Group4

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1 Preface

- Questions 1–3 were completed in the First Visualization assignment.
- Questions 4–6 are addressed in this report (First Analysis).

2 Data Preprocessing

2.1 Data Import and cleaning

```r
coffee <- read_csv("C:/Users/USER/Desktop/PBAwork/Final/psd_coffee.csv")

coffee_clean <- coffee |>
  filter(!is.na(Country), !is.na(Year))

coffee_clean <- coffee_clean |>
  mutate(across(where(is.numeric), ~ replace_na(.x, 0)))

coffee_clean <- coffee_clean |>
  mutate(across(where(is.numeric), ~ if_else(.x < 0, 0, .x)))

coffee_clean <- coffee_clean |>
  mutate(
    Net_Exports = Exports - Imports,
    Self_Sufficiency = Production / `Domestic Consumption`
  )

summary(coffee_clean)
```

```
   Country               Year      Arabica Production  Bean Exports
 Length:6016        Min.   :1960   Min.   :    0.0    Min.   :    0.0
 Class :character   1st Qu.:1976   1st Qu.:    0.0    1st Qu.:    0.0
 Mode  :character   Median :1992   Median :    0.0    Median :    4.0
                    Mean   :1992   Mean   :  744.3    Mean   :  814.6
                    3rd Qu.:2007   3rd Qu.:  200.0    3rd Qu.:  325.0
                    Max.   :2023   Max.   :49700.0    Max.   :41689.0

  Bean Imports     Beginning Stocks  Domestic Consumption Ending Stocks
 Min.   :    0.0   Min.   :    0.0   Min.   :    0        Min.   :    0.0
 1st Qu.:    0.0   1st Qu.:    0.0   1st Qu.:    0        1st Qu.:    0.0
 Median :    0.0   Median :    0.0   Median :   14        Median :    0.0
 Mean   :  372.7   Mean   :  457.2   Mean   :  673        Mean   :  449.4
 3rd Qu.:    0.0   3rd Qu.:   83.0   3rd Qu.:  227        3rd Qu.:   81.0
 Max.   :47000.0   Max.   :72461.0   Max.   :49070        Max.   :72461.0

    Exports           Imports        Other Production    Production
 Min.   :    0.0   Min.   :    0.0   Min.   :  0.000   Min.   :    0
 1st Qu.:    0.0   1st Qu.:    0.0   1st Qu.:  0.000   1st Qu.:    0
 Median :    9.0   Median :    0.0   Median :  0.000   Median :   21
 Mean   :  895.6   Mean   :  430.3   Mean   :  2.211   Mean   : 1131
 3rd Qu.:  439.0   3rd Qu.:    2.0   3rd Qu.:  0.000   3rd Qu.:  575
 Max.   :45675.0   Max.   :47000.0   Max.   :375.000   Max.   :69900

 Roast & Ground Exports Roast & Ground Imports Robusta Production
 Min.   :   0.00        Min.   :   0.00        Min.   :    0.0
```

```
1st Qu.:   0.00        1st Qu.:   0.00        1st Qu.:    0.0
Median :   0.00        Median :   0.00        Median :    0.0
Mean   :  13.16        Mean   :  10.65        Mean   :  383.9
3rd Qu.:   0.00        3rd Qu.:   0.00        3rd Qu.:   27.0
Max.   :2975.00        Max.   :1060.00        Max.   :30480.0

Rst,Ground Dom. Consum Soluble Dom. Cons. Soluble Exports  Soluble Imports
Min.   :    0.0        Min.   :   0.00    Min.   :   0.0   Min.   :   0.00
1st Qu.:    0.0        1st Qu.:   0.00    1st Qu.:   0.0   1st Qu.:   0.00
Median :   11.0        Median :   0.00    Median :   0.0   Median :   0.00
Mean   :  588.5        Mean   :  84.51    Mean   :  67.9   Mean   :  46.05
3rd Qu.:  188.2        3rd Qu.:   1.00    3rd Qu.:   0.0   3rd Qu.:   0.00
Max.   :47010.0        Max.   :6745.00    Max.   :4300.0   Max.   :6000.00

Total Distribution  Total Supply    Net_Exports       Self_Sufficiency
Min.   :    0      Min.   :    0   Min.   :-43970.0   Min.   : 0.00
1st Qu.:    0      1st Qu.:    0   1st Qu.:     0.0   1st Qu.: 1.00
Median :  112      Median :  112   Median :     1.0   Median : 3.20
Mean   : 2018      Mean   : 2018   Mean   :   465.3   Mean   :  Inf
3rd Qu.: 1105      3rd Qu.: 1105   3rd Qu.:   341.5   3rd Qu.:12.29
Max.   :97806      Max.   :97806   Max.   : 45603.0   Max.   :  Inf
                                                      NA's   :1948
```

3 Question 1

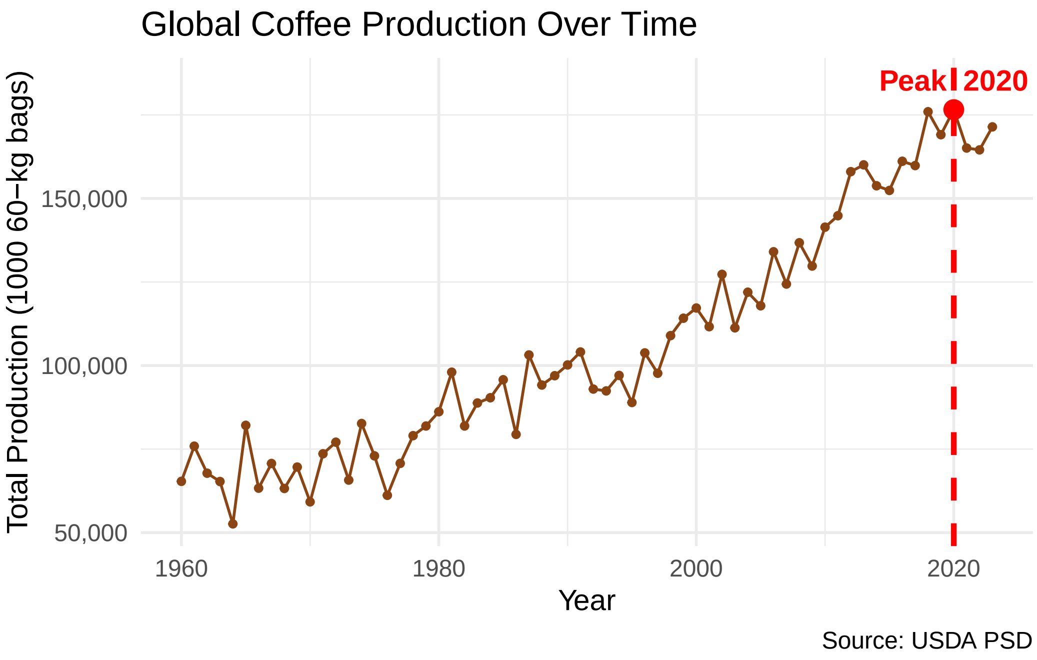
3.1 Has global coffee production increased over time? In which year did it reach its peak?

```r
global_production <- coffee_clean |>
  group_by(Year) |>
  summarise(Total_Production = sum(Production, na.rm = TRUE))

peak_year <- global_production |>
  filter(Total_Production == max(Total_Production))

plot1 <- ggplot(data = global_production,
                mapping = aes(x = Year, y = Total_Production)) +
  geom_line(color = "#8B4513", linewidth = 0.5) +
  geom_point(color = "#8B4513", size = 1) +
  geom_vline(xintercept = peak_year$Year,
             linetype = "dashed",
             color = "red",
             linewidth = 1) +
  geom_point(data = peak_year,
             aes(x = Year, y = Total_Production),
             color = "red",
             size = 3) +
  annotate("text",
           x = peak_year$Year,
           y = peak_year$Total_Production * 1.05,
           label = paste0("Peak  ", peak_year$Year),
           color = "red",
           fontface = "bold") +
  scale_y_continuous(labels = comma) +
  labs(
    title = "Global Coffee Production Over Time",
    x = "Year",
    y = "Total Production (1000 60-kg bags)",
    caption = "Source: USDA PSD"
  ) +
  theme_minimal()

print(plot1)
```



Global coffee production has shown a steady upward trend from 1960 to 2023, reflecting continuous expansion in global supply and cultivation capacity. The production reached its historical peak in 2020, at approximately 170 million 60-kg bags.

4 Question 2

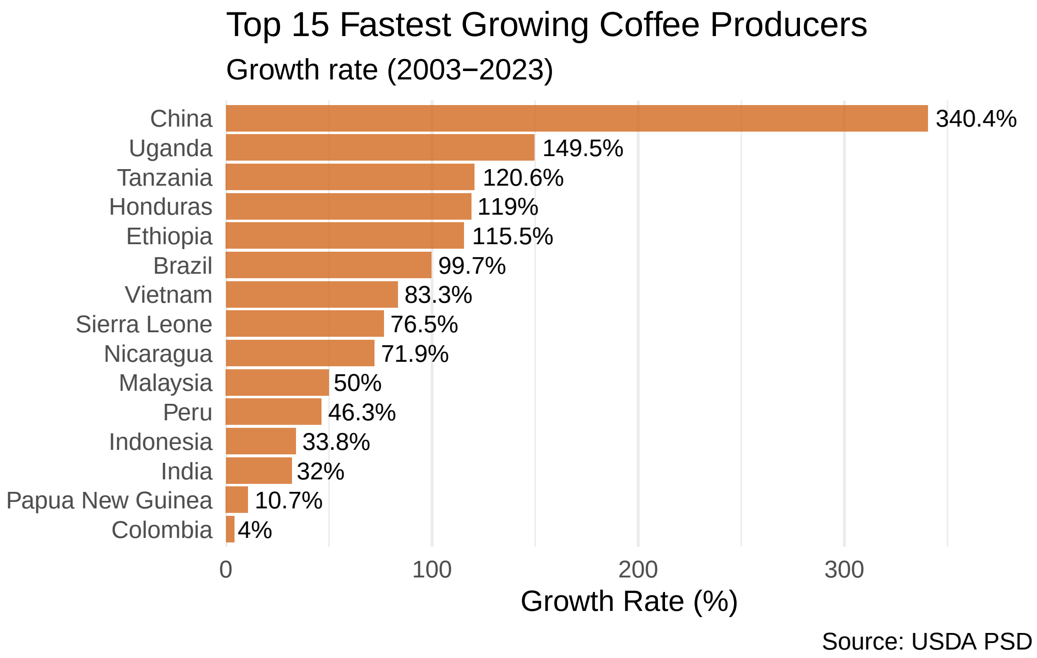
4.1 Which countries have shown the fastest growth in coffee production over the past 20 years?

```
max_year <- max(coffee_clean$Year, na.rm = TRUE)
start_year <- max_year - 20

country_growth <- coffee_clean |>
  filter(Year >= start_year, Year <= max_year) |>
  group_by(Country) |>
  summarise(
    First_Production = Production[Year == min(Year)][1],
    Last_Production = Production[Year == max(Year)][1],
    .groups = "drop"
  ) |>
  filter(First_Production > 0) |>
  mutate(
    Growth_Rate = ((Last_Production - First_Production) / First_Production) * 100
  ) |>
  filter(Growth_Rate > 0) |>
  arrange(desc(Growth_Rate)) |>
  head(15)

plot2 <- ggplot(data = country_growth,
                mapping = aes(x = reorder(Country, Growth_Rate),
                              y = Growth_Rate)) +
  geom_col(fill = "#D2691E", alpha = 0.8) +
  geom_text(aes(label = paste0(round(Growth_Rate, 1), "%")),
            hjust = -0.1,
            size = 3) +
  coord_flip() +
  scale_y_continuous(expand = expansion(mult = c(0, 0.15))) +
  labs(
    title = "Top 15 Fastest Growing Coffee Producers",
    subtitle = paste0("Growth rate (", start_year, "-", max_year, ")"),
    x = NULL,
    y = "Growth Rate (%)",
    caption = "Source: USDA PSD"
  ) +
  theme_minimal() +
  theme(
    panel.grid.major.y = element_blank()
  )

print(plot2)
```



Top 15 Fastest Growing Coffee Producers

Growth rate (2003−2023)

Source: USDA PSD

Over the past two decades, China has emerged as the fastest-growing coffee producer, with an exceptional 340% increase in output. Other countries showing strong expansion include Uganda, Tanzania, and Honduras, each exceeding 100% growth. This reflects the rapid development of coffee cultivation in Asia and Africa, reshaping the global coffee supply landscape.

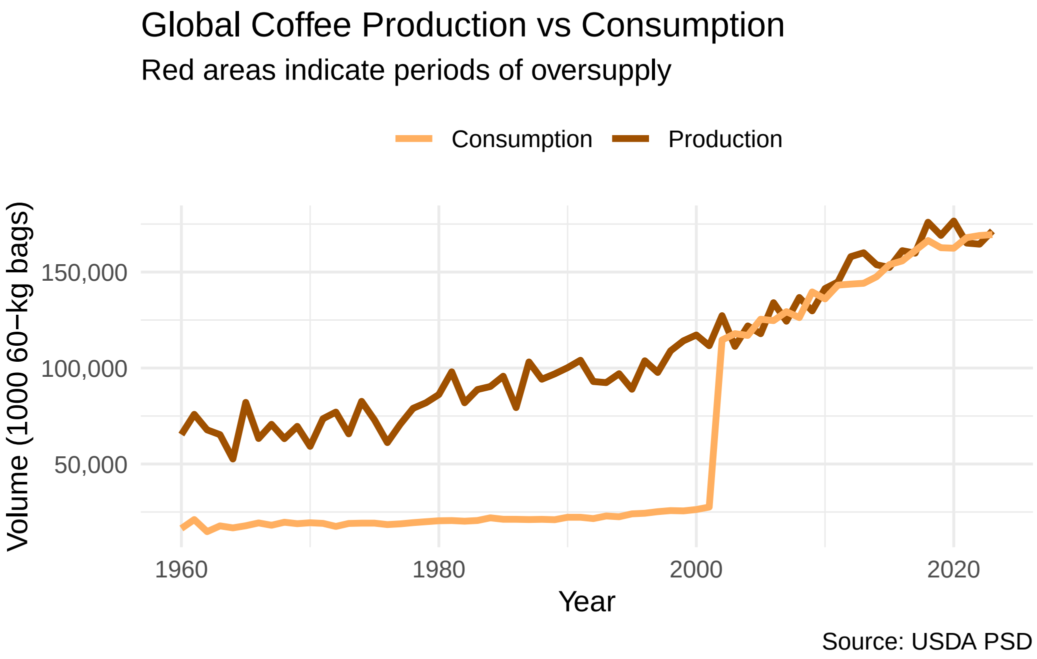
5 Question 3

5.1 Is production and consumption balanced over time? Are there periods of oversupply?

```r
global_balance <- coffee_clean |>
  group_by(Year) |>
  summarise(
    Production = sum(Production, na.rm = TRUE),
    Consumption = sum(`Domestic Consumption`, na.rm = TRUE),
    .groups = "drop"
  ) |>
  mutate(
    Gap = Production - Consumption
  )

plot3 <- ggplot(data = global_balance,
                mapping = aes(x = Year)) +
  geom_line(aes(y = Production, color = "Production"), linewidth = 1.2) +
  geom_line(aes(y = Consumption, color = "Consumption"), linewidth = 1.2) +
  scale_color_manual(values = c("Production" = "#9F5000",
                                "Consumption" = "#FFAF60")) +
  scale_y_continuous(labels = comma) +
  labs(
    title = "Global Coffee Production vs Consumption",
    subtitle = "Red areas indicate periods of oversupply",
    x = "Year",
    y = "Volume (1000 60-kg bags)",
    color = NULL,
    caption = "Source: USDA PSD"
  ) +
  theme_minimal() +
  theme(
    legend.position = "top"
  )

print(plot3)
```



Global coffee production and consumption have both increased steadily over time, with production generally outpacing consumption. Notable periods of oversupply appear after the early 2000s, when production began to grow more rapidly, creating occasional supply surpluses in the global market.

6 Question 4

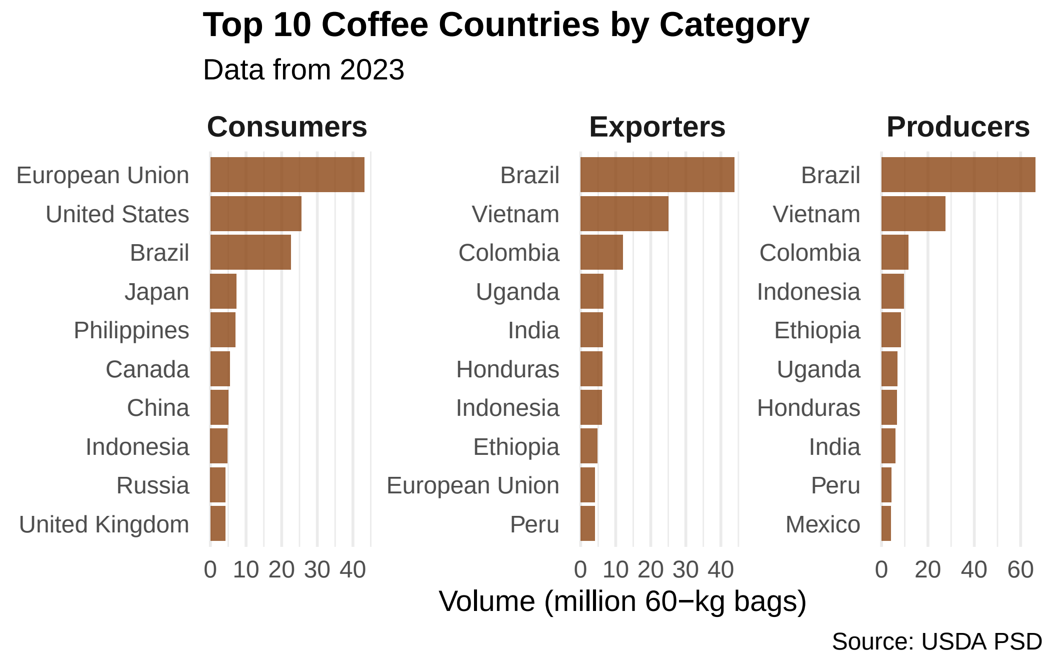
6.1 Which countries are the largest coffee consumers, exporters, and producers?

```
latest_year <- max(coffee_clean$Year, na.rm = TRUE)

top_countries <- coffee_clean |>
  filter(Year == latest_year) |>
  select(Country, Production, `Domestic Consumption`, Exports) |>
  pivot_longer(cols = c(Production, `Domestic Consumption`, Exports),
               names_to = "Category",
               values_to = "Volume") |>
  group_by(Category) |>
  slice_max(order_by = Volume, n = 10) |>
  ungroup()

top_countries <- top_countries |>
  mutate(Category = case_when(
    Category == "Production" ~ "Producers",
    Category == "Domestic Consumption" ~ "Consumers",
    Category == "Exports" ~ "Exporters"
    ),
    Country = reorder_within(Country, Volume, Category),
    Volume_million = Volume / 1000
  )

plot4 <- ggplot(data = top_countries,
                mapping = aes(x = Country, y = Volume_million)) +
  geom_col(fill = "#8B4513", alpha = 0.8) +
  coord_flip() +
  facet_wrap(~ Category, scales = "free") +
  scale_x_reordered() +
  scale_y_continuous(labels = comma) +
  labs(
    title = "Top 10 Coffee Countries by Category",
    subtitle = paste0("Data from ", latest_year),
    x = NULL,
    y = "Volume (million 60-kg bags)",
    caption = "Source: USDA PSD"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(face = "bold"),
    panel.grid.major.y = element_blank(),
    strip.text = element_text(face = "bold", size = 11)
  )
print(plot4)
```



Top 10 Coffee Countries by Category

Data from 2023

Consumers

Exporters

Producers

Source: USDA PSD

The largest coffee consumers in 2023 are primarily high-income regions, led by the European Union and the United States. In contrast, the biggest producers and exporters are mainly developing, tropical countries—Brazil, Vietnam, and Colombia dominate both categories. This highlights a clear global pattern: Coffee is mostly produced in the Global South but consumed in the Global North.

7 Question 5

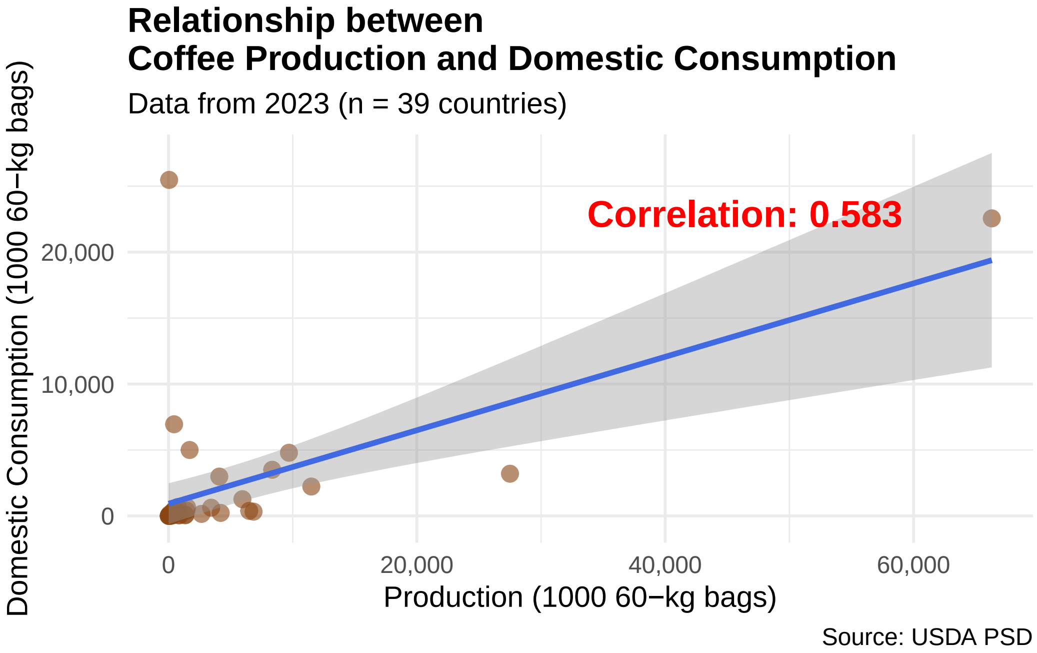
7.1 Is there a positive correlation between coffee production and domestic consumption?

```
production_consumption <- coffee_clean |>
  filter(Year == latest_year) |>
  select(Country, Production, Consumption = `Domestic Consumption`) |>
  filter(Production > 0, Consumption > 0)

correlation <- cor(production_consumption$Production,
                   production_consumption$Consumption,
                   use = "complete.obs")

plot5 <- ggplot(data = production_consumption,
                mapping = aes(x = Production, y = Consumption)) +
  geom_point(alpha = 0.6, color = "#8B4513", size = 2.5) +
  geom_smooth(method = "lm", color = "#4169E1", se = TRUE) +
  scale_x_continuous(labels = comma) +
  scale_y_continuous(labels = comma) +
  annotate("text",
           x = max(production_consumption$Production) * 0.7,
           y = max(production_consumption$Consumption) * 0.9,
           label = paste0("Correlation: ", round(correlation, 3)),
           color = "red",
           fontface = "bold",
           size = 5) +
  labs(
    title = "Relationship between \nCoffee Production and Domestic Consumption",
    subtitle = paste0("Data from ", latest_year,
                      " (n = ", nrow(production_consumption), " countries)"),
    x = "Production (1000 60-kg bags)",
    y = "Domestic Consumption (1000 60-kg bags)",
    caption = "Source: USDA PSD"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(face = "bold")
  )

print(plot5)
```



There is a moderate positive correlation between coffee production and domestic consumption (r = 0.58). Countries that produce more coffee tend to consume more as well, but the relationship is not very strong—indicating that many major producers export most of their output rather than consuming it domestically.

8 Question 6

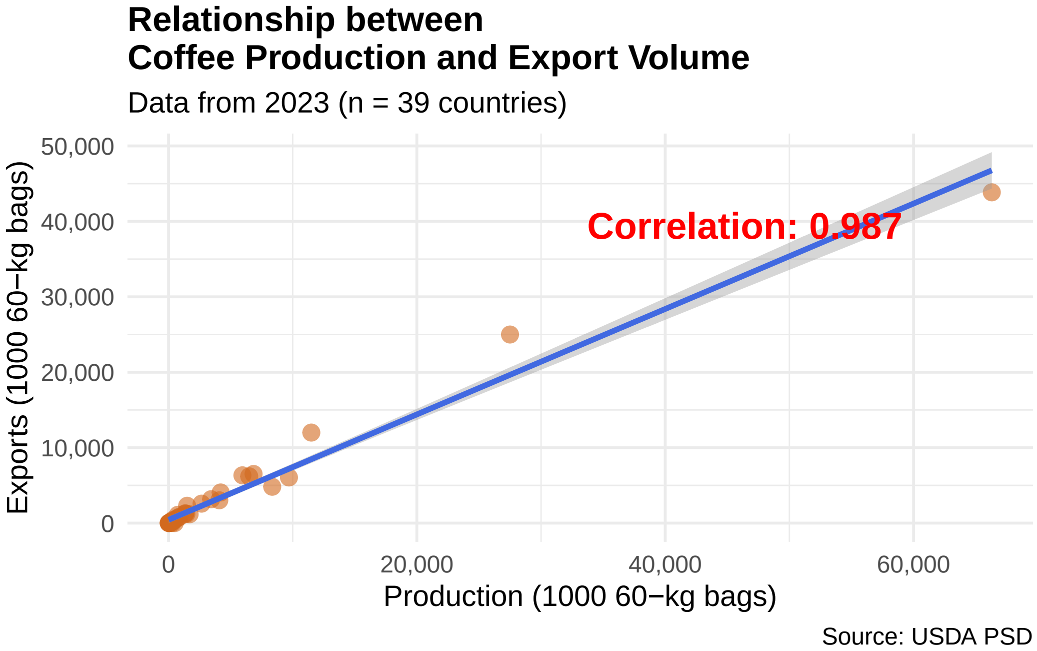
8.1 How strong is the relationship between export volume and production volume?

```r
export_production <- coffee_clean |>
  filter(Year == latest_year) |>
  select(Country, Production, Exports) |>
  filter(Production > 0, Exports > 0)

correlation_export <- cor(export_production$Production,
                          export_production$Exports,
                          use = "complete.obs")

plot6 <- ggplot(data = export_production,
                mapping = aes(x = Production, y = Exports)) +
  geom_point(alpha = 0.6, color = "#D2691E", size = 2.5) +
  geom_smooth(method = "lm", color = "#4169E1", se = TRUE) +
  scale_x_continuous(labels = comma) +
  scale_y_continuous(labels = comma) +
  annotate("text",
           x = max(export_production$Production) * 0.7,
           y = max(export_production$Exports) * 0.9,
           label = paste0("Correlation: ", round(correlation_export, 3)),
           color = "red",
           fontface = "bold",
           size = 5) +
  labs(
    title = "Relationship between \nCoffee Production and Export Volume",
    subtitle = paste0("Data from ", latest_year, " (n = ", nrow(export_production), " countr
    x = "Production (1000 60-kg bags)",
    y = "Exports (1000 60-kg bags)",
    caption = "Source: USDA PSD"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(face = "bold")
  )

print(plot6)
```



There is an extremely strong positive relationship between coffee production and export volume (r = 0.987). Countries that produce more coffee almost always export more as well, showing that most major producers are highly export-oriented.

9 Github repo URL

The GitHub URL I submitted last time was: https://github.com/ophelia0207/PBA_DataAnalysisProject

However, I applied for the GitHub Education Pack using a different account this time, so the previous link is no longer valid. The project has been moved to the new repository: **https://github.com/OpheliaLiu-0207/PBA_DataAnalysisProject**

All the work from the previous assignment has also been transferred to this new link.