Hey, What's Up? Gas Prices: Analyzing the Influences of U.S. Gas Price Trends

Our Team

Phillips Academy ‘23
Princeton, NJ

Karen Wang

Lynbrook High School ‘23
San Jose, California

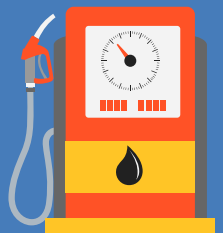
Brian Ling

Westlake High School ‘23
Texas

Jennifer Li

Hong Kong International School ‘24
Hong Kong

Christine Lam



Overview

01 Objectives

02 Data + EDA

03 Analysis

04 Conclusion

01

Objectives

Background

- Highest gas prices in U.S. history
- High Fluctuation in prices
  - Russia-Ukraine conflict
  - COVID-19
  - Lack of refinery space

Research Questions

What factors affect gas prices?

Why are gas prices so high?

02

Data + EDA

Explanatory Variables

Economics

Imports, Exports, Production, Consumption, Poverty, Income

Weather

Seasons

Energy

Coal, Gas, Renewable Energy, Natural Gas, CO2 emissions

Google Search

Oil, Gas

Datasets (Sources)

American Petroleum Institute

U.S. Energy Information Administration

The World Bank

National Broadcasting Company

Google Search Trends

Dataset

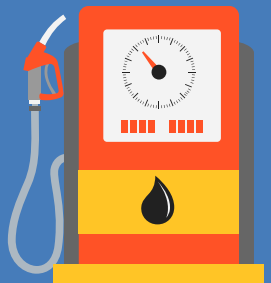
- Longitudinal data - 35 variables
- Each month from Jan 2000 - June 2022
- Descriptive data from previously mentioned sources

Month	allgasprice	premgasprice	reggasprice	importacqcost	totalimport	oilimport	oildemand	consumption	production	imports	exports	net.imports
2000-01-01	1.33	1.47	1.29	25.3	314334	242698	19.0	19.7	8.68	11.46	1.040	10.419
2000-02-01	1.42	1.55	1.38	27.4	319073	241236	19.6	19.7	8.68	11.46	1.040	10.419
2000-03-01	1.56	1.70	1.52	27.7	342602	272503	19.2	19.7	8.68	11.46	1.040	10.419
2000-04-01	1.51	1.65	1.47	24.3	346738	280228	18.8	19.7	8.68	11.46	1.040	10.419
2000-05-01	1.53	1.67	1.49	26.4	353879	281621	19.6	19.7	8.68	11.46	1.040	10.419
2000-06-01	1.67	1.79	1.63	28.9	360960	286000	20.1	19.7	8.68	11.46	1.040	10.419
2000-07-01	1.59	1.74	1.55	28.0	359227	291346	19.7	19.7	8.68	11.46	1.040	10.419
2000-08-01	1.51	1.65	1.47	28.8	377352	308103	20.5	19.7	8.68	11.46	1.040	10.419
2000-09-01	1.59	1.73	1.55	30.6	356996	284528	19.9	19.7	8.68	11.46	1.040	10.419
2000-10-01	1.57	1.71	1.53	29.7	350000	278052	19.8	19.7	8.68	11.46	1.040	10.419
2000-11-01	1.56	1.70	1.52	30.0	339272	267387	19.3	19.7	8.68	11.46	1.040	10.419
2000-12-01	1.48	1.63	1.44	25.2	373653	286114	20.8	19.7	8.68	11.46	1.040	10.419
2001-01-01	1.49	1.63	1.45	24.5	389212	276911	20.1	19.6	8.57	11.87	0.971	10.900
2001-02-01	1.49	1.64	1.45	25.0	326012	241046	19.7	19.6	8.57	11.87	0.971	10.900
2001-03-01	1.45	1.60	1.41	23.0	376103	297683	19.9	19.6	8.57	11.87	0.971	10.900
2001-04-01	1.59	1.73	1.55	23.0	379586	303320	19.7	19.6	8.57	11.87	0.971	10.900
2001-05-01	1.74	1.87	1.70	24.6	388410	306450	19.5	19.6	8.57	11.87	0.971	10.900
2001-06-01	1.66	1.80	1.62	23.9	351959	273160	19.6	19.6	8.57	11.87	0.971	10.900
2001-07-01	1.47	1.62	1.42	22.8	364564	296127	19.9	19.6	8.57	11.87	0.971	10.900
2001-08-01	1.46	1.60	1.42	23.8	360271	290870	20.1	19.6	8.57	11.87	0.971	10.900
2001-09-01	1.56	1.68	1.52	22.5	354529	280182	19.0	19.6	8.57	11.87	0.971	10.900
2001-10-01	1.36	1.50	1.31	18.8	352734	285531	19.8	19.6	8.57	11.87	0.971	10.900
2001-11-01	1.21	1.36	1.17	16.1	348854	279594	19.4	19.6	8.57	11.87	0.971	10.900
2001-12-01	1.13	1.27	1.09	15.9	340804	274020	19.0	19.6	8.57	11.87	0.971	10.900
2002-01-01	1.15	1.29	1.11	17.0	343737	269965	19.4	19.8	8.58	11.53	0.984	10.546
2002-02-01	1.16	1.30	1.11	18.2	305310	245094	19.4	19.8	8.58	11.53	0.984	10.546
2002-03-01	1.29	1.43	1.25	22.3	347145	272781	19.7	19.8	8.58	11.53	0.984	10.546
2002-04-01	1.44	1.58	1.40	24.0	352954	279024	19.6	19.8	8.58	11.53	0.984	10.546
2002-05-01	1.43	1.58	1.39	24.4	364849	289026	19.7	19.8	8.58	11.53	0.984	10.546

Response Variable:

Gas Price

Average retail gas price of premium and regular gas in the U.S. in USD per month from the U.S. Energy Information Administration



Economics

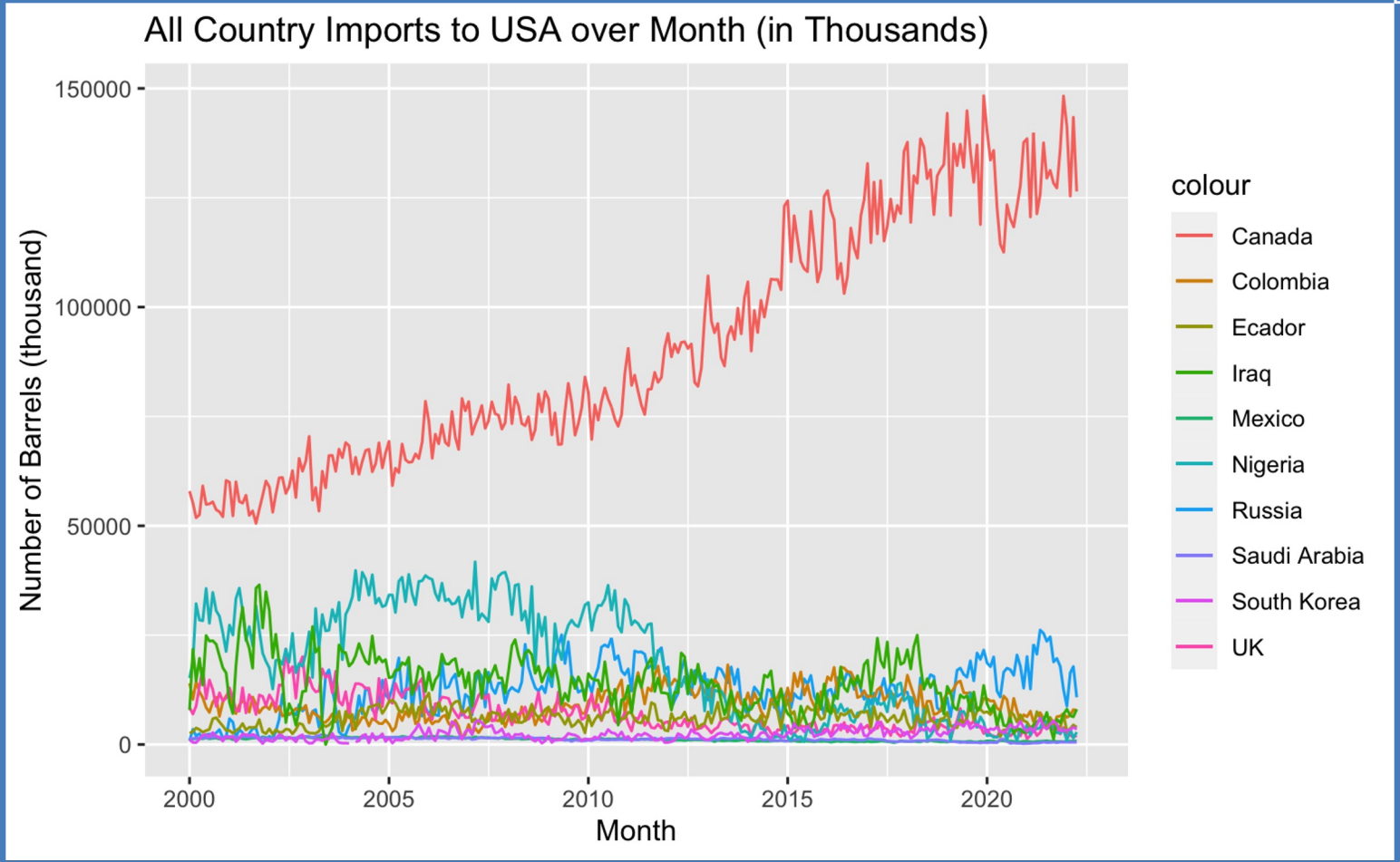
Production: Total operating oil rigs, wells drilled, gas barrels produced, gas demanded and consumed

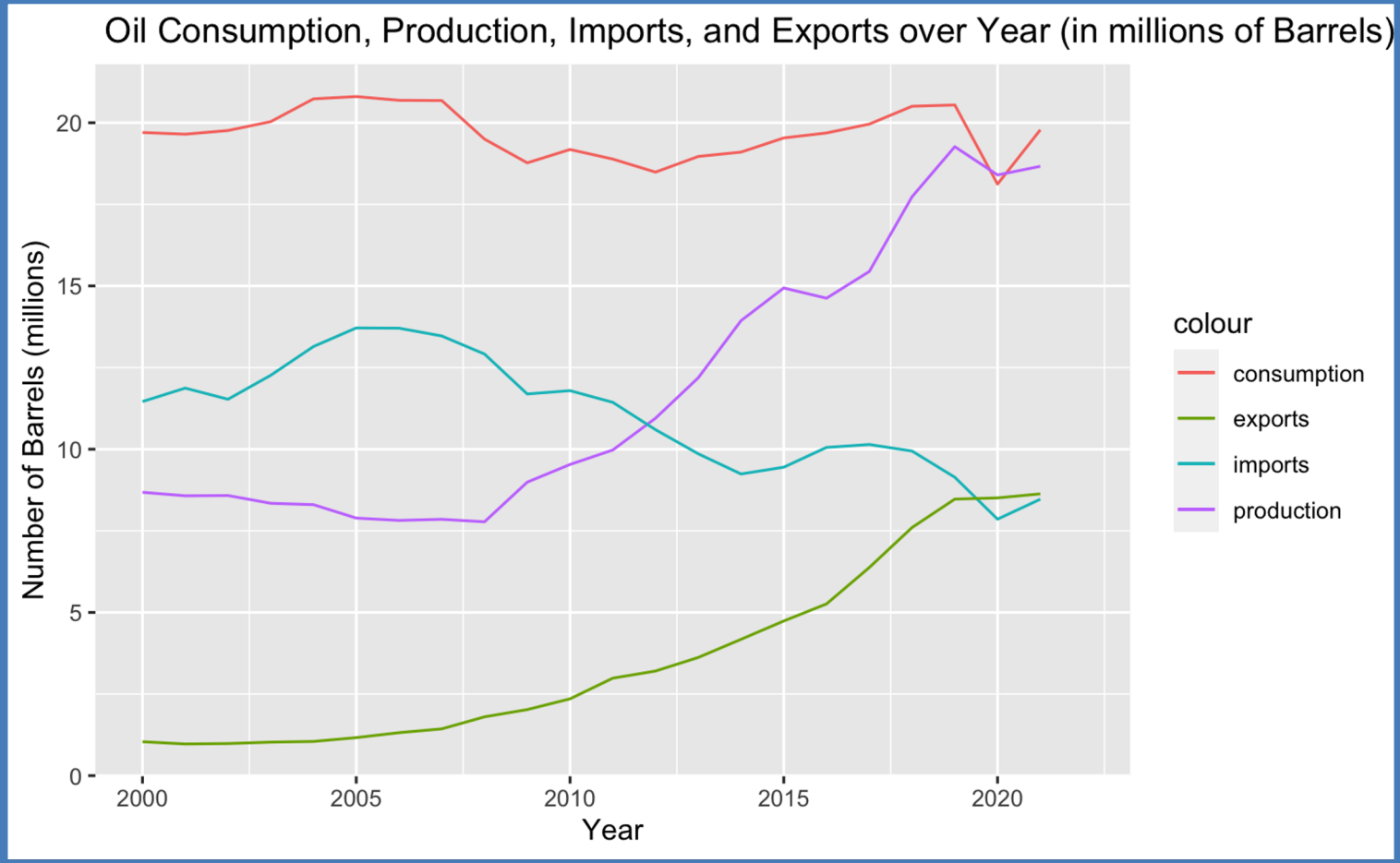
Trade: Oil imports and exports to the U.S. by Country, net imports and exports

Money: Income, Poverty %

Important Observations:

- Canada imports the most gas to the U.S.
- Consumption relatively consistent
- Production + Exports same behavior
- Drop in Imports


All Country Imports to USA over Month (in Thousands)
Number of Barrels (thousand)
150000
100000
50000
0
2000
2005
2010
2015
2020
Month
colour
Canada
Colombia
Ecador
Iraq
Mexico
Nigeria
Russia
Saudi Arabia
South Korea
UK


Oil Consumption, Production, Imports, and Exports over Year (in millions of Barrels)
Number of Barrels (millions)
0
5
10
15
20
2000
2005
2010
2015
2020
Year
colour
consumption
exports
imports
production

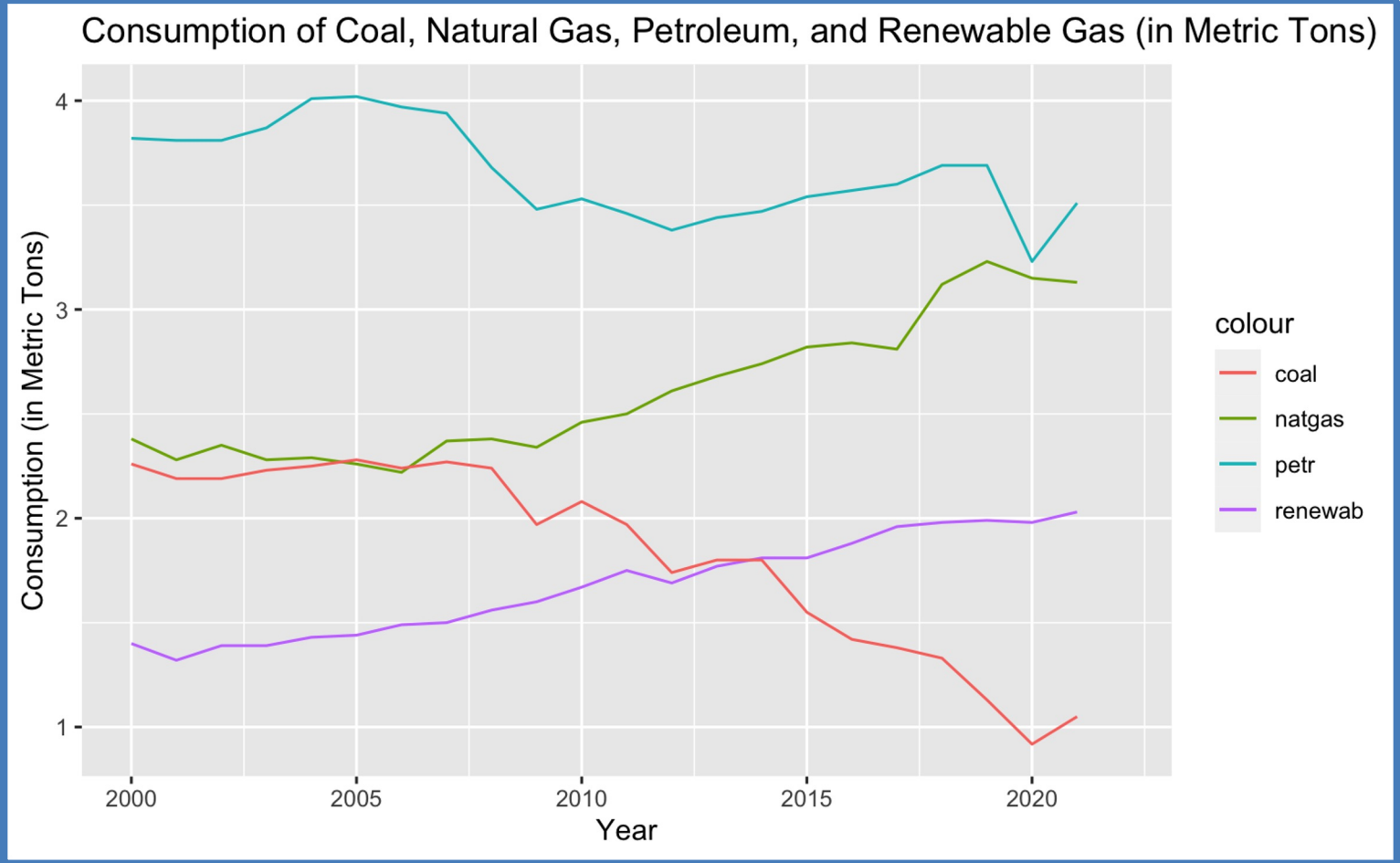
Energy

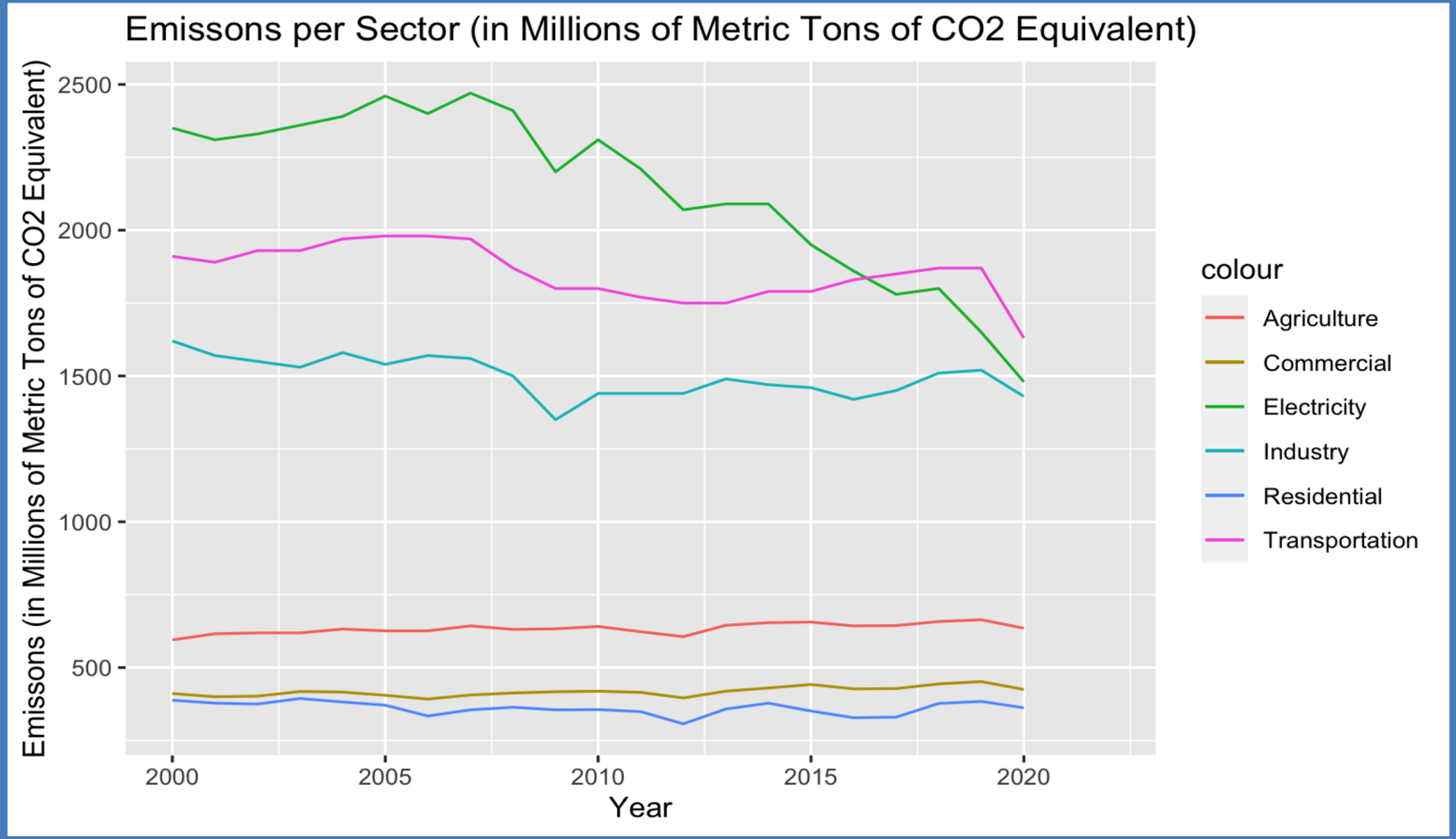
Energy Consumed: Coal, Natural Gas, Gas, Renewable Energy

CO_2 Emissions by Sector: Agriculture, Commercial, Electricity, Industry, Residential, Transportation

Important Observations:

- Steady increase of renewable energy consumed
- Drop in coal consumed
- Overall decline of gas consumed, mirroring gas price drops in 2008 and 2020
- Drop in CO_2 emissions for Electricity and Transportation


Consumption of Coal, Natural Gas, Petroleum, and Renewable Gas (in Metric Tons)
Consumption (in Metric Tons)
4
3
2
1
2000
2005
2010
2015
2020
Year
colour
coal
natgas
petr
renewab

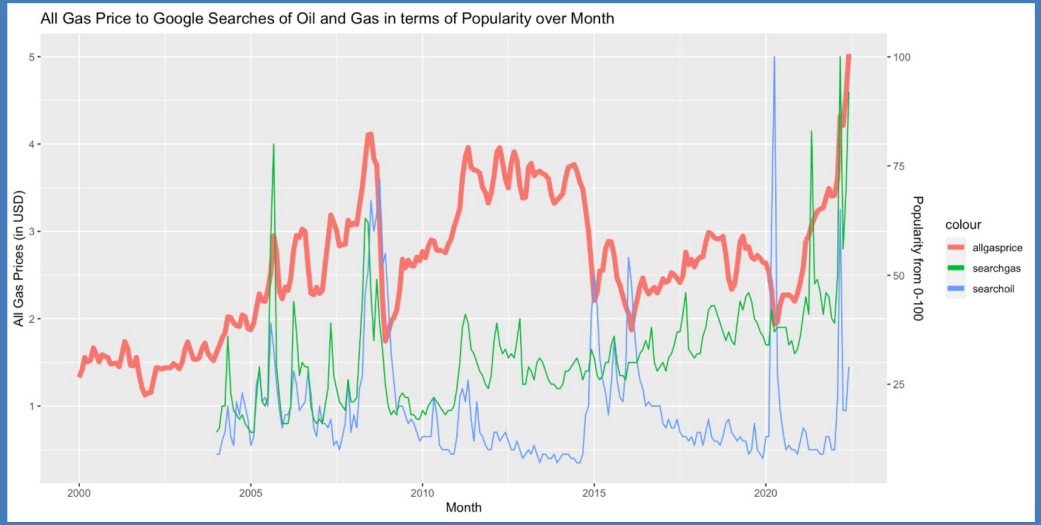

Emissons per Sector (in Millions of Metric Tons of CO2 Equivalent)
Emissons (in Millions of Metric Tons of CO2 Equivalent)
2500
2000
1500
1000
500
2000
2005
2010
2015
2020
Year
colour
Agriculture
Commercial
Electricity
Industry
Residential
Transportation

Google Search

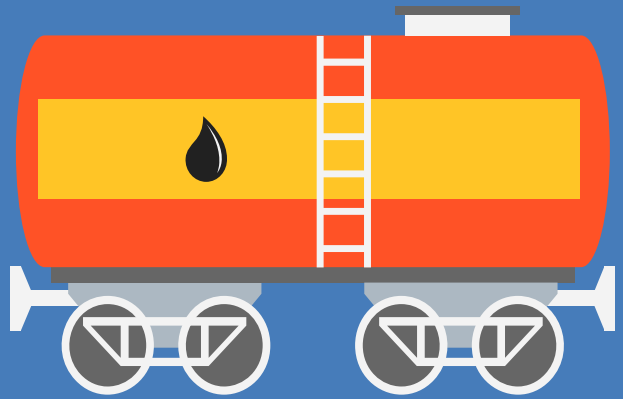
Search Variable: Popularity value from 0-100 for “Gas” and “Oil”

Important Observations:

- “Gas” and “Oil” generally mirror each other
- Spike in searches when sudden drop and rise in gas price

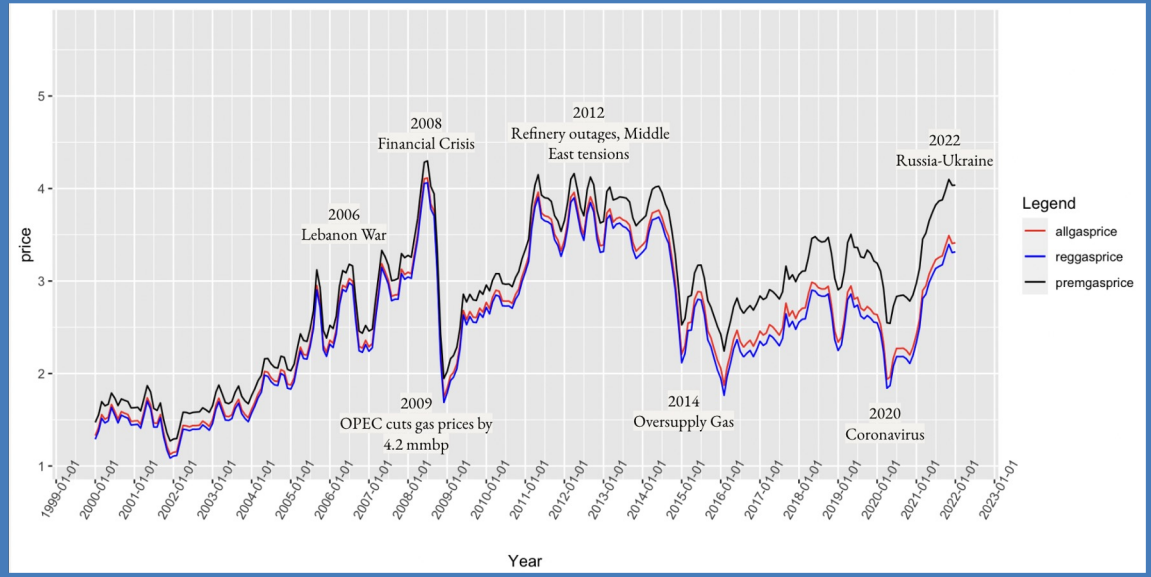


03



Analysis

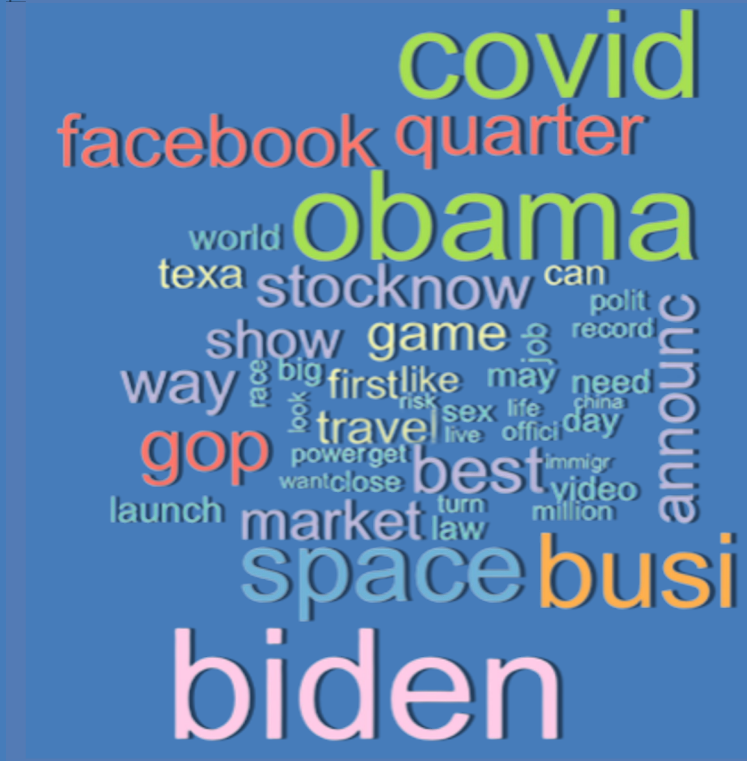
Sentiment Analysis
LASSO and Regression



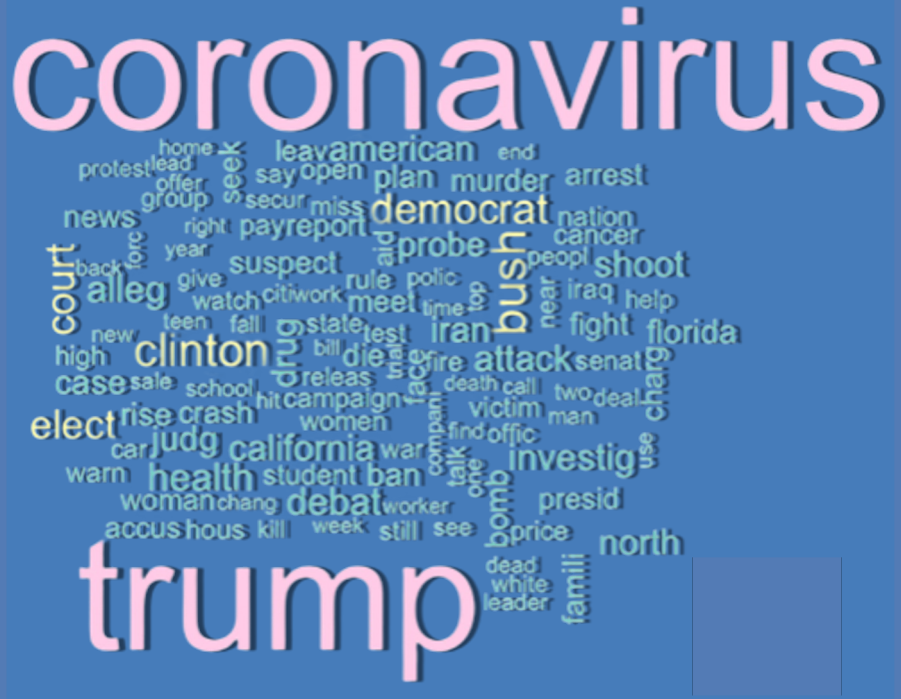
Obama seeks joint approach with Russia on Iran nuclear bomb

Oil rig workers hit with one-two punch of coronavirus and plummeting oil prices

Rise in Price



Fall in Price



Initial Factors

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Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-2.382e+01	8.889e+00	-2.680	0.00789	**
net.imports	3.812e-01	1.169e-01	3.262	0.00127	**
income	8.598e-05	1.873e-05	4.592	7.16e-06	***
poverty	1.606e-01	8.270e-02	1.942	0.05339	.
~~wells~~	-8.315e-05	1.551e-04	-0.536	0.59237	
operation	3.682e-04	2.529e-04	1.456	0.14683	
~~russiaImp~~	1.319e-06	5.253e-06	0.251	0.80194	
~~colomImp~~	-3.346e-06	7.817e-06	-0.428	0.66903	
~~mexImp~~	-2.404e-04	1.502e-04	-1.600	0.11087	
~~ukImp~~	-1.217e-05	7.660e-06	-1.588	0.11353	
~~saudiImp~~	4.553e-05	9.335e-05	0.488	0.62617	
~~nigeriaImp~~	1.697e-06	4.009e-06	0.423	0.67255	
~~ecuadorImp~~	-9.154e-06	1.131e-05	-0.809	0.41922	
canImp	6.761e-06	2.455e-06	2.754	0.00634	**
~~iraqImp~~	3.332e-06	3.616e-06	0.921	0.35780	
~~skImp~~	2.512e-05	2.014e-05	1.247	0.21352	
searchgas	2.564e-02	2.070e-03	12.384	< 2e-16	***
searchoil	-8.209e-03	1.780e-03	-4.611	6.58e-06	***
~~natgas~~	-1.020e-16	4.044e-17	-2.523	0.01229	*
~~petr~~	-1.818e-16	1.258e-16	-1.445	0.14986	
renewab	6.449e-17	1.829e-16	0.353	0.72472	
~~Agriculture~~	3.911e-09	5.171e-09	0.756	0.45018	
Commercial	-2.185e-09	7.192e-09	-0.304	0.76155	
Electricity	1.751e-09	9.706e-10	1.804	0.07246	.
~~Industry~~	6.486e-09	1.658e-09	3.912	0.00012	***
~~Residential~~	3.930e-09	3.575e-09	1.099	0.27282	
Transportation	-2.415e-10	2.428e-09	-0.099	0.92085	
~~us_emission~~	-9.110e-01	6.485e+00	-0.140	0.88840	
~~nuclear~~	5.453e+00	7.129e+00	0.765	0.44507	
~~hydroelectric~~	1.052e+01	5.548e+00	1.897	0.05909	.
~~geothermal~~	2.812e+02	9.331e+01	3.014	0.00286	**
~~wind~~	3.153e+01	1.184e+01	2.664	0.00827	**
seasonspring	6.480e-03	4.765e-02	0.136	0.89193	
seasonsummer	6.326e-02	4.586e-02	1.379	0.16912	
seasonwinter	-1.235e-01	5.043e-02	-2.449	0.01508	*

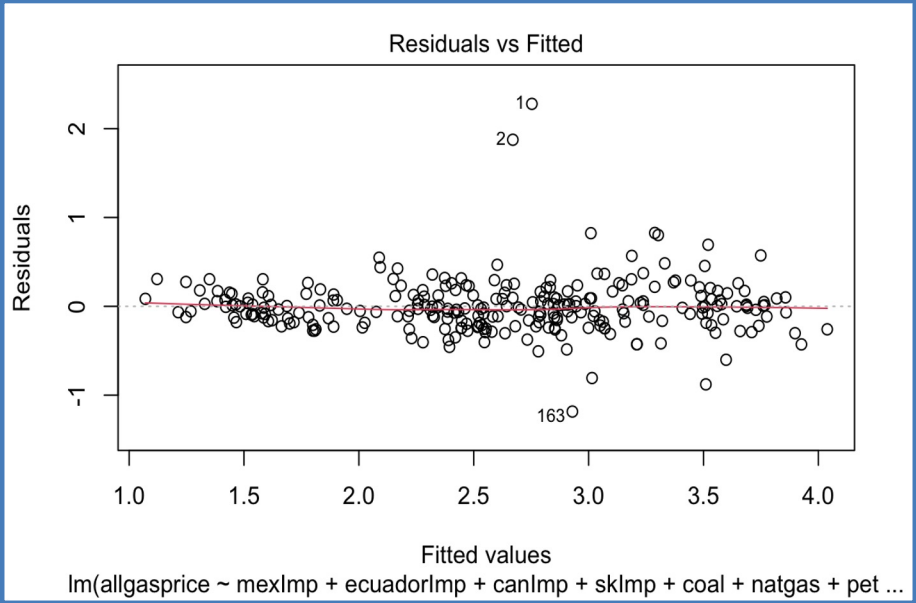
Factors after LASSO + Back Selection

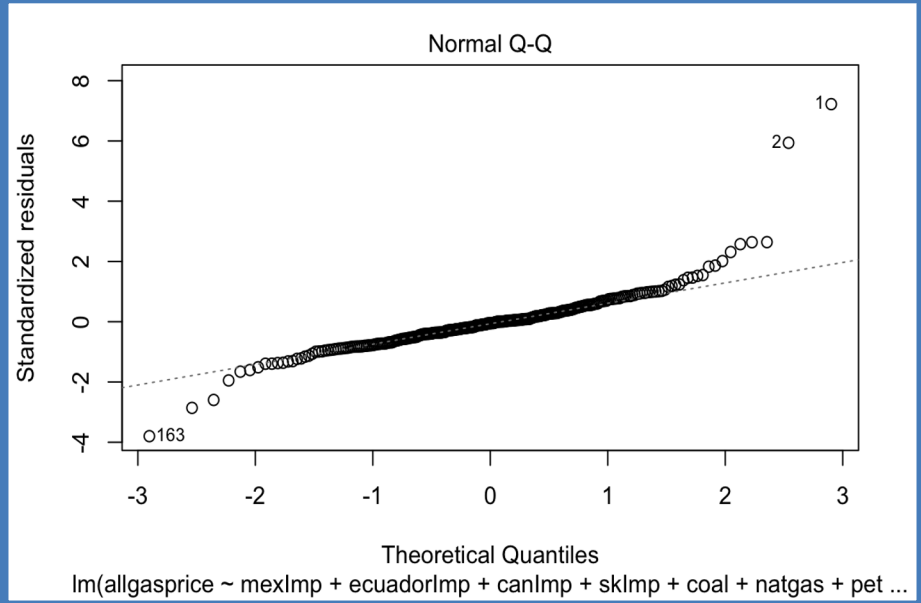
11

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-4.577e+00	8.926e-01	-5.128	5.79e-07	***
net.imports	1.213e-01	1.761e-02	6.886	4.42e-11	***
income	8.871e-05	8.229e-06	10.781	< 2e-16	***
operation	7.529e-04	5.219e-05	14.425	< 2e-16	***
canImp	7.984e-06	2.036e-06	3.922	0.000113	***
searchgas	2.741e-02	1.795e-03	15.266	< 2e-16	***
searchoil	-1.099e-02	1.558e-03	-7.055	1.61e-11	***
renewab	1.929e-16	3.399e-17	5.675	3.76e-08	***
Commercial	-7.971e-09	1.708e-09	-4.666	4.95e-06	***
Electricity	3.552e-09	2.435e-10	14.589	< 2e-16	***
Transportation	-4.118e-09	3.360e-10	-12.256	< 2e-16	***
seasonspring	2.724e-02	4.423e-02	0.616	0.538488	
seasonsummer	5.633e-02	4.441e-02	1.269	0.205769	
seasonwinter	-1.221e-01	4.602e-02	-2.653	0.008466	**

LASSO Assumption Check





04

Conclusion

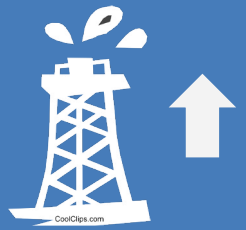
Findings

INCOME:

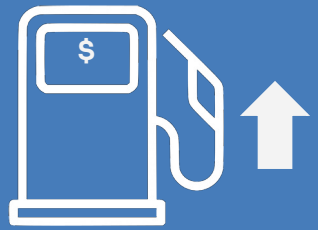
Median annual income of US residents

Gas price

RENEWAB:

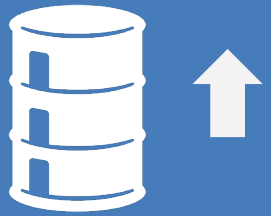


Metric tons of renewable energy usage in the US per month



Gas price

IMPORTS:



US petroleum net imports per month

Gas price

SEARCHGAS:

Google

Units popularity in “gas” as a google search term

Gas price

Transportation CO2 Emissions:

Metric tons CO2 emissions from Transportation Industry

Gas Prices

Commercial CO2 Emissions:

Metric tons CO2 emissions from Electricity Industry

Gas Prices

Electricity CO2 Emissions:

Metric tons CO2 emissions from Electricity Industry

Gas Prices

Oil Rotary Rigs in Operation:

Oil rotary rigs in operation per month

Gas Prices

Imports from Canada:

Barrels of oil imported from Canada monthly

Gas Prices

Winter Months:

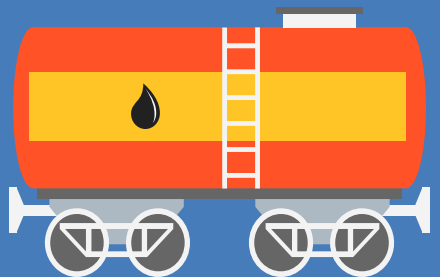
Being in a Winter Month (Dec, Jan, Feb)

Gas Prices

Limitations

Dataset

Time



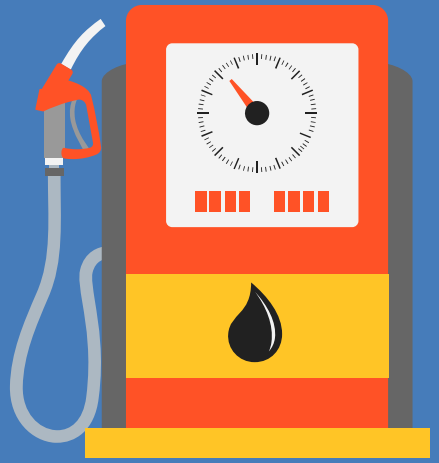
Takeaways:

Gas Prices are generally lower during Winter months

Importing more Gas into the U.S generally raises prices

CO_2 emissions of the Commercial, Electricity, and Transportation industries affect gas prices

Important to note other factors (politics, current events, etc.)



Thank You!

Any Questions?

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Our Teaching Fellow: Edward Zhang,
Our Advisor: Jeff Cai,
The Wharton Data Science Summer Academy
and finally...
The WiDS Organizational Committee!

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Appendix

Dataset Factors & Explanation

Variable	Units
Month	Time in year, month, day
allgasprice	Avg retail gas price of premium and regular gas in the U.S. in U.S. dollars per month
premgasprice	Premium retail gas price in the U.S. in U.S. dollars per month
reggasprice	Regular retail gas price in the U.S. in U.S. dollars per month
importacqcost	Gas price purchased by U.S. refiners in U.S. dollars per month
oilimport	U.S. import of crude oil in thousands of barrels per month
oildemand	U.S. total product demand in millions of barrels per day
consumption	U.S. petroleum consumption in millions of barrels per day
production	U.S. petroleum production in millions of barrels per day

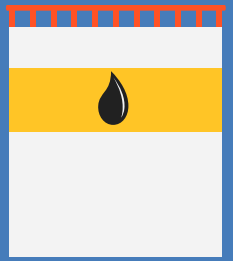
Dataset Factors & Explanation Cont.

Variable	Units
exports	U.S. petroleum exports in millions of barrels per day
net.imports	U.S. petroleum net.imports in millions of barrels per day
income	Median income per household in U.S. dollars per year
poverty	Poverty percentage in the U.S. per year
wells	Total crude oil wells drilled per month
operation	Total crude oil rotary rigs in operation per month
(country)Imp	U.S. crude oil imported from specific countries in thousands of barrels per month
searchgas	Google gas search result popularity value (0-100 where 100 is peak popularity) per month
searchoil	Google gas search result popularity value (0-100 where 100 is peak popularity) per month

Dataset Factors & Explanation Cont.

Variable	Units
coal/natgas/petr/renewab	Total Consumption of Coal, Natural Gas, Petroleum, and Renewable Gas (in Metric Tons)
us_emission	Percentage that US emissions of CO2 makes up of global emissions of CO2
nuclear/hydroelectric/geothermal/solar/wind	Percentage that Each Type of Renewable Energy makes up of total Renewable Energy Consumption
Agriculture/Commercial/Electricity/Industry/Residential/Transportation	Emissions of CO2 for Each Sector (in Metric Tons of CO2 Equivalent)
imports	U.S. petroleum imports in millions of barrels per day

Can we predict future gas prices?



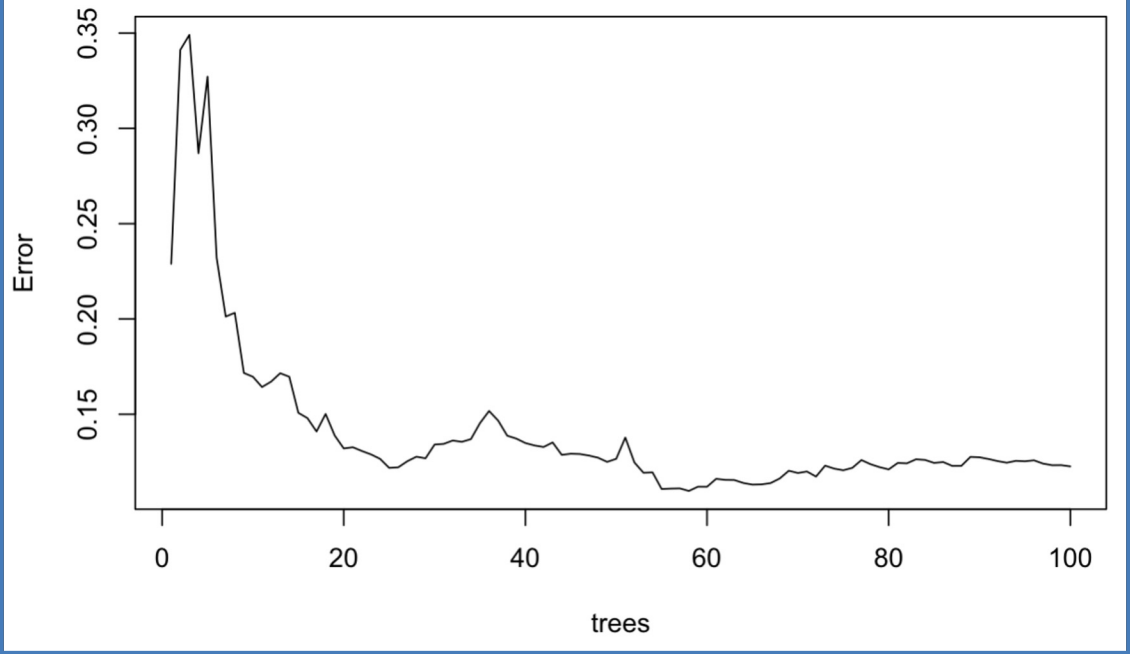
Yes

Using factors found with multiple regression

But...

Can't account for unpredictable factors (current events, politics) and potential lurking confounding variables (inflation)

Random Forest



0.572% mean testing error

Gas Supply Chain