Trends in Alternative Daily Cover in California

https://github.com/sarahko7/ADC_Analysis

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Abstract

Experimental overview. This section should be no longer than 250 words.

Contents

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1 Research Question and Rationale

2 Dataset Information

Column Name	Data Description
Report Year	Year that the ADC was used
Report Quarter	Quarter that the ADC was used
Ash	Ash and cement kiln dust materials
Auto Shredder Waste	Treated auto shredder waste
Construction and Demolition Waste	Processed construction and demolition wastes and materials
Compost	Compost materials
Contaminated Sediment	Contaminated sediment, dredge spoils, foundry sands
Green Material	Processed green material
Mixed	Mixtures of the other categories
Other	Before 1998, most ADC was classified in this category
Tires	Shredded tires
Sludge	Sludge and sludge-derived materials
Total	Sum of the columns Ash:Sludge

SKOTESTThis is the caption for the table Table 1: Summary of Data Structure

SKOTESTreference the table in text: Table 1

3 Exploratory Data Analysis and Wrangling

3.1 Import & Explore

```
# import dataset
ADC_raw <- read.csv("../Raw_Data/CalRecycle_ADC_raw.csv")

# explore dataset
view(ADC_raw)
class(ADC_raw)
```

```
## [1] "data.frame"
```

```
colnames(ADC_raw)
```

```
##  [1] "Report.Year"
##  [2] "Report.Quarter"
##  [3] "Ash"
##  [4] "Auto.Shredder.Waste"
##  [5] "Construction.and.Demolition.Waste"
##  [6] "Compost"
##  [7] "Contaminated.Sediment"
##  [8] "Green.Material"
##  [9] "Mixed"
## [10] "Other"
## [11] "Tires"
## [12] "Sludge"
## [13] "Total"
```

```
dim(ADC_raw)
```

```
## [1] 92 13
```

```
# per the CalRecycle website, segregation into ADC types started in 1998
# therefore, for the analysis, remove data from before 1998
class(ADC_raw$Report.Year)
```

```
## [1] "integer"
```

```
ADC_data <- filter(ADC_raw, Report.Year >= 1998)
dim(ADC_data)
```

```
## [1] 80 13
```

```
# explore new dataset
head(ADC_data)
```

```
##   Report.Year Report.Quarter      Ash Auto.Shredder.Waste
## 1        2017              1 32511.83            153270.6
```

```
## 2        2017              2 37294.78            159759.7
## 3        2017              3 33349.25            153342.6
## 4        2017              4 22248.85            123203.5
## 5        2016              1 31423.40            123193.3
## 6        2016              2 45504.45            126040.9
##   Construction.and.Demolition.Waste  Compost Contaminated.Sediment
## 1                          173548.6  6128.89               3396.36
## 2                          199486.8  2746.22               7585.58
## 3                          164028.4  1796.97               4280.92
## 4                          198901.7 15993.13               2979.12
## 5                          160446.5 15681.63              20203.18
## 6                          144982.9 42215.62              18089.73
##   Green.Material    Mixed    Other   Tires    Sludge    Total
## 1       380686.2     0.00 71983.68 3771.40  68063.34 893360.9
## 2       401034.3  1516.12 71066.46 5066.35  65585.25 951141.6
## 3       362474.4 10891.73 78980.55 5323.75  79967.05 894435.6
## 4       347204.0  7964.83 56849.63 4575.75 141423.92 921344.5
## 5       334512.7 12756.90 82081.97 3402.03  83424.85 867126.5
## 6       310959.5 17946.71 75803.52 3616.26  72882.61 858042.2
```

```r
tail(ADC_data)
```

```
##    Report.Year Report.Quarter     Ash Auto.Shredder.Waste
## 75        1999              3 1578.70            69300.25
## 76        1999              4 2718.22            63910.19
## 77        1998              1 2631.85            39181.17
## 78        1998              2  878.63            49391.25
## 79        1998              3 2457.00            35573.00
## 80        1998              4 2418.00            38495.89
##    Construction.and.Demolition.Waste Compost Contaminated.Sediment
## 75                          48321.13       0                  0.00
## 76                          62057.02     381                 16.50
## 77                           2693.48       0                  0.00
## 78                           6666.70       0                  2.74
## 79                          28278.30       0                 92.17
## 80                          29591.80       0                  0.00
##    Green.Material   Mixed   Other    Tires   Sludge    Total
## 75       349276.6    0.00 4695.69  1265.82 66864.38 541302.6
## 76       360153.2    0.00 6316.72  3307.48 69058.27 567918.6
## 77       191066.3 3907.20 1008.27 14802.71 43391.12 298682.1
## 78       279191.3 3602.22 3305.93 15394.54 92416.47 450849.8
## 79       299986.8    0.00 2706.53  2943.31 99312.34 471349.4
## 80       313452.3 4130.00 3767.93   733.71 57511.25 450100.9
```

```r
# tidy the data by gathering the type columns
ADC_gathered <- gather(ADC_data, "Type", "Quantity", Ash:Sludge) %>%
```

```r
  select(-Total) # remove Total column

# save the tidy dataset
write.csv(ADC_data, row.names = FALSE, file = "../Processed_Data/CalRecycle_ADC_tidy_pro

# generate summary data
ADC_summary_by_type <- ADC_gathered %>%
  group_by(Type) %>% # group the data by lakename
  filter(!is.na(Quantity)) %>% #remove the records when there are nas Quantity
  summarise(MeanQuarterlyQuantity = mean(Quantity),
            MinQuarterlyQuantity = min(Quantity),
            MaxQuarterlyQuantity = max(Quantity),
            sdQuarterlyQuantity = sd(Quantity),
            medianQuarterlyQuantity = median(Quantity))

ADC_summary_by_year <- ADC_gathered %>%
  group_by(Report.Year) %>% # group the data by year
  filter(!is.na(Quantity)) %>% #remove the records when there are nas Quantity
  summarise(MeanQuarterlyQuantity = mean(Quantity),
            MinQuarterlyQuantity = min(Quantity),
            MaxQuarterlyQuantity = max(Quantity),
            sdQuarterlyQuantity = sd(Quantity),
            medianQuarterlyQuantity = median(Quantity))
```

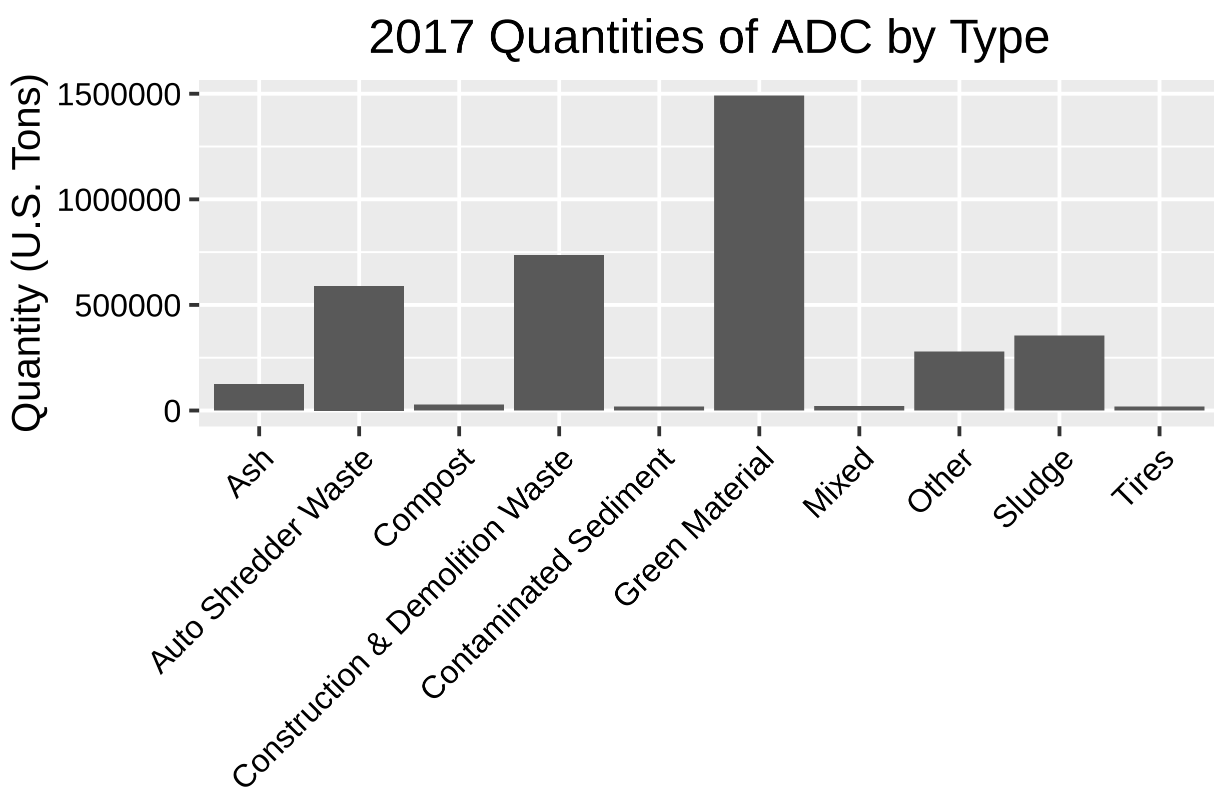
3.2 Create Graphs

```r
# Graph 1: for 2017 data, display total by type
total_bytype_2017 <- ADC_gathered %>%
  filter(Report.Year == 2017) %>%
  group_by(Type) %>%
  summarize(Quantity = sum(Quantity))

# save 2017 dataset
write.csv(total_bytype_2017, row.names = FALSE, file = "../Processed_Data/CalRecycle_ADC

# convert column Type into factor
class(total_bytype_2017$Type)
```

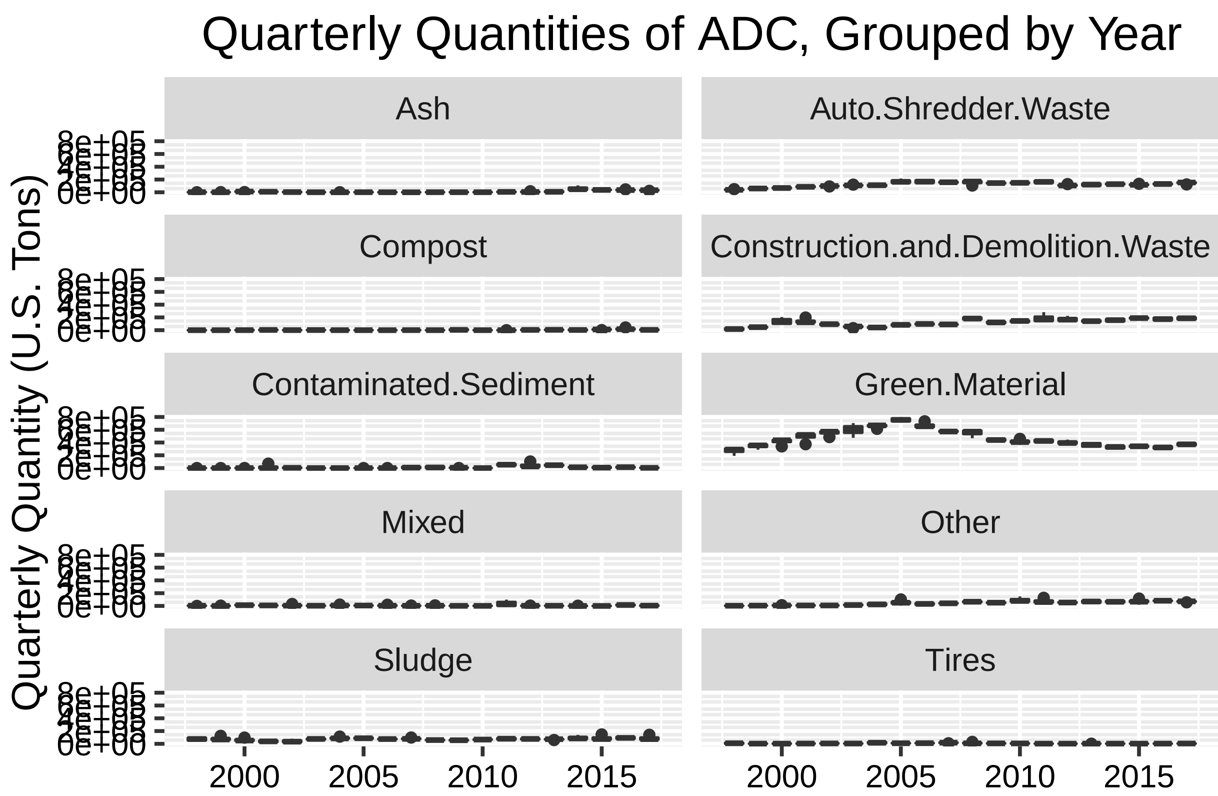
```
## [1] "character"
```

```r
total_bytype_2017$Type <- as.factor(total_bytype_2017$Type)

# plot as a bar chart
total_bytype_2017_plot <-
```

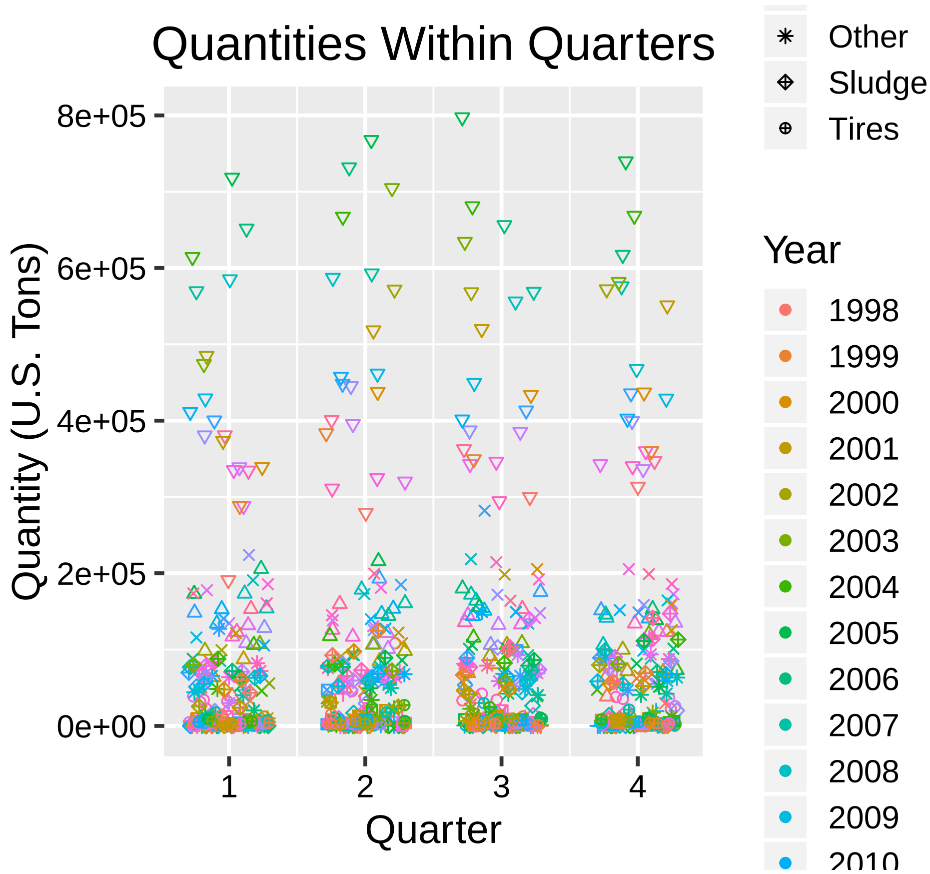
```
    ggplot(data=total_bytype_2017, aes(x=Type, y=Quantity)) +
    geom_bar(stat="identity") +
    xlab('') +
    ylab("Quantity (U.S. Tons)") +
    ggtitle("2017 Quantities of ADC by Type") +
    theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
    scale_x_discrete(labels = c('Ash','Auto Shredder Waste','Compost', 'Construction & I
print(total_bytype_2017_plot)
```




```
# save figure
ggsave("2017ADCbytype_alltypes.jpg", total_bytype_2017_plot, path = "../Output", height

# Graph 2: faceted by Type, display spread of quarterly values by year
quarterlyvalues_byyear_plot <- ggplot(ADC_gathered) +
  geom_boxplot(aes(x = Report.Year, y = Quantity, group = Report.Year)) +
  facet_wrap(vars(Type), nrow = 5) +
  xlab("") +
  ylab("Quarterly Quantity (U.S. Tons)") +
  ggtitle("Quarterly Quantities of ADC, Grouped by Year")
print(quarterlyvalues_byyear_plot)
```




```
# save figure
ggsave("ADCyeardistribution_alltypes.jpg", quarterlyvalues_byyear_plot, path = "../Outpu

# Graph 3: display data by quarter, all Types on same plot
quarterlyvalues_alltypes_plot <-
  ggplot(ADC_gathered) +
  geom_jitter(aes(x = Report.Quarter, y = Quantity, shape = as.factor(Type), color = as
  labs(shape="Type", colour="Year") +
  xlab("Quarter") +
  ylab("Quantity (U.S. Tons)") +
  ggtitle("Quantities Within Quarters") +
  scale_shape_manual(values=c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10), labels = c("Ash", "Auto Sh
  theme(legend.position="right", legend.box = "vertical", legend.direction = "vertical")
  guides(shape = guide_legend(order = 1), color = guide_legend(order = 2))
print(quarterlyvalues_alltypes_plot)
```




```
# save figure
ggsave("QuarterlyADC_alltypes.jpg", quarterlyvalues_alltypes_plot, path = "../Output", h
```

4 Analysis

4.1 Test 1: Statistical Modeling & Data Visualization

Is there a significant difference in total ADC between report quarters? (i.e. 1, 2, 3, 4)

```
# create dataset with only total values, from 1995-2017
ADC_total_only <- ADC_raw %>%
  select(Report.Year, Report.Quarter, Total) # keep all columns except ADC Types

# convert column Report.Quarter into factor
class(ADC_total_only$Report.Quarter)
```

```
## [1] "integer"
```

```
ADC_total_only$Report.Quarter <- as.factor(ADC_total_only$Report.Quarter)

# save the dataset
write.csv(ADC_total_only, row.names = FALSE, file = "../Processed_Data/CalRecycle_ADC_to

# perform one-way ANOVA
# assumption #0: observations are independent (cannot be tested, but assumed to be ind

# test assumption #1: normality
# null hypothesis is that the dataset is normally distributed
shapiro.test(ADC_total_only$Total[ADC_total_only$Report.Quarter == 1]) # p-value = 0.03
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ADC_total_only$Total[ADC_total_only$Report.Quarter == 1]
## W = 0.90566, p-value = 0.03312
```

```
shapiro.test(ADC_total_only$Total[ADC_total_only$Report.Quarter == 2]) # p-value = 0.02
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ADC_total_only$Total[ADC_total_only$Report.Quarter == 2]
## W = 0.89774, p-value = 0.02271
```

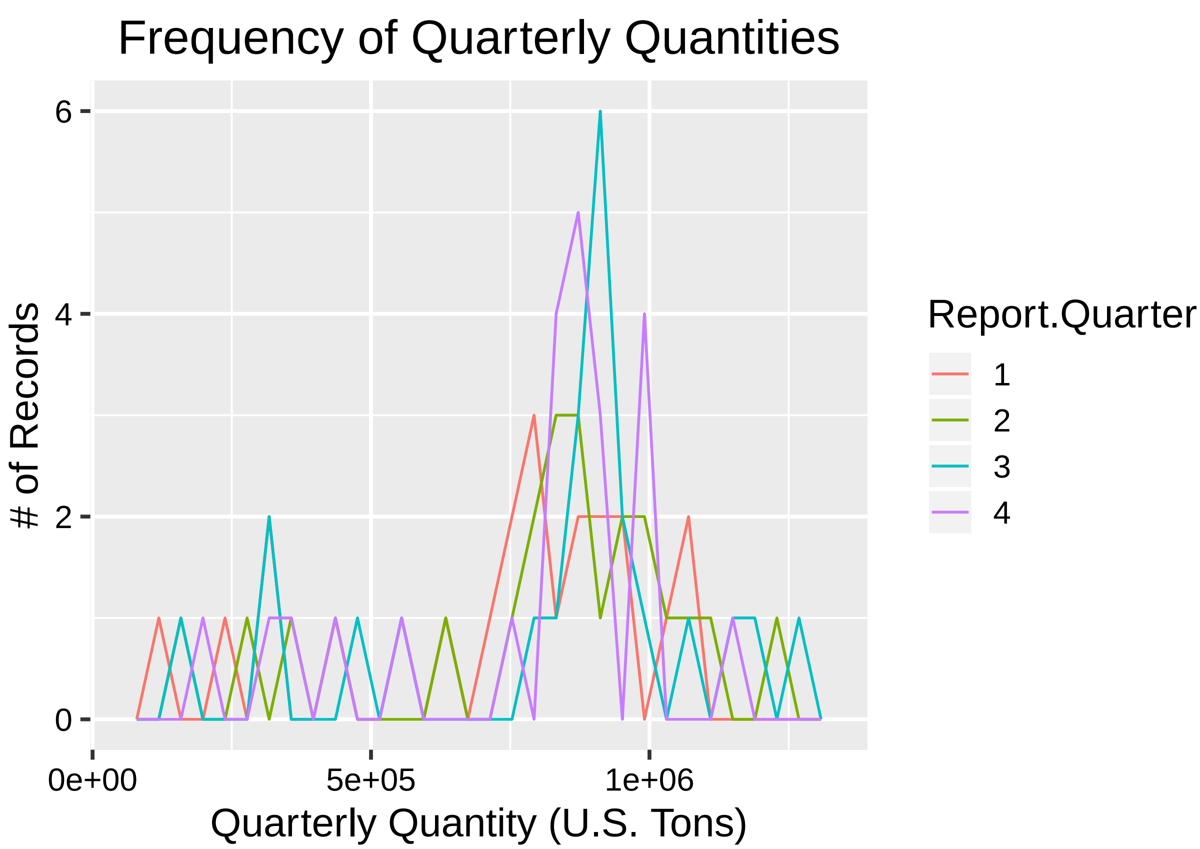
```
shapiro.test(ADC_total_only$Total[ADC_total_only$Report.Quarter == 3]) # p-value = 0.00
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ADC_total_only$Total[ADC_total_only$Report.Quarter == 3]
## W = 0.87982, p-value = 0.00993
```

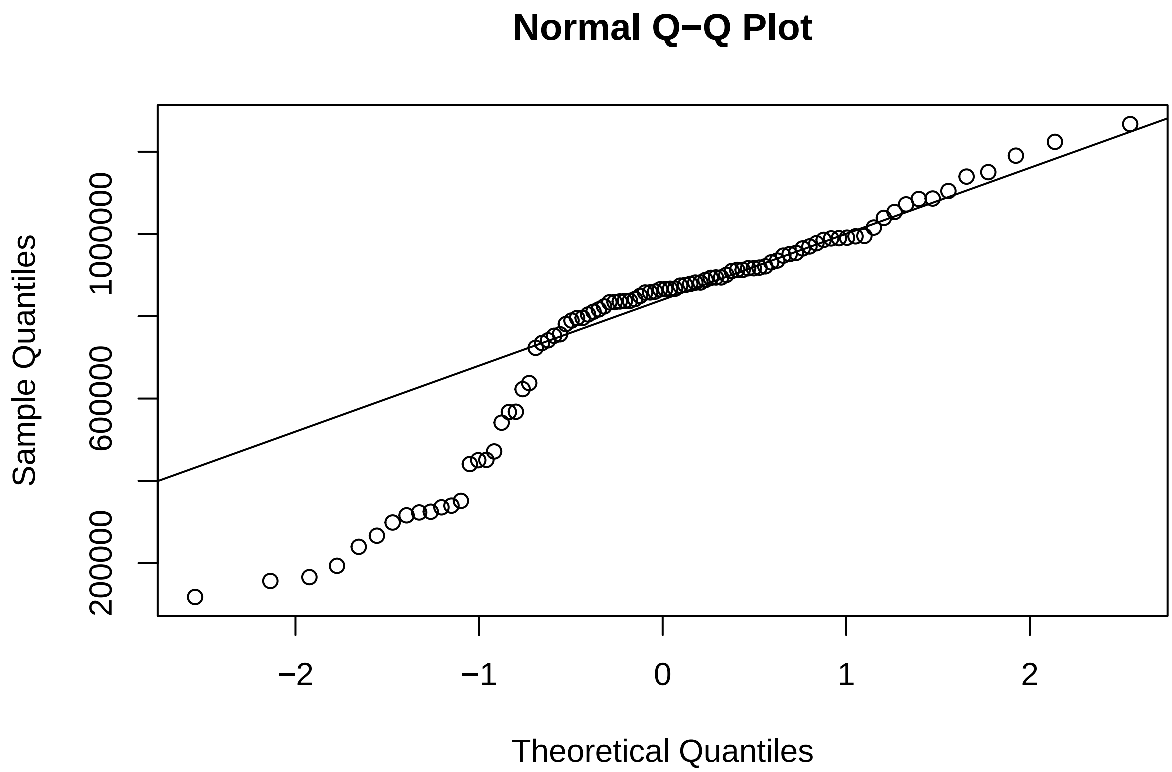
```r
shapiro.test(ADC_total_only$Total[ADC_total_only$Report.Quarter == 4]) # p-value = 0.00
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ADC_total_only$Total[ADC_total_only$Report.Quarter == 4]
## W = 0.83198, p-value = 0.001305
```

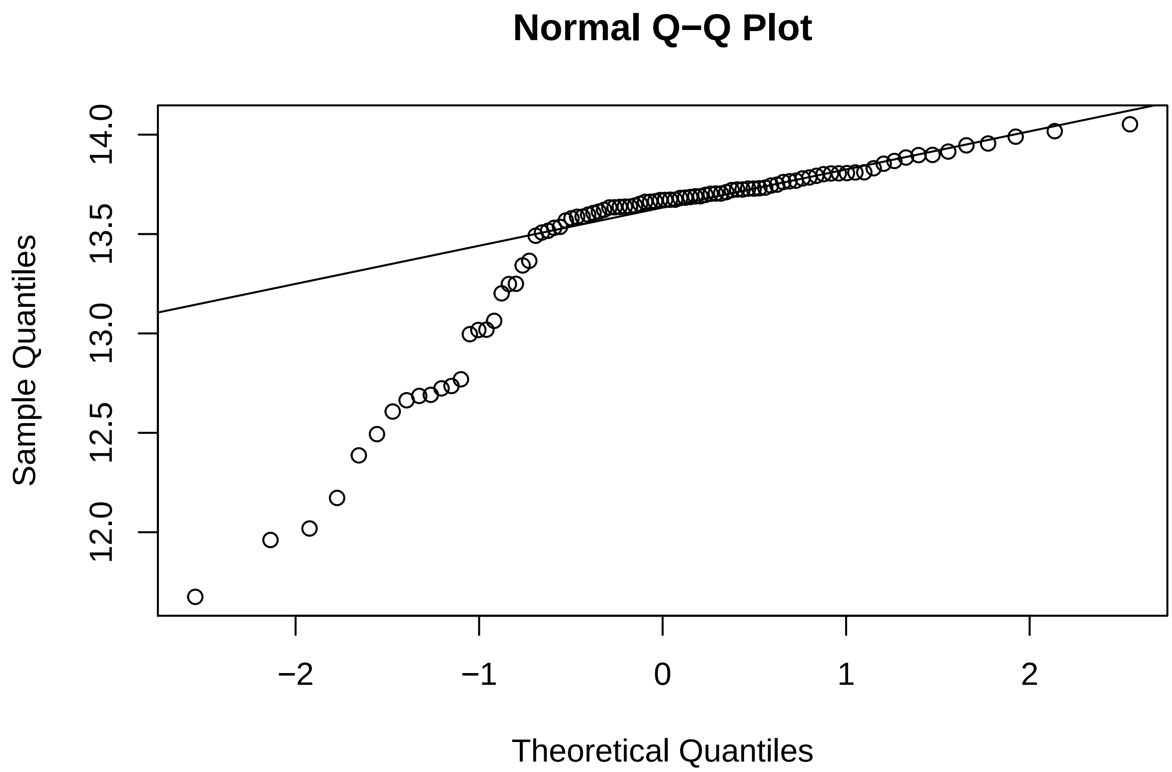
```r
ADC_freq_poly <- ggplot(ADC_total_only) +
  geom_freqpoly(aes(x = Total, color = Report.Quarter)) +
  xlab("Quarterly Quantity (U.S. Tons)") +
  ylab("# of Records") +
  ggtitle("Frequency of Quarterly Quantities")
print(ADC_freq_poly) # appears to be left skewed
```




```r
qqnorm(ADC_total_only$Total); qqline(ADC_total_only$Total) # does not match 1:1 ratio
```



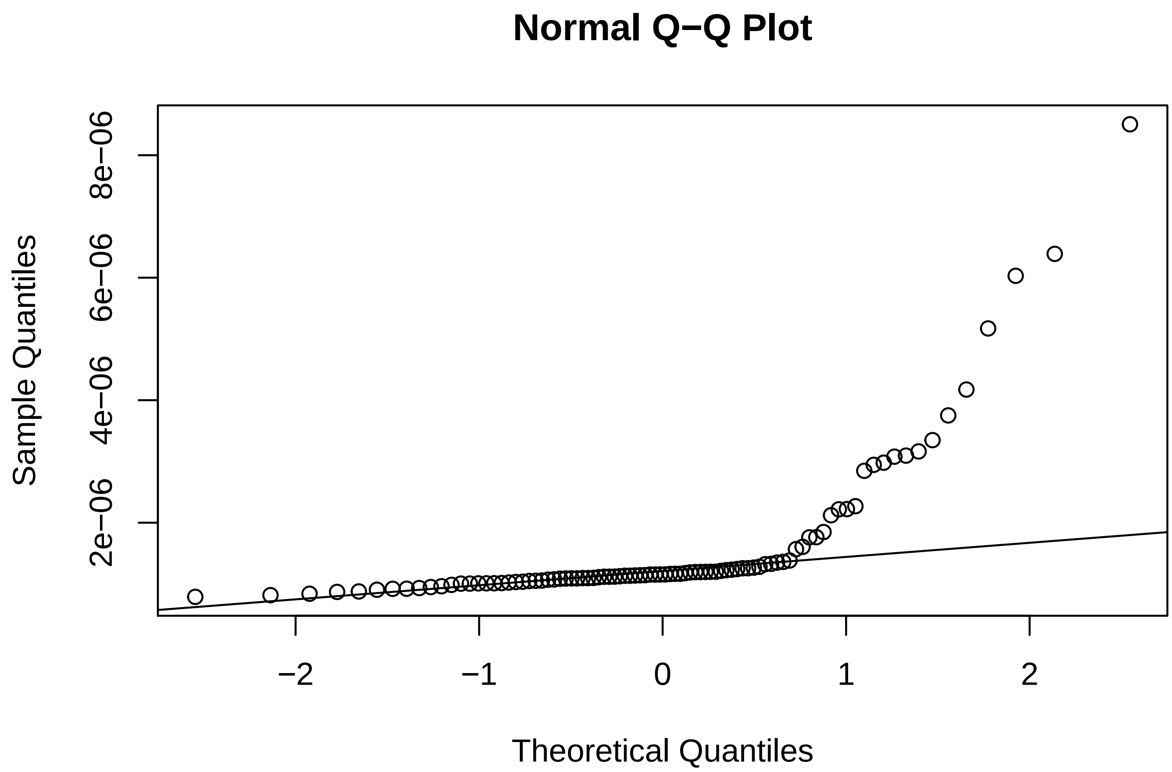

```
# Try to fix departure from normality with ln of Total. Result is not improved, so kee
ADC_LogTotal <- mutate(ADC_total_only, LogTotal = log(Total))
qqnorm(ADC_LogTotal$LogTotal); qqline(ADC_LogTotal$LogTotal)
```




```
bartlett.test(ADC_LogTotal$LogTotal ~ ADC_LogTotal$Report.Quarter)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  ADC_LogTotal$LogTotal by ADC_LogTotal$Report.Quarter
## Bartlett's K-squared = 1.1435, df = 3, p-value = 0.7666
```

```
# Try to fix departure from normality with 1/Total. Result is not improved, so keep no
ADC_InvTotal <- mutate(ADC_total_only, InvTotal = 1/Total)
qqnorm(ADC_InvTotal$InvTotal); qqline(ADC_InvTotal$InvTotal)
```




```r
bartlett.test(ADC_InvTotal$InvTotal ~ ADC_InvTotal$Report.Quarter)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  ADC_InvTotal$InvTotal by ADC_InvTotal$Report.Quarter
## Bartlett's K-squared = 6.519, df = 3, p-value = 0.08892
```

```r
# test assumption #2: equal variances among groups

# null hypothesis is that the variance is the same for the treatment groups
bartlett.test(ADC_total_only$Total ~ ADC_total_only$Report.Quarter) #p-value = 0.9308 #
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  ADC_total_only$Total by ADC_total_only$Report.Quarter
## Bartlett's K-squared = 0.44478, df = 3, p-value = 0.9308
```

```r
# dataset is not normal, but does fulfill requirement for same variances. proceed with

# try non-parametric w/ post hoc, bc sample size is on the smaller end for parametric
ADC_quarter_kw <- kruskal.test(ADC_total_only$Total ~ ADC_total_only$Report.Quarter)
```

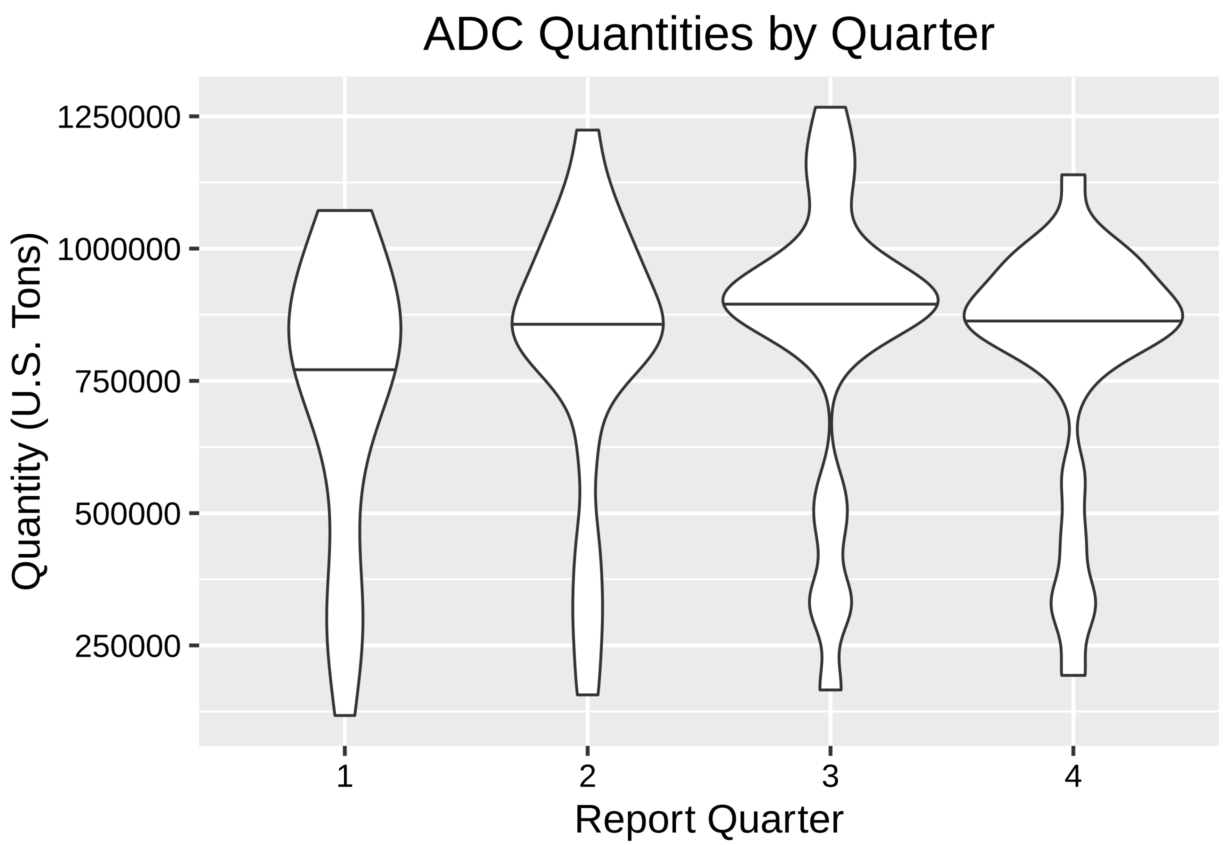
```
ADC_quarter_kw
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  ADC_total_only$Total by ADC_total_only$Report.Quarter
## Kruskal-Wallis chi-squared = 3.4581, df = 3, p-value = 0.3262
```

```
dunnTest(ADC_total_only$Total, ADC_total_only$Report.Quarter)
```

```
##   Comparison           Z     P.unadj     P.adj
## 1      1 - 2 -1.08778370 0.27669061 1.0000000
## 2      1 - 3 -1.84978446 0.06434462 0.3860677
## 3      2 - 3 -0.76200076 0.44605955 0.8921191
## 4      1 - 4 -1.00495753 0.31491730 1.0000000
## 5      2 - 4  0.08282617 0.93398976 0.9339898
## 6      3 - 4  0.84482693 0.39820748 1.0000000
```

```
# plot the results
ADC_quarter_plot <- ggplot(ADC_total_only, aes(x = Report.Quarter, y = Total)) +
  geom_violin(draw_quantiles = 0.5) +
  xlab('Report Quarter') +
  ylab('Quantity (U.S. Tons)') +
  ggtitle('ADC Quantities by Quarter')
print(ADC_quarter_plot)
```




```
# save figure
ggsave("QuarterlyADC_violinplot.jpg", ADC_quarter_plot, path = "../Output", height = 4,
```

4.2 Test 2: Statistical Modeling & Data Visualization

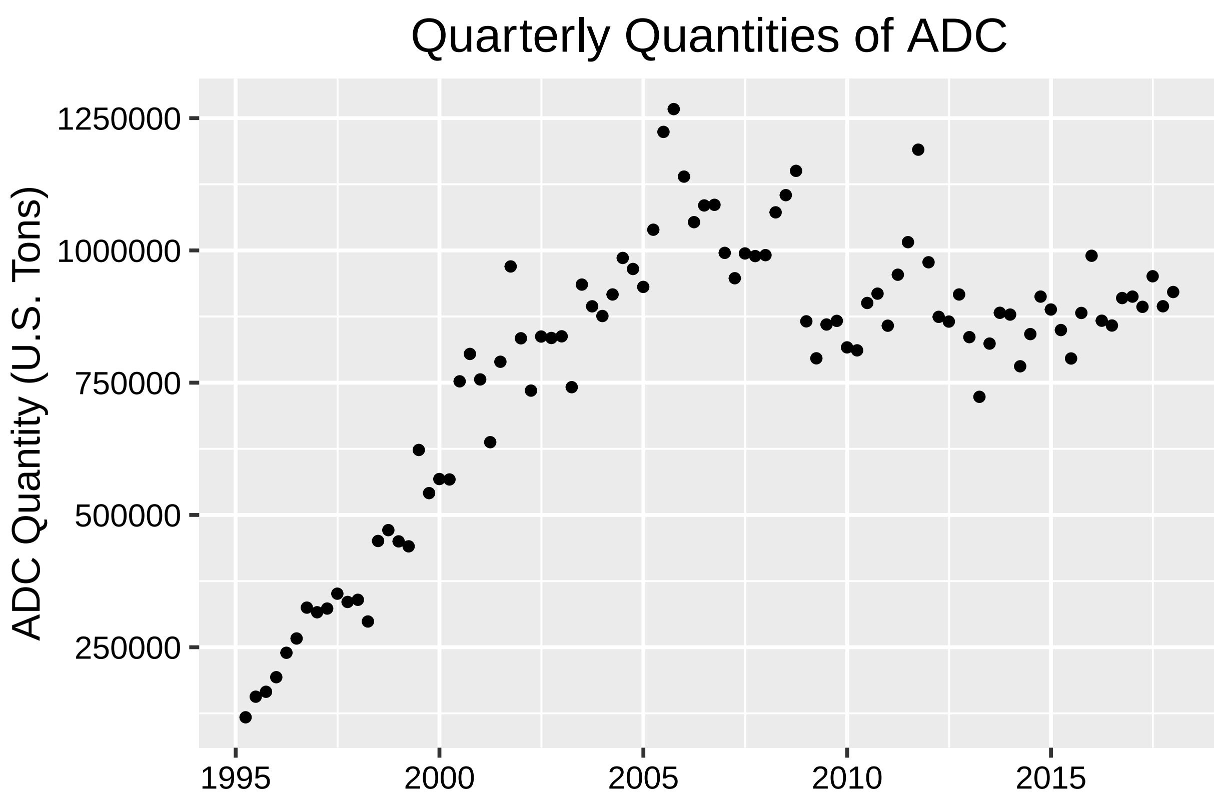
Can total annual ADC be represented with a linear model?

```
# assumptions for lm (independent observation, normal distribution, equal variances am

# create dates corresponding to year & quarter combination
# Q1: Mar 31
# Q2: Jun 30
# Q3: Sep 30
# Q4: Dec 31

# create dataframe of month-date
quarters_to_dates <- data.frame("Quarter" = as.factor(1:4), "Month.Date" = c('3-31', '6-

# create new dataframe with dates
ADC_fulldate <- ADC_total_only %>%
  inner_join(quarters_to_dates, by = c("Report.Quarter" =  "Quarter")) %>%
  unite('Quarter.End.Date', c(Report.Year, Month.Date), sep = "-", remove = FALSE)
```

```r
ADC_fulldate$Quarter.End.Date <- as.Date(ADC_fulldate$Quarter.End.Date, "%Y-%m-%d")
class(ADC_fulldate$Quarter.End.Date)
```

```
## [1] "Date"
```

```r
# create initial plot to visualize the data
ggplot(ADC_fulldate, aes(x = Quarter.End.Date, y = Total)) +
  geom_point() +
  xlab("") +
  ylab("ADC Quantity (U.S. Tons)") +
  ggtitle("Quarterly Quantities of ADC")
```




```r
# create lm
ADC_date_lm <- lm(data = ADC_fulldate, Total ~ Quarter.End.Date)
ADC_date_lm # Total = 73.14*Quarter.End.Date - 190264.58
```

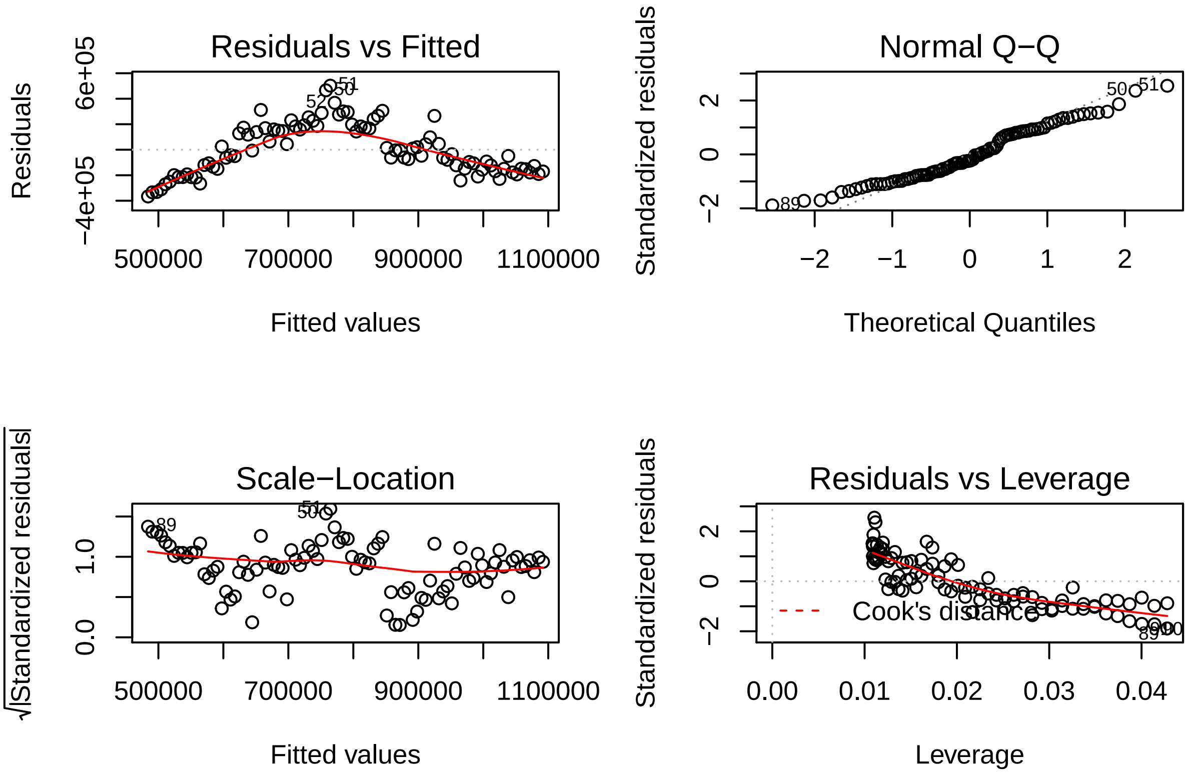
```
##
## Call:
## lm(formula = Total ~ Quarter.End.Date, data = ADC_fulldate)
##
## Coefficients:
##      (Intercept)  Quarter.End.Date
```

```
##       -190264.58             73.14
```

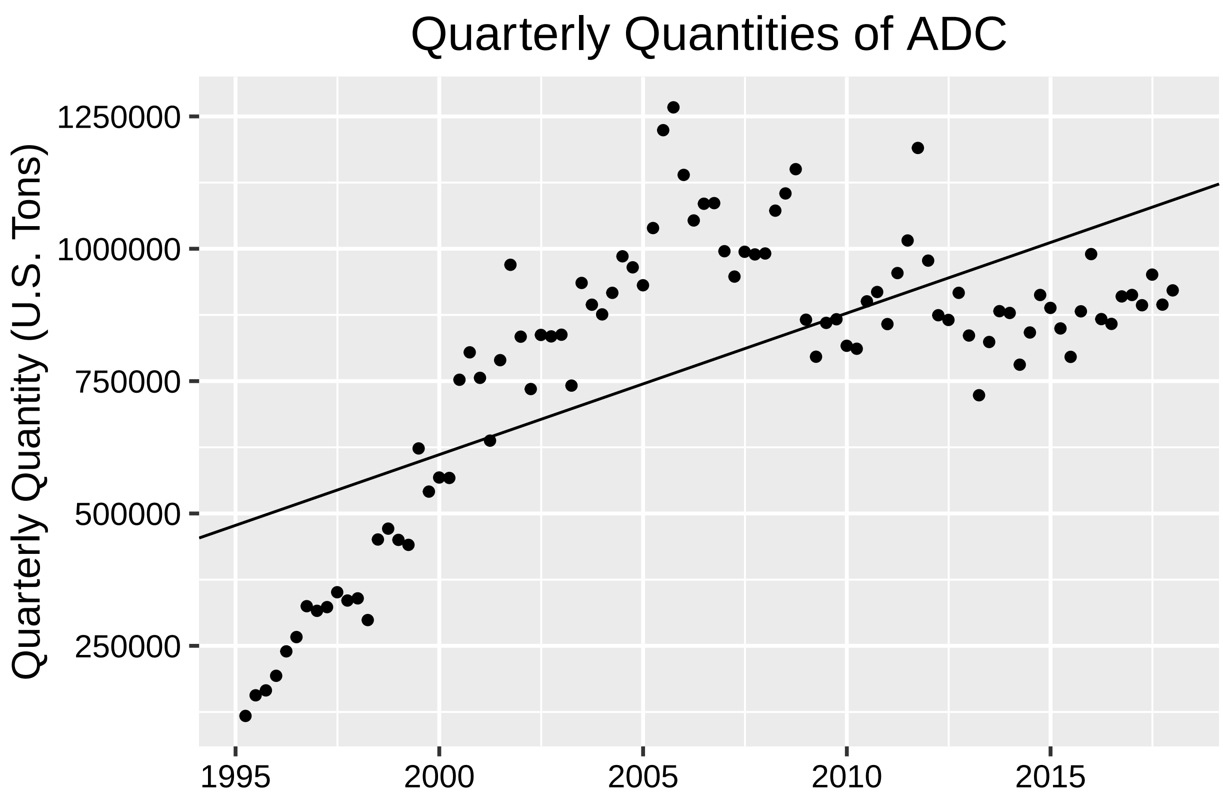
```r
summary(ADC_date_lm) # Adjusted R-squared:  0.4433 (date explains 44.33% of variation
```

```
##
## Call:
## lm(formula = Total ~ Quarter.End.Date, data = ADC_fulldate)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -366483 -153515  -45160  167108  502499
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)      -1.903e+05  1.160e+05   -1.64    0.104
## Quarter.End.Date  7.314e+01  8.534e+00    8.57 2.69e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 198500 on 90 degrees of freedom
## Multiple R-squared:  0.4494, Adjusted R-squared:  0.4433
## F-statistic: 73.45 on 1 and 90 DF,  p-value: 2.694e-13
```

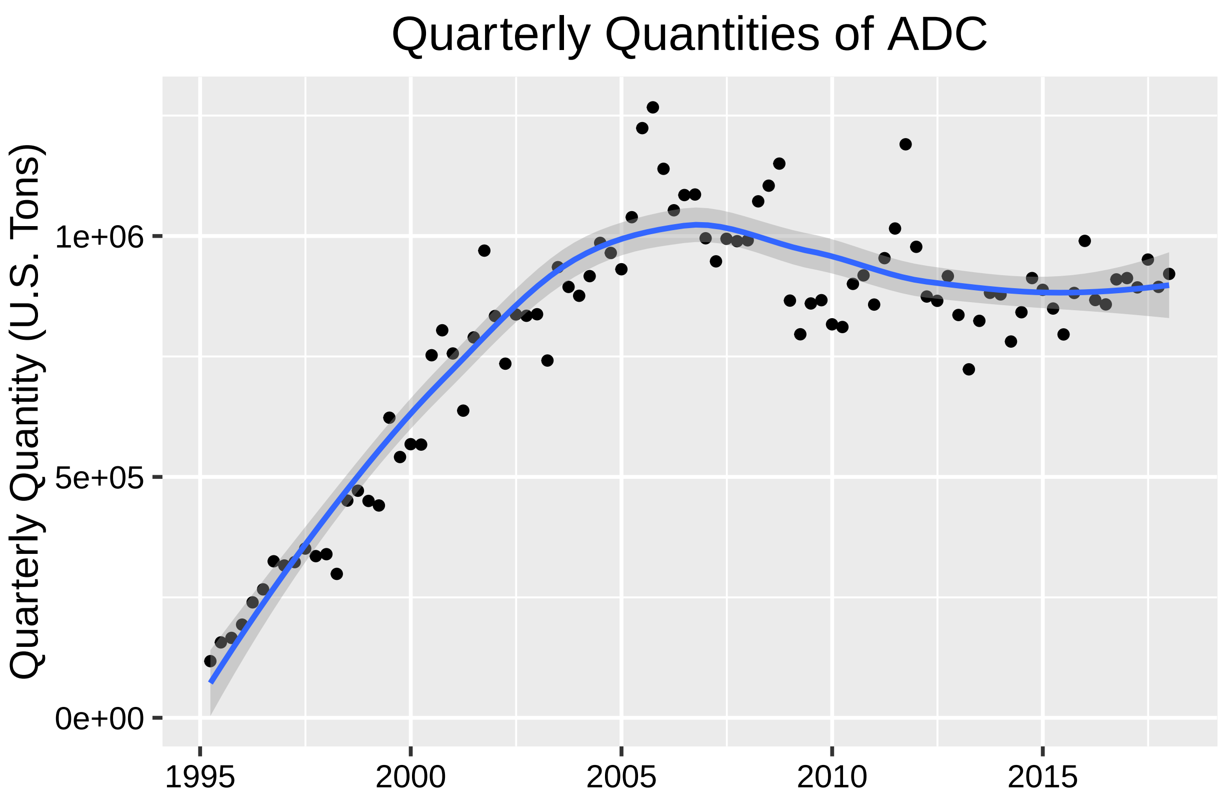
```r
# check normality of residuals
par(mfrow=c(2,2))
plot(ADC_date_lm) # QQ of residuals looks relatively normal
```




```
# plot data w/ model
ADC_fulldate_plot <- ggplot(ADC_fulldate, aes(x = Quarter.End.Date, y = Total)) +
  geom_abline(intercept = -190264.58, slope = 73.14) +
  geom_point() +
  xlab('') +
  ylab('Quarterly Quantity (U.S. Tons)') +
  ggtitle('Quarterly Quantities of ADC')
print(ADC_fulldate_plot)
```




```r
# visually, model does not appear to be a great fit

# save figure
ggsave("TotalADC_plot_calculatedmodel.jpg", ADC_fulldate_plot, path = "../Output", heigh

# plot with loess smoother
ADC_fulldate_plot_loess <- ggplot(ADC_fulldate, aes(x = Quarter.End.Date, y = Total)) +
  geom_point() +
  geom_smooth(method = loess) +
  xlab('') +
  ylab('Quarterly Quantity (U.S. Tons)') +
  ggtitle('Quarterly Quantities of ADC')
print(ADC_fulldate_plot_loess)
```



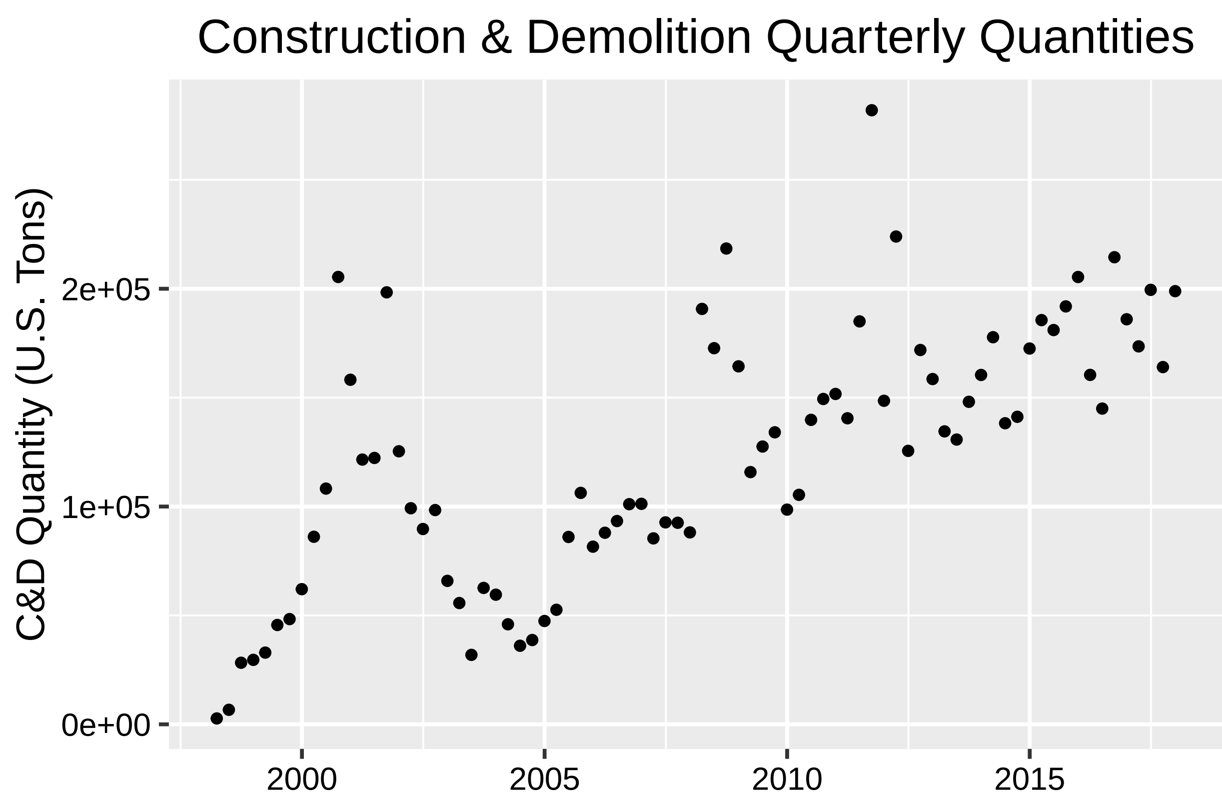

```
# visually, model appears to be a great fit

# save figure
ggsave("TotalADC_plot_loess.jpg", ADC_fulldate_plot_loess, path = "../Output", height =
```

4.3 Test 3: Statistical Modeling & Data Visualization

Is there a changepoint in the Construction & Demolition quantities over time?

```
# create dataframe with dates
quarters_to_dates$Quarter <- as.integer(quarters_to_dates$Quarter)

CD_only <- ADC_data %>%
  select(Report.Year, Report.Quarter, Construction.and.Demolition.Waste) %>%
  inner_join(quarters_to_dates, by = c("Report.Quarter" =  "Quarter")) %>%
  unite('Quarter.End.Date', c(Report.Year, Month.Date), sep = "-") %>%
  select(-Report.Quarter)

CD_only$Quarter.End.Date <- as.Date(CD_only$Quarter.End.Date, '%Y-%m-%d') # format colu

# arrange data from oldest to newest
CD_only <- CD_only %>%
```

```
  arrange(Quarter.End.Date)

# create initial plot to visualize the data
ggplot(CD_only, aes(x = Quarter.End.Date, y = Construction.and.Demolition.Waste)) +
  geom_point() +
  xlab("") +
  ylab("C&D Quantity (U.S. Tons)") +
  ggtitle("Construction & Demolition Quarterly Quantities")
```

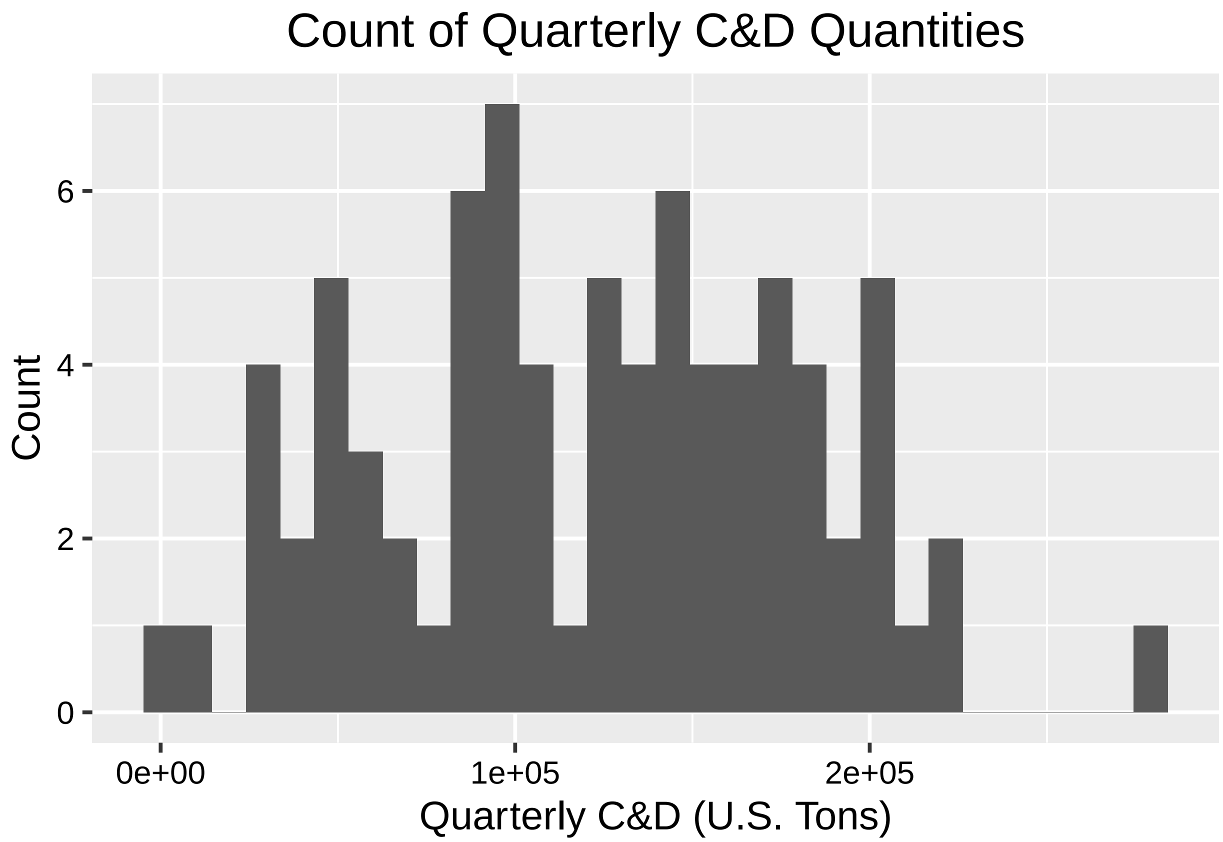



```
# check normality for C&D waste specifically
shapiro.test(CD_only$Construction.and.Demolition.Waste) # p-value = 0.4028, inferring t
```

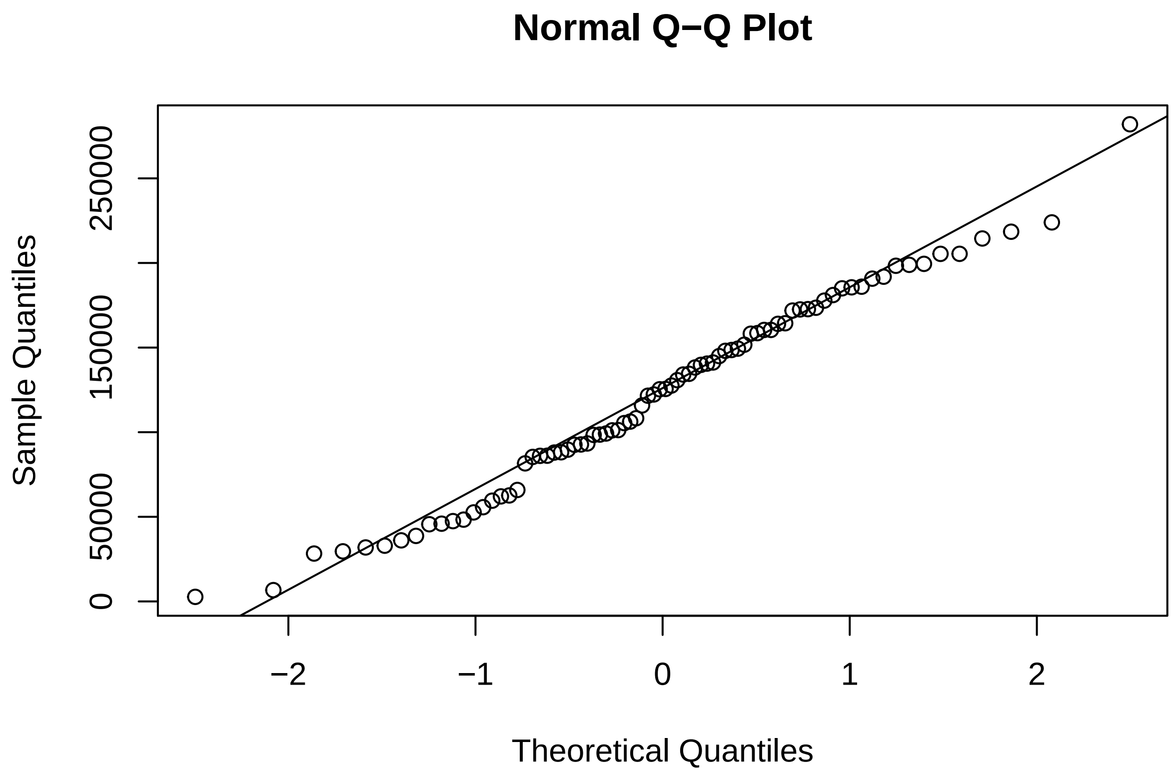
```
##
##  Shapiro-Wilk normality test
##
## data:  CD_only$Construction.and.Demolition.Waste
## W = 0.9837, p-value = 0.4028
```

```
ggplot(CD_only) +
  geom_histogram(aes(x = Construction.and.Demolition.Waste)) +
  xlab("Quarterly C&D (U.S. Tons)") +
  ylab("Count") +
```

```r
  ggtitle("Count of Quarterly C&D Quantities")
```




```r
qqnorm(CD_only$Construction.and.Demolition.Waste); qqline(CD_only$Construction.and.Demol
```




```r
# use Pettitt's test (nonparametric) to determine whether there is a shift in the cent
pettitt.test(CD_only$Construction.and.Demolition.Waste) # change point at time 40
```

```
##
##  Pettitt's test for single change-point detection
##
## data:  CD_only$Construction.and.Demolition.Waste
## U* = 1396, p-value = 3.2e-10
## alternative hypothesis: two.sided
## sample estimates:
## probable change point at time K
##                              40
```

```r
# Run separate Mann-Kendall for each section
mk.test(CD_only$Construction.and.Demolition.Waste[1:40])
```

```
##
##  Mann-Kendall trend test
##
## data:  CD_only$Construction.and.Demolition.Waste[1:40]
## z = 1.736, n = 40, p-value = 0.08256
## alternative hypothesis: true S is not equal to 0
```

```
## sample estimates:
##             S          varS           tau
##  150.0000000 7366.6666667    0.1923077
```

```r
mk.test(CD_only$Construction.and.Demolition.Waste[41:80])
```

```
##
##  Mann-Kendall trend test
##
## data:  CD_only$Construction.and.Demolition.Waste[41:80]
## z = 2.4817, n = 40, p-value = 0.01308
## alternative hypothesis: true S is not equal to 0
## sample estimates:
##            S        varS          tau
##  214.000000 7366.666667    0.274359
```

```r
# Is there a second change point?
pettitt.test(CD_only$Construction.and.Demolition.Waste[41:80])
```

```
##
##  Pettitt's test for single change-point detection
##
## data:  CD_only$Construction.and.Demolition.Waste[41:80]
## U* = 203, p-value = 0.04614
## alternative hypothesis: two.sided
## sample estimates:
## probable change point at time K
##                              27
```

```r
# position 27, so 41+27 = change point at time 68

# Run separate Mann-Kendall for new section
mk.test(CD_only$Construction.and.Demolition.Waste[69:80]) # p-value = 0.9453, not likel
```

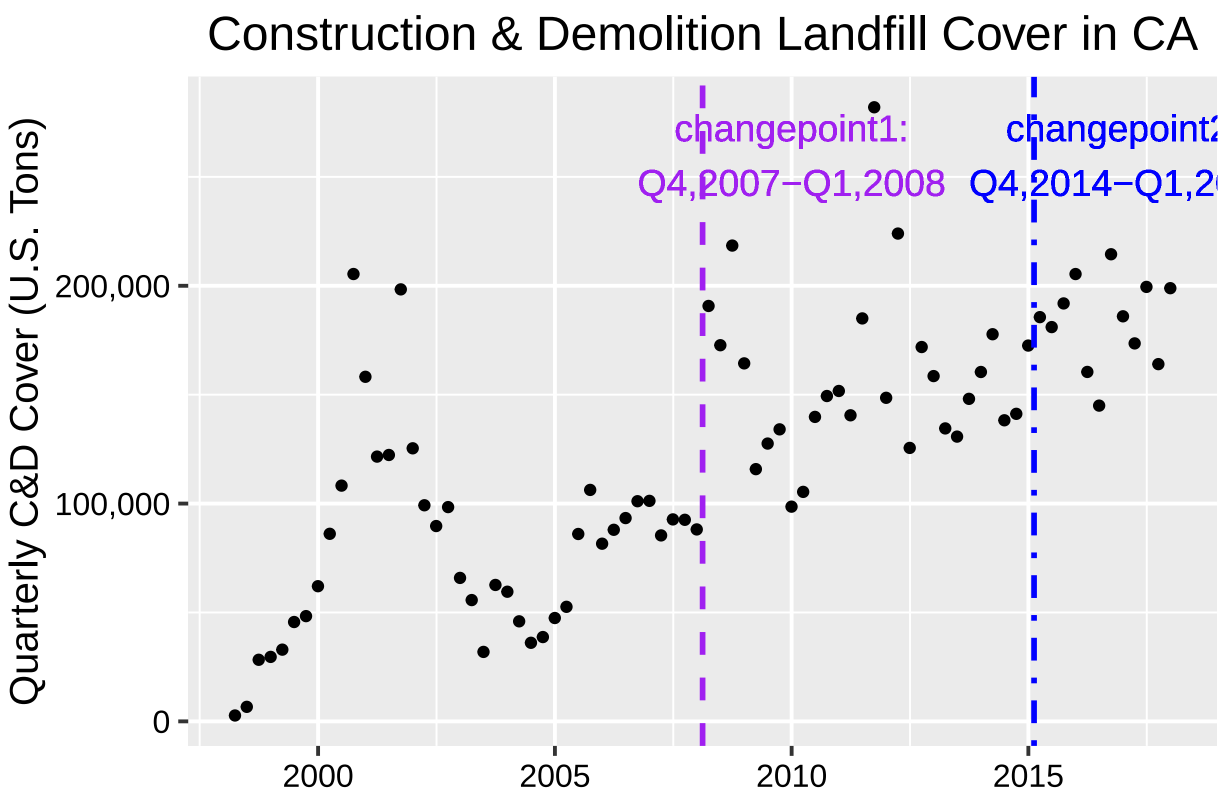
```
##
##  Mann-Kendall trend test
##
## data:  CD_only$Construction.and.Demolition.Waste[69:80]
## z = 0.068573, n = 12, p-value = 0.9453
## alternative hypothesis: true S is not equal to 0
## sample estimates:
##             S          varS           tau
##   2.00000000 212.66666667   0.03030303
```

```r
# Is there a third change point?
pettitt.test(CD_only$Construction.and.Demolition.Waste[69:80]) # p-value = p-value = 1.
```

```
##
```

```
##  Pettitt's test for single change-point detection
##
## data:  CD_only$Construction.and.Demolition.Waste[69:80]
## U* = 12, p-value = 1.261
## alternative hypothesis: two.sided
## sample estimates:
## probable change point at time K
##                               6
```

```
# years corresponding to changepoints
changepoint1 <- CD_only$Quarter.End.Date[40] # between Q4 2007 & Q1 2008 = ~ 2008-02-14
changepoint2 <- CD_only$Quarter.End.Date[68] # between Q4 2014 & Q1 2015 = ~ 2015-02-14

# Add vertical lines to the original graph to represent change points
CD_plot_changepoints <- ggplot(CD_only, aes(x=Quarter.End.Date, y=Construction.and.Demol
  geom_point() +
  geom_vline(aes(xintercept=as.Date('2008-02-14')), linetype=2, colour="purple", size=1)
  geom_vline(aes(xintercept=as.Date('2015-02-14')), linetype=4, colour="blue", size=1) +
  geom_text(x=as.Date('2010-1-1'), y=260000, label=stringr::str_wrap('changepoint1: Q4,2
  geom_text(x=as.Date('2017-1-1'), y=260000, label=stringr::str_wrap('changepoint2: Q4,2
  xlab('') +
  ylab('Quarterly C&D Cover (U.S. Tons)') +
  scale_y_continuous(labels = scales::comma) +
  ggtitle('Construction & Demolition Landfill Cover in CA')
print(CD_plot_changepoints)
```




```r
# save figure
ggsave("CD_plot_changepoints.jpg", CD_plot_changepoints, path = "../Output", height = 4,
```

5 Summary and Conclusions