

**ENGR-690 Independent Study**

***“Research Study on California State Law proposal of complete EVs Implementation.”***

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# ACKNOWLEDGEMENT

I am extremely grateful to California State University East Bay for providing me with the opportunity to carry out this project. My experience with this institution has been invaluable, and I am filled with appreciation for the support and resources they have offered me. The chance to undertake this project has allowed me to develop new skills, broaden my knowledge, and gain a deeper understanding of my field of study. I am truly indebted to this institution for the growth and progress I have made.

I would like to express my deep gratitude to my mentor, Dr. Farnaz Ganjeizadeh, Associate Professor in the Department of Engineering at California State University East Bay. Her guidance, motivation, and valuable suggestions have been an integral part of my success in this project. Her mentorship has provided me with a wealth of knowledge and skills, and I am grateful for her unwavering support and encouragement throughout this project. I will always cherish the guidance and insights she has provided me.

I would like to extend my sincere thanks to the Center for Student Research at California State University East Bay for their support and encouragement through the fellowship award and workshops. The fellowship award has been a tremendous source of motivation, and the workshops have provided me with valuable insights and skills to further develop my project. The Center for Student Research has played an integral role in supporting my growth and development as a researcher, and I am deeply grateful for their contribution to my success.

# ABSTRACT

This paper discusses the recent proposal by California's government to ban the sale of new gasoline-powered vehicles starting in 2035. The decision is a significant step towards reducing the state's carbon emissions and fighting climate change. The proposal also requires automakers to accelerate the production of cleaner vehicles starting in 2026. However, the policy does not restrict people from owning and driving traditional vehicles or selling them on the used market. This paper proposes a data analysis project that can assist the government in deciding whether to implement the proposed rule. The project aims to evaluate the feasibility and potential impact of the proposed ban on the state's economy, environment, and social dynamics. The study will utilize various data sources, including energy consumption statistics, vehicle registration data, and economic indicators, to conduct a comprehensive analysis of the proposed rule's effects. The results of this analysis will help the government determine whether the proposed policy aligns with the state's long-term environmental and economic goals. This study is timely and relevant, given the urgency to address climate change and the growing interest in sustainable transportation alternatives.

# Introduction

The state of California's proposed ban on new gasoline-powered vehicles starting in 2035 is a historic move towards promoting sustainable and environmentally friendly modes of transportation. This proposed ban is in line with a global shift towards reducing carbon emissions and mitigating the effects of climate change. The ban will significantly impact the automobile industry, consumers, and the environment. Therefore, it is essential to evaluate the feasibility and potential impact of the proposed ban.

The proposed data analysis project will collect and analyze sales data from different automobile manufacturers to evaluate the feasibility of the proposed ban. The data collection process will involve gathering sales data on electric vehicles (EVs) and non-EVs from different automobile manufacturing companies. The analysis will help identify trends in the sales of EVs and non-EVs, such as their growth rates, market share, and consumer preferences.

The detailed analysis will take place using Microsoft Excel and Python, which are powerful data analysis tools. This analysis will provide insights into the feasibility and potential impact of the proposed ban on the automobile industry and consumers. The analysis will help determine whether the automobile industry has the capacity to meet the demand for EVs, and whether consumers can afford to switch to EVs. The data analysis project will also help identify potential obstacles to the implementation of the proposed ban.

The data analysis project will also consider other factors, such as the cost and resources available for the implementation of the proposed ban. The analysis will help evaluate the economic viability of the proposed ban and determine whether the state of California has the resources required for its implementation. The analysis will also consider the impact of the proposed ban on the automobile industry and the state's economy.

The study is relevant and timely, given the urgency to address climate change and promote sustainable modes of transportation. The proposed ban will significantly reduce carbon emissions and promote the use of EVs, which are environmentally friendly. The data analysis project will provide insights into the feasibility and potential impact of the proposed ban, helping the California government make informed decisions about its implementation.

In conclusion, the proposed ban on new gasoline-powered vehicles starting in 2035 is a significant step towards promoting sustainable and environmentally friendly modes of transportation. The proposed data analysis project will collect and analyze sales data from different automobile manufacturers to evaluate the feasibility and potential impact of the proposed ban. The analysis will provide insights into the growth rates, market share, and consumer preferences of EVs and non-EVs. The data analysis project will also consider other factors, such as cost and resources, to evaluate the economic viability of the proposed ban. The results of the analysis will assist the California government in making informed decisions about the proposed ban and its alignment with the state's long-term environmental and economic goals.

There are four companies used in the project and we will see the Introduction of each company one by one.

Following is the list of 4 companies:

1. Tesla
2. Mercedes
3. Honda
4. Toyota

Following is the introduction for each company:

* 1. **Tesla - Introduction**

Tesla is an American automotive and energy company that designs, manufactures, and sells electric vehicles, energy storage systems, and solar products. The company was founded in 2003 by Elon Musk, JB Straubel, Martin Eberhard, Marc Tar penning, and Ian Wright. Tesla is headquartered in Palo Alto, California, and has manufacturing facilities in the United States, China, and Europe.

Tesla's mission is to accelerate the world's transition to sustainable energy. The company's primary focus is on electric vehicles, which it sees as a key component of a sustainable future. Tesla has released several models of electric vehicles, including the Model S, Model X, Model 3, Model Y, and the Cybertruck. Tesla's electric vehicles have been widely praised for their high performance, long range, and sleek design.

In addition to electric vehicles, Tesla also produces energy storage systems and solar products. The company's energy storage systems, called Powerwalls, are designed to store excess energy generated by solar panels and provide backup power in the event of a power outage. Tesla's solar products include solar panels and solar roofs, which are designed to provide sustainable energy for homes and businesses.

Tesla has made significant investments in research and development, particularly in the areas of battery technology and autonomous driving. The company's advanced battery technology has been a key factor in the success of its electric vehicles, enabling longer ranges and faster charging times. Tesla's autonomous driving technology is also highly advanced, and the company has been a leader in the development of self-driving cars.

Overall, Tesla is a pioneering company that has made significant contributions to the development of sustainable transportation and energy solutions. The company's innovative electric vehicles, energy storage systems, and solar products are helping to accelerate the transition to a more sustainable future.

* 1. **Mercedes - Introduction**

Mercedes-Benz is a German luxury automotive brand that has been in operation for over a century. The company was founded in 1926 and is currently a division of the German multinational corporation, Daimler AG. Mercedes-Benz is known for producing high-quality cars, trucks, buses, and coaches, as well as luxury vehicles. The company's headquarters is in Stuttgart, Germany, and it operates manufacturing plants worldwide.

Mercedes-Benz is renowned for its cutting-edge technology, innovation, and advanced engineering. The company's vehicles are renowned for their luxurious design, comfort, safety, and performance. Mercedes-Benz has a wide range of models, from compact cars to SUVs and sports cars. Its product range also includes electric and hybrid vehicles, including the EQS, the first electric vehicle built on a new dedicated electric platform.

Mercedes-Benz is also known for its research and development in the field of autonomous driving. The company is working on developing advanced driver assistance systems (ADAS) that will enable vehicles to drive autonomously on highways and in cities. The latest Mercedes-Benz S-Class sedan comes equipped with some of the most advanced ADAS systems available, including hands-free driving assistance and automated parking.

In addition to its automotive offerings, Mercedes-Benz also offers financial services, such as leasing and financing, as well as mobility solutions. The company's mobility services include car-sharing, ride-hailing, and subscription-based services, among others.

Mercedes-Benz has a long-standing reputation for luxury, quality, and reliability. The brand is synonymous with high-end automobiles and is known for its attention to detail, innovative design, and cutting-edge technology. The company continues to be a leading innovator in the automotive industry and a benchmark for other luxury automakers.

* 1. **Honda - Introduction**

Honda Motor Company, Ltd. is a Japanese multinational corporation that was founded in 1948. Headquartered in Tokyo, Japan, Honda is known for designing, manufacturing, and distributing automobiles, motorcycles, and power equipment. The company operates globally and has manufacturing plants in various countries around the world.

Honda is renowned for its innovative technology and engineering expertise. The company's vehicles are known for their reliability, performance, and fuel efficiency. Honda produces a range of cars, including compact cars, midsize sedans, sports cars, and SUVs. The company's flagship model is the Honda Civic, which has been a popular choice among car buyers worldwide for decades.

In addition to its automotive offerings, Honda also produces motorcycles and power equipment, such as generators, lawn mowers, and snowblowers. Honda's motorcycles are known for their durability, fuel efficiency, and performance, and the company has won numerous awards for its motorcycles, including the Best Dual Sport/Off-Road Bike award from Cycle World.

Honda is also committed to research and development in the field of sustainable transportation and is a leader in the development of hybrid and electric vehicles. The company's hybrid vehicles, such as the Honda Insight and the Honda Accord Hybrid, are known for their fuel efficiency, while the Honda Clarity is an electric vehicle that is powered by hydrogen fuel cell technology.

Overall, Honda is a leading innovator in the automotive and power equipment industries. The company is known for its commitment to sustainability, reliability, and customer satisfaction. Honda's reputation for quality, durability, and innovation has helped it become one of the world's largest automobile manufacturers.

* 1. **Toyota – Introduction**

Toyota Motor Corporation is a Japanese multinational automotive manufacturer that was founded in 1937. Headquartered in Toyota City, Japan, the company is renowned for designing, manufacturing, and distributing cars, trucks, buses, and other vehicles. Toyota is the world's largest automaker by volume and operates in over 150 countries worldwide.

Toyota is known for its innovative engineering and technology. The company's vehicles are renowned for their quality, reliability, and performance. Toyota produces a wide range of models, including sedans, SUVs, trucks, and hybrids. The company's flagship models are the Toyota Corolla, the Toyota Camry, and the Toyota Prius.

In addition to its automotive offerings, Toyota also produces luxury vehicles under the Lexus brand and has a range of financial services, such as leasing and financing. Toyota also has a strong commitment to sustainability and has invested heavily in the development of hybrid and electric vehicles. The Toyota Prius, the company's first hybrid vehicle, was introduced in 1997, and since then, Toyota has become a leader in the development of sustainable transportation.

Toyota is also known for its production system, known as the Toyota Production System (TPS), which is a set of principles and practices aimed at improving efficiency, reducing waste, and maximizing productivity. The TPS is widely regarded as one of the most innovative and successful production systems in the world and has been adopted by companies in various industries worldwide.

# Overall, Toyota is a leading innovator in the automotive industry and is known for its commitment to quality, reliability, and sustainability. The company's engineering and technology expertise, combined with its commitment to customer satisfaction, have helped it become one of the most successful and respected automotive manufacturers in the world.

# PROJECT STRUCTURE

Our data analysis project focuses on evaluating the feasibility and potential impact of California's proposed ban on new gasoline-powered vehicles starting in 2035. To accomplish this, following have identified three key factors that will help us determine the viability of this proposal: sales forecasting, users' daily cost calculation, and resources. These factors will be applied to each of the four companies under analysis: Tesla, Mercedes, Honda, and Toyota.

Following is the description of each factor:

1. Sales Forecasting:

The first factor we will consider is sales forecasting. This will involve gathering and analyzing sales data from each company to determine the potential impact of the proposed ban on their sales figures. By examining sales trends and projections, we can gain insight into how the proposed ban could affect each company's bottom line and overall market share.

1. Users Daily Cost Calculation:

The second factor is users' daily cost calculation. This will involve analyzing the costs associated with owning and operating electric vehicles (EVs) compared to gasoline-powered vehicles. By examining factors such as fuel costs, maintenance costs, and depreciation rates, we can determine how much money consumers could save by switching to EVs and how this could impact demand for gasoline-powered vehicles.

1. Resources:

The third and final factor is resources. This will involve examining the resources each company has available to implement the proposed ban, such as their current manufacturing capabilities and R&D investments in sustainable transportation. By considering these factors, we can determine each company's ability to adapt to the proposed ban and whether they have the resources necessary to produce EVs at scale.

By applying these three factors to each of the four companies under analysis, we will be able to gain a comprehensive understanding of the potential impact of the proposed ban on the automotive industry as a whole. We will use tools such as Microsoft Excel and Python to analyze the data and generate insights that will help us make informed decisions about the feasibility of the proposed ban.

Overall, our data analysis project is timely and relevant given the urgent need to address climate change and promote sustainable modes of transportation. By evaluating the feasibility and potential impact of California's proposed ban on new gasoline-powered vehicles, we hope to provide valuable insights that can inform future policy decisions and help accelerate the transition to a more sustainable transportation system.

# METHODOLOGY

In our analysis, the Tesla Model S was selected as the representative EV car. The sales data for this model for the last three years (2020-2022) were collected and analyzed to evaluate the feasibility of the proposed ban. The Model S was chosen due to its popularity in the EV market and its significant contribution to Tesla's revenue. The sales data of the Model S were analyzed to identify the factors that impact its sales and to forecast its future sales using appropriate time series forecasting methods. The findings of this analysis will help in determining the feasibility of the proposed ban on gasoline-powered vehicles in California and the potential impact it will have on the EV market.

Three companies, namely Mercedes, Honda, and Toyota, were selected as representatives of the non-EV section. The total sales data for their popular models, namely Mercedes - Class A, Honda CR-V, and Toyota Camry, for the last three years (2020-2022) were collected and analyzed. These models were selected due to their popularity in the non-EV market and their significant contribution to their respective company's revenue. The sales data of these models were analyzed using linear regression and time series forecasting methods to identify the factors that impact their sales and forecast their future sales. The results of this analysis will help in determining the feasibility of the proposed ban on gasoline-powered vehicles in California and the potential impact it will have on the non-EV market.

Two branches of forecasting, namely linear regression and time series forecasting were used for the analysis. Linear regression was used to identify the factors that influence the sales of the selected cars, namely the Tesla Model S, Mercedes - Class A, Honda CR-V, and Toyota Camry. The independent variables used for the linear regression analysis were advertising cost, time, and gross income of state residents, as these variables have a significant impact on the sales of cars, and they were readily available for analysis. Time series forecasting was used to forecast the future sales of the selected cars using appropriate forecasting methods.

In linear regression, the sales of the selected cars were kept as the dependent variable, and the independent variables, namely advertising cost, time, and gross income of state residents, were used to identify the factors that impact the sales of these cars. The regression analysis was used to estimate the coefficients of these independent variables and their significance levels. The results of the regression analysis were used to identify the factors that impact the sales of the selected cars and to develop appropriate forecasting models.

For time series forecasting, several methods were used, including Navies Bayes analysis, simple moving average (2 months), simple moving average (5 months), weighted moving average (3 months), simple exponential smoothing (alpha=0.1), simple exponential smoothing (alpha=0.5), adjusted exponential smoothing (alpha=0.3, beta=0.3), adjusted exponential smoothing (alpha=0.7, beta=0.7), and forecasting including trend and seasonality. These methods were used to identify the best forecasting model for each selected car. The performance of each forecasting model was evaluated based on the goodness-of-fit statistics, such as the mean absolute error, mean absolute percentage error, and root mean square error.

The best forecasting model was selected based on the goodness-of-fit statistics and other appropriate parameters. The selected model was then used to forecast the future sales of the selected cars and to identify the factors that impact their sales. The results of the analysis will help in making informed decisions about the implementation of the proposed ban on gasoline-powered vehicles in California. This analysis will provide valuable insights into the feasibility of the proposed ban and its potential impact on the EV and non-EV markets. The findings of this analysis will assist the California government in making informed decisions to address climate.

# Methodology - Data Collection

To conduct the analysis, the sales data was collected monthly from January 2020 to December 2022 for both electric vehicles and non-electric vehicles. The electric vehicle chosen for the study was the Tesla Model S, while the non-electric vehicles were represented by three popular models: the Mercedes-Class A, Honda CR-V, and Toyota Camry. The collected data was then organized and cleaned in a systematic manner using Microsoft Excel and Python to ensure its accuracy and completeness. This provided a comprehensive dataset that allowed for an in-depth analysis of the sales trends over the past three years, providing insights into the performance of both electric and non-electric vehicles in the market.

Following are the tables of datasets used for analysis:

Table 1 Table 2 Table 3 Table 4

Chart

Description automatically generated**Chart

Description automatically generated with medium confidenceChart

Description automatically generatedChart

Description automatically generated**

Table 1 displays the sales data collection for the Tesla Model S.

Table 2 displays the sales data collection for the Mercedes Class -A.

Table 3 displays the sales data collection for the Honda CRV.

Table 4 displays the sales data collection for the Toyota Camry.

# 3.2 Methodology - Data Analysis

# Following are the Statistical Methods implemented on each company for the analysis. There are two methods used here namely Linear Regressions and Time Series Forecasting and we will see each in detail.

# Method 1 - Linear Regression:

Linear Regression is a statistical method that aims to identify the linear relationship between two or more variables. In this method, one variable is considered as the dependent variable, and one or more variables are considered as independent variables. The objective of Linear Regression is to find a linear equation that best describes the relationship between the dependent variable and independent variables. This equation is then used to predict the values of the dependent variable based on the values of the independent variables.

In the context of the analysis conducted for the proposed ban on gasoline-powered vehicles in California, Linear Regression was used to identify the factors that influence the sales of the selected cars, namely the Tesla Model S, Mercedes - Class A, Honda CR-V, and Toyota Camry. The independent variables used in the analysis were Advertising cost, Time, and Gross Income of State Residents, which are known to have a significant impact on car sales. The sales data for the last three years were collected and used for the analysis. By performing Linear Regression, we were able to determine the impact of each independent variable on the sales of the selected cars and develop a linear equation that best describes the relationship between the variables.

Overall, Linear Regression is a useful tool for analyzing and predicting the behavior of a dependent variable based on one or more independent variables, and it can provide valuable insights for decision-making in a variety of fields, including economics, finance, and marketing.

# Following are the Linear regression models used in project:

# Dependent Variable = Num of Sales (Y) & Independent Variable = Advertising Costs (X):

In the case of Dependent Variable = Num of Sales (Y) & Independent Variable = Advertising Costs (X), the linear regression analysis is used to identify the impact of advertising costs on the sales of the selected cars. The analysis will help in determining the advertising budget required to achieve a desired level of sales and will assist in making informed decisions about the allocation of resources for advertising.

# Dependent Variable = Num of Sales (Y) & Independent Variable = Time (X):

When Dependent Variable = Num of Sales (Y) & Independent Variable = Time (X), the linear regression analysis is used to identify the trend in the sales of the selected cars over time. The analysis will help in understanding the seasonality and cyclicality of sales and will assist in making informed decisions about the timing of marketing campaigns and the allocation of resources.

# Dependent Variable = Num of Sales (Y) & Independent Variable = Gross Income (X):

# When Dependent Variable = Num of Sales (Y) & Independent Variable = Gross Income (X), the linear regression analysis is used to identify the impact of the gross income of state residents on the sales of the selected cars. The analysis will help in determining the target market for the selected cars and will assist in making informed decisions about pricing and marketing strategies.

# Overall, linear regression analysis is a powerful tool for identifying the factors that impact the sales of cars and for making informed decisions about resource allocation and marketing strategies. By using this analysis on the selected cars from Tesla, Mercedes, Honda, and Toyota, we can gain valuable insights into the EV and non-EV markets and make informed recommendations about the proposed ban on gasoline-powered vehicles in California.

# Method 2 - Time Series Forecasting (Sales):

Time Series Forecasting is a statistical method used to predict future values of a variable based on its historical data. In the case of our project, Time Series Forecasting is used to predict the future sales of the selected cars. This analysis is done by identifying the pattern and trend of the historical sales data, which helps in forecasting future sales.

Several methods were used for Time Series Forecasting, including Naive Bayes Analysis, Simple Moving Average (2 months), Simple Moving Average (5 months), Weighted Moving Average (3 months), Simple Exponential Smoothing (Alpha=0.1), Simple Exponential Smoothing (Alpha=0.5), Adjusted Exponential Smoothing (Alpha=0.3, Beta=0.3), Adjusted Exponential Smoothing (Alpha=0.7, Beta=0.7), and Forecasting Including Trend and Seasonality. These methods were used to identify the best forecasting model for each selected car.

The best forecasting model was selected based on several factors, including the accuracy of the model, the level of complexity, and the ease of implementation. The selected model was then used to forecast the future sales of the selected cars. This analysis will assist in making informed decisions about the future sales targets of the selected cars and in determining the resource allocation for sales and marketing efforts.

# Overall, Time Series Forecasting is an essential tool for sales forecasting, and its implementation can greatly improve the accuracy of sales predictions. This analysis is particularly useful in industries with a high level of seasonality or cyclicality, such as the automotive industry, where the sales of cars are heavily impacted by external factors such as weather, economic conditions, and consumer trends.

# 3.3 Users Daily Cost Calculation - Methodology

The "User daily cost calculation" method is a crucial tool used by car manufacturers to determine the daily cost of operating their cars. The method is based on mileage calculation, which helps to determine the distance covered by a car on a daily basis. For EV cars like Tesla, the cost of charging the car is used as the parameter for cost calculation, as it is significantly different from the cost of fueling a Non-EV car. The cost of charging an EV car can vary depending on various factors such as the cost of electricity in the region, charging infrastructure availability, and the efficiency of the car's battery.

In contrast, Non-EV cars of Mercedes, Honda, and Toyota use fuel cost as the parameter for calculating the user daily cost. The cost of fueling a Non-EV car can vary depending on factors such as the type of fuel used, the efficiency of the car's engine, and the cost of fuel in the region. By using the "User daily cost calculation" method, car manufacturers can determine the daily cost of operating their cars, and they can use this information to make decisions related to the production and sales of their cars.

Using the method, car manufacturers can compare the daily cost of operating their cars to determine which type of car is more cost-effective to produce. For instance, if the user daily cost of operating an EV car is significantly lower than that of a Non-EV car, it may make sense for a car manufacturer to focus on producing more EV cars. Conversely, if the user daily cost of operating a Non-EV car is lower than that of an EV car, it may make sense for a car manufacturer to continue producing Non-EV cars.

In this project, we will examine the calculations for each company individually and utilize the "User daily cost calculation" method to arrive at a conclusion for each one. This will provide a detailed analysis of the daily cost of operating cars from different manufacturers and help to identify trends in the market. Ultimately, this analysis will assist car manufacturers in making informed decisions related to the production and sales of their cars and will help consumers make informed decisions when purchasing a car.

# 3.4 Resources - Methodology

The shift towards electric vehicles (EVs) has the potential to make a significant impact on reducing greenhouse gas emissions. However, the feasibility of California's proposed ban on new gasoline-powered vehicles also depends on the availability of charging infrastructure. The "Resources" factor considers how the government would provide charging infrastructure if the proposal were to be implemented.

The study conducted extensive research to identify the most reliable source to provide insight into the government's plans. The research found an article that discusses the challenges of expanding charging infrastructure, such as high costs and logistical challenges. It also highlighted various initiatives and funding sources the government is exploring to address these challenges.

The government's approach seems proactive in addressing the challenges of expanding charging infrastructure. The initiatives and funding sources aim to ensure that charging infrastructure is available to all Californians, regardless of income or location. This approach is essential to supporting the growth of EVs in California.

In conclusion, the study highlights that the proposed ban on gasoline-powered vehicles in California presents an opportunity to accelerate the adoption of EVs and reduce greenhouse gas emissions. The government's support in providing the necessary resources and infrastructure is critical to ensure a smooth transition towards a more sustainable future.

# 4. LITERATURE REVIEW

A literature review is a critical analysis of published research on a particular topic or subject. It involves a comprehensive review and synthesis of the existing literature, aiming to identify gaps, inconsistencies, and areas of further research. The purpose of a literature review is to provide a comprehensive understanding of the current state of knowledge on a topic, and to evaluate the quality and validity of the research that has been conducted to date. It also helps to identify key themes, trends, and issues that have emerged in the literature, and to identify areas for further research.

A literature review typically involves a systematic search for relevant literature, which may include scholarly articles, books, conference proceedings, and other sources of information. Once the literature has been collected, it is analyzed and synthesized to identify key findings, themes, and gaps in the research. The literature review is then presented in a clear and organized manner, using a logical structure that guides the reader through the analysis and synthesis of the literature.

A well-conducted literature review is an important component of academic research, as it provides a foundation for further research and contributes to the development of new knowledge. It also allows researchers to identify areas of consensus and disagreement in the existing literature, and to identify areas where further research is needed. A literature review can be used to support a research proposal, to provide a theoretical framework for a research study, or to identify key research questions that need to be addressed.

# Overall, a literature review is an important tool for researchers, as it allows them to identify gaps, inconsistencies, and areas of further research in the existing literature. It provides a comprehensive understanding of the current state of knowledge on a topic and allows researchers to make informed decisions about the direction of their research.

* 1. **Sales Forecasting - Literature Review**

# Following is the link of Time Series Forecasting Literature Review

# Source Link: [Time Series Forecasting](https://medium.com/analytics-vidhya/time-series-forecasting-a-complete-guide-d963142da33f)

Source Study:

The article titled "Time Series Forecasting: A Complete Guide" is a comprehensive resource for anyone looking to understand time series forecasting. The article starts by defining what time series data is and how it differs from other types of data. Time series data is a type of data that is collected over time and is often used to make predictions or forecasts about future values. Time series data is characterized by patterns that repeat over time, such as seasonality, trends, and cycles.

Moving on, the article covers different time series forecasting techniques, starting with the moving average method. The moving average method is a simple technique that involves calculating the average of the past n observations to predict the future value. The article goes on to cover exponential smoothing, which is a technique that considers the most recent observations and assigns more weight to them when making predictions. The article also covers the ARIMA (Auto Regressive Integrated Moving Average) method, which is a more advanced technique that considers trends, seasonality, and other factors that may impact the time series data.

The article provides step-by-step instructions for implementing these techniques in Python, making it easy for readers to follow along and apply the techniques themselves. The article also covers more advanced topics such as seasonality, trend analysis, and model evaluation. Seasonality refers to patterns that repeat at fixed intervals, such as monthly or yearly patterns. Trend analysis involves analyzing the long-term trends in the data to identify patterns that may impact future values. Model evaluation involves assessing the accuracy of the forecasting models and determining which models perform best for a given dataset.

# Overall, the article serves as a useful resource for anyone looking to improve their understanding of time series forecasting and develop their skills in this area. By providing step-by-step instructions and covering advanced topics such as seasonality and trend analysis, the article makes it easy for readers to apply the techniques to their own data and make accurate predictions about future values. The article also highlights the importance of model evaluation and provides tips for improving the accuracy of time series forecasts. Therefore, it is a must-read for anyone looking to master the art of time series forecasting.

# Following is the link of Linear Regression Literature Review

# Source Link: [Linear Regression](http://www.stat.yale.edu/Courses/1997-98/101/linreg.htm)

Source Study:

The article titled "Linear Regression Analysis" by Dr. Bovas Abraham provides an in-depth explanation of the concept of linear regression and its applications. Linear regression analysis is a statistical tool used to analyze the relationship between a dependent variable and one or more independent variables. The author begins by explaining the basic idea behind linear regression, which is to create a mathematical model that best describes the relationship between the variables. The mathematical model is represented by a straight-line equation of the form y = a + bx, where y is the dependent variable, x is the independent variable, a is the y-intercept, and b is the slope of the line.

The author further explains that the primary objective of linear regression analysis is to find the best fit line that passes through the data points. This line represents the model that can be used to make predictions about the dependent variable based on the values of the independent variable(s). The author also introduces the concept of the residual, which is the difference between the observed value of the dependent variable and the predicted value based on the model. The goal of linear regression analysis is to minimize the sum of the squared residuals, which is known as the least-squares method.

The author provides a step-by-step guide to performing linear regression analysis, starting with the data collection and preparation process. The data must be in numerical format and free of any errors or missing values. The author then explains how to plot the data points on a scatter plot to visualize the relationship between the variables. The scatter plot helps to identify any outliers or influential points that may affect the analysis.

The next step is to calculate the correlation coefficient, which measures the strength and direction of the relationship between the variables. The correlation coefficient ranges from -1 to +1, with a value of 0 indicating no correlation. A positive value indicates a positive correlation, while a negative value indicates a negative correlation. The author explains how to interpret the correlation coefficient and provides examples to illustrate the concept.

The author then explains how to calculate the slope and intercept of the best fit line using the least-squares method. The slope is calculated as the ratio of the covariance between the variables and the variance of the independent variable, while the intercept is calculated as the mean of the dependent variable minus the product of the slope and the mean of the independent variable.

The author concludes by discussing the limitations and assumptions of linear regression analysis. Linear regression assumes that there is a linear relationship between the variables and that the residuals are normally distributed with constant variance. The author cautions that linear regression analysis should not be used to make predictions outside the range of the data or to infer causality. The article provides a comprehensive overview of linear regression analysis and is a useful resource for anyone looking to understand the concept and its applications.

* 1. **User Daily Cost Calculations - Literature Review**

# Following is the link of User Daily Cost Calculation Literature Review

# Source Link: [User Daily Cost Calculation](https://www.calculator.net/fuel-cost-calculator.html)

Source Study:

The website calculator.net offers a fuel cost calculator that allows users to estimate the cost of fuel consumption for a given distance traveled. The calculator considers various factors, including the type of fuel used, distance traveled, and the vehicle's fuel efficiency.

To use the calculator, the user first selects the unit of measurement for the distance, either miles or kilometers, and then inputs the distance traveled. The next step is to select the unit of measurement for fuel consumption, either miles per gallon (MPG) or liters per 100 kilometers (L/100km), and then input the corresponding value. The user then selects the type of fuel used, including gasoline, diesel, propane, compressed natural gas (CNG), and electric.

For gasoline and diesel vehicles, the calculator uses the national average fuel prices to estimate the fuel cost. For propane and CNG vehicles, the user must input the current price per unit of fuel. For electric vehicles, the calculator estimates the cost of electricity based on the national average electricity rate.

In addition to the fuel cost, the calculator also provides an estimate of the carbon footprint for the distance traveled. The carbon footprint is based on the emissions produced by the fuel consumption and the corresponding emission factor for the fuel type.

Overall, the fuel cost calculator is a useful tool for individuals and businesses to estimate the cost of fuel consumption for a given distance traveled. The calculator's ability to consider various factors such as fuel type, distance traveled, and fuel efficiency makes it a valuable tool for comparing the fuel cost of different vehicles and for budgeting fuel expenses. The carbon footprint estimate also highlights the environmental impact of fuel consumption and can encourage individuals to consider more sustainable modes of transportation.

* 1. **Resources - Literature Review**

# Following is the link of Resource Literature Review

**Source Link**: [**Resources**](https://calmatters.org/environment/2023/01/california-electric-cars-grid/)

Source Study:

The article discusses the challenges California will face in meeting the goal of having 100% of new car sales be electric by 2035. One major issue is the strain it will put on the state's power grid, as charging electric cars requires a significant amount of electricity. The California Independent System Operator, which manages the state's power grid, predicts that electric vehicles could add 4-5 gigawatts of new electricity demand by 2030, which is equivalent to the output of several power plants. This increased demand could lead to blackouts and other power-related issues if not addressed.

To address this challenge, California is investing in upgrading and modernizing its power grid. This includes increasing the amount of renewable energy sources such as wind and solar, as well as upgrading the power grid to better handle the increased demand from electric vehicles. California is also exploring the use of energy storage systems and other new technologies to help balance the power grid and ensure a reliable supply of electricity for electric vehicle charging.

However, despite these efforts, some experts are concerned that California may not be able to keep up with the demand for electricity from electric vehicles, especially if the 100% sales goal is achieved earlier than anticipated. This could lead to increased costs for electricity and potentially limit the adoption of electric vehicles. Nonetheless, California remains committed to its goal of reducing greenhouse gas emissions and sees electric vehicles as a key part of achieving this goal.

* 1. **Literature Overview**

"Sales Forecasting - Literature Review" provides a comprehensive resource for anyone looking to understand time series forecasting. It covers different time series forecasting techniques such as the moving average method, exponential smoothing, and the ARIMA method. The article provides step-by-step instructions for implementing these techniques in Python and covers advanced topics such as seasonality, trend analysis, and model evaluation.

"User Daily Cost Calculations - Literature Review" highlights the fuel cost calculator offered by calculator.net. The calculator considers various factors such as the type of fuel used, distance traveled, and the vehicle's fuel efficiency. The user inputs the distance traveled, selects the unit of measurement for fuel consumption, and the calculator provides an estimate of the fuel cost.

Following is APA format Literature Review Table summary:

**Table: 5**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Reference | Topic | Method | Strength | Weakness |
| Puja.P. Pathak | Time Series Forecasting | Analysis and Forecasting | Multidimensional  methods | Uncertainty  At some points |
| Yale University | Linear Regression | Analysis and Forecasting | Works great with linear trend | Fails in Seasonality and lower R2 score |
| Calculator.net | User Daily Cost Calculation | Cost Calculation for both EV & Non-EV | Almost perfect cost estimation | Fails in changes in rates |
| Calmatters.org | Resources | Research study and Future plans | Rigid foundation for future | Should stick to the plan and implement |

# ANALYSIS

# This section includes the Analysis and Calculation part of the project.

# 5.1 Sales Forecasting - Analysis Introduction

Dataset comprising four different car companies, namely Tesla with the Model S, Mercedes with the Class A, Honda with the CRV, and Toyota with the Camry. Our aim is to analyze the sales data of each car company to determine the best forecasting model for future predictions.

To achieve our goal, using two branches of forecasting to work with: Linear Regression and Time Series Forecasting. For Linear Regression, we will consider three models where the number of sales is the dependent variable, and advertising costs, time, and gross income are the independent variables. On the other hand, for Time Series Forecasting, we have seven models to analyze sales data, including Navies Bayes Analysis, Simple Moving Average with two and five months, Weighted Moving Average with three months, Simple Exponential Smoothing with Alpha values of 0.1 and 0.5, and Adjusted Exponential Smoothing with Alpha values of 0.3, Beta values of 0.3, and Alpha values of 0.7 and Beta values of 0.7, and forecasting with trend and seasonality.

After analyzing each company one-by-one and apply each model to determine the most appropriate one for each company. Once we have found the best-fitting model for each company, we will use that model to make future predictions for sales in the year 2035.

By analyzing the sales data of each car company using various forecasting models, we can gain insights into the factors that affect sales. For instance, it determines which variables, such as advertising costs or gross income, have the most significant impact on sales. We can also identify trends and patterns in sales data to make informed decisions about future sales strategies.

Overall, the analysis will provide a comprehensive understanding of the sales data of each car company and enable us to make accurate predictions for future sales, It will provide better understanding of which forecasting models work best for each company, allowing us to develop effective sales strategies and make informed decisions.

# 5.2 Sales Forecasting Analysis – Tesla

# Here we will implement all the previously discussed statistical methods in methodology and get the analysis results. *(Refer 3.2 Methodology – Data Analysis)*

# 5.2.1 Linear Regression: Independent Variable = Advertising Costs (X)

*Intro:* This model of Linear regression uses Independent variable as Advertising Cost on X axis and trying to predict Sales as Dependent Variable on Y axis.

**Step 1**: Excel Calculations on Tesla Sales with (Adv Costs) – Table 6

Following is the implementation of Excel to calculate the Linear Regression in table 6

**Table, Excel

Description automatically generated**

**Table 6**

**Step 2**: Output (b1/b0/R2/MAD/MSE) – Table 7

Following is the output from Linear Regression of step 1in table 7

Table

Description automatically generated

**Table 7**

**Step 3**: Linear Trendline – Fig 1

Following is the trend line generated from Linear Regression of step 1

Chart, scatter chart

Description automatically generated

**Fig 1**

Result: With the R2 of 91.5% and MAD of 10.27 we can state that this model of taking Independent variable as Advertising cost with dependent variable as Sales fits good and has Linear positive trend.

**All other Statistical models can be found in the Analysis Files with link provided at the end of the report.**

# 5.3 Sales Forecasting Analysis – Extension

After successfully implementing the Linear Regression and Time Series Forecasting models on Tesla's dataset, I proceeded to apply the same techniques on the other three car companies - Mercedes, Honda, and Toyota. Each company's dataset was analyzed and forecasted separately using all the forecasting models available, including Naive Bayes Analysis, Simple Moving Average (2 and 5 months), Weighted Moving Average (3 months), Simple Exponential Smoothing (Alpha=0.1 and 0.5), and Adjusted Exponential Smoothing (Alpha=0.3 and Beta=0.3, Alpha=0.7 and Beta=0.7). Finally, we applied Forecasting Including Trend and Seasonality to all the companies.

The analysis and forecasting process for each company took several iterations, and I compared the results of each model to determine the best-fit model for future forecasting. I carefully analyzed the forecasting results from each model and company, considering factors such as accuracy, reliability, and consistency.

After analyzing the forecasting results of every model from each car company, I finally got the best-suited model for future forecasting. This model will help us predict the sales trend of each car company for the next few years, and we can use this information to make informed business decisions and plan our strategies accordingly.

# 5.4 User Daily Cost Calculation – Analysis

# Here I have analyzed the daily cost for each user based on EV/NON-EV cars they own.

# By doing this I will have the estimate cost an individual has while owning the car.

# 5.4.1 Tesla

Intro: The "User daily cost calculation" method determines the daily cost of operating a car based on mileage calculation. For electric vehicles like Tesla, the cost of charging the car is used instead of fuel cost.

# All the rates applied of May 2023.

# A picture containing text, font, screenshot, line Description automatically generated

# Table 8

# Table 8 explanation:

# Output: Through our analysis and utilization of the “User daily cost calculation” method, we were able to consider the latest rates for each company and determine the cost of operating each vehicle. Specifically, for the Tesla Model S, we calculated that on average, the car can travel a distance of 976.25 miles on a charge costing $39.05. This calculation considers the car’s battery efficiency and the cost of electricity in the region. By comparing the cost of operating a Tesla to other non-EV cars, we can better understand the overall cost effectiveness of Evs versus traditional vehicles.

# Result: By Avg Tesla Model S will go 976.25 Miles for $39.05 charge.

# 5.4.2 Mercedes

Intro: The "User daily cost calculation" method determines the daily cost of operating a car based on mileage calculation. For Mercedes, the cost of fuel is used.

# All the rates applied of May 2023.

# A picture containing text, screenshot, font, line Description automatically generated

# Table 9

# Table 9 explanation:

# Output: Based on the current rates and the "User daily cost calculation" method, we have determined that the average Mercedes Class A can travel 240 miles on a charge costing $38.24. In order to make a fair comparison between the Mercedes and Tesla, we multiplied the miles and gallon of the Mercedes by a factor of eight. This allowed us to arrive at a similar range of cost calculation as the Tesla, which is important when comparing the cost effectiveness of EVs versus non-EV cars. By conducting these calculations for each car company, we can better understand the relative cost of operating different types of vehicles and make informed decisions about future transportation policies.

# Result: By Avg Mercedes Class-A will go 240 Miles for $38.24 charge.

# 5.4.3 Honda

Intro: The "User daily cost calculation" method determines the daily cost of operating a car based on mileage calculation. For Honda, the cost of fuel is used.

# All the rates applied of May 2023.

# A picture containing text, screenshot, font, line Description automatically generated

# Table 10

# Table 10 explanation:

# Output: After analyzing the current rates and applying the "User daily cost calculation" method, we have determined that the average Honda CR-V can travel 240 miles on a charge costing $38.24. To ensure a fair comparison between the Honda, Tesla, and Mercedes, we multiplied the miles and gallon of the Honda by a factor of eight. This allowed us to arrive at a similar range of cost calculation as the other two vehicles, which is important when comparing the relative cost effectiveness of EVs and non-EVs. By conducting this analysis for each car company, we can gain a better understanding of the cost of operating different types of vehicles and make informed decisions about future transportation policies.

# Result: By Avg Honda CR-V will go 240 Miles for $38.24 charge.

# 5.4.4 Toyota

Intro: The "User daily cost calculation" method determines the daily cost of operating a car based on mileage calculation. For Toyota, the cost of fuel is used.

# All the rates applied of May 2023.

# A picture containing text, screenshot, font, line Description automatically generated

# Table 11

# Table 11 explanation:

# Output: Upon considering the current rates and applying the "User daily cost calculation" method, it can be deduced that the typical Toyota Camry can cover a distance of 276 miles for a charge costing $38.24. In order to ensure a fair comparison, we multiplied the Miles and gallon by x8 to bring the cost calculation range of Toyota to the same level as that of Tesla, Mercedes, and Honda.

# Result: By Avg Toyota Camry will go 276 Miles for $38.24 charge.

# Conclusion

# By Implementing all the previous contents, we have reached to the conclusion, and it is discussed in this section.

# 6.1 Parameters for Model Selection

These parameters are used to evaluate and accept a regression model.

1. The R-squared value is a statistical measure that indicates the proportion of the variance in the dependent variable that is predictable from the independent variable(s). A high R-squared value indicates a good fit between the data and the regression line, which means that the model can explain a significant proportion of the variation in the dependent variable. Generally, an R-squared value greater than 60% is considered acceptable for a regression model.

2. The Mean Absolute Percentage Error (MAPE) is a measure of the accuracy of a forecasting model, which calculates the percentage difference between the forecasted values and the actual values. A lower MAPE indicates a better fit of the model to the data. An acceptable threshold for MAPE varies depending on the application, but a value less than 30% is generally considered acceptable.

3. The Mean Absolute Deviation (MAD) is a measure of the average distance between each data point and the mean value of the data set. It is used to evaluate the accuracy of a model's predictions. The model with the lowest MAD is selected as the best fit for the data.

# Overall, these parameters are used to ensure that the selected regression model is statistically significant, accurate, and has a good fit with the data.

# 6.2 Tesla – Sales Forecasting Summary

# Following is the summarized table of the results I got from analysis of Tesla by implementing Linear Regression and Time series methods on it.

# A picture containing text, screenshot, number, font Description automatically generated

# Table 12

# Table 12 explanation:

Based on the analysis and evaluation of different forecasting models, we have determined that Simple Exponential Smoothing (Alpha=0.5) is the most suitable model for Tesla's future sales forecasting. This model has an R-squared value of more than 60%, indicating a good fit between the independent variable and the dependent variable. Additionally, it has a MAPE value of less than 30%, which is an acceptable threshold for model accuracy. Finally, this model has the lowest MAD value compared to other models, which indicates that it is the most accurate model in predicting future sales for Tesla.

Using Simple Exponential Smoothing (Alpha=0.5) as the forecasting model for Tesla, we can make predictions for future sales with a high level of accuracy. This model considers the trend in sales data and places a higher weight on more recent data, making it suitable for predicting future sales trends. By analyzing and considering all the parameters, we can confidently say that this model will provide the best results for Tesla's future forecasting needs. With this model, Tesla can make informed business decisions regarding production, inventory management, and marketing strategies, which will ultimately contribute to the success of the company.

# 6.3 Mercedes – Sales Forecasting Summary

# Following is the summarized table of the results I got from analysis of Mercedes by implementing Linear Regression and Time series methods on it.

# A close-up of a spreadsheet Description automatically generated with low confidence

# Table 13

# Table 13 explanation:

After analyzing the data set for Mercedes, we have found that the model which fits best according to the given parameters is the Linear Regression model with Time as the independent variable and Sales as the dependent variable. The R-squared value for this model is greater than 60%, indicating that it is a good fit for the data set. Additionally, the model has a MAPE value less than 30%, which is the acceptable threshold for a good model. Moreover, the MAD value for this model is the lowest among all the other models, further supporting our conclusion.

The Linear Regression model is a popular statistical method for modeling the relationship between two variables. In this case, we are using the time as the independent variable and sales as the dependent variable to forecast future sales for Mercedes. This model works by fitting a line to the data points that represents the trend of the data, and then using this line to predict future sales. By using this model, we can identify the trend of sales over time and predict future sales based on this trend. Overall, the Linear Regression model with time as the independent variable is the best fit for forecasting future sales for Mercedes.

# 6.4 Honda – Sales Forecasting Summary

# Following is the summarized table of the results I got from analysis of Honda by implementing Linear Regression and Time series methods on it.

# A screenshot of a spreadsheet Description automatically generated with low confidence

# Table 14

# Table 14 explanation:

After analyzing all the parameters, we can conclude that Linear Regression (Time=X, Sales=Y) is the best future forecasting model for Honda. This model has an R-squared value greater than 60%, which indicates that the model is a good fit for the data. Additionally, the MAPE value is less than 30%, which means that the model has low prediction error. Lastly, the model has the lowest MAD value, which means that the predicted values are close to the actual values.

Honda is a company that has been in the automotive industry for many years and has a wide range of car models. By using Linear Regression with time as an independent variable, we can predict the future sales of Honda cars based on past sales trends. The model will consider the time factor and the number of sales to determine the relationship between them. This will enable us to make accurate predictions about the future sales of Honda cars, which will help the company in decision-making and planning for the future.

# 6.5 Toyota– Sales Forecasting Summary

# Following is the summarized table of the results I got from analysis of Toyota by implementing Linear Regression and Time series methods on it.

# A screenshot of a spreadsheet Description automatically generated with low confidence

# Table 15

# Table 15 explanation:

After analyzing the data for Toyota, we have found that the most suitable model for future forecasting is the Adjusted Exponential Smoothing (Alpha=0.7, Beta=0.7). This model has been selected based on the parameters we have set, including an R-squared value greater than 60%, a MAPE value less than 30%, and the lowest MAD. The Adjusted Exponential Smoothing model has a high R-squared value of 0.8527, which indicates that the model can explain 85.27% of the variability in the data. The MAPE value is also relatively low at 12.64%, which means that the model has a relatively small error rate in predicting future sales.

In addition, the Adjusted Exponential Smoothing model also has the lowest MAD among all the models applied to Toyota, which further supports the model's suitability for future forecasting. By using this model, we can accurately predict the future sales for Toyota based on the historical data. Overall, the Adjusted Exponential Smoothing model can provide valuable insights into future sales trends for Toyota, which can be used by the company for planning and decision-making.

# Final Decision

In the world of automobiles, Electric Vehicles (EVs) have become increasingly popular in recent years due to their environmental and cost-saving benefits. However, as with any new technology, there are questions about their feasibility in the long run, especially in the context of government proposals that aim to increase their usage. To answer these questions, a thorough analysis of various factors is required, including Sales Forecasting, User Cost Calculation, and Resources. This analysis helps in identifying the strengths and weaknesses of EVs and comparing them with Non-EV cars.

# Following is the proposal deciding table by including parameters:

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**Table 16**

# Table 16 explanation:

Decision: After analyzing the three main factors, it can be concluded that Tesla and EV cars are a better option in the proposed government initiative. Although Non-EV cars have a higher sales forecast, the cost of charging an EV car like Tesla is significantly lower than the cost of fueling a Non-EV car like Mercedes, Honda, and Toyota. Furthermore, the availability of resources and infrastructure in California to implement the proposal supports the feasibility of EVs. By considering all these points, it is clear that Tesla and other EVs are a viable and beneficial alternative to Non-EV cars.

1. **REFERENCES**

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Following is the Analysis Files Link as well for the reference:

[**Analysis Files**](https://drive.google.com/drive/folders/1bbRYHi25eAkobcL-AY5Tfg0BmXcc_iEn)

1. **Appendix**

In the Appendix you can find the Python codes Screenshots used for the analysis purpose.

Note: why python?

Ans: As python is widely used in data world and it is considered as the most preferred language in the industry. Thereby, I have used also used python to do the analysis.

**Following are the Python Codes for each company:**

* 1. Python code (Tesla Analysis):

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Fig 2

* 1. Python code (Mercedes Analysis)

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Fig 3

* 1. Python code (Honda Analysis)

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Fig 4

* 1. Python code (Toyota Analysis)

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Description automatically generated with medium confidence

Fig 5