Story 2 - The Feds Dual Mandate

waheeb Algabri

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library(tidyverse)  
library(openintro)  
library(tidyverse)  
library(fredr)  
library(httr)  
library(devtools)  
library(jsonlite)  
library(lubridate)  
library(zoo)

# Read in API keys

# API Key for BLS   
bls\_key <- "63914d4df0f240fc8da9b5cfd9dd8158"  
  
# API Key for FRED  
fred\_key <- "51ad4dae4f5ed3c82b1184efb95ca4df"

# BLS API Data Retrieval

year\_ranges <- list(c('2005', '2024'), c('1985', '2005'))  
  
cpi <- data.frame()  
ue <- data.frame()  
  
for (year\_range in year\_ranges) {  
 request <- list(  
 'seriesid' = c('CUUR0000SA0L1E', 'LNS14000000'),   
 'startyear' = year\_range[1],   
 'endyear' = year\_range[2],  
 'registrationkey' = bls\_key  
 )  
  
 # Use httr for BLS API requests  
 response <- POST("https://api.bls.gov/publicAPI/v2/timeseries/data/",  
 body = request, encode = "json")  
 json <- fromJSON(content(response, as = "text"))  
   
 df1 <- json$Results$series$data[[1]]  
 cpi <- rbind(cpi, df1[c('year', 'period', 'value')])  
   
 df2 <- json$Results$series$data[[2]]  
 ue <- rbind(ue, df2[c('year', 'period', 'value')])  
}  
  
# Process the CPI data  
cpi <- cpi %>%  
 mutate(  
 month = as.numeric(str\_remove(period, 'M')),  
 year = as.numeric(year),  
 value = as.numeric(value)  
 )  
  
# Process the Unemployment data  
ue <- ue %>%  
 mutate(  
 month = as.numeric(str\_remove(period, 'M')),  
 year = as.numeric(year),  
 value = as.numeric(value)  
 )

# FRED API Data Retrieval

# Set FRED API key  
fredr\_set\_key(fred\_key)  
  
  
# Retrieve data from FRED API  
fed\_funds <- fredr(  
 series\_id = 'FEDFUNDS',  
 observation\_start = as.Date('1985-01-01'),  
 observation\_end = as.Date('2024-02-01')  
)  
  
# Processing fed funds rate  
fed\_funds <- fed\_funds %>%  
 mutate(  
 year = year(date),  
 month = month(date)  
 )  
  
fed\_target <- fredr(  
 series\_id = 'DFEDTARU',  
 observation\_start = as.Date('1985-01-01'),  
 observation\_end = as.Date('2024-02-01')  
)  
  
fed\_target <- fed\_target %>%  
 mutate(  
 year = year(date),  
 month = month(date)  
 )  
  
recession <- fredr(  
 series\_id = 'JHDUSRGDPBR',  
 observation\_start = as.Date('1985-01-01'),  
 observation\_end = as.Date('2024-02-01')  
)  
  
recession <- recession %>%  
 mutate(  
 year = year(date),  
 month = month(date)  
 )  
  
# Recession dates  
recession\_dates <- recession %>%  
 mutate(recession\_start = value == 1 & lag(value) == 0,  
 recession\_end = value == 1 & lead(value) == 0) %>%  
 replace\_na(list(recession\_start = TRUE)) %>%  
 filter(recession\_start | recession\_end) %>%  
 mutate(period\_id = cumsum(recession\_start)) %>%  
 group\_by(period\_id) %>%  
 summarise(start = min(date), end = max(date)) %>%  
 ungroup()

# Merging and Creating New Columns

df <- left\_join(cpi, ue, by = c('year', 'month')) %>%  
 left\_join(fed\_funds, by = c('year', 'month')) %>%  
 left\_join(fed\_target, by = 'date') %>%  
 rename(  
 cpi = value.x, ue = value.y,   
 fed\_funds = value.x.x, fed\_target = value.y.y  
 ) %>%  
 select(date, cpi, ue, fed\_funds, fed\_target) %>%  
 arrange(date) %>%  
 mutate(  
 fed\_target = if\_else(is.na(fed\_target), ceiling(fed\_funds \* 4) / 4, fed\_target),  
 cpi\_growth = (cpi/lag(cpi, n = 12) - 1) \* 100  
 )   
  
head(df)

## date cpi ue fed\_funds fed\_target cpi\_growth  
## 1 1985-01-01 106.9 7.3 8.35 8.50 NA  
## 2 1985-02-01 107.4 7.2 8.50 8.50 NA  
## 3 1985-03-01 107.9 7.2 8.58 8.75 NA  
## 4 1985-04-01 108.2 7.3 8.27 8.50 NA  
## 5 1985-05-01 108.6 7.2 7.97 8.00 NA  
## 6 1985-06-01 108.8 7.4 7.53 7.75 NA

# clean data

df<- na.omit(df)  
head(df, 15)

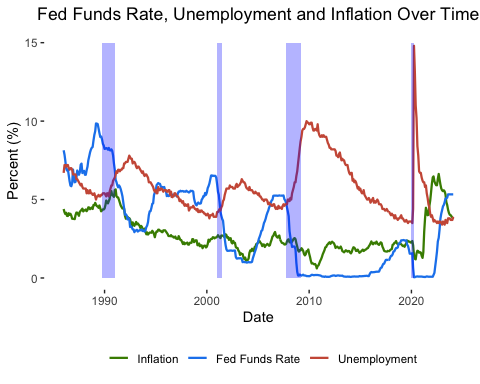
## date cpi ue fed\_funds fed\_target cpi\_growth  
## 13 1986-01-01 111.6 6.7 8.14 8.25 4.396632  
## 14 1986-02-01 111.9 7.2 7.86 8.00 4.189944  
## 15 1986-03-01 112.3 7.2 7.48 7.50 4.077850  
## 16 1986-04-01 112.7 7.1 6.99 7.00 4.158965  
## 17 1986-05-01 112.9 7.2 6.85 7.00 3.959484  
## 18 1986-06-01 113.1 7.2 6.92 7.00 3.952206  
## 19 1986-07-01 113.5 7.0 6.56 6.75 4.128440  
## 20 1986-08-01 113.8 6.9 6.17 6.25 4.021938  
## 21 1986-09-01 114.5 7.0 5.89 6.00 4.090909  
## 22 1986-10-01 115.1 7.0 5.85 6.00 3.974706  
## 23 1986-11-01 115.4 6.9 6.04 6.25 3.776978  
## 24 1986-12-01 115.5 6.6 6.91 7.00 3.773585  
## 25 1987-01-01 115.8 6.6 6.43 6.50 3.763441  
## 26 1987-02-01 116.1 6.6 6.10 6.25 3.753351  
## 27 1987-03-01 116.8 6.6 6.13 6.25 4.007124

# Check for missing values  
sum(is.na(df))

## [1] 0

# Visualizations: Levels

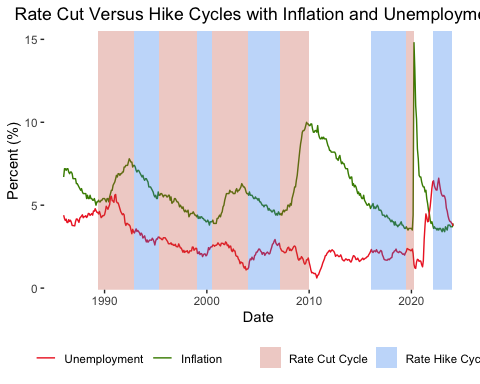
df %>%  
 pivot\_longer(cols = c(cpi\_growth, ue, fed\_funds)) %>%  
 ggplot(aes(x = date, y = value, color = name)) +  
 geom\_line(size = 0.8) +   
 geom\_rect(  
 data = recession\_dates,   
 aes(xmin = start, xmax = end, ymin = 0, ymax = 15),  
 fill = 'blue', alpha = 0.3, inherit.aes = FALSE  
 ) +   
 ggtitle('Fed Funds Rate, Unemployment and Inflation Over Time') +  
 xlab('Date') +  
 ylab('Percent (%)') +   
 scale\_color\_manual(  
 values = c('cpi\_growth' = 'chartreuse4', 'fed\_funds' = 'dodgerblue2', 'ue' = 'coral3'),   
 name = '',   
 labels = c('cpi\_growth' = 'Inflation', 'fed\_funds' = 'Fed Funds Rate', 'ue' = 'Unemployment')  
 ) +  
 theme(  
 plot.title = element\_text(hjust = 0.5),  
 legend.position = 'bottom',  
 panel.background = element\_blank()  
 )

 # Identify Rate & Hike Cycles

df <- df %>%  
 mutate(  
 fed\_roll\_peak = rollapply(  
 fed\_target, width = 52, FUN = max,   
 align = 'center', fill = c(NA, NA, 'extend')  
 ),  
 fed\_roll\_valley = rollapply(  
 fed\_target, width = 52, FUN = min,   
 align = 'center', fill = c(NA, NA, 'extend')  
 ),  
 fed\_status = case\_when(  
 fed\_target == fed\_roll\_peak & fed\_target > lead(fed\_target) ~ 'peak',  
 fed\_target == fed\_roll\_valley & fed\_target < lead(fed\_target) ~ 'valley',  
 .default = 'between'  
 )  
 ) %>%  
 select(-fed\_roll\_peak, -fed\_roll\_valley)  
  
# The rest of the loop logic remains unchanged

# Fine-Tune Dates and Set Up Cycle DFs

cut\_cycles <- data.frame(  
 start = as.Date(c('1989-05-01','1995-05-01','2000-07-01','2007-03-01','2019-07-01')),  
 end = as.Date(c('1992-12-01','1999-01-01','2004-01-01','2010-01-01','2020-04-01'))  
)  
  
hike\_cycles <- data.frame(  
 start = as.Date(c('1992-12-01','1999-01-01','2004-01-01','2016-01-01','2022-02-01')),  
 end = as.Date(c('1995-05-01','2000-07-01','2007-03-01','2019-07-01','2024-01-01'))  
)  
  
ggplot() +   
 geom\_line(data = df, aes(x = date, y = ue, color = 'Unemployment')) +  
 geom\_line(data = df, aes(x = date, y = cpi\_growth, color = 'Inflation')) +  
 geom\_rect(  
 data = cut\_cycles, aes(xmin = start, xmax = end, ymin = -Inf, ymax = Inf, fill = 'Rate Cut Cycle'),  
 alpha = 0.3, inherit.aes = FALSE  
 ) +  
 geom\_rect(  
 data = hike\_cycles, aes(xmin = start, xmax = end, ymin = -Inf, ymax = Inf, fill = 'Rate Hike Cycle'),  
 alpha = 0.3, inherit.aes = FALSE  
 ) +  
 ggtitle('Rate Cut Versus Hike Cycles with Inflation and Unemployment') +  
 xlab('Date') +  
 ylab('Percent (%)') +   
 scale\_fill\_manual(  
 values = c('Rate Cut Cycle' = 'coral3', 'Rate Hike Cycle' = 'dodgerblue2'),   
 name = '',   
 labels = c('Rate Cut Cycle', 'Rate Hike Cycle')  
 ) +  
 scale\_color\_manual(  
 values = c('Unemployment' = 'chartreuse4', 'Inflation' = 'firebrick2'),  
 name = '',  
 labels = c('Unemployment', 'Inflation')  
 ) +  
 theme(  
 plot.title = element\_text(hjust = 0.5),  
 legend.position = 'bottom',  
 panel.background = element\_blank()  
 )



# Calculate changes in UE and CPI after each cycle

for (row in 1:nrow(cut\_cycles)) {  
   
 time\_to\_change <- as.period(hike\_cycles[row, 2] - cut\_cycles[row, 2])  
 obs\_period <- if\_else(time\_to\_change < months(60), time\_to\_change, months(60))  
   
 cut\_cycles[row, 'obs\_period\_end'] <- cut\_cycles[row, 2] + obs\_period  
   
 cut\_cycles[row, 'ff\_change'] <-   
 df[df$date == cut\_cycles[row, 2], 'fed\_funds'] -   
 df[df$date == cut\_cycles[row, 1], 'fed\_funds']  
   
 cut\_cycles[row, 'infl\_change'] <-   
 df[df$date == cut\_cycles[row, 2] + obs\_period, 'cpi\_growth'] -  
 df[df$date == cut\_cycles[row, 2], 'cpi\_growth']  
   
 cut\_cycles[row, 'ue\_change'] <-   
 df[df$date == cut\_cycles[row, 2] + obs\_period, 'ue'] -   
 df[df$date == cut\_cycles[row, 2], 'ue']  
}  
  
for (row in 1:nrow(hike\_cycles)) {  
   
 if (row == nrow(hike\_cycles)) {  
 obs\_period <- 0  
 adjustment <- 1  
 } else {  
 time\_to\_change <- as.period(cut\_cycles[row+1, 2] - hike\_cycles[row, 2])  
 obs\_period <- if\_else(time\_to\_change < months(60), time\_to\_change, months(60))  
 adjustment <- 0  
 }  
   
 hike\_cycles[row, 'obs\_period\_end'] <- hike\_cycles[row, 2] + obs\_period  
   
 hike\_cycles[row, 'ff\_change'] <-   
 df[df$date == hike\_cycles[row, 2], 'fed\_funds'] -   
 df[df$date == hike\_cycles[row, 1], 'fed\_funds']  
   
 hike\_cycles[row, 'infl\_change'] <-   
 df[df$date == hike\_cycles[row, 2] + obs\_period, 'cpi\_growth'] -   
 df[df$date == hike\_cycles[row, 2 - adjustment], 'cpi\_growth']  
   
 hike\_cycles[row, 'ue\_change'] <-   
 df[df$date == hike\_cycles[row, 2] + obs\_period, 'ue'] -  
 df[df$date == hike\_cycles[row, 2 - adjustment], 'ue']  
}  
  
cut\_cycles <- cut\_cycles %>%  
 mutate(label = str\_c(  
 'Cut Cycle: ', format(start, "%b-%y"),  
 ' – ', format(end, "%b-%y"),  
 ' / Observation Period: ', format(end, "%b-%y"),   
 ' – ', format(obs\_period\_end, "%b-%y")  
 ))  
  
hike\_cycles <- hike\_cycles %>%  
 mutate(label = str\_c(  
 'Hike Cycle: ', format(start, "%b-%y"),  
 ' – ', format(end, "%b-%y"),  
 ' / Observation Period: ', format(end, "%b-%y"),   
 ' – ', format(obs\_period\_end, "%b-%y")  
 ))  
  
hike\_cycles[5,7] <- 'Hike Cycle: Feb-22 – Jan-24 / Observation Period: Feb-22 – Jan-24'  
  
cut\_cycles

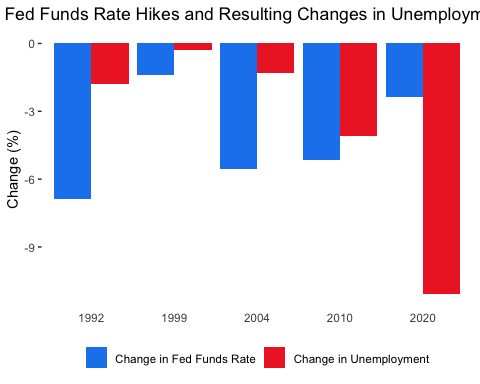
## start end obs\_period\_end ff\_change infl\_change ue\_change  
## 1 1989-05-01 1992-12-01 1995-05-01 -6.89 -0.24717665 -1.8  
## 2 1995-05-01 1999-01-01 2000-07-01 -1.38 0.09242114 -0.3  
## 3 2000-07-01 2004-01-01 2007-03-01 -5.54 1.30441157 -1.3  
## 4 2007-03-01 2010-01-01 2015-01-01 -5.15 0.09528951 -4.1  
## 5 2019-07-01 2020-04-01 2024-01-01 -2.35 2.42958952 -11.1  
## label  
## 1 Cut Cycle: May-89 – Dec-92 / Observation Period: Dec-92 – May-95  
## 2 Cut Cycle: May-95 – Jan-99 / Observation Period: Jan-99 – Jul-00  
## 3 Cut Cycle: Jul-00 – Jan-04 / Observation Period: Jan-04 – Mar-07  
## 4 Cut Cycle: Mar-07 – Jan-10 / Observation Period: Jan-10 – Jan-15  
## 5 Cut Cycle: Jul-19 – Apr-20 / Observation Period: Apr-20 – Jan-24

hike\_cycles

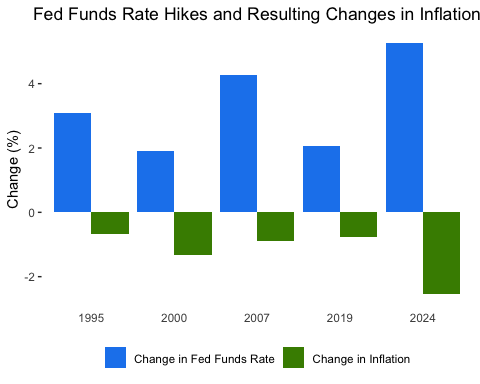
## start end obs\_period\_end ff\_change infl\_change ue\_change  
## 1 1992-12-01 1995-05-01 1999-01-01 3.09 -0.6820633 -1.3  
## 2 1999-01-01 2000-07-01 2004-01-01 1.91 -1.3402528 1.7  
## 3 2004-01-01 2007-03-01 2010-01-01 4.26 -0.8978150 5.4  
## 4 2016-01-01 2019-07-01 2020-04-01 2.06 -0.7778993 11.1  
## 5 2022-02-01 2024-01-01 2024-01-01 5.25 -2.5524621 -0.1  
## label  
## 1 Hike Cycle: Dec-92 – May-95 / Observation Period: May-95 – Jan-99  
## 2 Hike Cycle: Jan-99 – Jul-00 / Observation Period: Jul-00 – Jan-04  
## 3 Hike Cycle: Jan-04 – Mar-07 / Observation Period: Mar-07 – Jan-10  
## 4 Hike Cycle: Jan-16 – Jul-19 / Observation Period: Jul-19 – Apr-20  
## 5 Hike Cycle: Feb-22 – Jan-24 / Observation Period: Feb-22 – Jan-24

Plot separate Bar Charts

cut\_plot <- cut\_cycles %>%  
 pivot\_longer(cols = c(ff\_change, ue\_change)) %>%   
 mutate(  
 end = as.character(year(end)),  
 value = (value)  
 ) %>%  
 ggplot(aes(end, value, fill = name)) +  
 geom\_col(position = position\_dodge()) +  
 ggtitle('Fed Funds Rate Hikes and Resulting Changes in Unemployment') +  
 xlab(NULL) +  
 ylab('Change (%)') +   
 scale\_fill\_manual(  
 values = c('ff\_change' = 'dodgerblue2', 'ue\_change' = 'firebrick2'),   
 name = NULL,   
 labels = c('ff\_change' = 'Change in Fed Funds Rate', 'ue\_change' = 'Change in Unemployment')  
 ) +  
 theme(  
 plot.title = element\_text(hjust = 0.5),  
 panel.background = element\_blank(),  
 legend.position = 'bottom', legend.box = 'vertical',  
 axis.ticks.x = element\_blank()  
 )  
  
hike\_plot <- hike\_cycles %>%  
 mutate(  
 end = as.character(year(end)),  
 infl\_change = (infl\_change)  
 ) %>%  
 pivot\_longer(cols = c(ff\_change, infl\_change)) %>%   
 ggplot(aes(end, value, fill = name)) +  
 geom\_col(position = position\_dodge()) +  
 ggtitle('Fed Funds Rate Hikes and Resulting Changes in Inflation') +  
 xlab(NULL) +  
 ylab('Change (%)') +   
 scale\_fill\_manual(  
 values = c('ff\_change' = 'dodgerblue2', 'infl\_change' = 'chartreuse4'),   
 name = NULL,   
 labels = c('ff\_change' = 'Change in Fed Funds Rate', 'infl\_change' = 'Change in Inflation')  
 ) +  
 theme(  
 plot.title = element\_text(hjust = 0.5),  
 panel.background = element\_blank(),  
 legend.position = 'bottom', legend.box = 'vertical',  
 axis.ticks.x = element\_blank()  
 )  
  
cut\_plot



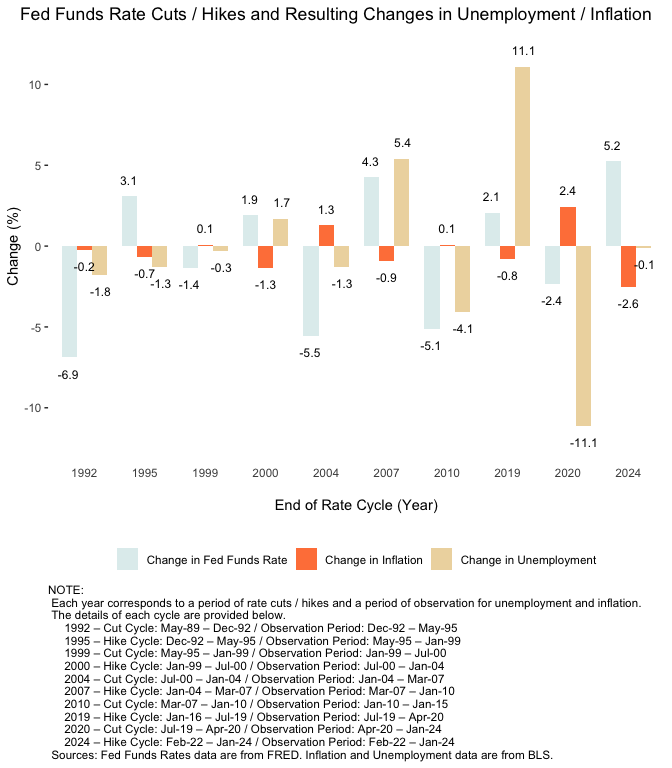
hike\_plot



# Final Plot

This final plots shows that the Fed typically succeeds in its dual mandate. After each cut cycle, we typically see unemployment decrease. After each hike cycle, we typically see inflation decrease. This plot, however, also shows that contradictory nature of the dual mandate. After many cut cycles, we see some increase in inflation, and after many hike cycles, we see some increase in unemployment. Historical context is important here, as sometimes the Fed may intend to drive up some unemployment to “cool” the economy. Similarly, it may sometimes intend to increase inflation during periods of high disinflation. Regardless, this plot helps us determine that cuts typically drive higher employment and hikes typically drive lower inflation.

caption <- str\_c(  
 'NOTE:',  
 '\n Each year corresponds to a period of rate cuts / hikes and a period of observation for unemployment and inflation.',  
 '\n The details of each cycle are provided below.'  
)  
   
for (row in 1:nrow(cut\_cycles)) {  
 cut\_caption <- str\_c(year(cut\_cycles[row, 'end']), ' – ', cut\_cycles[row, 'label'])  
 caption <- str\_c(caption, '\n ', cut\_caption)  
   
 hike\_caption <- str\_c(year(hike\_cycles[row, 'end']), ' – ', hike\_cycles[row, 'label'])  
 caption <- str\_c(caption, '\n ', hike\_caption)  
}  
  
caption <- str\_c(caption, '\n Sources: Fed Funds Rates data are from FRED. Inflation and Unemployment data are from BLS.')  
  
final\_plot <- rbind(cut\_cycles, hike\_cycles) %>%  
 pivot\_longer(cols = c(ff\_change, ue\_change, infl\_change)) %>%  
 filter(!is.na(value)) %>%  
 mutate(label = fct\_reorder(label, end), end = as.character(year(end))) %>%  
 arrange(end) %>%  
 ggplot(aes(x = end, y = value, fill = name)) +  
 geom\_col(position = position\_dodge(), width = 0.75) +  
 labs(  
 x = 'End of Rate Cycle (Year)', y = 'Change (%)',   
 title = 'Fed Funds Rate Cuts / Hikes and Resulting Changes in Unemployment / Inflation',  
 caption = caption  
 ) +  
 scale\_fill\_manual(  
 values = c(  
 'ff\_change' = 'azure2',  
 'ue\_change' = 'wheat2',  
 'infl\_change' = 'sienna1'  
 ),  
 labels = c(  
 'ff\_change' = 'Change in Fed Funds Rate',  
 'ue\_change' = 'Change in Unemployment',  
 'infl\_change' = 'Change in Inflation'  
 ),   
 name = NULL,  
 ) +  
 scale\_x\_discrete(position = 'bottom') +  
 geom\_text(  
 aes(label = round(value,1), y = ifelse(value > 0, value + 1, value - 1)),  
 position = position\_dodge(0.8),  
 color = "black", size = 3.2  
 ) +  
 theme(  
 plot.title.position = 'plot',  
 plot.title = element\_text(hjust = 0.5),  
 plot.caption = element\_text(hjust = 0),  
 panel.background = element\_blank(),  
 legend.position = 'bottom', legend.box = 'vertical',  
 axis.ticks.x = element\_blank(),  
 axis.title.x = element\_text(margin = margin(t = 15, b = 10))  
 )  
  
final\_plot



ggsave('story2\_waheeb\_finalPlot.png', plot = final\_plot, width = 7, height = 8, dpi = 500)