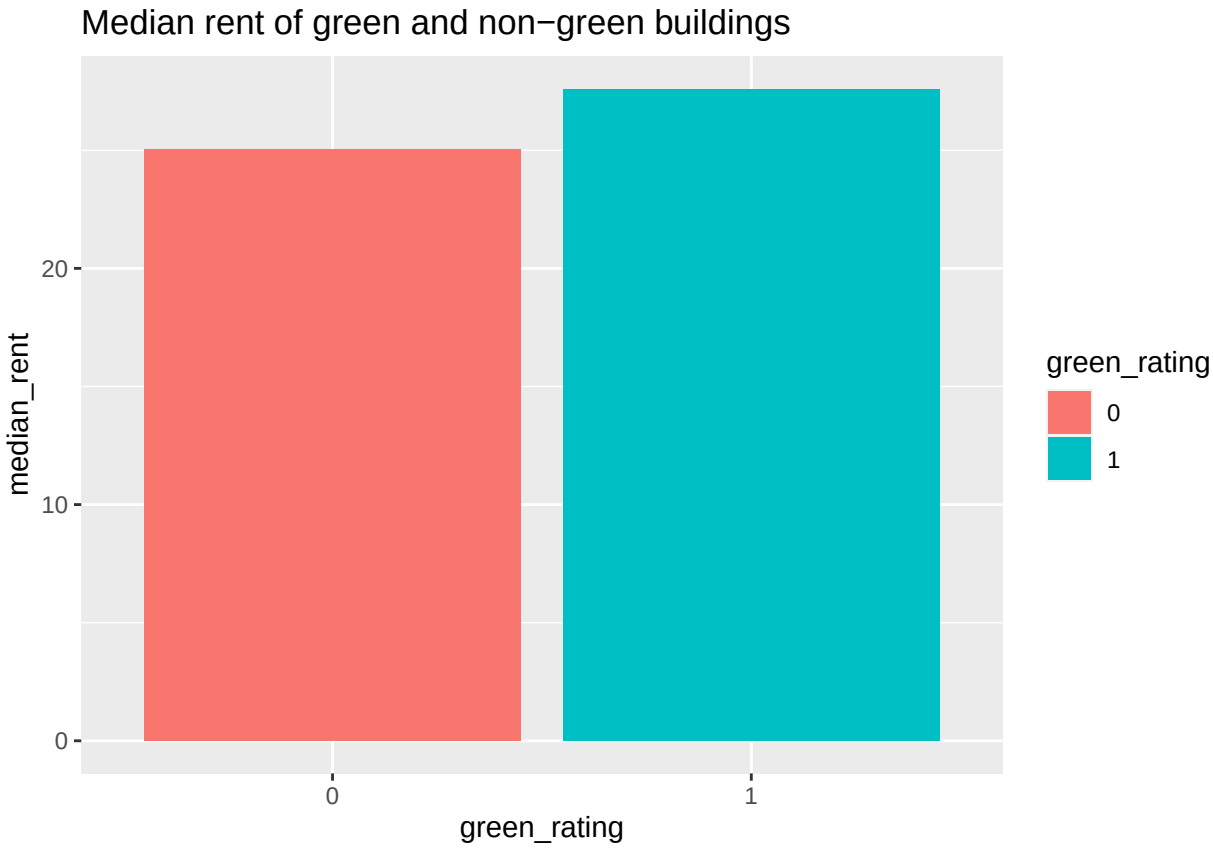
R, STA 380 - Exercises Second Half

ML Part 2 - Group 3 Rahul Singla | Vishal Gupta | Prakhar Bansal | Ramya Madhuri Desineedi

Git hub link - https://github.com/RahulSingla5209/data_viz_unsupervised_algo

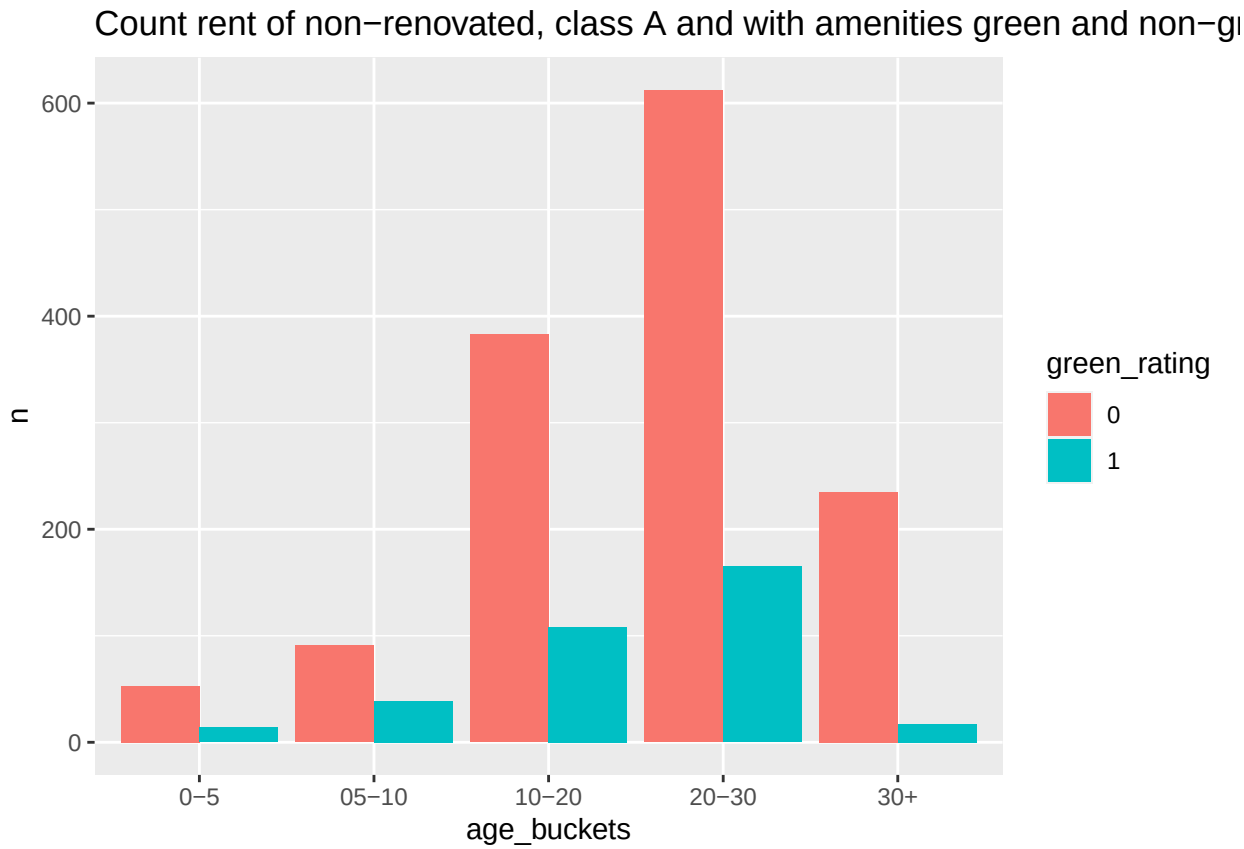
Question 1 - Visual story telling part 1: green buildings

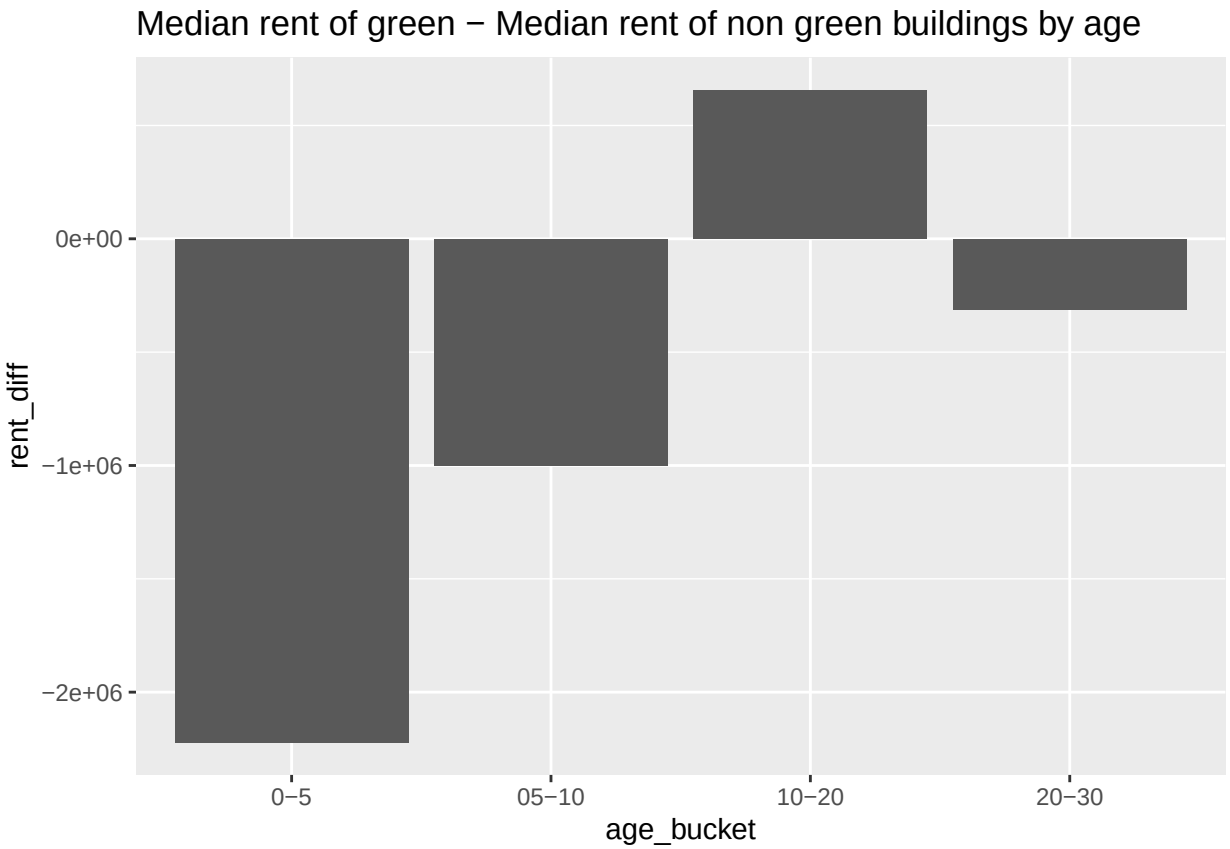



```
## `summarise()` has grouped output by 'age_buckets'. You can override using the `.groups` argument.
```


```
## `summarise()` has grouped output by 'age_buckets'. You can override using the `.groups` argument.
```


Median rent of non−renovated, class A and with amenities green and non−g
median_rent
40
30
20
10
0
0−5
05−10
10−20
20−30
30+
age_bucket
green_rating
0
1


Count rent of non−renovated, class A and with amenities green and non−gr
600
400
200
0
n
0−5
05−10
10−20
20−30
30+
age_buckets
green_rating
0
1



over the lifetime of the building, assumed to be 30 years, green building won't be able to break even before the non-green building, as overall expected rent diff (based on the median rent of the subset) is -2.88 million dollars.

There are some variables other than green rating that are affecting the rent of the building.

Namely, Class_a, Age, Amenties, and Renovation variables are found to be other factors affecting the rent of the building.

Having the building in class_a area with amenities, affect the rent of green building.

And since this is a new building, we need to filter for non-renovated buildings.

Only in 10-20 year range, The rent of new green buldings is higher than new non-green building in class_a area with amenities.

Question 2 - Visual story telling part 2: flights at ABIA

we have plotted scatter plot for arrival delay vs departure delay. Facetted by months. Colored by Delay not caused due to airlines or airport authorities.

insights

The delay count and delay times seems to be increased during vacation times - namely December, June, and July.

Delay caused due to authorities is increased in June and July.

Question 3 -Portfolio Modeling

In this problem, you will construct three different portfolios of exchange-traded funds, or ETFs, and use bootstrap resampling to analyze the short-term tail risk of your portfolios. We selected 4 ETFs to ensure diversity and different levels of risk for the portfolio. Below are the details:

- GOVT - Bond ETF to minimize our risks
- ISCV - Small Cap Value stock to expose us to the equity but with minimal risks
- VT - Large Cap Growth stock with the maximum holding to increase our returns

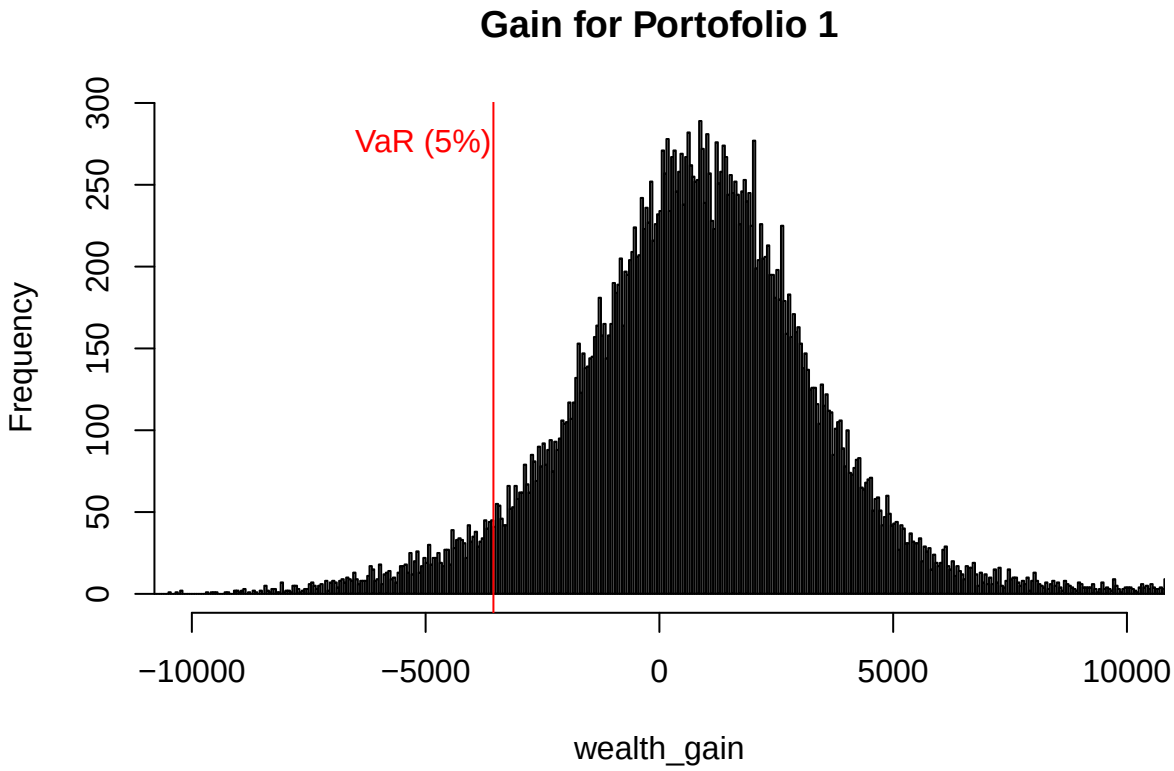
- IWS - Mid Cap Value stock with the maximum holding find a balance between growth and stability

We have come up with 3 portfolios which suits 3 different age groups based on their risk tolerance. (Risk - low, medium, high)

Portofolio 1 - Low Risk

Customers in their retirement period would want to have a stable income hence would not be interested to invest in high risk investments.

In this low risk portfolio, we gave maximum weightage(50%) in Govt. bonds, followed by Large Cap(25%) & Mid(25%) and least weightage to Small cap (5%).



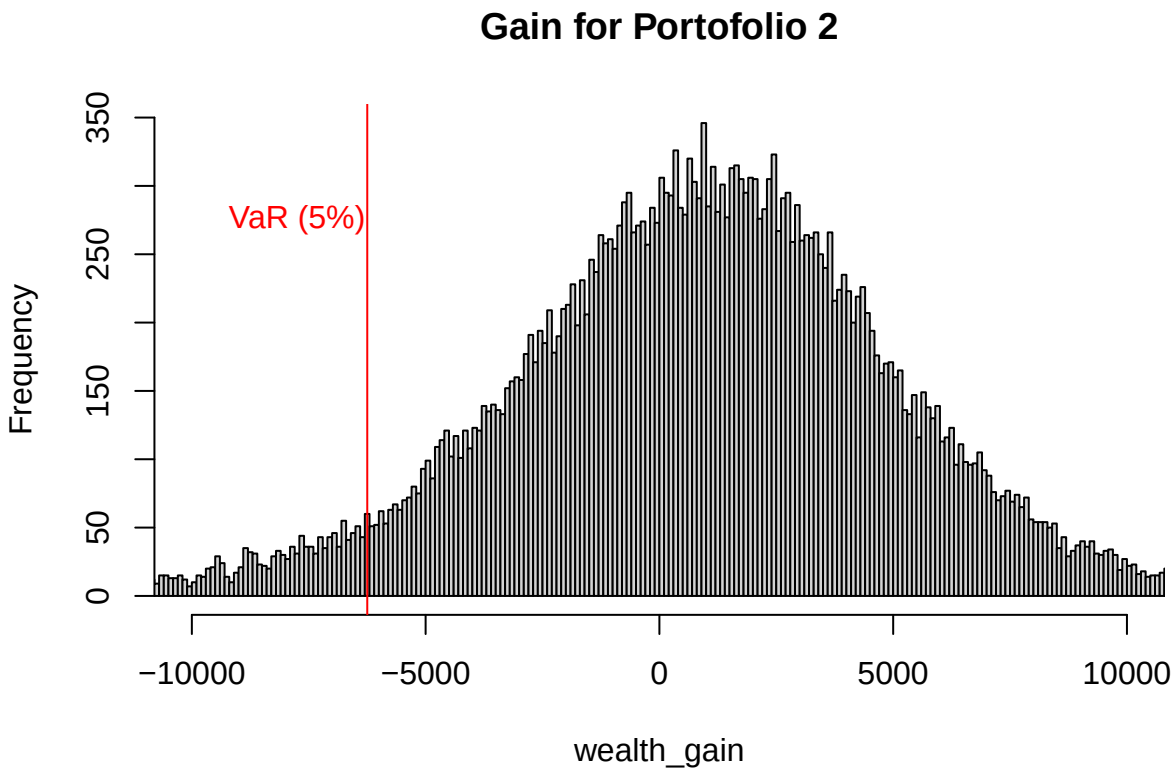

```
##
## Average return of investement after 20 days for Low risk portfolio 100830.4
```

```
##
## 5% Value at Risk for Low risk portfolio- -3549.724
```

-3549.7241893

Portofolio 2 - Medium Risk Customers in their mid age group (40-60 years) have moderate risk appetite and hence would be interested to invest equally in low & high risk investments.

In this medium risk portfolio, we gave equal weightage to all ETFs: Govt. bonds(25%) Large Cap(25%) & Mid(25%) and Small cap (25%).




```
##
## Average return of investement after 20 days for Medium risk portfolio 101604.5
```

```
##
## 5% Value at Risk for Medium risk portfolio- -6247.923
```

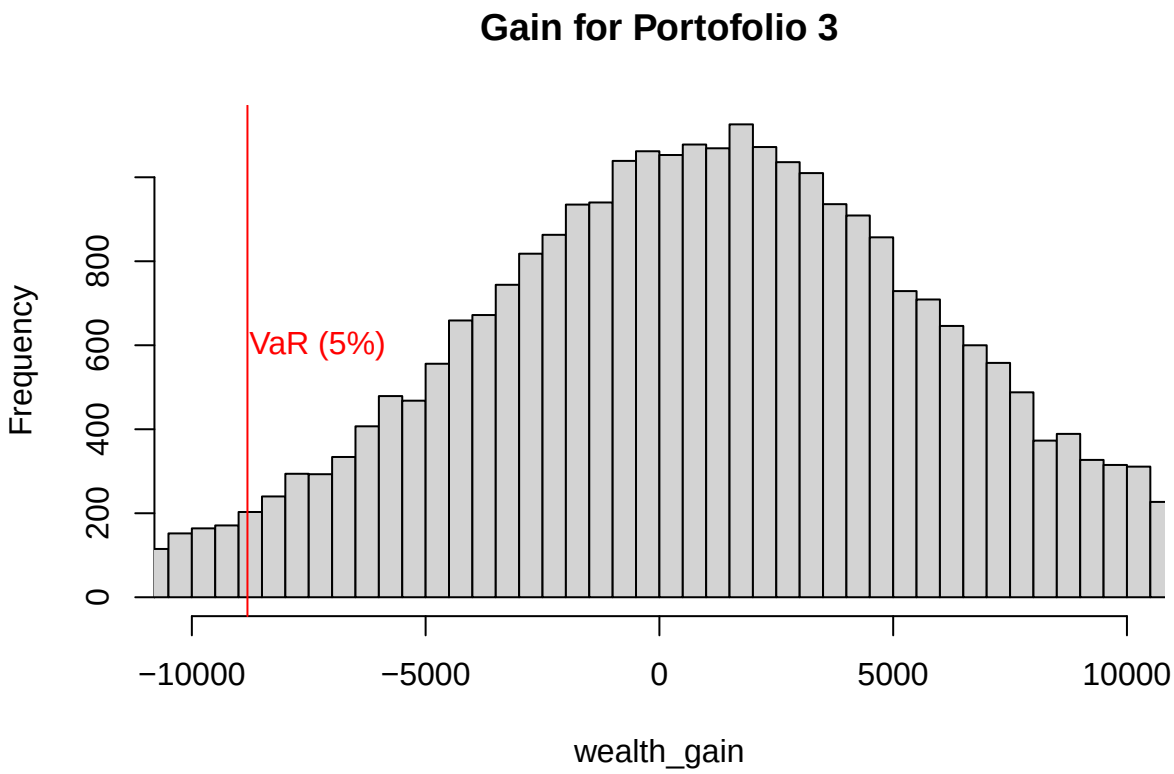
-6247.9228036

Portofolio 3 - High Risk

young customers would invest heavily in small cap and medium cap ETFs. And will have a minimal exposure in Bonds.

Customers in their youth have high risk appetite and hence would be interested to invest more in high risk investments.

In this high risk portfolio, we gave minimum weightage(5%) in Govt. bonds, Large Cap(50%) & Mid(15%) and Small cap (30%).




```
##
## Average return of investement after 20 days for High risk portfolio 102403.6
```

```
##
## 5% Value at Risk for High risk portfolio- -8810.394
```

-8810.3941131

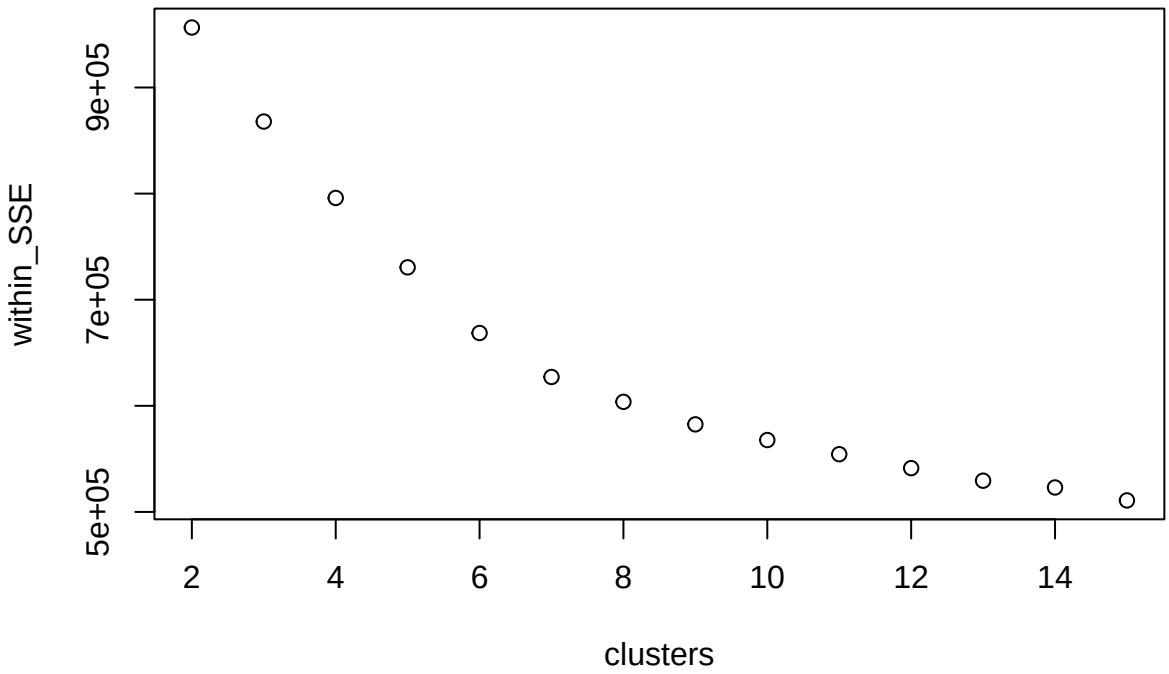
Summary For the High risk portfolio, we are observing the maximum return of investment ($102390.2) and the lowest 5% VaR(-$8749.14).
As the portfolio risk increases, we are able to witness the decrease in returns and increase in VaR value as expected.

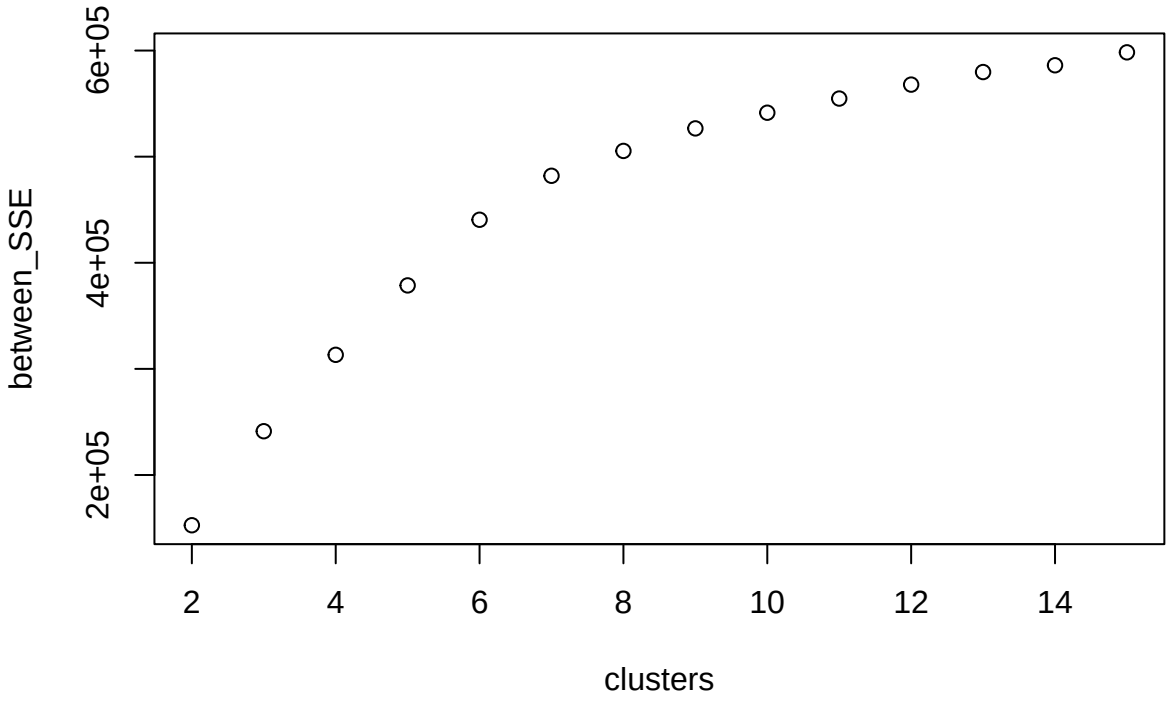
Question 4 - Market segmentation

K-Mean clustering

- K-Means works better when the number of samples is high
- scaling is not required because the unit of all the columns is same.
- We will explore different K and different distance metrics, starting with K = 2 and Euclidean distance metric.

Number of followers - 7882



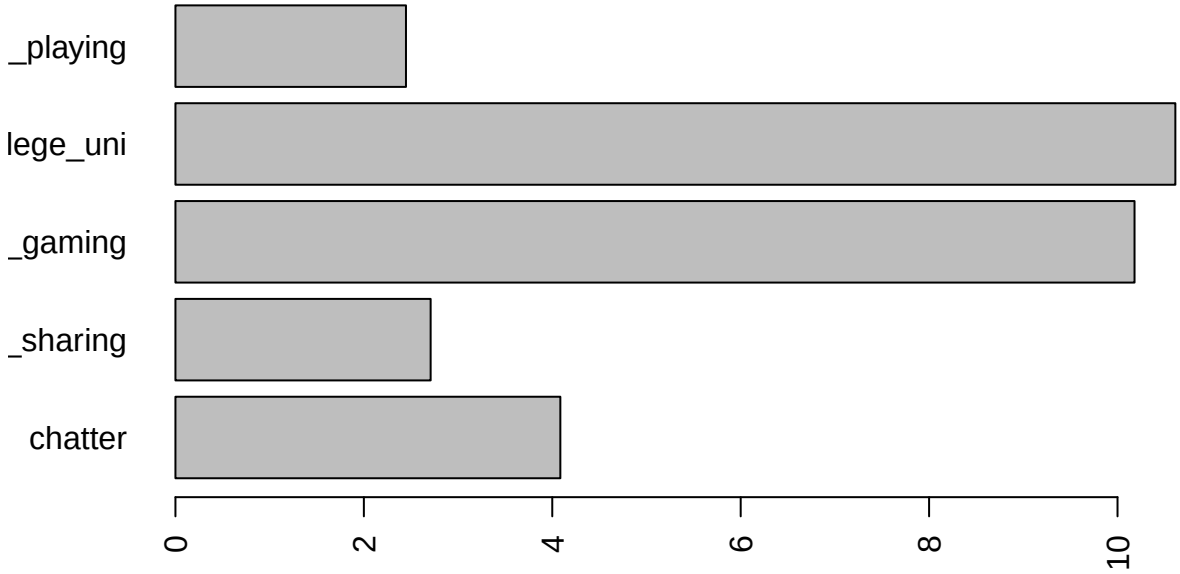


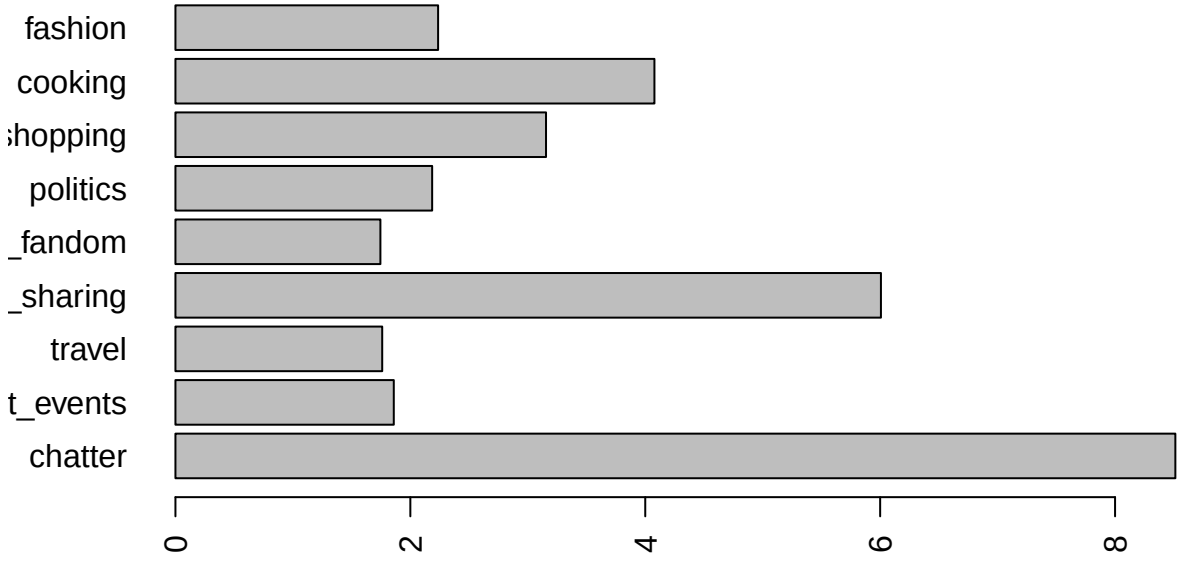
Scaled and Centered Cluster centroids (Z-scores)

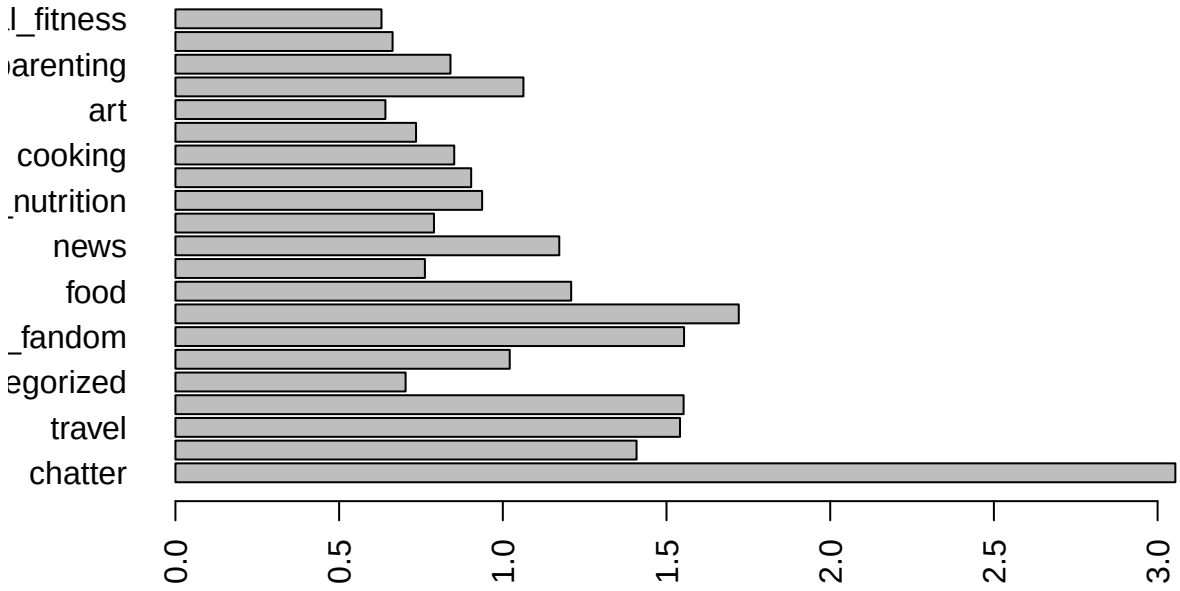
```
##       chatter current_events    travel photo_sharing uncategorized   tv_film
## 1 -0.08868426     0.71841989 0.1232091    0.71557797    -0.2309572 0.6764819
## 2  5.50651991     0.47553995 0.7917713    1.78522778     0.3704899 0.9890781
## 3  0.64285961    -0.08586167 1.3854028    0.08999201    -0.3776038 0.1971119
## 4  0.47298582    -0.08222480 0.7858856   -0.00702703     0.6006889 0.6799747
##   sports_fandom   politics      food     family home_and_garden       music
## 1     0.5904936 0.41091153  0.267310 -0.9221228      -0.2584652 -0.32684509
## 2     0.6260885 0.82745476  1.641534 -0.3789840      -0.2777545  0.05799701
## 3     0.2393073 0.80204191 14.435906 -0.3600817      -0.5249874  0.04242885
## 4     0.6112907 0.04307279  1.026870 -0.6538126      -0.3824259  0.10737656
##          news online_gaming    shopping health_nutrition college_uni
## 1 -0.05592945     2.9791671 0.479351851       0.54918523   6.3962789
## 2  0.02092842     0.1581264 3.945788574       0.38428947   0.3156359
## 3 -0.11994078    -0.4151491 0.005811054      -0.08284061   0.1141709
## 4 -0.28034858     0.5421898 0.996939360       8.56158891  -0.1655863
##   sports_playing    cooking        eco   computers   business    outdoors
## 1      0.7932445 -0.6713876 -0.3501236 -0.41202485 -0.3782863 -0.31043114
## 2      0.5540270  2.0111639 -0.2291664 -0.01949209 -0.2116605 -0.01935319
## 3      5.2891988 -0.3208730 -0.5648810  0.08143519 -0.5805220 -0.44139980
## 4      0.1484944  0.3929663 -0.3075304 -0.03743274 -0.4691700  2.46290734
##        crafts  automotive         art    religion      beauty    parenting
## 1 -0.02591343  0.08653198  0.19640360  0.03767655 -1.06476038  0.182942139
## 2  0.36824648  0.24946818  0.02857516  1.35565269 -0.02893089  0.006215571
```

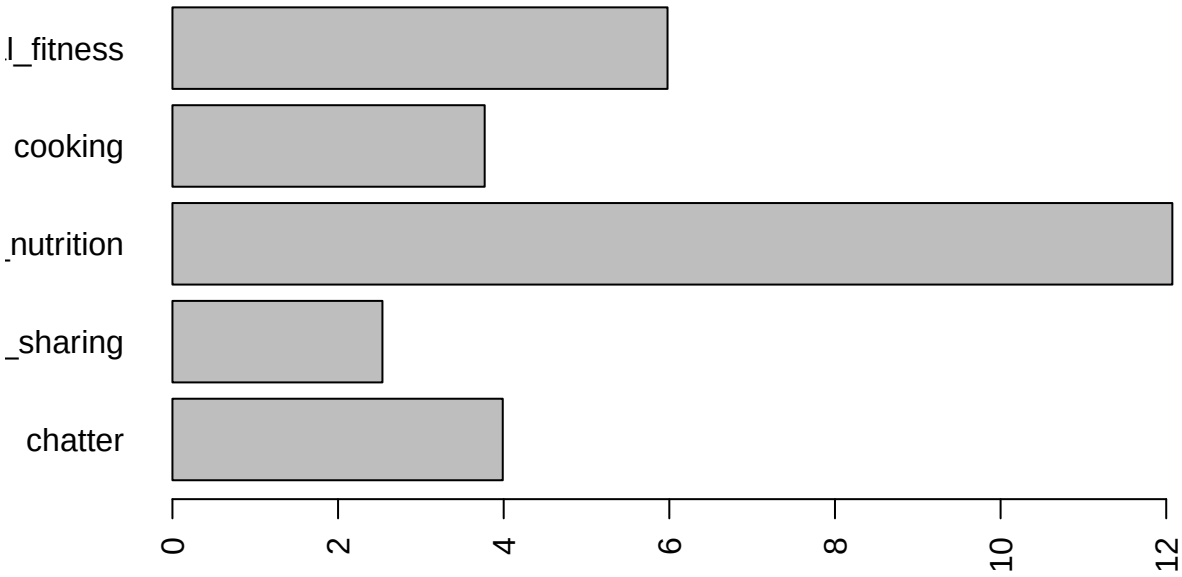
```
## 3 -0.30076300 -0.18822232 -0.10634196 12.68527902 -0.50210843 -0.348864281
## 4  0.15859074  0.01505361 -0.26309062  0.39886759 -0.73864016 -0.259250626
##        dating      school personal_fitness    fashion small_business       spam
## 1 -0.35862858 -0.24826904       -0.1725205  0.4161937     -0.2935046 -0.6020426
## 2  0.22457222 -0.04149517        0.4029258  2.6187610     -0.1516985 -0.3974940
## 3 -0.03616171 -0.40142016       -0.3990760 -0.2025607     -0.4223298 -0.6398003
## 4  0.31684914 -0.40532539        7.1013913  0.6064756     -0.3092033 -0.6047456
##         adult
## 1 -0.31665025
## 2  0.02765828
## 3  5.13074792
## 4 -0.03411253
```

Bar plots of cluster centers for visualization plots below




fashion
cooking
shopping
politics
_fandom
_sharing
travel
t_events
chatter
0
2
4
6
8


l_fitness
arenting
art
cooking
_nutrition
news
food
_fandom
egorized
travel
chatter
0.0
0.5
1.0
1.5
2.0
2.5
3.0




```
## [1] 443
```

```
## [1] 1675
```

```
## [1] 4698
```

```
## [1] 1066
```

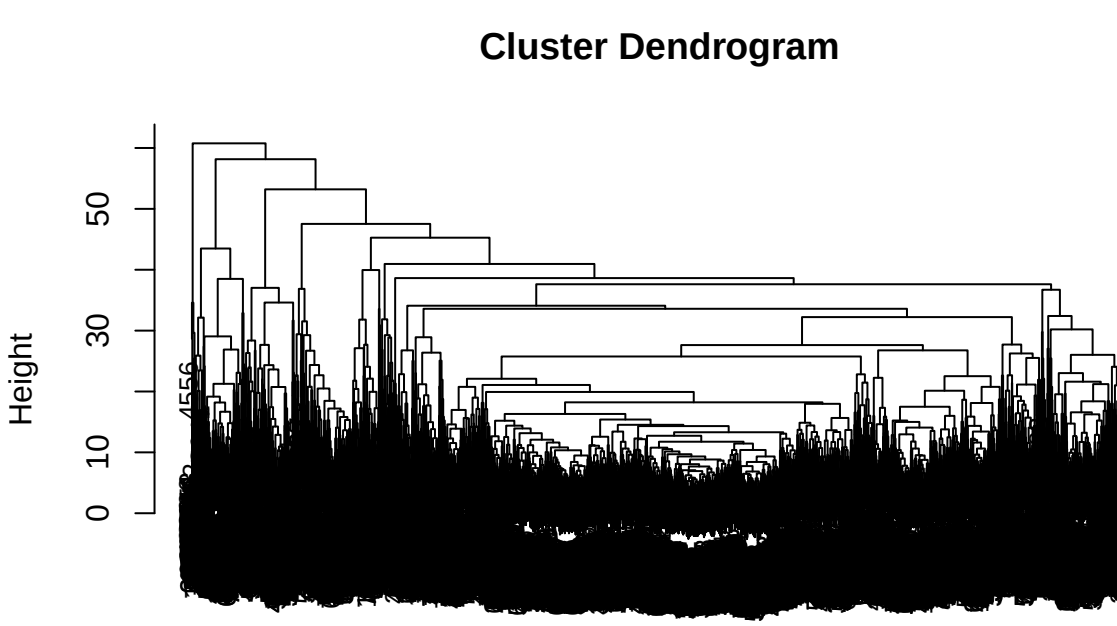
Profiling Methodology:

- We have ran iterations with k=2,15 and based on the results we got, we finalized on clustering into 4 groups
- For these clusters, we have found the cluster means through k-means algorithm and assigned tweets based on 0.2*max(feature value of these clusters) to a cluster

Insights from clustering: KMeans clustering has provided good insights from data.Below are groups identified- Cluster 1. Teen girls? - High shopping, fashion, school, chatter, photosharing Cluster 2. Fitness enthusiasts - high - Outdoors, personal_fitness , health_nutirition Cluster 3. Middle aged group - religion, adult, food Cluster 4. College students - high - college_uni, online_gaming, sport_playing

How these insights can help NutrientH20?

- If we define Cluster 2 as fitness enthusiasts and Cluster 4 as College students, we can do focussed marketing on these group and strategise marketing campaigns to improve revenue from these nische groups and work on their retention



Heirarchial Clustering

```
##    1    2    3    4
##  417 7014  420   31
```

H-clustering is biased for one cluster and is not giving any useful insights.

Question 5 - Author attribution

Explained variance of different Principal components

```
## Importance of first k=200 (out of 793) components:
##                             PC1     PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     3.95900 3.31200 2.94949 2.89421 2.74722 2.66560 2.54703
## Proportion of Variance 0.01977 0.01383 0.01097 0.01056 0.00952 0.00896 0.00818
## Cumulative Proportion  0.01977 0.03360 0.04457 0.05513 0.06465 0.07361 0.08179
##                             PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     2.38025 2.32864 2.24640 2.21198 2.18396 2.13510 2.08190
## Proportion of Variance 0.00714 0.00684 0.00636 0.00617 0.00601 0.00575 0.00547
## Cumulative Proportion  0.08893 0.09577 0.10214 0.10831 0.11432 0.12007 0.12553
##                            PC15    PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     2.0507 1.99909 1.99246 1.96315 1.91945 1.91681 1.87148
## Proportion of Variance 0.0053 0.00504 0.00501 0.00486 0.00465 0.00463 0.00442
## Cumulative Proportion  0.1308 0.13588 0.14088 0.14574 0.15039 0.15502 0.15944
##                            PC22    PC23    PC24    PC25    PC26    PC27    PC28
## Standard deviation     1.86112 1.85750 1.83292 1.81635 1.78586 1.77879 1.76050
```

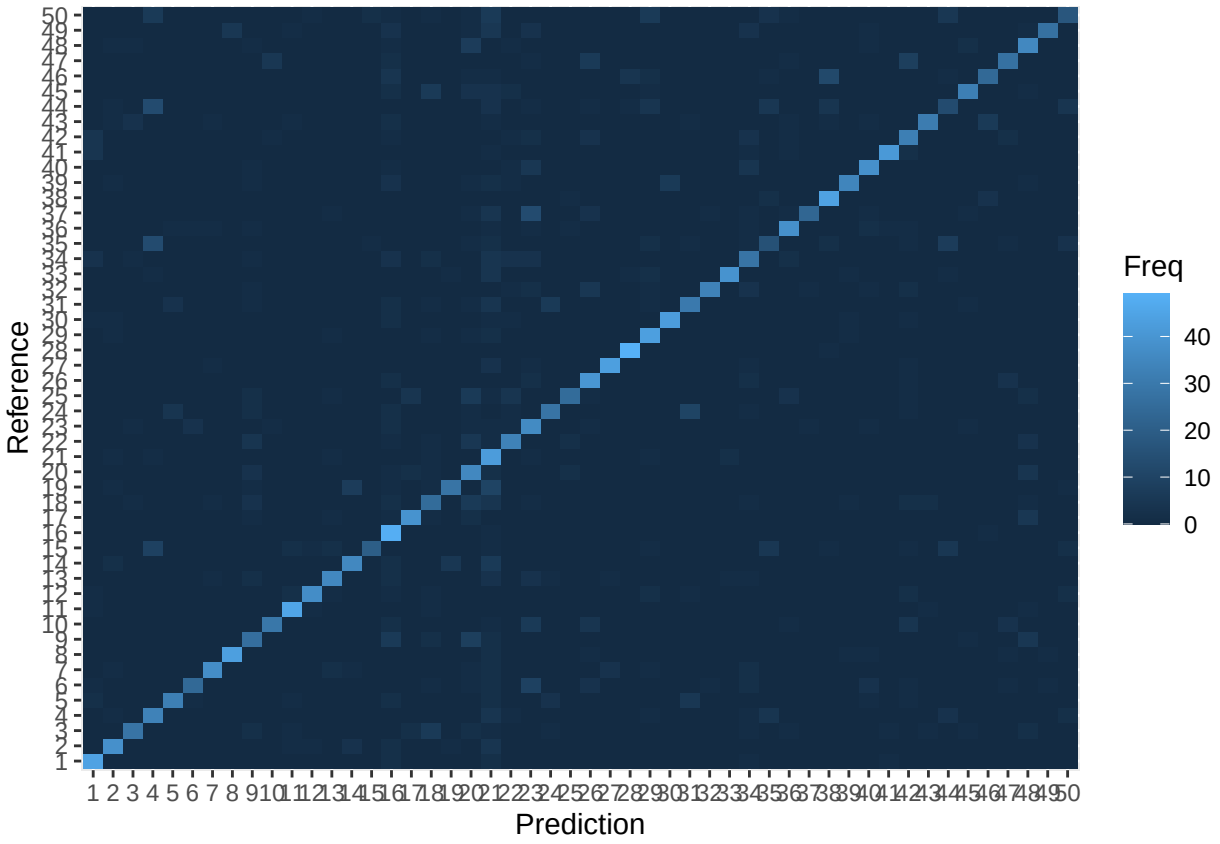
```
## Proportion of Variance 0.00437 0.00435 0.00424 0.00416 0.00402 0.00399 0.00391
## Cumulative Proportion  0.16381 0.16816 0.17239 0.17656 0.18058 0.18457 0.18848
##                           PC29   PC30    PC31    PC32    PC33    PC34    PC35
## Standard deviation     1.75281 1.7367 1.72458 1.71488 1.69654 1.68775 1.68195
## Proportion of Variance 0.00387 0.0038 0.00375 0.00371 0.00363 0.00359 0.00357
## Cumulative Proportion  0.19235 0.1961 0.19990 0.20361 0.20724 0.21083 0.21440
##                           PC36    PC37    PC38    PC39    PC40    PC41    PC42
## Standard deviation     1.6663 1.65774 1.65524 1.63988 1.63183 1.62287 1.60960
## Proportion of Variance 0.0035 0.00347 0.00346 0.00339 0.00336 0.00332 0.00327
## Cumulative Proportion  0.2179 0.22137 0.22482 0.22821 0.23157 0.23489 0.23816
##                           PC43    PC44   PC45    PC46    PC47    PC48   PC49
## Standard deviation     1.60724 1.59563 1.5934 1.58935 1.58211 1.57644 1.5673
## Proportion of Variance 0.00326 0.00321 0.0032 0.00319 0.00316 0.00313 0.0031
## Cumulative Proportion  0.24142 0.24463 0.2478 0.25102 0.25417 0.25731 0.2604
##                           PC50    PC51    PC52    PC53    PC54    PC55    PC56
## Standard deviation     1.56191 1.56014 1.55515 1.54520 1.54382 1.54015 1.53026
## Proportion of Variance 0.00308 0.00307 0.00305 0.00301 0.00301 0.00299 0.00295
## Cumulative Proportion  0.26348 0.26655 0.26960 0.27261 0.27562 0.27861 0.28156
##                           PC57    PC58    PC59    PC60    PC61    PC62    PC63
## Standard deviation     1.52585 1.51380 1.51198 1.50956 1.50201 1.49820 1.49512
## Proportion of Variance 0.00294 0.00289 0.00288 0.00287 0.00284 0.00283 0.00282
## Cumulative Proportion  0.28450 0.28739 0.29027 0.29314 0.29599 0.29882 0.30164
##                           PC64    PC65    PC66    PC67    PC68    PC69   PC70
## Standard deviation     1.48848 1.48584 1.48383 1.47971 1.47214 1.46834 1.4637
## Proportion of Variance 0.00279 0.00278 0.00278 0.00276 0.00273 0.00272 0.0027
## Cumulative Proportion  0.30443 0.30721 0.30999 0.31275 0.31548 0.31820 0.3209
##                           PC71    PC72    PC73    PC74    PC75    PC76    PC77
## Standard deviation     1.45970 1.45767 1.45079 1.44926 1.44440 1.44020 1.43364
## Proportion of Variance 0.00269 0.00268 0.00265 0.00265 0.00263 0.00262 0.00259
## Cumulative Proportion  0.32359 0.32627 0.32893 0.33157 0.33421 0.33682 0.33941
##                           PC78    PC79    PC80    PC81    PC82    PC83    PC84
## Standard deviation     1.42993 1.42680 1.42402 1.42251 1.41848 1.41217 1.41160
## Proportion of Variance 0.00258 0.00257 0.00256 0.00255 0.00254 0.00251 0.00251
## Cumulative Proportion  0.34199 0.34456 0.34712 0.34967 0.35220 0.35472 0.35723
##                           PC85    PC86    PC87    PC88    PC89    PC90    PC91
## Standard deviation     1.41017 1.40472 1.40211 1.39999 1.39591 1.39485 1.38971
## Proportion of Variance 0.00251 0.00249 0.00248 0.00247 0.00246 0.00245 0.00244
## Cumulative Proportion  0.35974 0.36223 0.36471 0.36718 0.36964 0.37209 0.37452
##                           PC92    PC93   PC94    PC95    PC96    PC97    PC98
## Standard deviation     1.38603 1.38221 1.3789 1.37539 1.37377 1.36977 1.36823
## Proportion of Variance 0.00242 0.00241 0.0024 0.00239 0.00238 0.00237 0.00236
## Cumulative Proportion  0.37695 0.37936 0.3817 0.38414 0.38652 0.38889 0.39125
##                           PC99   PC100   PC101   PC102   PC103  PC104   PC105
## Standard deviation     1.36445 1.36045 1.35777 1.35492 1.35280 1.3515 1.34606
## Proportion of Variance 0.00235 0.00233 0.00232 0.00232 0.00231 0.0023 0.00228
## Cumulative Proportion  0.39359 0.39593 0.39825 0.40057 0.40288 0.4052 0.40746
##                          PC106   PC107   PC108   PC109   PC110   PC111   PC112
## Standard deviation     1.34517 1.33862 1.33736 1.33507 1.32983 1.32892 1.32268
## Proportion of Variance 0.00228 0.00226 0.00226 0.00225 0.00223 0.00223 0.00221
## Cumulative Proportion  0.40975 0.41201 0.41426 0.41651 0.41874 0.42097 0.42317
##                         PC113   PC114   PC115   PC116   PC117   PC118   PC119
## Standard deviation     1.3210 1.31683 1.31508 1.31384 1.31014 1.30947 1.30713
## Proportion of Variance 0.0022 0.00219 0.00218 0.00218 0.00216 0.00216 0.00215
## Cumulative Proportion  0.4254 0.42756 0.42974 0.43192 0.43408 0.43624 0.43840
```

```
##                           PC120   PC121   PC122   PC123   PC124   PC125   PC126
## Standard deviation     1.30512 1.30229 1.30162 1.29920 1.29405 1.29296 1.28865
## Proportion of Variance 0.00215 0.00214 0.00214 0.00213 0.00211 0.00211 0.00209
## Cumulative Proportion  0.44055 0.44268 0.44482 0.44695 0.44906 0.45117 0.45326
##                           PC127   PC128   PC129   PC130   PC131   PC132   PC133
## Standard deviation     1.28749 1.28422 1.28185 1.28007 1.27810 1.27592 1.27398
## Proportion of Variance 0.00209 0.00208 0.00207 0.00207 0.00206 0.00205 0.00205
## Cumulative Proportion  0.45535 0.45743 0.45951 0.46157 0.46363 0.46568 0.46773
##                           PC134   PC135   PC136   PC137   PC138  PC139   PC140
## Standard deviation     1.27226 1.27026 1.26766 1.26559 1.26130 1.2602 1.25628
## Proportion of Variance 0.00204 0.00203 0.00203 0.00202 0.00201 0.0020 0.00199
## Cumulative Proportion  0.46977 0.47181 0.47383 0.47585 0.47786 0.4799 0.48185
##                           PC141   PC142   PC143   PC144   PC145   PC146   PC147
## Standard deviation     1.25416 1.25122 1.24959 1.24534 1.24366 1.24214 1.23926
## Proportion of Variance 0.00198 0.00197 0.00197 0.00196 0.00195 0.00195 0.00194
## Cumulative Proportion  0.48384 0.48581 0.48778 0.48974 0.49169 0.49363 0.49557
##                           PC148   PC149   PC150   PC151  PC152   PC153   PC154
## Standard deviation     1.23745 1.23609 1.23268 1.22934 1.2266 1.22539 1.22404
## Proportion of Variance 0.00193 0.00193 0.00192 0.00191 0.0019 0.00189 0.00189
## Cumulative Proportion  0.49750 0.49943 0.50134 0.50325 0.5051 0.50704 0.50893
##                           PC155   PC156   PC157   PC158   PC159   PC160   PC161
## Standard deviation     1.22174 1.22084 1.21707 1.21623 1.21385 1.21082 1.20843
## Proportion of Variance 0.00188 0.00188 0.00187 0.00187 0.00186 0.00185 0.00184
## Cumulative Proportion  0.51081 0.51269 0.51456 0.51642 0.51828 0.52013 0.52197
##                           PC162   PC163   PC164   PC165   PC166  PC167   PC168
## Standard deviation     1.20688 1.20458 1.20126 1.20024 1.19827 1.1935 1.19297
## Proportion of Variance 0.00184 0.00183 0.00182 0.00182 0.00181 0.0018 0.00179
## Cumulative Proportion  0.52381 0.52564 0.52746 0.52927 0.53108 0.5329 0.53468
##                           PC169   PC170   PC171   PC172   PC173   PC174   PC175
## Standard deviation     1.19157 1.18930 1.18690 1.18636 1.18534 1.18097 1.17856
## Proportion of Variance 0.00179 0.00178 0.00178 0.00177 0.00177 0.00176 0.00175
## Cumulative Proportion  0.53647 0.53825 0.54003 0.54180 0.54357 0.54533 0.54708
##                           PC176   PC177   PC178   PC179   PC180   PC181   PC182
## Standard deviation     1.17852 1.17541 1.17463 1.17210 1.17102 1.17005 1.16642
## Proportion of Variance 0.00175 0.00174 0.00174 0.00173 0.00173 0.00173 0.00172
## Cumulative Proportion  0.54883 0.55058 0.55232 0.55405 0.55578 0.55750 0.55922
##                           PC183  PC184   PC185   PC186   PC187   PC188   PC189
## Standard deviation     1.16505 1.1614 1.15932 1.15879 1.15664 1.15386 1.15359
## Proportion of Variance 0.00171 0.0017 0.00169 0.00169 0.00169 0.00168 0.00168
## Cumulative Proportion  0.56093 0.5626 0.56433 0.56602 0.56771 0.56939 0.57107
##                           PC190   PC191   PC192   PC193   PC194   PC195   PC196
## Standard deviation     1.15268 1.14994 1.14620 1.14475 1.14355 1.14100 1.13997
## Proportion of Variance 0.00168 0.00167 0.00166 0.00165 0.00165 0.00164 0.00164
## Cumulative Proportion  0.57274 0.57441 0.57607 0.57772 0.57937 0.58101 0.58265
##                           PC197   PC198   PC199   PC200
## Standard deviation     1.13723 1.13671 1.13342 1.13321
## Proportion of Variance 0.00163 0.00163 0.00162 0.00162
## Cumulative Proportion  0.58428 0.58591 0.58753 0.58915
```

Visualization for confusion matrix - Train

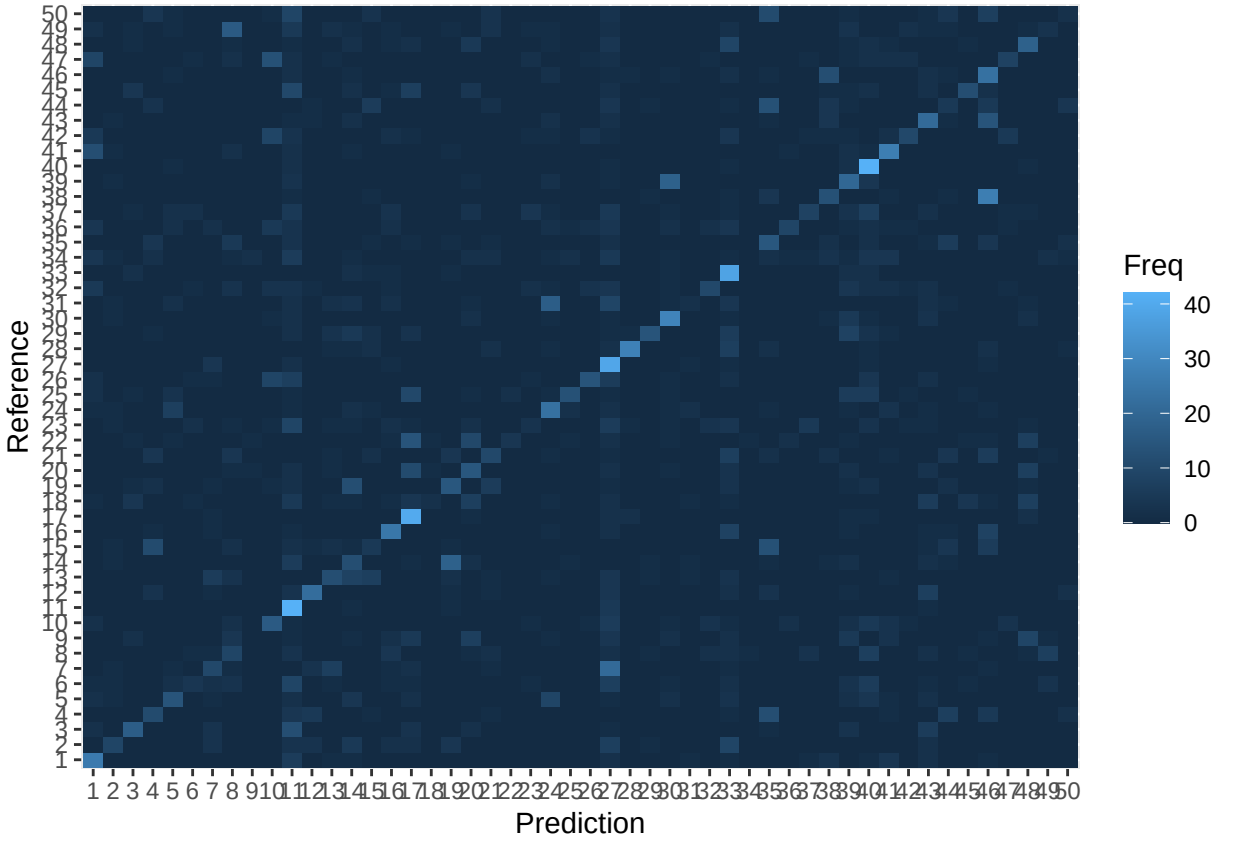
```
##       Accuracy          Kappa  AccuracyLower  AccuracyUpper   AccuracyNull
##      0.6652000      0.6583673      0.6463158      0.6836965      0.0200000
```

```
## AccuracyPValue  McnemarPValue
##      0.0000000            NaN
```



Visualization for confusion matrix - Test

```
##       Accuracy          Kappa  AccuracyLower  AccuracyUpper   AccuracyNull
##      0.3076000      0.2934694      0.2895436      0.3261082      0.0200000
## AccuracyPValue  McnemarPValue
##      0.0000000            NaN
```



Below is the summary of Steps followed:
1. Reading C50 train files 2. Pre-Processing (train & test):

- Created bag-of-words
- Change all words to lowercase
- Remove numbers and punctuations
- Removed white spaces
- Removed Stop words
- Created term frequency matrix for the independent features

3. Modelling:

- Created a y variable to find the author name for each document
- Created Principal components for train features and selected the 1st 200 features as they were able to explain 60% of variance of y.
- Multi-label Random Forest classification on the training set. Based on the confusion matrix table, we got train accuracy of 66%, while our baseline accuracy = 2% (50 classes).

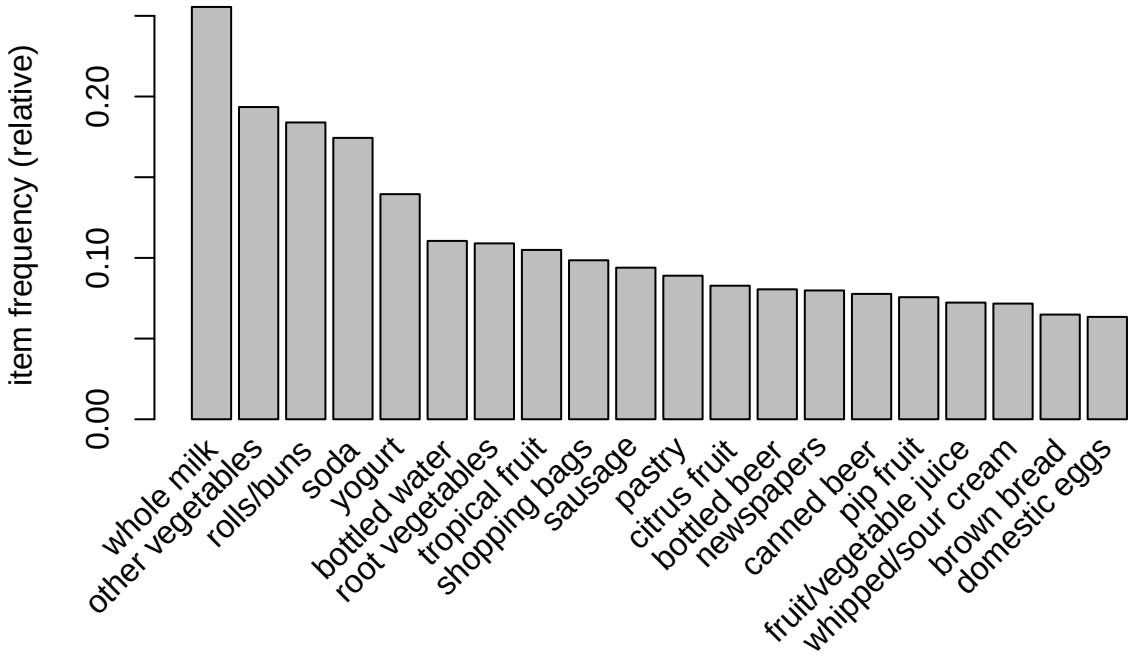
Note:

- Adding IDF factors, along with RF model was giving poor prediction accuracy of just 6%.
- Going from 793 features to just 200 features with PCA. Explained proportion with 200 components is 60% which good enough dimensional reduction and without much loss in prediction accuracy.

Results:

- Test accuracy achieved through Random Forest model with PCA features: and PCA: 33.2%

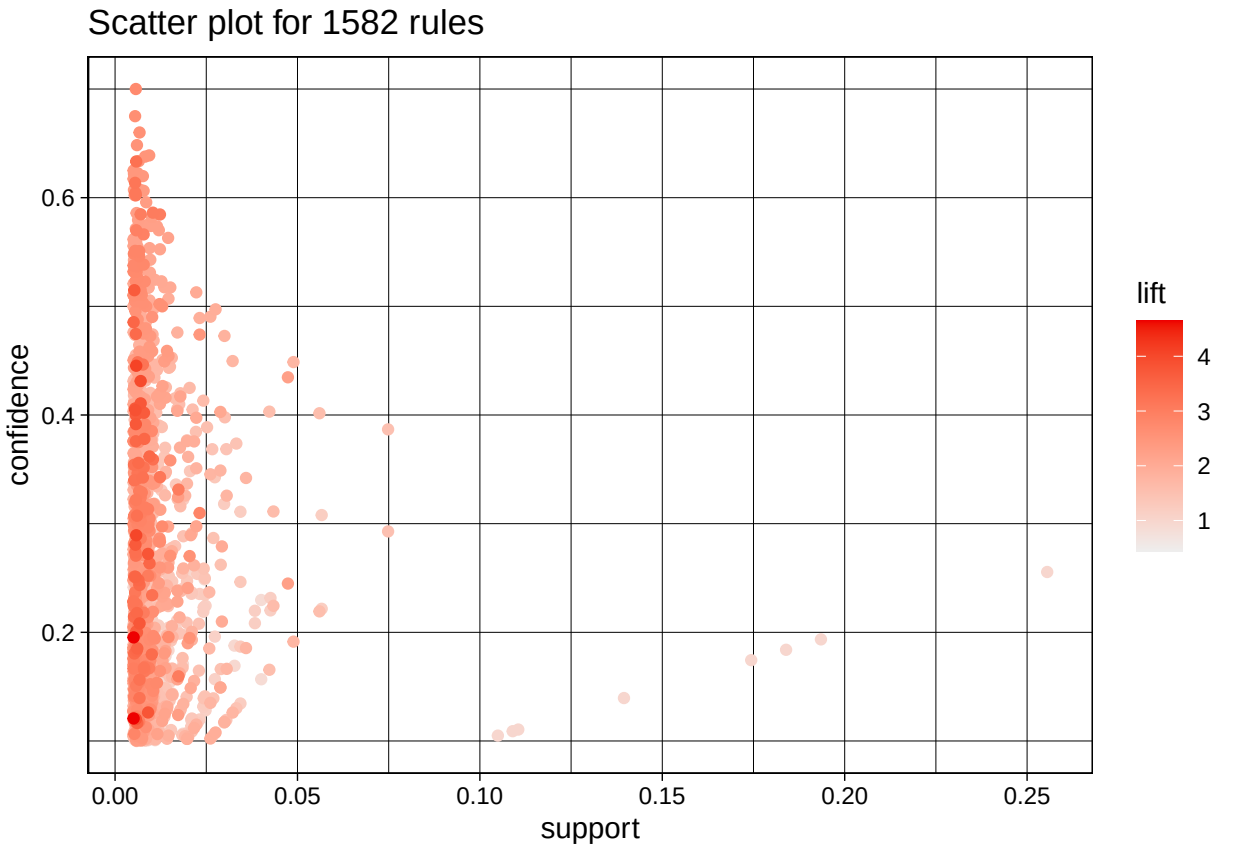
Question 6 - Association rule mining



Several purchase patterns can be observed. For example:

- The most popular transactions were of milk, other vegetables,rolls/buns
- Interestingly soda is 4th most frequent with a count of atleast 1600.
- If someone buys citrus fruit/tropical fruit,root vegetables, they are likely to have bought other vegetables/whole milk as well
- Relatively many people buy curd, yogurt along with whole milk

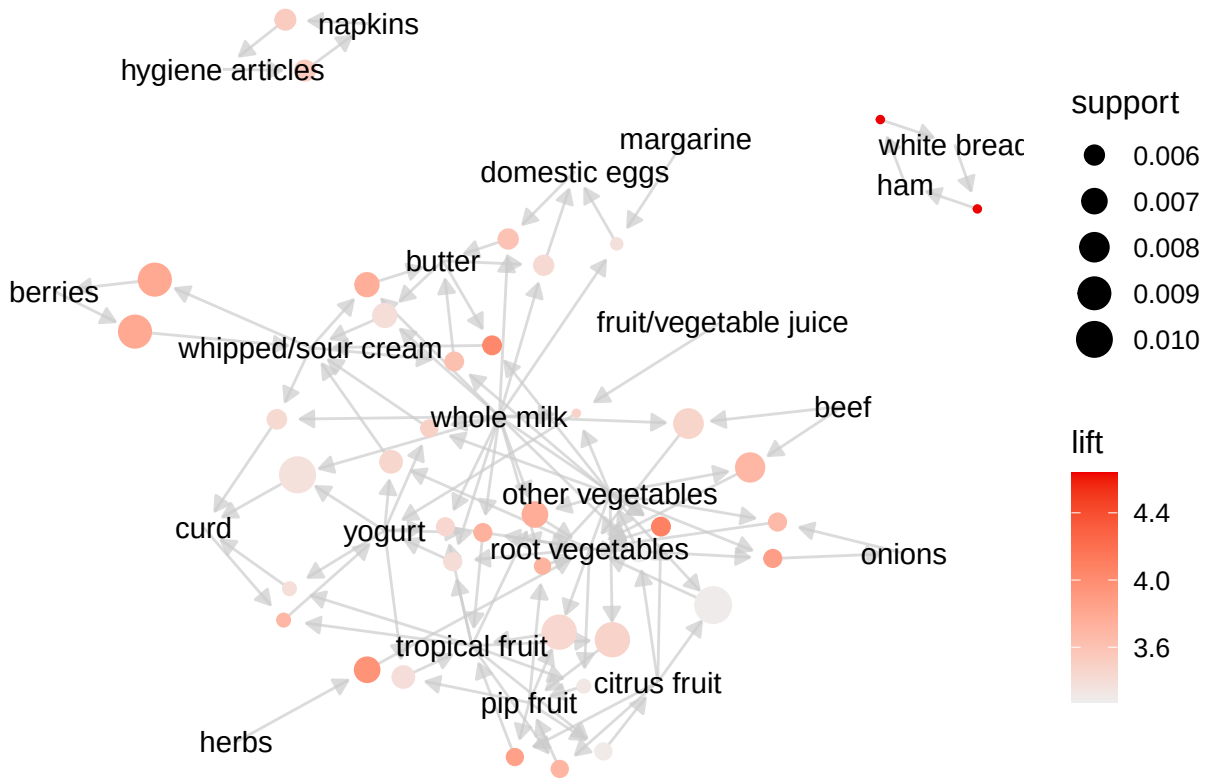
```
## Apriori
##
## Parameter specification:
##  confidence minval smax arem  aval originalSupport maxtime support minlen
##         0.1    0.1    1 none FALSE            TRUE       5   0.005      1
##  maxlen target  ext
##       5  rules TRUE
##
## Algorithmic control:
##  filter tree heap memopt load sort verbose
##     0.1 TRUE TRUE  FALSE TRUE    2    TRUE
##
## Absolute minimum support count: 49
##
## set item appearances ...[0 item(s)] done [0.00s].
## set transactions ...[169 item(s), 9835 transaction(s)] done [0.01s].
## sorting and recoding items ... [120 item(s)] done [0.00s].
## creating transaction tree ... done [0.01s].
## checking subsets of size 1 2 3 4 done [0.01s].
## writing ... [1582 rule(s)] done [0.00s].
## creating S4 object  ... done [0.00s].
```



- Anything with support >0.1 is clearly an outlier. Because these are individual items which have higher occurency in the item list. So, we will remove those rules.
- Looking at the graph above, Lift threshold should be 2 to make sure we evaluate only strong associations

```
##      lhs                     rhs                    support confidence   coverage     lift count
## [1]  {ham}                => {white bread}        0.005083884  0.1953125 0.02602949 4.639851    50
## [2]  {white bread}        => {ham}                0.005083884  0.1207729 0.04209456 4.639851    50
## [3]  {citrus fruit,
##       other vegetables,
##       whole milk}         => {root vegetables}    0.005795628  0.4453125 0.01301474 4.085493    57
## [4]  {butter,
##       other vegetables}   => {whipped/sour cream} 0.005795628  0.2893401 0.02003050 4.036397    57
## [5]  {herbs}              => {root vegetables}    0.007015760  0.4312500 0.01626843 3.956477    69
## [6]  {other vegetables,
##       root vegetables}    => {onions}             0.005693950  0.1201717 0.04738180 3.875044    56
## [7]  {citrus fruit,
##       pip fruit}          => {tropical fruit}     0.005592272  0.4044118 0.01382816 3.854060    55
## [8]  {berries}            => {whipped/sour cream} 0.009049314  0.2721713 0.03324860 3.796886    89
## [9]  {whipped/sour cream} => {berries}            0.009049314  0.1262411 0.07168277 3.796886    89
## [10] {other vegetables,
##       tropical fruit,
##       whole milk}         => {root vegetables}    0.007015760  0.4107143 0.01708185 3.768074    69
```

Association Graphs



Bidirectional rules with high lift and low support (which means highly complimentary items)

1. Ham -> whitebread & Whitebread -> Ham
2. Hygiene Articles -> Napkins & Napkins -> Hygiene Articles
3. whipped/sour cream -> berries & berries -> whipped/sour cream

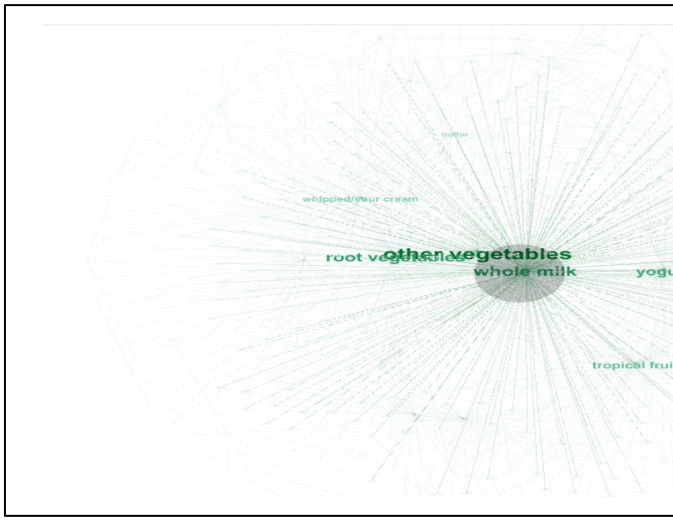
4. Vegetables are brought together in general

In the grocery store, there are different centers. For example, below are often brought together:

- Fruits/vegetables/dairy products
- Hygiene products

Next steps:

- We can deep dive and check why white bread is bought only with Ham and not milk. It could be because of thresholds we have set, but it needs further speculation.



Association rule graph visualization in Gephi