Deliverable 3 - Report

Objective:

The goal of this deliverable is to take a closer look at specific trends in the state of Colorado before and after legalization of recreational marijuana in 2012. The overarching question of our project is- *Is legalization of recreational marijauana beneficial to a society? If so, in what ways?* To answer this question, the key focus of this deliverable was to determine if, after legalization, there were significant changes in any of the following factors:

- Drug-related deaths
- GDP per capita
- Tax Revenue per capita
- Unemployment Rates
- Cigarette Sales
- Consumption of Alcoholic Beverages
- Admission to Rehabilitation Services
- Suicide Rates
- Alcohol-related Driving Fatalities

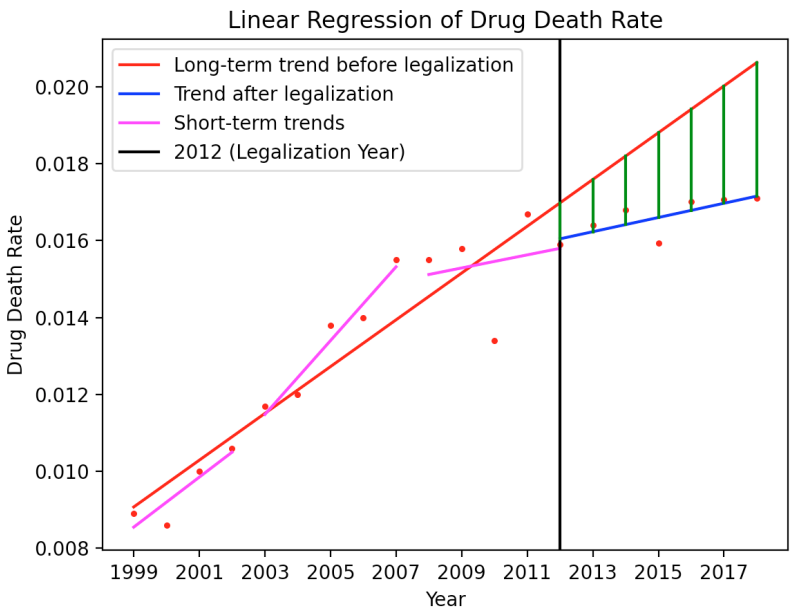
Methods:

Using python's pandas and matplotlib packages, the data for Colorado was parsed, processed, and ultimately placed into pandas dataframes. The Colorado dataset was used to train several of Scikit-Learn's Linear Regression models on different segments of data. The Linear Regression models that were constructed are the following:

- Long-term trend before legalization (Red line)
    - This line represents the overall trend of the data prior to 2012. The line has been extended to subsequent years in order to represent what one could hypothetically expect to see, should the trend (without legalization) continue.
- Trend after legalization (Blue line)
    - This line represents the overall trend of the data after 2012, representing what happened to the data after legalization of marijuana.
- Short-term trends (Magenta lines)
    - The short term trends 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.

With each of the aforementioned linear regression models, the slope and intercept of the model was reported, as well as the percent change in the slopes of the trends pre-legalization (pre-2012) and post-legalization (post-2012).

Effect of Legalization on Drug Deaths:

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Linear Regression for Drug Deaths before legalization:
Intercept is: -1.2070206593406594
Slope is: 0.0006083516483516483

Linear Regression for Drug Deaths after legalization:
Intercept is: -0.35617214285714244
Slope is: 0.00018499999999999978

Linear Regression for Drug Deaths between 1999-2003:
Intercept is: -1.2908
Slope is: 0.00065

Linear Regression for Drug Deaths between 2004-2018:
Intercept is: -1.9113999999999998
Slope is: 0.0009599999999999999

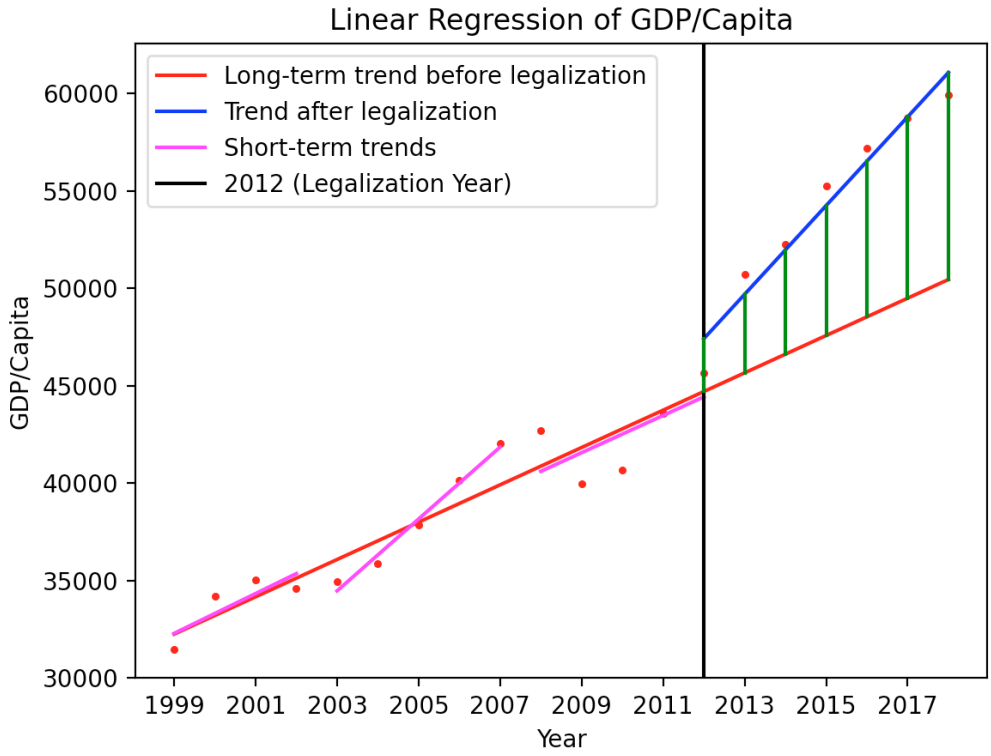
Linear Regression for Drug Deaths between 2009-2012:
Intercept is: -0.32624
Slope is: 0.00016999999999999999

The percent change in slopes was  -69.58995664739888 percent
The average percentage increase of drug deaths each year before 2012 legalization was  5.061289500638461 percent
The average percentage increase of drug deaths each year after 2012 legalization was  0.4643763796714287 percent
```

<u>Observations/Explanations:</u>

In the graph above, first we noticed that the short term trends aligned with the long term trend of the effect of legalization on drug deaths. After the year of legalization (2012), we show that the trend of drug related deaths decreases significantly because the slope of the trend goes from 6.08 * 10^{-4} to 1.85 * 10^{-4}. This leads us to believe that legalization of marijuana had a positive impact on drug deaths in Colorado.

Effect of Legalization on GDP per Capita

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Linear Regression for GDP/Capita before legalization:
Intercept is: -1882864.7164835166
Slope is: 958.0373626373628

Linear Regression for GDP/Capita after legalization:
Intercept is: -4533257.892857142
Slope is: 2276.6785714285706

Linear Regression for GDP/Capita between 1999-2003:
Intercept is: -2012487.6999999995
Slope is: 1022.8999999999997

Linear Regression for GDP/Capita between 2004-2018:
Intercept is: -3660662.000000001
Slope is: 1844.8000000000004

Linear Regression for GDP/Capita between 2009-2012:
Intercept is: -1877632.1999999997
Slope is: 955.2999999999998

The percent change in slopes was  137.63985207853958 percent
The average percentage increase of GDP/Capita each year before 2012 legalization was  2.9740653029692306 percent
The average percentage increase of GDP/Capita each year after 2012 legalization was  4.695734071857143 percent
```
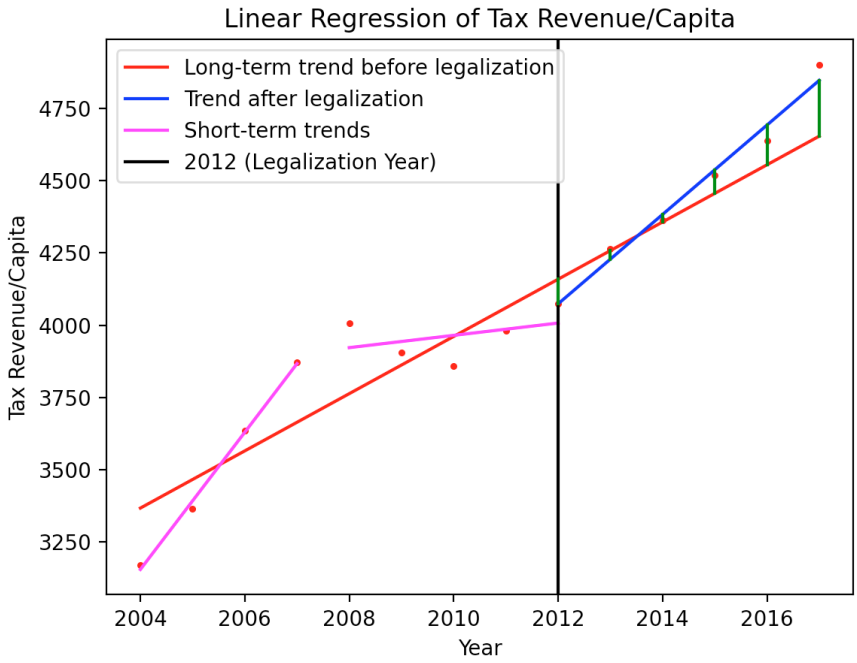

Observations/Explanations:

Again with this visualization, we see that the short term trends of GDP per capita align with the long term trend. After legalization in 2012, the slope of the GDP per capita increased significantly as the slope went from 958.0 to 2276.7. This leads us to believe that legalization of marijuana had a positive impact on GDP per capita in Colorado.

Effect of Legalization on Tax Revenue per Capita

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Linear Regression for Tax Revenue/Capita before legalization:
Intercept is: -195162.97777777782
Slope is: 99.06666666666668

Linear Regression for Tax Revenue/Capita after legalization:
Intercept is: -307326.20952380955
Slope is: 154.77142857142857

Linear Regression for Tax Revenue/Capita between 2004-2008:
Intercept is: -472996.30000000005
Slope is: 237.60000000000002

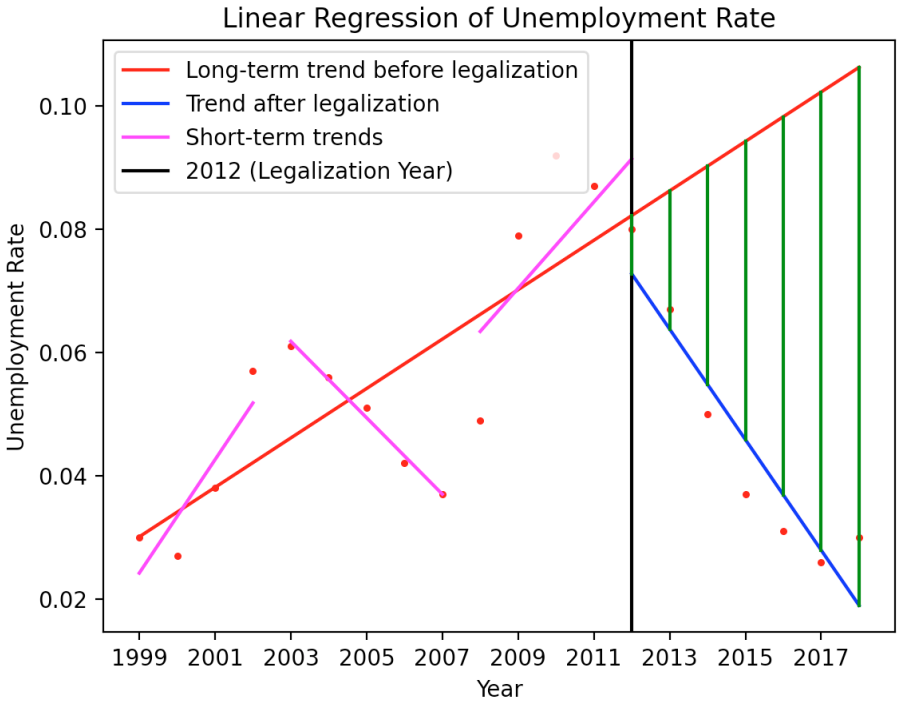
Linear Regression for Tax Revenue/Capita between 2008-2012:
Intercept is: -38848.19999999998
Slope is: 21.299999999999994

The percent change in slopes was  56.22957123630069 percent
The average percentage increase of Tax Revenue/Capita each year before 2012 legalization was  3.2475342595 percent
The average percentage increase of Tax Revenue/Capita each year after 2012 legalization was  3.5411907245 percent
```

Observations/Explanations:

This data prior to legalization is a bit more scattered than the previous two graphs. After legalization in 2012, the slope of the tax revenue per capita increased slightly as the slope went from 99.1 to 154.8.7. This leads us to believe that legalization of marijuana had a slightly positive impact or no impact on tax revenue per capita in Colorado.

Effect of Legalization on Unemployment Rates

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Linear Regression for Unemployment Rate before legalization:
Intercept is: -7.983487912087911
Slope is: 0.0040087912087912085

Linear Regression for Unemployment Rate after legalization:
Intercept is: 18.10889285714286
Slope is: -0.008964285714285715

Linear Regression for Unemployment Rate between 1999-2003:
Intercept is: -18.366600000000002
Slope is: 0.009200000000000002

Linear Regression for Unemployment Rate between 2004-2018:
Intercept is: 12.480400000000001
Slope is: -0.006200000000000001

Linear Regression for Unemployment Rate between 2009-2012:
Intercept is: -13.9926
Slope is: 0.007

The percent change in slopes was  -323.6156798245614 percent
The average percentage increase of Unemployment Rate each year before 2012 legalization was  10.593309996153847 percent
The average percentage increase of Unemployment Rate each year after 2012 legalization was  -13.232820634428572 percent
```
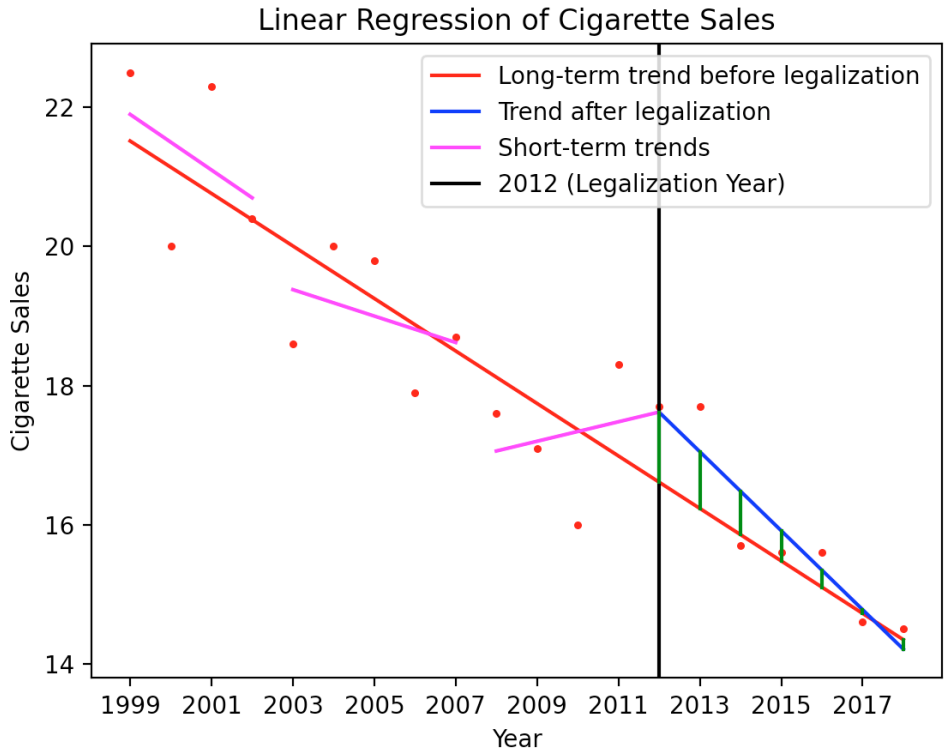

<u>Observations/Explanations:</u>

This data prior to legalization is a bit scattered compared to the first two graphs. After legalization in 2012, the slope of the unemployment rate decreased greatly as the slope went from $4.01 * 10^{-3}$ to $-9.00 * 10^{-3}$. This leads us to believe that legalization of marijuana had a large positive impact on the unemployment rate in Colorado.

Effect of Legalization on Cigarette Sales

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Linear Regression for Cigarette Sales before legalization:
Intercept is: 775.8650549450549
Slope is: -0.37736263736263737

Linear Regression for Cigarette Sales after legalization:
Intercept is: 1160.1464285714278
Slope is: -0.5678571428571425

Linear Regression for Cigarette Sales between 1999-2003:
Intercept is: 821.5000000000006
Slope is: -0.4000000000000003

Linear Regression for Cigarette Sales between 2004-2018:
Intercept is: 399.95000000000107
Slope is: -0.19000000000000053

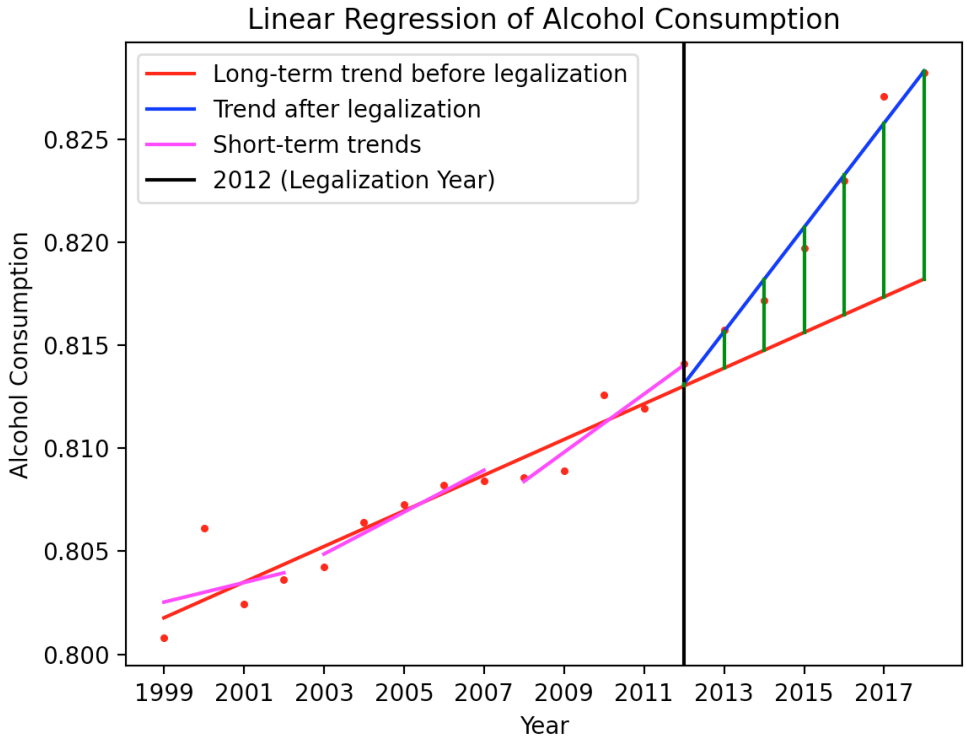
Linear Regression for Cigarette Sales between 2009-2012:
Intercept is: -264.059999999999
Slope is: 0.13999999999999949

The percent change in slopes was  50.48048922539303 percent
The average percentage increase of Cigarette Sales each year before 2012 legalization was  -1.5087940863076925 percent
The average percentage increase of Cigarette Sales each year after 2012 legalization was  -3.187179163857143 percent
```

<u>Observations/Explanations:</u>

Cigarette sales have been decreasing overall from 1999-2017. While short term trends prior to legalization seem to vary quite drastically, the trend after legalization has the lowest slope at a -3.187 percent decline through which we can conclude that legalization of marijuana had a positive impact on cigarette sales.

Effect of Legalization on Consumption of Alcoholic Beverages

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Linear Regression for Alcohol Consumption before legalization:
Intercept is: -0.9286780048993376
Slope is: 0.0008656550030769216

Linear Regression for Alcohol Consumption after legalization:
Intercept is: -4.27845486560355
Slope is: 0.0025306076249999895

Linear Regression for Alcohol Consumption between 1999-2003:
Intercept is: -0.1456076088200311
Slope is: 0.0004743050900000155 3

Linear Regression for Alcohol Consumption between 2004-2018:
Intercept is: -1.2323137119099967
Slope is: 0.0010170620899999983

Linear Regression for Alcohol Consumption between 2009-2012:
Intercept is: -2.029478521260006
Slope is: 0.0014132794300000032

The percent change in slopes was  192.33443069179847 percent
The average percentage increase of Alcohol Consumption each year before 2012 legalization was  0.12715028148923074 percent
The average percentage increase of Alcohol Consumption each year after 2012 legalization was  0.2847080490428572 percent
```
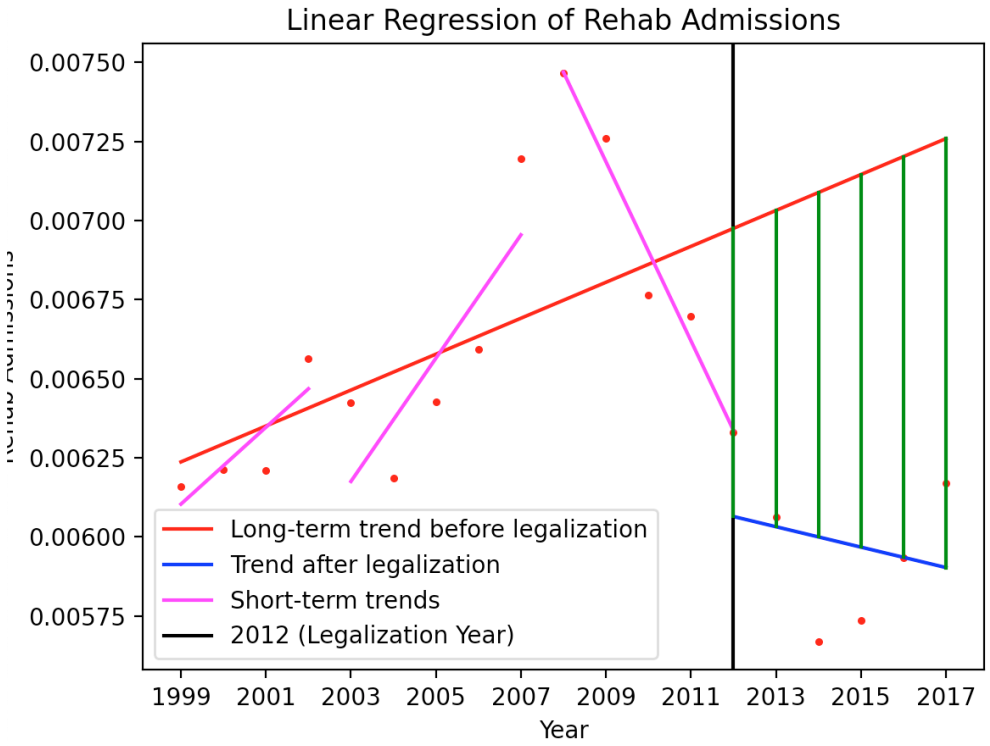

Observations/Explanations:

Alcohol consumption per capita is one of the more obvious changes that seems to occur following legalization in 2012. Colorado had been steadily increasing in alcohol consumption by ~0.13% every year from 1999-2012. Then after legalization in 2012, the annual rate doubled to ~0.28% increase every year. This points to alcohol possibly being a complement to marijuana rather than a substitute.

Effect of Legalization on Admission to Rehabilitation Services

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Linear Regression for admission to rehab before legalization:
Intercept is: -0.10726499027804619
Slope is: 5.677915649890111e-05

Linear Regression for admission to rehab after legalization:
Intercept is: 0.07097546434120007
Slope is: -3.226218060000003e-05

Linear Regression for admission to rehab between 1999-2003:
Intercept is: -0.23683497984059973
Slope is: 0.00012152982719999987

Linear Regression for admission to rehab between 2004-2018:
Intercept is: -0.3840984431881999
Slope is: 0.00019484440399999996

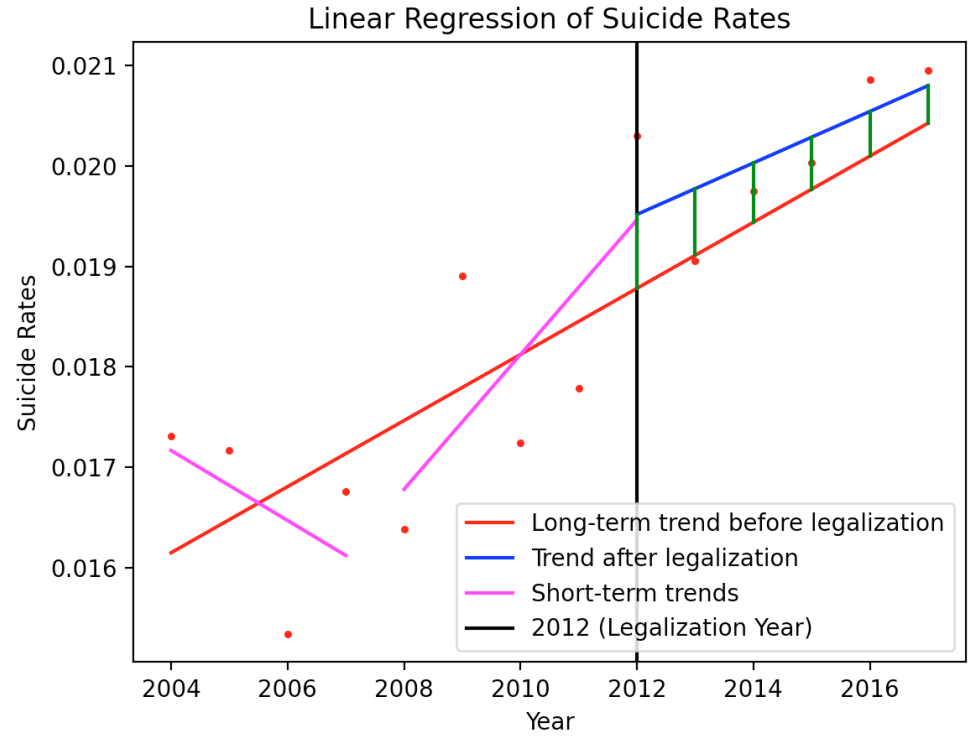
Linear Regression for admission to rehab between 2009-2012:
Intercept is: 0.5758882125901998
Slope is: -0.0002830773374999999

The percent change in slopes was  -156.82046474329786 percent
The average percentage increase of admission to rehab each year before 2012 legalization was  0.3111389481815388 percent
The average percentage increase of admission to rehab each year after 2012 legalization was  -1.264417538166667 percent
```

Observations/Explanations:

Admissions to rehab facilities have an erratic trend with an increase in rates up until the year 2008 and then a sharp/sudden decrease in admission rates until legalization. This could be due to the financial crisis in 2008 which could in turn have reduced funds available to pay for rehabilitation services. More research would be needed in order to confirm this decrease in 2008 and to check if the decrease after 2012 was due to recreational legalization.

Effect of Legalization on Suicide Rates

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Linear Regression for Suicide Rates before legalization:
Intercept is: -0.6439128981626671
Slope is: 0.00032937111866666684

Linear Regression for Suicide Rates after legalization:
Intercept is: -0.4968779005606667
Slope is: 0.000256658202

Linear Regression for Suicide Rates between 2004-2008:
Intercept is: 0.7162227536139998
Slope is: -0.00034883084299999994

Linear Regression for Suicide Rates between 2008-2012:
Intercept is: -1.331359836536
Slope is: 0.000671383877

The percent change in slopes was  -22.07628797601238 percent
The average percentage increase of Suicide Rates each year before 2012 legalization was  2.4266707171875 percent
The average percentage increase of Suicide Rates each year after 2012 legalization was  2.9459075010499998 percent
```
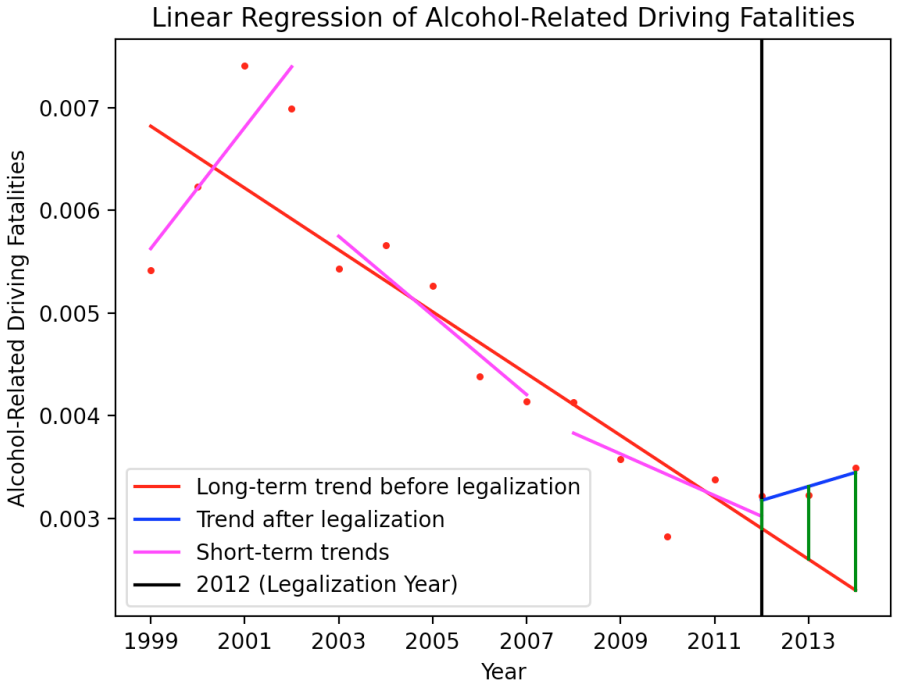

Observations/Explanations:

For suicide rates as well, we witness a sudden increase in rates in the year 2008 which could also be in effect of the financial crisis. There is however, an increase in suicide rates post legalization. The reasons could be that people are still experiencing the effects of the financial crisis or that the availability of recreational marijuana makes it easily accessible, affecting the mental health of more people. With respect to the numbers 2.42 and 2.95, we see almost very less change in the average percentage increase of suicide rates each year before and after legalization respectively.

Effect of Legalization on Alcohol-Related Driving Fatalities




```
Linear Regression for Alcohol-Related Driving Fatalities before legalization:
Intercept is: 0.6089979143857143
Slope is: -0.00030123922857142857

Linear Regression for Alcohol-Related Driving Fatalities after legalization:
Intercept is: -0.27072996208333316
Slope is: 0.00013613634999999999

Linear Regression for Alcohol-Related Driving Fatalities between 1999-2003:
Intercept is: -1.1742153912899997
Slope is: 0.0005902168299999999

Linear Regression for Alcohol-Related Driving Fatalities between 2004-2018:
Intercept is: 0.7778979610300004
Slope is: -0.0003854963700000002

Linear Regression for Alcohol-Related Driving Fatalities between 2009-2012:
Intercept is: 0.40997926358000025
Slope is: -0.00020226483000000014

The percent change in slopes was  -145.19210550551514 percent
The average percentage increase of Alcohol-Related Driving Fatalities each year before 2012 legalization was  -2.987829507215385 percent
The average percentage increase of Alcohol-Related Driving Fatalities each year after 2012 legalization was  1.2176593529333337 percent
```

<u>Observations/Explanations:</u>

Alcohol-Related Driving Fatalities was steadily decreasing in Colorado by on average ~-3.0% annually from 1999 to 2012. We see a stop in that decline following 2012, and a slight increase at ~1.2% annually. This data only represents until 2014, so we hope to find data on more years to prove this change.

Conclusions

Legalization of recreational marijuana appeared to affect Colorado in a variety of ways- some positive and some negative. Our findings, and possible rationales, were as follows:

Positive impacts:

- Reduction of drug-related deaths
    - Possible reasoning: Less drug abuse due to availability of safer options
- Increase in state GDP per capita
    - Possible reasoning: Higher degree of consumer spending
- Slight increase in Tax revenue per capita
    - Possible reasoning: same as above.
- Reduction in unemployment rate
    - Possible reasoning: Legalization paved the way for new jobs
- Admission to rehab went down
    - Possible reasoning: Less drug abuse due to availability of safer options

Negative impacts:

- Greater alcohol consumption
    - Possible reasoning: Marijuana could be a gateway drug to other substances, such as alcohol
- Greater alcohol-related driving fatalities
    - Possible reasoning: same as above.
- Slight increase in suicide rates
    - Possible reasoning: Greater mental health pressure

Our findings suggest that legalization of recreational marijuana has several benefits and consequences. The benefits are primarily economic, as can be seen by the reduced unemployment rate, the increase in income per capita, and the increase in tax revenue, which helps fund public education in Colorado. Additionally, it is certainly promising that legalization has the potential to reduce use of other potentially more harmful drugs. It is interesting to note that while drug-related deaths decreased, the amount of alcohol consumed increased- perhaps marijuana is a gateway drug to alcohol, but it is effective as an alternative to stronger drugs.

Potential Limitations and Risks:

- We were unable to find substantial data for certain variables that we would have liked to consider such as black market marijuana sales and drug tests administered by private companies.
- Another potential risk is the inability to conclude whether our prediction model accurately works on other states given the states' socio-economic factors.
- Data discrepancy issues may potentially skew the results.