Business analytics
Analysis of car advertisement data

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IndustrieRoboterHirataEngineering

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4.1 Model usage

Given the regression model, it can be applied to example data to examine its behavior.

4.1.1 Assessing expectations

Intuitive assumptions draw you to the conclusion, that the vehicle's mileage has an inverse relationship to the predicted advertisement price. To evaluate if the model also follows this behavior, it was applied to manually created data differentiating only by mileage.

Registration year	**Mileage (mi)**	Horse-power	Width (mm)	Length (mm)	Average mpg	Top speed (mph)	**Predicted price (£)**
2017	**60000**	135	2027	4284	49	116	**16157**
2017	**130000**	135	2027	4284	49	116	**13828**

Table 4.1: Influence of mileage on recently registered cars

As it is evident in Table 4.1, a higher mileage in fact reduces the predicted price. However, for an over 2-fold increase in miles, the depreciation is with 14.4 % not as high as initially expected.

While comparing two otherwise identical cars, it should be noted that the other values still contribute significantly to the result.
In particular the registration year, which, as shown before, strongly correlates with the target variable, has an effect on the limited influence of the mileage here. Given the data set's sampling of data up to 2017, both of the Volkswagen (VW) Golfs in Table 4.1 have been first registered very recently, so the base price is measurably higher. If you apply the same example to cars registered in 2010, which therefore have been running for seven years, the influence of the mileage grows.

Registration year	**Mileage (mi)**	Horse-power	Width (mm)	Length (mm)	Average mpg	Top speed (mph)	**Predicted price (£)**
2010	**60000**	135	2027	4284	49	116	**11122**
2010	**130000**	135	2027	4284	49	116	**8793**

Table 4.2: Influence of mileage on older cars

As shown in Table 4.2, the gap between the two otherwise identical vehicles has widened to 20.9 %, an increase by 45.3 %. Potential reasons for the strong correlation between year and target value will be investigated further in section 4.2.2. Nevertheless, for that small subset of data, the efficacy of the model is evident.

4.1.2 Usage of example data

However, this small example is not cohesive enough to demonstrate the ability to solve the aforementioned business problem. To apply the model to a day-to-day use case as it regularly appears in a dealership, it was used to predict the advertisement price of four automobiles as they could be in its yard.

Registration year	Mileage (mi)	Horse-power	Width (mm)	Length (mm)	Average mpg	Top speed (mph)	**Predicted price (£)**
2014	180000	110	1799	4204	45	110	**5601**
2016	150000	120	2027	4255	48	112	**12130**
2018	80000	130	2027	4255	50	115	**16136**
2015	190000	115	1799	4204	44	108	**5819**

Table 4.3: Assessing model for business use cases

Table 4.3 illustrates that the model is able to predict an appropriate advertisement price for a VW Golf. As the model's performance with $R^2 = 0.927$ is very good, the dealer can rely on it, receiving a data driven estimate for a competitive price, thus not having to rely solely on human estimate.

4.2 Findings

In section 4.1 the application of the model to exemplary vehicles has been demonstrated. Here, some trends that could have already been anticipated after the correlation analysis, have emerged more clearly.
These trends that have been found regarding the model and the underlying data can be divided into two groups, the predicted and the unexpected.

4.2.1 In line with presumptions

In this first part, the findings which can be considered logical or self-evident will be discussed.

Mileage ↔ Price

Mileage as a parameter can be seen as an indicator for wear of the vehicle. It directly implies more miles have been driven, yet indirectly affects other markers as well. It may mean doors have been opened and closed more often, electronics have been running for longer, the paint has suffered more damage from washing etc. Apart from that, maintenance parts are closer to their end of life and need to be replaced sooner, which costs customers money and time.

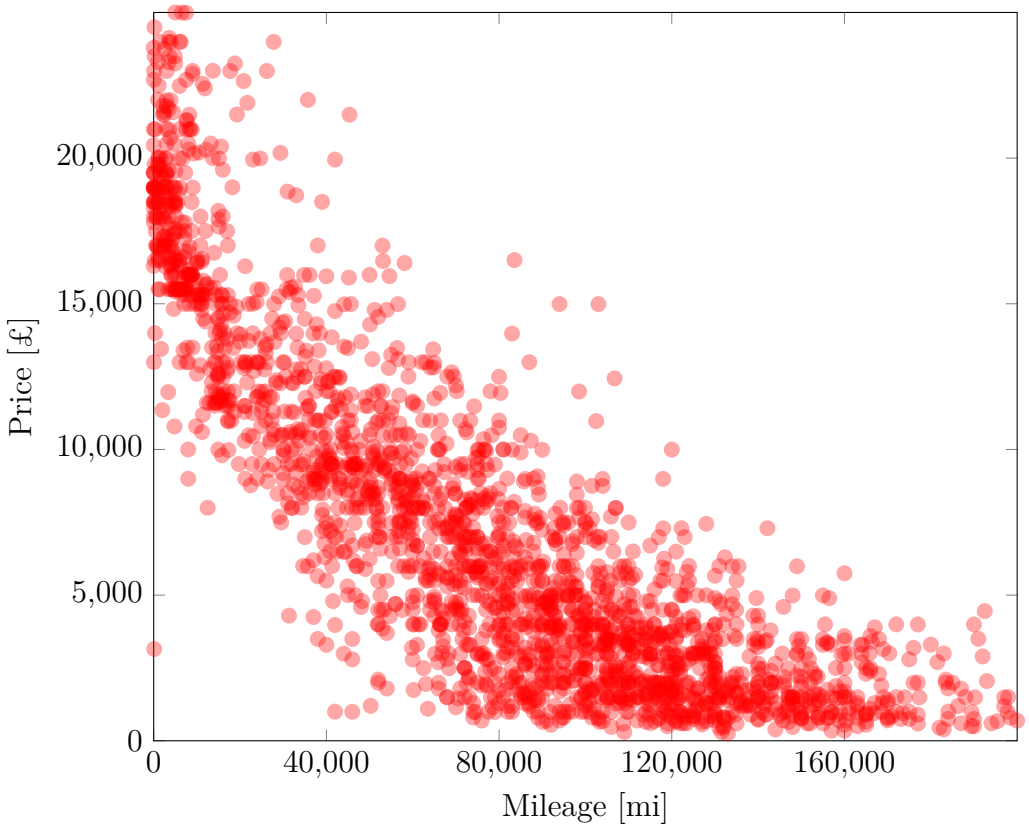

Figure 4.1: Effect of mileage on price

Looking at the data in Figure 4.1, it can be seen that there is a steep decline of the vehicle's value in the beginning up to ≈ 50000 miles, with the effect of mileage on the price notably decreasing from ≈ 100000 mi onwards. A potential reason for this could be that once vehicles reach certain points their mileage, most of the common maintenance has already been executed, so a high mileage becomes an indicator of the car's reliability, countering the diminishing effect of mileage on the price to a certain extent.

This also means that the relationship between the two markers is not clearly following a linear trend, making it difficult to fully explain with the linear Pearson correlation. Nevertheless, its negative value of -0.304 is behaving as expected, albeit not as strong.

Horsepower ↔ Price

On of the essential specifications of a vehicle is its power, measured in horsepower. It affects the maximum acceleration, the top speed, the fuel consumption and other key indicators of a car's capabilities. The improved performance is a reason, why customers are willing to spend extra for a car with more horsepower. As with new vehicles, the direct relationship between horsepower and price also manifests in the pre-owned market, with a correlation of 0.465.

4.2.2 Outliers

Nevertheless, there are also some outliers which ought to be investigated in more detail.

Engine size ↔ Price

The engine displacement, informally also referred to as engine size, describes the volume of air and fuel inside an engine's pistons [1] and is measured in liters in the data set. By definition, it is also related to its power output, in particular in older vehicles.

Given that, the intuitive prediction is that it will positively correlate with the final price. However, the analysis has shown that there the correlation is not significant, with -0.063 approaching 0. There are two main reasons for this.

Exploring the correlation of the engine size with other parameters, the lack of effect on the final price can be explained by looking at three key indicators:

- **Top speed:** With 0.552, there is a significant effect of the engine size on the top speed, increasing the predicted value of the Golf.
- **Registration year:** There is a measurable trend that for newer cars, the engines become smaller, notable by a coefficient of -0.295. Due to the strong effect of the registration year on the predicted price, the higher engine sizes negatively influence the target value, compensating the aforementioned effect of top speed.
- **Horsepower:** In newer cars, horsepower is not as limited by engine size as in the past [2]. Looking at the correlation value of -0.076, this effect is also resembled

in VW Golfs. Thus, one of the deciding factors determining the end price is not related to the engine size.

To conclude, the two measurable effects even each other out and for the horsepower, where correlation might be present, there is not any, rendering the engine size negligible for our analysis.

Width ↔ Price

At the first glance, a very strong tie between the width of a Golf and its advertisement price is not clear. From a potential customer's perspective, the width of a car can be a deciding factor, for example when it comes to narrow parking spots and small neighborhood roads. Nonetheless, there is a strong positive correlation with the target value, implying that the dimensions of the car can play a deciding factor in the purchase process.

Investigating the matter based on the data, the reason for the connection between width and price becomes evident: The width is very positively correlated with the registration year, which in turn is very strongly correlated with the Golf's advertisement price. This can be explained by the fact that VW Golfs get wider every model generation, as for instance a VW Golf V is 1759 mm, while the current 8th generation's width is already 1789 mm [3].

This is reflected in the analyzed data set, with a clear trend observable that in par with the registration year, the width increases, resulting in a positive correlation of 0.715.

Year ↔ Price

As expected, there is a relationship in between the registration year of the car and the final price. However, its strength with 0.842 is unprecedented and can not solely be clarified by the analyzed data. The main reason for this is the absence of the exact model generation (as of Golf V, Golf VI, Golf VII...), as well as its respective base price, in the data. Nonetheless, it can be assumed that year of registration is approximately equal to the manufacturing date and therefore also to the model.

As prices have risen between the model generations, for instance a 16.3 % price increase

happened between comparable models of Golf V and Golf VII [4], it can be expected that this trend is reflected in advertisement prices as well. Additionally, newer cars include more optional features which can drive up the price if they are present. If this affects the price in the given case cannot be checked using the available data, as there is no notice of a car's selected options.

To add to that, there might also be differences in a car's maintenance cost and reliability depending on the exact model, manifesting in price differences in pre-owned vehicles. Newer models can also contain more innovations, whose absence can make older vehicles disproportionately less attractive, with features such as air conditioning, heated seats, navigation and more being considered standard nowadays.

Overall, trends and innovations that originate from the cost and behavior of new vehicles also reflect in the future advertisement price.

5 Conclusion

5.1 Limitations of the analysis

5.1.1 Recency of the data

The training data has been collected between 2016 and 2017, thus even the most recent data is now over 6 years old. Given recent events such as the steep increase of inflation and the COVID-19 pandemic, predictions by the model might not accurately reflect current trends.

5.1.2 Lack of sales data regarding advertisement

Additionally, while the given dataset includes conclusive data regarding the advertisement price of cars in the used vehicle market, there is no indicator given, whether the car was actually sold at the price that it has been advertised for.
Nevertheless, while one may anticipate a few dealerships to over- / undershoot their prices, considering the scale of the dataset, that effect evens out for the overall market. However, evaluating whether there is a trend that pre-owned cars are systematically under- / overpriced in commercials is only possible if you compare the given data set to real sales information.

5.2 Further research topics

Given the scale of the available data, more potential research questions may be examined.

5.2.1 Inter-model comparison of findings

Additionally, the analysis is currently only valid for the small subset of the data including VW Golf. To levitate generalizability to the whole used vehicle market and to assess

potential disparities as well as similarities in between car models, expanding the scope to the entirety of available data is obligatory.

5.2.2 Assess value depreciation

Having inter-model differences evaluated, a possible further research topic is the comparison of each car's new price to its future advertisement prices. For each model in the advertisement dataset, there is a corresponding data point in the basic information table that contains, among others, the manufacturer's suggested retail price (MSRP).
Given that information, the following questions could be analyzed:

- Which model retains the most value compared to its MSRP?
- Given five years of use, which car's price decreased the most?
- Is there a correlation between value depreciation and the manufacturer of the car?

This information can be useful for customers considering the purchase of a new car in order to assess its potential resale value in the future.

5.3 Résumé

The conducted analysis provides a data driven solution to the business problem of a competitive advertisement price of a given VW Golf. After preparing the raw data, key influences have been separated using Pearson-correlation and used to train a linear regression model to predict a suitable advertisement price.

Considering the parameters

- Registration year
- Mileage (mi)
- Horsepower
- Width (mm)
- Length (mm)

- Average mpg
- Top speed (mph)

the model accurately predicts a suitable advertisement price with $R^2 = 0.927$, solving the business problem therewith. The end results align with logical assumptions, for instance that newer cars sell for higher prices. Nonetheless, they provide further insight by revealing each factor's contribution to the total amount.

Provided that outcome, further potential research areas are examined and left open for future analysis.

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