# LINEAR REGRESSION

Review

# WHAT WILL YOU LEARN/REVIEW

- Reviewing the basic idea behind linear regression
- Learning how to measure predictive quality with Mean Square Error ($MSE$).
- Calculating optimal OLS regression parameters using `tidymodels`
- Distinguish between unfitted and fitted models
- How to interpret the OLS regression parameters and their significance
- Using metrics to evaluate prediction quality on the testing

# LOADING THE LIBRARIES AND THE DATA

▶ Code

```
     Price Sqft Bedrooms Condition
1 523633.4 2040        4         3
2 530960.7 2120        4         3
3 523466.8 2130        4         4
4 759747.7 3330        4         3
5 546377.8 2440        4         3
6 186536.6  900        3         4
```

# SPLITTING IN TRAINING AND TESTING DATA:

```
set.seed(Seed)
Split7030=initial_split(DataHouses,prop=0.7, strata = Price)
DataTrain=training(Split7030)
DataTest=testing(Split7030)
```

# HOW MUCH IS A HOUSE WORTH IN KING COUNTY?

## A house with average properties should be predicted with an average price!

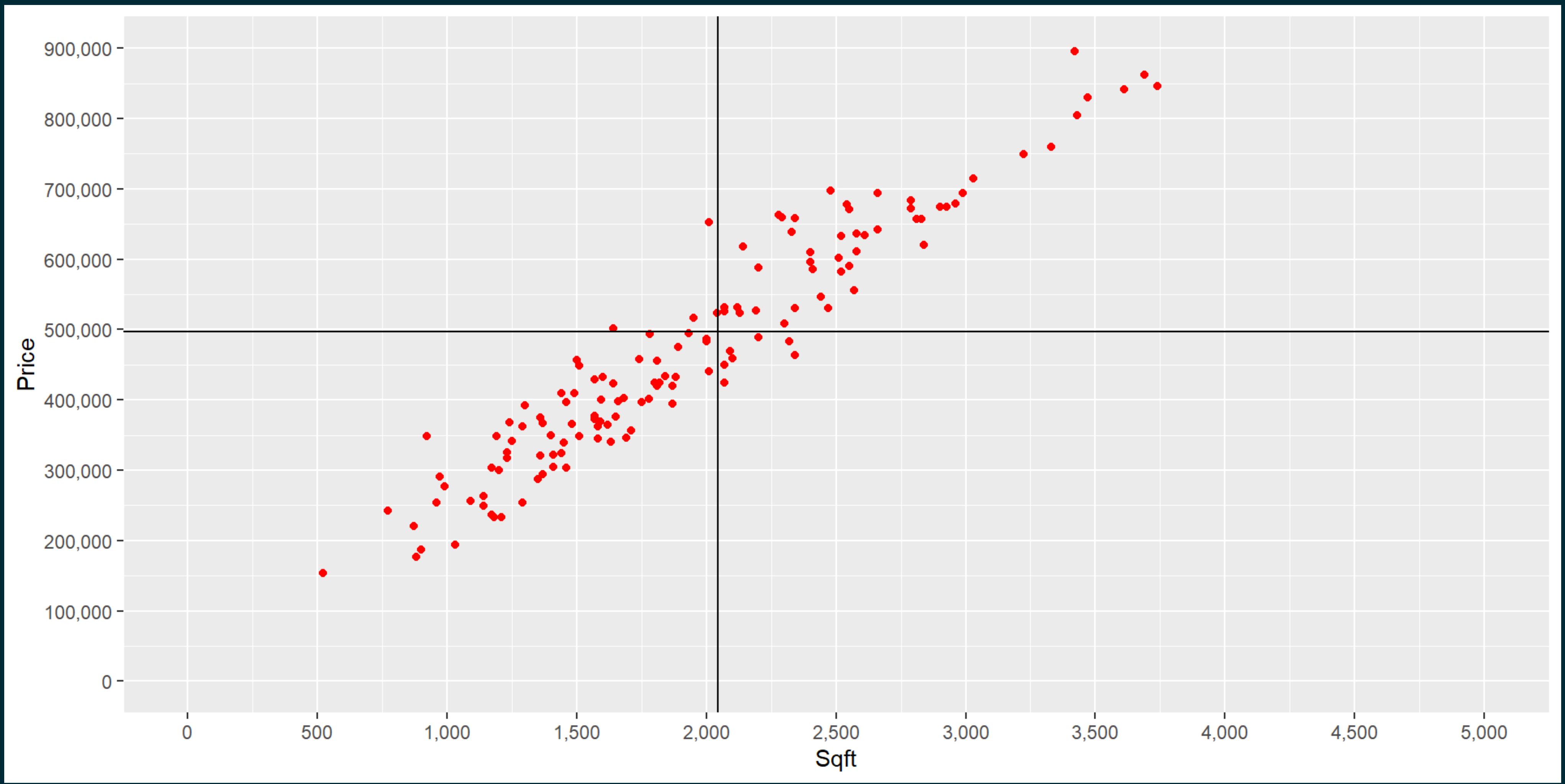
▶ Code

```
The mean square footage of a house in King county is: 2044.319
```

▶ Code

```
The mean price of a house in King county is: 497414.9
```

# PREDICTING THE PRICE OF AN AVERAGE SIZED HOUSE AS THE AVERAGE OF ALL HOUSE PRICES



# HOW TO MEASURE PREDICTION QUALITY WITH THE MEAN SQUARED ERROR (MSE)

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(\hat{y}_i - y_i)^2$$

$$\iff$$

$$MSE = \frac{1}{N}\sum_{i=1}^{N}\underbrace{(\overbrace{\beta_1 x_i + \beta_0}^{\text{Prediction } i} - y_i)}_{\text{Error } i}{}^2$$

**Note, when the data are given (i.e., $x_i$ and $y_i$ are given), the $MSE$ depends only on the choice of $\beta_1$ and $\beta_0$ »**

# INCLUDING SQFT AS DETERMINAT OF PRICE

## PREPARING THE DATA

Blueprint for the data:

```
RecipeHouses=recipe(Price~Sqft, data=DataTrain)
```

# CHOOSING THE MODEL BLUEPRINT

Blueprint for the model:

```
ModelDesignOLS=linear_reg() |>
              set_engine("lm") |>
              set_mode("regression")
```

# HOW DOES THE UNFITTED MODEL LOOKS LIKE?

$$\underbrace{\widehat{Price}}_{\hat{y}} = \underbrace{\beta_1}_{m} \underbrace{Sqft}_{x} + \underbrace{\beta_0}_{b}$$

# USING A WORKFLOW TO FIT THE MODEL TO THE DATA (FINDING THE OPTIMAL $\beta_1$ AND $\beta_0$ VALUES

$$\underbrace{\widehat{Price}}_{\hat{y}} = \underbrace{\beta_1}_{m}\underbrace{Sqft}_{x} + \underbrace{\beta_0}_{b}$$

```r
WFModelHouses=workflow() |>
              add_recipe(RecipeHouses) |>
              add_model(ModelDesignOLS) |>
              fit(DataTrain)
```

# UNFITTED MODEL VS FITTED WORKFLOW MODEL

Unfitted Model:

$$\underbrace{\widehat{Price}}_{\hat{y}} = \underbrace{\beta_1}_{m} \underbrace{Sqft}_{x} + \underbrace{\beta_0}_{b}$$

▶ Code

```
# A tibble: 2 × 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)    6584.  12191.       0.540 5.90e- 1
2 Sqft            238.      5.47    43.5   6.43e-66
```

Fitted Model:

$$\underbrace{\widehat{Price}}_{\hat{y}} = \underbrace{238}_{m} \cdot \underbrace{Sqft}_{x} + \underbrace{6584}_{b}$$

Predict the price for a house with 1,000 sqft and send it to me in a private chat!

# INTERPRETATION AND SIGNIFICANCE

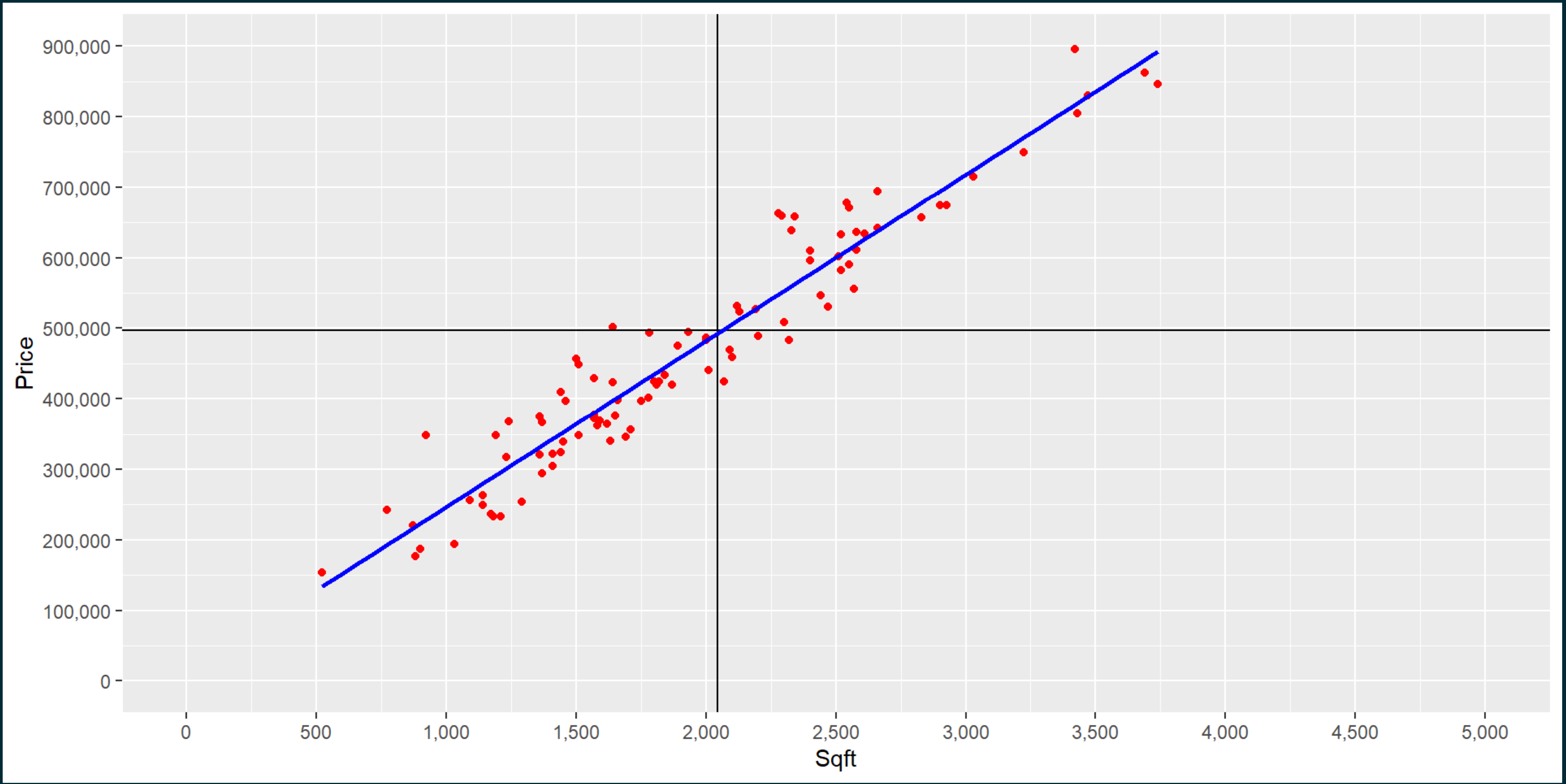
```
# A tibble: 2 × 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)    6584.   12191.      0.540 5.90e- 1
2 Sqft            238.       5.47   43.5   6.43e-66
```

$$
\begin{aligned}
\widehat{Price} &= 238 \cdot Sqft + 6584 \\
(+238) &= 238 \cdot (+1) + (+0) \\
(+476) &= 238 \cdot (+2) + (+0) \\
(+714) &= 238 \cdot (+3) + (+0)
\end{aligned}
$$

**For each extra $Sqft$ the predicted price increases by \$238**

**The variable $Sqft$ is significant. I.e., the probability that the related coefficient $\beta_1$ equals zero is extremely small.**

# HOW DOES THE FITTED MODEL THAT CONSIDERS SQFT IMPROVES THE PREDICTION COMPARED TO A SIMPLE AVERAGE




https://ai.lange-analytics.com/

# EVALUATING PREDICTIVE QUALITY WITH THE TESTING DATASET

```r
DataTestWithPred=augment(WFModelHouses, new_data=DataTest)
metrics(DataTestWithPred, truth=Price, estimate=.pred)
```

```
# A tibble: 3 × 3
  .metric .estimator .estimate
  <chr>   <chr>          <dbl>
1 rmse    standard   50915.
2 rsq     standard       0.923
3 mae     standard   39748.
```

# PROJECT: ANALYSIS WITH ALL VARIABLES

```r
library(rio)
library(janitor)
library(tidyverse)
DataHouses=import("https://ai.lange-analytics.com/data/HousingData.csv") |>
           clean_names("upper_camel") |>
           select(Price,Sqft=SqftLiving,Bedrooms,Condition)
```