Group 24: Jenny Jee, Karina Melnik, Josh Everts, Charlotte Kane

Examining the Effectiveness of Various Transportation Emissions Policies

After learning that the US was the first country to set vehicle emissions standards, our group was intrigued to analyze the effectiveness of these regulations[1]. Our hope is that our findings can guide transportation emissions regulation on a broader scale.

Background and Introduction

In September, the world witnessed one of California's worst fire seasons ever. During this period, Portland, Seattle, and San Francisco had the worst air quality among major cities globally[2]. These dystopian conditions were an inspiration for us to focus on air quality. Since we sought a variable that affects all states, we decided to focus on transportation emissions specifically. In addition, the transportation industry is the top producer of greenhouse gases in the US (Fig. 1). Thus, we decided to explore air quality and emissions trends, and assess the effectiveness of regulations on these parameters.

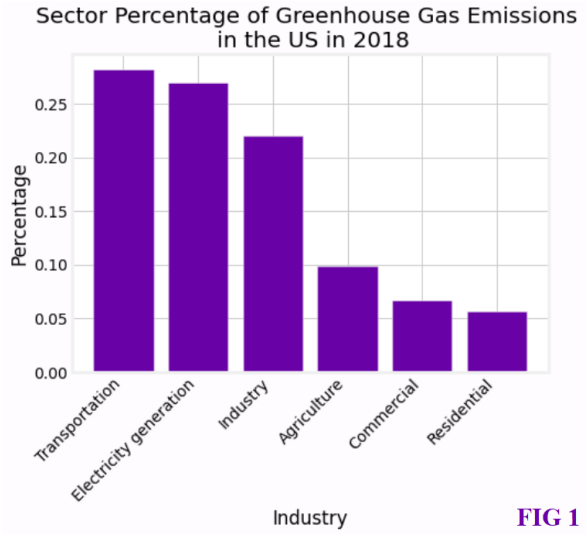


FIG 1

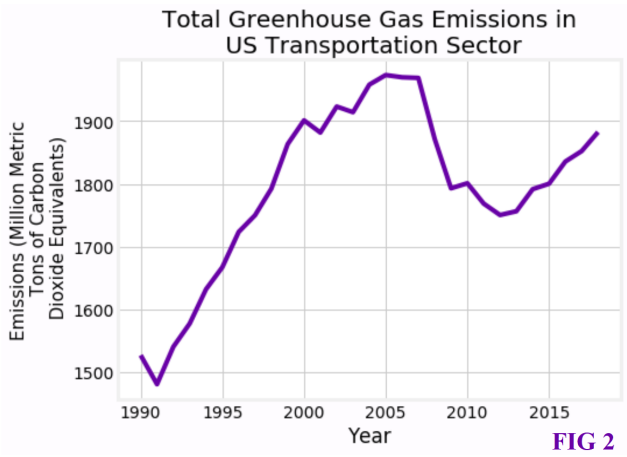


FIG 2

Our initial questions included the following: What do trends look like over time? What would cause a particular US state to perform better in reducing greenhouse gas emissions? Which gases should we prioritize in our analysis? What factors besides policies matter?

Data and Analysis

We have used data from the US Environmental Protection Agency (EPA), Bureau of Transportation Statistics (BTS), California Department of Tax and Fee Administration (CDTFA) and the California Air Resources Board (CARB) in our analysis using scraping and sourcing mainly.

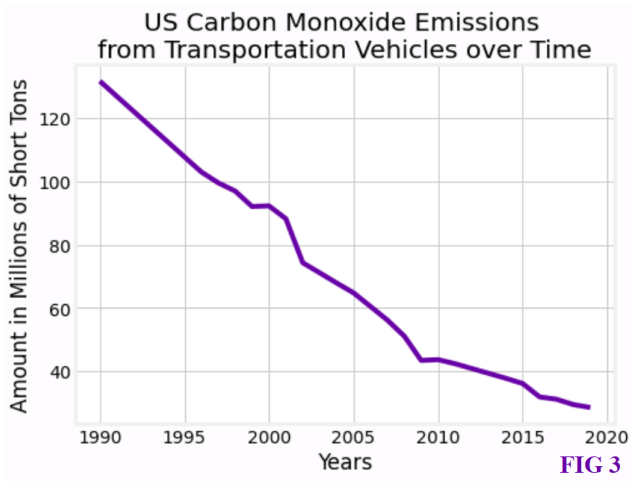


FIG 3

While the emissions from transportation increased nearly every year between 1991 and 2007, a large decrease took place between 2007 and 2012 (Fig 2). An EPA regulation enacted in 2008, in which "more stringent standards to drastically reduce emissions" of greenhouse gases could have possibly caused this decrease[3]. However, it seems unlikely that a policy could have caused such a rapid decrease, where emissions dropped from approximately 1,975 tons to 1,775 tons in five years[4]. Contributing factors may include the Great Recession which began in 2007, causing people to travel less. Later on, in the CO_2 section, we explore the idea that vehicle transportation emissions decreased

[1] "History of Reducing Air Pollution from Transportation in the United States." EPA. Environmental Protection Agency, November 4, 2020.
[2] P.Murphy, Paul. "The Western US Has the Worst Air Quality in the World, Group Says." CNN. Cable News Network, September 14, 2020.
[3] "History of Reducing Air Pollution." EPA. November 4. 2020.
[4] "Greenhouse Gas Inventory Data Explorer." EPA. Environmental Protection Agency. Accessed December 10, 2020.

due to an increase in vehicle fuel economy, possibly driven by rising gas prices.

Exploratory Analysis

Carbon Monoxide

First, we will analyze trends and policies related to carbon monoxide(CO). While CO is one of the most common gases emitted from motor vehicles, it is also one of the most dangerous: upon inhalation, CO outcompetes oxygen-hemoglobin binding, causing eventual asphyxiation[5]. Sourcing information provided from the Bureau of Transportation Statistics[6], we determined that CO emissions levels have been consistently decreasing nationally since 1990 (Fig. 3).

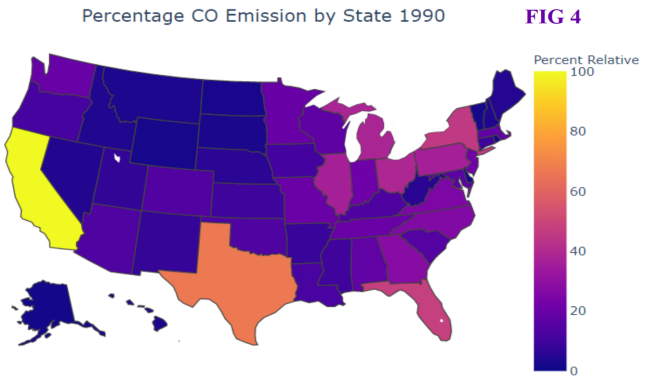


FIG 4

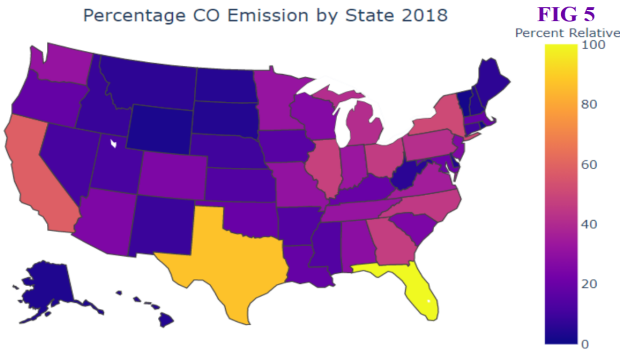


FIG 5

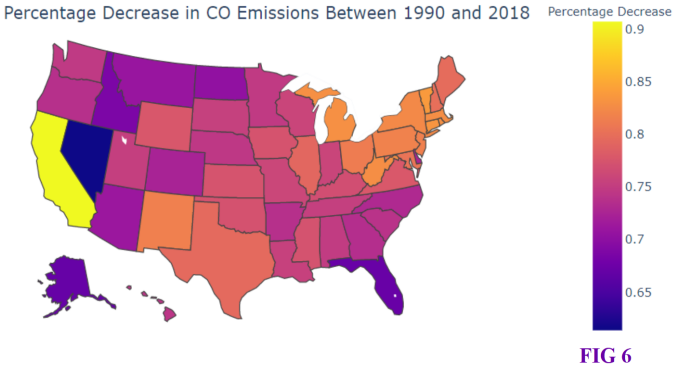


FIG 6

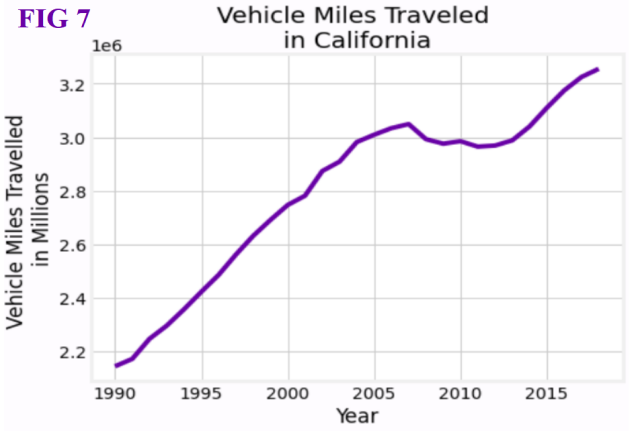


FIG 7

Next, we set out to determine which states were the greatest offenders in CO emissions. The heatmaps and tables are generated with data from BTS[7]. According to Fig. 4, California was the lead producer of carbon monoxide emissions in 1990, followed by Texas and Florida. However, this changed over time. In 2018, Florida climbed up the ranks and became the #1 producer of CO emissions in the US. Texas retained its #2 position, while California moved down to #3. (Fig. 5)

Let's take a closer look at the changes in emissions in US states between 1990 and 2018. According to the table above, California experienced the greatest decrease in CO emissions between 1990 and 2018 (90.7%.) Vermont and Connecticut followed California with an 83.7% and 83% decrease in emissions, respectively.

State	1990 CO Emissions	2018 CO Emissions	% Change in CO Emissions Btwn. 1990 & 2018
AL	2661.17	668.663	-0.748733
AK	327.679	108.09	-0.670134
AZ	2047.74	592.16	-0.710822
AR	1357.53	357.553	-0.736615
CA	14176	1323.66	-0.906627
CO	2130.68	589.039	-0.723545
CT	1504.76	251.057	-0.833158
DE	400.852	110.292	-0.724857
DC	155.221	31.1061	-0.799601
FL	6836.09	2247.21	-0.671272

Despite displaying the greatest decrease in CO emissions (see Fig. 6), California experienced an increase in vehicle miles travelled (See Fig. 7 above). Such a phenomenon is indicative of a shift towards fuel-efficient and safe-exhaust vehicles. It is worth noting that California was the first state to lead the Clean Air Act with the efforts of EPA[8]. This action, combined with other significant regulations, could explain such reduction.

[5] U.S. Environmental Protection Agency, Air Emissions Inventories, *Air Pollutant Emissions Trends Data*, National Annual Emissions, May 7, 2020.

[6] "Estimated U.S. Emissions of Carbon Monoxide." Bureau of Transportation Statistics.

[7] ibid

[8] "History of Reducing Air Pollution." EPA. November 4. 2020.

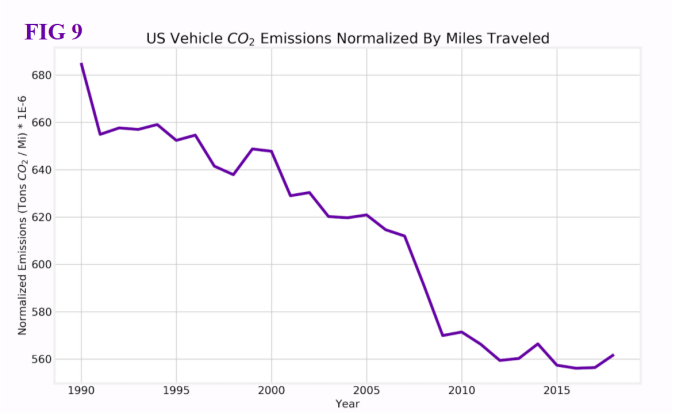
Thus, we will make California our model state for the remainder of this portion of the analysis.

We then analyzed other potential reasons for California's success in reducing CO emissions. One possibility is the increase in gas taxes. We hypothesize that higher gasoline tax rates disincentivize people from purchasing less fuel efficient cars. Unfortunately, we were unable to locate information regarding gasoline tax rates in California years prior to 2010. Based on the available data[9], we are able to state that gasoline tax rates have, on average, increased between 2010 and 2018 (Fig. 8). It is possible that the increase in gasoline tax rates encouraged people to buy cars that utilize gasoline more efficiently, or no gasoline at all. Another potential factor is the passage of the Pavley Bill[10], which outlines the establishment of emissions goals and programs that incentivise various sectors of the California economy to reduce gas emissions. We do not currently have evidence on whether the Pavley Bill or the gas tax increase contributed more to the decrease in CO emissions.

Carbon Dioxide

After this analysis, we decided to analyze CO2 emissions[11] because it accounts for 81% of all greenhouse gas emissions in the US[12]. In Fig. 9, the CO_2 emissions have been normalized by the miles driven in every year, so that the y-value plotted is CO_2/Miles Driven. We can observe two main trends: First, the normalized CO_2 emissions have nearly monotonically decreased since 1990. Second, emissions plummeted at an even sharper rate between 2007 to 2009.

FIG 9



Why might this be? There are a couple of potential explanations: 1) Policies that were enacted around 2007 could've had an effect; 2) Fuel prices increased significantly during the period before and after, thereby causing people to buy more fuel efficient cars that also produce less emissions; 3) People started to use more efficient forms of transport (biking/bus/train etc). In the interest of space, we chose to investigate just (2). It is first crucial to note that no true statistical significance test can be performed with the data we have collected, as there is no control to compare against. However, we can still look at fuel economy and emissions trends to see if this hypothesis is plausible.

Firstly, we find a strong inverse correlation between fuel economy and CO_2 emissions: R^2 = .996

FIG 8

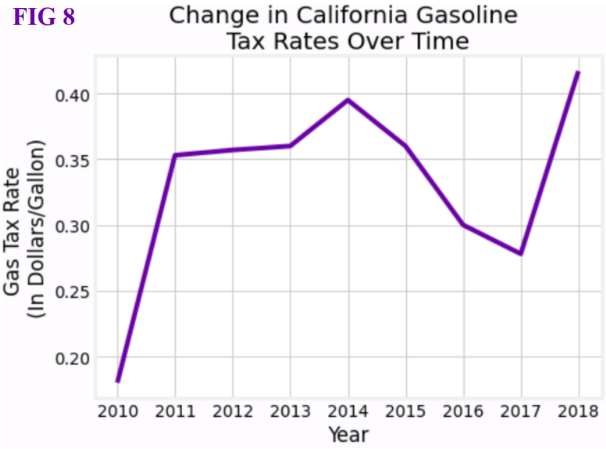
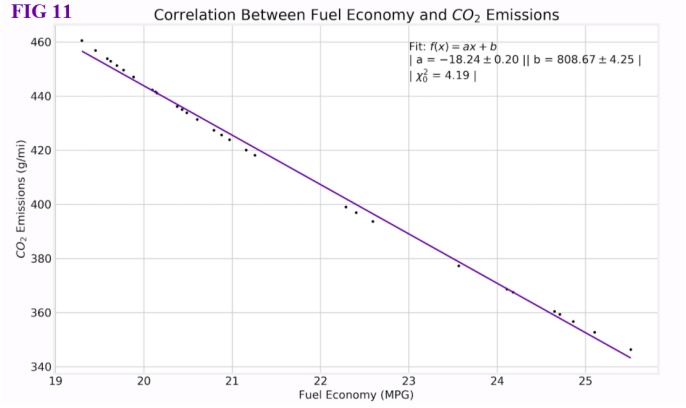


FIG 11



(Fig. 11). While the reduced X^2 value is not particularly close to 1, this indicates that the data is slightly nonlinear. From a visual inspection, there is a clear decreasing trend in the data; this seems logical as a more efficient car will use less fuel to travel the same distance, decreasing emissions. We note that the extremely strong correlation is still somewhat suspicious.

Additionally, looking at the appendix Fig. 1 and Fig. 2, we see that the Corporate Average Fuel Economy (CAFE) sharply spikes around the 2007

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[9] "Explore the Automotive Trends Data." EPA. Environmental Protection Agency, May 12, 2020.

[10] California's Greenhouse Gas Vehicle Emission Standards under Assembly Bill 1493 of 2002 (Pavley). California Air Resources Board. Accessed December 10, 2020.

[11] "Overview of Greenhouse Gases." EPA. Environmental Protection Agency, September 8, 2020.

[12] "History of Reducing Air Pollution." EPA. November 4. 2020

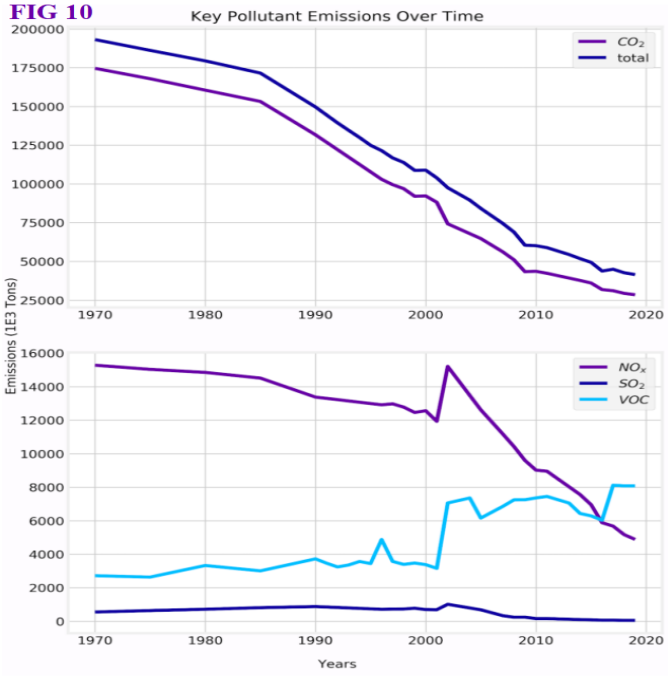
period[13]. As Appx. Fig. 2 shows, this shift occurs in the light of ever-increasing fuel prices throughout the 2000s.

Together, this data seems to suggest that increasing fuel prices are correlated with consumers choosing to buy higher MPG cars. We have also shown a clear correlation between vehicle MPG and emissions. In summary, it is likely that the sudden drop in normalized CO_2 emissions seen in 2007 is at least partially attributable to gas prices leading consumers to purchase more efficient cars.

Final Analysis

Fig. 10 was generated by sourcing air pollutant emissions data released by the EPA[14], then splicing it to generate our own data set pertaining to relevant information: the four main gases emissions solely from the transportation sector. From the figure, we see that CO_2 was the main gas released; it closely follows the overall trend, reconfirming it as the largest percentage

FIG 10



emission out of 4. It is evident that total transportation emissions, largely CO_2, have decreased since 1970, with a stronger decreasing trend observed around 1984. This is likely due to amendment of Clean Air Act in 1981 along with a new requirement of periodic testing of malfunctioning emission control systems in passenger vehicles[15]. The second graph in Fig. 10 shows the trends of three other pollutants. Interestingly, an overall decreasing trend is only observed in two of them.

Conclusion

Through our analysis, we found that policies, both regulatory and tax-based, have played a role in the US's, and most notably, California's success in decreasing vehicle emissions.

First, we note an important point: while Fig. 1 shows that transportation greenhouse gas emissions have been generally increasing since 1970, we have found evidence that both road vehicle CO and normalized CO_2 emissions have steadily decreased since the 1990s. Since not all states have reduced emissions equally, we conclude state-based policy measures play a significant role in influencing emissions and air quality.

While efficient vehicle buying trends could vary between states, our analysis of the California gas tax indicates that taxes have increased over time. While the significance of the impact of gas tax increase on consumer buying habits is still unclear from our analysis, our Appx. Fig. 1 and Fig. 2 show that there is a relationship between fuel prices and MPG of new vehicles (specifically, between 2002-2008). Together, these data suggest that part of California's success in reducing CO emissions could be due to its willingness to increase the gas tax more than other states.

Our analysis of the relationship between MPG and CO_2 emissions revealed a strong inverse correlation: as MPG increases, emissions decrease. While we mentioned that there is a likely correlation between fuel prices and new car MPG, there are also environmental regulations that target MPG and the reduction of CO_2 emissions. One factor which indicates that gas prices themselves may play a role again comes from appx. Fig. 1 and Fig. 2. Through a quick visual analysis, it appears that the dramatic falls in gas prices seen in 2008-2009 and starting in 2012 have corresponding decreases in new-car MPG those same years. Further statistical analysis is needed to verify this correlation.

Lastly, our general vehicle emissions analysis indicates that not all pollutants have had decreasing trends since 1970. The reason as to why pollutants like CO and CO_2 have garnered more attention than others must be explored in future research endeavors. Based on our analysis, we recommend for future policies aimed at decreasing transportation emissions to raise gasoline taxes, create incentive-based programs for decreasing car emissions among automakers and businesses (using California's Pavley example), and potentially focus decreasing the emissions on other greenhouse gases such as VOC and SO_2 that have not been adequately addressed in past years.

[13] "Explore the Automotive Trends", EPA.
[14] U.S. Environmental Protection Agency, *Air Pollutant Emissions Trends Data*, May 7, 2020.
[15] "History of Reducing Air." EPA. November 4, 2020.

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Group member contributions

Karina Melnik: Contributed 5 independently-created graphs, and 3 heatmaps in collaboration with Josh Everts. Helped create write-up.

Jenny Jee: Contributed graphs and generated a database, helped draft and edit write-up, and created all citations. Consistently referred back to project guidelines to ensure the report contained necessary components. Formatted and edited the presentation.

Josh Everts: Contributed 3 graphs (1 in appendix), and collaborated with Karina to make heatmaps. Helped finalize an additional graph. Created the presentation helped write-up analysis/design, and made code doc.

Charlotte Kane: Independently contributed 2 graphs in report and others not included, wrote analyses on a majority of the graphs, edited the report document.

Works Cited:

[1]: “History of Reducing Air Pollution from Transportation in the United States.” EPA. Environmental Protection Agency, November 4, 2020. https://www.epa.gov/transportation-air-pollution-and-climate-change/accomplishments-and-success-air-pollution-transportation.

[2]: Paul P.Murphy. “The Western US Has the Worst Air Quality in the World, Group Says.” CNN. Cable News Network, September 14, 2020. https://edition.cnn.com/2020/09/14/weather/wildfire-air-quality-trnd/index.html.

[3]: “Greenhouse Gas Inventory Data Explorer.” EPA. Environmental Protection Agency. Accessed December 10, 2020. https://cfpub.epa.gov/ghgdata/inventoryexplorer/.

[4]: “California Air Resources Board.” Carbon Monoxide & Health . California Air Resources Board. Accessed December 10, 2020. https://ww2.arb.ca.gov/resources/carbon-monoxide-and-health.

[5]: U.S. Environmental Protection Agency, Air Emissions Inventories, Air Pollutant Emissions Trends Data, National Annual Emissions, May 7, 2020. Accessed December 10, 2020. https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data

[6]: “Estimated U.S. Emissions of Carbon Monoxide.” Estimated U.S. Emissions of Carbon Monoxide . Bureau of Transportation Statistics. Accessed December 10, 2020. https://www.bts.gov/content/estimated-national-emissions-carbon-monoxide.

[7]: “Explore the Automotive Trends Data.” EPA. Environmental Protection Agency, May 12, 2020.

[8]: California's Greenhouse Gas Vehicle Emission Standards under Assembly Bill 1493 of 2002 (Pavley). California Air Resources Board. Accessed December 10, 2020. https://ww2.arb.ca.gov/californias-greenhouse-gas-vehicle-emission-standards-under-assembly-bill-1493-2002-pavley.

[9]: “Overview of Greenhouse Gases.” EPA. Environmental Protection Agency, September 8, 2020. https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

Appendix

Fig. 1: Retail Gas Prices across years in the United States. Note the extremely sharp increase in prices beginning around 2002.

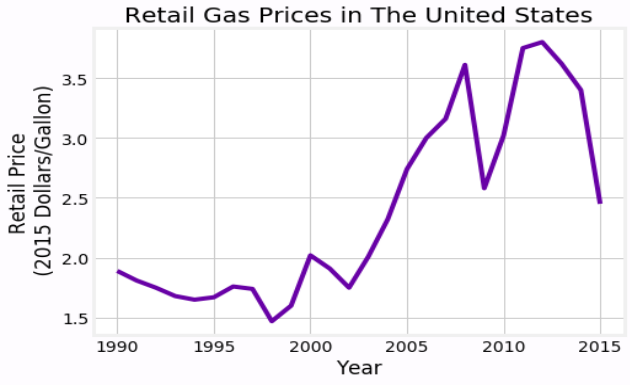

Fig. 2: