Price Prediction for Used BMWs

Business Problem

- We are an online auction site for used BMW cars, and we want to provide sellers with the best opportunity to sell for the highest price
- Our objective is to try and stand out amongst our competitors by offering a twist on a common tool in the used car industry: **Price Prediction**
- Right now, there are many online calculators that sellers can use to input car details to get a potential selling price for their car

Price Prediction Tool

Selling Price

Predicted Selling Price:

$ 10,200

Our estimated price helps you get the best value for your used BMW 320.

Business Solution

- Our solution is to enhance the **Price Prediction** process and tell sellers how to improve their selling price. For example:
  - Is there a special feature that can add more value to your used BMW?
- Our plan is to use data mining techniques to not only predict the average bid price for our sellers, but also improve their selling price based on potential car features

Price Prediction Tool

Selling Price **Price Increase**

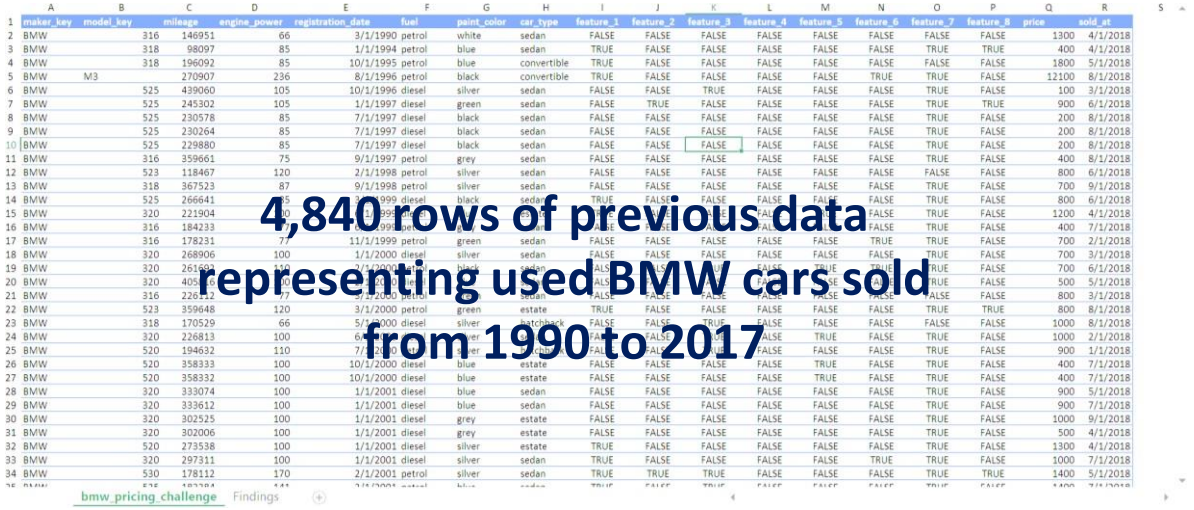
Did you know?

Equipping your car with LED Cornering Lights can increase your selling price by 10%.

$ 11,220

This modification gets you even more value for your used BMW 320.

Dataset Description



maker_key	model_key	mileage	engine_power	registration_date	fuel	paint_color	car_type	feature_1	feature_2	feature_3	feature_4	feature_5	feature_6	feature_7	feature_8	price	sold_at
BMW	316	146951	66	3/1/1990	petrol	white	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	1300	4/1/2018
BMW	318	98097	85	1/1/1994	petrol	blue	sedan	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	400	4/1/2018
BMW	318	196092	85	10/1/1995	petrol	blue	convertible	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	1800	5/1/2018
BMW	M3	270907	236	8/1/1996	petrol	black	convertible	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	12100	8/1/2018
BMW	525	439060	105	10/1/1996	diesel	silver	sedan	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	100	3/1/2018
BMW	525	245302	105	1/1/1997	diesel	green	sedan	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	900	6/1/2018
BMW	525	230578	85	7/1/1997	diesel	black	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	200	8/1/2018
BMW	525	230264	85	7/1/1997	diesel	black	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	200	8/1/2018
BMW	525	229880	85	7/1/1997	diesel	black	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	200	8/1/2018
BMW	316	359661	75	9/1/1997	petrol	grey	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	400	8/1/2018
BMW	523	118467	120	2/1/1998	petrol	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	800	6/1/2018
BMW	318	367523	87	9/1/1998	petrol	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	700	9/1/2018
BMW	525	266641	85	1/1/1999	diesel	black	sedan	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	800	6/1/2018
BMW	320	221904	110	1/1/1999	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	1200	4/1/2018
BMW	316	184233	77	1/1/1999	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	400	7/1/2018
BMW	316	178231	77	11/1/1999	petrol	green	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	700	2/1/2018
BMW	320	268906	100	1/1/2000	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	700	3/1/2018
BMW	320	261	100	1/1/2000	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	700	6/1/2018
BMW	320	40	100	1/1/2000	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	500	5/1/2018
BMW	316	226	77	3/1/2000	petrol	blue	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	800	3/1/2018
BMW	523	359648	120	3/1/2000	petrol	green	estate	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	800	8/1/2018
BMW	318	170529	66	5/1/2000	diesel	silver	hatchback	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	1000	8/1/2018
BMW	320	226813	100	6/1/2000	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	1000	2/1/2018
BMW	520	194632	110	7/1/2000	diesel	silver	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	900	1/1/2018
BMW	520	358333	100	10/1/2000	diesel	blue	estate	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	400	7/1/2018
BMW	520	358332	100	10/1/2000	diesel	blue	estate	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	400	7/1/2018
BMW	320	333074	100	1/1/2001	diesel	blue	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	900	5/1/2018
BMW	320	333612	100	1/1/2001	diesel	blue	sedan	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	900	7/1/2018
BMW	320	302525	100	1/1/2001	diesel	grey	estate	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	1000	9/1/2018
BMW	320	302006	100	1/1/2001	diesel	grey	estate	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	500	4/1/2018
BMW	520	273538	100	1/1/2001	diesel	silver	estate	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	1300	4/1/2018
BMW	320	297311	100	1/1/2001	diesel	silver	sedan	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	1000	7/1/2018
BMW	530	178112	170	2/1/2001	petrol	silver	sedan	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	1400	5/1/2018

bmw_pricing_challenge | Findings

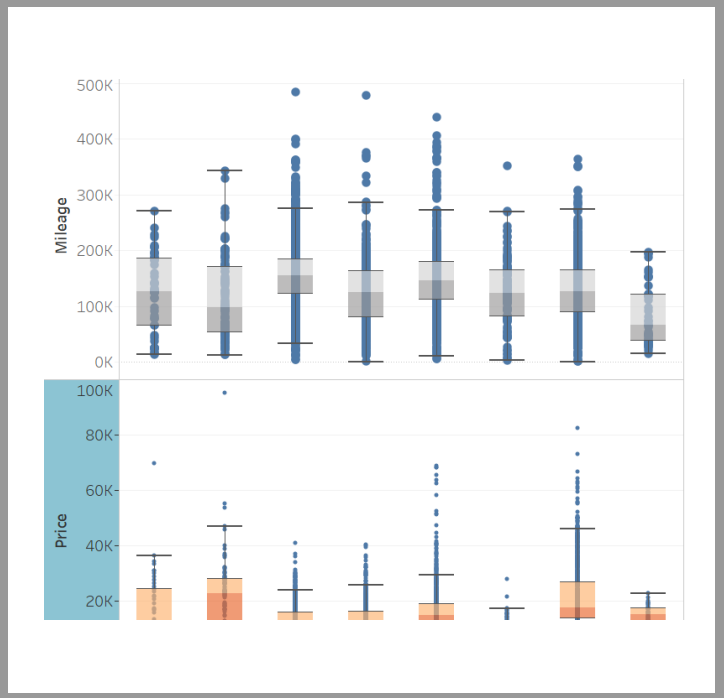
4,840 rows of previous data representing used BMW cars sold from 1990 to 2017

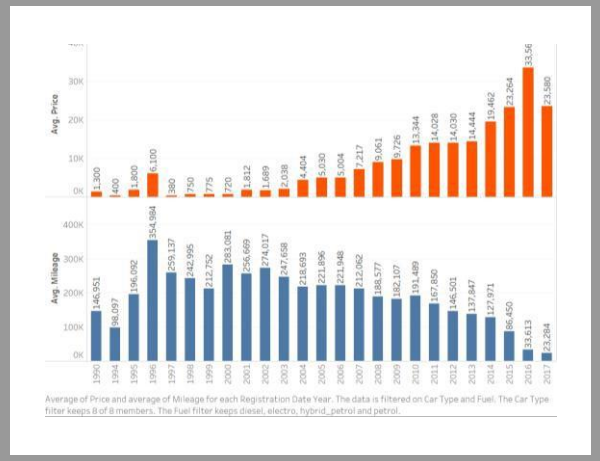
- Initial pre-processing:
  - Identified a few outliers & data entry errors
- Visualization techniques utilized:
  - Box Plots – to compare and identify outliers
  - Scatter Plots – to identify relationships to target variable
  - Bar Charts – to visualize trends & identify unusual patterns

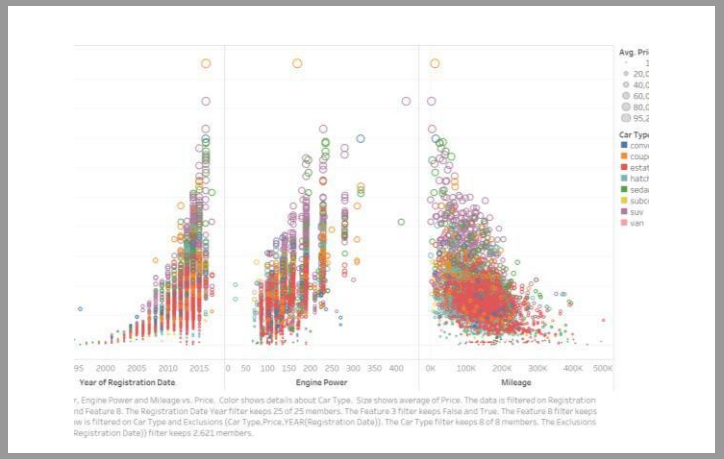
- Dependent variable = Price
- Independent variables include:

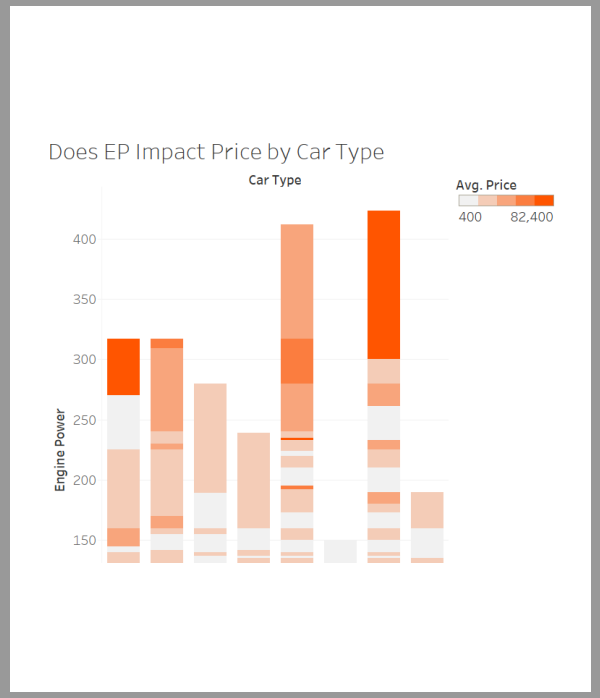
Make	LED Cornering Lights
Model	Bluetooth®
Mileage	Parking Sensors
Engine Power	Rear View Camera
Fuel Type	Smartphone Compatible
Car Type	Universal Garage Door Opener
Paint Color	Heated Side Mirrors
Age	Leather Interior

Data Visualization









TOP LEFT

- **Box Plot – comparing Price & Mileage variation by Car Type**

TOP RIGHT

- **Bar Chart – graphing Price and Mileage trends**

BOTTOM LEFT

- **Scatter Plot – relationship of Mileage, Age & Engine Power to Price**

BOTTOM RIGHT

- **Bar Chart – visualizing impact of Engine Power on Price by Car Type**

Linear Regression

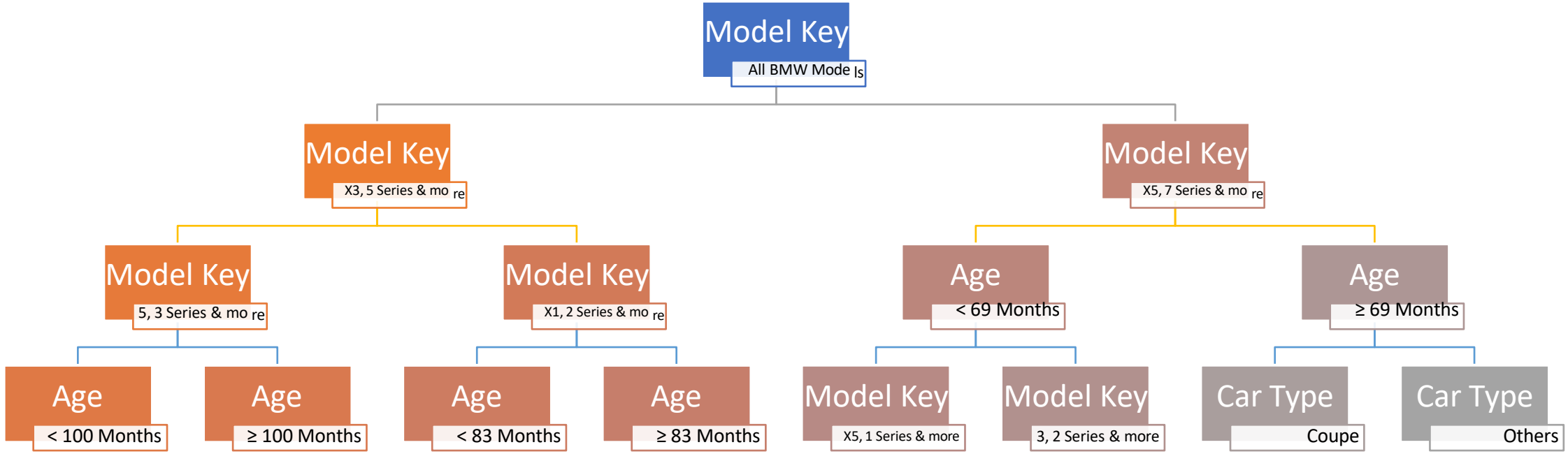
- Numeric Outcome Variable = Price
  - Mix of numeric and categorical predictors
  - Special focus on car equipment features
- Adjusted R^2 based on Stepwise Selection Model:

Steps	Variable Selection	Adj R-Square
1-3	Model, Age & Mileage	**81%**
4-5	Engine Power & Car Type	**82%**
6-13	Universal Garage Opener, Leather, Rearview Camera, LED Cornering Lights, Parking Sensors, Heated Side Mirrors, Paint Color & Fuel	**84%**

- Statistically Significant Features (with p-value < .01):

Types	Variables
Other	Age, Car Type (Estate & Convertible), Engine Power, Mileage, Model (30 types)
Equipment Features	Universal Garage Opener, Leather, Rearview Camera, LED Cornering Lights, Parking Sensors, Heated Side Mirrors

Decision Tree



Classification Rules:

IF model_key is X3, 5, 4, 3 and 2 series,
AND age_months < 181.5 and >= 138.5,
AND mileage >= 253947,

THEN Predicted Price = $4,636.36

IF model_key is Z4, X1, 3 and 1 series,
AND age_months < 83.5,
AND mileage >= 120,907,
AND leather is True & smartphone_compatible is False,

THEN Predicted Price = $11,488.24

Results & Interpretation

Per SAS:

- Best Model = Decision Tree
- Similar Error Rates
- Similar Variable Selection & Classification Rules

For our Business Problem:

- Best Model = Linear Regression
  - Predict selling price of used BMW
  - Calculate price increase with coefficients of features (holding other variables constant)

Business Insights:

- Expected results:
  - Age and Mileage are important predictors
- Unexpected results:
  - Removed the need to be a car expert in order to get the best price for a used BMW
  - Determined how much the selling price increases with additional car equipment features

Managerial Insights

- Data-driven talking points for managers to share with sellers
  - Black BMW 520 that is an older model with higher mileage
  - Additional features can increase the price by **$3,383.69**

Used Car	Price Prediction	Added Features	Total Price Increase
BMW 520  **167K Mileage – 100 HP – 7 years old** **Diesel – Estate – Black**	$10,098.86 Base Offer	LED Cornering Lights (+$611.20) Rear View Camera (+1,461.78) Universal Garage Opener (+$1,310.71)	$13,482.55 ↑ 34%


Thank you
Any Questions?