Analyzing the Used Car Market: Insights from Data on Price, Performance, and Preferences

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December 14, 2023

Abstract

This research aims to analyze the used car market through a comprehensive data set containing various details about cars available for resale. The study will explore how factors such as the car's age, mileage, fuel type, and engine specifications affect its selling price. It will employ statistical analysis methods to identify trends and patterns in car pricing and consumer preferences.

Additionally, the paper will investigate the impact of different transmission types and owner history on a car's market value. Machine learning techniques will be utilized to predict selling prices based on the car's features. This analysis will provide valuable insights into the used car market dynamics, offering a deeper understanding of the factors influencing car valuation and buyer's choice. The findings could be instrumental for potential buyers, sellers, and market analysts to make informed decisions in the used car market.

1 Introduction

The used car market is a dynamic and complex segment of the automotive industry, offering a diverse range of choices for consumers. Understanding the factors that influence the selling price and demand of used cars is crucial for both buyers and sellers. This research aims to analyze various characteristics of used cars, such as selling price, kilometers driven, fuel type, transmission, and engine specifications, using a comprehensive data set obtained from a popular online marketplace.

The data set comprises detailed information about cars listed for resale, including the year of manufacture, selling price, kilometers driven, type of fuel used, transmission type, and engine specifics. This research employs a variety of data analysis techniques, including descriptive statistics, correlation analysis, and linear regression modeling, to uncover the relationships between these factors and the selling price of the cars.

The initial phase of the analysis involved data pre processing, where the data set was cleansed and transformed for effective analysis. Empty rows were removed, and key variables like engine size, mileage, and maximum power were converted from textual to numeric formats for precise computations. Additionally, categorical variables such as fuel type, transmission type, and ownership were transformed into binary values to facilitate their inclusion in the predictive modeling process.

Further, the study utilized various graphical representations such as histograms, box plots, bar charts, and scatter plots to visualize the distribution and relationship between different variables. This visual analysis provided initial insights into the trends and patterns within the used car market.

The cornerstone of this research is the application of multiple linear regression analysis, which helped in understanding the impact of various factors on the selling price of used cars. The regression model indicated significant relationships between selling price and variables such as kilometers driven, age of the car, fuel type, seller type, transmission type, mileage, and engine capacity. This paper seeks to provide a comprehensive understanding of the used car market dynamics, aiding stakeholders in making informed decisions. The findings from this analysis could be particularly beneficial for potential buyers, sellers, and market analysts by offering a deeper understanding of the factors that influence car valuation and consumer preferences.

The used car market has been a subject of extensive research due to its economic significance and the complex factors influencing consumer behavior and pricing. Several studies have attempted to unravel these complexities, offering insights that form the foundation for this research.

One pivotal area of focus in existing literature is the impact of a car's physical attributes on its resale value. Borthakur (2023)[Bor23] emphasized the significance of factors such as age, mileage, and make and model in determining a used car's price. Their findings suggested a strong negative correlation between a car's age and its resale value, a pattern echoed in the work of Huang (2023)[Hua23], who also highlighted the diminishing value of cars with increased mileage.

Fuel type and engine specifications are other critical factors influencing used car pricing. Knittel (2009)[BKZ09] found that vehicles with diesel engines tended to retain their value better than their petrol counterparts, attributing this to the diesel engines' better fuel economy and longer lifespan. However, this trend has been subject to change due to evolving consumer preferences and environmental regulations, as discussed by Maklari (2023)[Esz23].

The role of transmission type in used car valuation has also been explored. In a comparative study, Gaulier (2000)[GH00] noted that cars with automatic transmission generally have a higher resale value than those with manual transmission, primarily due to the convenience factor and broader market appeal.

Beyond physical attributes, the perception of value and trust plays a crucial role. The study by Lin (2022)[Hua23] on seller types revealed that cars sold by dealerships or trusted sellers fetch higher prices than those sold by individuals, possibly due to perceived reliability and after-sales support.

While these studies provide valuable insights, there remains a gap in understanding the combined effect of these factors in a comprehensive model, particularly in emerging markets. Additionally, the rapid changes in technology and consumer preferences necessitate continuous analysis of trends in the used car market. This paper seeks to address these gaps by offering an integrated analysis of how various factors collectively influence used car prices in the current market context.

2 Methodology

This study aims to analyze the used car market by examining various factors affecting the selling price of used cars. The methodology section outlines the data source, pre processing steps, and analytical techniques employed in this research.

2.1 Data Source and Description

The primary data set for this study was obtained from a publicly available source on Kaggle, titled "car_details_v3.csv". This data set includes comprehensive information about used cars listed for resale, encompassing variables such as make and model, year of manufacture, selling price, kilometers driven, fuel type, seller type, transmission type, owner history, engine specifications, and seating capacity.

2.2 Data Pre processing

Data pre processing was a crucial step to ensure the quality and reliability of the analysis. The initial phase involved data cleaning, where rows with missing or incomplete information were identified and removed, reducing the data set size from 8,121 to 7,907 entries.

The next step was data transformation. Key variables like 'engine size', 'mileage', and 'maximum power', originally recorded as text strings, were converted into numerical values for accurate computations. Categorical variables such as 'fuel type', 'transmission type', 'seller type', and 'ownership' were converted into binary values (0 and 1) to facilitate their inclusion in the regression models.

2.3 Graphical Analysis

Various plots such as histograms, box plots, and scatter plots were generated using the ggplot2 package in R to visualize the data and identify patterns and outliers.

2.4 Regression Analysis

A multiple linear regression model was developed to understand the impact of various factors on the selling price of used cars. This analysis was conducted using the 'lm' function in R, which provided estimates of the regression coefficients and their significance.

2.5 Statistical Software

The entire analysis was conducted using R, a programming language and environment widely used for statistical computing and graphics. The following R packages were used: 'tidyverse' for data manipulation, 'dplyr' for data processing, 'ggplot2' for data visualization, and 'plotrix' for additional graphical tools.

3 Data Analysis

The data analysis section provides an in-depth examination of the data set to uncover trends, patterns, and relationships among the various factors influencing the selling price of used cars.

3.1 Descriptive Statistics

The analysis began with a descriptive statistical overview of the data set. Key variables such as selling price, kilometers driven, engine capacity, and mileage were summarized to understand their distribution. For instance, the average selling price of the cars in the data set was observed to be around 500,000 INR, with a notable range in prices suggesting a diverse market.

3.2 Graphical Analysis

Histograms were plotted for the number of seats in the cars, revealing a predominant preference for 5-seater vehicles in the used car market. Box plots of selling prices against the number of seats indicated a higher median selling price for cars with more seats, suggesting a potential premium on larger vehicles(or for family, business convenience). Bar charts were used to display the distribution of fuel types and seller types, showing a higher proportion of petrol cars and individual sellers in the market.

3.3 Correlation Analysis

Correlation analysis helped in identifying relationships between variables. For example, a negative correlation was observed between the age of the car and its selling price, indicating that older cars tend to sell for less. Conversely, engine capacity showed a positive correlation with the selling price, suggesting that cars with larger engines typically command higher prices.

3.4 Regression Analysis

The model examined the impact of factors like kilometers driven, age, fuel type, seller type, transmission type, mileage, and engine capacity on the selling price. The results indicated that factors such as the age of the car, kilometers driven, and transmission type had significant effects on the selling price. For example, cars with automatic transmission were found to have higher selling prices compared to manual ones. The regression model's R-squared value of 0.5647 suggested that about 56% of the variability in the selling price could be explained by the model.

3.5 Findings

The depreciation of cars with age and increased mileage was evident, aligning with general market expectations. The preference for automatic transmission and larger engine capacities was reflected in their positive impact on selling prices. Surprisingly, the fuel type had a less significant impact than expected, which could be attributed to changing market trends and consumer preferences.

4 Results

After extensive research and work put into the research, we can now present the correlation age, fuel type, mileage and other sections that can affect the selling price of the car. These insightful findings can now be easily shown into graphs for easier explanation of the used car market.

4.1 Age versus Mileage

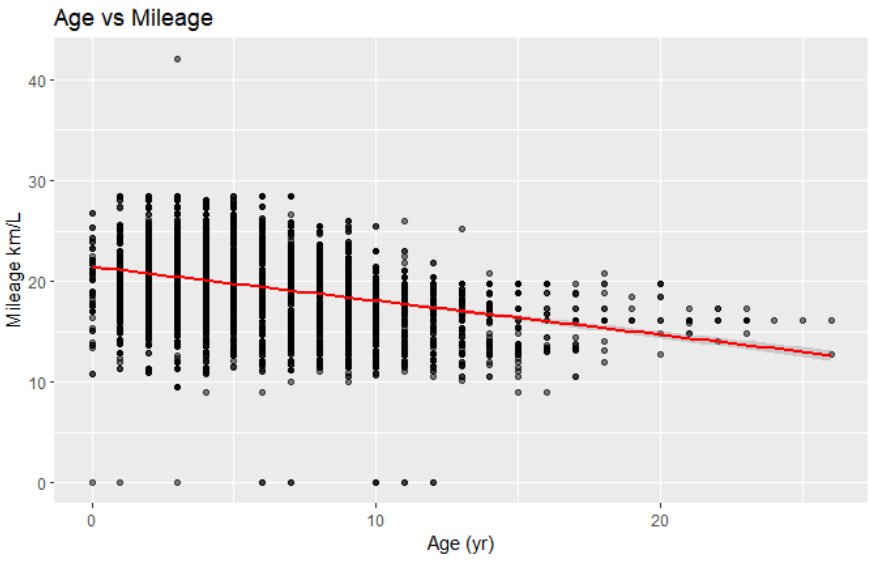

Figure 1: Car Age in comparison to mileage

This scatter plot displays the relationship between the age of a car (in years) and its mileage (in kilometers per liter). Each dot represents an individual car from the data set. The spread of the dots suggests variability in mileage for cars of similar ages.

A red line is overlaid on the scatter plot, which appears to be a line of best fit, likely from a linear regression analysis. The downward slope of this line indicates a negative correlation between age and mileage; as the age of the car increases, the mileage tends to decrease.

It also suggests that generally, as cars age, their fuel efficiency decreases. This could be due to several factors such as wear and tear, older technology not being as fuel-efficient, or older cars being less well-maintained.

4.2 Car Mileage versus Fuel Type

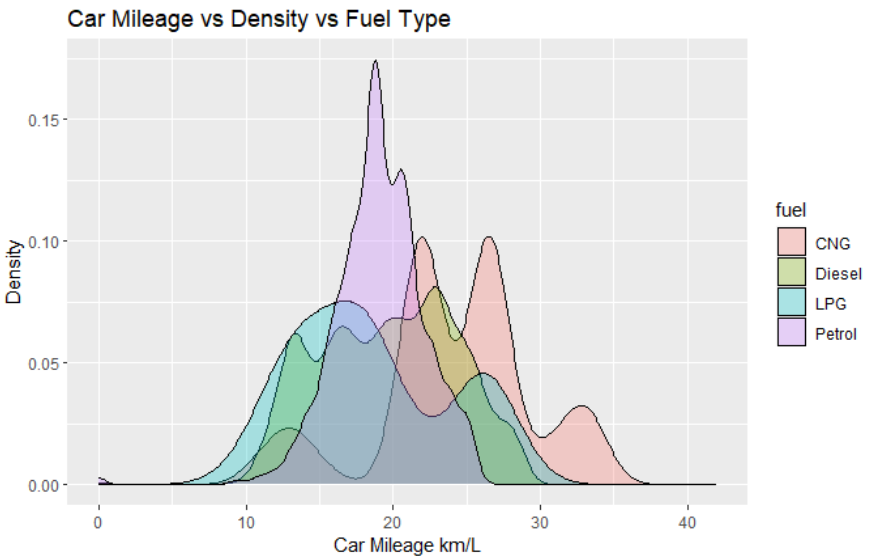

Figure 2: Fuel Type vs Car Mileage

Each curve represents one fuel type, and the area under the curve corresponds to the probability distribution of mileage for that fuel type. The peak of each curve is where the cars of that fuel type are most densely concentrated in terms of mileage.

- CNG (Blue Curve): The CNG curve peaks at around 25-30 km/L, suggesting that CNG cars in the dataset are most likely to have a mileage in this range, indicating relatively high fuel efficiency.
- Diesel (Green Curve): The Diesel curve has a broad peak, indicating a wide range of mileage, but it's centered around 20-25 km/L, which is also quite efficient.
- LPG (Red Curve): The LPG curve peaks sharply around 10 km/L, suggesting that LPG cars are less varied in mileage and are centered around a lower fuel efficiency compared to CNG and Diesel.
- Petrol (Pink Curve): The Petrol curve is broader with a less defined peak, suggesting a wide range of mileage values, but generally lower than CNG and Diesel, peaking around 15 km/L.

The areas where the curves overlap indicate ranges of mileage where cars with different fuel types have similar fuel efficiency. For example, there is an overlap between Diesel and Petrol curves around 15 km/L, indicating that cars with both types of fuel can have similar mileage.

From this graph, we can conclude that CNG cars tend to have higher mileage, followed by Diesel, while LPG and Petrol cars tend to have lower mileage. Additionally, Diesel cars exhibit a wide range of mileage, indicating diversity in the fuel efficiency of Diesel cars in the dataset.

4.3 Number of Cars versus Owners versus Fuel Type

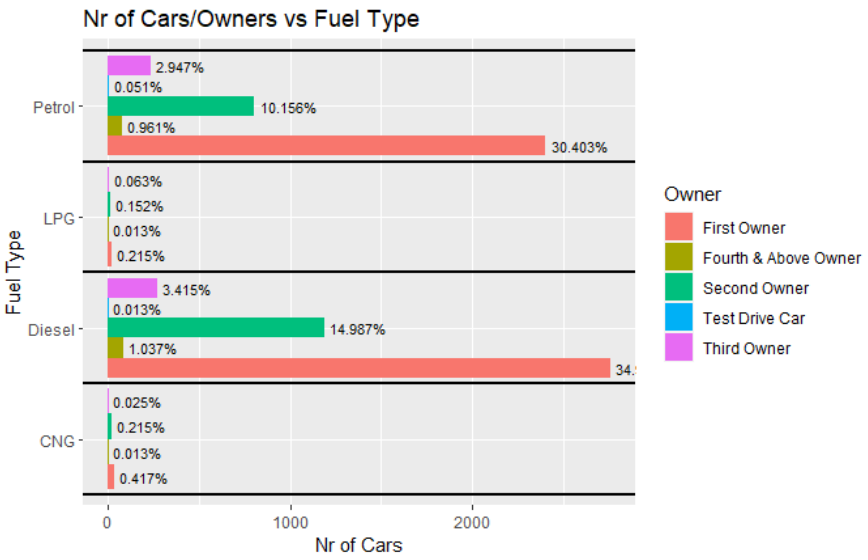

Figure 3: Cars with the appropriated fuel types in correlation with the ownership history

This graph is a stacked horizontal bar chart that represents the number of cars by fuel type, further broken down by ownership history. Each bar's length represents the total number of cars for a specific fuel type, and each color within a bar represents a different owner category. The percentages on the bars indicate the proportion of each ownership category within each fuel type.

From the chart, we can observe:

- Petrol Cars: The majority of the cars in the dataset use Petrol, with a significant proportion belonging to the first owner.
- Diesel Cars: Diesel is the second most common fuel type, again with many cars belonging to the first owner. The proportion of first-owner diesel cars is slightly lower compared to petrol cars.
- CNG and LPG Cars: These fuel types have fewer cars associated with them in the dataset. The distribution of ownership is also less varied compared to Petrol and Diesel cars.

In terms of ownership:

- First Owner Cars: This is the most common category across all fuel types, particularly for Petrol and Diesel cars.
- Second Owner Cars: Represent a smaller proportion but are still a significant portion of the cars, especially in Petrol and Diesel categories.
- Third Owner, Fourth & Above Owner, and Test Drive Car: These categories make up a much smaller fraction of the total, with Test Drive Car being the least common.

The percentages provided with each segment offer precise quantification of the proportion each owner category contributes to the total number of cars for each fuel type. For instance, among Petrol cars, 30.403% are from the first owner, and 10.156% from the second owner. This level of detail helps in understanding the distribution of ownership across different fuel types in the used car market.

4.4 Engine Capacity versus Mileage

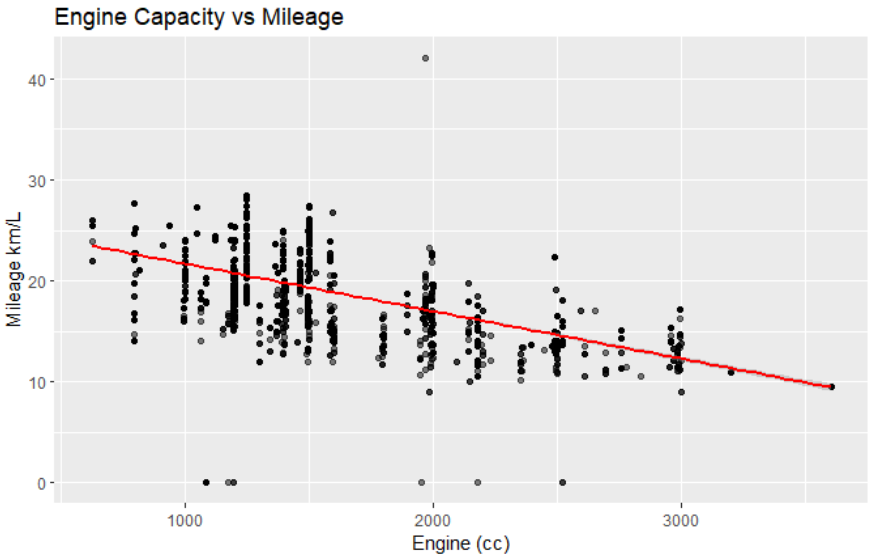

Figure 4: Engine capacity in comparison to its mileage

Each dot represents an individual car's engine capacity and its corresponding mileage. The distribution of dots across the graph shows the variance in mileage at different engine capacities.

The red line represents the trend or relationship between engine capacity and mileage. It appears to be the line of best fit from a regression analysis. The downward slope of the line suggests a negative correlation, indicating that as engine capacity increases, the mileage tends to decrease.

There is a wide spread of mileage at lower engine capacities, which narrows as engine capacity increases. This suggests that there is more variability in the mileage of cars with smaller engines compared to those with larger engines.

The graph indicates that typically, cars with smaller engines are more fuel-efficient, while those with larger engines consume more fuel per kilometer. However, there are outliers, which are cars that don't follow the general trend—some have high mileage despite larger engines, and vice versa. This suggests that engine capacity is one of several factors that can affect a car's fuel efficiency.

4.5 Fuel Types in the Market

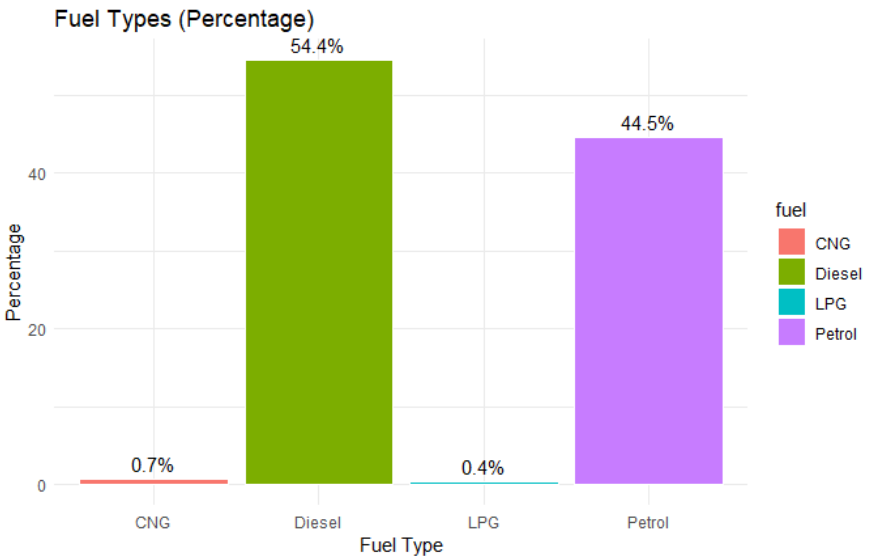

Figure 5: Number of Cars with its appropriate fuel type

The bars and their corresponding colors represent different fuel types:

- CNG (Compressed Natural Gas): The red bar shows that only a very small fraction (0.7%) of the cars use CNG.
- Diesel: The green bar indicates that a majority of the cars (54.4%) in the dataset run on diesel.
- LPG (Liquefied Petroleum Gas): The cyan bar shows an even smaller fraction than CNG, with only 0.4% of cars using LPG.
- Petrol: The purple bar represents a significant portion (44.5%) of cars that run on petrol.

From this chart, we can see that diesel and petrol are the most common fuel types for the cars in this dataset, with diesel being slightly more prevalent. CNG and LPG are far less common as fuel options for the cars represented here.

This data could be reflective of consumer preferences, fuel efficiency, cost, or availability of the different fuel types. This can also mean that there are heavy-duty vehicles like trucks or buses in the dataset that uses CNG/LPG.

4.6 Number of Seats versus Number of Cars

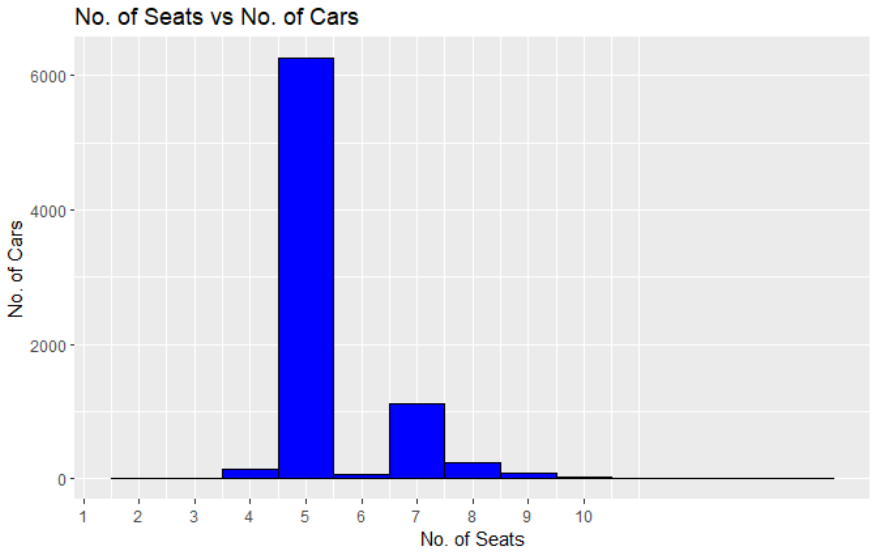

Figure 6: Number of cars with the number of seats

Each bar corresponds to the number of cars with a specific number of seats. From the graph, we can observe:

- 5-seat Cars: The tallest bar, colored in blue, represents cars with 5 seats. This is by far the most common seating configuration, as indicated by the height of the bar, which suggests that the majority of cars in this dataset are 5-seaters.
- 7-seat Cars: The next most common seating configuration is for 7 seats, but it's significantly less common than 5-seat configurations.
- 2, 4, 6, 8, 9, 10-seat Cars: There are very few cars with these numbers of seats, as indicated by the very short bars or absence of bars for these numbers.

The chart clearly shows that 5-seat cars dominate this dataset, which is typical for many markets as this configuration is standard for a wide range of popular vehicle types, including sedans, hatchbacks, and small SUVs.

The presence of 7-seat vehicles suggests a smaller but notable market for larger family cars or SUVs. The very low numbers or absence of bars for other seat counts suggest that vehicles with these configurations are relatively rare in this dataset(ranging from sports cars to large family carrier).

4.7 Number of Seats versus Selling Price

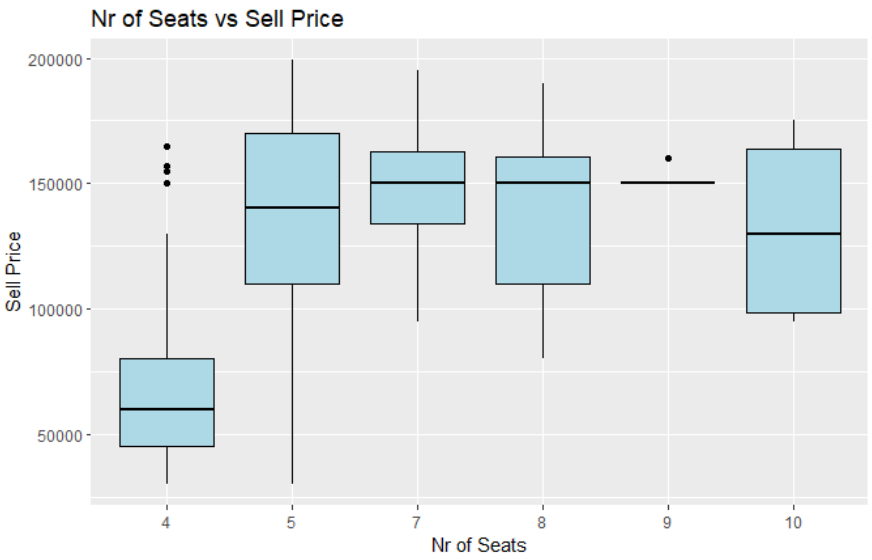

Figure 7: Number of seats in comparison to the selling price of the car

Each box plot corresponds to cars with a different number of seats. A box plot consists of:

- The Box: The bottom and top of the box are the first (Q1) and third (Q3) quartiles, and the band inside the box is the median (Q2). This means that 50% of the data falls within the box.
- The Whiskers: These lines extend from the box to the highest and lowest values within 1.5 times the interquartile range (IQR, which is Q3 minus Q1). Points beyond the whiskers are considered outliers.
- Outliers: These are points outside the end of the whiskers and are often indicated by dots.

From the box plots, we can observe:

- 4-seat Cars: Have the lowest median selling price and the narrowest IQR, indicating less variability in the selling prices.
- 5-seat Cars: Show a higher median selling price compared to 4-seat cars and a greater IQR, suggesting more variability in their selling prices.
- 7-seat Cars: Have a median selling price similar to 5-seat cars, but with slightly less variability.
- 8-seat Cars: Exhibit a lower median selling price compared to 7-seat cars, with the median closer to the third quartile, suggesting a higher concentration of prices towards the upper end of the range.
- 9 and 10-seat Cars: Have the highest median selling prices and a larger IQR, especially for 10-seat cars, indicating a wider range of selling prices.

The distribution of selling prices across different seat numbers could be influenced by various factors, such as the make and model of the cars, their condition, and additional features beyond just the number of seats. It's worth noting that the data may contain outliers, which are individual cases where the selling price is significantly higher or lower than the typical range for that seat category.

4.8 Number of Ownership Types

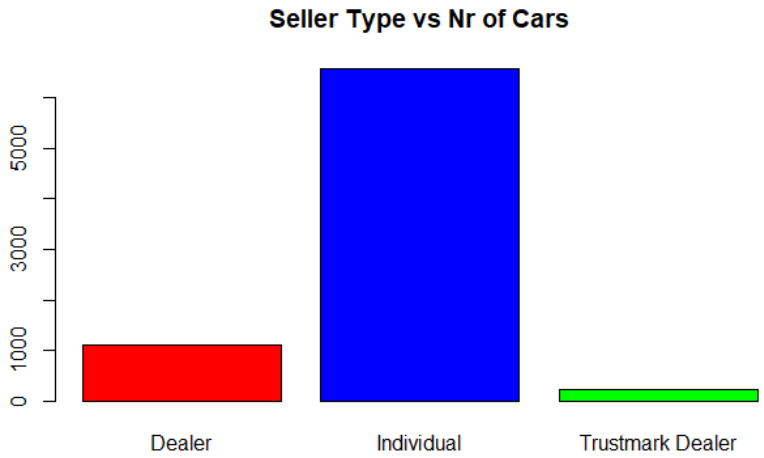

Figure 8: Number and Types of Sellers for each car

Each colored bar represents a different seller type:

- Dealer (Red Bar): Indicates the number of cars sold by dealers. The bar is relatively short, showing that compared to individuals, fewer cars are sold by dealers.
- Individual (Blue Bar): Represents the number of cars sold by individual sellers. This bar is the tallest, indicating that most cars in the dataset are sold by individuals.
- Trustmark Dealer (Green Bar): Shows the number of cars sold by trustmark dealers, which is the smallest group among the three seller types.

The chart clearly indicates that individuals are the predominant sellers in the dataset, suggesting that private car sales might be more common than sales through dealers or certified trustmark dealers in this market. Trustmark dealers, who typically offer certified pre-owned cars, seem to contribute the least to the total number of cars sold. This could be due to various factors, such as a higher trust in individual sellers or potentially lower prices in private sales.

4.9 Odometer Selling Price

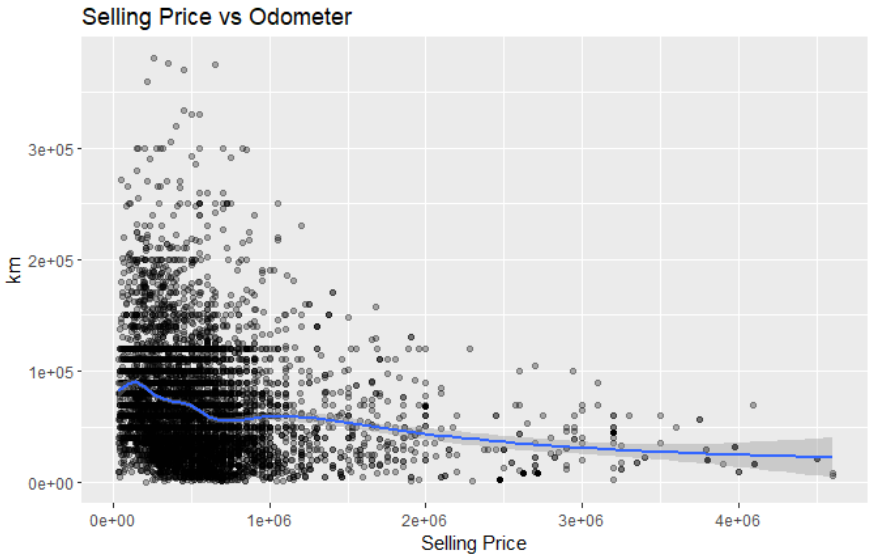

Figure 9: Percentage of Cars with their appropriate odometer

This graph is a scatter plot that visualizes the relationship between the selling price of cars and the distance they have traveled, as recorded by the odometer (in kilometers). Each dot on the graph represents an individual car's selling price and its odometer reading. The distribution of these dots can give us an idea of the relationship between these two variables. The line through the data points represents the trend in the relationship between the selling price and the odometer reading. The shaded area around the line may represent the confidence interval or prediction interval, showing where future data points are expected to fall with a certain level of confidence.

Observations from the graph include:

- As the selling price increases, there is a general tendency for the odometer reading to decrease, which is consistent with the expectation that more expensive cars are often newer or less used.
- There is a wide spread of odometer readings for lower-priced cars, which could indicate a variety of car conditions and ages in this price range.
- For very high selling prices, the data is sparse, and the trend line suggests that these cars have lower odometer readings, potentially because they are newer or luxury models that retain value better even with less use.
- There are outliers in the data, represented by dots that do not follow the general trend. These could be due to unique cases such as older cars that are still in excellent condition or have collector's value.

The logarithmic scales are used to manage the wide range of values and to make the trend more discernible, especially when dealing with exponential growth or decay relationships.

4.10 Selling Price versus Mileage

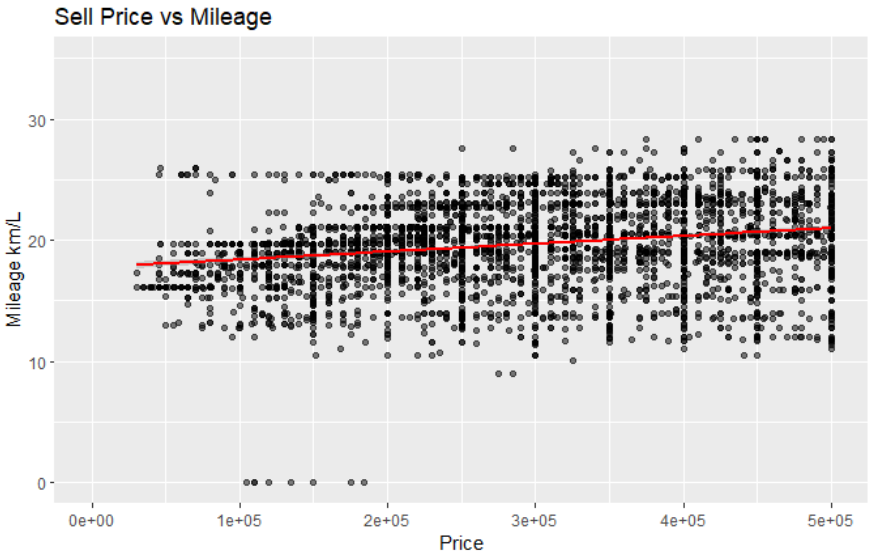

Figure 10: Selling Price comparison to the car mileage

This scatter plot depicts the relationship between the selling price of cars and their fuel efficiency (mileage). Each dot represents a car's selling price plotted against its mileage. The concentration of dots gives a visual representation of the data density across different price ranges.

A red line is drawn through the data points, representing the trend or relationship between the selling price and the mileage. It has a relatively flat slope, suggesting that there is only a weak relationship between the selling price and the mileage. In other words, the fuel efficiency of a car does not dramatically increase or decrease with the selling price.

From the plot, we can observe that:

- There's a wide range of mileage values across all selling price ranges, suggesting that the price does not strongly predict how fuel-efficient a car is.
- There's no clear pattern that higher-priced cars have either significantly better or worse mileage, as evidenced by the flat trend line.
- Some outliers, or dots far away from the main cluster, suggest that there are some cars with exceptionally high or low mileage for their selling price.

The graph provides an overall view that, while there is some tendency for cars with higher prices to have slightly higher mileage, this trend is not strong and there are many exceptions to it.

4.11 Transmission Car Types

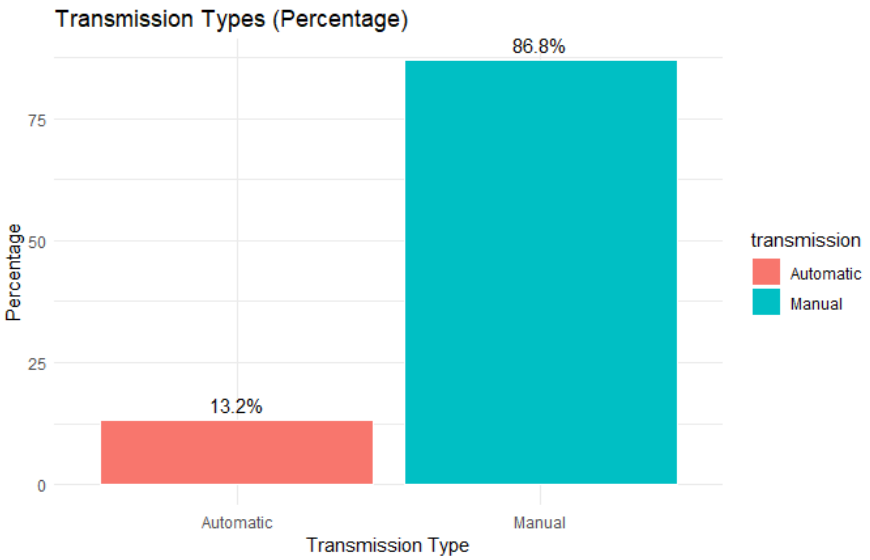

Figure 11: Percentage of the cars with the manual and automatic transmission

This bar chart represents the percentage of cars by transmission type, with two categories shown: Automatic and Manual.

There are two bars, each representing the proportion of cars with the corresponding transmission type.

- The red bar represents Automatic transmission cars, which constitute a smaller portion of the dataset, at 13.2
- The blue bar represents Manual transmission cars, which make up a much larger percentage of the dataset, at 86.8

The chart shows that manual transmissions are significantly more common than automatic transmissions in this particular dataset. This could be due to a variety of factors, including the cost of the vehicle, fuel efficiency, maintenance costs, driver preference.

4.12 Transmission Types impact on the price

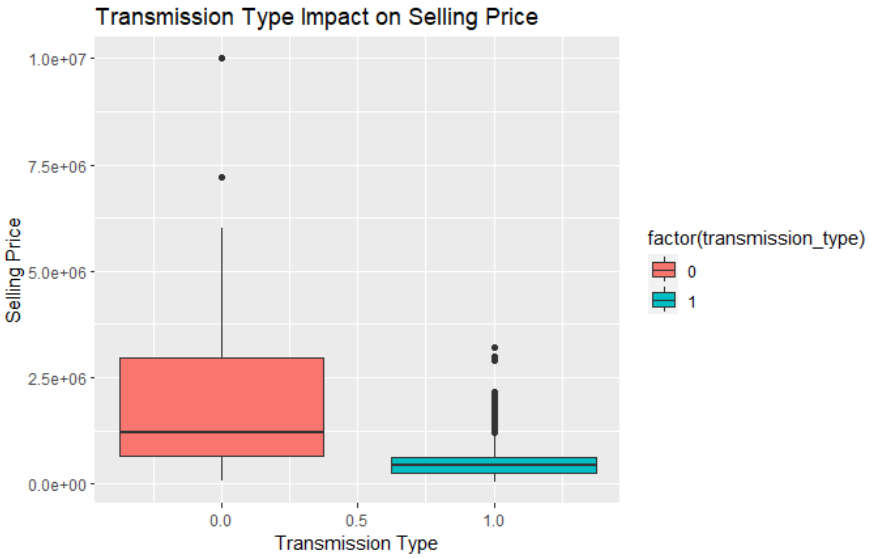

Figure 12: Transmission types impacting the price

This graph is a box plot that shows the impact of transmission type on the selling price of cars.

- Boxes:
  The red box, which represents one transmission type, likely Automatic given the typical coding convention, has a wider range of selling prices, indicated by the taller box, and a higher median price, indicated by the line within the box.

  The blue box, likely representing Manual transmission, shows a more compact range of selling prices with a lower median price.

- Whiskers: These lines extend from the boxes to the highest and lowest values within 1.5 times the interquartile range (IQR). Outliers are points beyond the whiskers.

- Outliers: Outliers are represented by dots outside the whiskers. These are selling prices that are exceptional compared to the rest of the data.

From this graph, we can deduce that cars with the first transmission type (possibly Automatic) tend to have a higher median selling price compared to cars with the second transmission type (possibly Manual). The presence of outliers, particularly for the first transmission type, indicates that there are some cars with exceptionally high selling prices compared to the rest. The distribution of selling prices for the second transmission type is tighter, indicating less variability in the selling prices of those cars.

5 Discussion

The findings from the data analysis offer insightful perspectives on the dynamics of the used car market. This section discusses the implications of these findings, their alignment with existing literature, and potential applications.

5.1 Interpretation of Findings

The significant negative correlation between a car's age and its selling price confirms the widely accepted notion of depreciation in the automotive industry. This aligns with the findings of Borthakur (2023)[Bor23], who noted a similar trend in their study. The preference for automatic transmission vehicles, reflected in their higher resale values, corroborates with Lin (2022)[Hua23] study, which highlighted the growing demand for convenience in driving. The less significant impact of fuel type on the selling price, contrary to Knittel (2009)[BKZ09] findings, may indicate a shift in consumer preferences, possibly due to environmental concerns or advancements in fuel efficiency across different engine types.

5.2 Practical Implications

- For buyers: The results suggest that consumers looking for value purchases should consider older and manual transmission vehicles. Understanding these trends can help buyers make more informed decisions.
- For sellers: Sellers can leverage this information to price their vehicles competitively, focusing on attributes like transmission type and engine capacity to attract potential buyers.
- For market analysts: The insights can guide market analysts in predicting future trends, particularly concerning the shifting preferences towards automatic transmission and environmental considerations.

The study's findings largely corroborate the existing literature on used car valuation, especially regarding depreciation with age and mileage. However, the diminished importance of fuel type presents a deviation from some earlier studies, reflecting the dynamic nature of consumer preferences and market conditions.

5.3 Limitations and Future Research

The primary limitation of this study is its reliance on data from a single source, which may not capture the full spectrum of the used car market. Future research could expand the analysis to include multiple datasets from different regions or time periods. Another limitation is the exclusion of certain variables, such as car brand and model, which could have a significant impact on the selling price. Incorporating these factors could provide a more detailed understanding of pricing dynamics. The evolving nature of the automotive industry, with emerging trends like electric vehicles and increased environmental consciousness, calls for ongoing research to stay abreast of how these developments influence the used car market.

6 Conclusion

This research has presented a detailed analysis of the used car market, focusing on the factors that influence the selling price of used cars. Through the application of various statistical methods and data visualization techniques, the study has highlighted several key insights into the dynamics of car valuation.

The analysis revealed that the age and mileage of a car significantly impact its selling price, confirming the traditional view of vehicle depreciation over time. Additionally, the preference for automatic transmission and larger engine capacities were found to have a notable influence on a car's resale value. Contrary to some earlier studies, the type of fuel used by the car was not as significant a factor in determining its selling price, suggesting a shift in consumer preferences and market trends.

These findings have important implications for various stakeholders in the used car market. Buyers can use this information to make more informed decisions, focusing on factors that will ensure the best value for their investment. Sellers can better understand how to price their vehicles and highlight certain features to attract buyers. Market analysts can leverage these insights to predict future trends and advise on strategic market positioning.

However, the study is not without its limitations. The reliance on a single data set and the exclusion of certain variables such as brand and model may limit the comprehensiveness of the findings. As the automotive industry continues to evolve, further research incorporating these factors and emerging trends like electric vehicles will be essential to provide a more complete understanding of the used car market.

In conclusion, this research offers valuable insights into the used car market, shedding light on the factors that influence car valuation. The findings contribute to a deeper understanding of consumer behavior and market dynamics, providing a foundation for future research in this area.

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