Data Visualization Live Class

Data Viz Slide:

https://s3-us-west-2.amazonaws.com/secure.notion-static.com/49e1bf11-d6ac-48ca-93b8-bfe71e98fee9/Data_Viz_Slide.pdf

Chinook:

chinook.db

-การใช้ RStudio (Posit Desktop) อย่าลืมโหลดภาษา R ลงเครื่องด้วย

-Library ที่ต้องโหลด

1. tidyverse
2. RSQLite
3. RPostgreSQL
4. lubridate
5. janitor

-เราสามารถใช้ R ในการ Query ข้อมูลใน Database (แบบ SQL) ได้ และเราสามารถเก็บ Table ที่เรา Query ข้อมูลไว้ในตัวแปรได้ด้วย ทำให้สะดวกต่อการ Manipulate ข้อมูลด้วย dplyr

*ใช้ R ควบคู่กับ SQL จะยืดหยุ่นกว่าการใช้ Pure SQL และเราสามารถใช้ function เหล่านี้กับทุก Database

```
library(tidyverse)
library(RSQLite) #DBI
library(RPostgreSQL)
library(lubridate)
library(janitor)
```

```
##Connect Database
connection <- dbConnect(SQLite(), "chinook.db")

##List table name
dbListTables(connection)

##List fields in a table
dbListFields(connection, "customers")

##Query data by writing SQL Queries
df <- dbGetQuery(connection, "SELECT * FROM customers LIMIT 1

df %>%
  select(FirstName, LastName)

clean_df <- clean_names(df)
View(clean_df)

##Write JOIN syntax
df2 <- dbGetQuery(connection, "SELECT * FROM albums, artists
                               WHERE albums.artistid = artists
  clean_names()

##Write a table
dbWriteTable(connection, "cars", mtcars)
dbListTables(connection)

dbGetQuery(connection, "SELECT * FROM cars LIMIT 5")

##Remove a table
dbRemoveTable(connection, "cars")

##Close Connection
dbDisconnect(connection)
```

-PostgreSQL เป็นหนึ่งใน SQL ที่ได้รับความนิยมมากที่สุด

ElephantSQL (PostgreSQL as a Service): https://www.elephantsql.com/

-การเลือก Database ควรเลือก Database ที่อยู่ใกล้กับ User มากที่สุด เช่น User ของเราอยู่ที่ญี่ปุ่น ก็ควรตั้ง Database ที่ Region Tokyo เป็นต้น

Connecting PostgreSQL with R:

```
##Connecting with PostgreSQL
con <- dbConnect(PostgreSQL(),
                 host = "floppy.db.elephantsql.com",
                 port = 5432,
                 user = "ujcgydew",
                 pass = "vvh5YMY6I6i6I8FxuemPK_dvVafio2B8",
                 dbname = "ujcgydew")

#Write table
dbWriteTable(con, "cars", mtcars %>% slice(1:5))

#List table
dbListTables(con)

#Get query
dbGetQuery(con, "SELECT * FROM cars")

#Disconnect
dbDisconnect(con)
```

Working with date

```
#Working With Date
library(lubridate)
library(tidyverse)

#YYYY-MM-DD
date_df <- data.frame(
  x = c(
    "2023-02-25",
    "2023-02-26",
    "2023-02-27",
```

```
    "2023-02-28",
    "2023-03-01"))

date_df %>%
  mutate(date_x = ymd(x),
         year = year(date_x),
         month = month(date_x, label = TRUE, abbr = FALSE),
         day = day(date_x),
         wday = wday(date_x, label = TRUE, abbr = FALSE),
         week = week(date_x))

#Excel default USA date
date_df <- data.frame(
  x = c(
    "02/25/2023",
    "02/26/2023",
    "02/27/2023",
    "02/28/2023",
    "03/01/2023"))

date_df %>%
  mutate(date_x = mdy(x),
         year = year(date_x),
         month = month(date_x, label = TRUE, abbr = FALSE),
         day = day(date_x),
         wday = wday(date_x, label = TRUE, abbr = FALSE),
         week = week(date_x))

#Messy date format
date_df <- data.frame(
  x = c(
    "Feb 2023 - 25",
    "Feb 2023 - 26",
    "Feb 2023 - 27",
    "Mar 2023 - 9",
    "April 2023 - 1"))

date_df %>%
```

```
  mutate(date_x = myd(x),
         year = year(date_x),
         month = month(date_x, label = TRUE, abbr = FALSE),
         day = day(date_x),
         wday = wday(date_x, label = TRUE, abbr = FALSE),
         week = week(date_x))

convert_thai_to_eng_date <- function(year) {
  return(year - 543)
}
```

*ไม่ว่า Date Format จะเละแค่ไหนก็สามารถใช้ Lubridate เพื่อแก้ไขและ Extract วันเดือนปีออกมาได้ เหมือนทำด้วย Google Sheets / Excel

Skill Stacking > Specialization (การบูรณาการความรู้หลายเรื่องสำคัญกว่ารู้ลึกเรื่องเดียว)

ทำให้ได้ทุกเรื่องจะมีโอกาสในชีวิตมากกว่าเก่งแค่เรื่องเดียว

Data Visualization

-เราใช้ library ชื่อ ggplot2 เพื่อใช้ในการสร้าง Chart ที่ทำได้ง่ายกว่าและสวยกว่าการใช้ Base R

-ประเภทของข้อมูลมีผลต่อการเลือกใช้ Chart

-Histogram = The most common graph to show data distribution

-ggplot ไม่สามารถสร้าง 3D Chart ได้ สร้างได้แต่ 2D

-เราสามารถเก็บ chart ไว้ในตัวแปรได้

```
library(tidyverse)

#Data Viz
#ggplot = grammar of graphics

#Base R (Not beautiful and hard to use):
plot(mtcars$mpg, mtcars$hp, pch = 16, col = 'red')

boxplot(mtcars$mpg)

t1 <- table(mtcars$am)
barplot(t1)
```

```
hist(mtcars$mpg)

#ggplot (beautiful and easy to use):
ggplot(data = mtcars,
       mapping = aes(x = mpg)) +
  geom_histogram(bins = 10)

ggplot(data = mtcars,
       mapping = aes(x = mpg)) +
  geom_density()

ggplot(data = mtcars,
       mapping = aes(x = mpg)) +
  geom_freqpoly()

p1 <- ggplot(mtcars, aes(mpg)) +
  geom_histogram(bins = 5)

p2 <- ggplot(mtcars, aes(hp)) +
  geom_histogram(bins = 10)

mtcars %>%
  filter(hp <= 200) %>%
  count()

#Summary table before creating a bar chart
mtcars <- mtcars %>%
  mutate(am = ifelse(am == 0, "Auto", "Manual"))

View(mtcars)

#Approach 1 - Summary table + geom_col()
t2 <- mtcars %>%
  mutate(am = ifelse(am == 0, "Auto", "Manual")) %>%
  count(am)

ggplot(t2, aes(x = am, y = n)) +
```

```
  geom_col()

#Approach 2 - geom_bar()
ggplot(mtcars, aes(am)) +
  geom_bar()

#Two variables (numeric)
#Scatter plot
ggplot(mtcars, aes(x = hp, y = mpg)) +
  geom_point(col = 'red', size = 5)
```

*geom_col() ใช้กับ Summary Table ส่วน geom_bar() ใช้กับ Database ได้เลย

Diamonds database

```
library(tidyverse)

#Data frame -> diamonds
#Ordinal factor
temp <- c("high", "med", "low", "high")
temp <- factor(temp, levels = c("low", "med", "high"),
               ordered = TRUE)

#Categorical factor
gender <- c("m", "f", "nb")
gender <- factor(gender)

glimpse(diamonds)

#Frequency table
diamonds %>% count(cut, color, clarity)

#Sample
set.seed(42)
diamonds %>%
  sample_n(5)
```

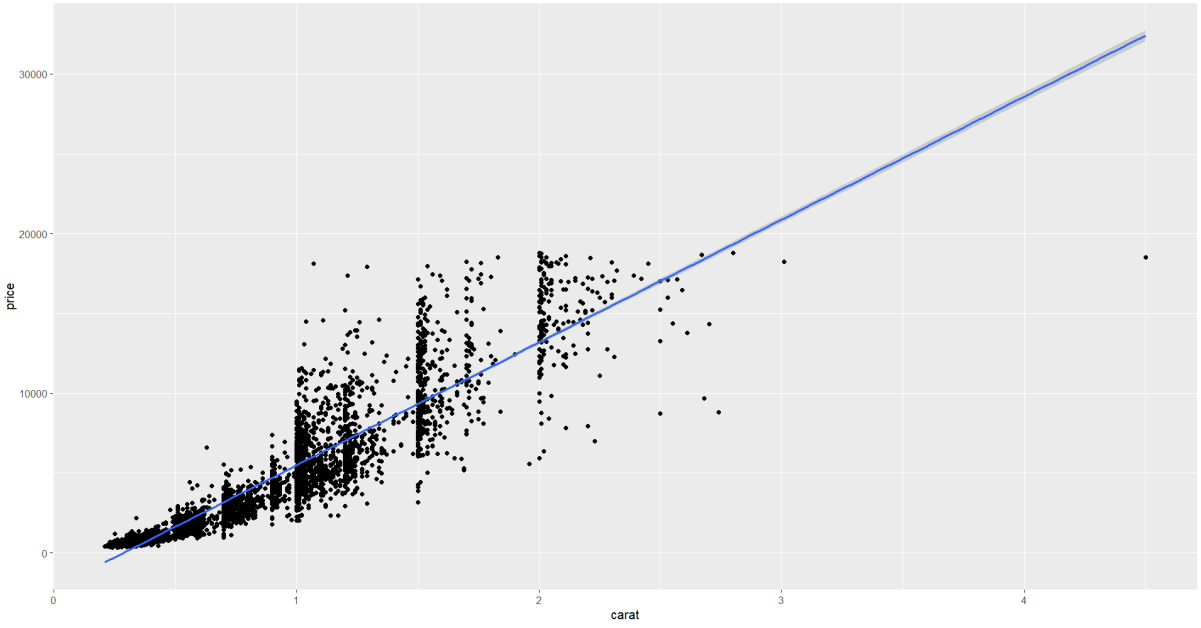
```
diamonds %>%
  sample_frac(0.1)

diamonds %>%
  slice(500:510)

#Relationship (Pattern)
p3 <- ggplot(diamonds %>% sample_n(500), aes(carat, price)) +
  geom_point() +
  geom_smooth(method = "loess") +
  geom_rug()

#Setting VS Mapping
colors()

#Setting (Manually set options)
ggplot(diamonds, aes(price)) +
  geom_histogram(bins = 100, fill = 'salmon')

ggplot(diamonds %>% sample_n(500),
       aes(carat, price)) +
  geom_point(size = 5, alpha = 0.2, col = 'red')

#Mapping (Occurs in aesthetic function)
ggplot(diamonds %>% sample_n(500),
       mapping = aes(carat, price, col = cut)) +
  geom_point(size = 5, alpha = 0.8) +
  theme_minimal() +
  labs(
    title = "Relationship between carat and price",
    x = "Carat",
    y = "Price (USD)",
    subtitle = "We found a positive relationship",
    caption = "Data source: diamonds (ggplot2)"
  ) +
  scale_color_brewer(type = "qual", palette = 1)
```

```
#Map color scale
ggplot(mtcars, aes(hp, mpg, col = wt)) +
  geom_point(size = 5, alpha = 0.7) +
  theme_minimal() +
  scale_color_gradient(low = "green", high = "red")

#Facet
ggplot(diamonds %>% sample_n(500),
       aes(carat, price)) +
  geom_point(alpha = 0.6) +
  geom_smooth(col = "red", fill = "gold") +
  theme_minimal() +
  facet_wrap( ~cut)

ggplot(diamonds %>% sample_n(500),
       aes(carat, price)) +
  geom_point(alpha = 0.6) +
  geom_smooth(col = "red", fill = "gold") +
  theme_minimal() +
  facet_grid(cut ~ color)

library(patchwork)
library(ggplot2)

p1 <- qplot(mpg, data = mtcars, geom = "histogram", bins = 10
p2 <- qplot(hp, mpg, data = mtcars, geom = "point")
p3 <- qplot(hp, data = mtcars, geom = "density")

p1 + p2 + p3
(p1 + p2) / p3
p1 / p2 / p3
p1 / (p2 + p3)
```

-ถ้าเจอข้อมูลมาก ๆ ให้ sample ข้อมูลมาก่อน เพื่อให้พอเห็นแนวโน้มของข้อมูลและเสียเวลาน้อยกว่าการเรียกใช้ข้อมูลทั้งหมด

*ggplot สามารถ plot graph ได้มากกว่า 1 graph ในรูปเดียวกันด้วยการ + ทับ

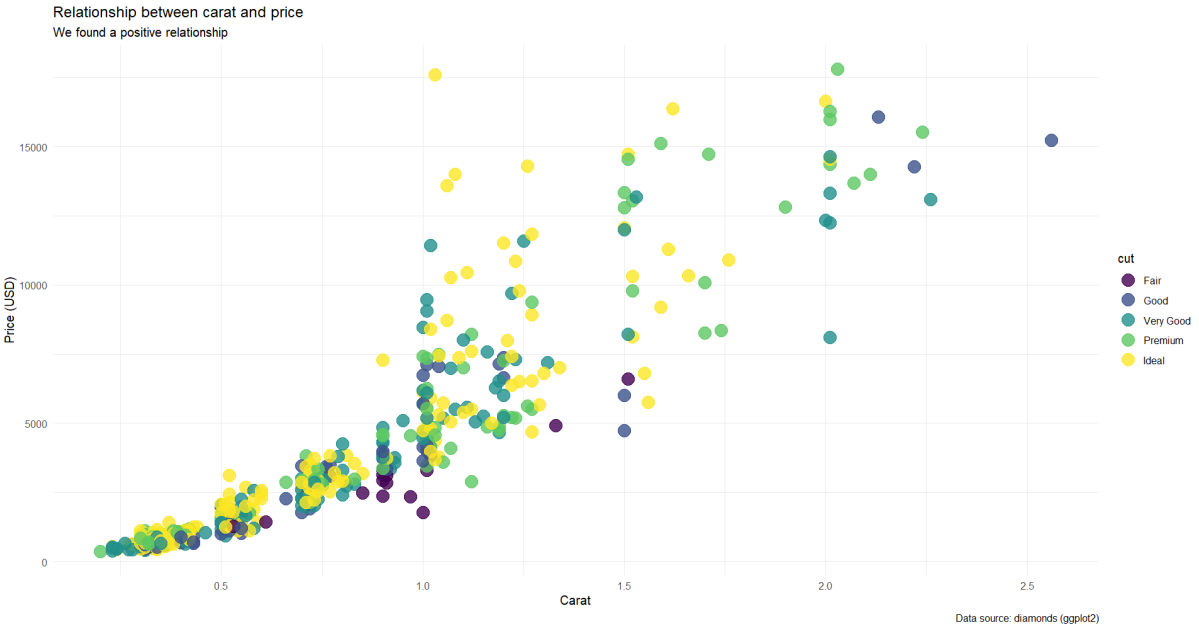
```
ggplot(diamonds %>% sample_n(5000), aes(carat, price)) +
  geom_point() +
  geom_smooth(method = "lm")
```



*การตีความ chart จะต้องเข้าใจ business context เช่น ยิ่งกะรัตของเพชรสูง ราคาก็ควรจะมีแนวโน้มเพิ่มขึ้น ไม่ใช่ลดลง เป็นต้น

-เราสามารถดึง Hex code มาใช้เติมสี chart ใน R ได้

```
ggplot(diamonds %>% sample_n(500),
       mapping = aes(carat, price, col = cut)) +
  geom_point(size = 5, alpha = 0.8) +
  theme_minimal() +
  labs(
    title = "Relationship between carat and price",
    x = "Carat",
    y = "Price (USD)",
    subtitle = "We found a positive relationship",
    caption = "Data source: diamonds (ggplot2)"
  )
```



*Setting = เราต้องเซ็ตออพชั่นต่าง ๆ เอง เช่นสีหรือรูปลักษณ์ แต่ Mapping = การเซ็ตออพชั่นอิงจาก column ใน Data Frame ซึ่งเราจะกำหนดในส่วนของ mapping (aes)

-เราสามารถเปลี่ยน Palette สีของการ Mapping ได้ด้วย scale เช่น:

```
#Manual
scale_color_manual(values = c(
    "red", "blue", "green", "gold", "salmon"
  ))

#Auto
scale_color_brewer(type = "qual", palette = 1)
```

เว็บ Color Palette Generator: https://coolors.co/

-การเปลี่ยนสี Chart เป็นสีพาสเทลจะทำให้ Chart ของเราดูสวยขึ้น

-facet ใช้แบ่ง Chart ของเราอิงจากค่าใน column ได้ เช่น:

```
facet_wrap( ~cut)
```

```
#facet_grid()
ggplot(diamonds %>% sample_n(500),
       aes(carat, price)) +
  geom_point(alpha = 0.6) +
  geom_smooth(col = "red", fill = "gold") +
  theme_minimal() +
  facet_grid(cut ~ color)
```

-Patchwork ช่วยในการรวม chart เข้าด้วยกัน

-qplot() = Chart แบบย่อ (Quickplot)

*พลังของความรู้ อยู่ที่การเลือกใช้เครื่องมือให้เหมาะสมกับงาน

Markdown

-เราสามารถสร้าง Report ได้ด้วย library ชื่อ rmarkdown

-# คือการทำให้เป็น Heading มี 6 ขนาด (ตั้งแต่ # ถึง ###### ยิ่ง # มาก ขนาดยิ่งน้อย)

-เราสามารถ knit Report ของเราเป็น HTML หรือ PDF ได้

-การ Insert R code chunk ให้กดปุ่มสีเขียว แล้วเลือก R

R Markdown cheat sheet:

https://s3-us-west-2.amazonaws.com/secure.notion-static.com/432aed0f-b733-4aa4-8a24-3903331e9e3c/rmarkdown-cheatsheet.pdf

```
## intro_sql_in_r.R
library(tidyverse)
library(RSQLite)
library(RPostgreSQL)
library(lubridate)
library(janitor)

## connect database
con <- dbConnect(SQLite(), "chinook.db")

## list table names
dbListTables(con)

## list fields in a table
dbListFields(con, "customers")

## write SQL queries
df <- dbGetQuery(con, "select * from customers limit 10")

clean_df <- clean_names(df)
View(clean_df)

## write JOIN syntax
df2 <- dbGetQuery(con, "select * from albums, artists
                  where albums.artistid = artists.artistid") %
  clean_names()

View(df2)

## write a table
dbWriteTable(con, "cars", mtcars)
```

```
dbListTables(con)

dbGetQuery(con, "select * from cars limit 5;")

## drop table cars
dbRemoveTable(con, "cars")

## close connection
dbDisconnect(con)

#####################################################################
## RPostgreSQL
library(RPostgreSQL)

## connect database
con <- dbConnect(PostgreSQL(),
          host = "floppy.db.elephantsql.com",
          port = 5432,
          user = "fzpjbbnm",
          pass = "MrENDQ1N7tqt7CHI-nLHeQOySJjgau9y",
          dbname = "fzpjbbnm")

## write table
dbWriteTable(con, "cars", mtcars %>% slice(1:5))

## list table
dbListTables(con)

## gety query
dbGetQuery(con, "select count(*) from cars")
dbGetQuery(con, "select * from cars")

## disconnect
dbDisconnect(con)

#####################################################################
lubridate
library(lubridate)
```

```
library(tidyverse)

## YYYY-MM-DD
date_df <- data.frame(
  x = c(
    "2023-02-25",
    "2023-02-26",
    "2023-02-27",
    "2023-02-28",
    "2023-03-01"))

date_df %>%
  mutate(date_x = ymd(x),
         year = year(date_x),
         month = month(date_x, label=TRUE, abbr=FALSE),
         day = day(date_x),
         wdat = wday(date_x, label=TRUE, abbr=FALSE),
         week = week(date_x))

## Excel default USA date
date_df <- data.frame(
  x = c(
    "02/25/2023",
    "02/26/2023",
    "02/27/2023",
    "02/28/2023",
    "09/09/2023"))

## MM/DD/YYYY
date_df %>%
  mutate(date_x = mdy(x),
         year = year(date_x),
         month = month(date_x, label=TRUE, abbr=FALSE),
         day = day(date_x),
         wdat = wday(date_x, label=TRUE, abbr=FALSE),
         week = week(date_x))

## Excel default USA date
```

```r
date_df <- data.frame(
  x = c(
    "Feb 2023 - 25",
    "Feb 2023 - 26",
    "Feb 2023 - 27",
    "Mar 2023 - 9",
    "April 2023 - 1"))

date_df %>%
  mutate(date_x = myd(x),
         year = year(date_x),
         month = month(date_x, label=TRUE, abbr=FALSE),
         day = day(date_x),
         wdat = wday(date_x, label=TRUE, abbr=FALSE),
         week = week(date_x))
##############################################################
library(tidyverse)

## data visualization
## ggplot => grammar of graphic

## base R visualization

ggplot(data = mtcars, mapping = aes(x=mpg)) +
  geom_histogram(bins =10)

ggplot(data = mtcars, mapping = aes(x=mpg)) +
  geom_density()

ggplot(data = mtcars, mapping = aes(x=mpg)) +
  geom_freqpoly()

## ย่อ code
p1 <- ggplot(mtcars, aes(mpg)) +
  geom_histogram(bins =5)

p2 <- ggplot(mtcars, aes(hp)) +
  geom_histogram(bins =10)
```

```
mtcars %>%
  filter(hp <= 200) %>%
  count()

## summary table before make bar chart
mtcars <- mtcars %>%
  mutate(am = ifelse(am == 0, "Auto", "Manual"))


## approach 01 - summary table + geom_col()
t2 <- mtcars %>%
  mutate(am = ifelse(am == 0, "Auto", "Manual")) %>%
  count(am)

ggplot(t2, aes(am, n)) +
  geom_col()

## approach 02 - geom_bar
ggplot(mtcars, aes(am)) +
  geom_bar()

## two variables, numeric
## scatter plot

ggplot(mtcars, aes(x=hp, y=mpg)) +
  geom_point(col="red", size=5) #setting



## ordinal factor
temp <- c("high", "med", "low", "high")
factor(temp, levels =c("low", "med", "high"), ordered = TRUE)

## categorical factor
gender <- c("m", "f", "m")
gender <- factor(gender)
```

```
## dataframe => diamonds

glimpse(diamonds)

## frequency table
diamonds %>%
  count(cut, color, clarity)

## sample
set.seed(42) ##lock ผลลัพธ์
diamonds %>%
  sample_n(5)

diamonds %>%
  sample_frac(0.1)

diamonds %>%
  slice(1:5)

##relationship (pattern)
p3 <- ggplot(diamonds %>% sample_n(500), aes(carat, price)) +
  geom_point() +
  geom_smooth(method = "loess") +
  geom_rug()

##setting vs. mapping
#setting
ggplot(diamonds, aes(price)) +
  geom_histogram(bins = 100, fill="#2585F9")

ggplot(diamonds %>% sample_n(500),
       aes(carat, price)) +
  geom_point(size=5, alpha=0.2, col="red")

#mapping
ggplot(diamonds %>% sample_n(500),
       mapping = aes(carat, price, col=cut)) +
```

```
  geom_point(size=5, alpha=0.5) +
  theme_minimal() +
  labs(
    title = "Relationship between carat and price",
    x = "Carat",
    y = "Price USD",
    subtitle = "We found a positive relationship",
    caption = "Datasource: diamonds ggplot2"
  ) +
  scale_color_manual(values = c(
    "red", "green","blue","gold","salmon"
  ))

##scale color
ggplot(diamonds %>% sample_n(500),
       mapping = aes(carat, price, col=cut)) +
  geom_point(size=5, alpha=0.5) +
  theme_minimal() +
  labs(
    title = "Relationship between carat and price",
    x = "Carat",
    y = "Price USD",
    subtitle = "We found a positive relationship",
    caption = "Datasource: diamonds ggplot2"
  ) +
  scale_color_brewer(type="div", palette = 4)

## map color scale
ggplot(mtcars, aes(hp, mpg, col=wt))+
  geom_point(size=5, alpha=0.7)+
  theme_minimal()+
  scale_color_gradient(low="gold", high="purple")
```

Homework

Explore Data Frame `diamonds` and create 5 visualizations.

```
title: "Homework Data Viz"
author: "Arnonnut M"
```

````
date: "2023-03-13"
output:
  html_document: default
  pdf_document: default
---

This is markdown language. Today we learn a few topics in R.

- database
- working with date
- ggplot2
- rmarkdown

## Homework
### Chart 1 Diamonds - Relationship between carat and price

```{r message=FALSE, warning=FALSE}
library(tidyverse)

```


```{r message=FALSE, warning=FALSE}
set.seed(10)
ggplot(diamonds %>% sample_n(500),
       mapping = aes(carat, price, col=cut)) +
  geom_point(size=2, alpha=0.6) +
  theme_minimal() +
  labs(
    title = "Relationship between carat and price",
    x = "Carat",
    y = "Price USD",
    subtitle = "We found a positive relationship",
    caption = "Data source : diamonds ggplot2"
  ) +
  scale_color_brewer(type="seq", palette = 4)
```

### Chart 2 found a positive relationship between two variabl
````

```{r message=FALSE, warning=FALSE}
ggplot(diamonds, mapping = aes(cut, fill=color))+
  geom_bar(position="fill")+
  theme_minimal()
```
Chart 3

```{r message=FALSE, warning=FALSE}
ggplot(diamonds %>% sample_n(5000), aes(carat, price)) +
  geom_point(alpha=0.5) +
  geom_smooth(col="red", fill="gold") +
  theme_minimal() +
  facet_grid(cut ~ color)
```

Comment what did we find in this chart?

[google](https://www.google.com)

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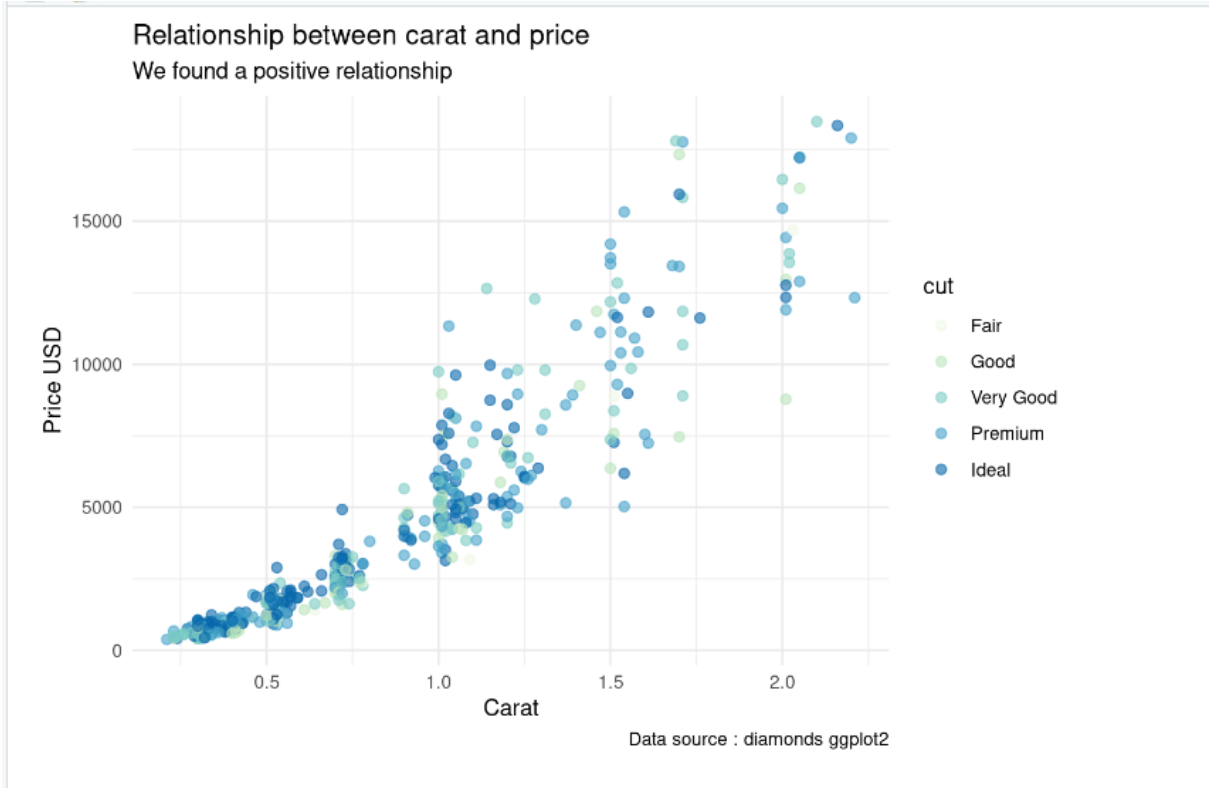
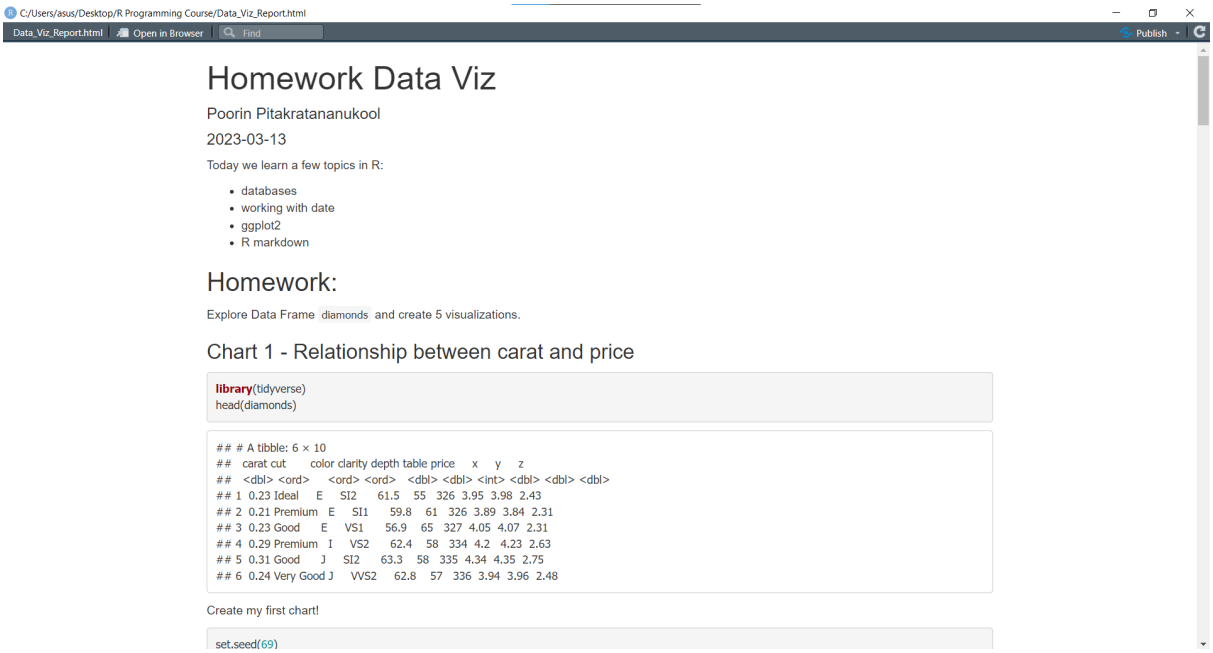

Relationship between carat and price
We found a positive relationship
Price USD
15000
10000
5000
0
0.5
1.0
1.5
2.0
Carat
cut
Fair
Good
Very Good
Premium
Ideal
Data source : diamonds ggplot2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Homework Data Viz
Poorin Pitakratananukool
2023-03-13
Today we learn a few topics in R:
databases
working with date
ggplot2
R markdown
Homework:
Explore Data Frame diamonds and create 5 visualizations.
Chart 1 - Relationship between carat and price
library(tidyverse)
head(diamonds)
A tibble: 6 × 10
carat cut color clarity depth table price x y z
<dbl> <ord> <ord> <ord> <dbl> <dbl> <int> <dbl> <dbl> <dbl>
1 0.23 Ideal E SI2 61.5 55 326 3.95 3.98 2.43
2 0.21 Premium E SI1 59.8 61 326 3.89 3.84 2.31
3 0.23 Good E VS1 56.9 65 327 4.05 4.07 2.31
4 0.29 Premium I VS2 62.4 58 334 4.2 4.23 2.63
5 0.31 Good J SI2 63.3 58 335 4.34 4.35 2.75
6 0.24 Very Good J VVS2 62.8 57 336 3.94 3.96 2.48
Create my first chart!
set.seed(69)

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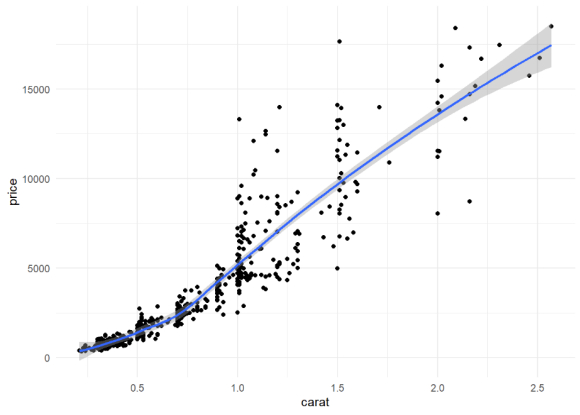
Create my first chart!

```
set.seed(69)
ggplot(diamonds %>% sample_n(500),
       aes(carat, price)) +
  geom_point() +
  geom_smooth() +
  theme_minimal()
```

```
## `geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



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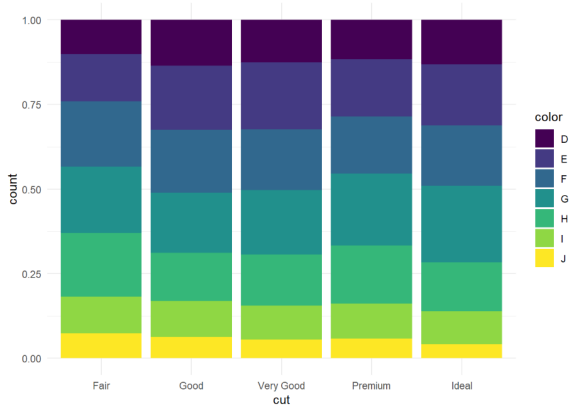
We found a positive relationship between two variables.

Another chart!

```
ggplot(diamonds, aes(cut, fill = color)) +
  geom_bar(position = "fill") +
  theme_minimal()
```



We found that diamonds with color [J] have the least quantity compared to other colors of diamonds.

R Markdown

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R Markdown

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Chart 2 - Relationship between color and price

```
set.seed(69)
ggplot(diamonds %>% sample_frac(0.1),
       aes(color, price)) +
  geom_col() +
  theme_minimal() +
  labs(
    title = "Relationship between color and price",
    x = "Color",
    y = "Price (USD)",
    subtitle = "We found that color G is the most expensive diamond of all colors.",
    caption = "Data source: diamonds (ggplot2)"
  )
```

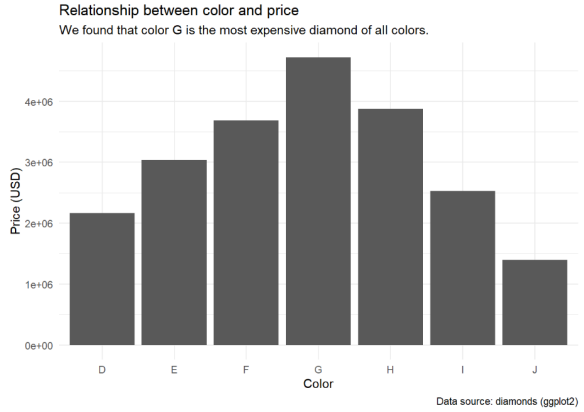


Chart 3 - Cut count for each clarity type

```
set.seed(69)
ggplot(diamonds %>% sample_frac(0.1),
       aes(cut, fill = clarity)) +
  geom_bar(position = "fill") +
  theme_minimal() +
  labs(
    title = "Cut count for each clarity type",
    x = "Cut",
    y = "Count in Percentage",
    subtitle = "SI1 is the most common clarity for each type of cut, and IF is the least common.",
    caption = "Data source: diamonds (ggplot2)"
  )
```

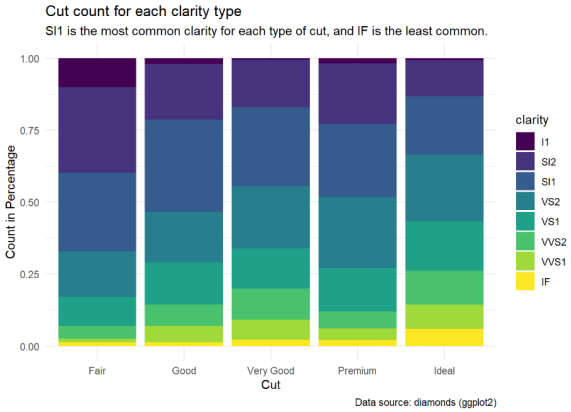


Chart 4 - Relationship between cut and price

```
set.seed(69)
ggplot(diamonds %>% sample_frac(0.1),
       aes(cut, price, fill = cut)) +
  geom_col() +
  theme_minimal() +
  labs(
    title = "Relationship between cut and price",
    x = "Cut",
    y = "Price (USD)",
    subtitle = "We found that Ideal cut is the most expensive of all cuts of diamonds.",
    caption = "Data source: diamonds (ggplot2)"
  )
```

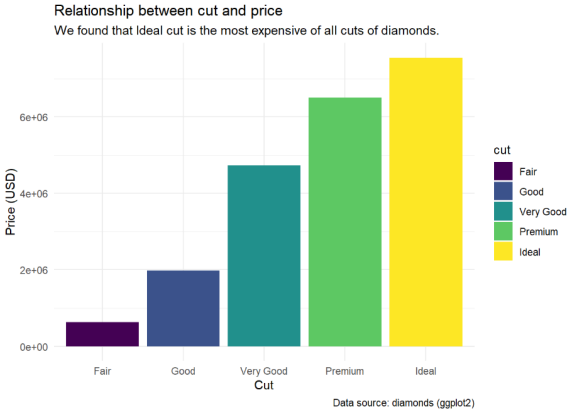
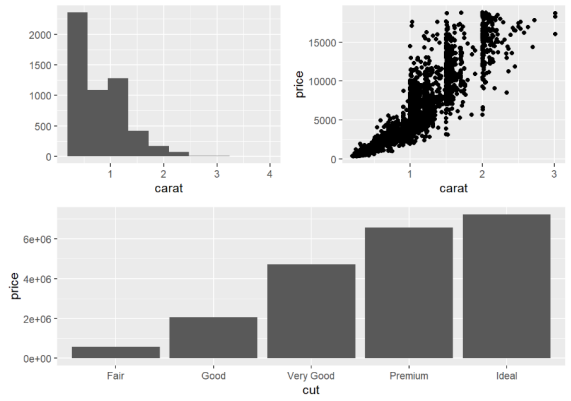


Chart 5 - Multiple charts in one board

```
library(patchwork)
p1 <- qplot(carat, data = diamonds %>% sample_frac(0.1), geom = "histogram", bins = 10)
p2 <- qplot(carat, price, data = diamonds %>% sample_frac(0.1), geom = "point")
p3 <- qplot(cut, price, data = diamonds %>% sample_frac(0.1), geom = "col")

((p1 + p2) / p3)
```



We found that:

1. The more carat a diamond has, the rarer it will be.
2. The more carat a diamond has, the more expensive it will be.
3. The cut quality of diamonds affects their price. The better quality diamonds are, the more expensive they will be.

In conclusion:

Diamonds with more carats are harder to find and are more expensive. Also, diamonds with better quality are more expensive.