Purpose of the Study

This research project aims to investigate the reasons behind the variations in the adoption of Alternative Fuel Vehicles (AFVs) and Electric Vehicles (EVs) across the different states in the United States. The study utilizes data collected from 8 to 10 different sources, including the Department of Energy (DOE) for AFV data and the Census Bureau for demographic data. The dataset comprises approximately 36 columns and 50 rows, each representing a state in the US. The AFV category includes various types of vehicles, such as EVs, Plug-In Hybrid EVs, Hybrid EVs, and Hydrogen Fuel vehicles.

Typical questions to ask (or hypotheses to raise, to use terms of statistics):

1. EVs are more expensive than gas cars in general. Do states with higher average income show higher EV adoption?
2. Some states such as California, Nevada and Arizona have better solar irradiation, i.e. higher solar productivity . How does this impact AFV adoption?
3. Many potential EV owners are concerned about the limited driving range of EV and possible difficulty finding EV stations when traveling long distance. EVs are more popular among people living in or near cities where driving distances are generally shorter. Do states with higher population densities tend to have higher EV adoption rates?
4. Using correlation table, we look for other factors that are correlated with the AFV adoption rate.
5. Blue states are more supportive for green energy. How is this party affiliation reflected in EV adoption?

Tools Used:

- MS Excel for data processing - dataset merge, null imputation & feature engineering.
- Power BI for graphic presentation of the finding.
- Used the built-in Python Script function to create a correlation table - used Pandas, Numpy, Seaborn & Matplotlib
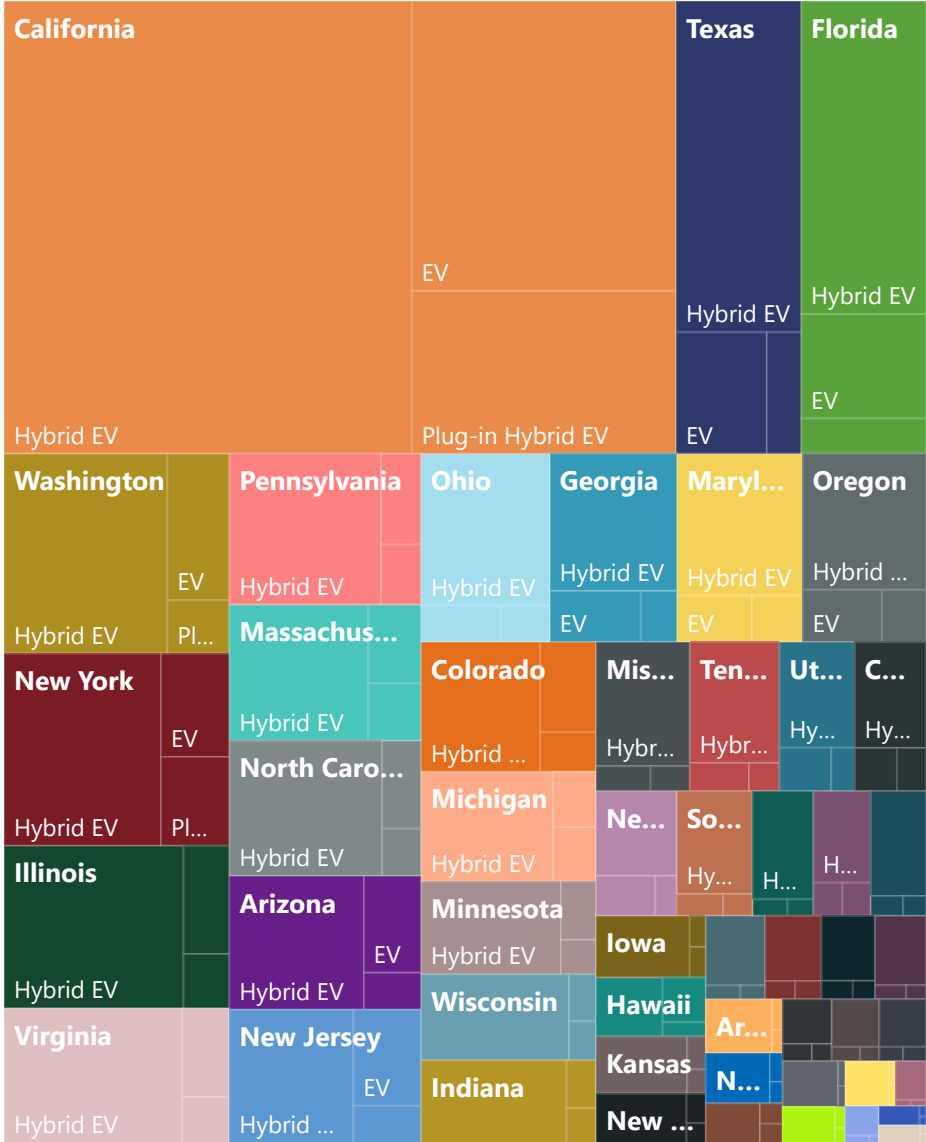
Key Findings:

- The research findings show that income level is the most significant predictor of the adoption rate of Alternative Fuel Vehicles (AFVs), as demonstrated by a strong correlation coefficient of 0.70.
- In contrast, the level of solar irradiation or potential has a minimal impact on the rate of AFV ownership.
- Moreover, the study found that high population density, which is an indicator of high urbanicity, is highly correlated with the availability of Electric Vehicle (EV) charging stations. States with high population density, and consequently a high number of EV charging stations per square mile and per number of EVs, tend to have a higher ownership rate of AFVs.
- Finally, the research suggests that residents of Blue states are more likely to purchase AFVs than those in Red states.
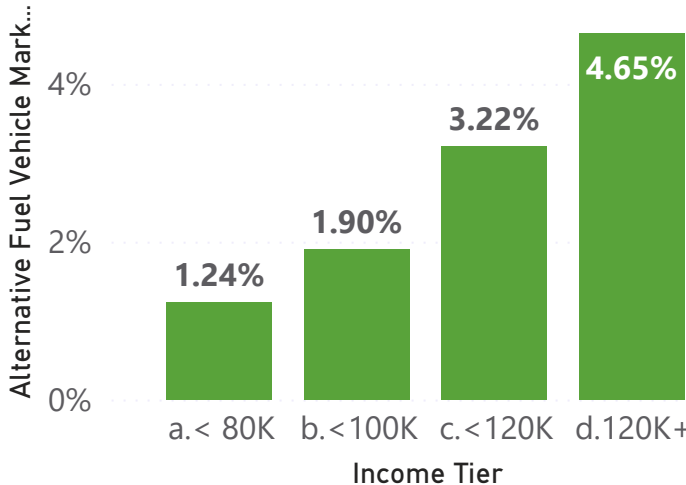
Special Thanks to **Alec Lin** for guiding me & providing valuable insight & resources for this project.
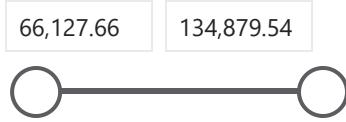
State of Alternative Fuel Vehicles in the US (by States)

Avg Income

66,127.66   134,879.54

Party Leaning Score

0.00   1.00

Alternate Fuel Vehicle (EV, Hybrid EV, Plug-in Hybrid EV & Hydrogen Fuel Cell) Distribution by State

California
EV
Hybrid EV

Texas
Hybrid EV
EV

Florida
Hybrid EV
EV
Plug-in Hybrid EV

Washington
EV
Hybrid EV
Pl...

Pennsylvania
Hybrid EV

Ohio
Hybrid EV

Georgia
Hybrid EV
EV

Maryl...
Hybrid EV
EV

Oregon
Hybrid ...
EV

New York
EV
Hybrid EV
Pl...

Massachus...
Hybrid EV

North Caro...
Hybrid EV

Colorado
Hybrid ...

Mis...
Hybr...

Ten...
Hybr...

Ut...
Hy...

C...
Hy...

Illinois
Hybrid EV

Arizona
Hybrid EV

Michigan
Hybrid EV

Minnesota
Hybrid EV

Ne...
Hy...

So...
H...

Iowa

Virginia
Hybrid EV

New Jersey
Hybrid ...
EV

Wisconsin

Indiana

Hawaii

Ar...

Kansas

N...

New ...

Average AFV Adoption Rate vs. Income

Alternative Fuel Vehicle Mark...

a.< 80K: 1.24%
b.<100K: 1.90%
c.<120K: 3.22%
d.120K+: 4.65%

Income Tier

AFV Market Share vs Population Density
by States (excludes DC)

AFV Market Share

Population density is an approximation for

Pop Density (# of People per Sq.Mile)

AFV Market Share vs. Political Affiliation
(Bubble Size = No. of AFVs)

AFV Market Share

Political Party Affiliation Demarkation Line

Dem <<<   Rep >>>

Political Party Score
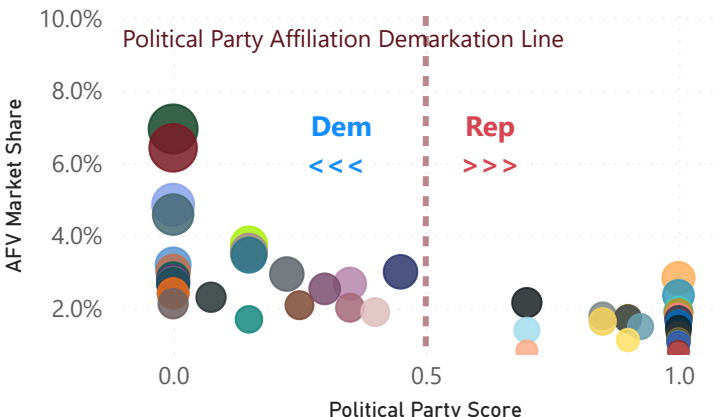
Correlation Heatmap of Major Features
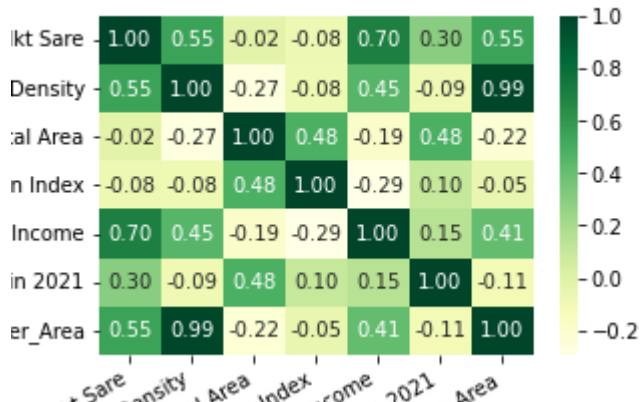
	kt Sare	Density	al Area	n Index	Income	n 2021	er_Area
Ikt Sare	1.00	0.55	-0.02	-0.08	0.70	0.30	0.55
Density	0.55	1.00	-0.27	-0.08	0.45	-0.09	0.99
al Area	-0.02	-0.27	1.00	0.48	-0.19	0.48	-0.22
n Index	-0.08	-0.08	0.48	1.00	-0.29	0.10	-0.05
Income	0.70	0.45	-0.19	-0.29	1.00	0.15	0.41
n 2021	0.30	-0.09	0.48	0.10	0.15	1.00	-0.11
er_Area	0.55	0.99	-0.22	-0.05	0.41	-0.11	1.00

# Alternate Fuel Vehicle (EV, Hybrid EV, Plug-in Hybrid EV & Hydrogen Fuel Cell) Distribution by State

Q1: Is the Alternative Fuel Vehicle (AFV*) adoption rate impacted by income?
Answer: There seems to be a strong correlation between the income and the adoption rate.

Average Income vs AFV Adoption Rate by States


Average AFV Adoption Rate vs. Income
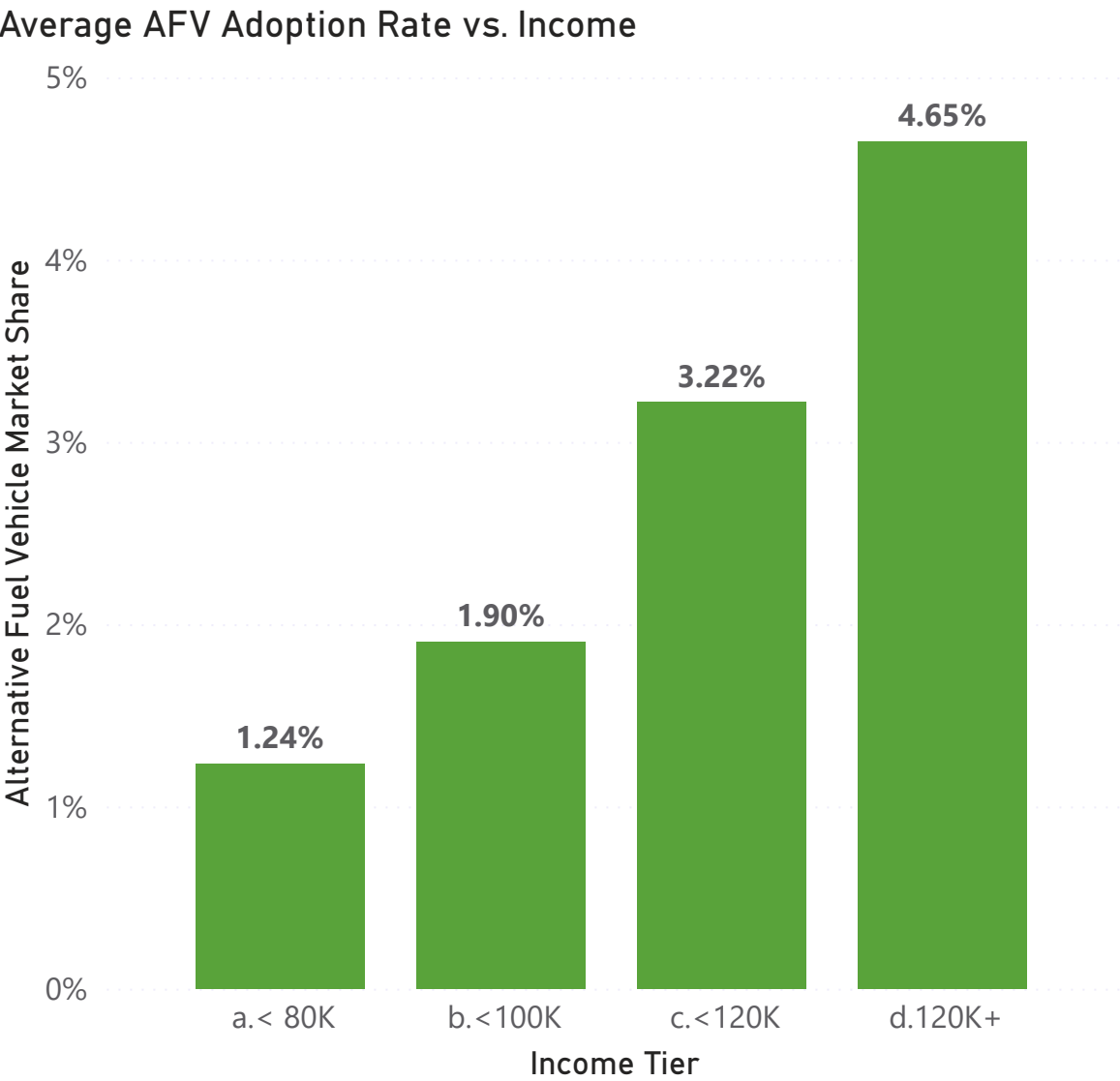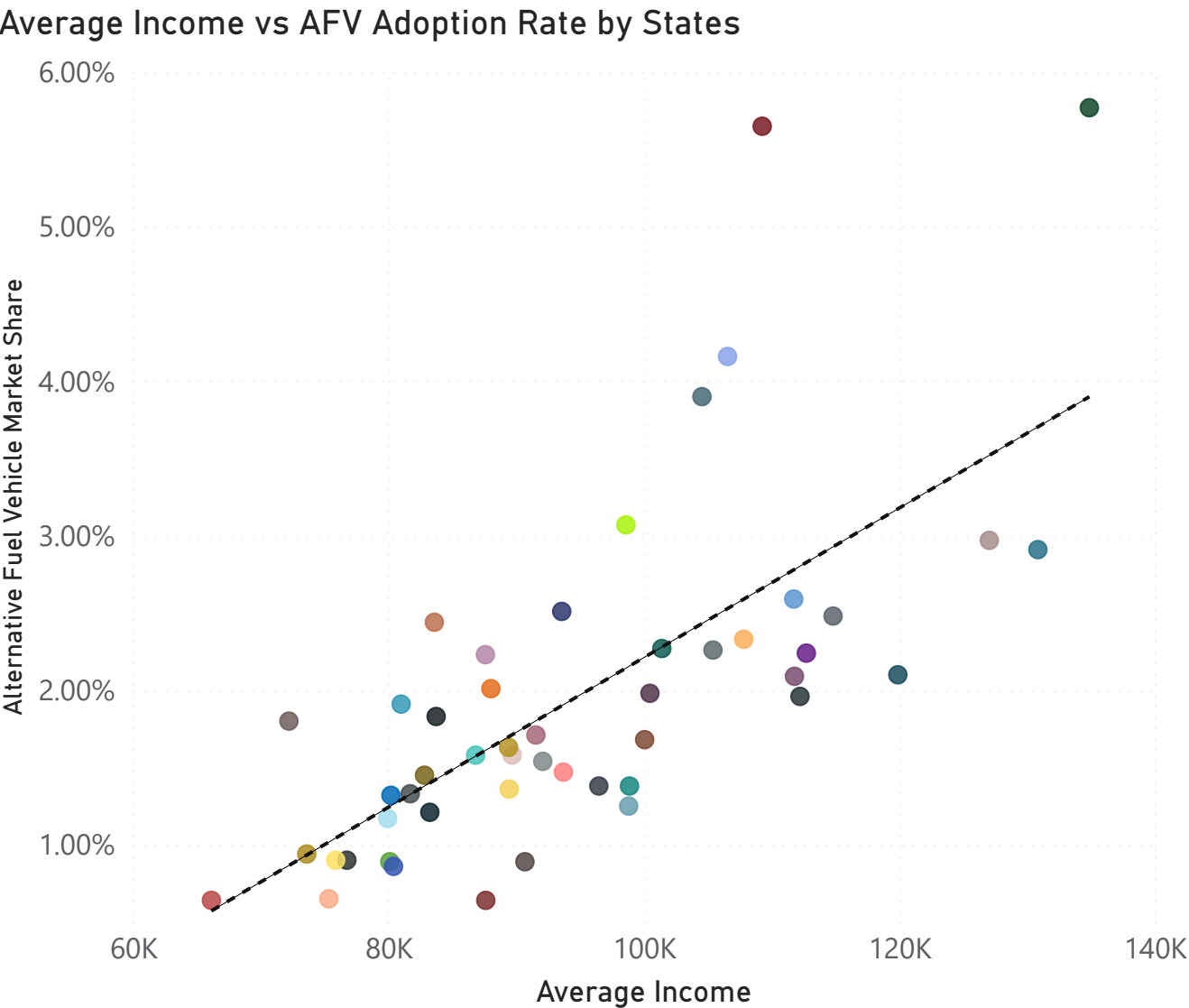
* Market share is determined by the total number of *registered* Alternative Fuel vehicles divided by the total number of registered vehicles

Q2: Is the EV adoption rate impacted by solar potential*?
Answer: There seems to be a sight positive correlation but it not definitive

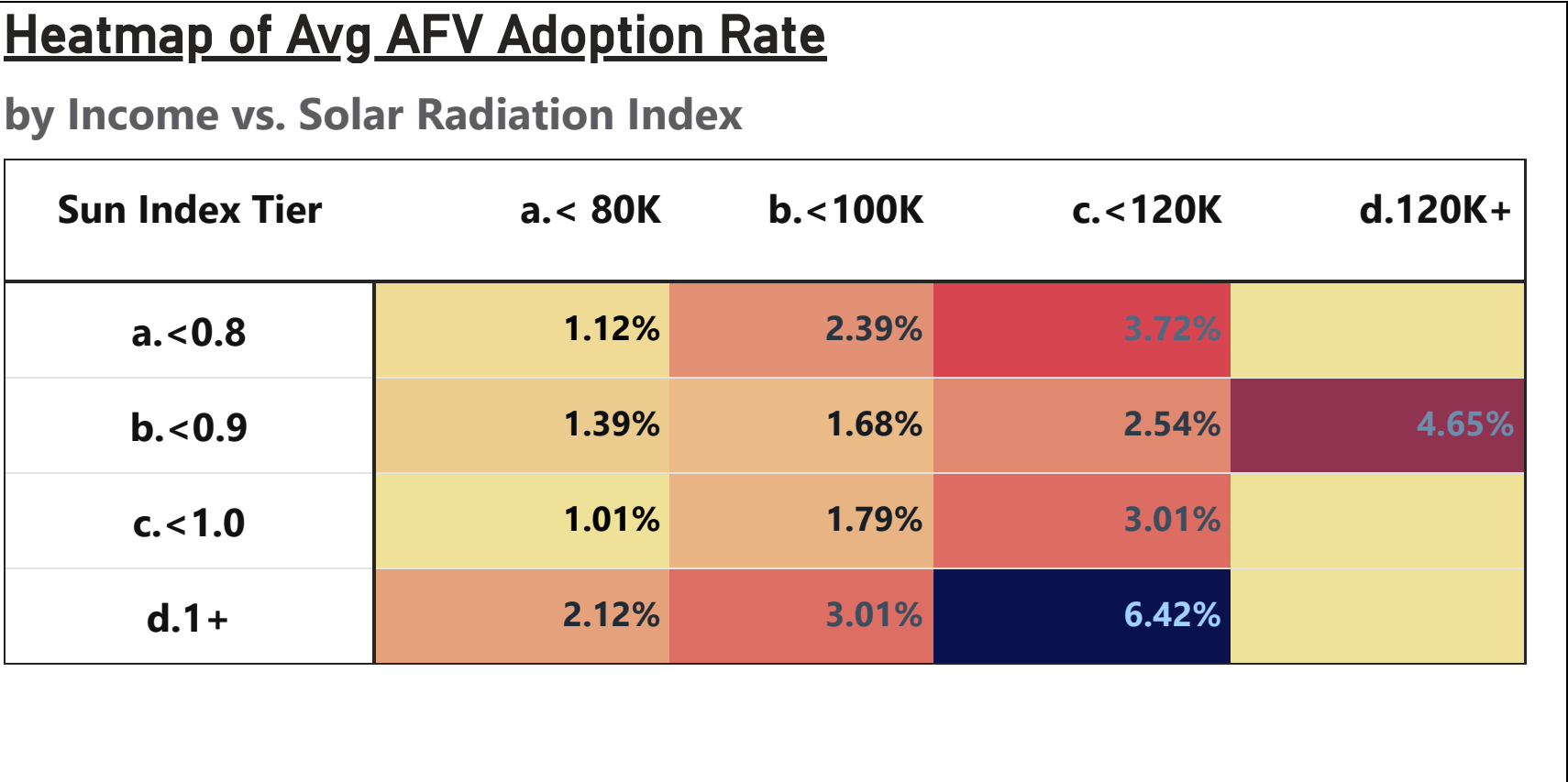
EV Adoption Rate vs. Solar Index by States
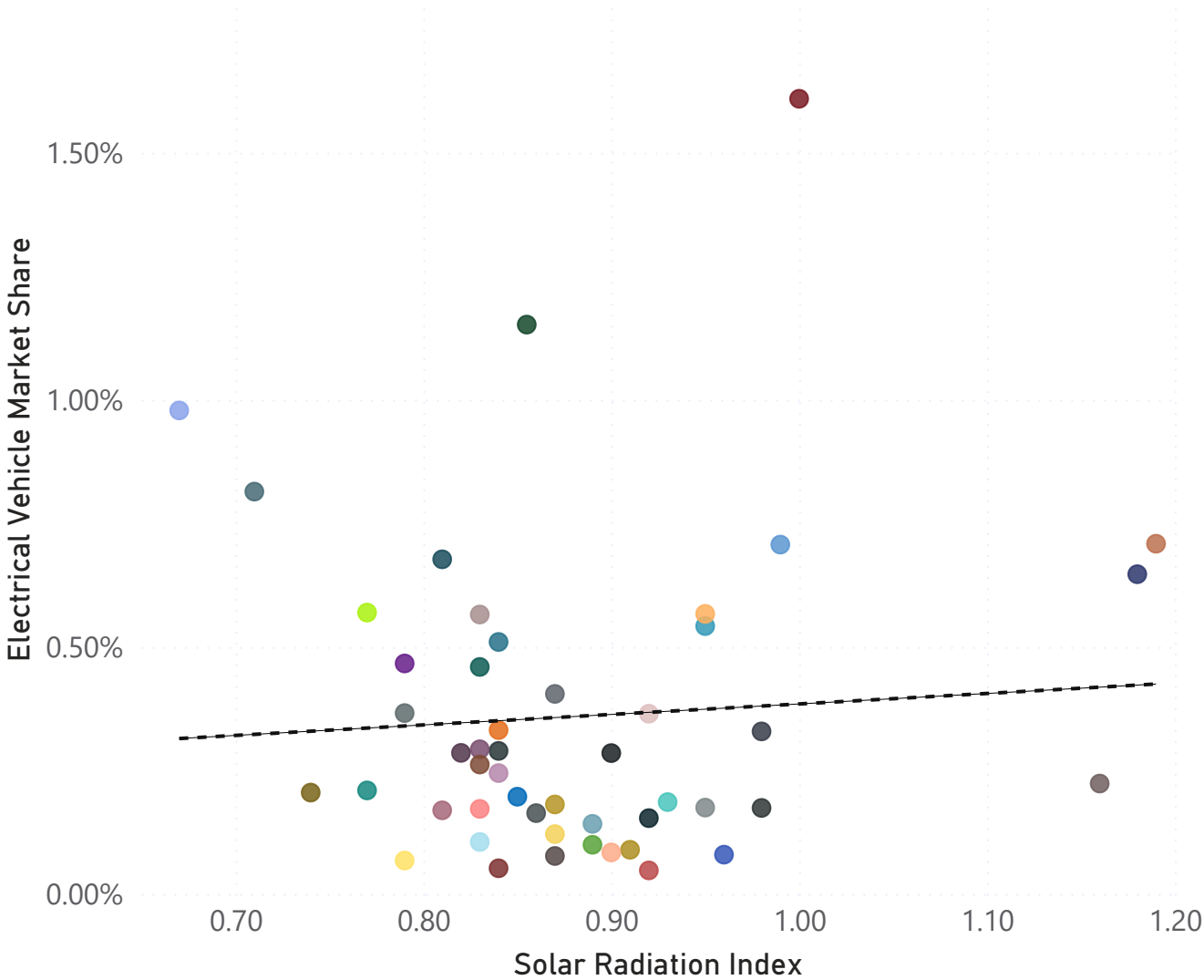
Average EV Adoption Rate vs. Solar Index
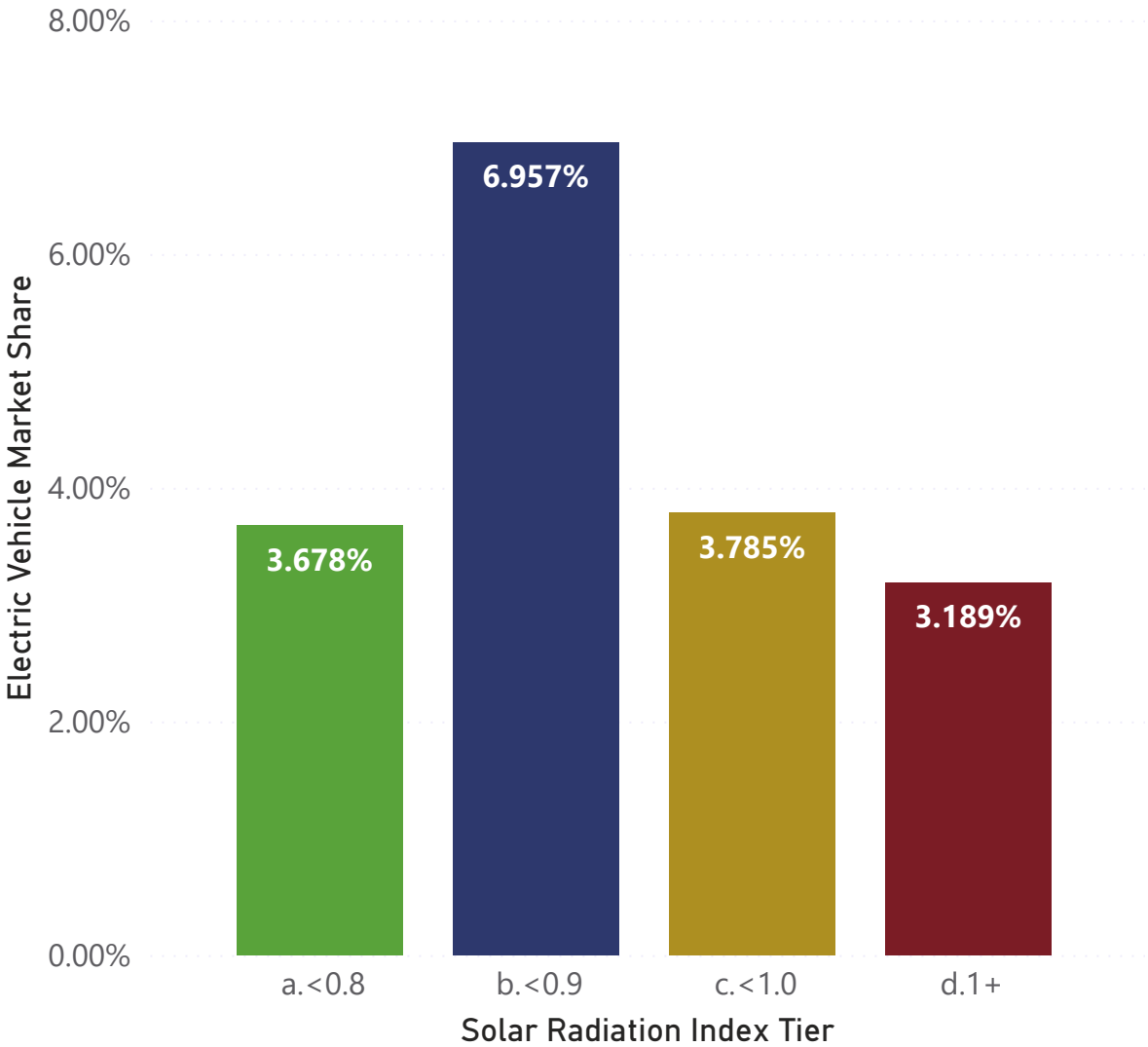
Solar Radiation Index: This is a measure of the amount of solar radiation that reaches a particular location on the Earth's surface. The index takes into account factors such as the angle of incidence of the sun's rays, atmospheric conditions, and the Earth's surface characteristics.
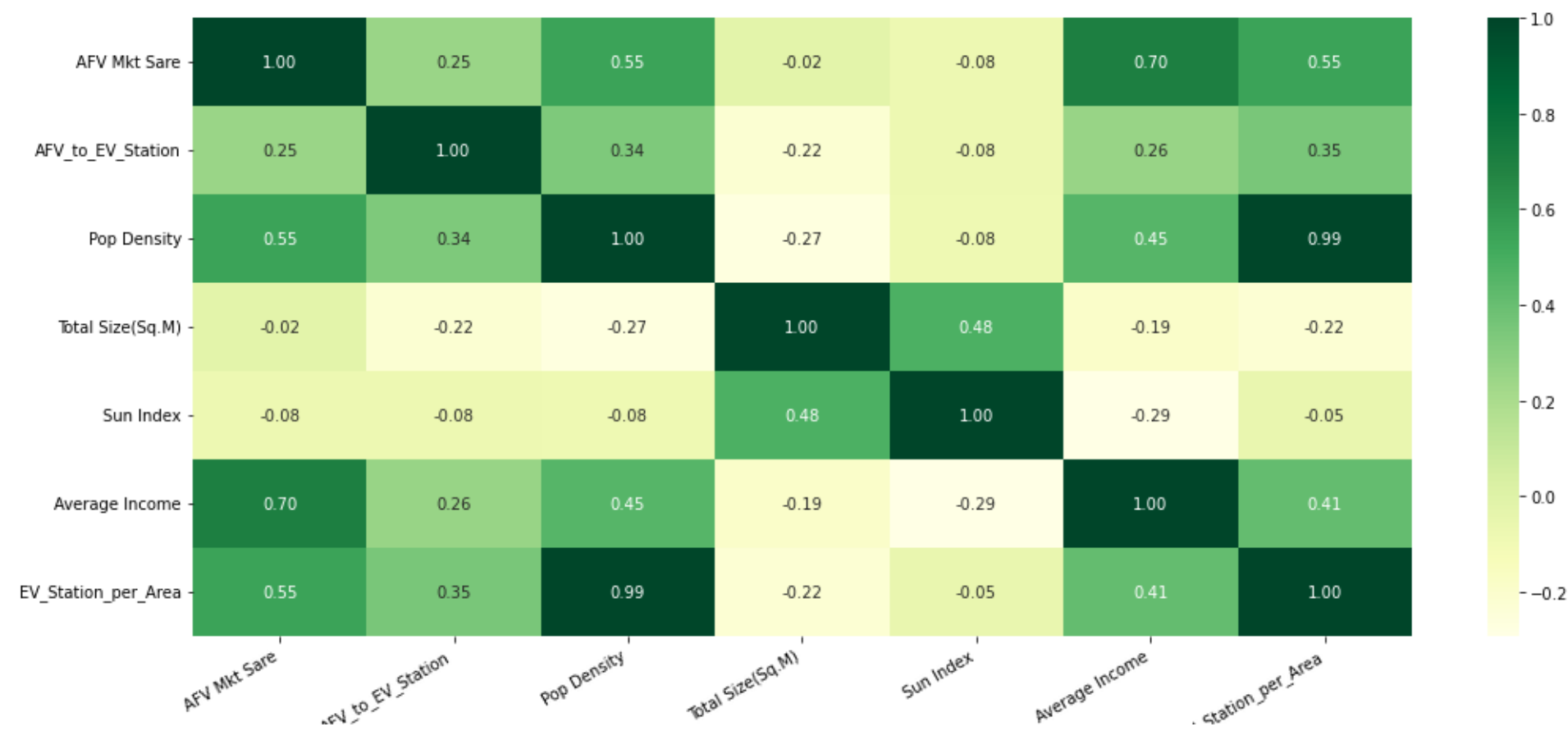
Q3: What if we plot Income and Solar Radiation Index in one chart?
Answer: We use the heatmap to show this.

Heatmap of Avg AFV Adoption Rate

by Income vs. Solar Radiation Index

Sun Index Tier	a.< 80K	b.<100K	c.<120K	d.120K+
a.<0.8	1.12%	2.39%	3.72%	
b.<0.9	1.39%	1.68%	2.54%	4.65%
c.<1.0	1.01%	1.79%	3.01%	
d.1+	2.12%	3.01%	6.42%	

NFFV adoption rate or the market share is the highest the regions with "High Income & High Solar Radiation Index." The adoption rate of 6.42% is solely attributed to California which tops the market, selling almost 30% of all NFFV in the US.

Q4: Are there other factors correlated with AFV adoption?
Answer: A heatmap is used to show the correlation table.

Correlation Heatmap of Major Factors

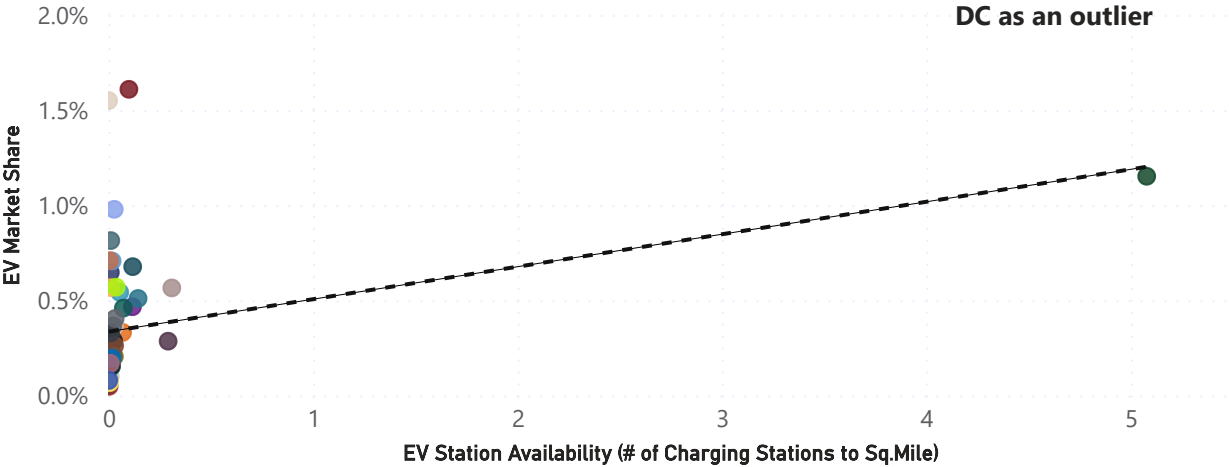|	AFV Mkt Sare	AFV_to_EV_Station	Pop Density	Total Size(Sq.M)	Sun Index	Average Income	Station_per_Area
AFV Mkt Sare	1.00	0.25	0.55	-0.02	-0.08	0.70	0.55
AFV_to_EV_Station	0.25	1.00	0.34	-0.22	-0.08	0.26	0.35
Pop Density	0.55	0.34	1.00	-0.27	-0.08	0.45	0.99
Total Size(Sq.M)	-0.02	-0.22	-0.27	1.00	0.48	-0.19	-0.22
Sun Index	-0.08	-0.08	-0.08	0.48	1.00	-0.29	-0.05
Average Income	0.70	0.26	0.45	-0.19	-0.29	1.00	0.41
EV_Station_per_Area	0.55	0.35	0.99	-0.22	-0.05	0.41	1.00

Only meaningful correlation is that of NFFV market share /adoption rate and the income which is 0.70.

Q6: Having more EV stations promote greater EV adoption?
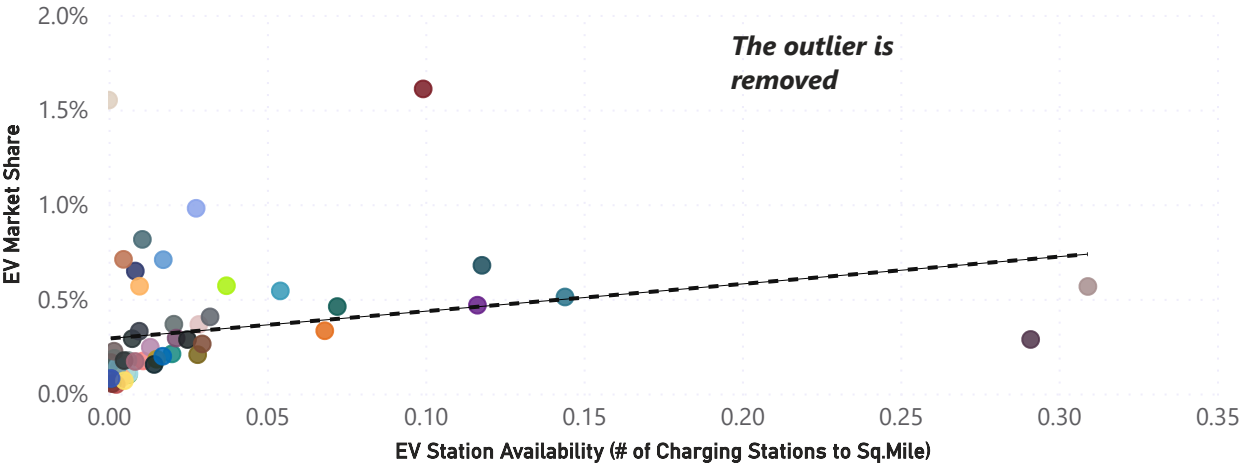*Answer: Yes, there seems to be a weak correlation*

EV Market Share vs. EV Station Availability
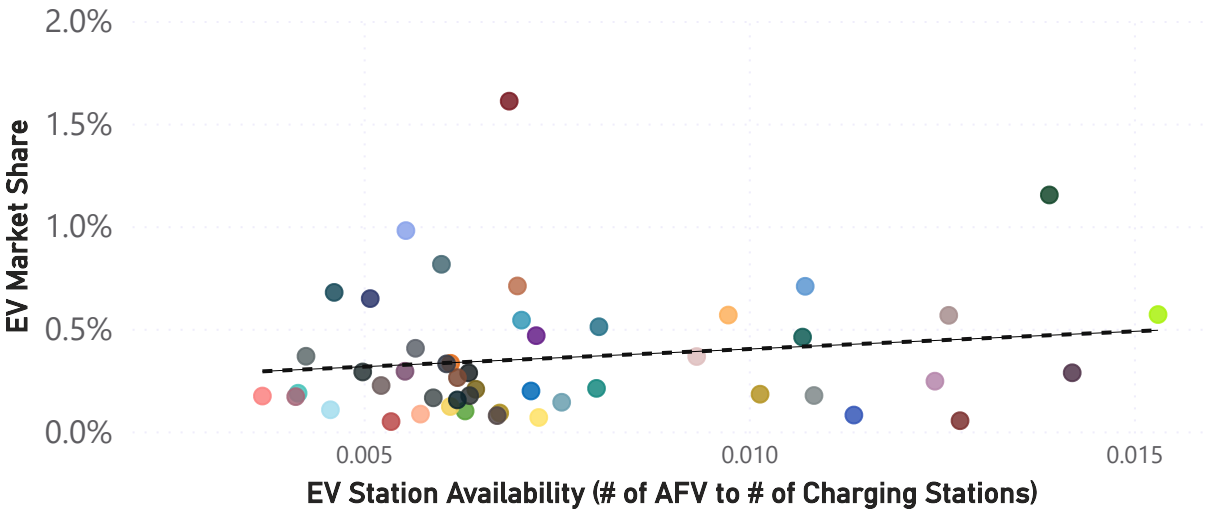
(Bubble Size = No of EV Station)

DC as an outlier

EV Market Share (y-axis) vs. EV Station Availability (# of Charging Stations to Sq.Mile) (x-axis)

EV Market Share vs. EV Station Availability

excludes DC

The outlier is removed

EV Market Share (y-axis) vs. EV Station Availability (# of Charging Stations to Sq.Mile) (x-axis)

EV Market Share vs. EV Station Availability

EV Market Share (y-axis) vs. EV Station Availability (# of AFV to # of Charging Stations) (x-axis)

EV Market Share vs. EV Station Availability

(Bubble Size = No of Registered EV in 2021)

EV Market Share (y-axis) vs. EV Station Availability (# of AFV to # of Charging Stations) (x-axis)
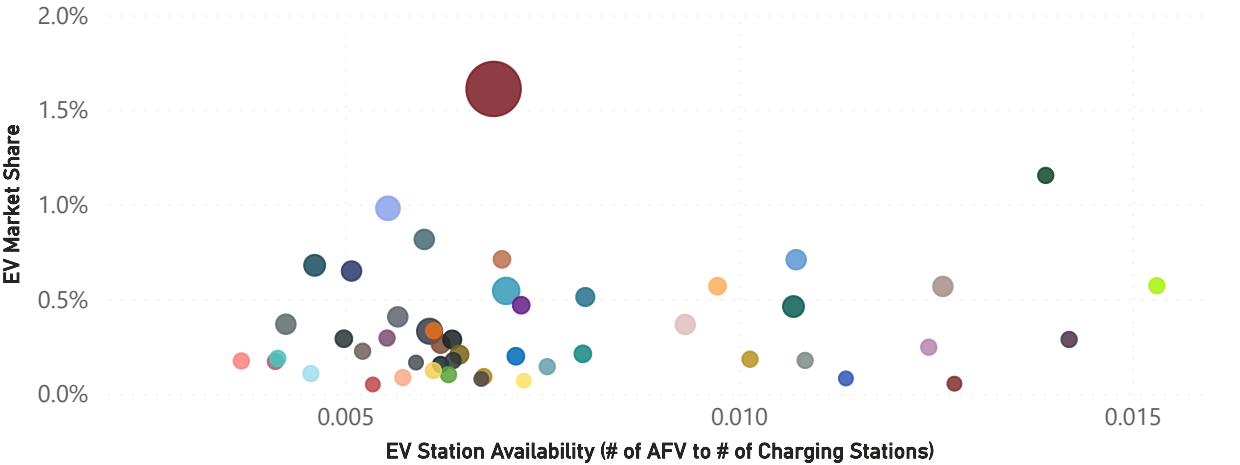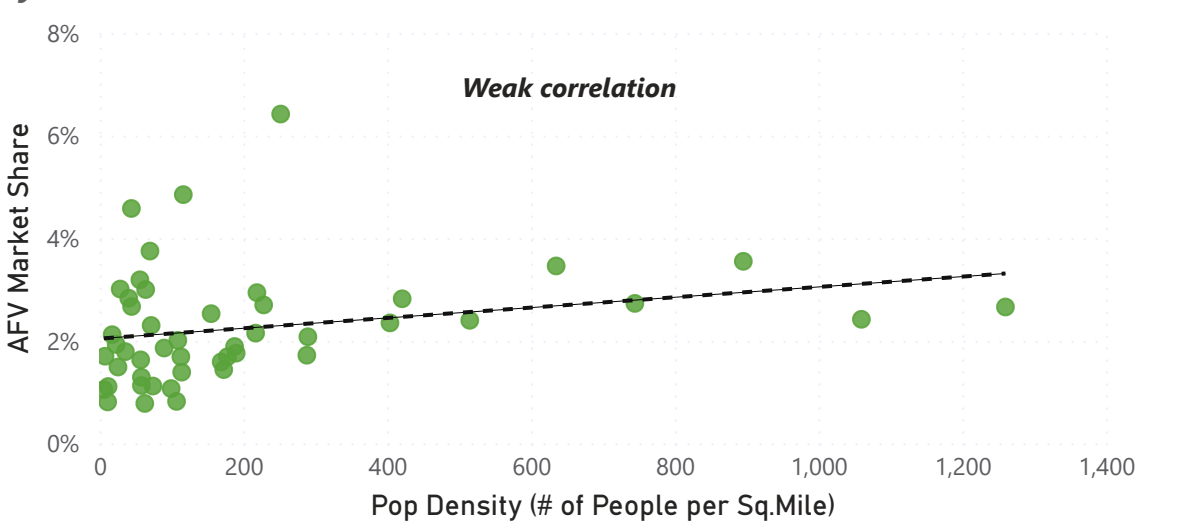
Q5: What are the relationship between major variables vs. AFV market share?
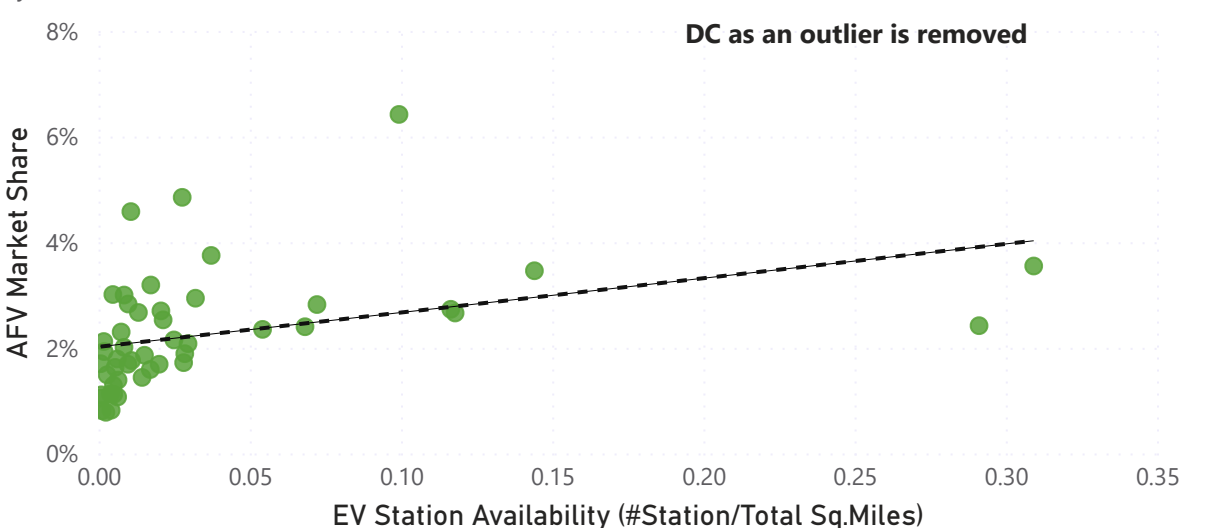
AFV Market Share vs Population Density
by States

DC is an outlier w/ 11K population density

Y-axis: AFV Market Share (0% – 8%)
X-axis: Pop Density (# of People per Sq.Mile) (0K – 10K)

AFV Market Share vs Population Density
by States (excludes DC)

Weak correlation
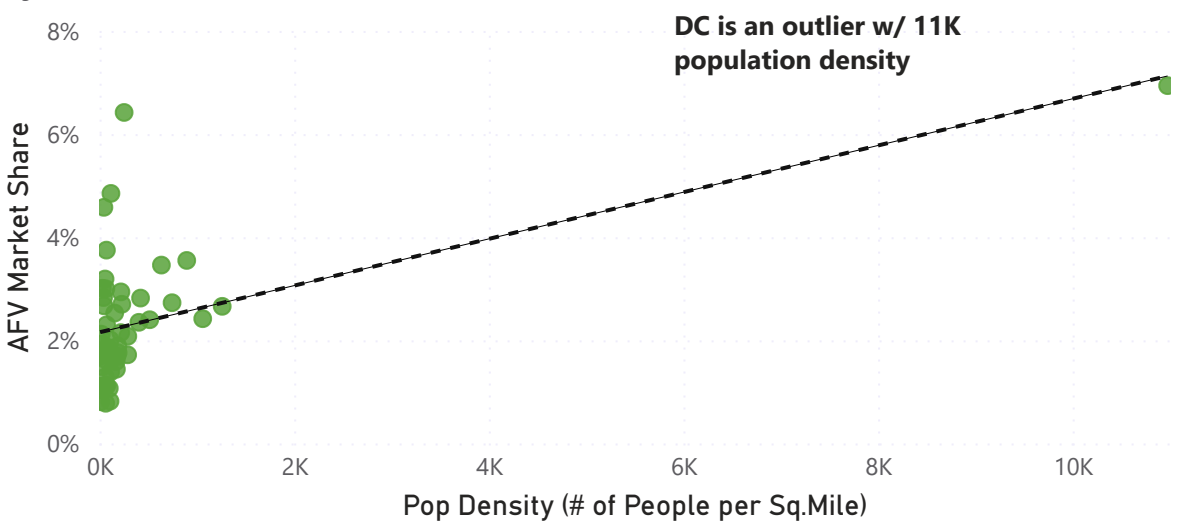
Y-axis: AFV Market Share (0% – 8%)
X-axis: Pop Density (# of People per Sq.Mile) (0 – 1,400)

AFV Market Share vs Sun Radiation Index
by States

No significant correlation

Y-axis: AFV Market Share (0% – 8%)
X-axis: Sun Index (0.7 – 1.2)
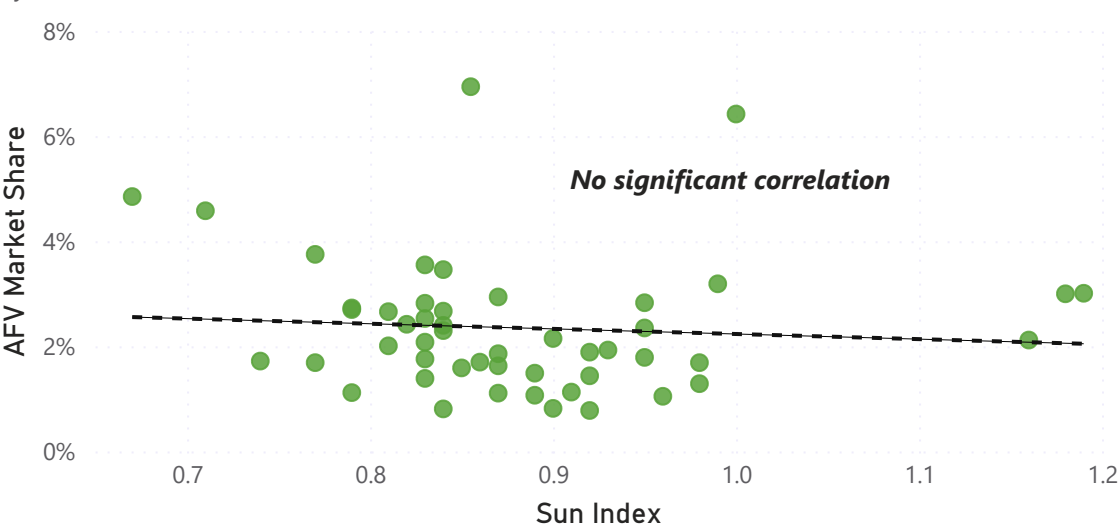
AFV Market Share vs. EV Station Availability
by States (excludes DC)

DC as an outlier is removed

Y-axis: AFV Market Share (0% – 8%)
X-axis: EV Station Availability (#Station/Total Sq.Miles) (0.00 – 0.35)

Q7: Does political party affiliation impact AFV adoption?
Answer: Yes, both the adoption rate and the absolute numbers are higher among 'Democrat' leaning states.

AFV Market Share vs. Political Affiliation

(Bubble Size = No. of AFVs)
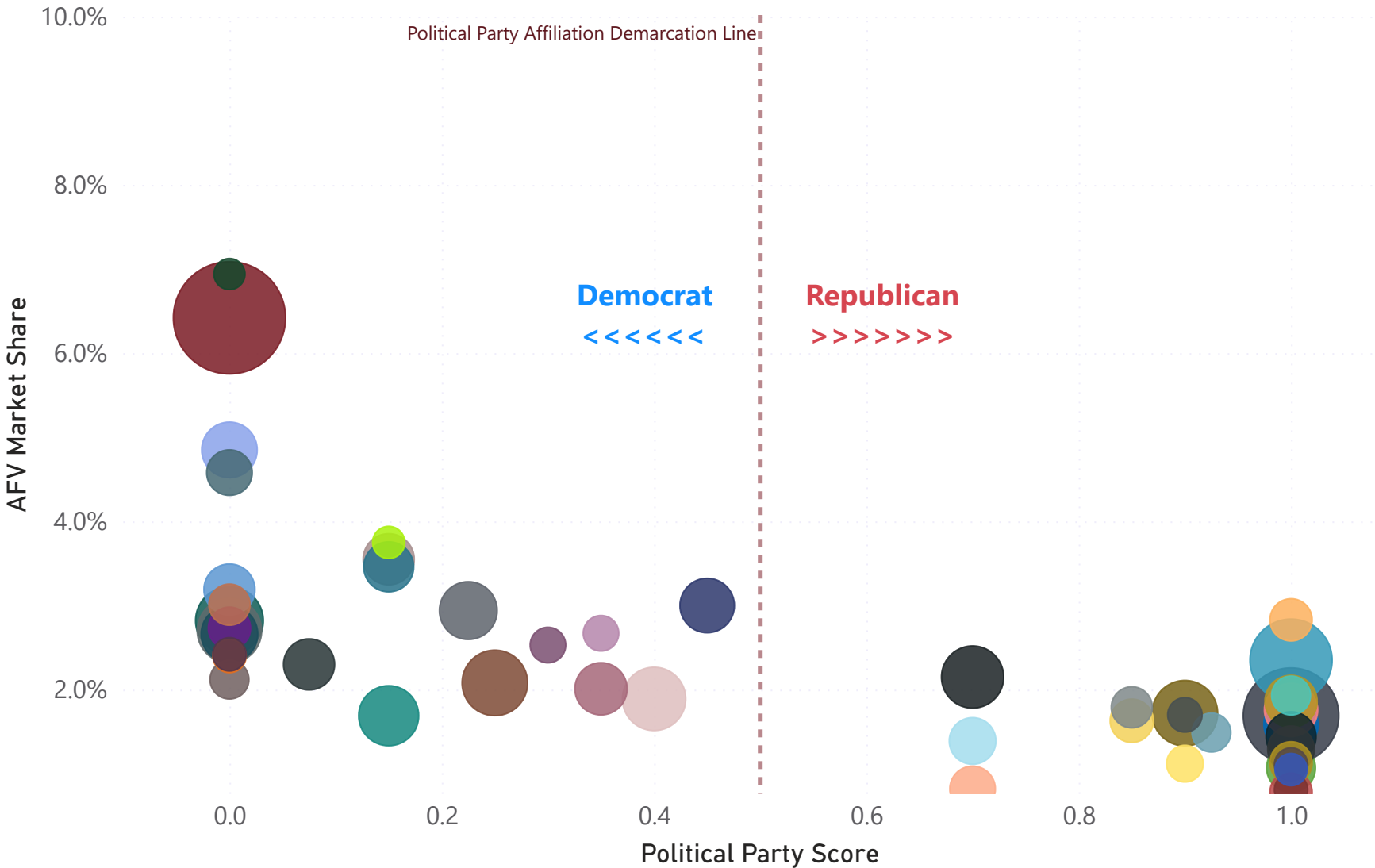
Political Party Leaning Scoring System

Factors	Weight
Presidential Election	0.250
Gubernatorial Election	0.150
US Senate Election	0.200
US House Majority	0.100
State Senate Majority	0.075
State House Majority	0.075
Majority Voter Party Registration	0.150
Total	**1.000**

1. Weights are arbitrary assigned.
2. **Party score over 0.5 is considered 'Republican' state where as 'Democrat' leaning states are those with the score less than 0.5.**
3. For example, when a State voted for Republican in the last Presidential election, a value of "1" is assigned. If 'Democrat' then "0" is assigned.

Q8: What is the geographical representation of the US AFV Adoption Rate?

Alternative Fuel Vehicle Market Share by States

Political Party Score

0.00	1.00