Almond Model

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Summary

After developing an R function to represent the California almond yield anomaly regression model from *Lobell 2006*, the yield anomalies for all years 1989 - 2010 were calculated. We found that the year in which there was the most extreme anomaly was in 1995 where the yield anomaly was nearly 2000 ton acre^{-1}. There were other much smaller spikes in 1997, 2005, and 2008. With the full production of almond crop being 6 years, we may see such a high spike in 1995 due to the crop reaching it's full maturity. This reasoning requires the assumption that the almond crops studies in *Lobell 2006* were planted at the start of the study period.

```r
#read in the clim data
clim <- read.table("clim.txt", sep=" ", header=T)

#read in almond model from function script
source("almond_model.R")
```

Testing to see if the function works

```r
#create temperature subset for February
temperature <- clim %>%
  filter(month == "2") %>%
  group_by(year) %>%
  summarize(
    avg = mean(tmin_c)
  )

#create precipitation subset for January
rain <- clim %>%
  filter(month == "1") %>%
  group_by(year) %>%
  summarize(
    sum = sum(precip)
  )

#combine the temperature and precipitation data
df <- data.frame(temperature, rain) %>%
  select(-year.1)
```

Calculate the Almond Anomaly model

```
#test the model on the clim data
almond_output <- almond_model(clim)
almond_output
```

```
## [1]   -0.3552237    9.2906757   68.9130633   15.4280698   20.2083803
## [6]    2.4820009 1919.9811511    3.5818399  329.6938750   27.8636956
## [11]  -0.1436364    9.5999883  159.5119587    0.2450914   -0.2585997
## [16]  -0.2367722  656.3724121   18.6324135   20.2007396  576.2821943
## [21]   0.7367438  153.7655092
```

```
#turn the model output into a data frame
almond_yield_anomaly <- data.frame(year = df$year, anomaly = almond_model(clim)) %>%
  mutate(year = lubridate::ymd(year, truncated = 2L))

#plot the anomalies
ggplot(data = almond_yield_anomaly, aes(y = anomaly, x = year)) +
  geom_line() +
  scale_x_date(date_breaks = "1 year",
               date_labels = "%Y",
               limits = as.Date(c("1989-01-01","2010-01-01"))) +
  labs(x = "Year",
       y = expression("Anomaly (ton" ~acre^-1~ ")"),
       title = "Annual Almond Yield Anomaly (1989 - 2010)") +
  theme_minimal() +
  theme(panel.grid.minor.x = element_blank(),
        plot.title = element_text(hjust = 0.5),
        axis.text.x = element_text(angle = 60, vjust = 1, hjust = 1))
```

Assignment 3: Sensitivity Analysis & NPV

Sensitivity Analysis

```
#create normal distribution
clim_var4 <- rnorm(n = 500, mean = 0.0043, sd = 0.001)

#use map_dfc to run for each value of clim_var4
almond_sens <-clim_var4 %>%
  map_dfc(~almond_model(clim = clim, clim_var1 = -0.015,
                        clim_var2 = 0.0046, clim_var3 = 0.07,
                        clim_var4 = .x, intercept = 0.28))

#create vectors to change the column names of the transposed data frame
oldyears <- c("v1", "v2", "v3", "v4", "v5", "v6", "v7", "v8", "v9",
              "v10", "v11", "v12", "v13", "v14", "v15", "v16",
              "v17", "v18", "v19", "v20", "v21", "v22")

newyears <- as.character(pull(df, year))
```

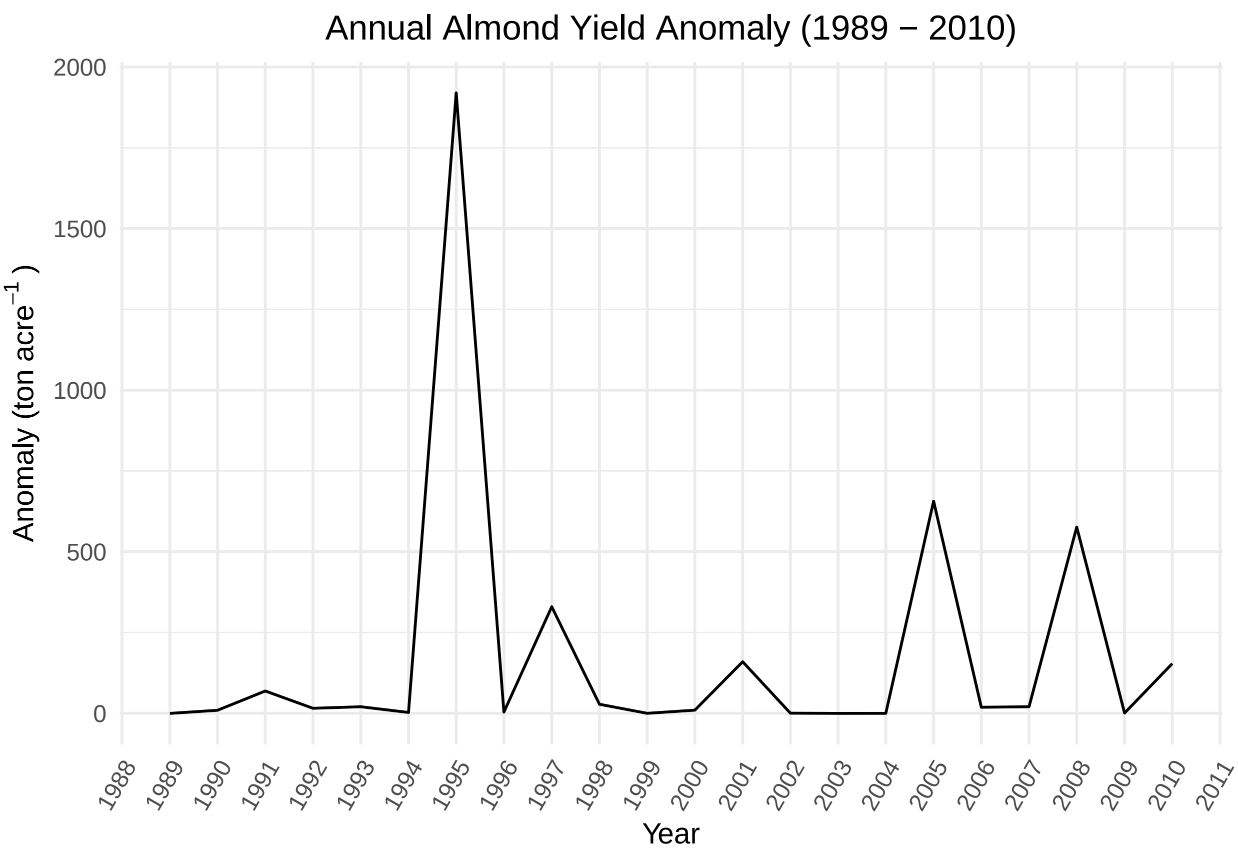

Figure 1: Almond yield anomaly in California for all years 1989 to 2010. The anomaly is calculated using the regression model: $Y = -0.015T_{n,2} - 0.0046T^2{}_{n,2} - 0.07P_1 + 0.0043P^2{}_1 + 0.28$

```r
#transpose so columns are years and rows are the anomaly;
#use pivot longer to get one column for the anomaly and one column for the corresponding year
almond_sens_transpose <- as.data.frame(t(almond_sens)) %>%
  clean_names() %>%
  rename_at(vars(oldyears), ~ newyears) %>%
  pivot_longer(everything(), names_to = "year", values_to = "anomaly") %>%
  mutate(value = ((anomaly)*2000*2.5)-3800) %>% #convert to almond
  #production ($/acre) minus the almond production cost
  mutate(time = (as.numeric(year) - 1989)) #time since 1989

#plot as a boxplot
ggplot(almond_sens_transpose, aes(x = year, y = anomaly, fill = year)) +
  geom_boxplot() +
  labs(x = "Year",
       y = expression("Anomaly (ton" ~acre^-1~ ")"),
       title = "Almond Yield Anomaly Sensitivity (1989 - 2010)") +
  theme_minimal() +
  theme(legend.position = "none",
        plot.title = element_text(hjust = 0.5),
        axis.text.x = element_text(angle = 60, vjust = 1, hjust = 1))
```

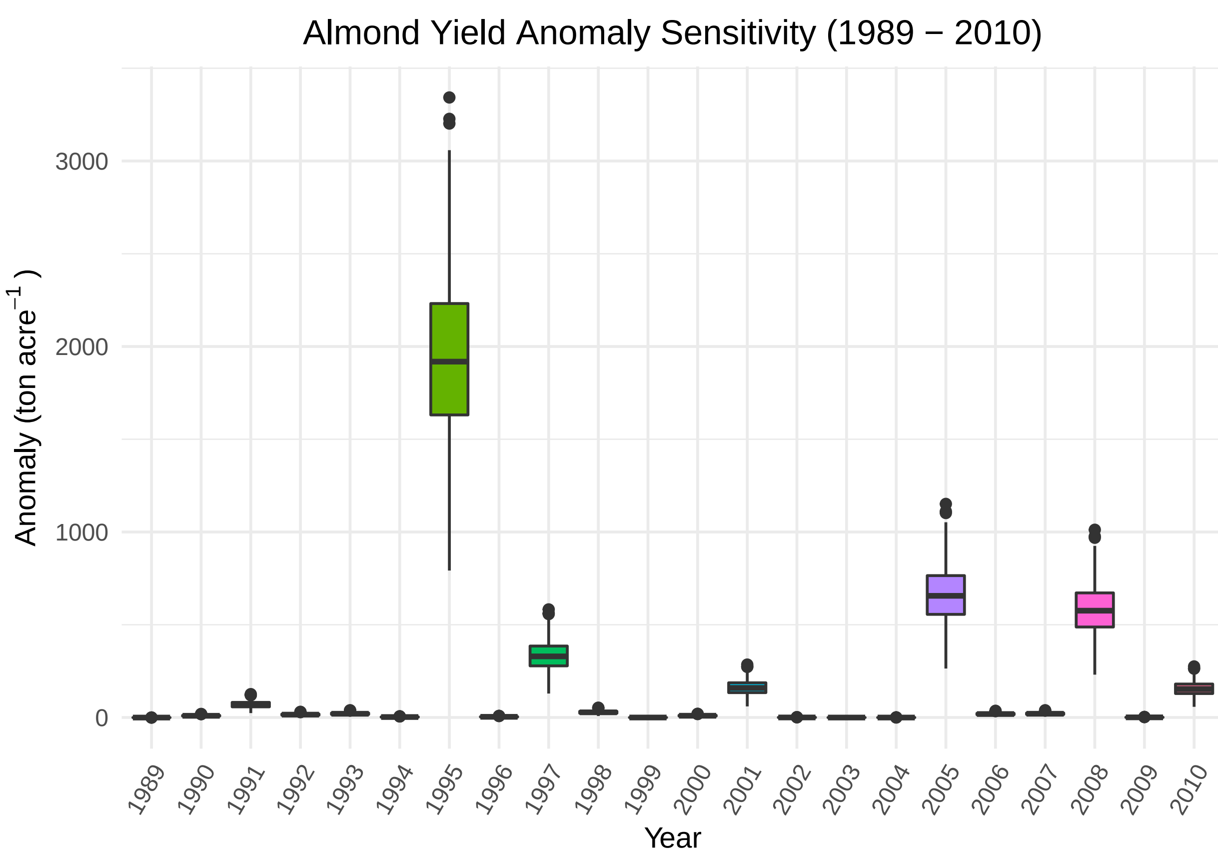

Figure 2: Almond yield anomaly sensitivity box plot for all years 1989 to 2010. The almond yield anomaly is calculated 500 times pulling a precipitation squared variable from a random normal distribution with a mean of 0.0043 and a standard deviation of 0.001.

Net Present Value (NPV)

```r
source("compute_NPV.R")

#find the net present value using the compute_npv function
npv <- compute_NPV(value = almond_sens_transpose$value, time = almond_sens_transpose$time)

#add npv to previous data frame
almond_npv <- almond_sens_transpose %>%
  mutate(npv = npv)

#create a boxplot
ggplot(almond_npv, aes(x = year, y = npv, fill = year)) +
  geom_boxplot() +
  labs(x = "Year",
       y = "Net Present Value ($/acre)",
       title = "Almond Yield Anomaly NPV (1989 - 2010)") +
  theme_minimal() +
  theme(legend.position = "none",
        plot.title = element_text(hjust = 0.5),
        axis.text.x = element_text(angle = 60, vjust = 1, hjust = 1))
```

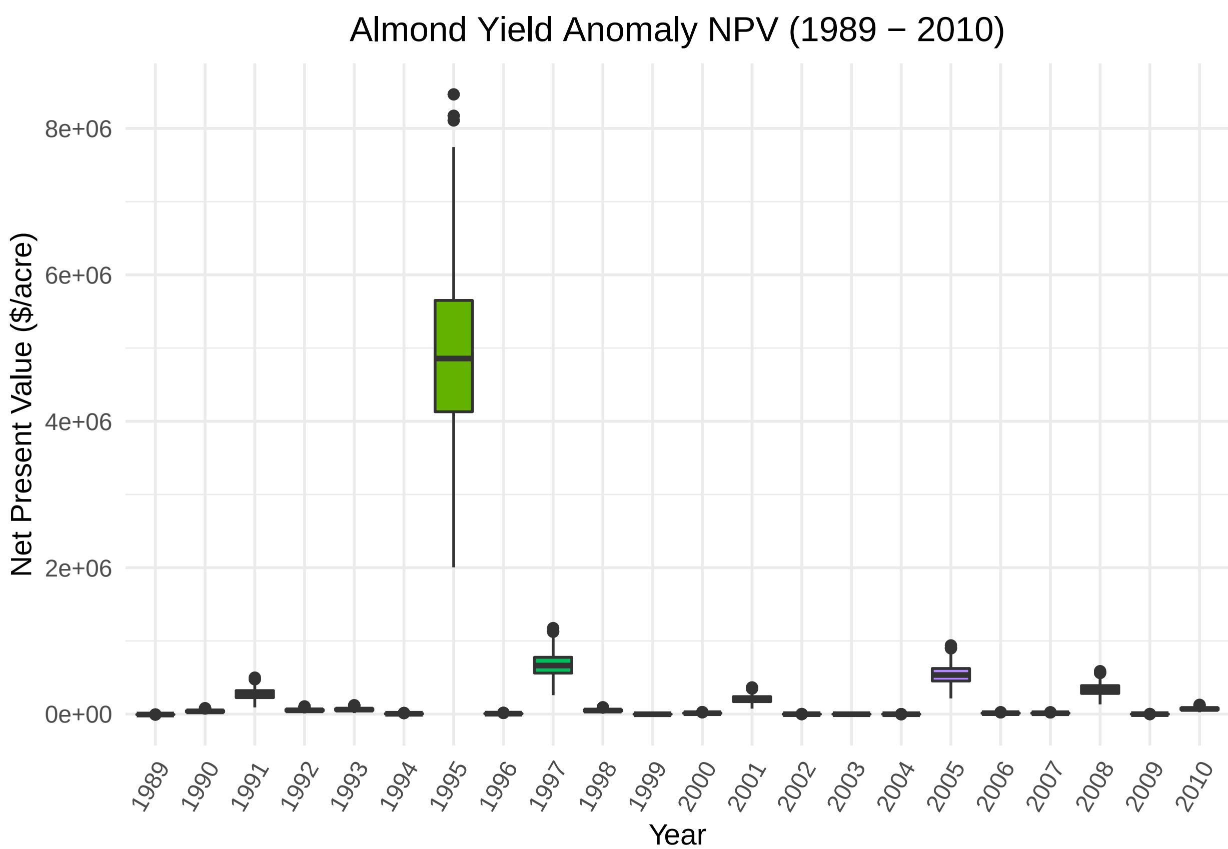

Figure 3: Almond yield anomaly net present value (NPV) box plot for all years 1989 to 2010. The almond yield anomaly NPV uses a discount rate of 0.12 and is calculated with 1989 as the reference year.