Week 5 Video Lecture Notes

A. Learning Outcomes and Key Concepts

- introduces EDA techniques and concepts for analyzing and interpreting numerical data

What is Numerical Data?

- It is data predominantly analysed using regression analysis (regression is a major part of statistics)
- the chapter covers:
    - univariate data analysis
    - bivariate data analysis - correlation of variables and related concepts
- Introduces Simple linear regression concepts
    - how this technique is being used for real data sets

Modelling or Plotting Numerical data

- use of *histograms, boxplots and scatter plots*
- can be done for both univariate and bivariate data sets

B. Motivation

- attempt to solve issue problem using real housing data collected in Singapore
- Dataset (`housing-raw.csv`): Sales of HDB Resale flat information between Jan 2017 to Jun 2021

Using the PPDAC

Problem: What factors may affect the popularity and pricing of resale flats sold in Singapore?

Plan: Narrow down the factors in the Problem state (by shortlisting)

- Age? (of the resale flats at the point of sale)
- Floor Area?
- Time Period?

Data: Clean and prepare the data

- Remove irrelevant columns from 11 down to 4 in the cleaned dataset (have just `month` , `floor_area_sqm` , `age` and `relae_price` left)
- Filter the months to include just Jan to Jun 2021
- create the `age` column using calculation

C. Univariate Data Analysis

> *def:* A **distribution** is an *orientation of data points* broken down by their observed number of frequency of occurrence.

can present / relate the variables `age` with its frequency (which can be called `freq_of_ages`) in a tabular form

- may not be very useful to see the patterns in the data

Histogram

- graphical display of the distribution that organizes data points into **bins**

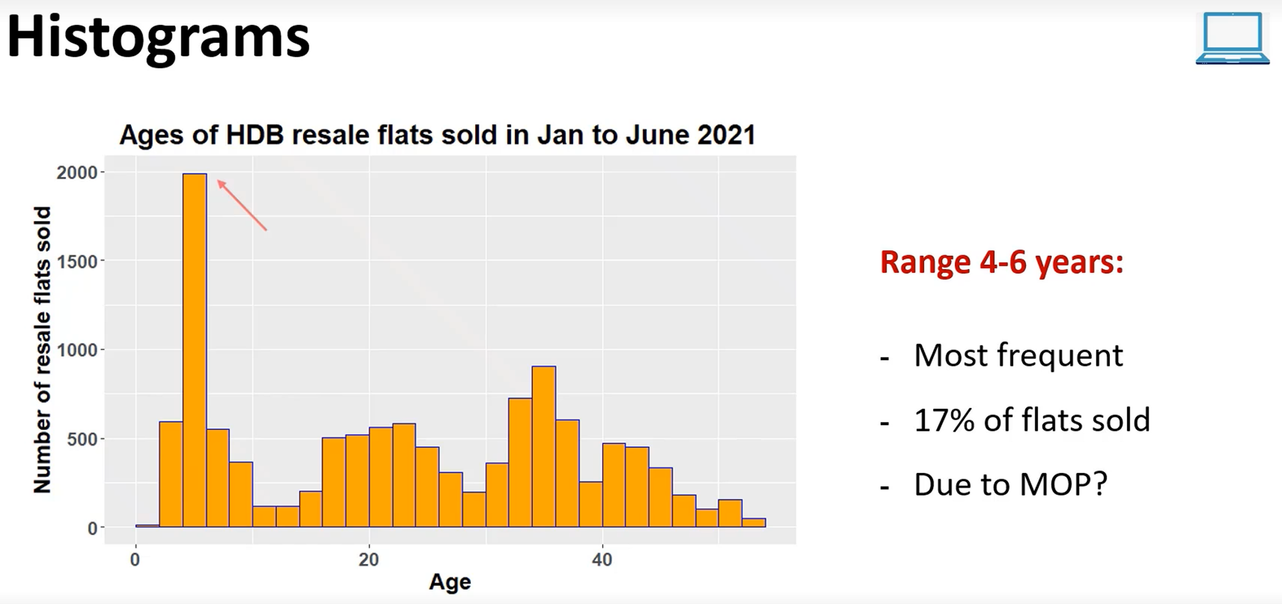
- provides a view of **data density** (higher bars = more common)

Steps for Creation of the histogram plot

- divide frequency table into smaller bins containing a range of values (i.e. distinct age counts of `2, 3, 4, 5, 6, 7, ...` become `0-2`, `2-4`, `4-6` etc.)
  - bins *exclude the lower end-point* and include the upper end-point of the interval
- Construct bars for each bin on the x-axis
- *deciding bin range*: often unclear and requires iterations
  - is an important factor since data gets grouped differently after adjusting the bin sizes and can affect our description/judgement based on the data
  - affects how we "estimate" the central tendency and skew of the distributions

Considerations / Best practices

- avoid histograms with **large bin widths** that group data to a limited number of bins (no variability in description of data)
  - loose interesting details
- avoid histograms with **small bin widths** that group data into too many bins (also affects one perception of distribution)
  - difficult to get an overall picture of the distribution
- may have to iterate over different bin sizes and see which is the most appropriate (based on ability to extract useful insights)
- **don't confuse histograms with bar plots**
  - one shows distribution across numerical bins/ranges while the other compares categories of the same variable
  - one has breakages or gaps while the other doesn't
  - numerical order doesn't matter for matter for bar plots but matters for histograms



Advantages

- presents the same info as a frequency table but is easier to understand
  - good for describing shapes of distributions
- useful for large(r) data sets $\Longrightarrow$ impractical to show the value of individual observations

Describing distributions

When graphing a distribution of a quantitative variable we look out for the:

- **Overall pattern** (Shape, Centre and Spread)
- **Deviations/Exceptions from the general pattern** (Outliers)

1. Shape

We look out for the shape of the distributions via its *peaks and skewness* (a.k.a. descriptors)

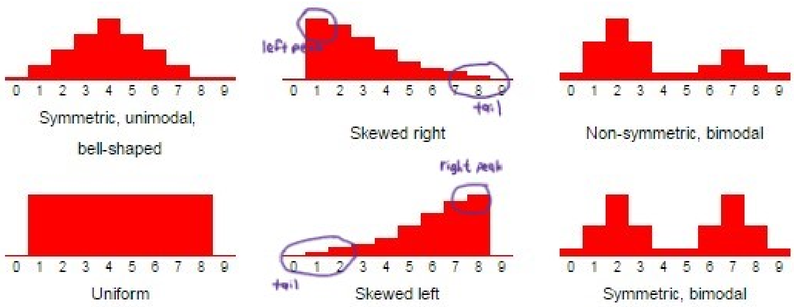
Modality

Good to imagine a smooth curve outlining the distribution

Types

- unimodal distribution: have one distinct peak
- bimodal distribution: have two peaks
  - may indicate the presence of **two distinct groups**
- multimodal distribution: have multiple peaks
- uniform distribution: no apparent trend

Characteristics of Unimodal/Bimodal distributions



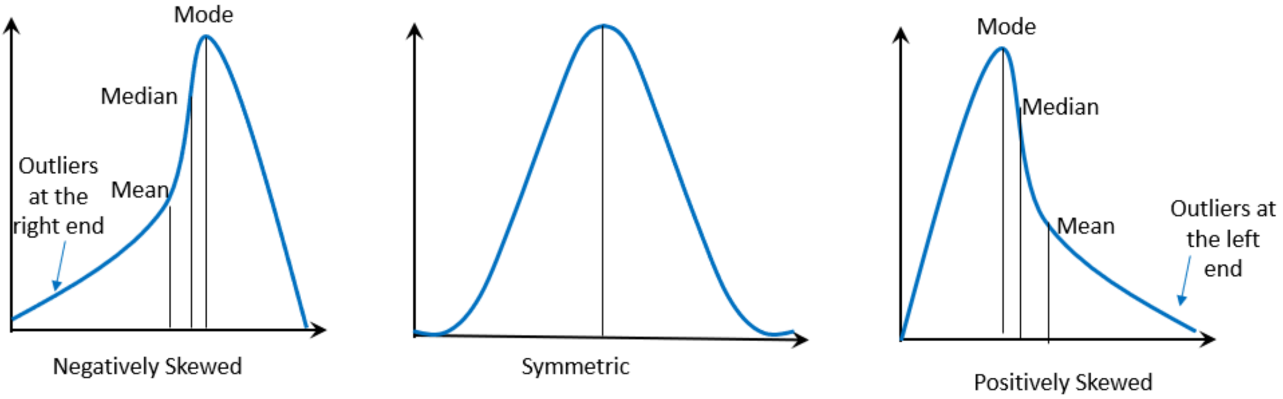
Classifications

- Symmetrical: Left and right halves are approximate mirror images, peak is in the centre
- Left-skewed: long left tail, peak to the right
- Right-skewed: long right tail, peak to the left

2. Measures of Central Tendency (or centre)

- use mean, median and mode are the measures of skewness to describe a distribution more precisely
- usual occurrence of mean, median and mode in the different types of distributions listed below (usually $\underline{\textit{but not always}}$ true)

$\text{Mean} < \text{Median} < \text{Mode}$ $\quad$ $\text{Mean} = \text{Median} = \text{Mode}$ $\quad$ $\text{Mode} < \text{Median} < \text{Mean}$



3. Spread

- **variability** of the distribution around their measures of central tendency using the measures of range and standard deviation
- "spread" across a wider range or higher frequency at the centre?

> *def:* the **range** of a data variable is the difference between the highest and lowest recorded data points

- may be misleading at times (give the wrong impression if we don't consider the distribution)

4. Outliers

> *def:* Outliers are observations that fall **well above or well below** the overall bulk of the data

- use our judgement or more precise calculation/plotting methods (i.e. using a box plot computation)

Why examine outliers?

1. to identify strong skew in a distribution
2. for identifying possible data collection and/or entry errors
3. providing interesting insights to the data

Key considerations

- mean may be affected as a result of outliers such that it **does not stand a good measure** of central tendency
- median and mode are called **robust statistics** (since outliers don't have effects on these)
    - robust to extreme observations (i.e. outliers) $\implies$ values at the endpoints are irrelevant to its calculation
- standard deviation may indicate the spread of value and hence may change drastically if there are many outliers
- may be worth repeating data analysis twice (to evaluate/provide some justifications to whether they should be dropped)
    - with outliers
    - without outliers (with them removed) $\implies$ should not be removed unnecessarily and may be a naive approach
- don't remove outliers if they have minimal effect on conclusions $\implies$ need to have good justifications to remove

Boxplots

- use a five-number summary to construct the box plot
    - Minimum (Q0)
    - Quartile 1 (Q1)
    - Median (Q2)
    - Quartile 3 (Q3)
    - Maximum (Q4)
- IQR is calculated using $Q3 - Q1$
    - find the **median** and then the median of upper and lower halves
    - computation of quartiles also differ in Excel (use a different computational algorithm)

Outlier definition in terms of statistics used

An Outlier is valid if it meets one of the two conditions:
$outlier > Q3 + (1.5 \times IQR) \vee outlier < Q1 - (1.5 \times IQR)$

Steps in constructing box plots

1. Draw a box from Q1 to Q3
2. Draw a vertical line in the box where the median is *(also can be labelled as Q2)*
3. Draw lines touching the box, as per the specifications below (a.k.a. *whiskers*)
    1. Extend a line from Q1 to the smallest value that is not an outlier (i.e. $value \geq Q1 - 1.5 \cdot IQR$)
    2. Extend the line also from Q3 to the largest value that is not an outlier (i.e. $value \leq Q3 - 1.5 \cdot IQR$)
4. Indicate outlier points with **dots** (using the considerations above).

5. Add the mean (indicated by X on the box plot), if necessary.
    1. can be added in excel

Describing Boxplots

- can obtain the "shape" of the plot
    - comparing the variability in the *upper versus lower halves* (i.e. below and above the median value) $\implies$ useful of **highlighting outliers, median & IQR**
    - i.e. is it right or left skewed, or is it a normal distribution?
- the **centre (median) is prominently shown** in a boxplot $\implies$ can compute relative positions of median to mean and determine if the distribution is left-skewed, right-skewed or normal etc.
- looking at the **spread**: not really meaningful on its own (need some basis of comparison)
    - are there many outliers? where do the outliers lie (nearer to Quartile 3??)
    - look at the trends over different time periods (by comparing box plots)

Histograms versus Boxplots

- Histogram provide a better sense of the **shape** of the distribution variable, especially when great differences in the frequencies in data points
- Boxplots are more useful
    - when comparing distributions of different datasets (of the same category to draw some conclusion $\implies$ trends)
    - identify and exhibit outliers clearly (dots are very apparent)
- Boxplots don't give information with how many data points there are *while histograms are able to show the frequencies*

D. Bivariate Data Analysis

- use analytical techniques to answer questions investigating relationships
- two-variable data (i.e. using two columns)
    - use other forms of visualization to pick up patterns

Can be done through a $\underline{combination}$ of

1. Scatter Plots - give idea of the pattern
2. combined with Correlation Coefficients - checks for linear r/s
3. Regression Analysis - fit a line or curve to the data

Relationships

Deterministic Relationships

> *def:* the value of one variable can be **determined exactly** if we know the value of the other variable in question. (and probably the function of computation, f)

- commonly represented by straight lines on a plot
    - i.e. Fahrenheit-Celsius conversion or Meter-Feet conversion

Non-deterministic Relationships

- is the main focus of this section
- often not possible for a statistical or non-deterministic relationship to find or approximate the value of one variable given another (i.e. not predictable)
    - associative relationship is used instead to describe how entities are linked to each other

Association between two variables

- natural variability exists in measurements of two variables
- average value of one of the variable can be described based on the value of the other variable

Scatter plots

- use if data points are patchy (lots of data)
- if not sure which is the independent and which is the dependent variable, then arbitrarily choose both

Describing Scatter Plots

when describing these plots **overall pattern** / the "general trend", we use a combination of:

- *Direction*
  - **Positive** Relationship: ↑ indep, ↑ dep variable (↑ explanatory, ↑ response)
  - **Negative** Relationship: ↑ indep, ↓ dep variable
- *Form*
  - its general shape (linear or non-linear/curve patterns) $\implies$ linear if it appear to scatter around a straight line
- *Strength*
  - description of ***how closely*** data follows the form (as described above)
  - do points deviate from the best fit curve or line?

i.e. Positive Linear relationship or Negative Non-linear relationship

and for deviations, we look at **outliers**.

Univariate data		Bivariate data	
Overall pattern	Deviation from the pattern	Overall pattern	Deviation from the pattern
1) Shape 2) Center 3) Spread	Outliers	1) Direction 2) Form 3) Strength	Outliers