POLI 30 D: Political Inquiry

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(Based on DSS Materials)

Lecture 09 | Prediction II

Before we start

Announcements:

- Quizzes and Participation: On Canvas.
- GitHub page: https://github.com/umbertomig/POLI30Dpublic
- Piazza forum: Not sure what the link is. Ask your TA!
- Note to self: Turn on the mic!

Before we start

Recap: We learned:

- The definitions of theory, scientific theory, and hypotheses.
- Data, datasets, variables, and how to compute means.
- Causal effect, treatments, outcomes, and randomization.
- Sampling, descriptive statistics, and descriptive plots for one variable.
- Correlation between two continuous variables.
- Prediction of a non-binary variable.

Great job!

- Do you have any questions about these contents?

Plan for Today

- Prediction and Linear Regression
- Example with Binary Outcome Variable:
  Using status quo Scores to Predict Probability of Supporting a Dictator

1. Load and explore data
2. Identify X and Y
3. What is the relationship between X and Y?
   - Create scatter plot
   - Calculate correlation
4. Fit a linear model using the least squares method
5. Interpret coefficients
6. Make predictions
7. Measure how well the model fits the data

Predicting Support for a Dictator

- In 1988, FLACSO ran a survey to estimate the support for Augusto Pinochet in Chile.
- This survey was conducted on the eve of a referendum that could have ousted Pinochet.

variable	**meaning**
`statusquo`	Scale with status-quo evaluation. Roughly from -5 to 5.
`vote`	Declared vote in the upcoming referendum.
`voteYES`	1 means vote for Pinochet, and 0 means vote against it.

- We will study whether a person satisfied with the status quo would tend to favor Pinochet in the plebiscite.

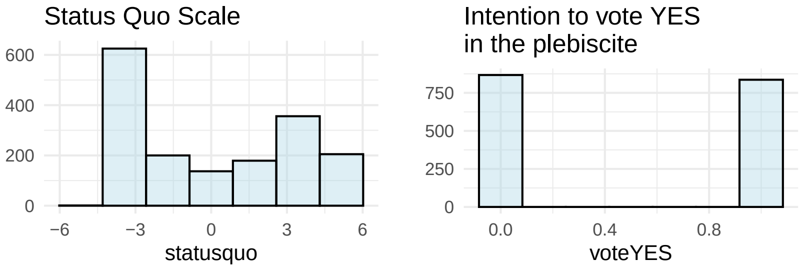
Step 1: Load and explore data

```
survchile <- read.csv("https://raw.githubusercontent.com/um
head(survchile)
##   statusquo vote voteYES
## 1   3.02460    Y       1
## 2  -3.88851    N       0
## 3   3.69216    Y       1
## 4  -3.09489    N       0
## 5  -3.31488    N       0
## 6  -3.14055    N       0
```

- What is the unit of observation?
- For each variable: type and unit of measurement?
- Substantively interpret the first observation.

Step 2: Identify the Dependent and Independent Variables

- The **predictor (X)** is the variable we want to use to predict the outcome (Y).
- The **target (Y)** is the variable that we want to predict.
- What are they?



Step 2: Identify the Dependent and Independent Variables

- What type of variable is *voteYES*?
  - Binary
- How would you compute the proportion of intended `Yes` votes?
  - By computing the mean of *voteYES*
  - Since *voteYES* is a binary variable, its mean should be interpreted as the proportion of the observations that have the characteristic identified by the variable

Step 2: Identify the Dependent and Independent Variables

- Code to compute the mean of *voteYES*
  - Answer:

```
mean(survchile$voteYES)
## [1] 0.4908984
```

- Interpretation?
  - Close to 49.09% of people responded that they intended to support Pinochet in the upcoming plebiscite.
  - RECALL: You need to multiply the output by 100

Step 2: Identify the Dependent and Independent Variables

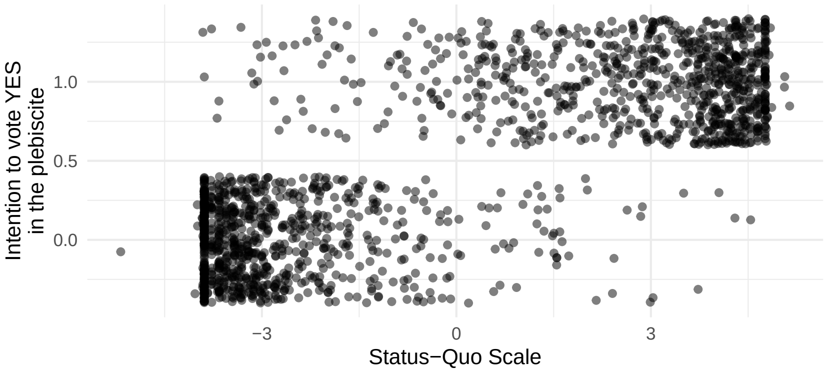
- Since Y is binary:
  - unit of measurement of $\overline{Y}$?
    - % (after x 100)
  - unit of measurement of $\widehat{\beta}_0$?
    - % (after x 100)
  - unit of measurement of $\widehat{Y}$?
    - % (after x 100)
  - unit of measurement of $\triangle\overline{Y}$?
    - p.p. (after x 100)
  - unit of measurement of $\widehat{\beta}_1$?
    - p.p. (after x 100)
  - unit of measurement of $\triangle\widehat{Y}$?
    - p.p. (after x 100)

Step 3: What is the relationship between X and Y?

- Create **scatter plot** to visualize the relationship between *statusquo* and *voteYES*.

- It is hard to see the y-axis variation. We add a little `jitter` on y, then.

Step 3: What is the relationship between X and Y?



- What does each dot represent?
- Does the relationship look positive or negative?
- Does the relationship look weekly or strongly linear?

Step 3: What is the relationship between X and Y?

- Calculate **correlation** to measure direction and strength of linear association between *statusquo* and *voteYES*

```
cor(survchile$statusquo, survchile$voteYES)
## [1] 0.8535779
```

- We find a strong positive correlation
- Are we surprised by this?

Step 4: Fit a linear model using the least squares method

- R function to fit a linear model: `lm()`

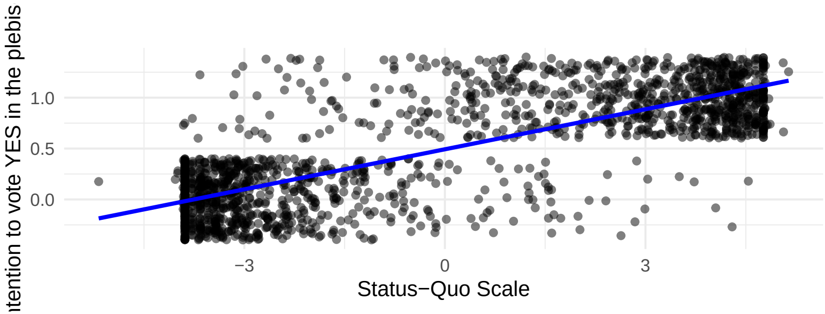
```
lm(voteYES ~ statusquo, data = survchile)
##
## Call:
## lm(formula = voteYES ~ statusquo, data = survchile)
##
## Coefficients:
## (Intercept)    statusquo
##      0.4927       0.1311
```

- $\widehat{\beta}_0 = 0.49$ and $\widehat{\beta}_1 = 0.13$
- The fitted line is $\widehat{Y} = 0.49 + 0.13\ X$
- More specifically, it is $\widehat{\text{voteYES}} = 0.49 + 0.13\ \textit{statusquo}$

Step 4: Fit a linear model using the least squares method

- R function to add a fitted line to scatter plot: `geom_smooth()`

```
ggplot(data = survchile, aes(x = statusquo, y = voteYES)) +
  geom_jitter(fill = 'lightblue', alpha = 0.5, height = 0.4, width = 0) +
  labs(title = '', y = 'Intention to vote YES in the plebiscite', x = 'Status-Quo Scale') +
  geom_smooth(formula = 'y ~ x', method = 'lm', se = F, color = 'blue', lwd = 1) +
  theme_minimal()
```



Step 5: Interpretation of Coefficients

- **Substantive interpretation of $\widehat{\beta}_0$?**
  - Start with the mathematical definition:
    - $\widehat{\beta}_0$ is the $\widehat{Y}$ when X=0
  - Substitute X, Y, and $\widehat{\beta}_0$:
    - $\widehat{\beta}_0 = 0.49$ is the $\widehat{voteYES}$ when $statusquo$=0
  - Put it in words (using units of measurement):
    - When a person is neither happy nor sad with things as they are, we predict that her probability of voting YES in the plebiscite is 49%, on average
- **Unit of measurement of $\widehat{\beta}_0$?**
  - Same as $\overline{Y}$
  - Since Y is binary, $\overline{Y}$ is measured in %, and so is $\widehat{\beta}_0$ (after x 100)

Step 5: Interpretation of Coefficients

- **Substantive interpretation of $\widehat{\beta}_1$?**
  - Start with the mathematical definition:
    - $\widehat{\beta}_1$ is the $\triangle\widehat{Y}$ associated with $\triangle X$=1
  - Substitute X, Y, and $\widehat{\beta}_1$:
    - $\widehat{\beta}_1$ =0.13 is the $\triangle\widehat{voteYES}$ associated with $\triangle statusquo$=1
  - Put it in words (using units of measurement):
    - Increasing satisfaction with the status quo by 1 point is associated with a predicted increase in the chance of voting YES of 13 p.p., on average
- **Unit of measurement of $\widehat{\beta}_1$?**
  - Same as $\triangle\overline{Y}$
  - Since Y is binary, $\triangle\overline{Y}$ is measured in p.p., and so is $\widehat{\beta}_1$ (after x 100)

Step 5: Interpretation of Coefficient

THE FITTED LINE IS

$$\widehat{Y} = \widehat{\beta}_0 + \widehat{\beta}_1 X$$

- $\widehat{\beta}_0$ (beta-zero-hat) is the estimated intercept coefficient
  the $\widehat{Y}$ when X=0
  (in same unit of measurement as $\overline{Y}$)

- $\widehat{\beta}_1$ (beta-one-hat) is the estimated slope coefficient
  the $\triangle\widehat{Y}$ associated with $\triangle X$=1
  (in the same unit of measurement as $\triangle\overline{Y}$)

Step 6: Make predictions

USING THE FITTED LINE
TO MAKE PREDICTIONS

- To predict $\widehat{Y}$ based on X: $\widehat{Y} = \widehat{\beta}_0 + \widehat{\beta}_1 X$
- To predict $\triangle\widehat{Y}$ based on $\triangle$X: $\triangle\widehat{Y} = \widehat{\beta}_1 \triangle X$

Step 6: Make predictions

To predict $\widehat{Y}$ based on X: $\widehat{Y} = \widehat{\beta}_0 + \widehat{\beta}_1 X$

- Example 1: Imagine a person is unsatisfied with things and evaluates the status quo as -2. What would we predict her chance of favoring Pinochet in the plebiscite?

$$\begin{aligned}
\widehat{\text{voteYES}} &= 0.49 + 0.13 \ \text{ statusquo} \\
\widehat{\text{voteYES}} &= 0.49 + 0.13 \times \text{-}2.0 \quad (\text{if statusquo} = \text{-}2.0) \\
\widehat{\text{voteYES}} &= 0.23
\end{aligned}$$

- Answer: If her status quo evaluation is -2.0 points, we would predict that her probability of supporting Pinochet is of 23%, on average
- Note: since Y is binary, $\widehat{Y}$ is measured in % (after x 100)

Step 6: Make predictions

- Example 2: Imagine a person is happy with things and evaluates the status quo as 2. What would we predict her chance of favoring Pinochet in the plebiscite?

$$\begin{aligned}
\widehat{\text{voteYES}} &= 0.49 + 0.13 \ \text{statusquo} \\
\widehat{\text{voteYES}} &= 0.49 + 0.13 \times 2.0 \quad (\text{if statusquo} = 2.0) \\
\widehat{\text{voteYES}} &= 0.75
\end{aligned}$$

- Answer: If the person scores 2.0 points on the status quo scale, we would predict that she would vote for Pinochet 75% of the time, on average

Step 6: Make predictions

To predict $\triangle\widehat{Y}$ associated with $\triangle X$: $\triangle\widehat{Y} = \widehat{\beta}_1 \triangle X$

- Example 3: If we raise a person's status quo evaluation by three points, how much would we predict that her support for Pinochet would change?

$$\begin{aligned}
\triangle\widehat{\text{voteYES}} &= 0.13\ \triangle\text{statusquo} \\
\triangle\widehat{\text{voteYES}} &= 0.13 \times 3.0 \quad (\text{if } \triangle\text{statusquo} = 3.0) \\
\triangle\widehat{\text{voteYES}} &= 0.39
\end{aligned}$$

- Answer: An increase of status quo scores of 3 points is associated with a predicted increase in the probability of voting yes in the plebiscite of 39 p.p., on average.
- Note: Since Y is binary, $\triangle\widehat{Y}$ is in p.p. (after x 100)

Step 7: Measure how well the model fits the data

- How good is the model at making predictions? How well does the model fit the data?
- One way of answering is by calculating R^2

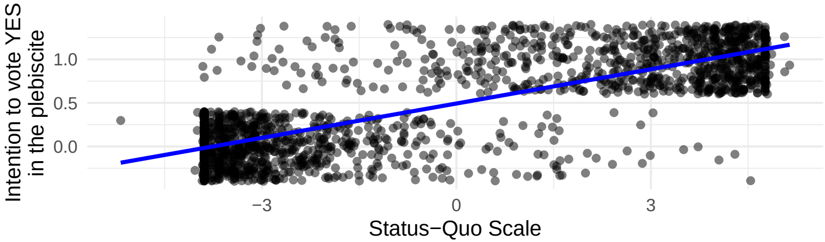
R^2 measures the proportion of the variation in the outcome variable explained by the model

- It ranges from 0 to 1
- The higher the R^2, the better the model fits the data
- In the simple linear model: $R^2 = cor(X, Y)^2$
- The higher the correlation between X and Y (in absolute terms), the better the model fits the data

Step 7: Measure how well the model fits the data

- When cor(X,Y) = 1 or cor(X,Y) = -1, the relationship between X and Y is perfectly linear.
- R^2 = cor(X,Y)^2 = 1, the model explains 100% of the variation of Y.
- All prediction errors (vertical distance between the dots and the line) = 0.
- When cor(X,Y) = 0, the relationship between X and Y is non-linear.
- R^2=cor(X,Y)^2 = 0, the model explains 0% of the variation of Y.
- The prediction errors (vertical distance between the dots and the line) are large.

Step 7: Measure how well the model fits the data



- Let us compute R^2

```
cor(survchile$statusquo, survchile$voteYES)^2
## [1] 0.7285953
```

Step 7: Measure how well the model fits the data

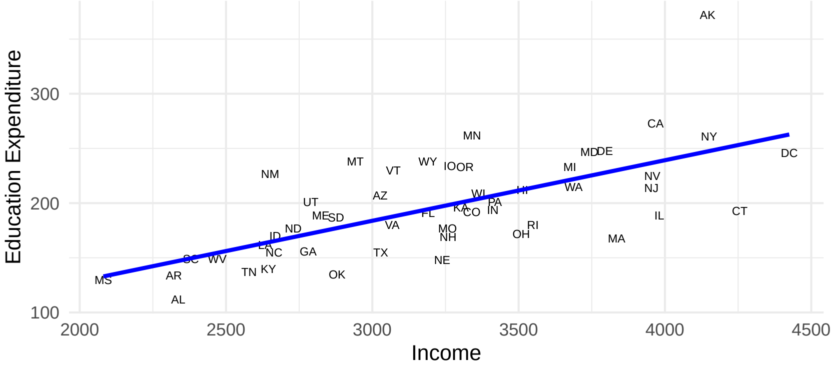
- Let us compute R^2:

```
cor(survchile$statusquo, survchile$voteYES)^2
## [1] 0.7285953
```

- Interpretation?
  - It means that the linear model explains 73% of the variation of the outcome variable (*voteYES*)
  - **Note:** It does NOT mean that the model is right 73% of the time.

Step 7: Measure how well the model fits the data

Let us return to the predictive model from the last lecture:



Step 7: Measure how well the model fits the data

```
cor(educexp$income, educexp$education)^2
## [1] 0.4456595
```

- Interpretation?
  - It means that the linear model explains 45% of the variation of the outcome variable (*education*)
  - It does NOT mean that the model is right 45% of the time
- **Warnings:**
  1. Only compare R^2 between models with the same outcome variable (Y)
  2. Some variables are intrinsically harder to predict than others

PREDICTING OUTCOMES USING LINEAR MODELS: We look for X variables that are highly correlated with Y because the higher the correlation between X and Y (in absolute terms), the higher the R^2 and the better the fitted linear model will usually be at predicting Y using X.

Summary

- **Today's Class:**
  - Practice summarizing the relationship between X and Y with a line: `lm()`.
  - Practice interpreting the two estimated coefficients ($\widehat{\beta}_0$ and $\widehat{\beta}_1$) when outcome variable is binary.
  - Practice making predictions with the fitted line: predict $\widehat{Y}$ based on X and predict $\triangle\widehat{Y}$ based on $\triangle X$.
  - Learned how to measure how well the model fits the data with R^2.

- **Next class**:
  - Causality with Observational Data

Questions?

See you in the next class!