

Stack Overflow User Segmentation with k-means clustering and PCA

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```
library(corrplot)

## corrplot 0.92 loaded
library(lubridate)

##
## Attaching package: 'lubridate'
## The following objects are masked from 'package:base':
##   date, intersect, setdiff, union
library(readr)
library(dlookr)

##
## Attaching package: 'dlookr'
## The following object is masked from 'package:base':
##   transform
library(cluster)
library(grid)
library(gridExtra)
library(NbClust)
library(factoextra)

## Loading required package: ggplot2
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
library(GGally)

## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
library(flextable)
library(ggstatsplot)

## You can cite this package as:
##   Patil, I. (2021). Visualizations with statistical details: The 'ggstatsplot' approach.
##   Journal of Open Source Software, 6(61), 3167, doi:10.21105/joss.03167
library(tidyverse)

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
```

```

## v dplyr    1.1.2      v stringr 1.5.0
## vforcats 1.0.0      v tibble   3.2.1
## v purrr   1.0.1      v tidyverse 1.3.0

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::combine() masks gridExtra::combine()
## x purrr::compose() masks flextable::compose()
## x tidyR::extract() masks dlookr::extract()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(ClusterR)
library(recipes)

## 
## Attaching package: 'recipes'
##
## The following object is masked from 'package:stringr':
## 
##     fixed
## 
## The following object is masked from 'package:stats':
## 
##     step

library(tidyR)
library(ggplot2)
library(scales)

## 
## Attaching package: 'scales'
##
## The following object is masked from 'package:purrr':
## 
##     discard
## 
## The following object is masked from 'package:readr':
## 
##     col_factor

library(rpart)
library(rpart.plot)
library(FactoMineR)
library(factoextra)

data <- read.csv("~/Desktop/DS4A Women Summer 2023/DS4A Project/Merged Stack Overflow Dataset/final_df_"

#View(data)

# Specify the variables to drop
variables_to_drop <- c("id", "display_name", "location", "about_me",
                      "highest_scoring_question", "highest_scoring_answer",
                      "creation_date", "last_access_date", "_merge", "account_age",
                      "harmonic_mean", "ques_answer_cnt_avg", "ques_score_avg",
                      "ques_view_cnt_avg", "ans_score_avg", "account_age_days", "score_difference",
                      "ques_median_score", "ans_median_score", "X_merge", "year")

```

```

# Drop the variables from the dataset
data <- data[, setdiff(names(data), variables_to_drop)]


str(data)

## 'data.frame':    78103 obs. of  14 variables:
##   $ reputation_x          : int  1421 251590 5616 57082 3012 ...
##   $ user_upv               : int  377 2348 660 1303 47 308 ...
##   $ user_downv              : int  1 20 13 36 14 21 ...
##   $ user_views              : int  96 19758 864 4560 116 334 ...
##   $ ques_cnt                : int  9 159 24 10 26 25 ...
##   $ ques_answer_cnt_tot     : int  26 215 24 21 44 35 ...
##   $ ques_score_tot          : int  83 131 26 49 86 35 ...
##   $ ques_view_cnt_tot       : int  117954 88421 75303 26203 144613 ...
##   $ ans_cnt                 : int  1 1 1 2 3 1 1 3 1 1 ...
##   $ ans_score_tot           : int  1 1 0 2 0 2 2 2 0 1 ...
##   $ ques_score               : num  72 16 10 11 61 14 100 5 14 524 ...
##   $ ans_score                : num  1 1 0 2 0 2 2 1 0 1 ...
##   $ account_age_years        : num  6.1 13.9 11.31 12.41 6.35 ...
##   $ harmonic_mean_with_reputation: num  2803 473581 0 193201 0 ...

```

Data Preparation

```

# Check for missing values in each variable
missing_values <- sapply(data, function(x) sum(is.na(x)))

# Print the number of missing values in each variable
print(missing_values)

```

Missing values

```

##             reputation_x                  user_upv
##                   0                         0
##             user_downv                  user_views
##                   0                         0
##             ques_cnt      ques_answer_cnt_tot
##                   0                         0
##             ques_score_tot      ques_view_cnt_tot
##                   0                         0
##             ans_cnt      ans_score_tot
##                   0                         0
##             ques_score                  ans_score
##                   0                         0
##             account_age_years harmonic_mean_with_reputation
##                   0                         0

```

```

# Calculate the correlation coefficient
cor_matrix <- cor(data)

# Print the correlation matrix
print(cor_matrix)

```

Correlations

```

##                                     reputation_x   user_upv  user_downv user_views
## reputation_x                         1.00000000  0.40054647  0.195886833  0.70618682
## user_upv                            0.40054647  1.00000000  0.199352161  0.35754422
## user_downv                           0.19588683  0.19935216  1.000000000  0.29412553
## user_views                           0.70618682  0.35754422  0.294125528  1.00000000
## ques_cnt                            0.08582604  0.05840342  0.004236227  0.08589518
## ques_answer_cnt_tot                 0.08186886  0.05009784  0.004332237  0.07752637
## ques_score_tot                      0.09491931  0.07065335  0.018422021  0.06195851
## ques_view_cnt_tot                  0.04172136  0.02262584  0.001950301  0.02931318
## ans_cnt                             0.02539131  0.04372997  0.022918655  0.02896142
## ans_score_tot                       0.05417778  0.05817550  0.012869023  0.02510452
## ques_score                          0.06446366  0.04830036  0.013718307  0.03645724
## ans_score                           0.04608722  0.04546659  0.009301328  0.01911337
## account_age_years                   0.29257986  0.30476985  0.073395331  0.21759880
## harmonic_mean_with_reputation      NaN          NaN          NaN          NaN
##                                     ques_cnt ques_answer_cnt_tot ques_score_tot
## reputation_x                      0.085826038  0.081868858  0.09491931
## user_upv                          0.058403420  0.050097842  0.07065335
## user_downv                         0.004236227  0.004332237  0.01842202
## user_views                          0.085895184  0.077526371  0.06195851
## ques_cnt                           1.000000000  0.938418309  0.42434858
## ques_answer_cnt_tot                0.938418309  1.000000000  0.51210339
## ques_score_tot                     0.424348576  0.512103386  1.00000000
## ques_view_cnt_tot                  0.421174824  0.525871042  0.81952579
## ans_cnt                            0.146780759  0.133610168  0.04266387
## ans_score_tot                      -0.022140502 -0.007593420  0.10527702
## ques_score                          0.192781171  0.291711177  0.91510282
## ans_score                           -0.023174854 -0.008429486  0.10192915
## account_age_years                  0.020155710  -0.003675926  0.07163335
## harmonic_mean_with_reputation      NaN          NaN          NaN
##                                     ques_view_cnt_tot     ans_cnt ans_score_tot
## reputation_x                      0.041721356  0.025391305  0.05417778
## user_upv                           0.022625836  0.043729970  0.05817550
## user_downv                          0.001950301  0.022918655  0.01286902
## user_views                          0.029313180  0.028961418  0.02510452
## ques_cnt                           0.421174824  0.146780759  -0.02214050
## ques_answer_cnt_tot                0.525871042  0.133610168  -0.00759342
## ques_score_tot                     0.819525795  0.042663867  0.10527702
## ques_view_cnt_tot                  1.000000000  0.043331327  0.06956263
## ans_cnt                            0.043331327  1.000000000  0.06015028
## ans_score_tot                      0.069562628  0.060150285  1.00000000
## ques_score                          0.754173548  0.021607722  0.12100645
## ans_score                           0.068823352  0.001814562  0.98733270
## account_age_years                  0.001991040 -0.013577673  0.05770519
## harmonic_mean_with_reputation      NaN          NaN          NaN
##                                     ques_score     ans_score account_age_years
## reputation_x                      0.06446366  0.046087220  0.292579860
## user_upv                           0.04830036  0.045466586  0.304769851
## user_downv                          0.01371831  0.009301328  0.073395331
## user_views                          0.03645724  0.019113370  0.217598804
## ques_cnt                            0.19278117 -0.023174854  0.020155710
## ques_answer_cnt_tot                0.29171118 -0.008429486  -0.003675926
## ques_score_tot                      0.91510282  0.101929146  0.071633351
## ques_view_cnt_tot                  0.75417355  0.068823352  0.001991040

```

```

## ans_cnt          0.02160772  0.001814562      -0.013577673
## ans_score_tot   0.12100645  0.987332703      0.057705185
## ques_score       1.00000000  0.119835693      0.054176365
## ans_score        0.11983569  1.000000000      0.052146422
## account_age_years 0.05417637  0.052146422      1.000000000
## harmonic_mean_with_reputation      NaN          NaN          NaN
##                                     harmonic_mean_with_reputation
## reputation_x                  NaN
## user_upv                     NaN
## user_downv                   NaN
## user_views                    NaN
## ques_cnt                      NaN
## ques_answer_cnt_tot           NaN
## ques_score_tot                 NaN
## ques_view_cnt_tot             NaN
## ans_cnt                       NaN
## ans_score_tot                  NaN
## ques_score                     NaN
## ans_score                      NaN
## account_age_years              NaN
## harmonic_mean_with_reputation 1

# Specify the variables to drop
variables_to_drop <- c("ques_answer_cnt_tot", "ques_score", "ans_score", "ques_view_cnt_tot")

# Drop the variables from the dataset
data <- data[, setdiff(names(data), variables_to_drop)]

# Check for infinite values
is_inf <- apply(data, 2, function(x) any(!is.finite(x)))
inf_vars <- names(is_inf)[is_inf]

# Print variables with infinite values
print(inf_vars)

## [1] "harmonic_mean_with_reputation"

# Drop harmonic_mean_with_reputation
data <- subset(data, select = -harmonic_mean_with_reputation)
summary(data)

##    reputation_x      user_upv      user_downv      user_views
## Min. :     1      Min. :    0      Min. :    0.00      Min. :    0.0
## 1st Qu.: 181      1st Qu.:   19      1st Qu.:    0.00      1st Qu.:  36.0
## Median : 699      Median :   82      Median :    2.00      Median : 100.0
## Mean   : 2638     Mean   : 330      Mean   :  22.58      Mean   : 304.4
## 3rd Qu.: 2052     3rd Qu.:  316      3rd Qu.:  10.00      3rd Qu.: 262.0
## Max.   :485622    Max.   :29379     Max.   :25583.00     Max.   :131862.0
##    ques_cnt      ques_score_tot      ans_cnt      ans_score_tot
## Min. : 1.000     Min. :-25.000     Min. : 1.000     Min. : -27.000
## 1st Qu.: 1.000     1st Qu.: 0.000     1st Qu.: 1.000     1st Qu.:  0.000
## Median : 2.000     Median : 1.000     Median : 1.000     Median :  0.000
## Mean   : 3.386     Mean   : 4.755     Mean   : 1.516     Mean   :  2.143
## 3rd Qu.: 4.000     3rd Qu.: 4.000     3rd Qu.: 2.000     3rd Qu.:  2.000
## Max.   :229.000    Max.   :917.000     Max.   :51.000     Max.   :1222.000
##    account_age_years

```

```

## Min.    : 0.000162
## 1st Qu.: 5.951863
## Median  : 8.038155
## Mean    : 7.946053
## 3rd Qu.:10.060076
## Max.    :14.155830

str(data)

## 'data.frame':    78103 obs. of  9 variables:
##   $ reputation_x      : int  1421 251590 5616 57082 3012 6004 39359 661 3742 23602 ...
##   $ user_upv          : int  377 2348 660 1303 47 308 2891 21 1979 147 ...
##   $ user_downv         : int  1 20 13 36 14 21 58 0 2 2 ...
##   $ user_views         : int  96 19758 864 4560 116 334 4514 514 336 1169 ...
##   $ ques_cnt           : int  9 159 24 10 26 25 36 21 64 44 ...
##   $ ques_score_tot     : int  83 131 26 49 86 35 162 23 77 685 ...
##   $ ans_cnt            : int  1 1 1 2 3 1 1 3 1 1 ...
##   $ ans_score_tot      : int  1 1 0 2 0 2 2 2 0 1 ...
##   $ account_age_years: num  6.1 13.9 11.31 12.41 6.35 ...

for (i in colnames(data)){
  low <- quantile(data[[i]], .01, names = F) # get the 1st percentile for the column
  high <- quantile(data[[i]], .99, names = F) # get the 99th percentile for the column

  data[i] [data[i] < low] <- low # any row value in the column < 1st percentile replace with the 1st percentile
  data[i] [data[i] > high] <- high # any row value in the column > 99th percentile replace with the 99th percentile
}

summary(data)

```

Outliers

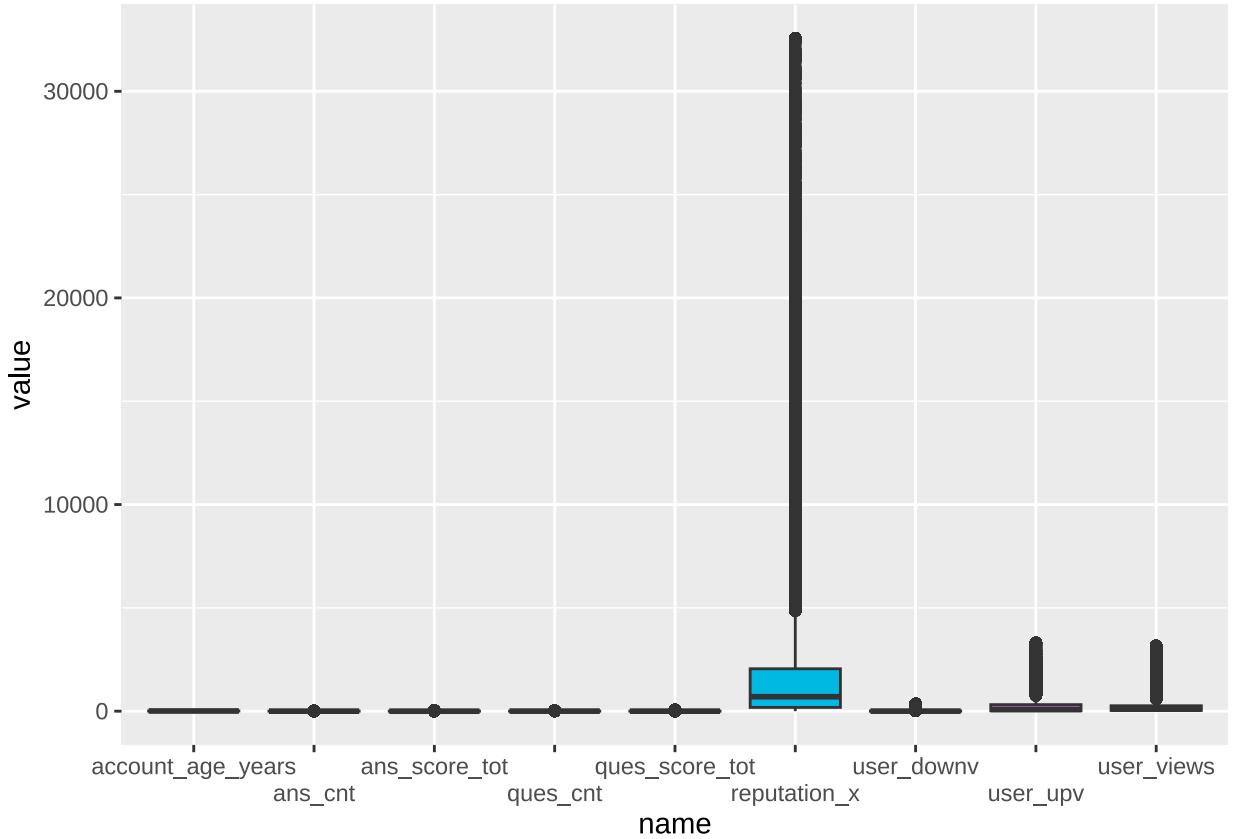
```

##   reputation_x      user_upv       user_downv      user_views
## Min.    : 1      Min.   : 0.0      Min.   : 0.00      Min.   : 2.0
## 1st Qu.: 181    1st Qu.: 19.0     1st Qu.: 0.00     1st Qu.: 36.0
## Median  : 699    Median : 82.0     Median : 2.00     Median : 100.0
## Mean    : 2298   Mean   :310.7     Mean   :15.55     Mean   :263.6
## 3rd Qu.: 2052   3rd Qu.:316.0     3rd Qu.:10.00     3rd Qu.:262.0
## Max.    :32564   Max.   :3303.8    Max.   :350.00    Max.   :3158.0
##   ques_cnt        ques_score_tot  ans_cnt        ans_score_tot
## Min.   :1.000    Min.   :-3.000    Min.   :1.000    Min.   :-2.000
## 1st Qu.:1.000    1st Qu.: 0.000   1st Qu.:1.000    1st Qu.: 0.000
## Median :2.000    Median : 1.000   Median :1.000    Median : 0.000
## Mean   :3.244    Mean   : 4.254   Mean   :1.494    Mean   : 1.721
## 3rd Qu.:4.000    3rd Qu.: 4.000   3rd Qu.:2.000    3rd Qu.: 2.000
## Max.   :23.000   Max.   :55.000   Max.   :6.000    Max.   :31.000
##   account_age_years
## Min.   : 0.4389
## 1st Qu.: 5.9519
## Median : 8.0382
## Mean   : 7.9471
## 3rd Qu.:10.0601

```

```
## Max. :13.8843
```

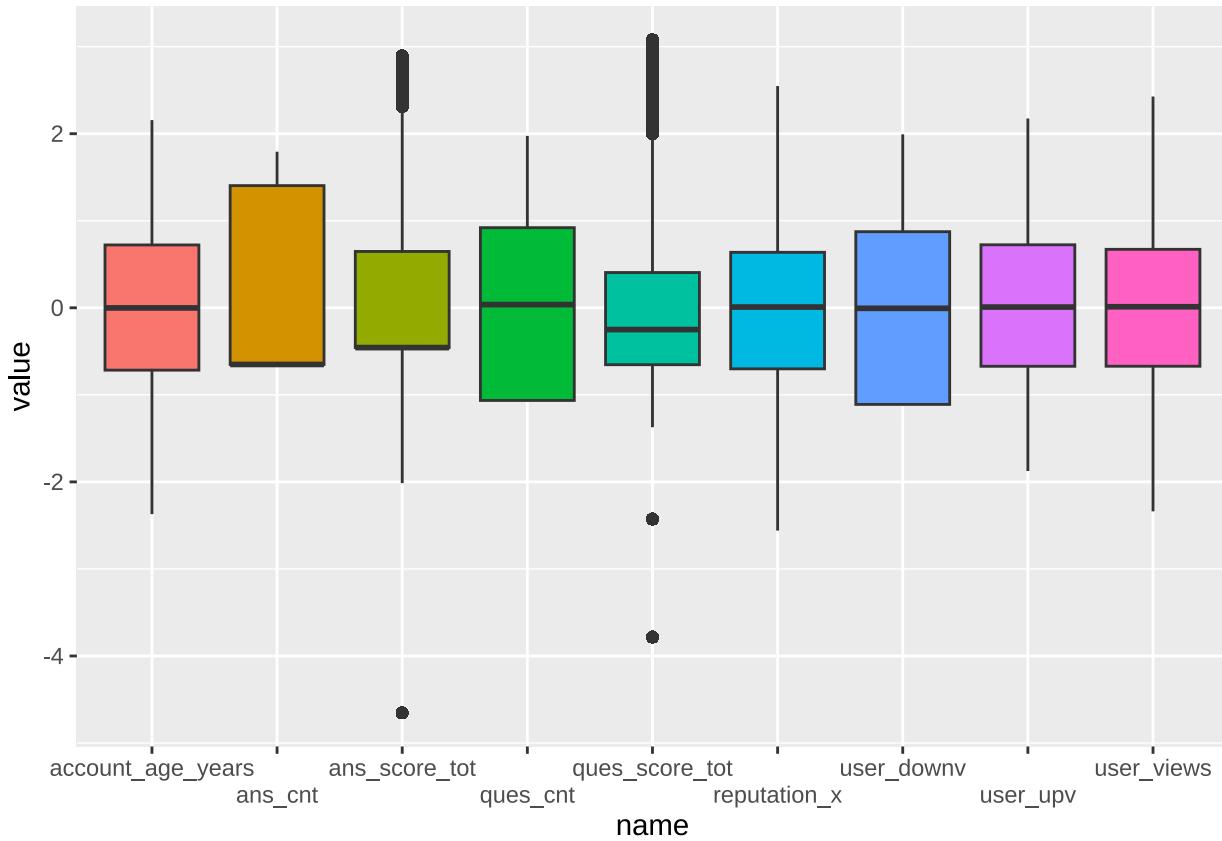
```
# Plot the current distributions
data %>%
  pivot_longer(cols = everything()) %>%
  ggplot(aes(x = name, y = value, fill = name)) +
  geom_boxplot(show.legend = FALSE) +
  scale_x_discrete(guide = guide_axis(n.dodge = 2))
```



Scaling

```
# Scale the data
scaled_data <- recipe(~ ., data = data) %>%
  step_YeoJohnson(all_numeric_predictors()) %>%
  step_normalize(all_numeric_predictors()) %>%
  prep() %>%
  bake(new_data = NULL)

# Plot the new distributions
scaled_data %>%
  pivot_longer(cols = everything()) %>%
  ggplot(aes(x = name, y = value, fill = name)) +
  geom_boxplot(show.legend = FALSE) +
  scale_x_discrete(guide = guide_axis(n.dodge = 2))
```



Reduce dimensions with PCA

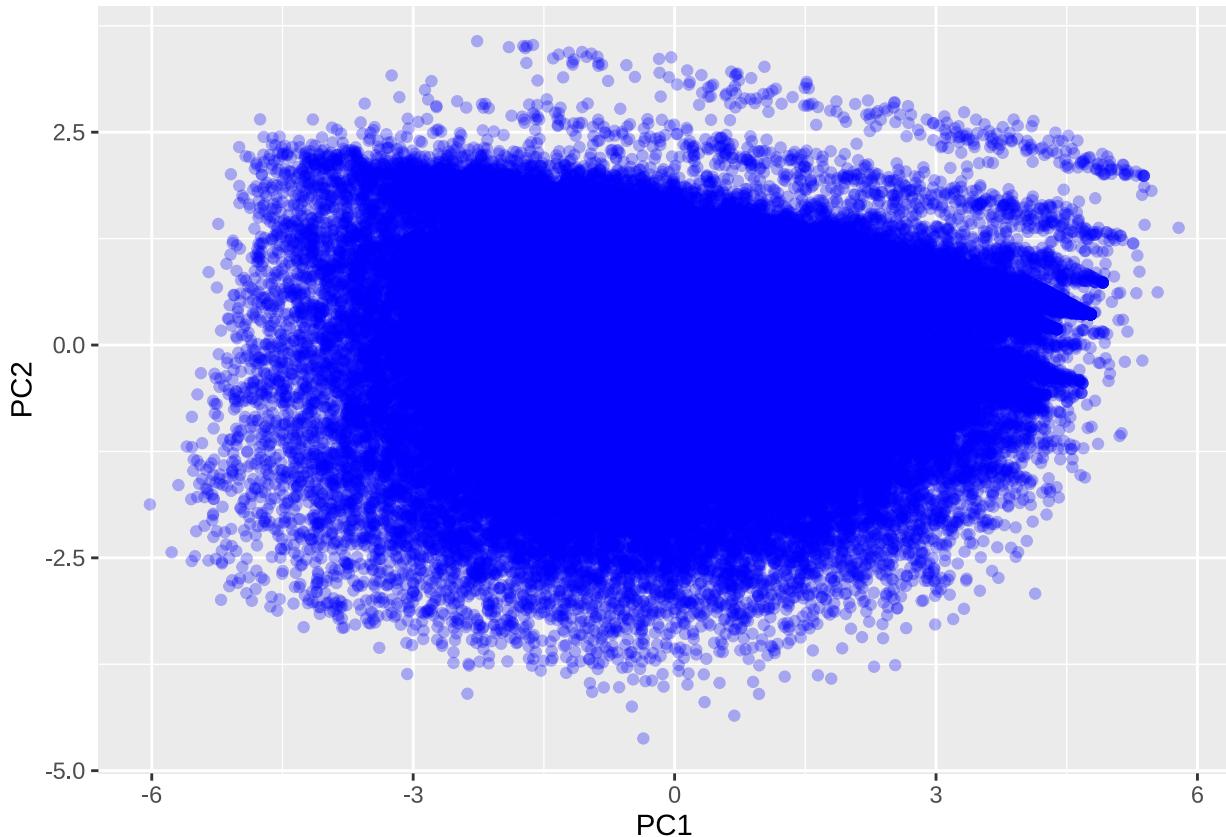
```
# Use PCA to reduce the dimensions in our data
pc <- prcomp(scaled_data, center = FALSE, scale = FALSE)
summary(pc) # how much variation is explained?
```

```
## Importance of components:
##          PC1    PC2    PC3    PC4    PC5    PC6    PC7
## Standard deviation   1.9962 1.1656 1.0347 0.94028 0.74242 0.71090 0.54537
## Proportion of Variance 0.4428 0.1510 0.1190 0.09824 0.06124 0.05615 0.03305
## Cumulative Proportion 0.4428 0.5937 0.7127 0.81093 0.87217 0.92833 0.96137
##          PC8    PC9
## Standard deviation   0.50446 0.30522
## Proportion of Variance 0.02828 0.01035
## Cumulative Proportion 0.98965 1.00000
```

We can see that the first two principal components between them explain 59% of the variance in our data which is pretty good. By having just 3 principal components we can explain 71%.

```
# Plot the loadings for each factor
data.frame(pc$rotation) %>%
  rownames_to_column(var = "variables") %>%
  select(variables:PC3) %>%
  pivot_longer(PC1:PC3, names_to = "PC", values_to = "loading") %>%
  ggplot(aes(x = variables, y = loading)) +
  geom_col() +
  facet_wrap(vars(PC)) +
  scale_x_discrete(guide = guide_axis(n.dodge = 2)) +
```





Creating clusters with k-means


```

## [3925] 1 2 3 2 2 1 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 1 1 3 1 2 2 2 1 2 2 2 2
## [3961] 2 1 2 2 1 2 2 1 1 2 2 2 2 2 2 2 2 1 2 2 3 1 2 1 1 2 2 2 1 2 2 2 1 2 2 2 2 2 1 1 2 2
## [3997] 1 2 1 1 2 2 1 3 2 1 2 1 1 2 2 1 1 2 2 2 2 2 2 2 1 2 2 2 2 1 2 2 2 2 2 2 1 1 2 2
## [4033] 2 3 2 2 2 1 3 2 2 1 2 2 2 1 2 2 2 2 2 2 2 2 2 3 2 1 2 3 2 2 2 2 2 2 2 2 2
## [4069] 2 2 2 1 2 2 2 2 3 3 2 2 2 2 2 2 2 1 2 2 2 1 1 2 2 2 2 1 2 2 2 1 2 1 3 2 1 2 1 1 2
## [4105] 2 1 1 1 1 1 1 1 1 1 2 2 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4141] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4177] 1 1 1 1 2 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4213] 1 1 1 1 1 2 1 1 1 1 1 2 1 1 1 1 1 1 1 1 2 1 2 2 1 1 1 1 1 1 2 1 2 2 1 1 2 2 2 2 2 2 1 1
## [4249] 2 2 2 2 2 2 1 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4285] 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4321] 1 1 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4357] 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1
## [4393] 2 1 1 1 1 1 1 1 1 3 2 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 2 1 2 1 1 1
## [4429] 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 2 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4465] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1
## [4501] 1 1 1 1 1 1 1 2 1 2 2 1 1 1 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1
## [4537] 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4573] 1 1 2 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4609] 1 1 1 1 1 1 2 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4645] 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 2 2 2 1 2 2 2 2 2 2 2 2 1 1 2 2 2 2 2 1 1 2 2 2
## [4681] 2 1 2 2 2 2 2 2 2 1 1 2 1 2 2 1 2 2 2 1 1 1 2 1 1 2 2 2 2 1 1 1 2 1 1 2 2 2 2 1 1 1 2 1 1 2
## [4717] 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4753] 1 1 2 2 1 1 2 1 1 1 1 1 1 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 2 2 1 1 2 1 1 1 1 1 1 1 1 1 2 1
## [4789] 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 2 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [4825] 1 1 1 2 1 2 1 1 1 2 2 1 1 1 1 1 1 1 1 1 1 1 1 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 2 2
## [4861] 2 2 2 2 2 2 2 2 2 2 3 1 2 2 2 3 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2
## [4897] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 2 2 2 2 2 1 2 1 2 2 2 1 2 2 3 2 2 2 2 1 1 2
## [4933] 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1
## [4969] 2 2 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 2 1 1 1 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [5005] 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
## [5041] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 1 2 1 1 1 1 2 2 2 2 2 2
## [5077] 1 2 2 2 2 2 1 2 2 2 3 2 1 2 2 1 1 1 2 2 1 2 1 2 2 3 2 1 2 2 2 2 1 2 2 2 2 1
## [5113] 1 2 2 2 2 2 2 2 1 2 2 2 1 1 1 2 2 2 1 1 2 2 2 1 1 2 2 1 2 2 2 2 2 2 1 2 2 2 2 3
## [5149] 2 2 2 2 3 2 2 2 2 1 2 1 2 2 1 2 2 2 3 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2
## [5185] 3 1 1 2 2 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 1 2 1 2 1 2 2 2 2 2 2 2 2 2
## [5221] 2 2 2 1 1 2 2 2 3 1 1 1 1 2 2 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 3 2 2
## [5257] 1 2 1 2 2 2 1 1 2 1 2 1 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 1 2 2 2 2
## [5293] 2 2 2 2 2 1 2 2 2 2 1 2 1 2 2 2 2 2 1 2 1 3 2 2 2 3 2 2 2 2 2 2 2 2 2 2
## [5329] 2 2 2 2 2 2 2 1 2 2 2 1 1 1 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 1 2 2 2 2 1 2 2
## [5365] 2 2 2 2 2 3 2 2 2 2 2 1 2 2 2 1 2 2 2 3 2 1 1 2 2 2 1 2 2 2 2 2 2 2 2 2 2
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##
## Within cluster sum of squares by cluster:
## [1] 171860.7 139476.1 130874.4
##   (between_SS / total_SS =  37.1 %)

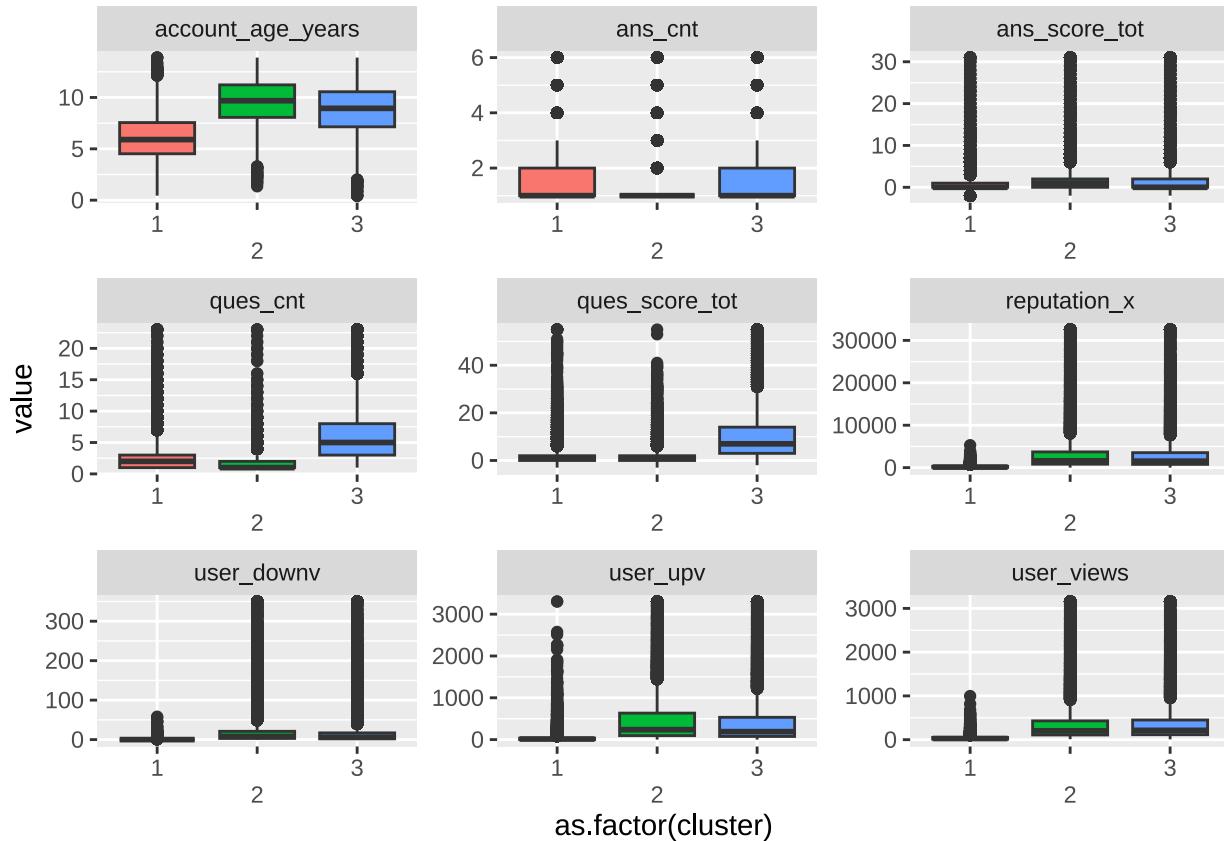
##
## Available components:

## [1] "cluster"      "centers"       "totss"        "withinss"      "tot.withinss"
## [6] "betweenss"    "size"          "iter"          "ifault"

# Compare the averages across the distributions
kmeans_clusters <-
  bind_cols(data, cluster=kmeans_clusters$cluster) # add cluster assignment back to our data

kmeans_clusters %>%
  pivot_longer(-cluster) %>% # convert the data from wide to long to work with geom_boxplot
  ggplot(aes(x = as.factor(cluster), y = value, fill = as.factor(cluster))) +
  geom_boxplot(show.legend = FALSE) +
  facet_wrap(vars(name), scales = "free") +
  scale_x_discrete(guide = guide_axis(n.dodge = 2))

```



Finding the best value of k for our k-means clustering

```

# Blank object to append within sum of squares error to
wss <- NULL

# For 1 to 10 cluster centres
for (i in 1:10) {
  set.seed(123)
  kmeans_clusters <-
    kmeans(scaled_data,
           centers = i, # just runs the solution for 1-10 clusters
           nstart = 20,
           iter.max = 200,
           algorithm = "MacQueen")

  # Append the tot sum of squares i.e. compactness of the clusters for each run into our empty object
  wss <- rbind(wss, tibble("clusters" = i, "WSS" = kmeans_clusters$tot.withinss)) # record WSS and number of clusters
}

wss

## # A tibble: 10 x 2
##   clusters     WSS
##       <int>   <dbl>
## 1       1 702918.
## 2       2 494271.
## 3       3 442211.
## 4       4 400901.

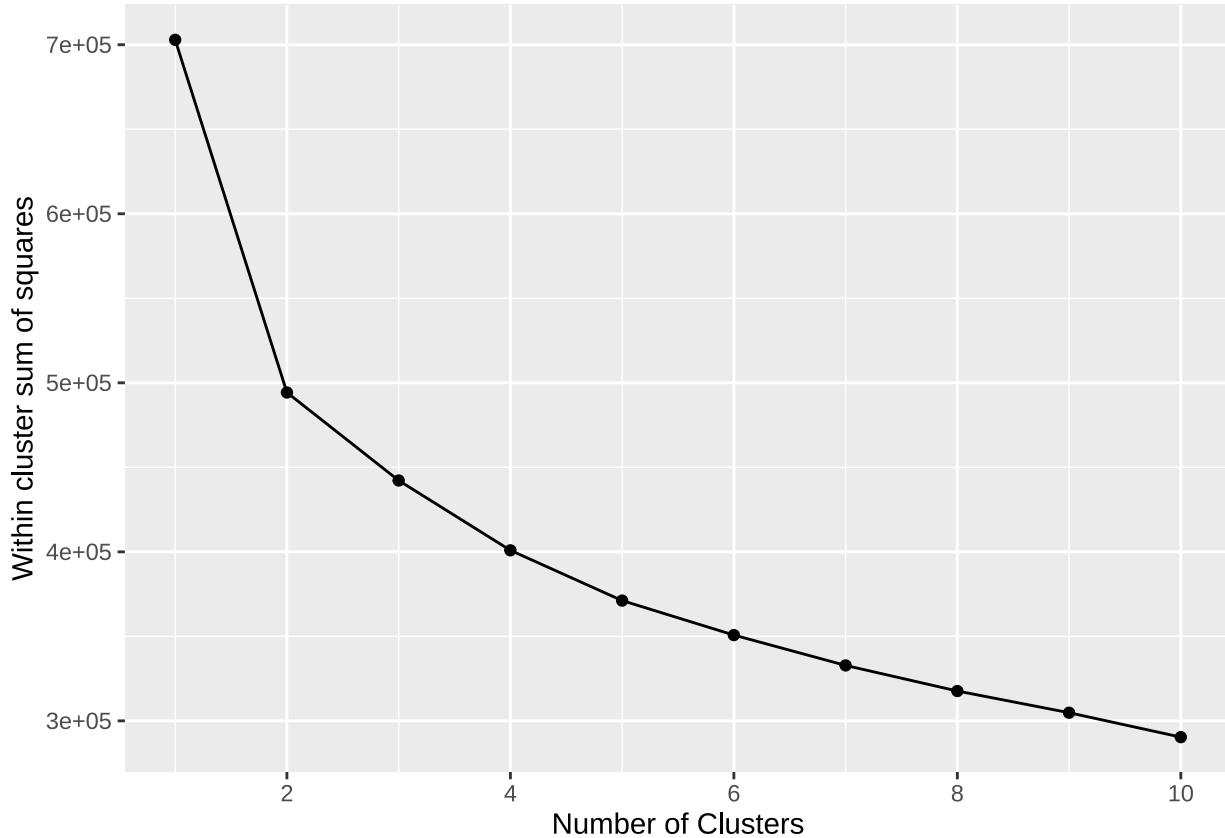
```

```

## 5      5 371155.
## 6      6 350752.
## 7      7 332801.
## 8      8 317652.
## 9      9 304827.
## 10    10 290374.

# Plot total within sum of squares vs. number of clusters
ggplot(wss, aes(x=clusters, y=WSS)) +
  geom_point() + # add dots to the plot
  geom_line() + # connect the dots with a line
  scale_x_continuous(breaks= pretty_breaks()) + # tick marks on whole numbers
  labs(x = "Number of Clusters", y ="Within cluster sum of squares") # add titles to the axes

```



```

# Silhouette Scores (run it on a sample)
sample <- scaled_data %>% sample_frac(.10)

sample_clusters <-
  kmeans(sample, # our data set
         centers = 4, # how many clusters we'd like
         nstart = 20, # how many times we repeat the process with different random initialisations
         iter.max = 200, # how many iterations to run k-means for
         algorithm = "MacQueen") # The default algorithm can struggle with close points

# Calculate the silhouette score for each observation
sil_score <- as_tibble(silhouette(sample_clusters$cluster, dist(sample))) # it takes the cluster and the
sil_score

```

```

## # A tibble: 7,810 x 3
##   cluster neighbor sil_width
##   <dbl>     <dbl>     <dbl>
## 1 1         3        4  0.153
## 2 2         3        1 -0.00138
## 3 3         3        4  0.0580
## 4 4         4        2  0.0465
## 5 5         1        3  0.0910
## 6 6         4        2  0.0788
## 7 7         2        4  0.172
## 8 8         4        1  0.215
## 9 9         1        4  0.115
## 10 10        4        3  0.248
## # i 7,800 more rows

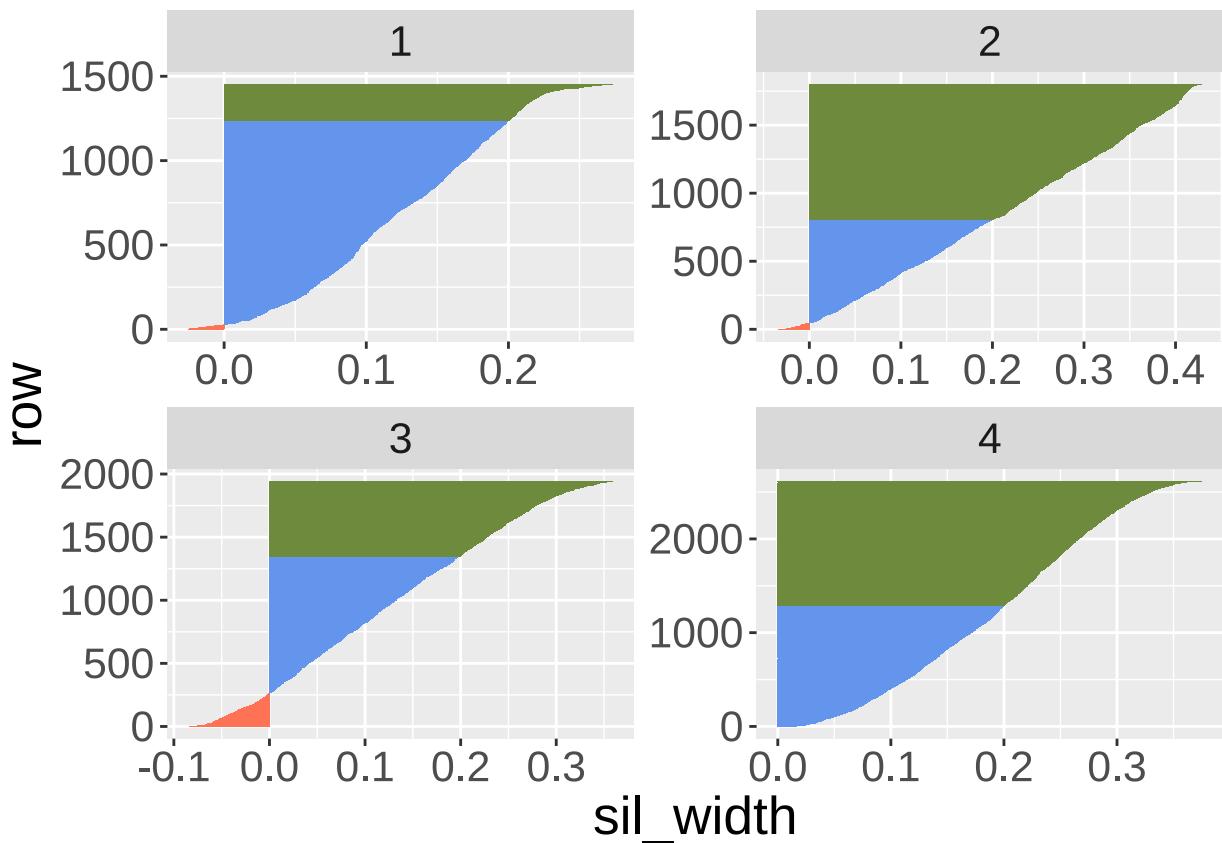
# Prep data ready for plotting
sil_score <-
  sil_score %>%
  arrange(cluster, sil_width) %>% # sort the data
  group_by(cluster) %>%
  mutate(row=row_number(), # add index and colours to help with plotting
    colours = case_when(sil_width < 0 ~ "coral1", # add some manual colour names
                         sil_width < 0.2 ~ "cornflowerblue",
                         sil_width > 0.2 ~ "darkolivegreen4"))

# Get the average
bind_rows(sil_score %>% summarise(avg_sil = mean(sil_width)),
          sil_score %>% ungroup() %>% summarise(avg_sil = mean(sil_width)))

## # A tibble: 5 x 2
##   cluster avg_sil
##   <dbl>    <dbl>
## 1 1        0.128
## 2 2        0.220
## 3 3        0.130
## 4 4        0.197
## 5 NA       0.173

# Create the plots
ggplot(data = sil_score, aes(x=row, y=sil_width, fill = colours)) +
  geom_bar(stat="identity") +
  coord_flip() +
  facet_wrap(vars(cluster), scales = "free") + # one lot per cluster
  scale_fill_identity() + # use the colour names we defined with mutate above
  theme(text = element_text(size=20)) # make the text bigger

```

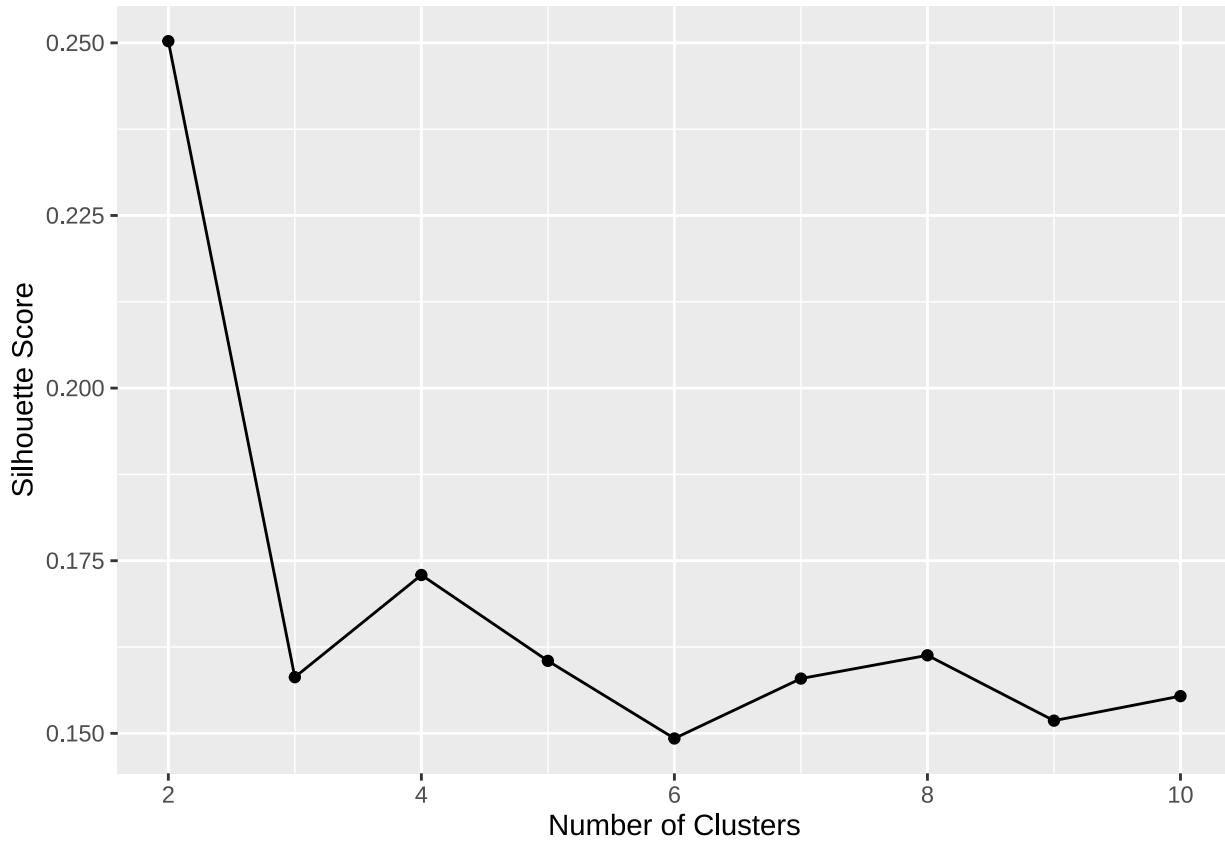


```
# Blank object to append Silhouette Scores to
sil_score <- NULL

# For 2 to 10 cluster centres on a sample (need 2+ clusters to get a score)
for (i in 2:10) {
  set.seed(123)
  sample_clusters <-
    kmeans(sample, # our randomly sampled, smaller data set
           centers = i,
           nstart = 20,
           iter.max = 200,
           algorithm = "MacQueen")

  sil_score <-
    rbind(sil_score,
          as_tibble(silhouette(sample_clusters$cluster, dist(sample))) %>% # calculate silhouette score
          summarise(clusters = max(cluster), # keep track of how many clusters are in the solution
                    avg_silhouette=mean(sil_width))) # get the average silhouette score
}

# Plot the Silhouette Scores vs. number of clusters. This time higher is better.
ggplot(sil_score, aes(x=clusters, y=avg_silhouette)) +
  geom_point() + # add dots to the plot
  geom_line() + # connect the dots with a line
  scale_x_continuous(breaks= pretty_breaks()) + # tick marks on whole numbers
  labs(x = "Number of Clusters", y ="Silhouette Score") # add titles to the axes
```

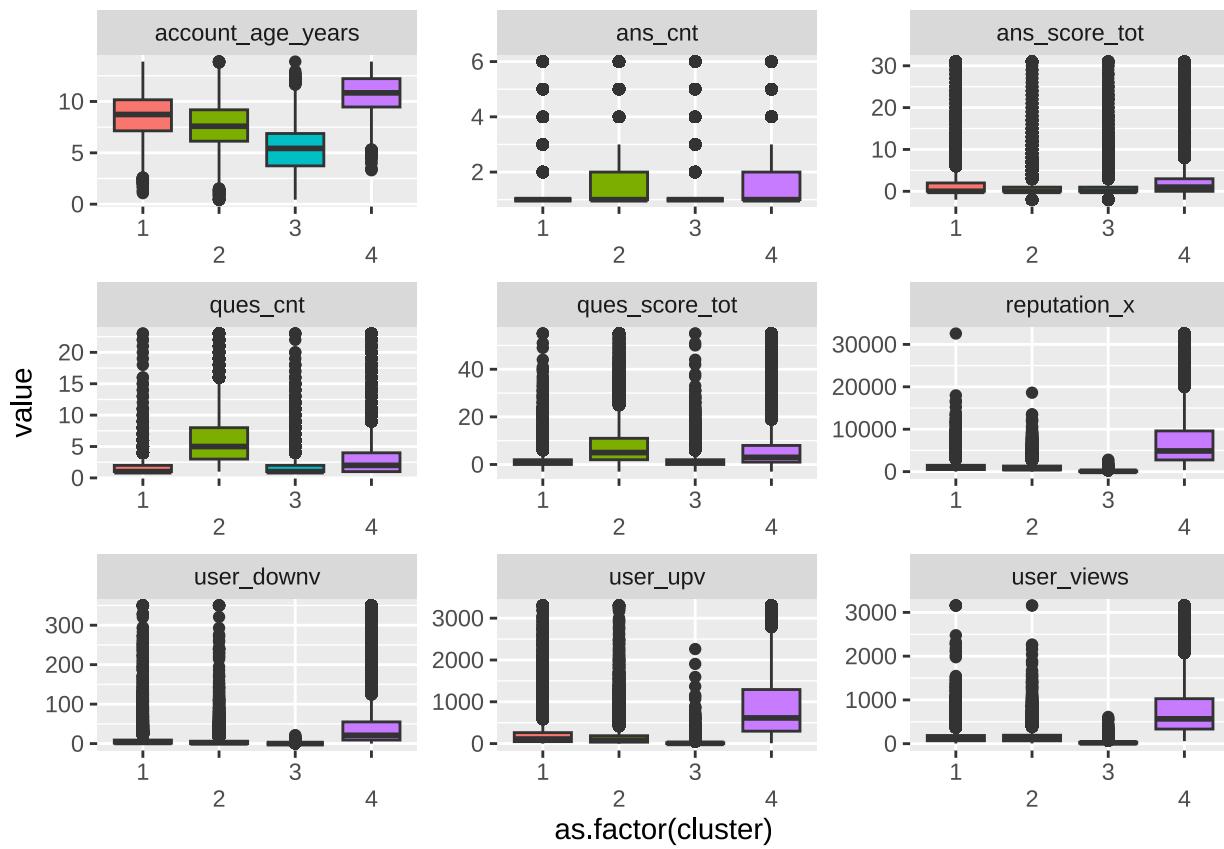


Picking a final value of k

```
# Let's try 4 clusters
set.seed(123)
kmeans_clusters <-
  kmeans(scaled_data, # our data set
         centers = 4, # how many clusters we'd like
         nstart = 20, # how many times we repeat the process with different random initialisations
         iter.max = 200, # how many iterations to run k-means for
         algorithm = "MacQueen") # The default algorithm can struggle with close points

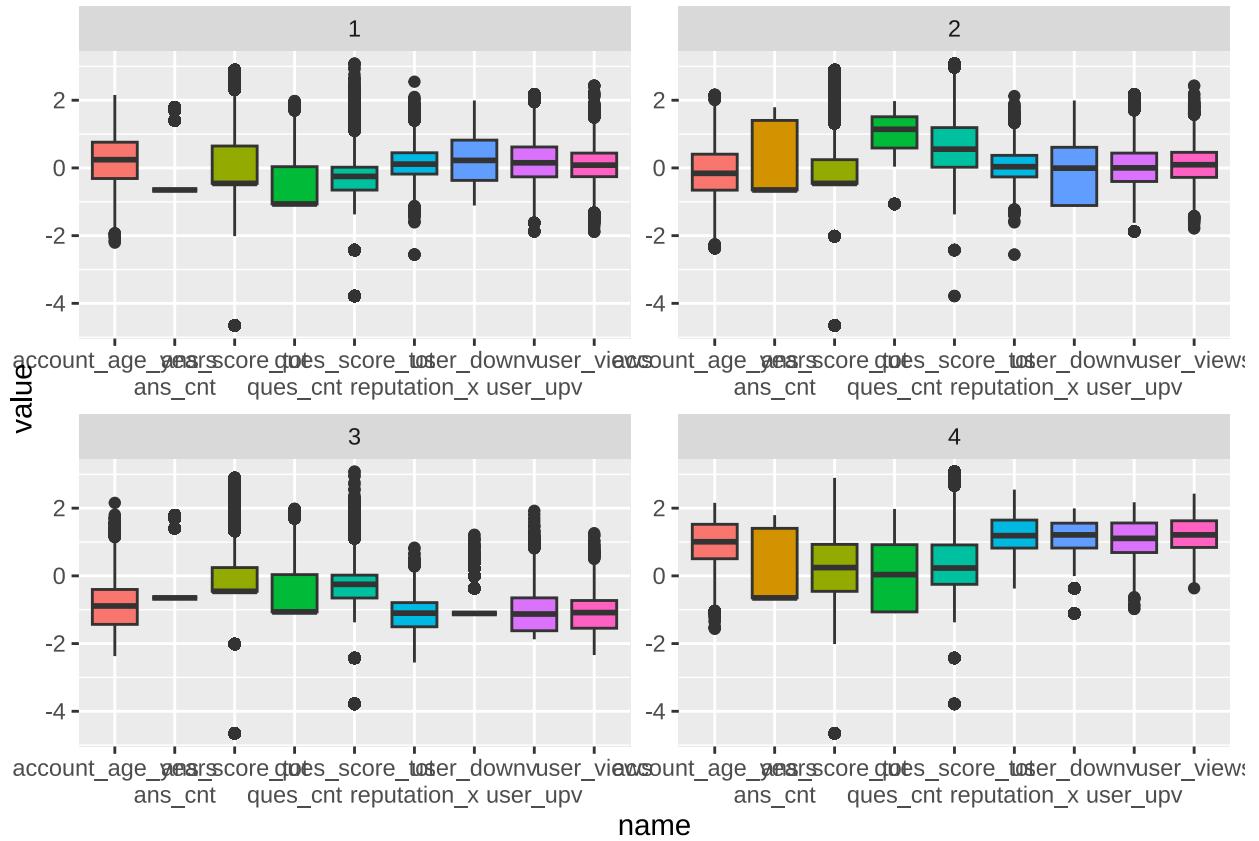
# Compare the averages across the distributions
clustered_data <-
  bind_cols(data, cluster=kmeans_clusters$cluster) # add cluster assignment back to our data

clustered_data %>%
  pivot_longer(-cluster) %>%
  ggplot(aes(x = as.factor(cluster), y = value, fill = as.factor(cluster))) +
  geom_boxplot(show.legend = FALSE) +
  facet_wrap(vars(name), scales = "free") +
  scale_x_discrete(guide = guide_axis(n.dodge = 2))
```



```
# Compare the averages across the distributions
clustered_scaled_data <-
  bind_cols(scaled_data, cluster=kmeans_clusters$cluster) # add cluster assignment back to our data

clustered_scaled_data %>%
  pivot_longer(-cluster) %>%
  ggplot(aes(x = name, y = value, fill = name)) +
  geom_boxplot(show.legend = FALSE) +
  facet_wrap(vars(cluster), scales = "free") +
  scale_x_discrete(guide = guide_axis(n.dodge = 2))
```



```

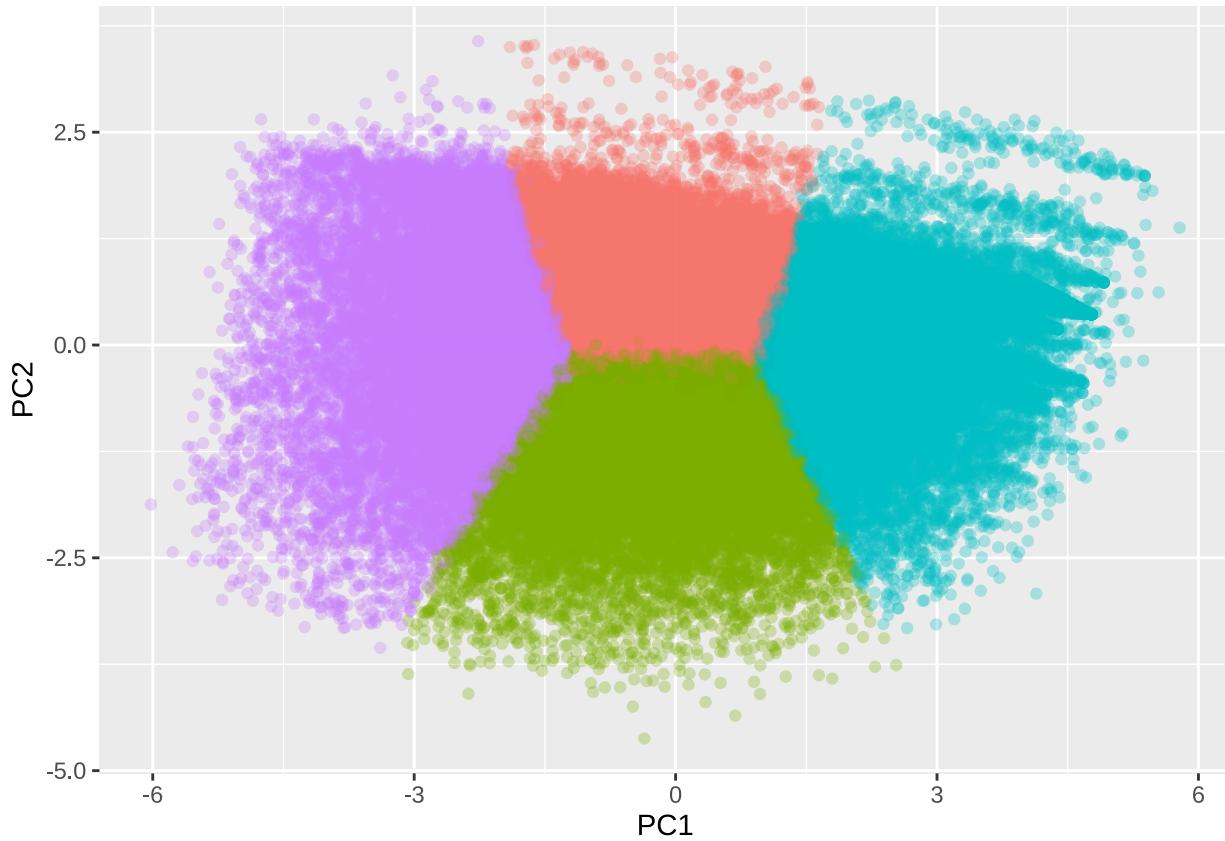
# How big are the clusters?
clustered_data %>%
  group_by(cluster) %>%
  summarise(num_users = n()) %>%
  mutate(pct_users = num_users / sum(num_users))

## # A tibble: 4 x 3
##   cluster num_users pct_users
##       <int>     <int>     <dbl>
## 1       1      22522    0.288
## 2       2      17505    0.224
## 3       3      21557    0.276
## 4       4      16519    0.212

# Visualize the relationships in the data
pca_with_clusters <-
  bind_cols(pca, cluster=kmeans_clusters$cluster) # add the clusters onto our PCA'd data so we can plot

ggplot(pca_with_clusters, aes(x = PC1, y = PC2, color = as.factor(cluster))) +
  geom_point(alpha = 0.3, show.legend = FALSE)

```



Running k-means after PCA

```
# Create a 4 cluster solution with PC1-3 as inputs
set.seed(123)
pca_clusters <-
  kmeans(pca %>% select(PC1:PC3), # our post-PCA data set
         centers = 4, # how many clusters we'd like
         nstart = 20, # how many times we repeat the process with different random initialisations
         iter.max = 200, # how many iterations to run k-means for
         algorithm = "MacQueen") # The default algorithm can struggle with close points

# Plot the results
pca_with_clusters <- bind_cols(pca_with_clusters, pca_cluster=pca_clusters$cluster)
ggplot(pca_with_clusters, aes(x = PC1, y = PC2, color = as.factor(pca_cluster))) +
  geom_point(alpha = 0.3, show.legend = T)
```

