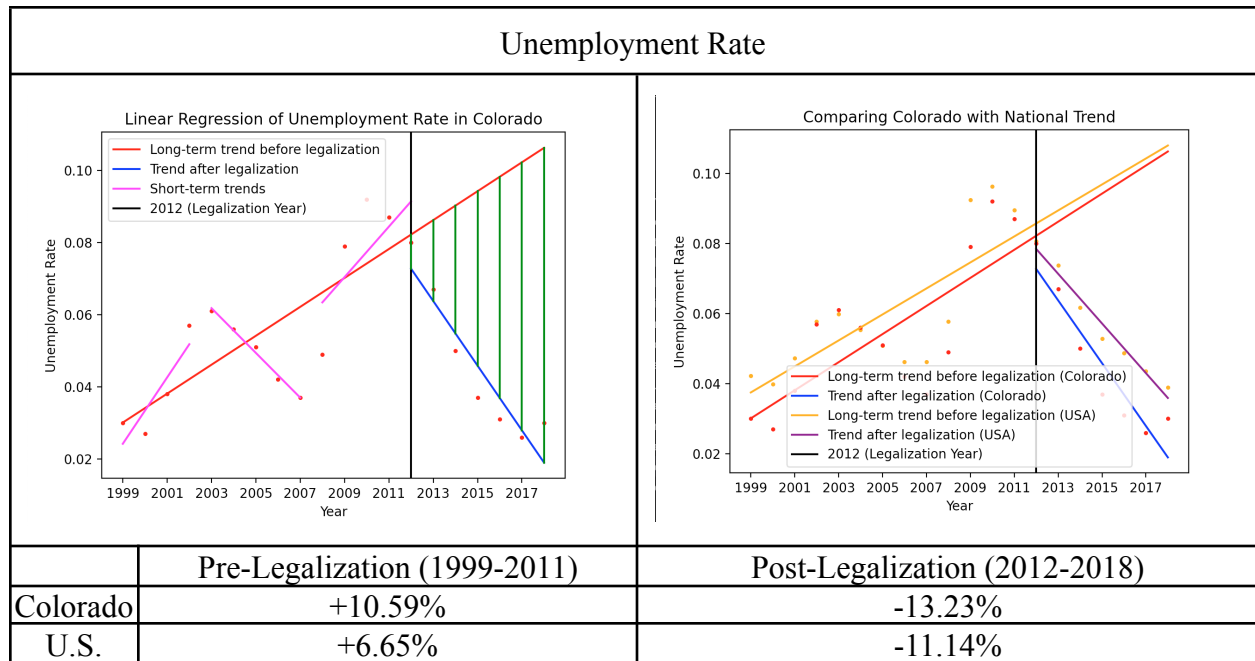
Results



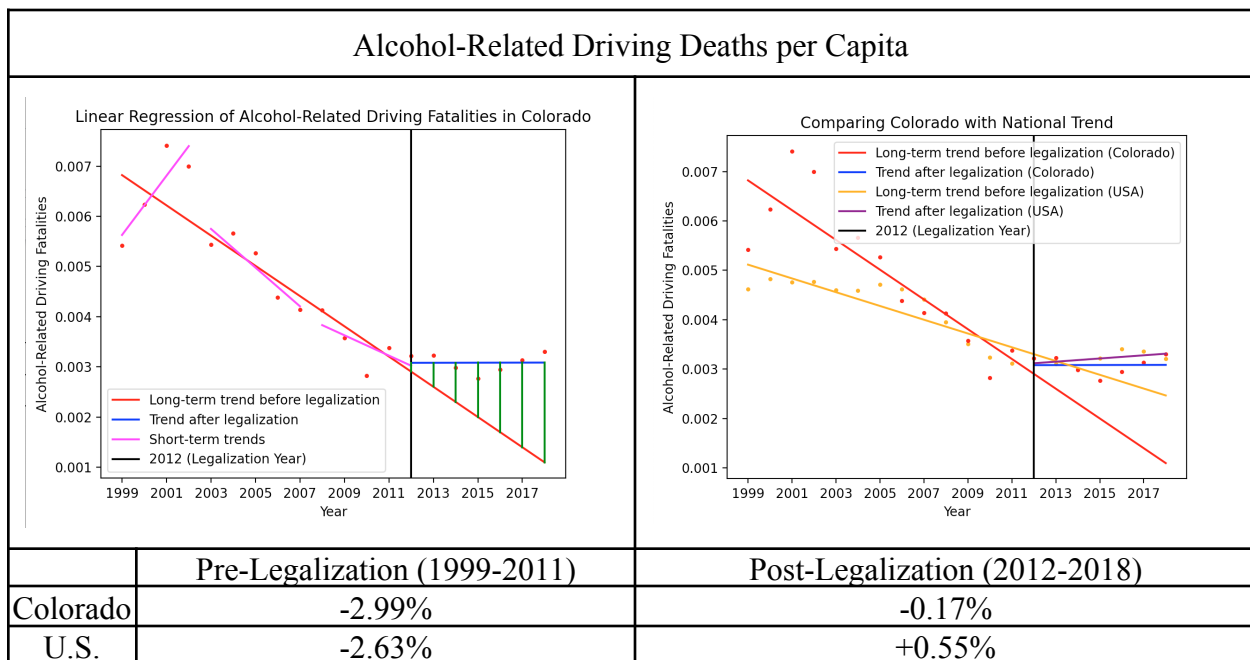
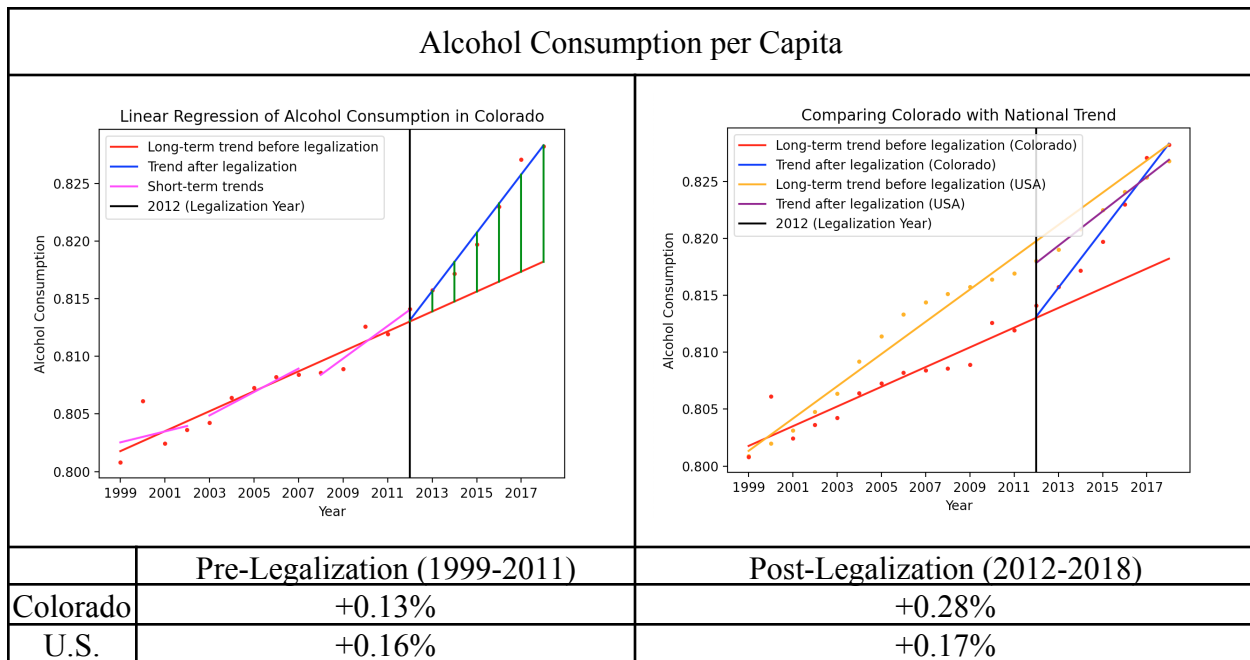
Cannabis is a growing industry, especially in states allowing for recreational sales. The medicinal and recreational consumer spending has increased annually in Colorado, hitting \$1.7 and \$2.2 billion in sales in 2019 and 2020 respectively. The 2019 Colorado GDP was \$353 billion, with cannabis sales contributing 0.5%. Colorado's GDP growth rate after the Great Recession and post-legalization was 1.4% higher than nationally (4.7% vs. 3.3%). Statewide GDP growth can be affected by a variety of factors, and an emerging and fast-growing cannabis industry definitely played its part.



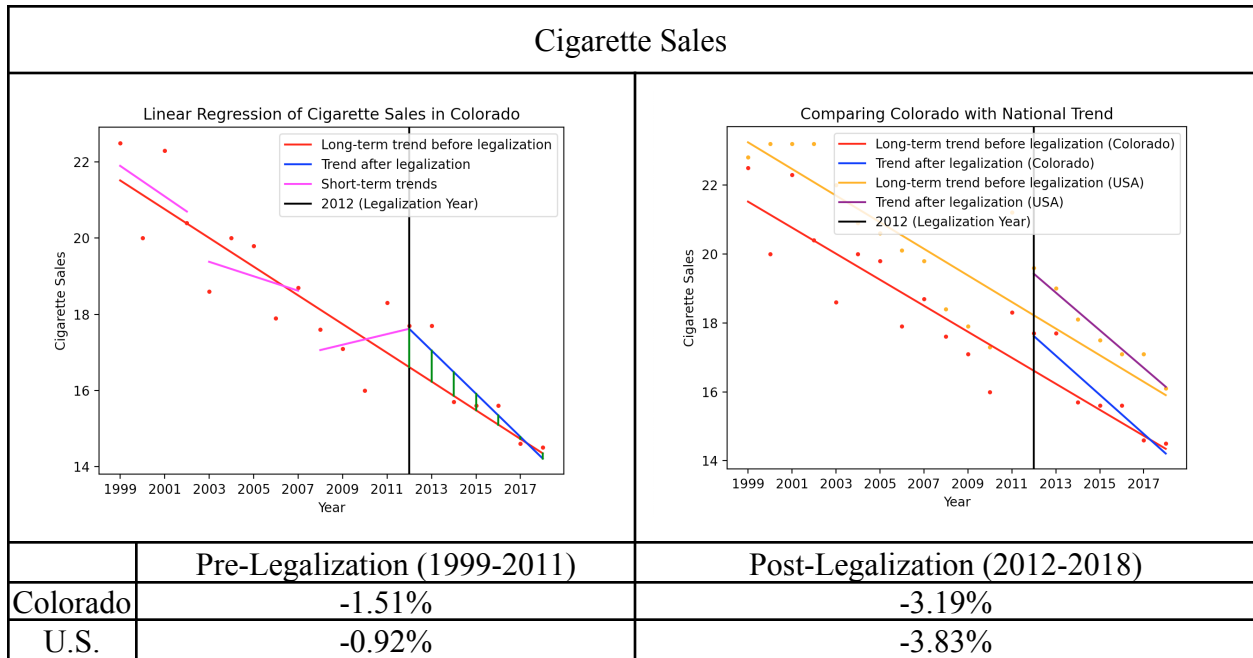
The legalization of medicinal and recreational cannabis in Colorado also came with state-levied taxes focused on that industry. Colorado has specialized excise and sales taxes on retail cannabis sales of 15%. The excise tax revenue has solely been put towards public education and over 60% of sales tax revenue goes towards health, human services, and education. Between 2014 (when the tax was put in place) and 2019, \$1 billion in tax revenue has been collected from the cannabis industry in Colorado. \$302 million in tax revenue was collected in 2019 alone, with a majority being spent to build better education systems in the state.



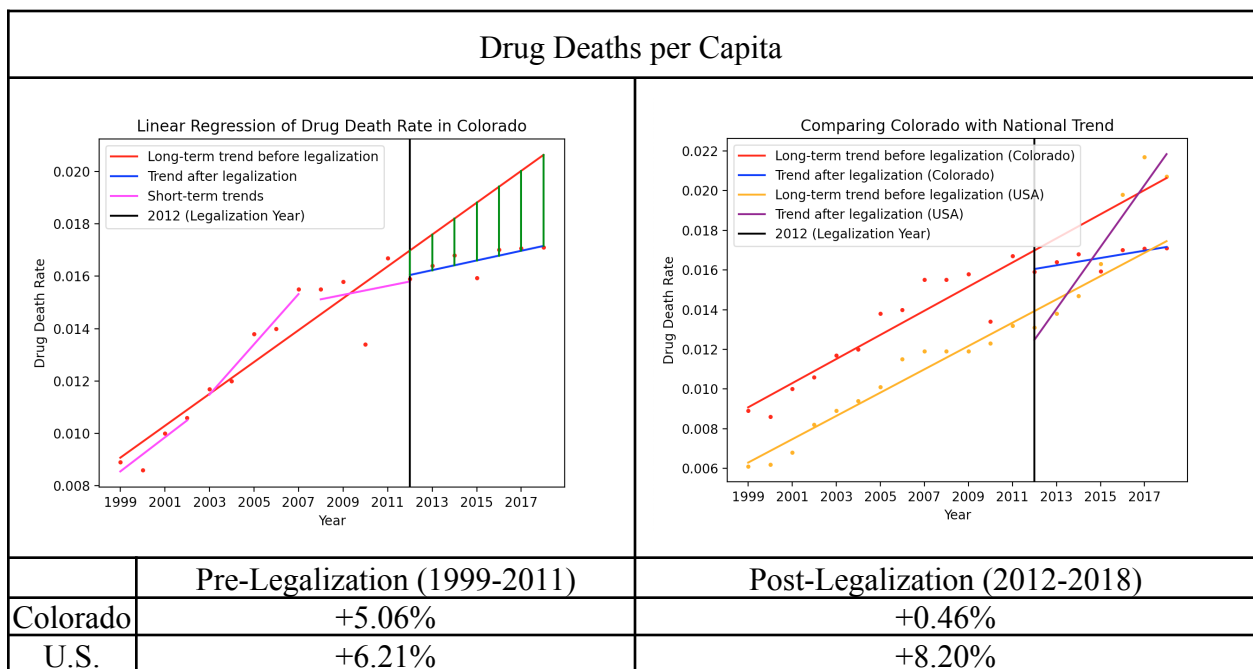
The effect of legalization on unemployment is hard to see, especially due to recovery from the Great Recession where Colorado fared better than the U.S. as a whole. The creation of this new booming industry does bring jobs, with some sources estimating a 250% increase in job growth in the cannabis industry nationwide from 2018 to 2028. In Colorado alone, the industry has provided over 34,000 jobs as of 2019.

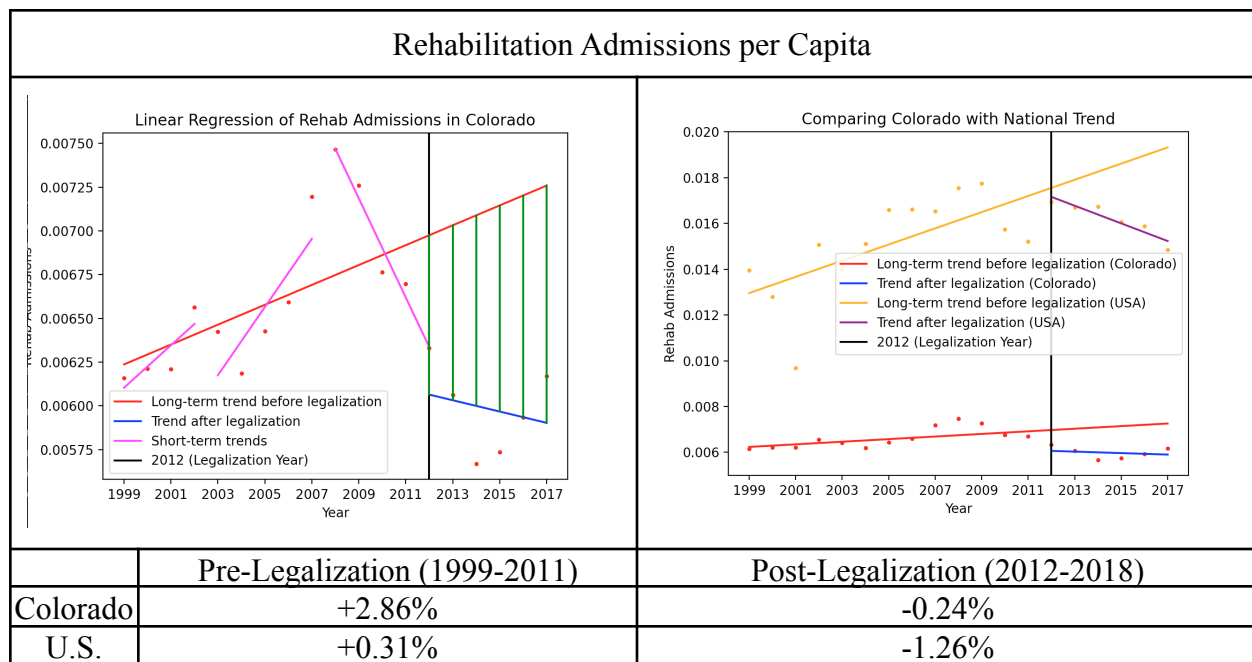


Would recreational cannabis be a substitute away from alcohol or complement and increase alcohol consumption? The growth rate of alcohol consumption doubled in Colorado after 2012, while nationally the rate stayed the same. This points to alcohol being a complementary product to cannabis, causing an increase in consumption. Would this increase in alcohol consumption cause more alcohol-related driving deaths? Though Colorado leveled out in this category after legalization in 2012, the rate also leveled out nationally. In comparison to national data, legalized recreational cannabis did not affect alcohol-related driving deaths, even with the increase in alcohol consumption.

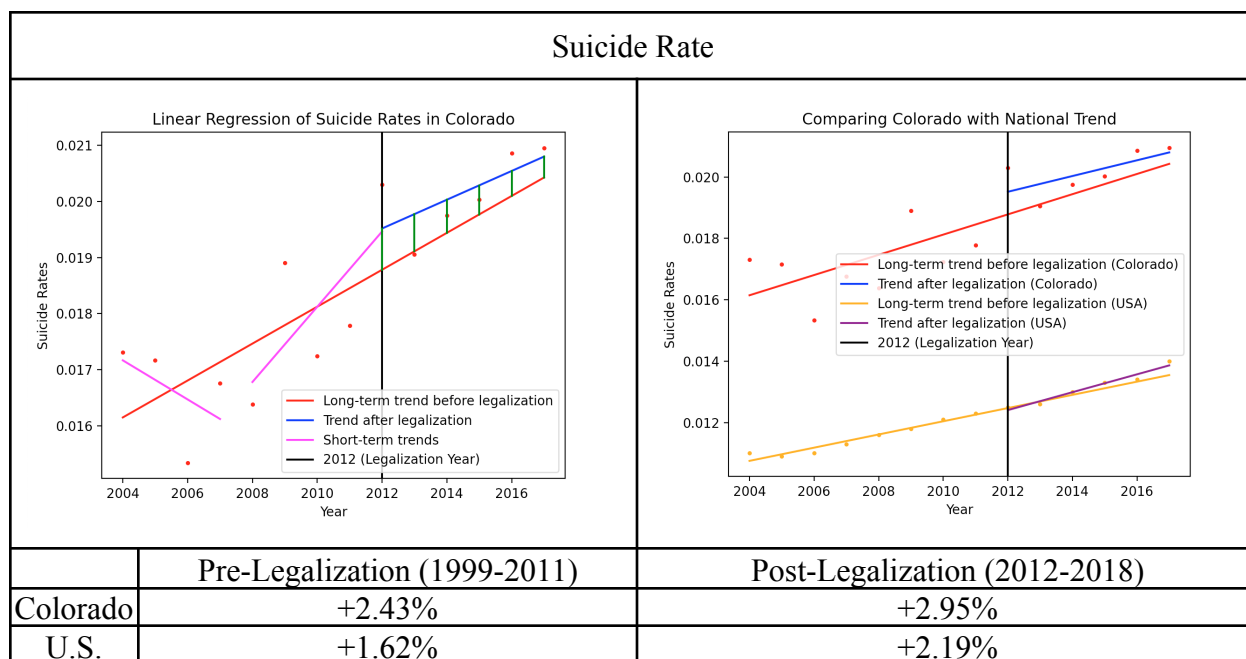


The same question asked about alcohol consumption can be asked about cigarette consumption: would recreational cannabis increase or decrease cigarette consumption and sales? Since 1999, annual cigarette sales have been declining at a rate of -1.51% in Colorado and -0.92% nationally. Some outlier years, from 2011-2013, throw off post-legalization rates, but the graphs above show that the trend from 1999-2011 holds for post-legalization. Colorado's rate of decline also stays comparable with the rest of the country. This data shows no noticeable impact of recreational cannabis on cigarette sales versus the national rate.





Legalizing a drug can be a big step for many states, especially those who are considering legalizing drugs such as cocaine, heroin, and other similar ones.. Could recreational cannabis be seen as a substitute away from these more dangerous drugs? Drug consumption statistics are hard to come by, so drug deaths and rehabilitation admissions have been used as a proxy. Medical studies show that cannabis only causes death in extreme cases that include other external factors, and rehabilitation services are generally used for alcohol and dangerous drugs. The rate of drug deaths decreased dramatically in Colorado following recreational legalization and is especially striking given the increased national rate. Rehabilitation admissions in Colorado were at a 20-year low in 2014 and 2015, but decreased at a higher rate nationally, so the decreasing rate of rehabilitation admission slowed down. Whether this is due to a higher need for rehabilitation or a higher acceptance of rehabilitation is unknown.



Medicinal cannabis is used to treat a variety of diseases and disorders, but one of the main recreational usages is the self-treatment of mental disorders such as anxiety and depression. Thus, supporters argue that legalizing recreational cannabis allows easier access to a drug that helps treat these disorders. The tracking of mental illness statistics is fairly recent, so suicide rates are used as a proxy to see if legalized recreational cannabis affected mental health in a positive way. In both Colorado and the United States, there was a slight increase in the rate after legalization, so comparably there was no change.

Summary

Recreational cannabis legalization has led to positive impacts in Colorado including adding a growing multi-billion dollar industry in the state, tax dollars for education and health, job creation, and decreasing drug deaths. Many pro-legalization supporters point to statistics like these in order to continue growing their 68% support for legalization. Other statistics in Colorado show some possible caveats of legalization, including increased alcohol consumption and a slow down in the decrease of rehabilitation admissions. Alcohol-related driving deaths, cigarette sales, and most notably the suicide rate saw no noticeable affect in Colorado compared to the rest of the nation after legalization. Mental health care is a common argument used for legalization, so more research on the effects of legalization on mental health should be conducted in the future when more statistics become available.

Limitations and Challenges

Given the relatively recent nature of the conversation surrounding the legalization of recreational cannabis, there is a limited amount of public data available and accessible on the subject. Furthermore, several trends that are logically likely to have been impacted by legalization are not easily quantified. For instance, descriptive mental health statistics were

difficult to find due to confidentiality limitations, as well as the fact that mental health had not been taken as seriously until recent years. Additionally, other meaningful statistics, such as drug tests administered by private companies and information about black-market sales of cannabis and other drugs, are equally elusive and presented a significant challenge during the research and data-gathering phase.

There is also a significant risk in using the above results to conclude whether the prediction model accurately reflects the true impact of cannabis legalization. For instance, many trends in the data may be the result of national and global events, such as the 2007-2008 Financial Crisis or the COVID-19 pandemic. Through comparing the data in Colorado to what was seen in the entire United States, the structure of this project aimed to eliminate the effects of extraneous confounding variables as much as possible, but it is impossible to do so entirely. Ultimately, however, the findings and results are indeed effective in guiding the future conversation about the potential benefits and consequences of the legalization of recreational cannabis.

Further Research

_____Currently, the project is limited to cannabis legalization in the state of Colorado, but there are many areas of further research that can help enhance the project's results and findings. These are discussed more in detail below:

1. As of 2020, recreational use of cannabis is legal in 16 U.S. states and medical use of cannabis is legal in 36 U.S. states for adults over the age of 21. To better understand the effects of cannabis legalization, further research can be done on the other states that have legalized cannabis for recreational use.
2. Certain variables displayed discrepancies in trends during the years of 2008-2010 which could be due to the financial crisis. Further research could be conducted to study the effects of unforeseen circumstances. These include the financial crisis or the COVID-19 pandemic, which caused changes in socio-economic conditions like financial stability, availability of legalized cannabis/professional help during lockdowns, etc.
3. As of November 2020, the state of Oregon decriminalized small quantities of possession of all drugs. As a result, the scope of the project can be expanded by doing further research on the effects of the decriminalization of other drugs like cocaine and methamphetamine to name a few.
4. Data regarding cannabis-related crime was difficult to find on open-source databases. However, this information could be beneficial in drafting new decriminalization policies. It could potentially help reduce crimes due to the reduction in the underground market and criminal activity associated with it.

5. Tax revenue from cannabis sales was used to improve healthcare and education in Colorado. Therefore, the improving trends seen in the socio-economic factors discussed above can possibly share a cause-and-effect relationship. As a result, it may be beneficial to do further research on the state's use of drug tax income and its correlation with cannabis legalization.

Conclusion

Since the beginning stages of the project, several positive, negative, and inconclusive effects regarding the legalization of cannabis have been discovered. While some trends may have been affected by extraneous confounding variables, a majority of them produced conclusive results. In Colorado, positive effects of cannabis legalization include its contribution to an increasing GDP, an increase in tax revenue spent to improve the state educational system, and an increase in job growth. Trends that were not noticeably affected by cannabis legalization include the cigarette sales and suicide rates. Despite the promising positive impacts in Colorado due to the legalization of cannabis, one negative impact was found in the research. It was discovered that instead of being a substitute for cannabis, alcohol tends to be a complement; so the consumption of alcohol increased after legalization in Colorado compared to the national trend. Fortunately, the increased alcohol consumption was not correlated with an increase in alcohol-related driving deaths.

Throughout the project, there were many limitations and challenges with collecting certain data, however, the results are still conclusive regarding the effects of cannabis legalization in Colorado. Overall, these findings can be utilized to make decisions about whether or not states should legalize in the future and can warn decision-makers of potential negative effects as well as potential benefits of legalization.

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