Final Exam

Jacob Aylward

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```
library(readr)
data<- read_csv("C:/Users/jacob/Downloads/out_eia923__fuel_receipts_costs-
2.csv")
```

```
## Rows: 696244 Columns: 36
## ── Column specification
────────────────────────────────────────────────────────
## Delimiter: ","
## chr  (25): plant_name_eia, utility_name_eia, state, contract_type_code,
ener...
## dbl   (9): plant_id_eia, plant_id_pudl, utility_id_eia, utility_id_pudl,
fue...
## dttm  (2): report_date, contract_expiration_date
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
View(data)
```

```
library(tidyverse)
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse
2.0.0 ──
## ✓ dplyr     1.1.4     ✓ purrr     1.0.4
## ✓ forcats   1.0.0     ✓ stringr   1.5.1
## ✓ ggplot2   3.5.2     ✓ tibble    3.2.1
## ✓ lubridate 1.9.4     ✓ tidyr     1.3.1
## ── Conflicts ──────────────────────────────────────────
tidyverse_conflicts() ──
## ✕ dplyr::filter() masks stats::filter()
## ✕ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all
conflicts to become errors
```

```
library(factoextra)
```

```
## Welcome! Want to learn more? See two factoextra-related books at
https://goo.gl/ve3WBa
```

```
Data <- na.omit(data)
str(Data)
```

```
## tibble [696,244 × 36] (S3: tbl_df/tbl/data.frame)
##  $ report_date                          : POSIXct[1:696244], format:
"2008-01-01" "2008-01-01" ...
##  $ plant_id_eia                         : num [1:696244] 3 3 3 7 7 7 7 8
8 8 ...
##  $ plant_id_pudl                        : num [1:696244] 32 32 32 207
207 207 207 231 231 231 ...
##  $ plant_name_eia                       : chr [1:696244] "Barry" "Barry"
"Barry" "Gadsden" ...
##  $ utility_id_eia                       : num [1:696244] 195 195 195 195
195 195 195 195 195 195 ...
##  $ utility_id_pudl                      : num [1:696244] 18 18 18 18 18
18 18 18 18 18 ...
##  $ utility_name_eia                     : chr [1:696244] "Alabama Power
Co" "Alabama Power Co" "Alabama Power Co" "Alabama Power Co" ...
##  $ state                                : chr [1:696244] "AL" "AL" "AL"
"AL" ...
##  $ contract_type_code                   : chr [1:696244] "C" "C" "C" "C"
...
##  $ contract_expiration_date             : POSIXct[1:696244], format:
"2008-04-01" "2008-04-01" ...
##  $ energy_source_code                   : chr [1:696244] "BIT" "BIT"
"NG" "BIT" ...
##  $ fuel_type_code_pudl                  : chr [1:696244] "coal" "coal"
"gas" "coal" ...
##  $ fuel_group_code                      : chr [1:696244] "coal" "coal"
"natural_gas" "coal" ...
##  $ supplier_name                        : chr [1:696244] "interocean
coal" "interocean coal" "bay gas pipeline" "alabama coal" ...
##  $ fuel_received_units                  : num [1:696244] 259412 52241
2783619 25397 764 ...
##  $ fuel_mmbtu_per_unit                  : num [1:696244] 23.1 22.8 1.04
24.61 24.45 ...
##  $ fuel_cost_per_mmbtu                  : chr [1:696244]
"2.134999990463257" "2.115000009536743" "8.630999565124512"
"2.7760000228881836" ...
##  $ bulk_agg_fuel_cost_per_mmbtu         : chr [1:696244] "null" "null"
"8.603500366210938" "null" ...
##  $ fuel_consumed_mmbtu                  : num [1:696244] 5992418 1191095
2892180 625020 18677 ...
##  $ total_fuel_cost                      : chr [1:696244] "12793811"
"2519165.5" "24962406" "1735056" ...
##  $ fuel_cost_per_mmbtu_source           : chr [1:696244] "original"
"original" "original" "original" ...
##  $ sulfur_content_pct                   : num [1:696244] 0.49 0.48 0
1.69 0.84 ...
##  $ ash_content_pct                      : num [1:696244] 5.4 5.7 0 14.7
15.5 ...
##  $ mercury_content_ppm                  : chr [1:696244] "null" "null"
"null" "null" ...
```

```
##  $ primary_transportation_mode_code       : chr [1:696244] "RV" "RV" "PL"
"TR" ...
##  $ secondary_transportation_mode_code     : chr [1:696244] "null" "null"
"null" "null" ...
##  $ natural_gas_transport_code             : chr [1:696244] "firm" "firm"
"firm" "firm" ...
##  $ natural_gas_delivery_contract_type_code: chr [1:696244] "null" "null"
"null" "null" ...
##  $ moisture_content_pct                   : chr [1:696244] "null" "null"
"null" "null" ...
##  $ chlorine_content_ppm                   : chr [1:696244] "null" "null"
"null" "null" ...
##  $ data_maturity                          : chr [1:696244] "final" "final"
"final" "final" ...
##  $ mine_id_msha                           : chr [1:696244] "null" "null"
"null" "null" ...
##  $ mine_name                              : chr [1:696244] "mina
pribbenow" "mina pribbenow" "null" "alabama coal" ...
##  $ mine_state                             : chr [1:696244] "COL" "COL"
"null" "AL" ...
##  $ coalmine_county_id_fips                : chr [1:696244] "null" "null"
"null" "01007" ...
##  $ mine_type_code                         : chr [1:696244] "SU" "SU"
"null" "SU" ...
```

```
Data_New <- Data[, !(names(Data)
%in%c("mercury_content_ppm","natural_gas_delivery_contract_type_code","moistu
re_content_pct","chlorine_content_ppm","mine_id_msha"))]
str(Data_New)
```

```
## tibble [696,244 × 31] (S3: tbl_df/tbl/data.frame)
##  $ report_date                       : POSIXct[1:696244], format: "2008-
01-01" "2008-01-01" ...
##  $ plant_id_eia                      : num [1:696244] 3 3 3 7 7 7 7 8 8 8
...
##  $ plant_id_pudl                     : num [1:696244] 32 32 32 207 207 207
207 231 231 231 ...
##  $ plant_name_eia                    : chr [1:696244] "Barry" "Barry"
"Barry" "Gadsden" ...
##  $ utility_id_eia                    : num [1:696244] 195 195 195 195 195
195 195 195 195 195 ...
##  $ utility_id_pudl                   : num [1:696244] 18 18 18 18 18 18 18
18 18 18 ...
##  $ utility_name_eia                  : chr [1:696244] "Alabama Power Co"
"Alabama Power Co" "Alabama Power Co" "Alabama Power Co" ...
##  $ state                             : chr [1:696244] "AL" "AL" "AL" "AL"
...
##  $ contract_type_code                : chr [1:696244] "C" "C" "C" "C" ...
##  $ contract_expiration_date          : POSIXct[1:696244], format: "2008-
04-01" "2008-04-01" ...
```

```
##  $ energy_source_code               : chr [1:696244] "BIT" "BIT" "NG"
"BIT" ...
##  $ fuel_type_code_pudl              : chr [1:696244] "coal" "coal" "gas"
"coal" ...
##  $ fuel_group_code                  : chr [1:696244] "coal" "coal"
"natural_gas" "coal" ...
##  $ supplier_name                    : chr [1:696244] "interocean coal"
"interocean coal" "bay gas pipeline" "alabama coal" ...
##  $ fuel_received_units              : num [1:696244] 259412 52241 2783619
25397 764 ...
##  $ fuel_mmbtu_per_unit              : num [1:696244] 23.1 22.8 1.04 24.61
24.45 ...
##  $ fuel_cost_per_mmbtu              : chr [1:696244] "2.134999990463257"
"2.115000009536743" "8.630999565124512" "2.7760000228881836" ...
##  $ bulk_agg_fuel_cost_per_mmbtu     : chr [1:696244] "null" "null"
"8.603500366210938" "null" ...
##  $ fuel_consumed_mmbtu              : num [1:696244] 5992418 1191095
2892180 625020 18677 ...
##  $ total_fuel_cost                  : chr [1:696244] "12793811"
"2519165.5" "24962406" "1735056" ...
##  $ fuel_cost_per_mmbtu_source       : chr [1:696244] "original"
"original" "original" "original" ...
##  $ sulfur_content_pct               : num [1:696244] 0.49 0.48 0 1.69
0.84 ...
##  $ ash_content_pct                  : num [1:696244] 5.4 5.7 0 14.7 15.5
...
##  $ primary_transportation_mode_code  : chr [1:696244] "RV" "RV" "PL" "TR"
...
##  $ secondary_transportation_mode_code: chr [1:696244] "null" "null" "null"
"null" ...
##  $ natural_gas_transport_code       : chr [1:696244] "firm" "firm" "firm"
"firm" ...
##  $ data_maturity                    : chr [1:696244] "final" "final"
"final" "final" ...
##  $ mine_name                        : chr [1:696244] "mina pribbenow"
"mina pribbenow" "null" "alabama coal" ...
##  $ mine_state                       : chr [1:696244] "COL" "COL" "null"
"AL" ...
##  $ coalmine_county_id_fips          : chr [1:696244] "null" "null" "null"
"01007" ...
##  $ mine_type_code                   : chr [1:696244] "SU" "SU" "null"
"SU" ...
```

```
sample_data <- round(0.02 * nrow(Data_New))
sample. <-sample(1:nrow(Data_New), size = sample_data, replace =FALSE)
new_sample <- Data_New[sample.,]
str(new_sample)
```

```
## tibble [13,925 × 31] (S3: tbl_df/tbl/data.frame)
##  $ report_date                      : POSIXct[1:13925], format: "2011-07-
```

```
01" "2017-01-01" ...
##  $ plant_id_eia                     : num [1:13925] 6823 54844 3149 165
7953 ...
##  $ plant_id_pudl                    : num [1:13925] 2673 230 2249 1325
2942 ...
##  $ plant_name_eia                   : chr [1:13925] "D B Wilson"
"Gordonsville Energy LP" "Montour" "GRDA" ...
##  $ utility_id_eia                   : num [1:13925] 1692 19876 15534 7490
9191 ...
##  $ utility_id_pudl                  : num [1:13925] 40 349 3401 1912 140
...
##  $ utility_name_eia                 : chr [1:13925] "Big Rivers Electric
Corp" "Dominion Virginia Power" "PPL Montour LLC" "Grand River Dam Authority"
...
##  $ state                            : chr [1:13925] "KY" "VA" "PA" "OK"
...
##  $ contract_type_code               : chr [1:13925] "C" "S" "C" "C" ...
##  $ contract_expiration_date         : POSIXct[1:13925], format: "2011-12-
01" "1970-01-01" ...
##  $ energy_source_code               : chr [1:13925] "PC" "NG" "BIT" "NG"
...
##  $ fuel_type_code_pudl              : chr [1:13925] "coal" "gas" "coal"
"gas" ...
##  $ fuel_group_code                  : chr [1:13925] "petroleum_coke"
"natural_gas" "coal" "natural_gas" ...
##  $ supplier_name                    : chr [1:13925] "marathon" "virginia
power services energy" "murray american energy inc." "clearwater enterprises"
...
##  $ fuel_received_units              : num [1:13925] 29111 5 77114 7926
1484 ...
##  $ fuel_mmbtu_per_unit              : num [1:13925] 28.17 1.05 25.93 1.02
1 ...
##  $ fuel_cost_per_mmbtu              : chr [1:13925] "0.5680000185966492"
"9.069000244140625" "2.0588932037353516" "5.129000186920166" ...
##  $ bulk_agg_fuel_cost_per_mmbtu     : chr [1:13925] "2.337399959564209"
"null" "null" "4.623000144958496" ...
##  $ fuel_consumed_mmbtu              : num [1:13925] 8.20e+05 5.27
2.00e+06 8.08e+03 1.48e+03 ...
##  $ total_fuel_cost                  : chr [1:13925] "465792.3125"
"47.79363250732422" "4116892.75" "41465.50390625" ...
##  $ fuel_cost_per_mmbtu_source       : chr [1:13925] "original" "original"
"rolling_avg" "original" ...
##  $ sulfur_content_pct               : num [1:13925] 5.52 0 2.44 0 0 ...
##  $ ash_content_pct                  : num [1:13925] 0.2 0 7.5 0 0 ...
##  $ primary_transportation_mode_code  : chr [1:13925] "RV" "PL" "RR" "PL"
...
##  $ secondary_transportation_mode_code: chr [1:13925] "null" "null" "null"
"null" ...
##  $ natural_gas_transport_code       : chr [1:13925] "null"
"interruptible" "null" "interruptible" ...
```

```
##  $ data_maturity                     : chr [1:13925] "final" "final"
"final" "final" ...
##  $ mine_name                         : chr [1:13925] "null" "null"
"blacksville 2" "null" ...
##  $ mine_state                        : chr [1:13925] "null" "null" "WV"
"null" ...
##  $ coalmine_county_id_fips           : chr [1:13925] "null" "null" "null"
"null" ...
##  $ mine_type_code                    : chr [1:13925] "null" "null" "U"
"null" ...
```

From the 2% sample of data what is the most common fuel type used?

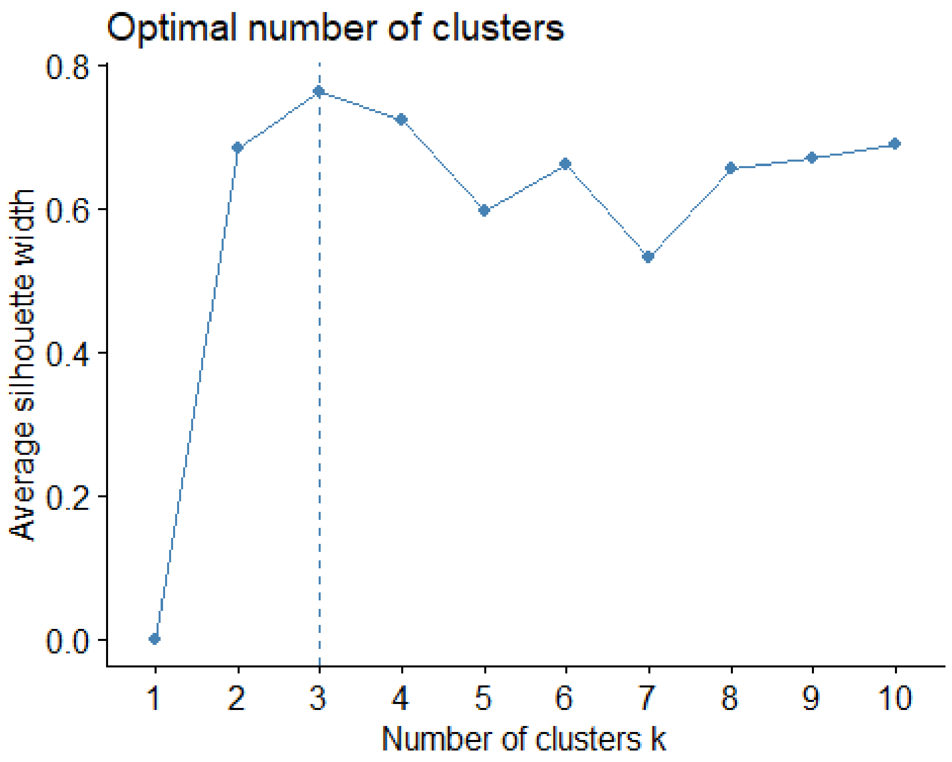
```
table(new_sample$fuel_group_code)

## 
##            coal     natural_gas       other_gas       petroleum petroleum_coke 
##            4720            7946              50            1151              58
```

Does the average amount of fuel recieved units for each type support natural gas being the most commonly used? If not what are some assumptions that can be made?

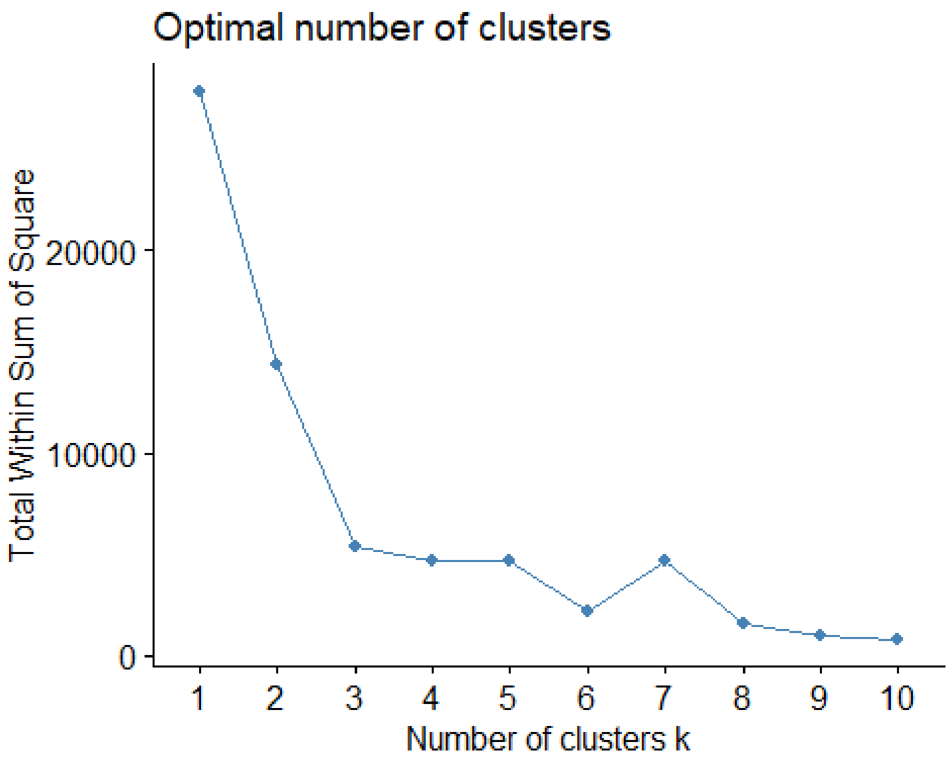
```
aggregate(fuel_received_units ~ fuel_group_code, data = new_sample, FUN =
mean, na.rm = TRUE)

##   fuel_group_code fuel_received_units
## 1            coal           48569.311
## 2     natural_gas          415964.362
## 3       other_gas         1475901.180
## 4       petroleum            6232.374
## 5  petroleum_coke           19838.793
```

What are the clusters like for fuel_received_units and fuel_mmbtu_per_unit and what can this tell us based on the units received and fuel in each unit? Finding clusters based on fuel_received_units and fuel_mmbtu_per_unit (units received and fuel in each unit) The number of clusters is determined based on k-means

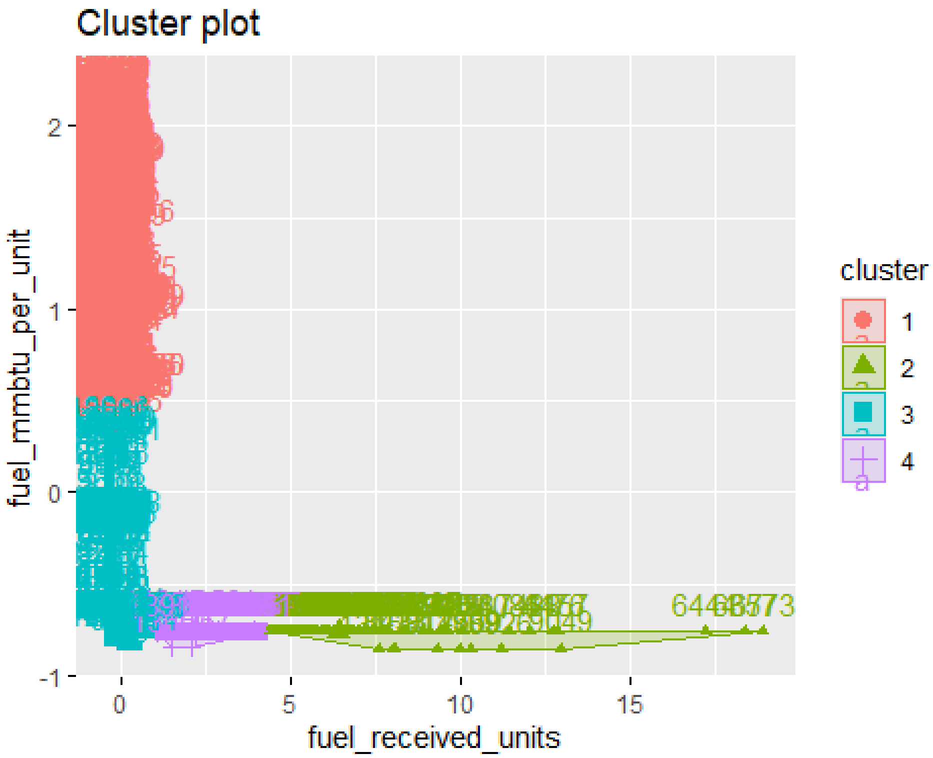
```
set.seed(1738)
SD <- new_sample[,c(15,16)]
SD <- scale(SD)
fviz_nbclust(SD, kmeans, method = "silhouette")
```



```
fviz_nbclust(SD, kmeans, method = "wss")
```



```
k4 <- kmeans(SD, centers = 4, nstart = 25)
centers <- k4$centers
k4$size

## [1] 4733  156 8096  940

fviz_cluster(k4, data = SD)
```



From these clusters we find:

Cluster 1 represents fuel orders received that have the most fuel per unit based on the units received indicating that the most value may be gained from orders within this cluster.

Cluster 2 represents a large variety of fuel units ordered but with a common variable of being below positive value in terms of the fuel received in each unit. Specifically, fuel received units of 10 or more have very little value gained in terms of fuel per unit indicating that the overall cost paid for the units is not likely to be worth the value.

Cluster 3 represents fuel units received with the worst value of fuel per unit based on the units received. By having a limited amount of fuel per unit with minimal units being ordered there is not much value gained per unit.

Cluster 4 represents a mixed value of fuel per unit with small amounts of units received. For any orders that have a positive value for fuel received per unit likely gains value due to small amount of units ordered but any orders with a negative value for fuel do not gain much value.

What this data shows:

“Other Gases” likely has many units within Cluster 2 due to being the most units received on average but being the lowest form of fuel used. Due to Cluster 2 having many negative values of fuel per unit it likely means more units are needed per order to meet demand leading to having the highest average

Petroleum may have many orders in Cluster 1 due to being the lowest units received on average but being the 3rd most used fuel form. Meaning the orders that are created have positive value of fuel per unit leading to less units being needed.

Natural Gas likely has many orders in Cluster 4 and a good portion of Cluster 1 to support being the most used fuel form but also having the 2nd highest units received on average. Meaning more value of fuel per unit is gained in some orders compared to others.