CS 732: Data Visualization Assignment 1

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I. Dataset

For this assignment, we worked with Electric Vehicle Population Data [2] [3]. This dataset shows the Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) that are currently registered through the Washington State Department of Licensing. The major variables in our dataset are -

- **Clean Alternative Fuel Vehicle Type** : BEV or PHEV
- **Make** : The manufacturer of the vehicle
- **Model** : The model of the vehicle
- **Model Year** : The model year of the vehicle
- **Base MSRP** : MSRP of the model
- **Electric Range** : The range of the vehicle (in miles)
- **City & County** : Residence of vehicle owner
- **Transaction Year** : The year upon which the transaction was recorded with Department of Licensing.

Please be aware that **Base MSRP** of most data points was NULL. We have taken this into consideration when visualizing this variable.

II. Visualization Tasks

Our objective is to explore the transformation and development of the Electric Vehicle (EV) market over time through data visualizations. This overarching goal is divided into three tasks -

- **Task 1** : Identify and analyze the major contributors that have played a significant role in shaping the EV landscape.
- **Task 2** : Spot temporal trends and anomalies over the years. Provide insights into the factors driving these changes, whenever possible.
- **Task 3** : Compare and analyze the trends between Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs).

All visualizations were created using Tableau. We also used Tableau Prep and Pandas for data processing and cleaning.

III. Task 1

We began by plotting the total number of sales of each manufacturer to gain insight about the market share within the electric vehicle (EV) landscape. We observed from a simple bar graph that a single manufacturer holds a significant majority of the market share. A bar graph is not an ideal representation of such a skewed distribution data, so we experimented with alternate visualization options such as bubble charts and Tree Maps. Ultimately, we decided to go with a Tree Map (Fig 1) as it effectively portrayed the data's skewness and made optimal use of the available space.

Over the past few years, Tesla has become synonymous with electric vehicles. As anticipated, Tesla stands out as the dominant player in the electric vehicle industry, commanding a substantial 46.6% market share. In contrast, traditional automobile giants such as Ford, Chevrolet, and Toyota trail far behind, each holding only a single-digit market share.

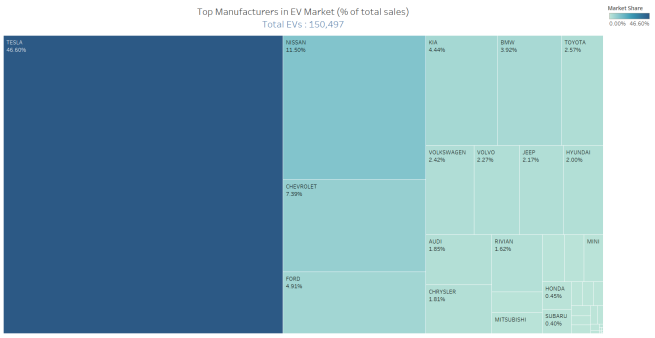

Fig. 1. TreeMap : Visualizing the market share of manufacturers

In order to understand Tesla's dominance in the EV market, we turned our attention to two pivotal factors that significantly influence buyers: Electric Range and the Retail Price (MSRP).

To gain a better insight, we superimposed a line graph depicting the average Electric Range across all models from a manufacturer with a bar graph representing that manufacturer's market share (Fig 2). Tesla offers an impressive average range of 240 miles per charge, surpassing its competitors comfortably. The next two top manufacturers, Nissan and Chevrolet, also offer comparatively better electric ranges. It's worth noting that electric range is the most influential factor for a model's success, primarily due to the lack of electric charging stations compared to conventional petrol/gas stations. Tesla's Supercharger infrastructure has played a significant role in driving the popularity of electric vehicles. Introduced in 2012, as of September 2023, Tesla operates a network of 5,500 Supercharger stations worldwide. Still, it's important to acknowledge that the charging infrastructure has a long way to go before it can provide competition to conventional fuel vehicles.

We made a similar visualization for the base MSRP, plotting the average selling price of top manufacturers alongside their market share (Fig 3). Once again, we observe that, on

average, the top three manufacturers offer more cost-effective alternatives than their competition.

Succeeding in the EV market depends on striking a balance between price and electric range. Tesla offers the best of both factors. Toyota, while offering a highly competitive price, suffers due to its very low electric range (Toyota deals with mostly PHEV's, which have less electric range. We will explore this factor in the third task).

It's important to note here that both these variables in our dataset contained a lot of NULL values, indicating missing data for many data points. We filtered out these data points while making these visualizations. For base MSRP, there were very few data points, so we used another variable Selling Price, which should yield approximately similar results for new vehicles. Nevertheless, our visualizations make sense and gives the results we expected, barring some outliers.

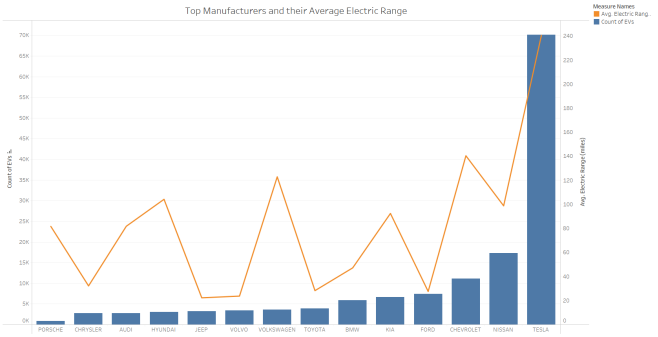

Fig. 2. BarChart and Line graph: Top manufacturers & avg. electric ranges

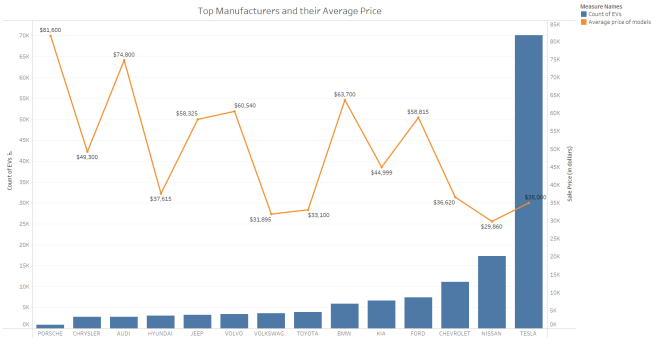

Fig. 3. BarChart and Line graph: Top manufacturers & avg. MSRP

Finally, we also explored the distribution of electric vehicles across counties in Washington State. We visualized the count of EVs in each county on a map (Fig 4). Remarkably, 75% of the market share is concentrated within just four out of the total 39 counties in Washington. King County dominates with 52% stake, due to the presence of major urban centers like Seattle, Redmond and Bellevue.

For a more granular view at the city level, we created a bubble chart (Fig 5) where the size of each bubble corresponds to the market share, and the color denotes the county of the city. Unsurprisingly, Seattle, being the most populous city, is the home of highest number of electric vehicles. Vancouver and Olympia, the capital, are other notable cities with significant influence on their respective counties.

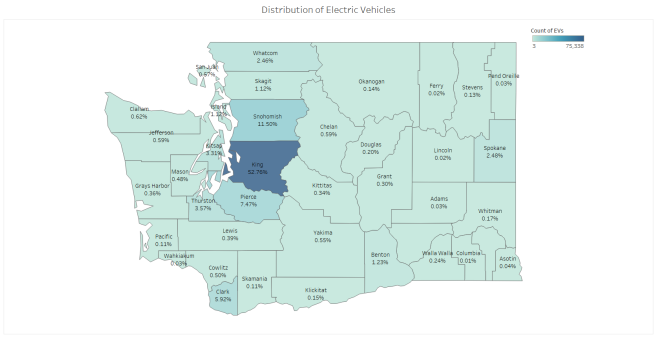

Fig. 4. Map of Washington which illustrates the distribution of EVs

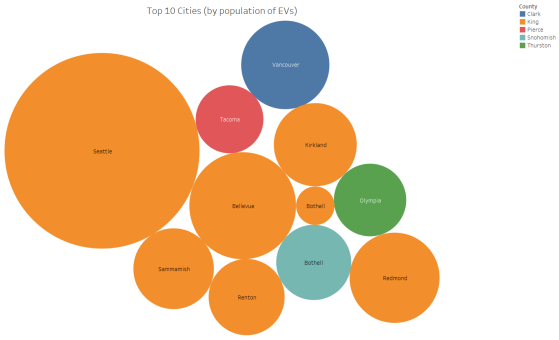

Fig. 5. Bubble Chart: Cities dominating the EV Market

IV. Task 2

Our second task aims to uncover trends, anomalies, and significant milestones in the electric vehicle (EV) market over the years. We began by creating a time series graph illustrating the annual count of new EVs sold (Fig 6). To provide further context, we included labels indicating the percentage difference from the previous year. Another visualization we utilized to analyze trends was the evolution of market share over time. We visualized this by plotting the sales figures for the top 5 manufacturers each year from 2011-2022 (Fig 7).

Now, let's delve into the evolution of the EV market year by year.

The initial breakthrough in the EV market occurred in December 2010 when Nissan introduced the LEAF, the world's first mass-market electric vehicle. The LEAF held the title of the world's all-time best-selling electric car until it was surpassed by the Tesla Model 3 in early 2020 [4]. This event is evident in the sales spike observed in 2011 (Fig 6), surging from 21 to 1,182 units. A staggering 87% of all EV sales in 2011 were accounted for by the Nissan LEAF.

Following this, Tesla unveiled its second vehicle, the Model S luxury sedan, in June 2012. Simultaneously, Tesla introduced its Supercharger network. We discussed the importance of this

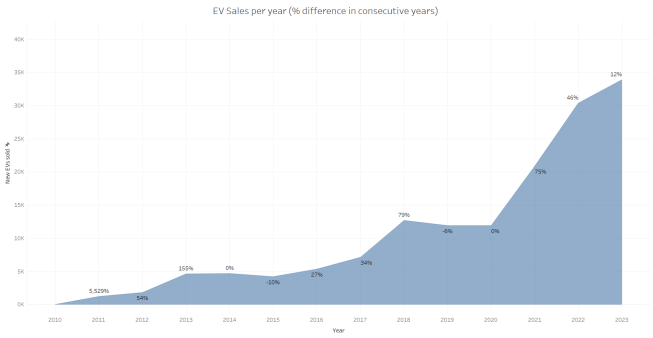

Fig. 6. Area Graph with percent difference in EV sales in consecutive years

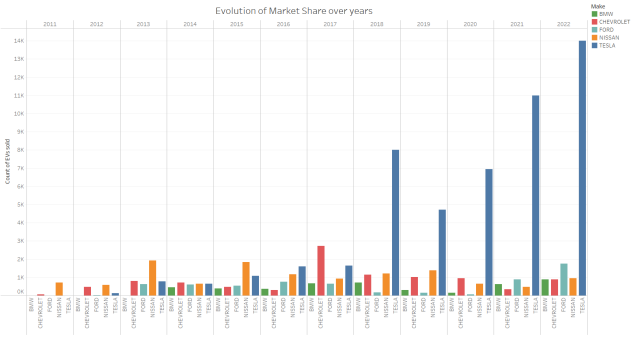

Fig. 7. BarChart showing top 5 manufacturers across years

network in Task 1. These developments, along with strong sales of Nissan's LEAF, contributed to a remarkable 155% increase in EV sales in 2013.

Another visualization we will now use is the sale distribution of Top EV Models over years. We create a stacked area chart depicting the top 7 best selling EV models (Fig 8). This chart will provide valuable insights into the contribution of each model over time.

From fig 6, we observe a dip in EV sales by 10% in 2015. Tesla began shipping its luxury SUV, Model X, in September 2015, and EV sales saw a modest growth of 27% and 34% in the subsequent two years. Fig. 7 also reflects a period from 2015 to 2017 when market share among manufacturers was relatively evenly distributed, with no clear industry leader emerging. However, starting in 2018, Tesla established itself as the undisputed leader in terms of sales, effectively dictating industry trends from 2017 onwards.

In 2016, Tesla announced its first mass market vehicle, the Model 3 sedan. Compared to Tesla's previous luxury vehicles, the Model 3 was less expensive and within weeks the company received over 325,000 paid reservations [5]. After 2 years of delays and production issues (famously described as "Production Hell" by Elon Musk), Tesla began shipping the Model 3 in 2018 and it became the world's best selling electric car from 2018 to 2021. Fig. 6 demonstrates an impressive 80% surge in EV sales in 2018.

However, 2019 saw a surprising 6% decrease in EV sales, attributable to several factors. The Model 3's growth was more modest compared to the record-breaking year of 2018. General Motors also discontinued the Chevy Volt, a popular EV [7], and there were no new high-selling models introduced.

The COVID-19 pandemic adversely affected EV sales during the first half of 2020, although Tesla's introduction of the Model Y, an affordable SUV based on the Model 3, helped mitigate this impact. Nevertheless, overall EV sales remained stagnant in 2020 (Fig. 6).

Following the easing of COVID-19 lockdowns in 2021, the EV industry experienced another surge, driven primarily by the strong sales performance of the Tesla Model Y. This upward trend has continued. In the first quarter of 2023, the Model Y outsold the Toyota Corolla to become the world's best-selling car, the first ever electric vehicle to claim the title.

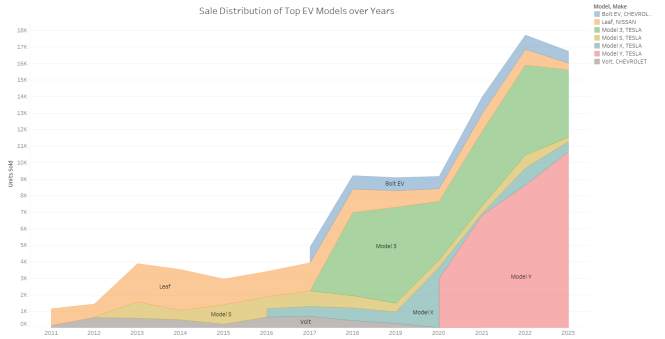

Fig. 8. Stacked Area Chart : Top 7 Best Selling EV models

In this task, through a series of insightful visualizations, we traced the growth of EV sales over the years, pinpointed key moments of transformations, and shed light on the influence of major players like Tesla. We observed how innovations like the introduction of Tesla's Model 3 and Model Y reshaped the market, along with external factors like the COVID-19 pandemic.

V. Task 3

Now, let's delve into an in-depth analysis of the electric vehicle (EV) landscape within the market, focusing on Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs).

Our initial approach to visualizing the market share of BEVs versus PHEVs involved a bar chart. However, we opted for a pie chart instead, as it offers a more straightforward and intuitive representation of the market distribution. This pie chart visually illustrates the proportion of BEVs and PHEVs in the market, making it easier to grasp at a glance.

In addition to the pie chart, we've created an area graph to provide a dynamic view of the sales performance of BEVs and PHEVs over the years. This area graph presents a year-by-year comparison of BEVs and PHEVs, allowing us to observe how they have competed and evolved over time. We chose the area graph for its effectiveness in facilitating comparisons when dealing with only two distinct categories.

The Pie Chart vividly demonstrates that BEVs have established a dominant presence in the market [Fig 9]. This

prevalence can be attributed to the fact that PHEVs tend to incur higher ownership costs due to their lower efficiency and increased susceptibility to maintenance issues, stemming from their more intricate design with multiple moving parts. Opting for a BEV can lead to substantial long-term savings, encompassing both maintenance and fuel expenses. Meanwhile, the Area Graph unveils a clear trend of rising BEV popularity over the years, with expectations of continued growth in the foreseeable future, while PHEVs lag behind [Fig 9]. This shift is primarily driven by the inherent advantages of BEVs, including simplicity, cost-efficiency, positive environmental impact, and superior efficiency. In contrast, PHEVs come with complex and costly components like batteries and electric motors, often necessitating the installation of charging stations, which adds to the initial financial outlay. For those seeking an economical and environmentally friendly option, BEVs emerge as the preferred choice. [1]

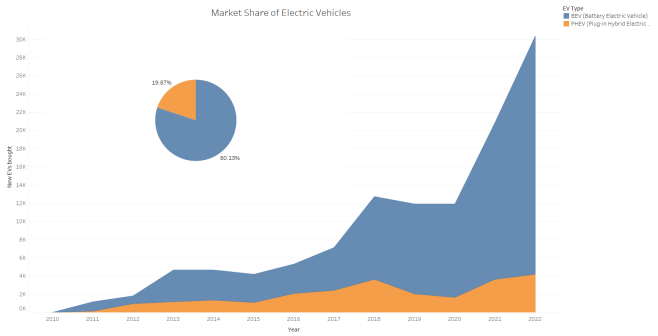

Fig. 9. Area Graph & Pie Chart: Market Capture by Different Types of EVs among the years

Let's now look at the top 15 manufacturers and their market shares. Initially, we developed two different graphs, one concentrating on BEVs and the other on PHEVs. However, in our pursuit of a more comprehensive analysis, we decided to incorporate a Stacked Bar Chart. This decision was motivated by the fact that, when comparing data points, a stacked bar chart provides a clearer and more intuitive way of comparison [Fig 10].

Tesla has undoubtedly had a significant impact on the EV market. Tesla has clearly intentionally committed a major percentage of its resources in BEVs. Nissan, the second candidate on our list, has shown a similar commitment to BEVs [Fig 10]. This reinforces the premise that BEVs can play a critical part in a manufacturer's road to success if they invest intelligently.

Next, we compared the avg. electric range of BEVs and PHEVs from 2011 to 2023 for this task we chose a line graph [Fig 11] for this visualization because it provides a clear and effective way to compare the numeric values of different EV types.

The graph confirmed our expectations: BEVs have been steadily increasing their average electric range each year, highlighting the significant research and development focus on improving BEV range. In contrast, the line representing

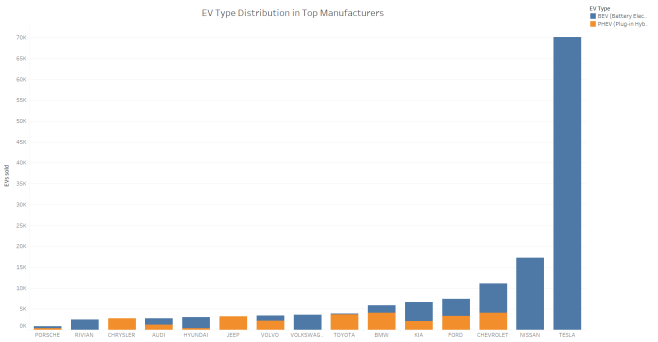

Fig. 10. Stacked BarChart: BEV vs PHEV in different manufacturers

PHEVs showed a flat slope, indicating limited progress in the development of PHEVs.

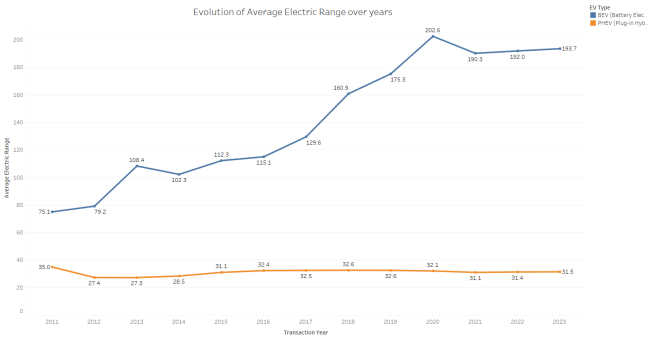

Fig. 11. Line Graph: Avg Electric Range of BEVs vs PHEVs

VI. Work Distribution

We initially brainstormed and established a list of tasks together. Following that, we worked together to create visualizations and dashboards. Instead of assigning specific duties to each other, we discovered that when we worked as a unified team, our productivity and creativity increased. Every team member contributed significantly to every aspect of the assignment. However, roughly speaking, Task 1 was done by Harsh, Task 2 by Shridhar and Task 3 by Mayank.

References

[1] What are the pros and cons of plug-in hybrid electric vehicles (PHEVs)?
[2] Electric Vehicle Population Data
[3] Electric Vehicle Title and Registration Activity
[4] Nissan Leaf Wikipedia
[5] Tesla Wikipedia
[6] Chevy Volt discontinued
[7] Model Y wikipedia