

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.

```
#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

```
#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))
```

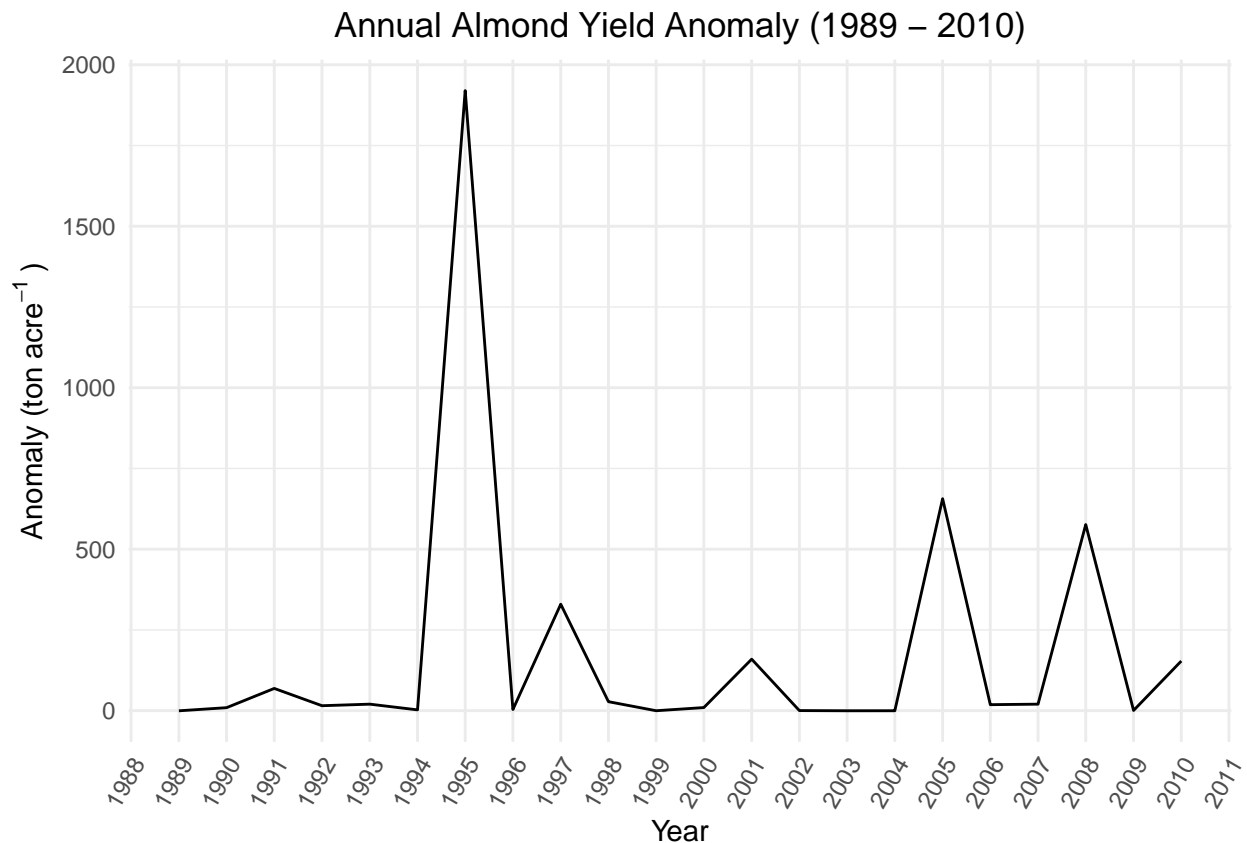


Figure 1: Almond yield anomaly in California for all years 1989 to 2010. The anomaly is calculated using the regression model: $Y = -0.015T_{n,2} - 0.0046T_{n,2}^2 - 0.07P_1 + 0.0043P_1^2 + 0.28$

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 = clim_var4))

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

#transpose so columns are years and rows are the anomaly; use pivot longer to get one column for the anomaly
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")

#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))
```

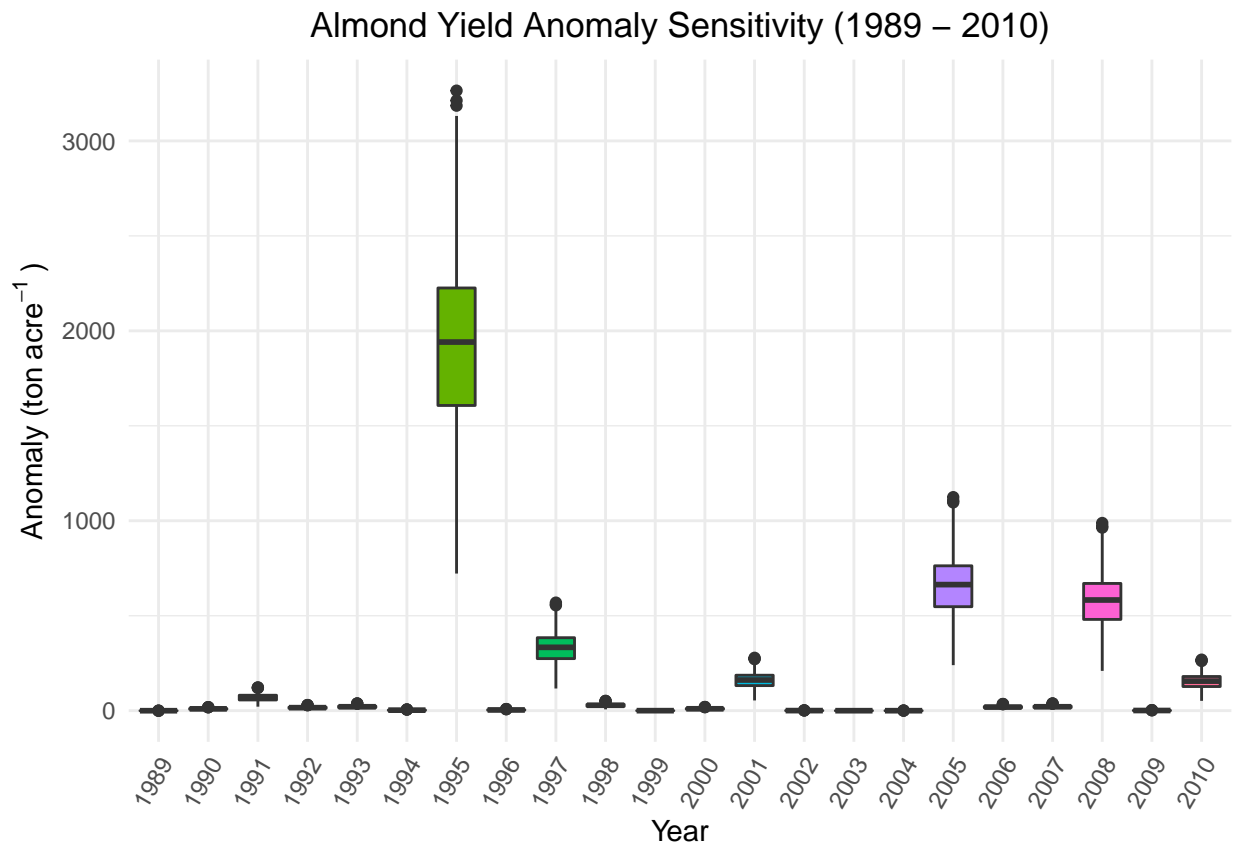


Figure 2: Almond yield anomaly sensitivity box plot for all years 1989 to 2010. The almond yield anomaly is calculated 500 times pulling a precipitation squared variable from a random normal distribution with a mean of 0.0043 and a standard deviation of 0.001.