wheat

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```
# ------------------------------------------------------------------------
# Setup chunk for R Markdown
# ------------------------------------------------------------------------
knitr::opts_chunk$set(echo = TRUE, warning = FALSE, message = FALSE)
```

```
# ------------------------------------------------------------------------
# Check if packages are installed; if not, install them
# ------------------------------------------------------------------------
required_packages <- c("ggplot2", "dplyr")
for(p in required_packages){
  if(!requireNamespace(p, quietly = TRUE)){
    install.packages(p)
  }
}

library(ggplot2)
library(dplyr)
```

```
# ------------------------------------------------------------------------
# Load data
# ------------------------------------------------------------------------
df <- read.csv("data/Wheat.csv", header = TRUE)

# Inspect structure
str(df)
```

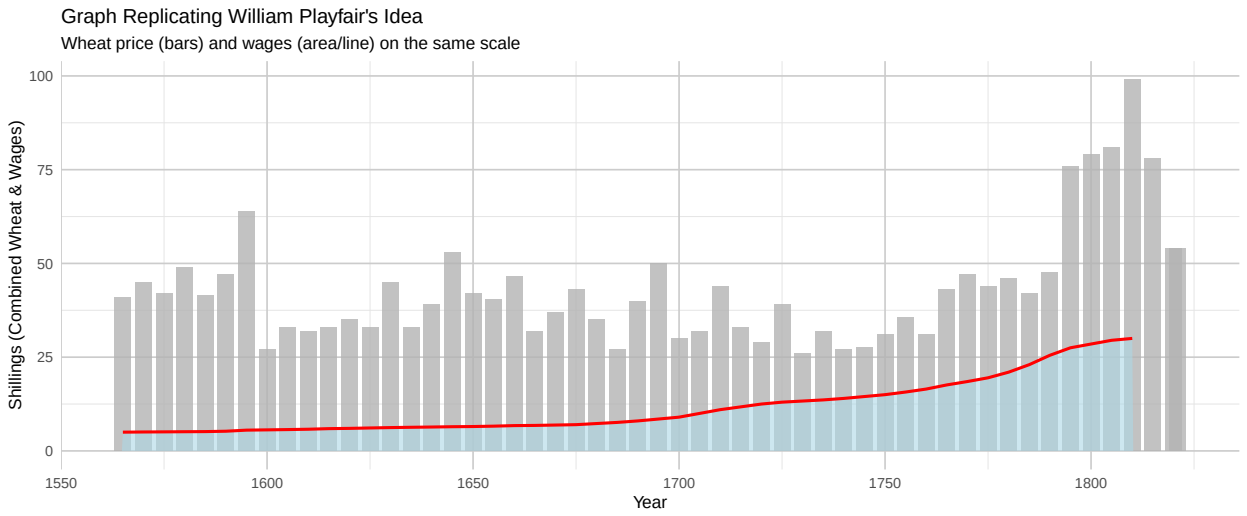
```
## 'data.frame':    53 obs. of  4 variables:
##  $ rownames: int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Year    : int  1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 ...
##  $ Wheat   : num  41 45 42 49 41.5 47 64 27 33 32 ...
##  $ Wages   : num  5 5.05 5.08 5.12 5.15 5.25 5.54 5.61 5.69 5.78 ...
```

```
# ------------------------------------------------------------------------
# Create a data frame of monarch reigns (for background shading)
# ------------------------------------------------------------------------
monarch_df <- data.frame(
  name = c("Elizabeth", "James I", "Charles I", "Cromwell",
           "Charles II", "James II", "W&M", "Anne",
           "George I", "George II", "George III", "George IV"),
  start = c(1565, 1603, 1625, 1649,
            1660, 1685, 1689, 1702,
```

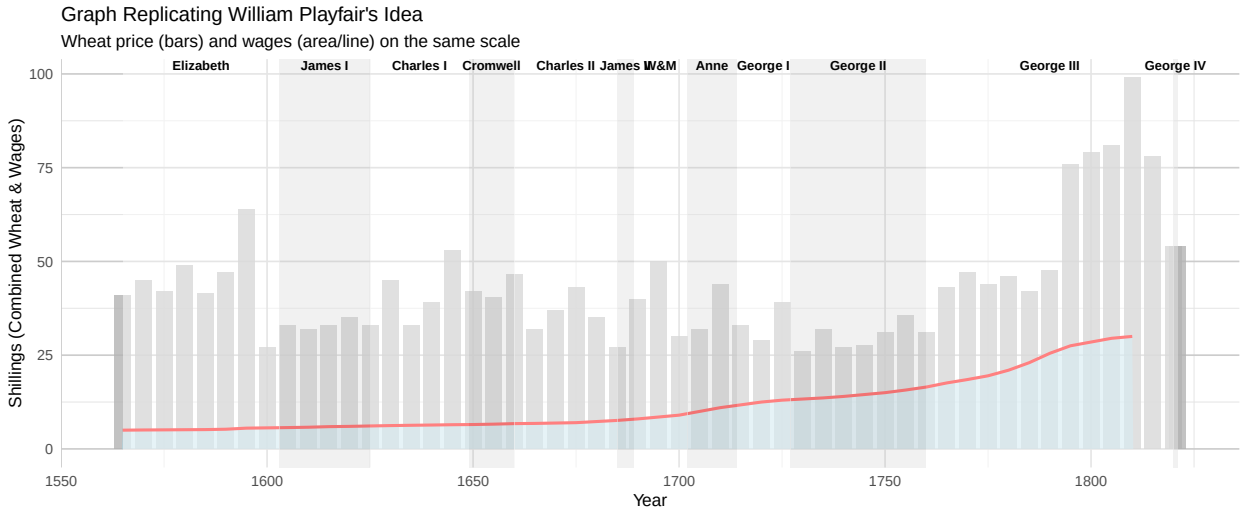
```
            1714, 1727, 1760, 1820),
  end   = c(1603, 1625, 1649, 1660,
            1685, 1689, 1702, 1714,
            1727, 1760, 1820, 1821)
)

monarch_df$fill_color <- ifelse(
  seq_len(nrow(monarch_df)) %% 2 == 1,
  "white",
  "gray90"
)
```

```
# ------------------------------------------------------------------
# Minimalistic theme
# ------------------------------------------------------------------
theme_playfair <- theme_minimal(base_size = 12) +
  theme(
    panel.grid.major = element_line(color = "grey80"),
    panel.grid.minor = element_line(color = "grey90")
  )
```

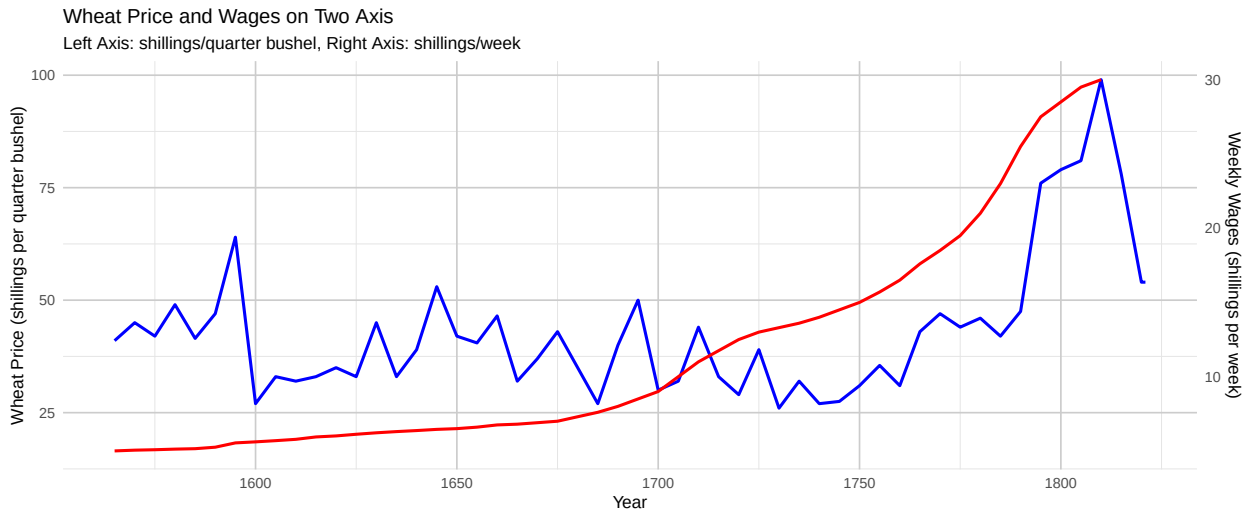
```
# ------------------------------------------------------------------
# First Plot (Bars for Wheat, Area & Line for Wages)
# ------------------------------------------------------------------
g1 <- ggplot(df, aes(x = Year)) +
  # Bars for Wheat prices
  geom_bar(
    aes(y = Wheat),
    stat = "identity",
    fill = "grey70",
    width = 4,
    alpha = 0.8
  ) +
  # Area for Wages
  geom_area(aes(y = Wages), fill = "lightblue", alpha = 0.6) +
  # Red line on top of the area for Wages
  geom_line(aes(y = Wages), color = "red", linewidth = 1) +
  labs(
    x = "Year",
    y = "Shillings (Combined Wheat & Wages)",
    title = "Graph Replicating William Playfair's Idea",
    subtitle = "Wheat price (bars) and wages (area/line) on the same scale"
  ) +
  theme_playfair

print(g1)
```



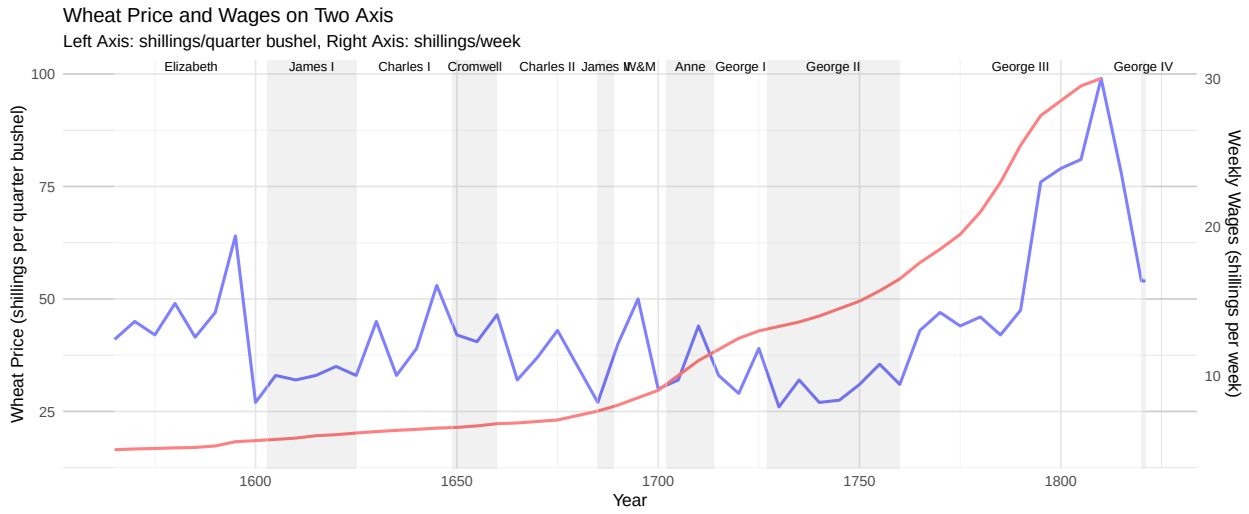

```
# Add monarch backgrounds and labels
g1 <- g1 +
  geom_rect(
    data = monarch_df,
    aes(
      xmin = start,
      xmax = end,
      ymin = -Inf,
      ymax = Inf,
      fill = fill_color
    ),
    inherit.aes = FALSE,
    alpha = 0.5,
    color = NA
  ) +
  scale_fill_identity() +
  geom_text(
    data = monarch_df,
    aes(
      x = (start + end)/2,
      y = Inf,
      label = name
    ),
    inherit.aes = FALSE,
    vjust = 1.2,
    size = 3,
    color = "black",
    fontface = "bold"
  )

print(g1)
```



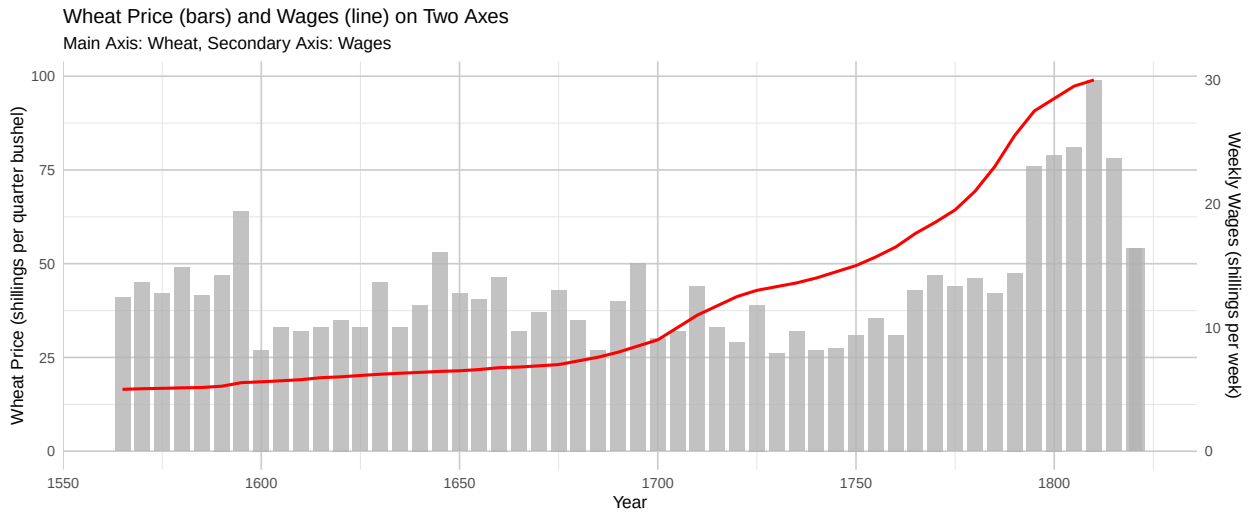

```r
# ------------------------------------------------------------------------
# Second Plot with Two Axes (Wheat vs. Wages)
# ------------------------------------------------------------------------

# Calculate scaling factor
scale_factor <- max(df$Wheat, na.rm = TRUE) / max(df$Wages, na.rm = TRUE)

g2 <- ggplot(df, aes(x = Year)) +
  geom_line(aes(y = Wheat), color = "blue", size = 1) +
  geom_line(aes(y = Wages * scale_factor), color = "red", size = 1) +
  scale_y_continuous(
    name = "Wheat Price (shillings per quarter bushel)",
    sec.axis = sec_axis(
      trans = ~ . / scale_factor,
      name = "Weekly Wages (shillings per week)"
    )
  ) +
  labs(
    x = "Year",
    title = "Wheat Price and Wages on Two Axis",
    subtitle = "Left Axis: shillings/quarter bushel, Right Axis: shillings/week"
  ) +
  theme_playfair

print(g2)
```



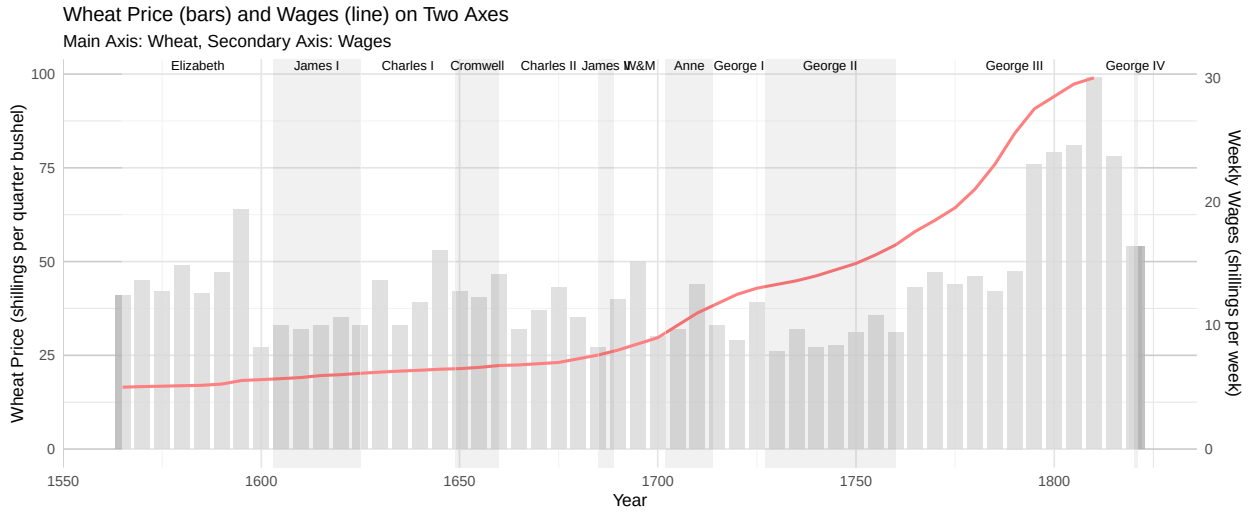

```
# Add monarch backgrounds and labels
g2 <- g2 +
  geom_rect(
    data = monarch_df,
    aes(xmin = start, xmax = end, ymin = -Inf, ymax = Inf, fill = fill_color),
    alpha = 0.5,
    inherit.aes = FALSE
  ) +
  scale_fill_identity() +
  geom_text(
    data = monarch_df,
    aes(x = (start + end)/2, y = Inf, label = name),
    inherit.aes = FALSE,
    vjust = 1.2,
    size = 3
  )

print(g2)
```



```r
# ------------------------------------------------------------------------
# Third Plot: Bars for Wheat, Line for Wages on Two Axes
# ------------------------------------------------------------------------

scale_factor <- max(df$Wheat, na.rm = TRUE) / max(df$Wages, na.rm = TRUE)

g2b <- ggplot(df, aes(x = Year)) +
  geom_bar(
    aes(y = Wheat),
    stat = "identity",
    width = 4,
    fill = "grey70",
    alpha = 0.8
  ) +
  geom_line(
    aes(y = Wages * scale_factor),
    color = "red",
    size = 1
  ) +
  scale_y_continuous(
    name = "Wheat Price (shillings per quarter bushel)",
    sec.axis = sec_axis(
      trans = ~ . / scale_factor,
      name = "Weekly Wages (shillings per week)"
    )
  ) +
  labs(
    x = "Year",
    title = "Wheat Price (bars) and Wages (line) on Two Axes",
    subtitle = "Main Axis: Wheat, Secondary Axis: Wages"
  ) +
  theme_playfair

print(g2b)
```

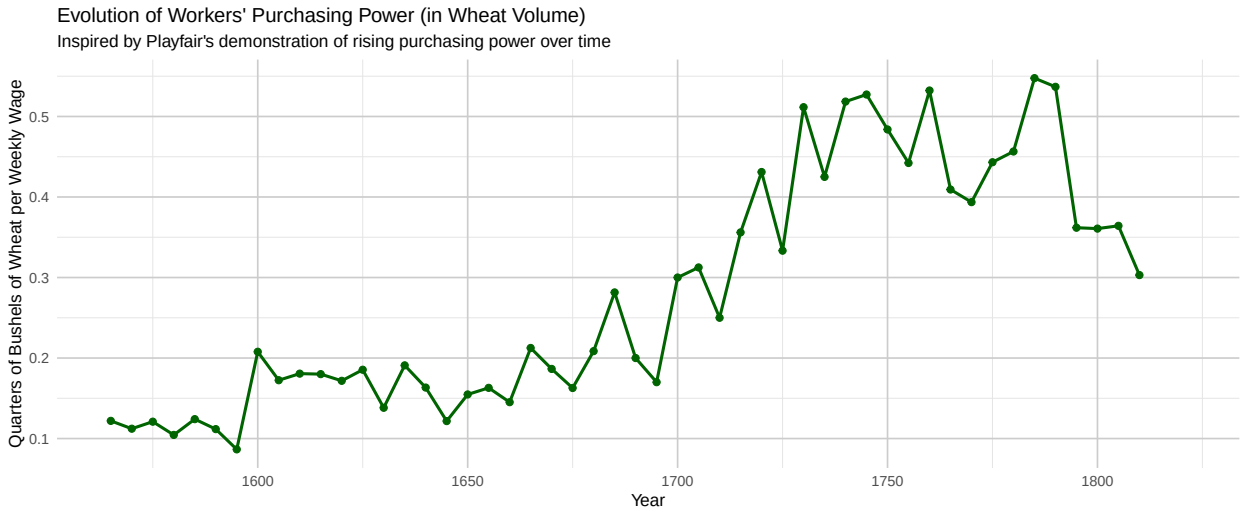


```r
# Add monarch backgrounds and labels
g2b <- g2b +
  geom_rect(
    data = monarch_df,
    aes(
      xmin = start,
      xmax = end,
      ymin = -Inf,
      ymax = Inf,
      fill = fill_color
    ),
    inherit.aes = FALSE,
    alpha = 0.5
  ) +
  scale_fill_identity() +
  geom_text(
    data = monarch_df,
    aes(
      x = (start + end)/2,
      y = Inf,
      label = name
    ),
    inherit.aes = FALSE,
    vjust = 1.2,
    size = 3,
    color = "black"
  )

print(g2b)
```

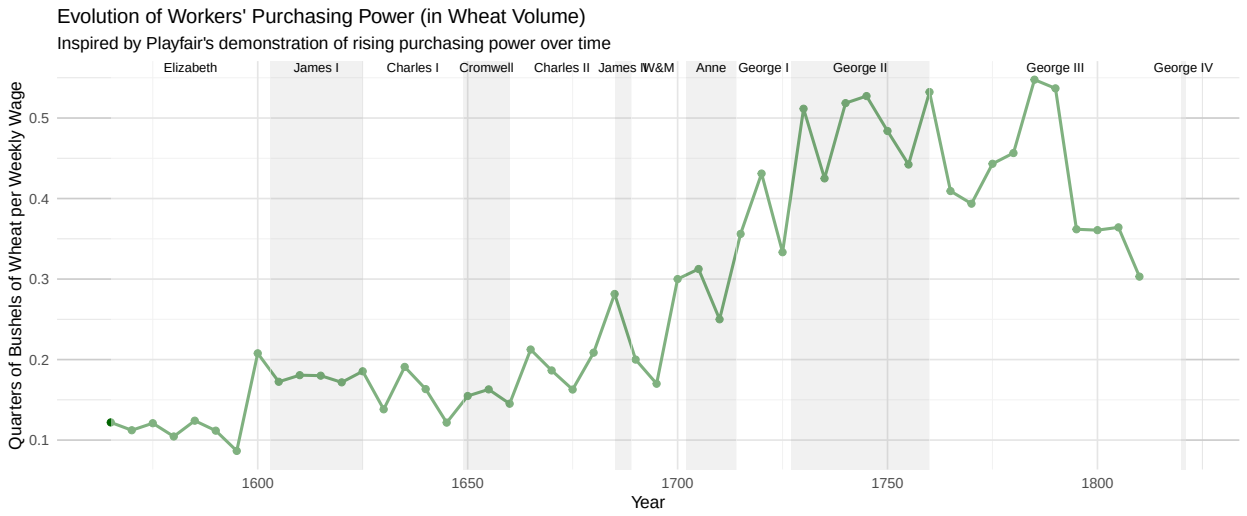



```r
# ------------------------------------------------------------------------
# Fourth Plot: Purchasing Power = Wages / Wheat
# ------------------------------------------------------------------------

df$PurchasingPower <- df$Wages / df$Wheat
```

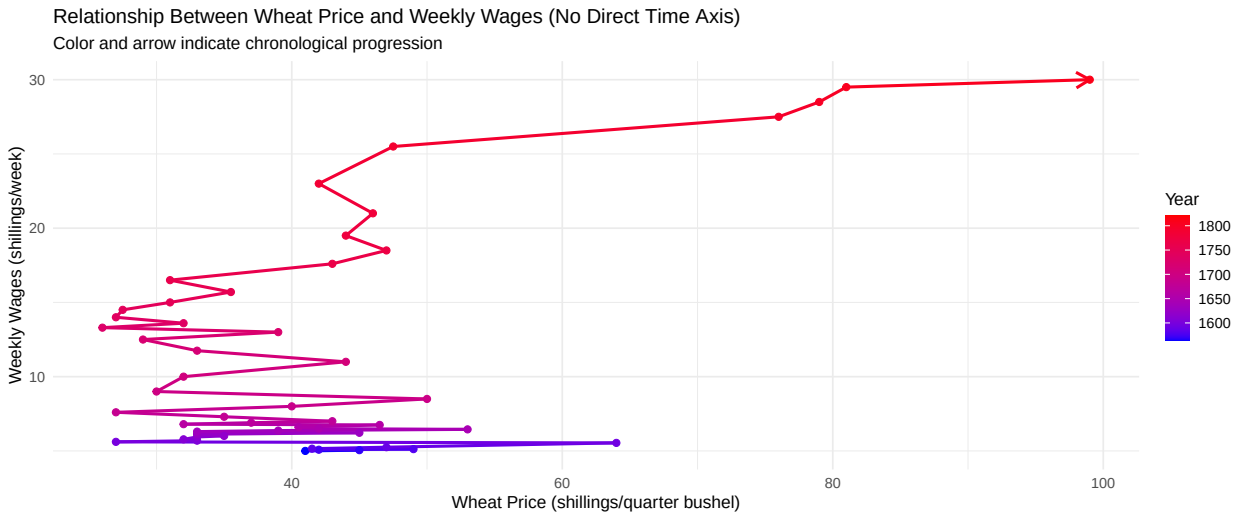
```r
g3 <- ggplot(df, aes(x = Year, y = PurchasingPower)) +
  geom_line(color = "darkgreen", size = 1) +
  geom_point(color = "darkgreen", size = 2) +
  labs(
    x = "Year",
    y = "Quarters of Bushels of Wheat per Weekly Wage",
    title = "Evolution of Workers' Purchasing Power (in Wheat Volume)",
    subtitle = "Inspired by Playfair's demonstration of rising purchasing power over time"
  ) +
  theme_playfair

print(g3)
```



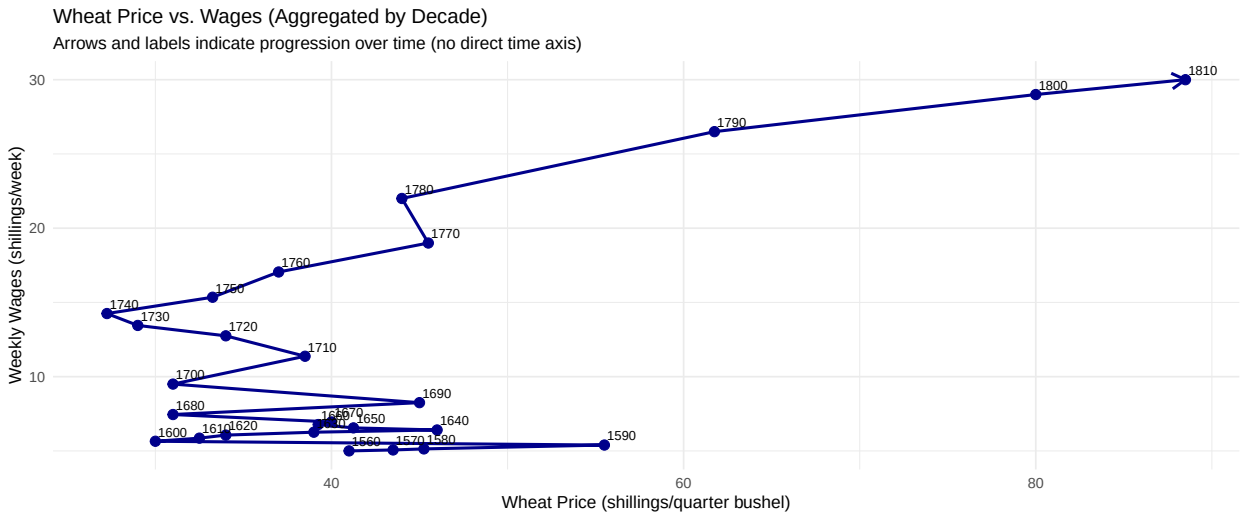

```r
# Add monarch backgrounds and labels
g3 <- g3 +
  geom_rect(
    data = monarch_df,
    aes(xmin = start, xmax = end, ymin = -Inf, ymax = Inf, fill = fill_color),
    alpha = 0.5,
    inherit.aes = FALSE
  ) +
  scale_fill_identity() +
  geom_text(
    data = monarch_df,
    aes(x = (start + end)/2, y = Inf, label = name),
    inherit.aes = FALSE,
    vjust = 1.2,
    size = 3
  )

print(g3)
```




```r
# ------------------------------------------------------------------------
# Fifth Plot: Scatter/Path of Wheat vs. Wages (Time as a Color Gradient)
# ------------------------------------------------------------------------

# Make sure df is sorted by Year
df <- df[order(df$Year), ]

g4 <- ggplot(df, aes(x = Wheat, y = Wages)) +
  geom_path(
    aes(color = Year),
    arrow = arrow(type = "open", length = unit(0.15, "inches")),
    size = 1
  ) +
  geom_point(aes(color = Year), size = 2) +
  scale_color_gradient(low = "blue", high = "red") +
  labs(
    x = "Wheat Price (shillings/quarter bushel)",
    y = "Weekly Wages (shillings/week)",
    color = "Year",
    title = "Relationship Between Wheat Price and Weekly Wages (No Direct Time Axis)",
    subtitle = "Color and arrow indicate chronological progression"
  ) +
  theme_minimal(base_size = 12)

print(g4)
```




```r
# ------------------------------------------------------------------------
# Summarize by Decade, Then Plot (Path + Arrow + Labels)
# ------------------------------------------------------------------------
df_decade <- df %>%
  mutate(decade = floor(Year / 10) * 10) %>%
  group_by(decade) %>%
  summarize(
    Wheat = mean(Wheat, na.rm = TRUE),
    Wages = mean(Wages, na.rm = TRUE)
  ) %>%
  ungroup()

g_better <- ggplot(df_decade, aes(x = Wheat, y = Wages)) +
  geom_path(
    arrow = arrow(length = unit(0.15, "inches"), type = "open"),
    color = "darkblue",
    size = 1
  ) +
  geom_point(color = "darkblue", size = 3) +
  geom_text(
    aes(label = decade),
    hjust = -0.1,
    vjust = -0.5,
    color = "black",
    size = 3
  ) +
  labs(
    x = "Wheat Price (shillings/quarter bushel)",
    y = "Weekly Wages (shillings/week)",
    title = "Wheat Price vs. Wages (Aggregated by Decade)",
    subtitle = "Arrows and labels indicate progression over time (no direct time axis)"
  ) +
  theme_minimal(base_size = 12)

print(g_better)
```



I find g3 does a better job of illustrating purchasing power. g4 and g_better become too cluttered between 1560 and 1700, making it difficult to interpret the data at a glance. Even when the data is aggregated by decade (g4 vs. g_better), it remains challenging to grasp the information quickly.