Atlantic Conference on Energy and System Modelling

Modelling the Impact of Rebates and Other Key Drivers on EV Adoption

June 18, 2025

dunsky
Energy + Climate

ACCELERATING THE CLEAN ENERGY TRANSITION

ANALYSIS + STRATEGY

BUILDINGS **MOBILITY** **INDUSTRY** **ENERGY**

Agenda

1. Introduction
2. Model Development and Results
3. Interpretation of Results

Introduction

Introduction

Context

About Maine

- Population
  - Maine: 1.4 million
  - Nova Scotia: 0.9 million
- EV adoption
  - Maine: 5.8% sales in 2023
  - Nova Scotia: 5.7% sales in 2024
  - US: 9.3% in 2023
- Efficiency Maine Trust (EMT):
  - Efficiency Maine is the independent, quasi-state agency established to plan and implement energy efficiency programs in Maine.

Project Context

- Statewide EV rebate offered by EMT from 2019 to 2024:
  - $2,000 for a new Battery Electric Vehicle (BEV) and $1,000 for a new Plug-in Hybrid Electric Vehicle (PHEV).
  - Qualifying low-income households could receive $7,500 for a BEV, $3,000 for a PHEV, and $2,500 for a used EV. Qualifying moderate-income households could receive $3,500 for a BEV and $2,000 for a PHEV.
- The program suspended rebates in November 2024, **except for qualifying low-income Mainers,** due to funding constraints.
  - This change was unrelated to Dunsky's recommendations.
- EMT retained Dunsky to support evidence-based decision-making about the rebate program and associated budget forecasting in future years.

Research Questions

Objective

- Understand the extent to which State-level rebate programs have uplifted EV sales in Maine, based on a comparison to other states.

Research Questions

- What factors explain the rate of adoption of EVs in different states?
- To what degree do those factors have an impact?
- Specifically, what is the impact of EV rebates?

Key Findings

- We were able to build a regression model with **high explanatory power** for EV adoption across US states in the years 2017-2022 (R-squared=0.89). The model can accurately predict historical EV sales in Maine.
- The variables that most explain EV adoption, are:
  - **Charging infrastructure ports** (normalized by length of highway)
  - **Household income** above $75,000
  - **Political affiliation**
  - **Population density** (negatively correlated)
- The model shows a **positive impact of rebates in some, but not all states**. We hypothesize that the uplifting effect of the rebate is possible when other supporting factors are in place.
  - The model suggests that ZEV sales in Maine would have been 10% lower in 2022 without the incremental benefit of the state rebate.

Model Development and Results

Model Development

Methodology

Steps:

1. Collect, clean and transform data to represent all identified variables;
2. Conduct data visualizations to form hypothesis about the relationships between variables;
3. Define several models that may explain adoption of EVs, including by transforming and/or combining explanatory variables;
4. Address collinearity issues;
5. Test the different models to select the model that best meets the project requirements;
6. Analyse the results and present the findings.

Regression approach:

- We developed a balanced and fixed[1] panel dataset, with the units being the 50 states, across 6 years (2017-2022).
- We removed two geographic areas: Puerto Rico (lack of data) and District of Columbia (outlier).
- We used a Random Effects model to estimate individual-specific characteristics in a panel dataset.
  - We conducted a Hausman test to confirm that there is no endogeneity (no correlation between the independent variables and unexplained variation or "error" in the dependent variable). With the test confirmed, we selected the Random Effects model over the Fixed Effects model.
- We included year dummies to fit the trend across time.

[1] Balanced: all units are tracked across the same number of time periods
Fixed: the same units are tracked throughout the study.

Model Development

Variable Selection and Final Model

Description	Type	Pre-Treatment	Log transformation	Final Model
Share of EV sales out of all light-duty vehicle (LDV) sales	**Target**		**Yes**	**Keep**
Population density per square mile	**Independent**	**Standardize with max obs. value**	**Yes**	**Keep**
Share of households in the state with a household income above $75,000	**Independent**		**Yes**	**Keep**
Share of commute trips taken on public transport	**Independent**		**Yes**	**Keep**
Share of commute trips done either by carpooling or driving alone	Independent		Yes	Discard
Ratio of the car registration with the state population over 18 years old	Independent		Yes	Discard
Political affiliation: share of people who are 18 years old or older voting for the Democratic party in the latest presidential election	**Independent**		**Yes**	**Keep**
Share of housing units that are owned	**Independent**		**Yes**	**Keep**
Share of Multi-Unit Residential Buildings	Independent	** Correlated with Perc_owner*	Yes	Discard*
Number of charging ports (public and private non-residential) per 100 miles of public roads (all types)	**Independent**		**Yes**	**Keep**
Binary indicator of rebate presence	Independent		No	Discard
Rebate amount in $	**Independent**	**Standardize with max obs. value**	**No**	**Keep**
Binary indicator of whether the rebate is income-based	Independent		No	Discard
Binary indicator if the rebate if at the point of sale	Independent		No	Discard

Results

Regression Model Performance

PanelOLS Estimation Summary

Dep. Variable:	ratio_ZEV_sales_LDV_sales_log	R-squared:	0.8924
Estimator:	PanelOLS	R-squared (Between):	0.9076
No. Observations:	300	R-squared (Within):	0.8782
Date:	Wed, Jun 05 2024	R-squared (Overall):	0.8924
Time:	12:53:31	Log-likelihood	134.73
Cov. Estimator:	Unadjusted		
		F-statistic:	198.35
Entities:	50	P-value	0.0000
Avg Obs:	6.0000	Distribution:	F(12,287)
Min Obs:	6.0000		
Max Obs:	6.0000	F-statistic (robust):	198.35
		P-value	0.0000
Time periods:	6	Distribution:	F(12,287)
Avg Obs:	50.000		
Min Obs:	50.000		
Max Obs:	50.000		

Parameter Estimates

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
const	-1.8742	0.1141	-16.425	0.0000	-2.0988	-1.6496
Population_density	-0.1883	0.0231	-8.1437	0.0000	-0.2338	-0.1428
Perc_hh_above_75000	0.6256	0.2107	2.9694	0.0032	0.2109	1.0403
%_commute_public_transport	0.0959	0.0380	2.5202	0.0123	0.0210	0.1707
ratio_democrats_pop_18	0.7620	0.1159	6.5738	0.0000	0.5338	0.9901
Perc_owner_housing	-1.0105	0.3993	-2.5306	0.0119	-1.7965	-0.2245
ratio_stations_100miles_highway	0.4146	0.0315	13.144	0.0000	0.3525	0.4767
Rebate_amount	0.1087	0.0573	1.8950	0.0591	-0.0042	0.2215
Year.2018	0.2218	0.0318	6.9810	0.0000	0.1592	0.2843
Year.2019	0.0704	0.0331	2.1279	0.0342	0.0053	0.1355
Year.2020	0.1410	0.0351	4.0212	0.0001	0.0720	0.2100
Year.2021	0.4567	0.0391	11.670	0.0000	0.3797	0.5337
Year.2022	0.6708	0.0405	16.566	0.0000	0.5911	0.7505

The model explains EV adoption rates very well with an R-squared of 0.89.

The Parameter (coefficient) describes the directionality of the relationship between the independent variable and the target variable (EV sales).

For significance, we look at the T-stat and its associated P-value, which indicate the probability that the result would happen under the null-hypothesis.
- The P-value is considered significant below 5%.
- The T-stat is considered significant at around +/-2, but interpretation requires judgement.

The upper & lower CI indicate the range of impact that the input variable has on the target variable. We see that the rebate amount has a positive impact in some states/years, but a small negative one in others.

Interpretation of Results

Interpretation of Results

Regression Analysis Findings

Independent Variable	Impact on ZEV Sales Share	Coefficient	T-stat	Comments
Number of charging ports (public and private non-residential) per 100 miles of public roads (all types)	Significant, positive	0.41	+13.1	
Share of households in the state with a household income above $75,000	Significant, positive	0.63	+3.0	$71,773 is the median household income in Maine. Higher income household are more likely to buy new vehicles and bear the additional purchase price.
Political affiliation: share of people who are 18 years old or older voting for the Democratic party in the latest presidential election	Significant, positive	0.76	+6.6	Democrat vote share (2016 and 2020 Presidential elections) is significant to EV adoption, as a representation of a system of beliefs and mindset.
Population density per square mile	Significant, negative	-0.18	-8.1	While there are real and perceived barriers to EV adoption in rural areas, **the barriers in high-density areas appear to be more impactful** at the state level. Lower population density means there are more people who can easily install **home charging.** Population density at the state level is an imperfect indicator.
Share of commute trips done by public transport	Significant, positive	0.10	+2.5	
Share of housing units that are owned	Significant, negative	-1.01	-2.53	
Rebate amount in $	Significant (mixed findings), positive	0.11	+1.89	The impact of the rebate is **likely positive**, particularly where other supportive characteristics are in place, but it is uncertain.

Interpretation of Results

Regression Analysis Findings: Year Impact

- The year dummy values show that there was a relative decline and slowdown in 2019 and 2020 in the share of ZEV sales due supply issues and the pandemic.
  - The coefficient decreases from 0.22 in 2018 to 0.07 in 2019 and rises all the way to 0.67 in 2022.

- The T-stat shows that the significance of the year follows the magnitude of its impact (coefficient) on ZEV sales.

Description	Impact on ZEV Sales Share	Coefficient	T-stat
Year 2018	Significant, positive	+0.22	+6.98
Year 2019	Significant, positive	+0.07	+2.13
Year 2020	Significant, positive	+0.14	+4.02
Year 2021	Significant, positive	**+0.46**	+11.67
Year 2022	Significant, positive	**+0.67**	+16.57

*2019 supply issues**

Pandemic impact

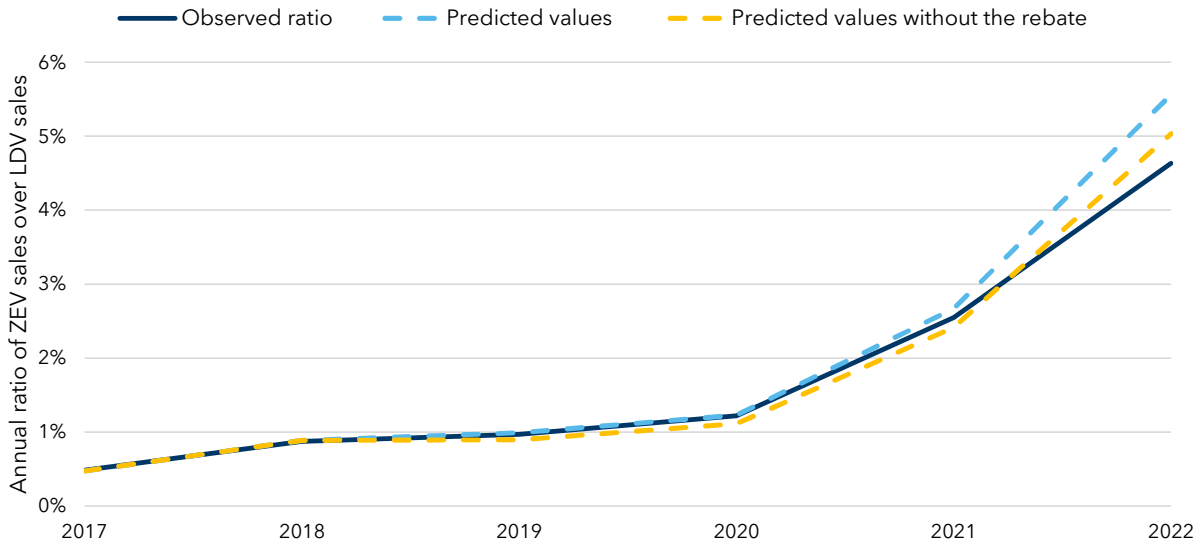
Accelerating adoption

*For an explanation of the sales drop in 2019, see: https://evadoption.com/2019-us-ev-sales-decreased-an-estimated-7-to-9-6-reasons-why/.

Interpretation of Results

Impact of the Rebate in Maine

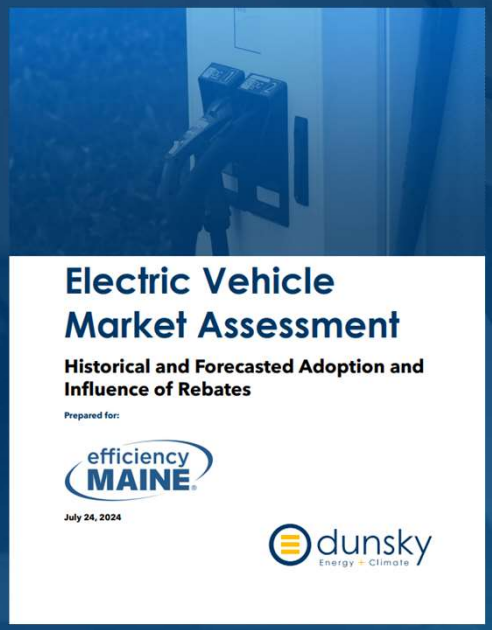
- We used the model to predict ZEV sales in Maine with the current state rebates (blue) and without (yellow).
- The model suggests that without the rebates, **the share of ZEV sales in 2022 would have been 5.0%** instead of the **5.6%** observed currently, or 10% less.
  - Because of the uncertainty around the impact of the rebate variable, this difference could be higher or lower.
  - Since more expensive EVs were excluded from the rebate, the rebate had a greater than 10% uplift on applicable vehicles.
- Importantly, **this is the incremental impact of the state rebate,** over and above any impact from the federal tax credit.



Conclusion

- Modelling is a useful approach to **quantify the impact** of specific programs on EV adoption. It can be used as a decision-making tool to prioritize different programs and policies.
- **Panel regression** allows analysis of datasets that have both **cross-sectional** and **longitudinal** data. It enables identification of jurisdiction archetypes to better predict the impact of a specific policy in a new jurisdiction in the future.
- While EV rebates do have a positive impact on EV adoption, they must be **accompanied by other supporting measures**, particularly access to charging infrastructure.

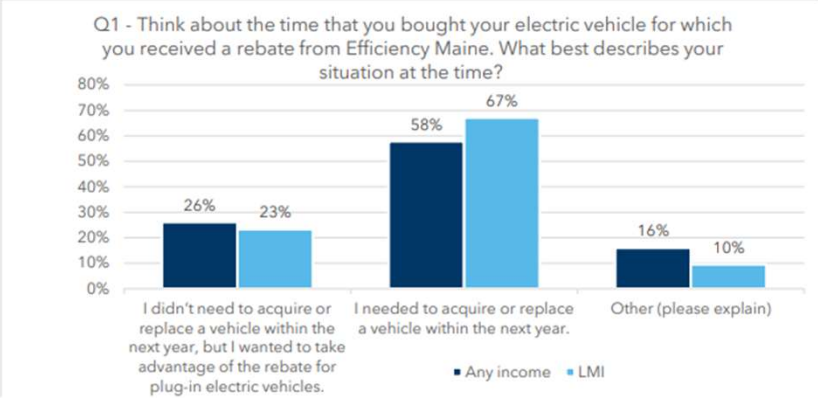
Thank You !

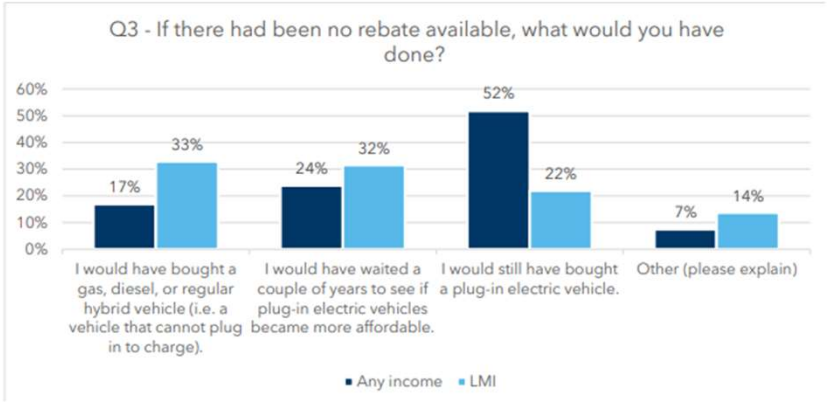


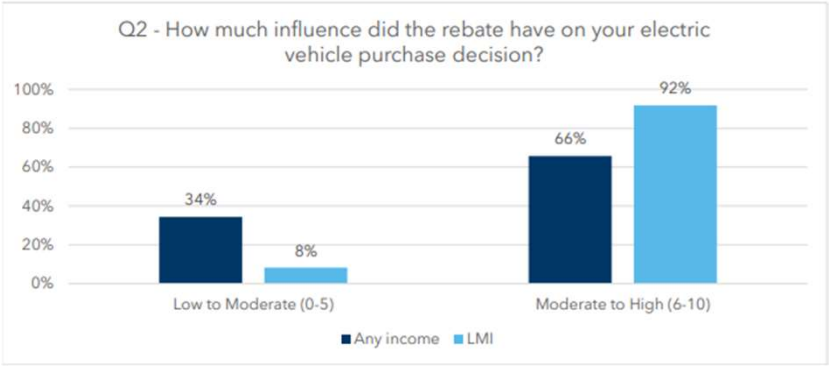
The full report is available on the Efficiency Maine website

https://www.efficiencymaine.com/docs/TPVI_Appendix_L3_EV_Market_Assessment.pdf

EMT survey – impact of income on EV purchase decision







Survey administered to EMT rebate recipients.

LMI (Low- and Moderate- Income) recipients indicate that receiving the rebate **greatly influenced their purchase decision**.

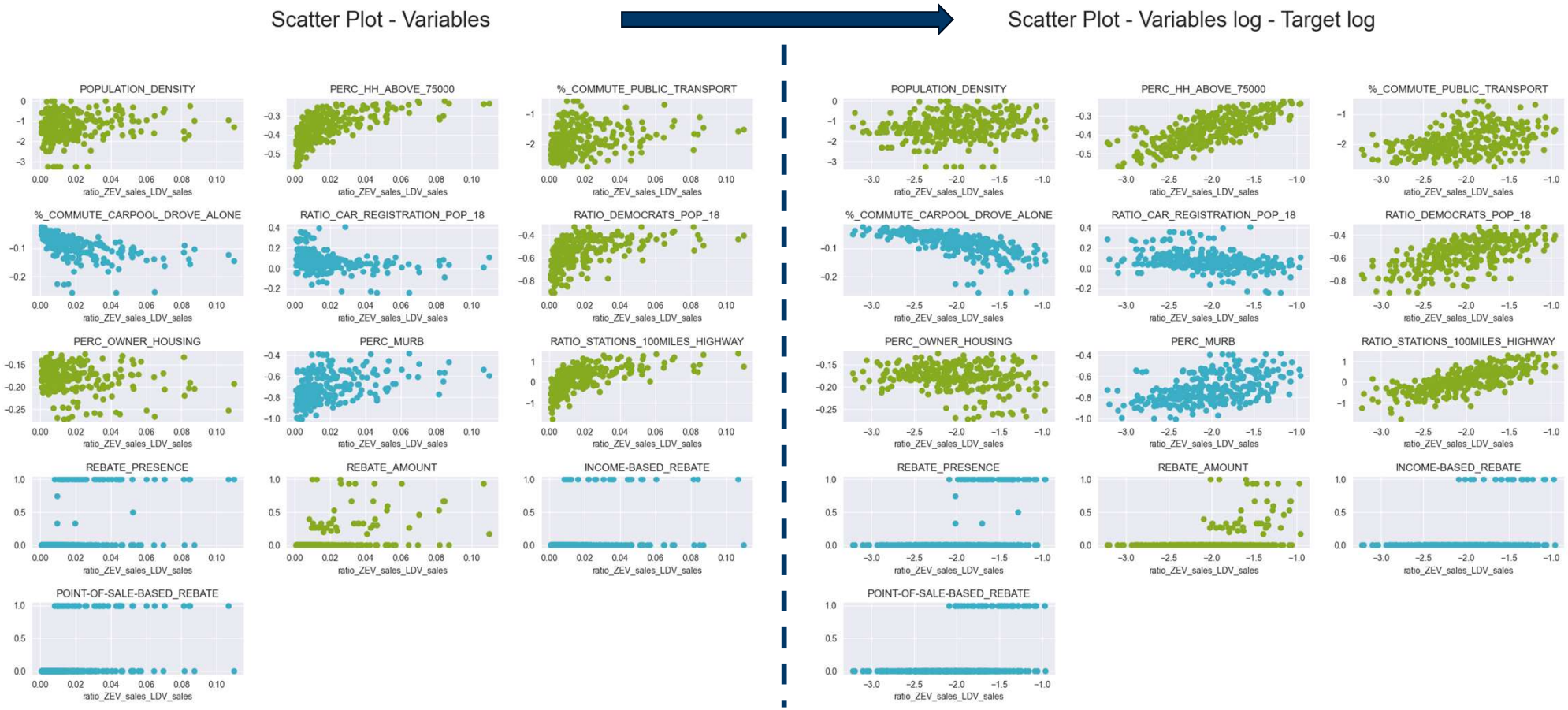
LS1

Slide 18

LS1 Removed ", for a vehicle they were considering buying anyway" - I think that statement was off but now it sounds right after removal.
Lauren Scott, 2025-06-13T17:58:49.088

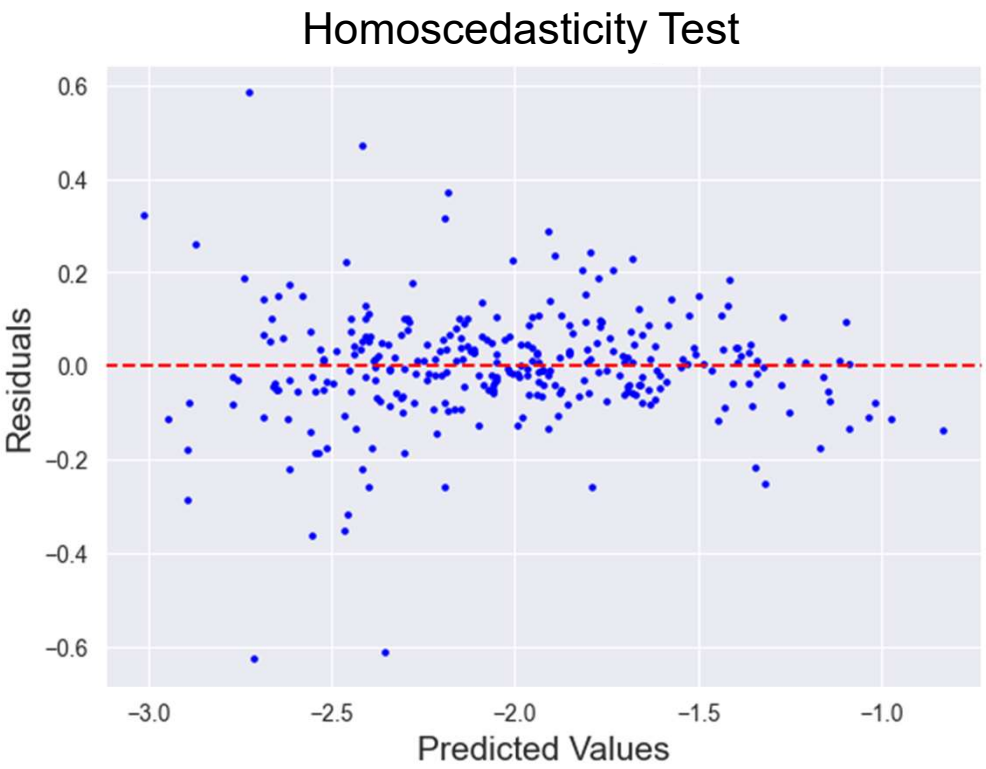
Task 1: Data Collection & Regression Analysis

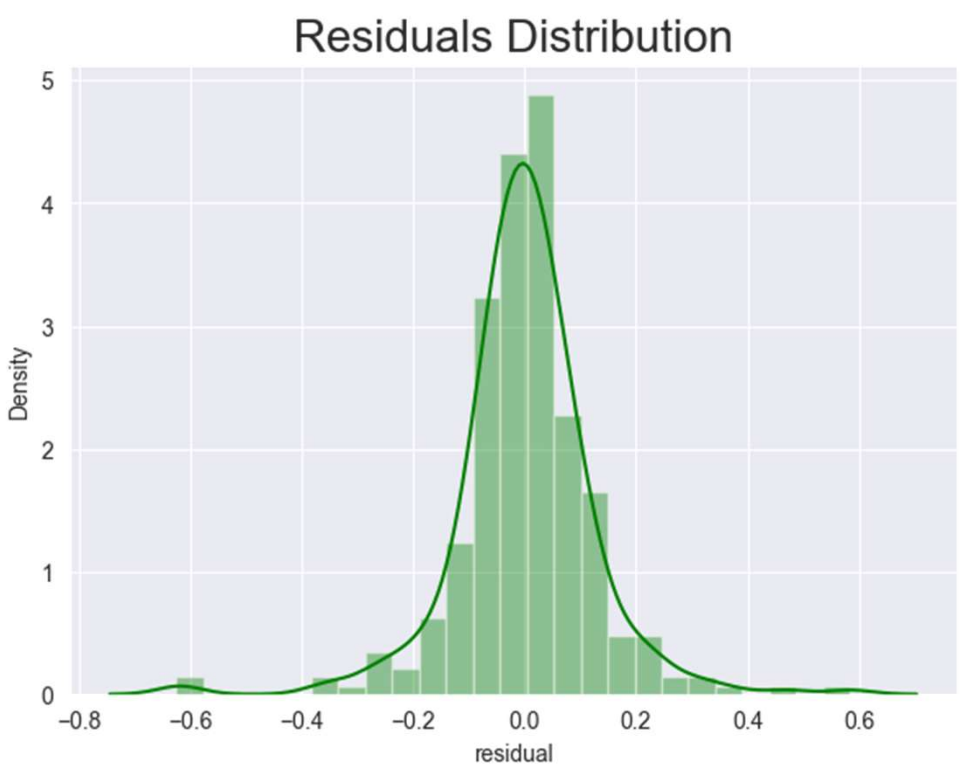
Step 2: Data Visualisation and Log Transformation



Results

Quality of the Model: Residuals





- Residuals are the difference between observed results and model-predicted results.
- Normally distributed residuals indicate a model that is unbiased, and it supports the choice of a linear regression.