

STA380 II

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Github link for this project: <https://github.com/BashfulBaobab/ML-Project-Repo>

R Markdown

STA380 Part II

Question 1 - Green Buildings

```
##   CS_PropertyID      cluster        size      empl_gr
##   Min. : 1   Min. : 1.0   Min. : 1624   Min. :-24.950
##   1st Qu.: 157452 1st Qu.: 272.0  1st Qu.: 50891  1st Qu.: 1.740
##   Median : 313253 Median : 476.0  Median : 128838 Median : 1.970
##   Mean   : 453003 Mean   : 588.6  Mean   : 234638 Mean   : 3.207
##   3rd Qu.: 441188 3rd Qu.:1044.0 3rd Qu.: 294212 3rd Qu.: 2.380
##   Max.   :6208103 Max.   :1230.0  Max.   :3781045 Max.   : 67.780
##                               NA's   :74
##      Rent      leasing_rate      stories      age
##   Min. : 2.98  Min. : 0.00  Min. : 1.00  Min. : 0.00
##   1st Qu.: 19.50 1st Qu.: 77.85 1st Qu.: 4.00  1st Qu.: 23.00
##   Median : 25.16 Median : 89.53 Median : 10.00 Median : 34.00
##   Mean   : 28.42 Mean   : 82.61 Mean   : 13.58 Mean   : 47.24
##   3rd Qu.: 34.18 3rd Qu.: 96.44 3rd Qu.: 19.00 3rd Qu.: 79.00
##   Max.   :250.00 Max.   :100.00 Max.   :110.00 Max.   :187.00
##
##      renovated      class_a      class_b      LEED
##   Min. :0.0000  Min. :0.0000  Min. :0.0000  Min. :0.0000000
##   1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000000
##   Median :0.0000 Median :0.0000 Median :0.0000 Median :0.0000000
##   Mean   :0.3795 Mean   :0.3999 Mean   :0.4595 Mean   :0.006841
##   3rd Qu.:1.0000 3rd Qu.:1.0000 3rd Qu.:1.0000 3rd Qu.:0.0000000
##   Max.   :1.0000 Max.   :1.0000 Max.   :1.0000 Max.   :1.0000000
##
##      Energystar      green_rating      net      amenities
##   Min. :0.00000  Min. :0.00000  Min. :0.00000  Min. :0.0000
##   1st Qu.:0.00000 1st Qu.:0.00000 1st Qu.:0.00000 1st Qu.:0.0000
##   Median :0.00000 Median :0.00000 Median :0.00000 Median :1.0000
##   Mean   :0.08082 Mean   :0.08677 Mean   :0.03471 Mean   :0.5266
##   3rd Qu.:0.00000 3rd Qu.:0.00000 3rd Qu.:0.00000 3rd Qu.:1.0000
##   Max.   :1.00000 Max.   :1.00000 Max.   :1.00000 Max.   :1.0000
```

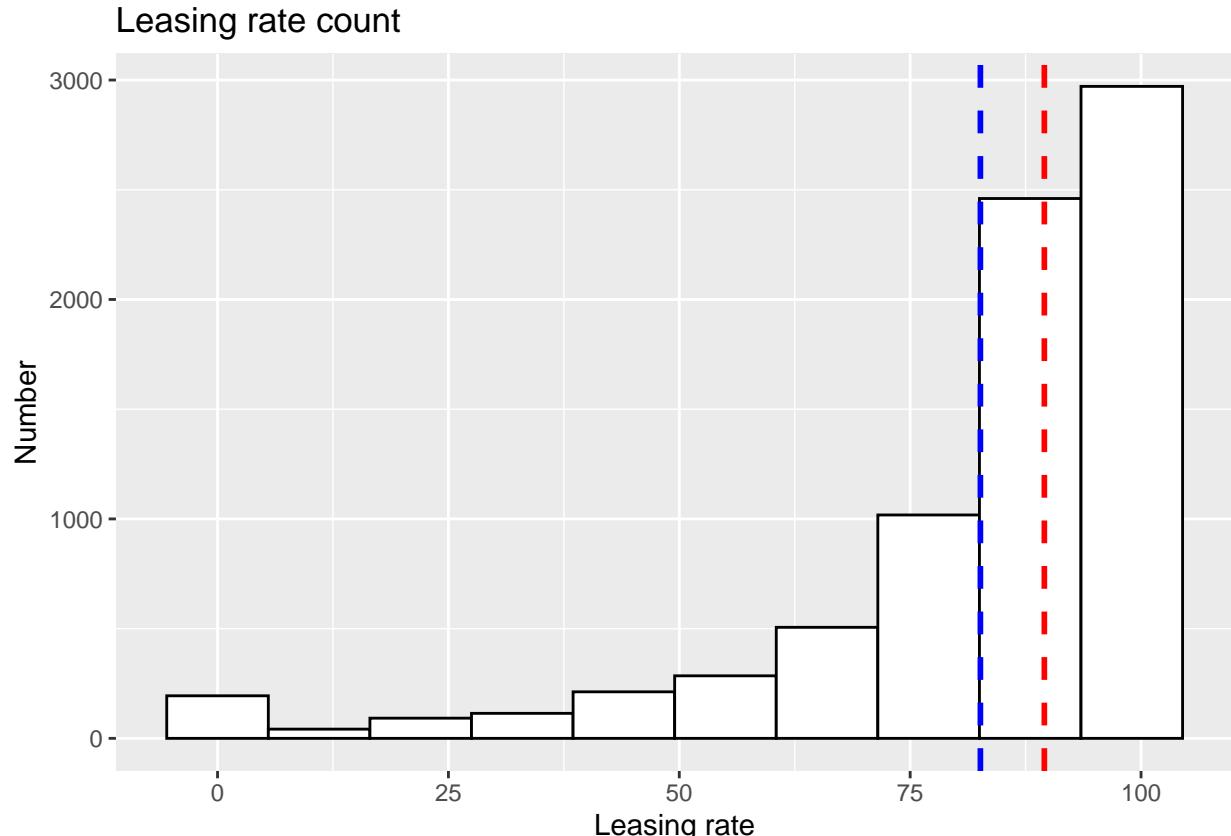
```

## 
##   cd_total_07      hd_total07      total_dd_07      Precipitation
##   Min.    : 39      Min.    : 0       Min.    :2103      Min.    :10.46
##   1st Qu.: 684     1st Qu.:1419     1st Qu.:2869     1st Qu.:22.71
##   Median  : 966     Median  :2739     Median  :4979      Median  :23.16
##   Mean    :1229     Mean    :3432     Mean    :4661      Mean    :31.08
##   3rd Qu.:1620     3rd Qu.:4796     3rd Qu.:6413     3rd Qu.:43.89
##   Max.    :5240     Max.    :7200     Max.    :8244      Max.    :58.02
##
##   Gas_Costs        Electricity_Costs   cluster_rent
##   Min.    :0.009487  Min.    :0.01780     Min.    : 9.00
##   1st Qu.:0.010296  1st Qu.:0.02330     1st Qu.:20.00
##   Median  :0.010296  Median  :0.03274     Median  :25.14
##   Mean    :0.011336  Mean    :0.03096     Mean    :27.50
##   3rd Qu.:0.011816  3rd Qu.:0.03781     3rd Qu.:34.00
##   Max.    :0.028914  Max.    :0.06280     Max.    :71.44
##

```

Part 1

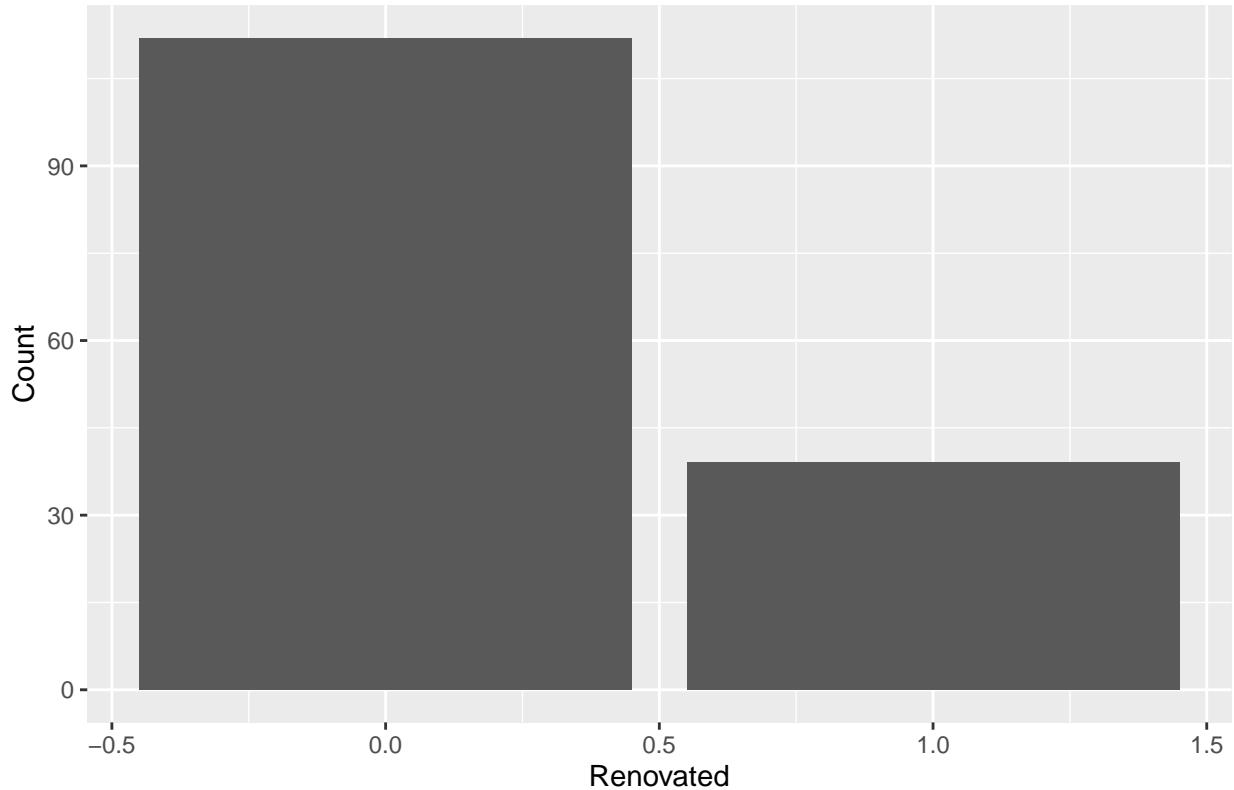
Dropping 10% low occupancy



We found the median leasing rate to be ~90%, and the buildings with the lowest occupancy were highly skewed toward 0%, showing there is likely a variable not included in this data set that is impacting the buildings with the lowest occupancy rates. Further, considering 0% occupancy is quite far from the 90%

median, it can be concluded that dropping the bottom 10% of buildings based on occupancy will likely not impact the model, and could even help increase its accuracy.

0 occup,renovated count



```
##   CS_PropertyID      cluster      size      empl_gr
##   Min.   : 10098   Min.   : 8.0   Min.   : 1624   Min.   :-1.490
##   1st Qu.: 240228  1st Qu.: 256.0  1st Qu.: 9784   1st Qu.: 1.755
##   Median : 410242  Median : 383.0  Median : 21340   Median : 2.380
##   Mean   :1335707   Mean   : 549.9   Mean   : 49114   Mean   : 4.120
##   3rd Qu.: 999549  3rd Qu.:1010.5  3rd Qu.: 71000   3rd Qu.: 3.700
##   Max.   :6008486   Max.   :1230.0   Max.   :427383   Max.   :67.780
##   Rent      leasing_rate      stories      age
##   Min.   : 7.00   Min.   :0       Min.   : 1.000   Min.   : 0.00
##   1st Qu.: 13.75  1st Qu.:0       1st Qu.: 2.000   1st Qu.: 28.00
##   Median : 19.40  Median :0       Median : 3.000   Median : 57.00
##   Mean   : 21.73  Mean   :0       Mean   : 4.212   Mean   : 55.04
##   3rd Qu.: 27.30  3rd Qu.:0       3rd Qu.: 5.000   3rd Qu.: 80.00
##   Max.   :111.11  Max.   :0       Max.   :19.000   Max.   :118.00
##   renovated      class_a      class_b      LEED
##   Min.   :0.00000  Min.   :0.00000  Min.   :0.00000  Min.   :0
##   1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0
##   Median :0.00000  Median :0.00000  Median :0.00000  Median :0
##   Mean   :0.2583   Mean   :0.0596   Mean   :0.4503   Mean   :0
##   3rd Qu.:1.00000  3rd Qu.:0.00000  3rd Qu.:1.00000  3rd Qu.:0
##   Max.   :1.00000  Max.   :1.00000  Max.   :1.00000  Max.   :0
##   Energystar      green_rating      net      amenities
##   Min.   :0.0000000  Min.   :0.0000000  Min.   :0.0000000  Min.   :0.0000000
```

```

## 1st Qu.:0.000000 1st Qu.:0.000000 1st Qu.:0.000000 1st Qu.:0.00000
## Median :0.000000 Median :0.000000 Median :0.000000 Median :0.00000
## Mean   :0.006622 Mean   :0.006622 Mean   :0.006622 Mean   :0.08609
## 3rd Qu.:0.000000 3rd Qu.:0.000000 3rd Qu.:0.000000 3rd Qu.:0.00000
## Max.   :1.000000 Max.   :1.000000 Max.   :1.000000 Max.   :1.00000
## cd_total_07    hd_total07    total_dd_07    Precipitation
## Min.   :130     Min.   :0      Min.   :2103    Min.   :10.46
## 1st Qu.:684     1st Qu.:1419   1st Qu.:2869   1st Qu.:22.71
## Median :1113    Median :2080    Median :4651    Median :25.55
## Mean   :1683    Mean   :3013    Mean   :4696    Mean   :30.54
## 3rd Qu.:2746    3rd Qu.:4694   3rd Qu.:6363   3rd Qu.:41.32
## Max.   :5240    Max.   :7200    Max.   :8244    Max.   :53.93
## Gas_Costs      Electricity_Costs cluster_rent
## Min.   :0.009487 Min.   :0.01782   Min.   :10.22
## 1st Qu.:0.010118 1st Qu.:0.02463   1st Qu.:18.00
## Median :0.010296 Median :0.02887   Median :20.25
## Mean   :0.011799 Mean   :0.03182   Mean   :24.17
## 3rd Qu.:0.011955 3rd Qu.:0.03781   3rd Qu.:28.03
## Max.   :0.028914 Max.   :0.06278   Max.   :65.94

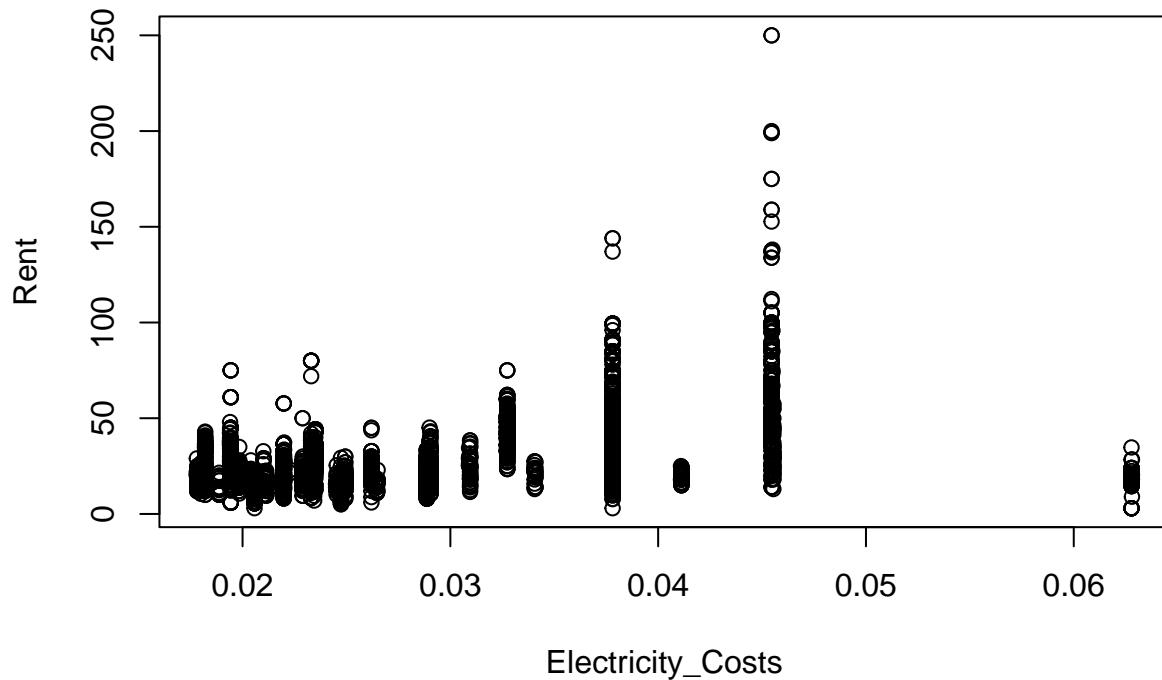
```

There appear to be a notable number of buildings with 0% occupancy. On further analysis, it is apparent that the median age for low occupancy buildings is 57 as opposed to 34 for the main data set, as well as a lower number of renovated buildings among the buildings with lower occupancy. This could provide insight into the variables impacting the lowest 10% of buildings based on occupancy rate, such as ongoing renovation projects or lack of permit for occupancy due to hazardous conditions in these older buildings. This is a better explanation to account for the dropping of the bottom 10% of buildings as opposed to simply stating “something weird” is happening with them.

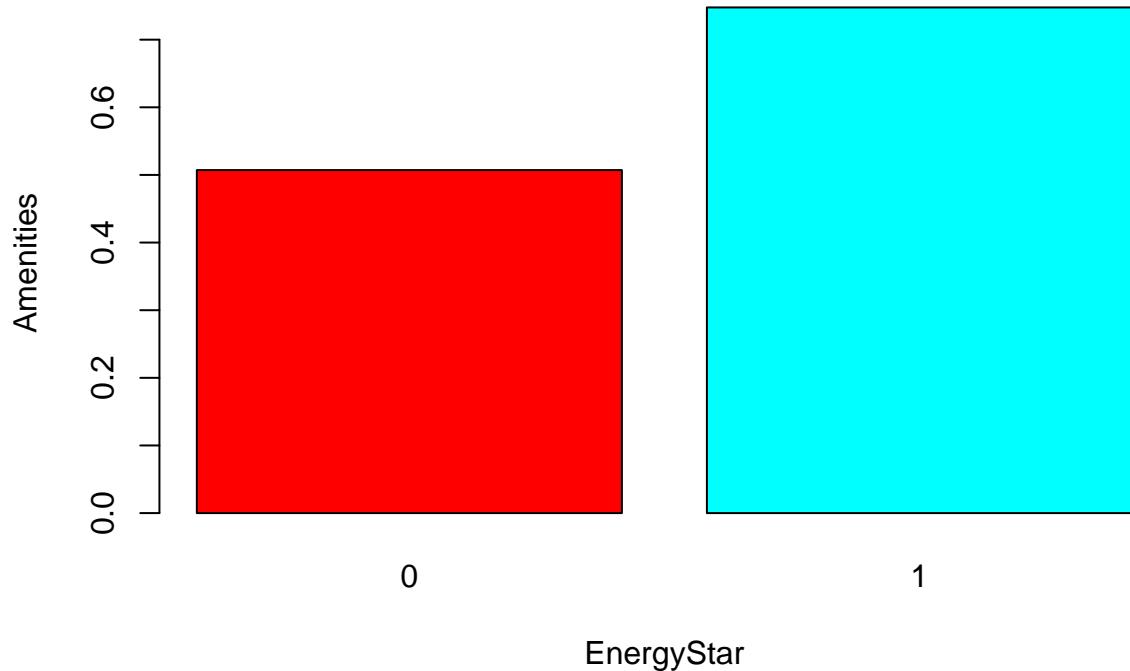
Part 2

To test for a premium in rent for green buildings, we cannot simply subtract the difference between the two median rents among green and non-green buildings as we are not accounting for different factors that also affect revenue. To test if there is a true difference in price per square-foot, ideally, we would run a regression and hold other variables constant to see the individual effect on rent for a green building versus a non-green building.

Rent vs Electricity Cost



Amenities for Energy star



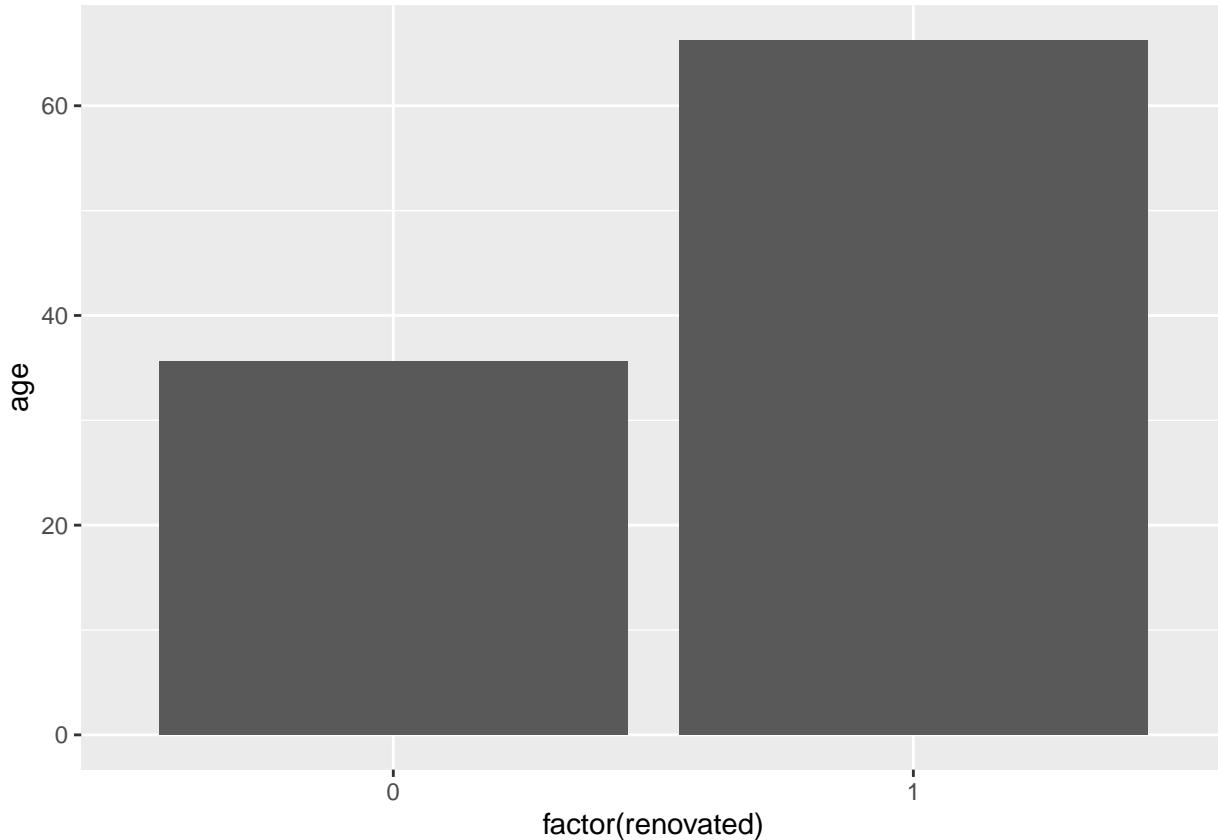
Part 3

As seen above, as rent increases, electricity costs also increase, therefore one cannot simply assume a direct increase in profit with the increase in rent for green buildings. Furthermore, energy efficient buildings are more likely to have amenities. Both of these variables will increase overhead costs, further justifying a lack of certainty in a profit stemming from increased rent revenue generation in green buildings.

Part 4

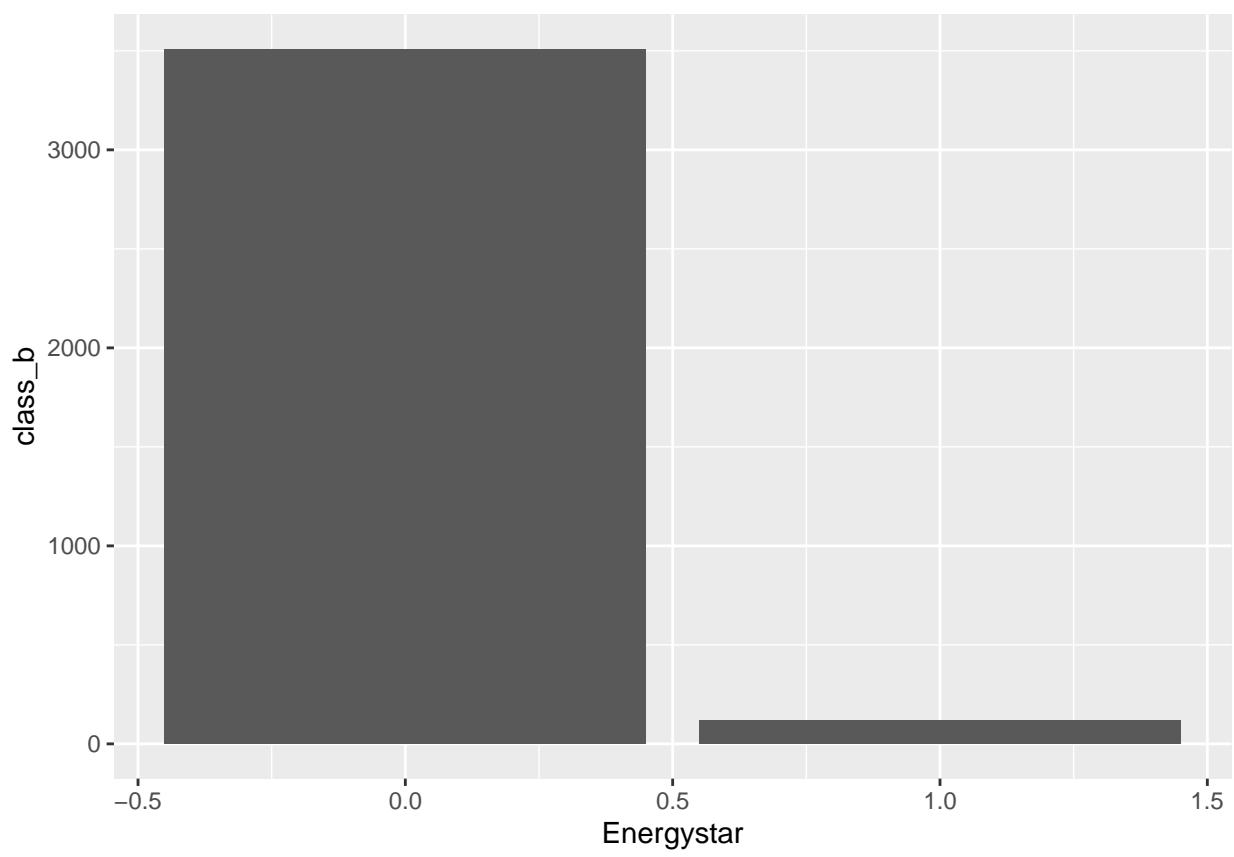
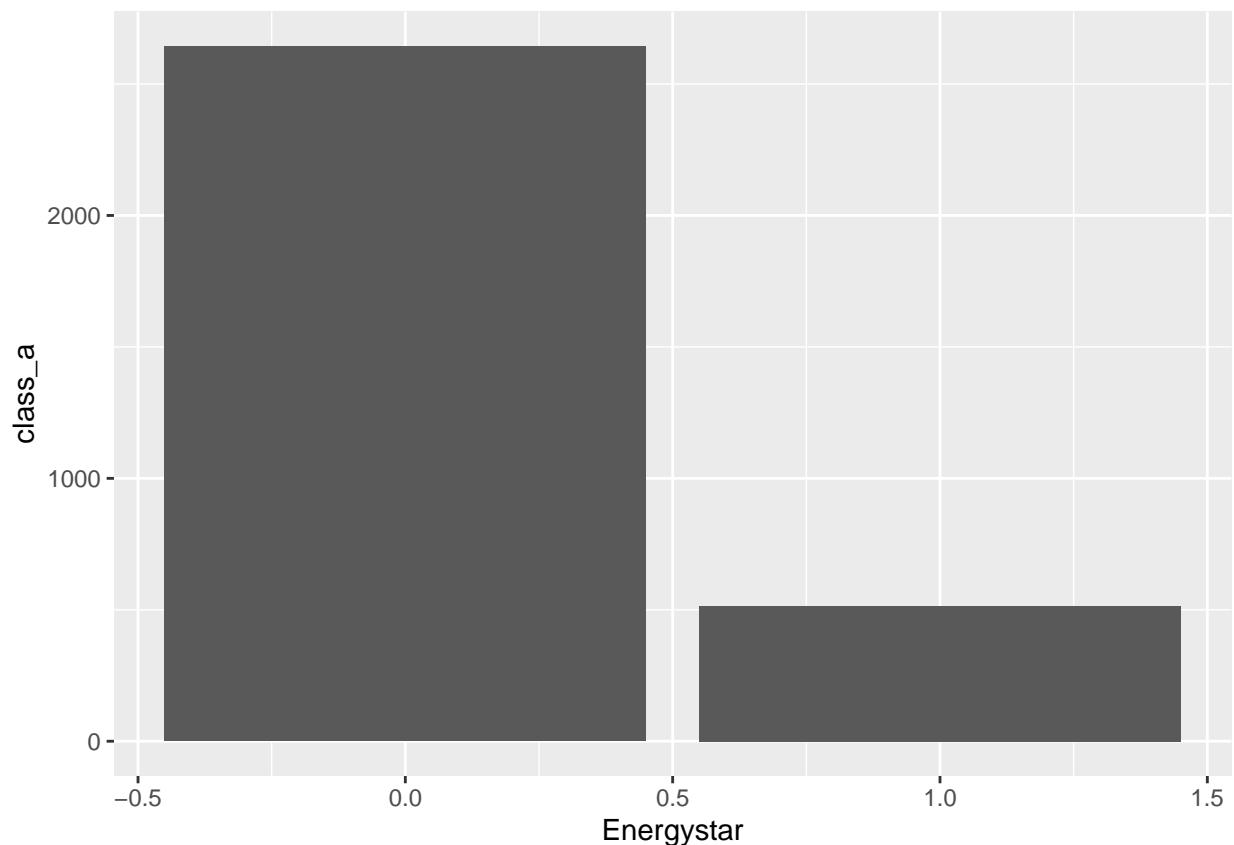
The calculation for \$5 million in extra construction costs for a green building is valid, and as we previously stated, the Median occupancy rate is 90%, therefore it is safe to take a 90% test occupancy rate for recuperation calculations. This however does not mean the recuperation calculations are accurate due to variables not accounted for such as increased amenity and electricity costs, as explained above.

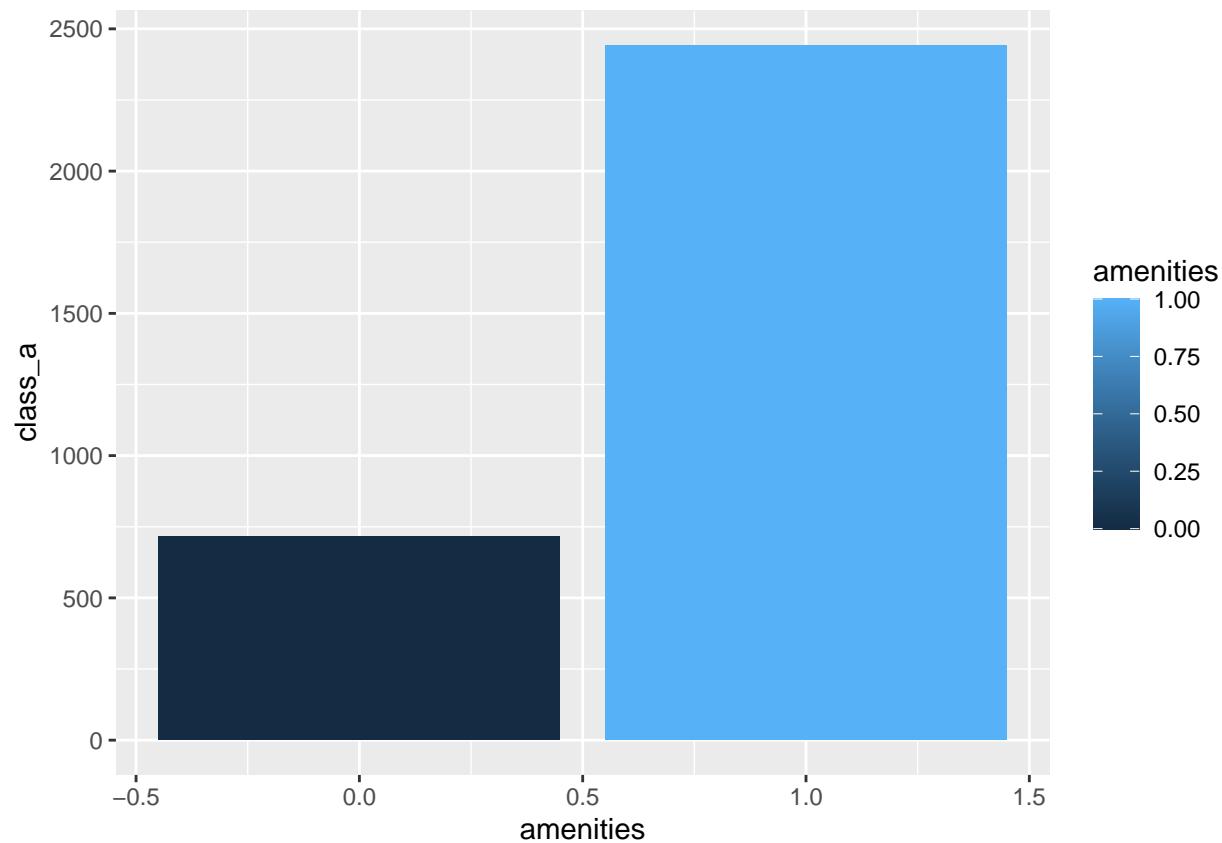
Part 5

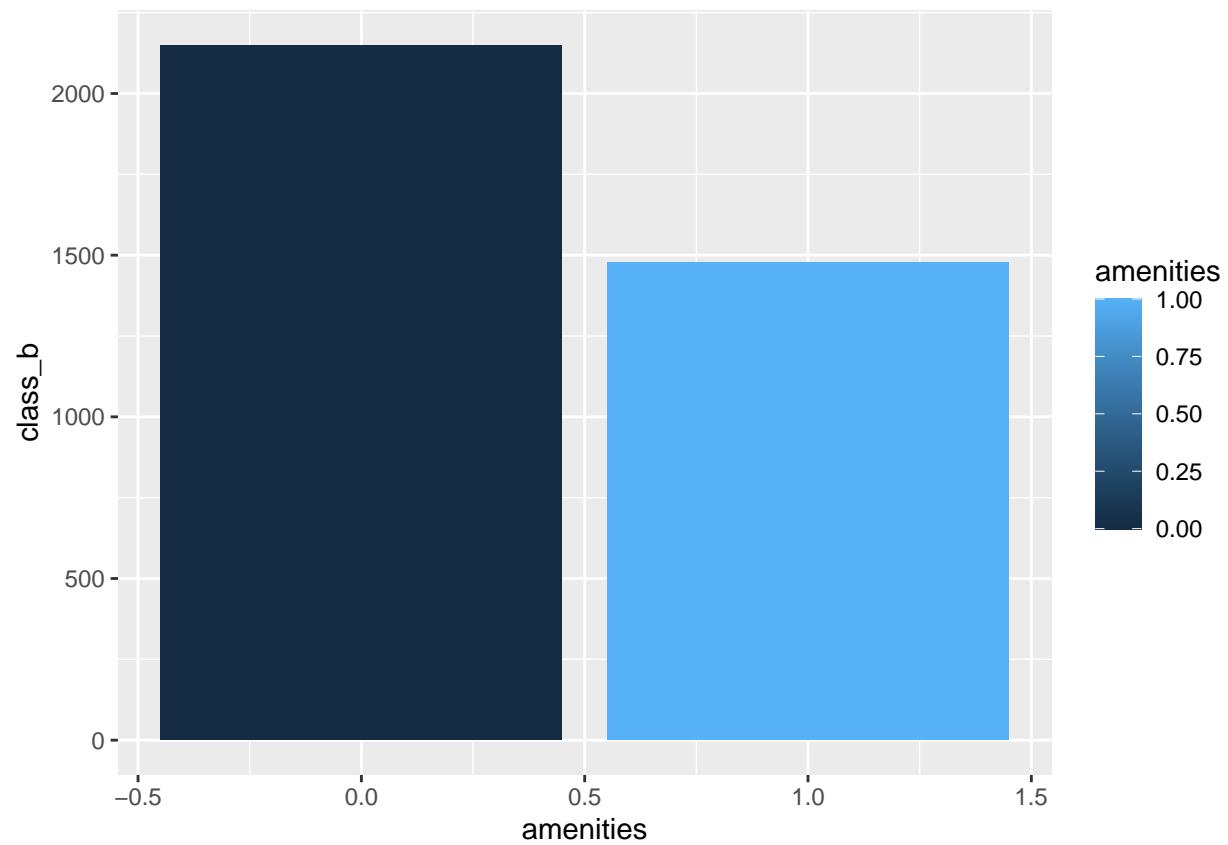


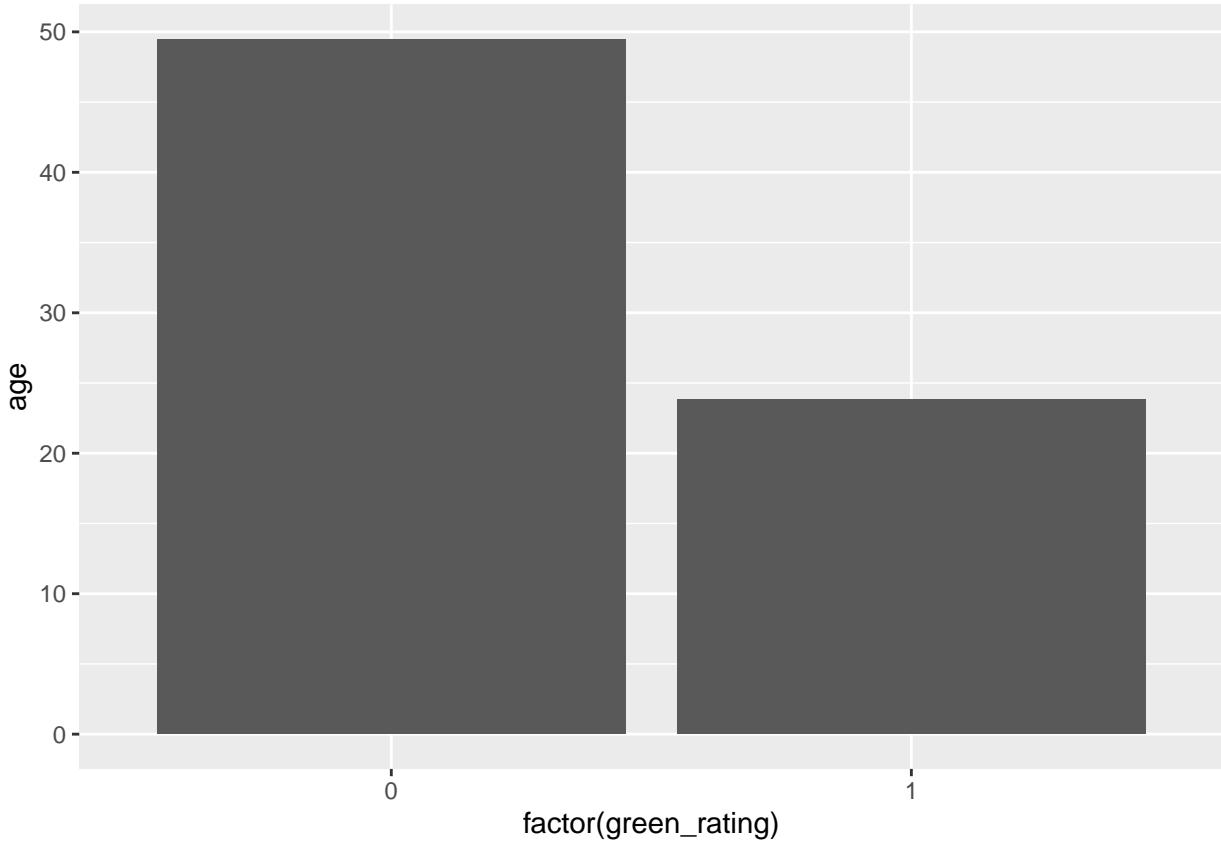
The stats guru assumes that the building will be earning rent for 30 years. This assumption is accurate since the average age for non-renovated buildings is 35. Therefore, the building will likely generate rent revenue for at least 30 years before undergoing a renovation. However, we cannot confirm that this is a financially good decision based purely on the stats guru's conclusions, due to the presence of multiple confounding variables that are unaccounted for, as depicted in part 4.

Part 6









As seen above, the rent in a green status building can also be impacted by other variables beyond its green status. For example, building class type is correlated with green status. Green status buildings are more likely to be Class A buildings, and Class A buildings tend to experience an increase in amenities. So, it could be said that beyond green status, the rent of a green building is impacted by other variables such as amenities and class type. Some other confounding variables are Age and Employment Growth.

Conclusion

For the majority of conclusions found by the stats guru, we are also unconvinced his findings are correct. The most common issue his work has is in not accounting for all variables that affect Rent. As described, we found several confounding variables in our data set that impact Rent of Green Buildings, so we know that the variables play off one another. Therefore, to create a model that accurately reflects the factors that impact the profit and financial attractiveness of this green building, all variables should be taken into account in a far deeper level than that which the stats guru attempted to do.

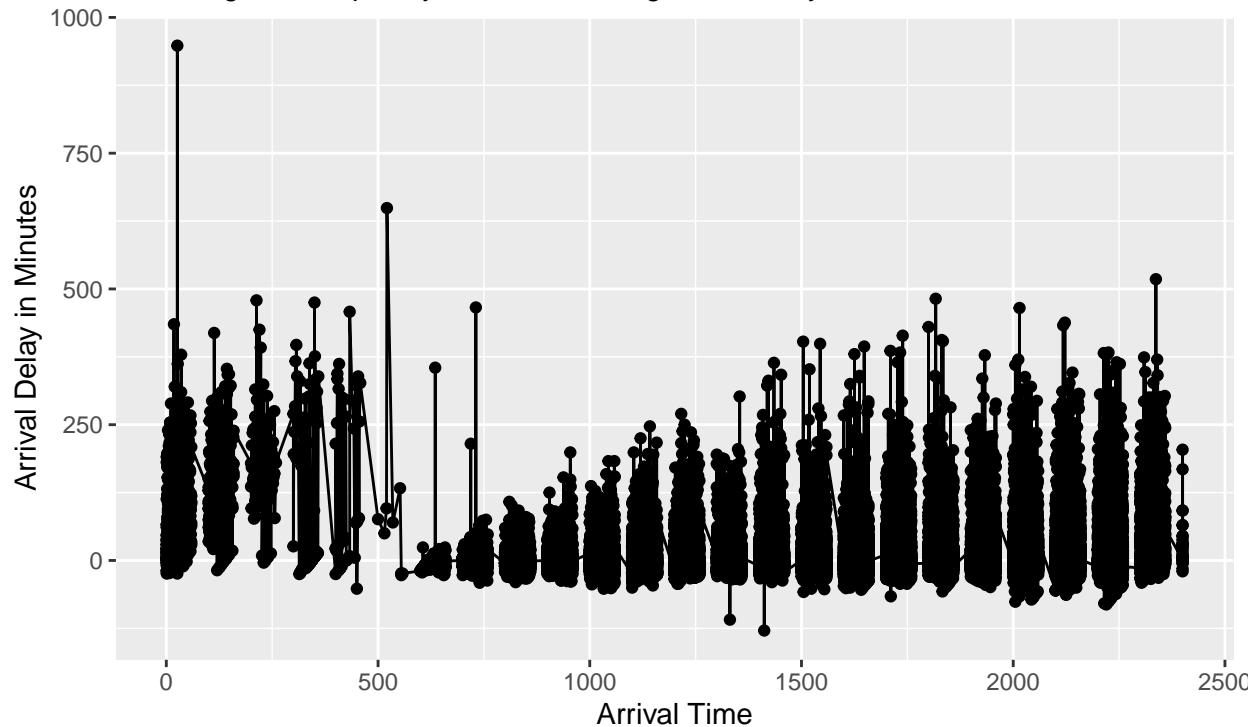
Question 2 - Flights at ABIA

The intended audience for our analysis is airport schedulers / passengers of air travel. The plots display delays by various time periods.

Part 1

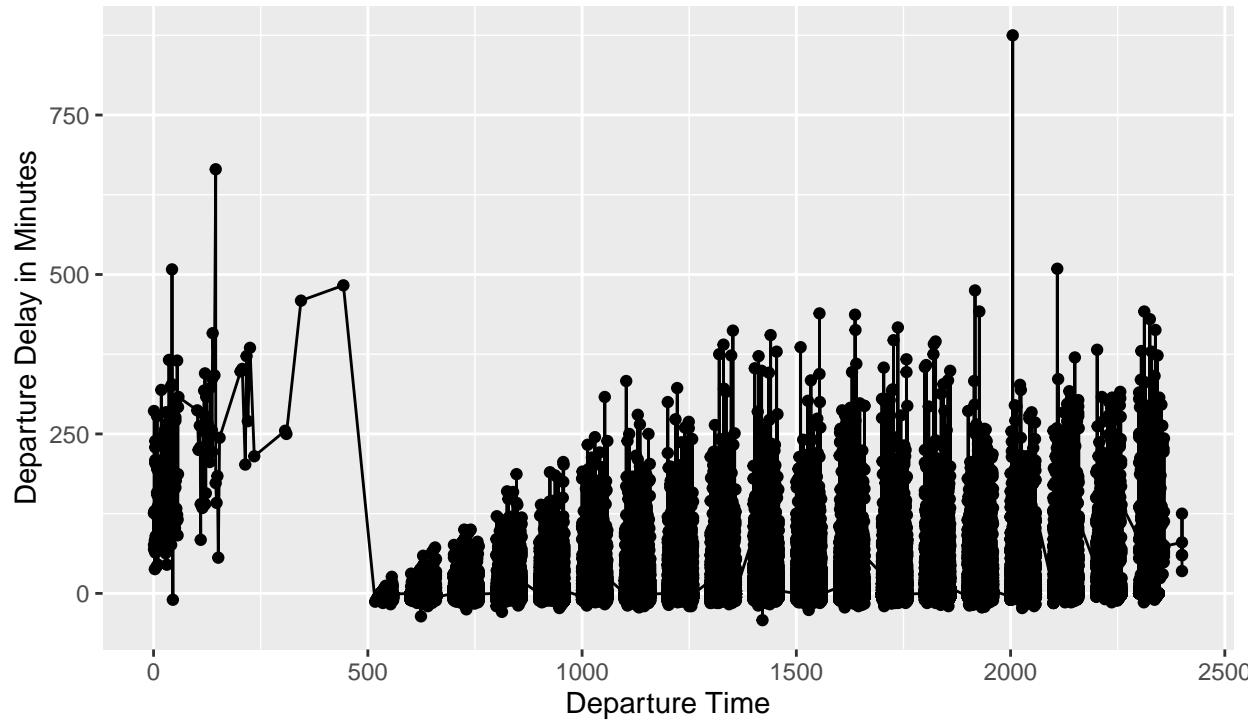
Arrival Delay for Time of Day at AUS

5–6 am has the lowest arrival delay,
and range subsequently increases throughout the day



Departure Delay for Time of Day at AUS

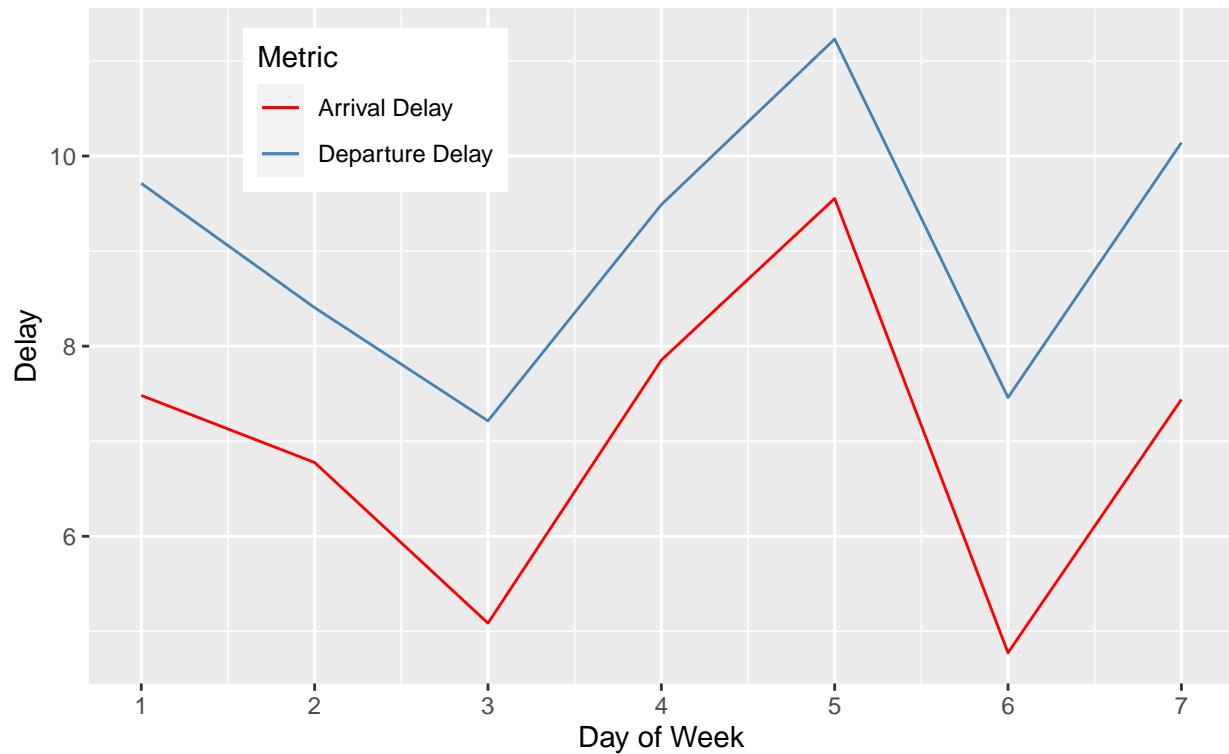
Departure delay shows a similar trend – best times are early in the morning,
and then they worsen throughout the day



Part 2

Delay by Day of Week

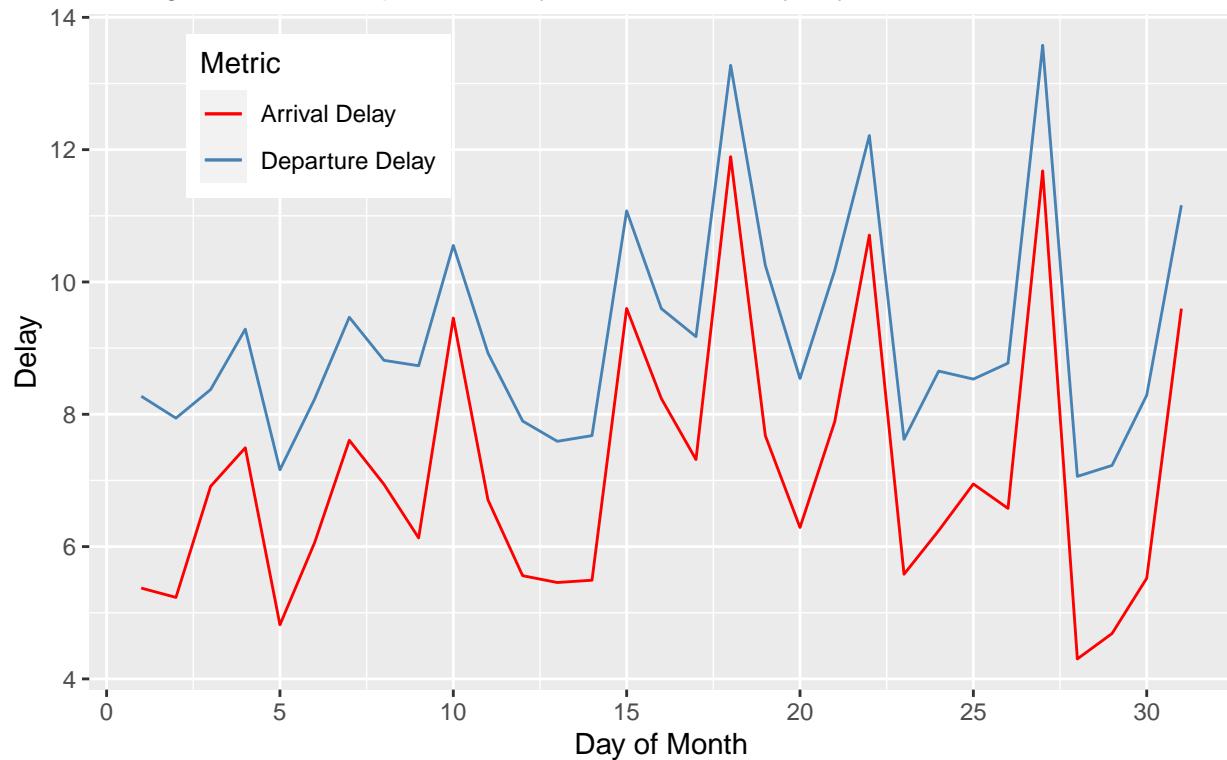
Average arrival and departure delay time in minutes by day of week



Part 3

Delay by Day of Month

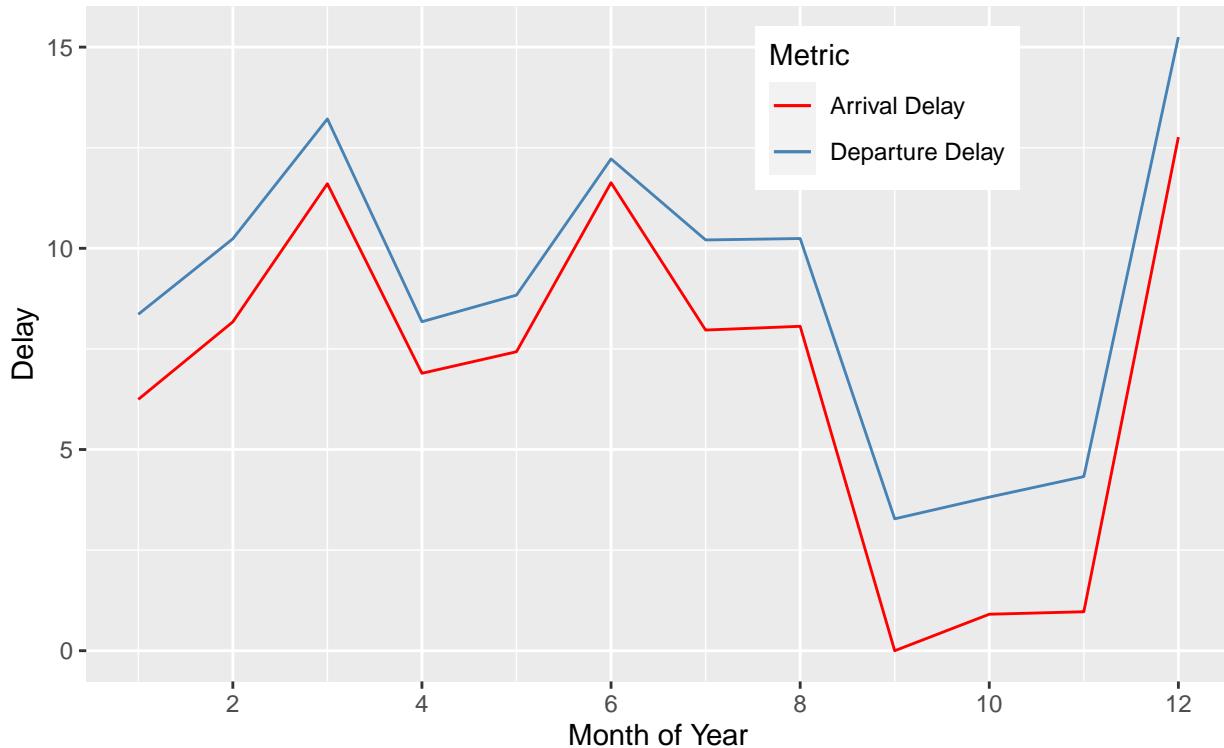
Average arrival and departure delay time in minutes by day of month



Part 4

Delay by Month of Year

Average arrival and departure delay time in minutes by month

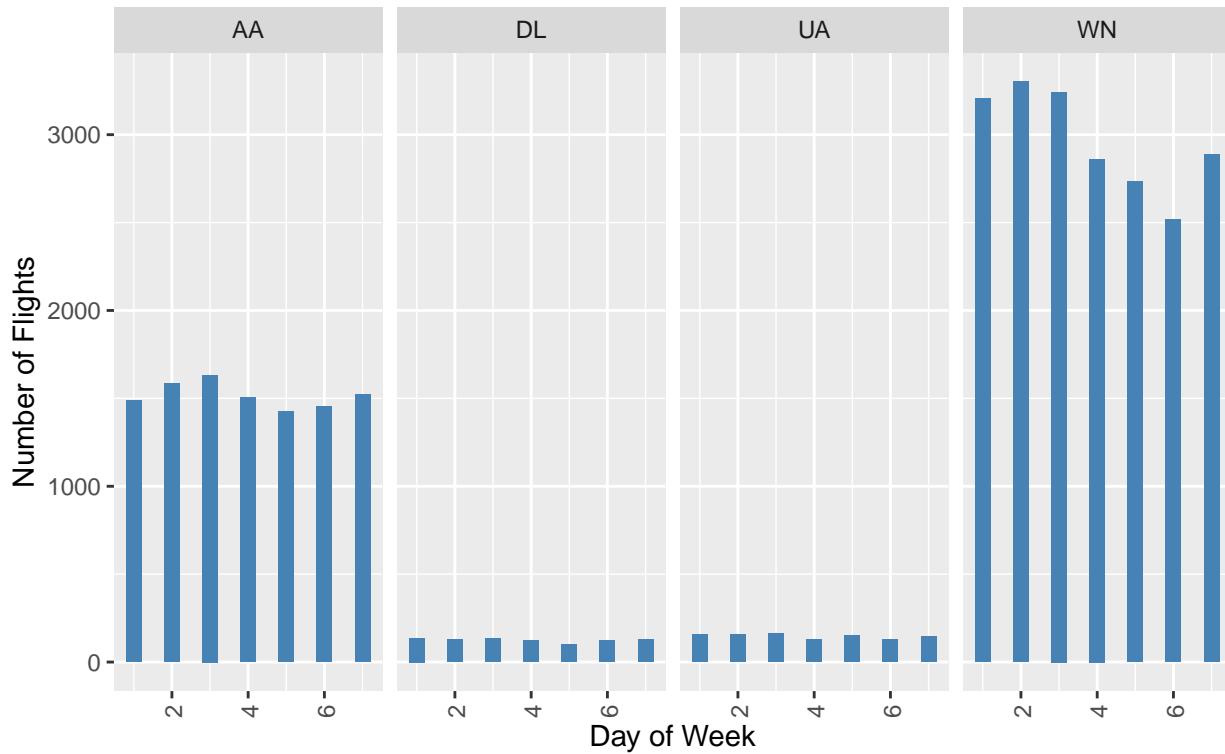


Part 5

This plot shows flights on time for the best 4 airlines, as determined by The Points Guy.

Non-delayed flights by day of week

Early or timely flights by United, Delta, American, Southwest



Question 3 - Portfolio Modelling

Here is a short description of the ETFs we chose for this model:

- Equity- Large Cap Growth - SPY
- Equity- Small Cap Growth - IWM
- Large Cap- Blend - RSP
- Bonds- UST 1-3 YR - SHY
- Hedge Fund - DBEF

Part 1

Adjusting all stocks

Part 2

Combine all the returns in a matrix

```
##          C1C1.SPYa   C1C1.IWMa   C1C1.RSPa   C1C1.SHYa   C1C1.DBxEFa
## 2015-12-01        NA         NA         NA         NA         NA
## 2015-12-02 -0.010205022 -0.010759872 -0.013179302 -0.0008276188 -0.006657358
## 2015-12-03 -0.014002772 -0.016863407 -0.014245777  0.00000000000  -0.025044127
```

```

## 2015-12-04 0.019502913 0.010120077 0.015871006 0.0002366229 0.015195370
## 2015-12-07 -0.006058530 -0.015027993 -0.008002095 -0.0001183249 -0.003207413
## 2015-12-08 -0.006719505 -0.005516757 -0.007042190 -0.0001182560 -0.018591277

```

Part 3

Calculating returns for each ETF

```

##          SPY      IWM      RSP      SHY      DBEF
## 2015-12-01 0.5921  0.2341  0.6443  0.0828 -0.0350
## 2015-12-02 -1.0205 -1.0760 -1.3179 -0.0828 -0.6657
## 2015-12-03 -1.4003 -1.6863 -1.4246  0.0000 -2.5044
## 2015-12-04  1.9503  1.0120  1.5871  0.0237  1.5195
## 2015-12-07 -0.6059 -1.5028 -0.8002 -0.0118 -0.3207
## 2015-12-08 -0.6720 -0.5517 -0.7042 -0.0118 -1.8591
## 2015-12-09 -0.7780 -1.1181 -0.6963  0.0355 -1.2750
## 2015-12-10  0.2581  0.3331  0.1428 -0.0591  0.1845
## 2015-12-11 -1.9381 -2.2278 -1.9450  0.1184 -1.9889
## 2015-12-14  0.5052 -0.7149  0.1455 -0.1182  0.2631

##          SPY      IWM      RSP      SHY      DBEF
## SPY    1.0000000 0.8779136 0.9569717 -0.3188806 0.8802487
## IWM    0.8779136 1.0000000 0.9254979 -0.2865132 0.8175091
## RSP    0.9569717 0.9254979 1.0000000 -0.3151058 0.8760220
## SHY   -0.3188806 -0.2865132 -0.3151058 1.0000000 -0.3790187
## DBEF   0.8802487 0.8175091 0.8760220 -0.3790187 1.0000000

```

Now, let's figure out how to set their weights accordingly. For this, we calculate the daily returns for each ETF and find their the median and standard deviation to understand their mean returns and volatility.

Part 4

Getting the median return and volatility for each ETF

```

##          SPY      IWM      RSP      SHY      DBEF
## mean     0.0669  0.0588  0.0614  0.0060  0.0394
## sd       1.1522  1.4543  1.2477  0.0621  1.1162
## median   0.0767  0.1066  0.0830  0.0000  0.1125
## min     -10.9424 -13.2669 -12.0415 -0.4384 -10.6925
## max      9.0603  9.1491  10.6754  0.5452  7.1341

```

As is visible from the above table, IWM has the highest volatility, followed by DBEF, RSP, SPY and finally SHY. This is congruent with our ETF behaviors so far. The median value for DBEF is the highest, followed by IWM, RSP, SPY and SHY.

Part 5 - Modelling the Portfolios

Portfolio 1 - Aggressive portfolio

Profit/loss

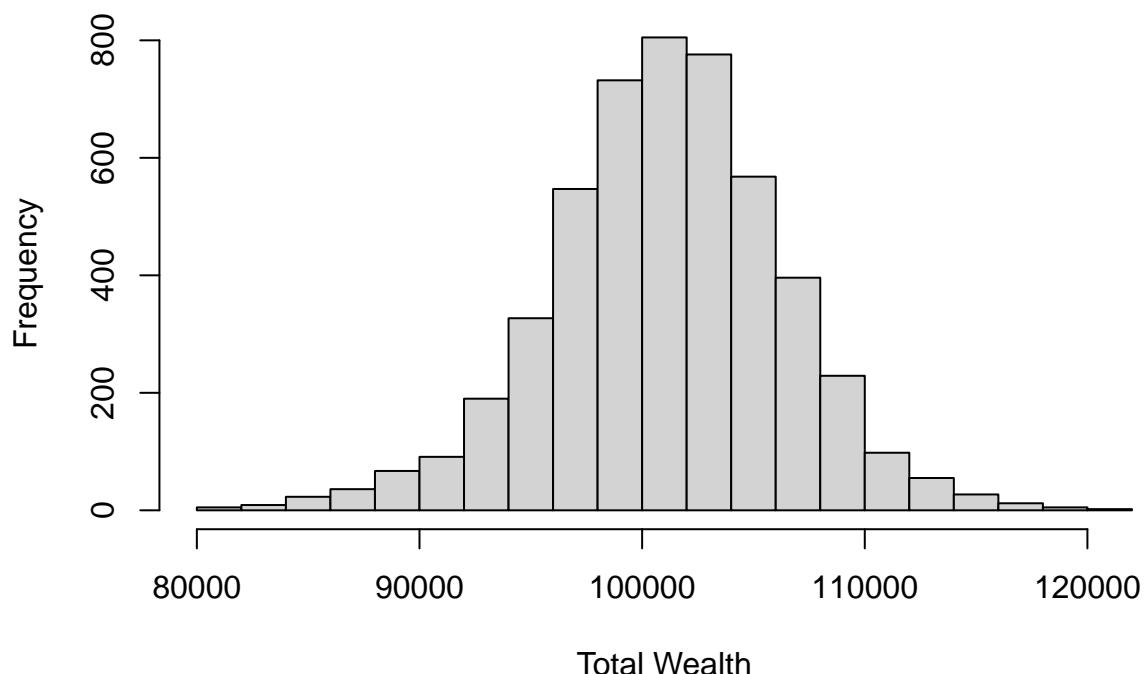
```
## [1] 101078.3
```

```
## [1] 1078.317
```

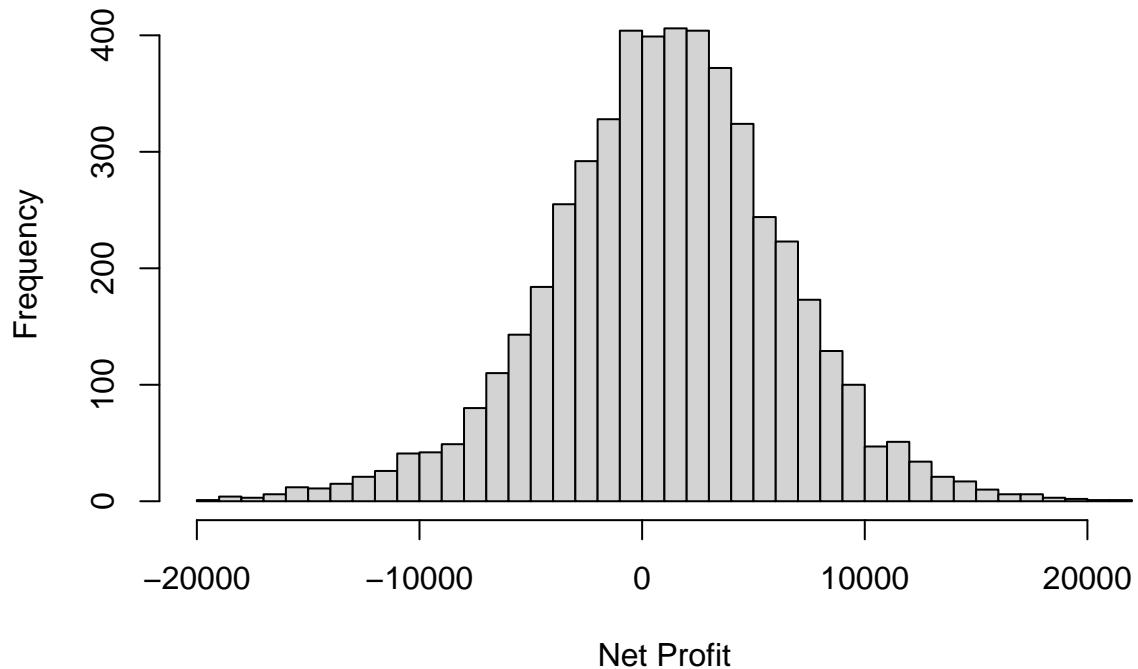
5% value at risk:

```
##      5%
## 7741.783
```

Histogram of Total Wealth Plot



Histogram of Net Profit



Portfolio 2 - Balanced

Profit/loss

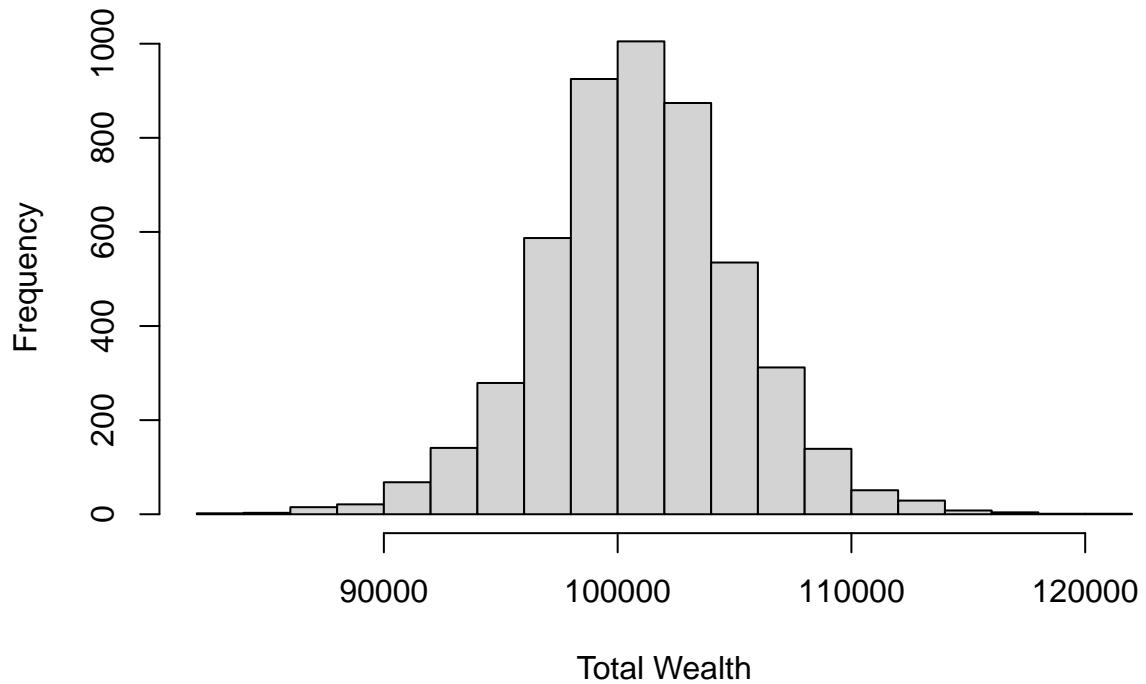
```
## [1] 100956.1
```

```
## [1] 956.0512
```

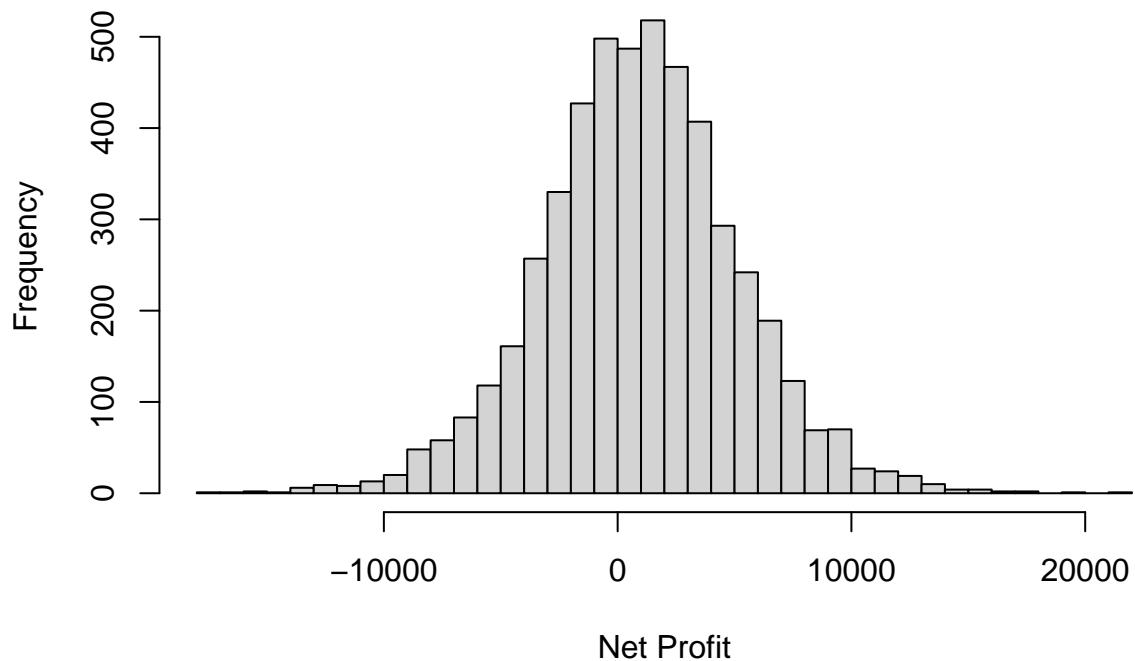
5% value at risk

```
##      5%
## 5995.7
```

Total Wealth Plot



Histogram of Net Profit



Portfolio 3 - Safe

Profit/loss

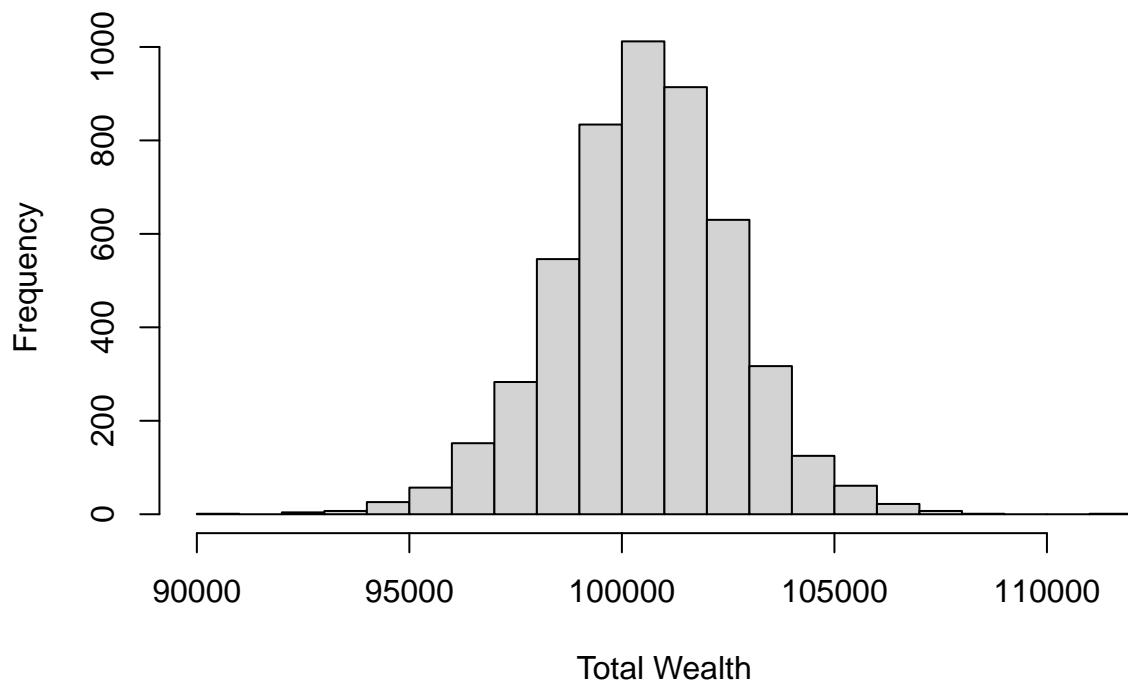
```
## [1] 100541
```

```
## [1] 541.0138
```

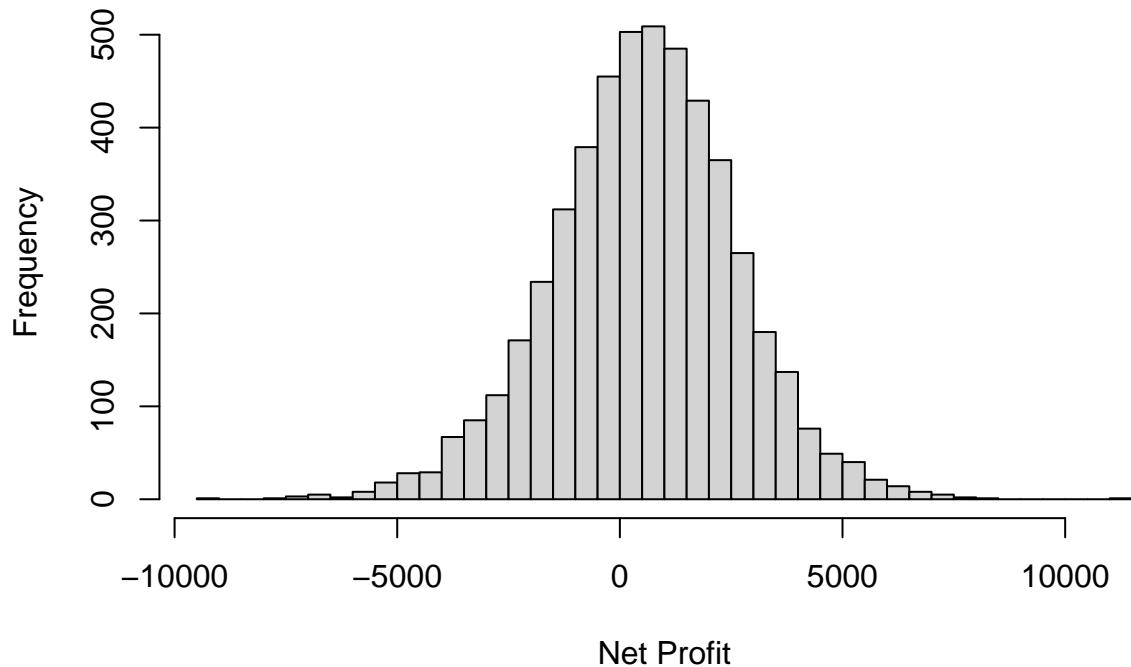
5% value at risk

```
##      5%
## 2991.321
```

Total Wealth Plot



Histogram of Net Profit



Conclusion

- Aggressive Portfolio:
In creating our aggressive portfolio, we avoided the UST Bond completely as we selected this knowing it has a lower expected return and risk. We did so to create a balance of risk, but as this is an aggressive approach, we aren't concerned with that here. But as to how we would weigh our Equity ETFs and Hedge fund ETF, we tested the standard deviation and median return for all our ETFs and then allocated the weight accordingly based on those metrics. We found the Hedge fund to have the lowest risk while also having the highest expected return, so we valued 'DBEF' at 35%. The next most efficient stock was IWM and we placed a 30% weight there. 'SPY' and 'RSP' were about equal in terms of both risk and reward, so we gave each of those the remaining 17.5%.
- Balanced Portfolio:
We created a balanced portfolio and weighted each ETF equally at 20%. We found a profit of about \$950 and a 5% VaR 6400. We did this in hope of getting baseline values and then being able to compare our safe and aggressive combinations.
- Safe Portfolio:
We purposefully selected a UST Government Bond for our portfolio as those bonds are known to be “risk-free”, so when creating our Safe portfolio we assumed this would garner a large portion of the weight. To test this, we obtained the standard deviation and median return for all of our ETFs and then allocated the weight accordingly based on those metrics. Our portfolio is comprised of a combination of Small & Large Cap Growth Equities, a Value Equity fund, a Hedge Fund, and lastly the UST Government Bond. As we expected, the standard deviation and expected return was considerably less for the UST Bond than compared with the others so we placed 60% of our weight here. All the others

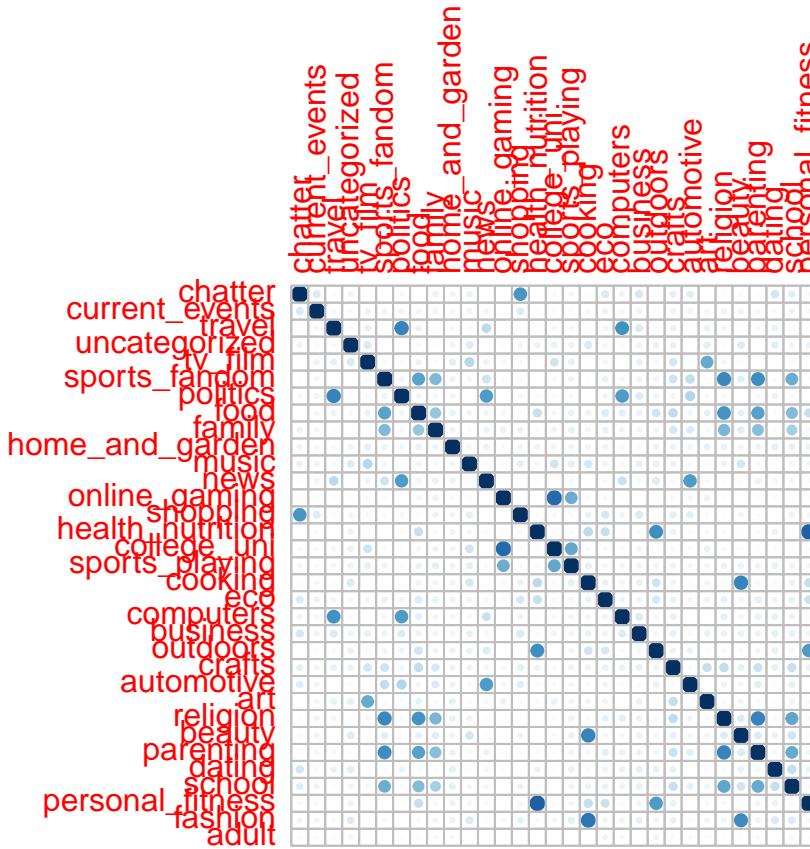
had ranges similar to one another so in still wanting to be profitable we gave each Equity fund and the Hedge fund 10%. This portfolio combination had about \$540 profit and our lowest 5% VaR of 2900.

Question 4 - Market Segmentation

Part 1

Removing unwanted columns and scaling the data

Part 2



Plotting the correlation between variables

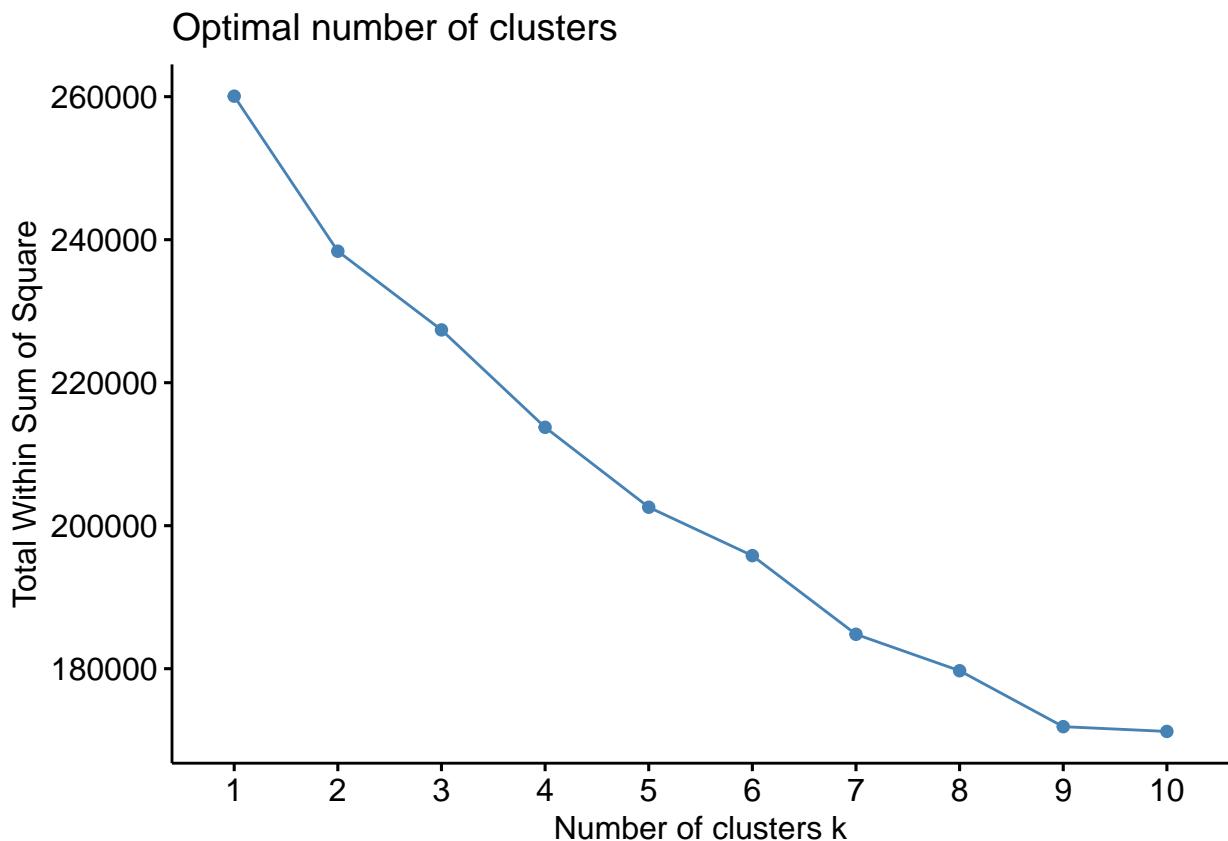
As is visible from this correlation plot, a lot of variables in this dataset are highly correlated. Certain examples of this are:

- Politics and travel
- Parenting and sports
- Health nutrition and Personal fitness

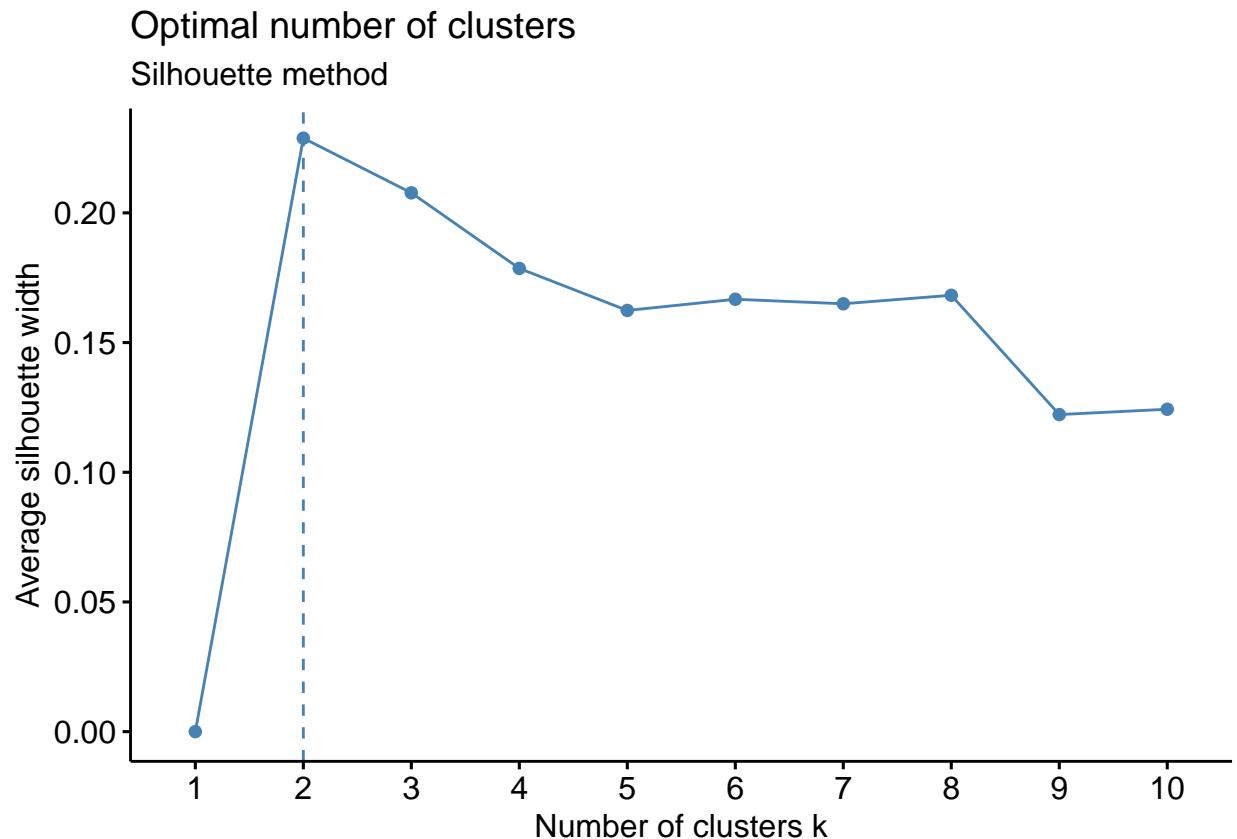
Part 3

Determining the optimum number of clusters

Elbow method

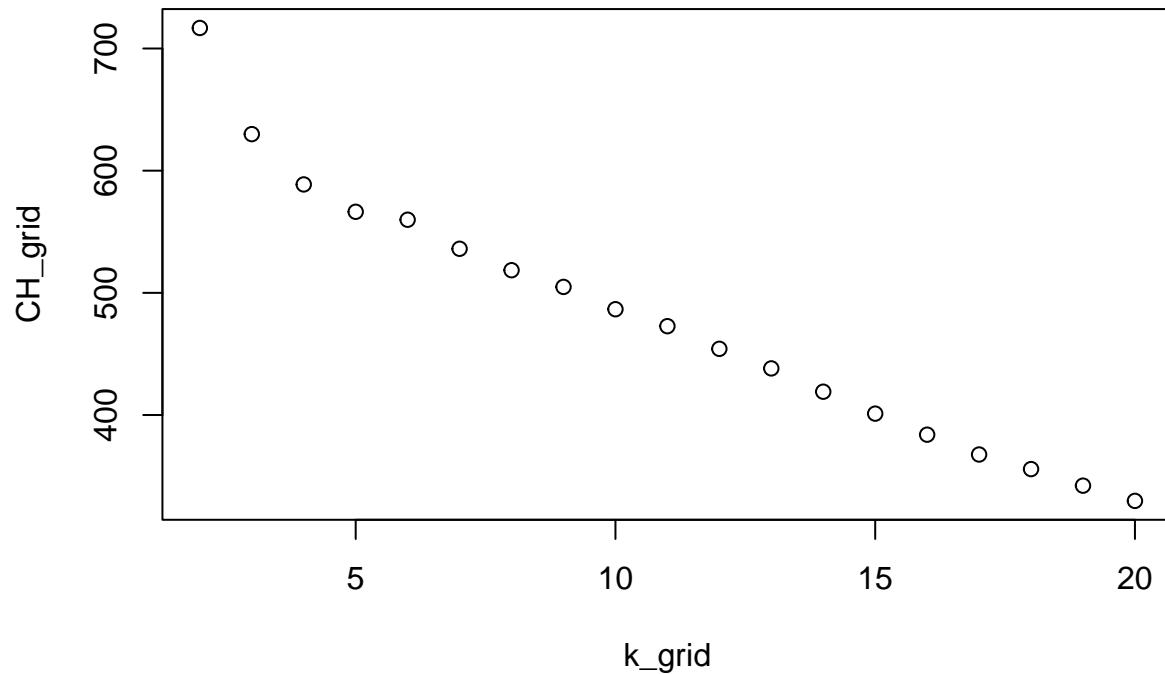


Silhouette method



This plot shows optimum number of clusters at 2, but intuitively it seems too less. The silhouette width tends to stabilize at $k=5$, before further reducing at $k=8$.

CH method



The first dip appears to be at $k=2$, thereby again giving us 2 optimal clusters.

Part 4

Principal Component Analysis

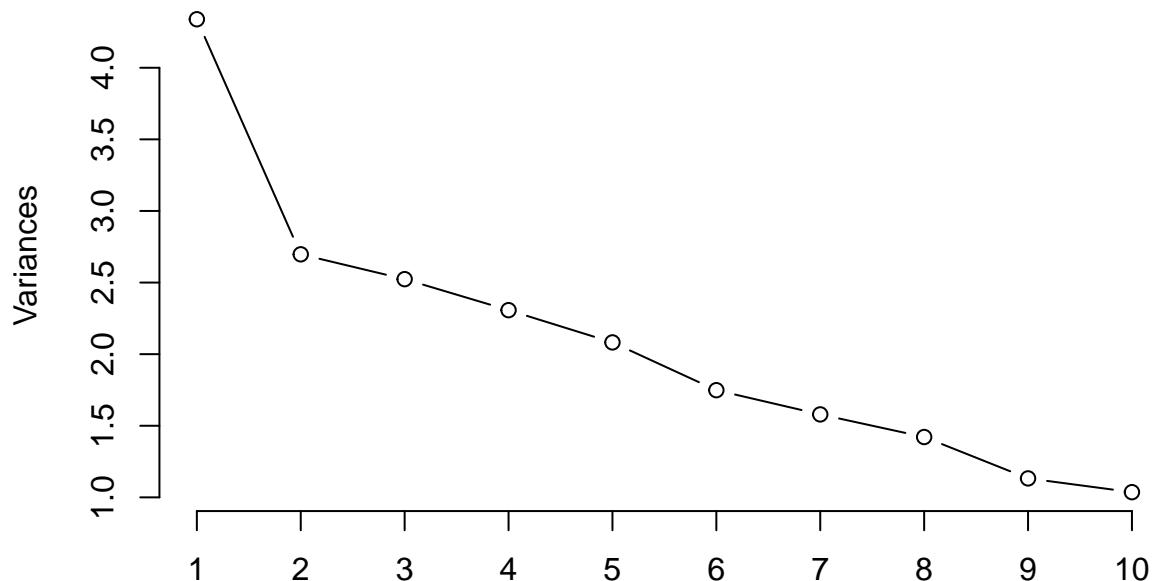
We run PCA to reduce the number of correlated variables. This will allow us to segment the data into the appropriate categories later on.

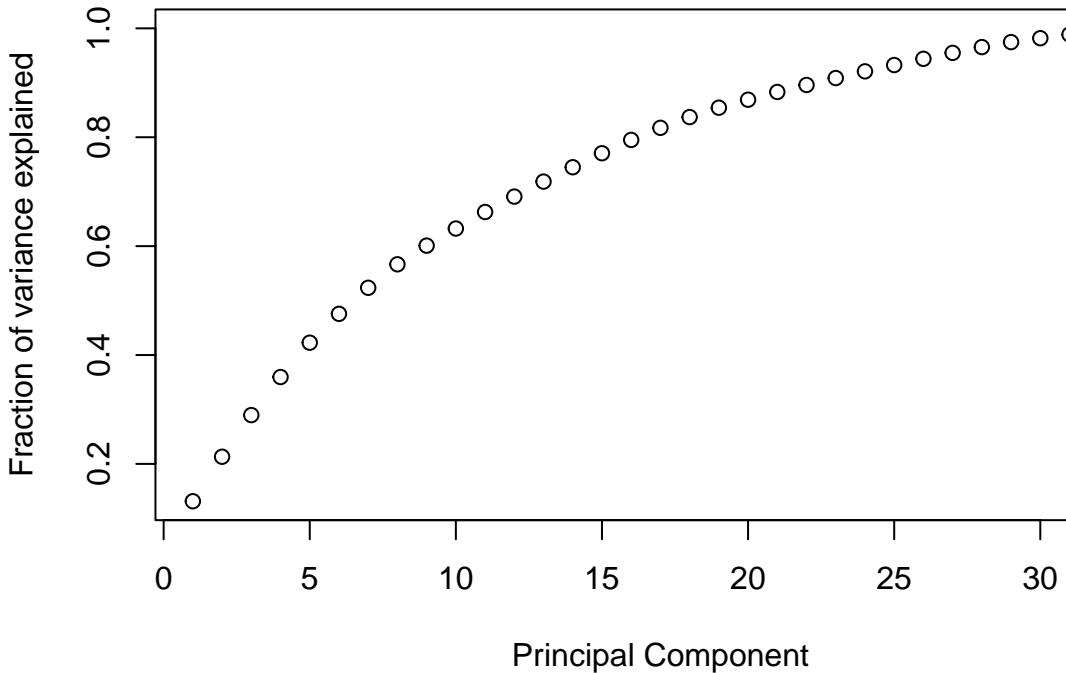
Generating the PCA

```
## Importance of components:  
##          PC1      PC2      PC3      PC4      PC5      PC6      PC7  
## Standard deviation 2.0829 1.64230 1.58865 1.51896 1.44293 1.32230 1.25674  
## Proportion of Variance 0.1315 0.08173 0.07648 0.06992 0.06309 0.05298 0.04786  
## Cumulative Proportion 0.1315 0.21320 0.28968 0.35960 0.42269 0.47568 0.52354  
##          PC8      PC9      PC10     PC11     PC12     PC13     PC14  
## Standard deviation 1.19226 1.06418 1.01806 1.00121 0.96569 0.95422 0.93249  
## Proportion of Variance 0.04308 0.03432 0.03141 0.03038 0.02826 0.02759 0.02635  
## Cumulative Proportion 0.56661 0.60093 0.63234 0.66271 0.69097 0.71857 0.74492  
##          PC15     PC16     PC17     PC18     PC19     PC20     PC21  
## Standard deviation 0.92140 0.89865 0.85510 0.80800 0.75311 0.69629 0.68531  
## Proportion of Variance 0.02573 0.02447 0.02216 0.01978 0.01719 0.01469 0.01423  
## Cumulative Proportion 0.77064 0.79511 0.81727 0.83705 0.85424 0.86893 0.88317  
##          PC22     PC23     PC24     PC25     PC26     PC27     PC28
```

```
## Standard deviation      0.65218 0.64662 0.63668 0.61925 0.61465 0.59863 0.59287
## Proportion of Variance 0.01289 0.01267 0.01228 0.01162 0.01145 0.01086 0.01065
## Cumulative Proportion  0.89605 0.90872 0.92101 0.93263 0.94408 0.95494 0.96559
##                           PC29    PC30    PC31    PC32    PC33
## Standard deviation      0.54993 0.48486 0.4771  0.43832 0.4223
## Proportion of Variance 0.00916 0.00712 0.0069  0.00582 0.0054
## Cumulative Proportion  0.97475 0.98188 0.9888  0.99460 1.0000
```

scaled_pca





Calculating cumulative variance

```
## [1] 0.6323374
```

By the Kaiser criterion, we should drop all principal components with eigen values < 1.

Generating PCA data

```
##
## Loadings:
##          PC1    PC2    PC3    PC4    PC5    PC6    PC7    PC8    PC9
## chatter           0.608   -0.186
## current_events      0.280   0.120
## travel            -0.595
## uncategorized           -0.315
## tv_film           0.547
## sports_fandom     -0.431   -0.145
## politics           0.494   -0.276
## food              -0.395   0.142
## family             -0.330
## home_and_garden        0.130  -0.101  -0.289
## music               0.148
## news               -0.111   -0.629
## online_gaming        0.620
## shopping            0.635
## health_nutrition    0.588
## college_uni          0.598
## sports_playing        0.499
```

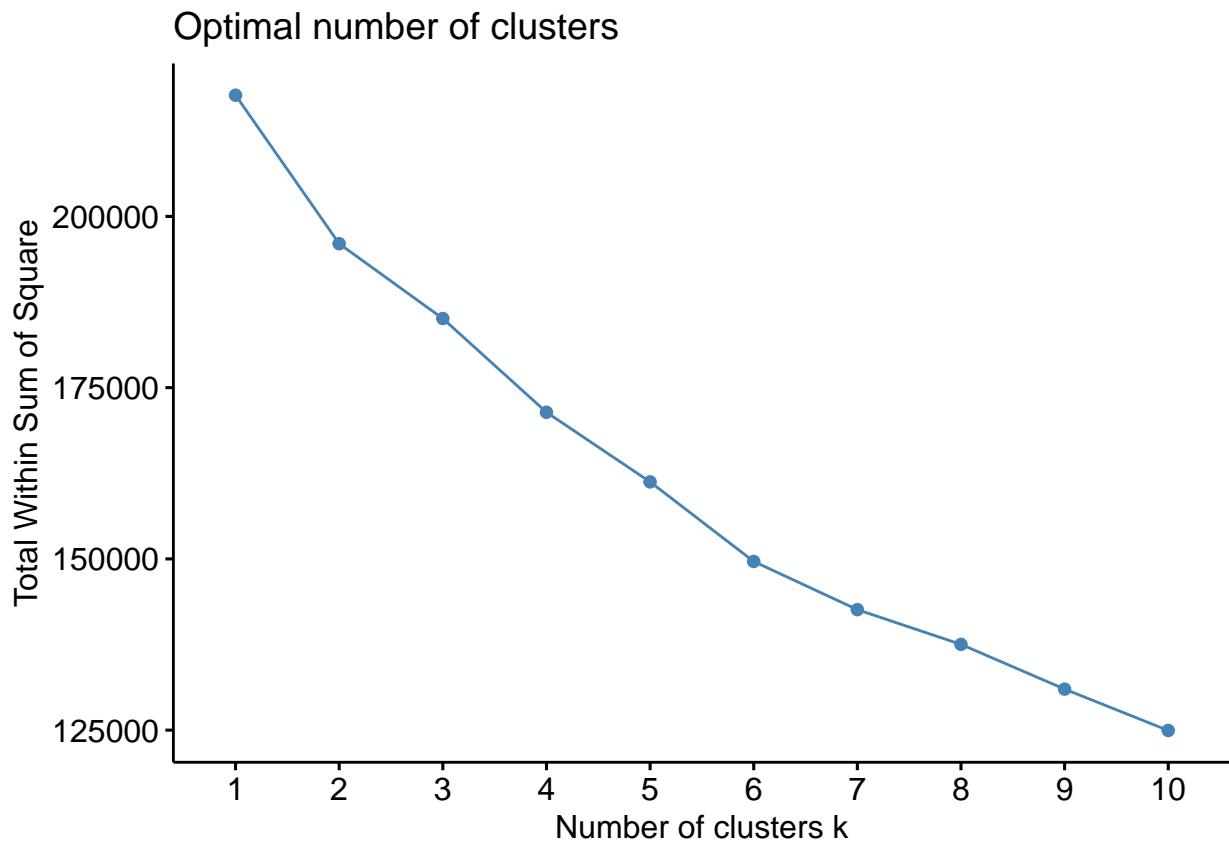
## cooking	0.112	-0.582
## eco	0.179	0.258
## computers	-0.574	
## business	-0.151	0.180
## outdoors	0.493	-0.115
## crafts	-0.108	0.378
## automotive	0.133	-0.666
## art		0.703
## religion	-0.462	
## beauty		-0.560
## parenting	-0.437	
## dating		-0.764
## school	-0.327	-0.308
## personal_fitness	0.571	
## fashion		-0.574
## adult		
##	PC10 PC11	
## chatter		
## current_events		
## travel		
## uncategorized	-0.477	
## tv_film	-0.337	
## sports_fandom		
## politics		
## food		
## family		
## home_and_garden	-0.168	
## music	-0.751	
## news		
## online_gaming	0.114	
## shopping		
## health_nutrition		
## college_uni	-0.108	
## sports_playing		
## cooking		
## eco	-0.235	
## computers		
## business	0.229 -0.126	
## outdoors		
## crafts	0.130	
## automotive		
## art	0.105	
## religion		
## beauty		
## parenting		
## dating	0.114	
## school		
## personal_fitness		
## fashion		
## adult	-0.895	
##		
##	PC1 PC2 PC3 PC4 PC5 PC6 PC7 PC8 PC9 PC10 PC11	
## SS loadings	1.00 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	
## Proportion Var	0.03 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.030	

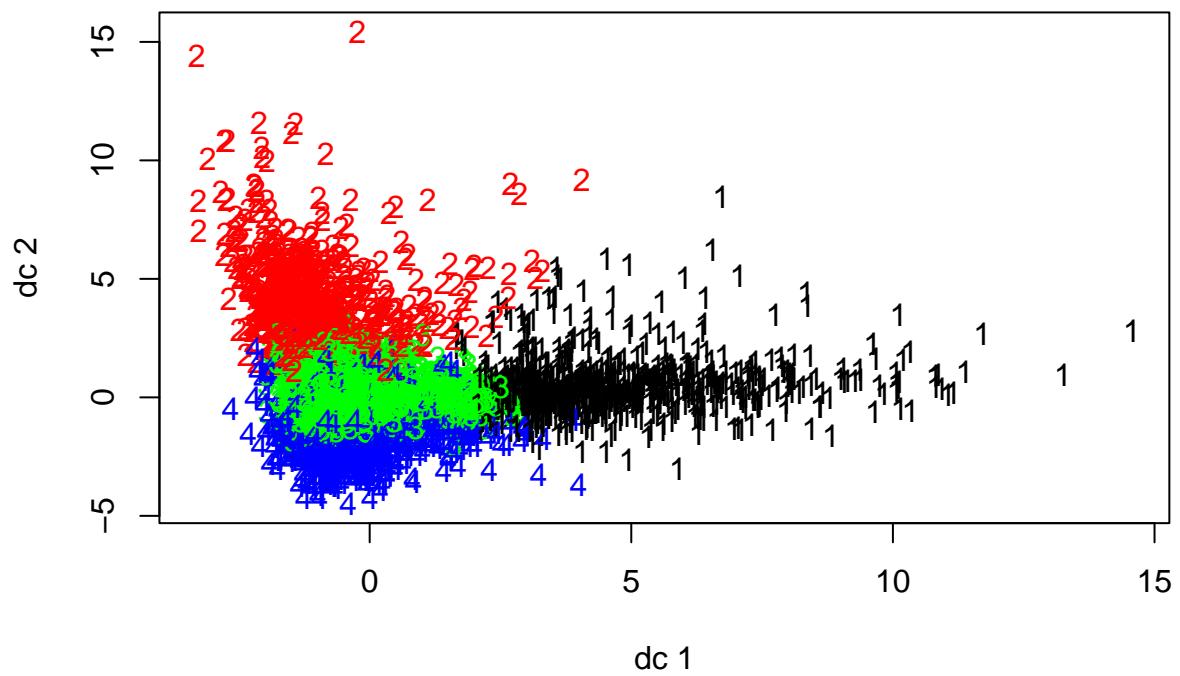
```
## Cumulative Var 0.03 0.061 0.091 0.121 0.152 0.182 0.212 0.242 0.273 0.303 0.333
```

Part 5

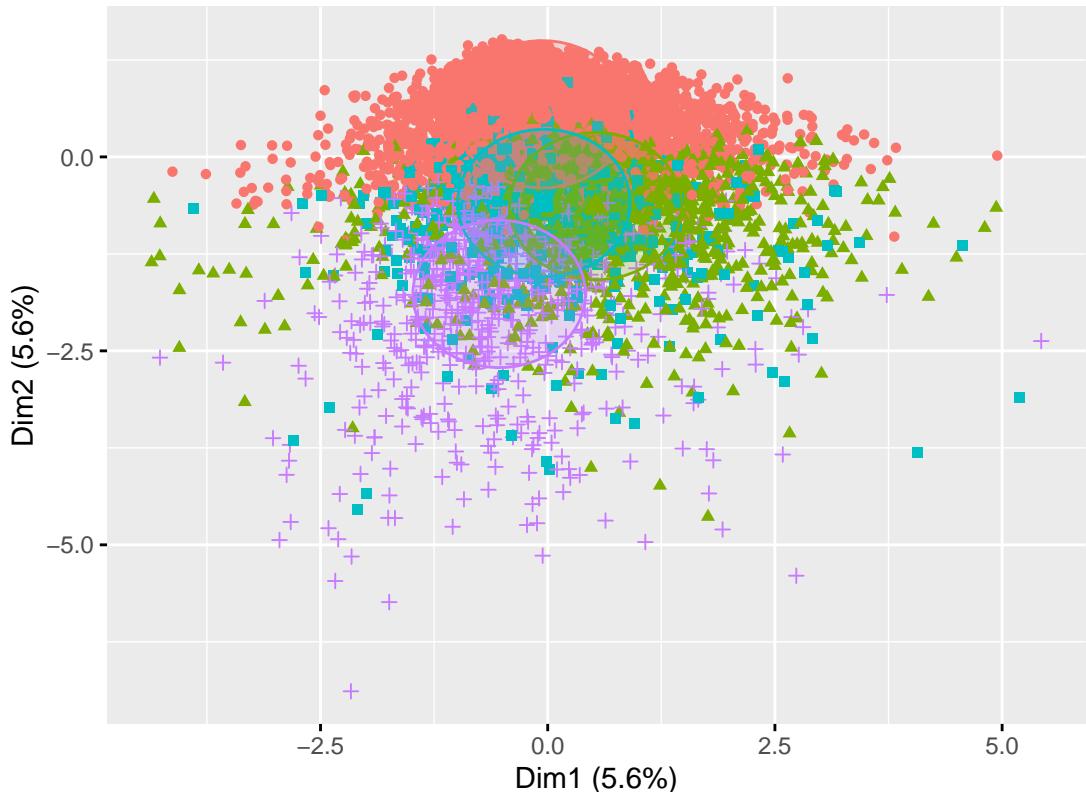
K means clustering

After running PCA and identifying various plots, we chose to proceed with k-means clustering method using 4 clusters and 25 starts. This is because 4 segments were found to be the most practical in terms of data interpretability and prevented any significant overlap of cluster data.





Cluster plot



Re visualizing the same plot

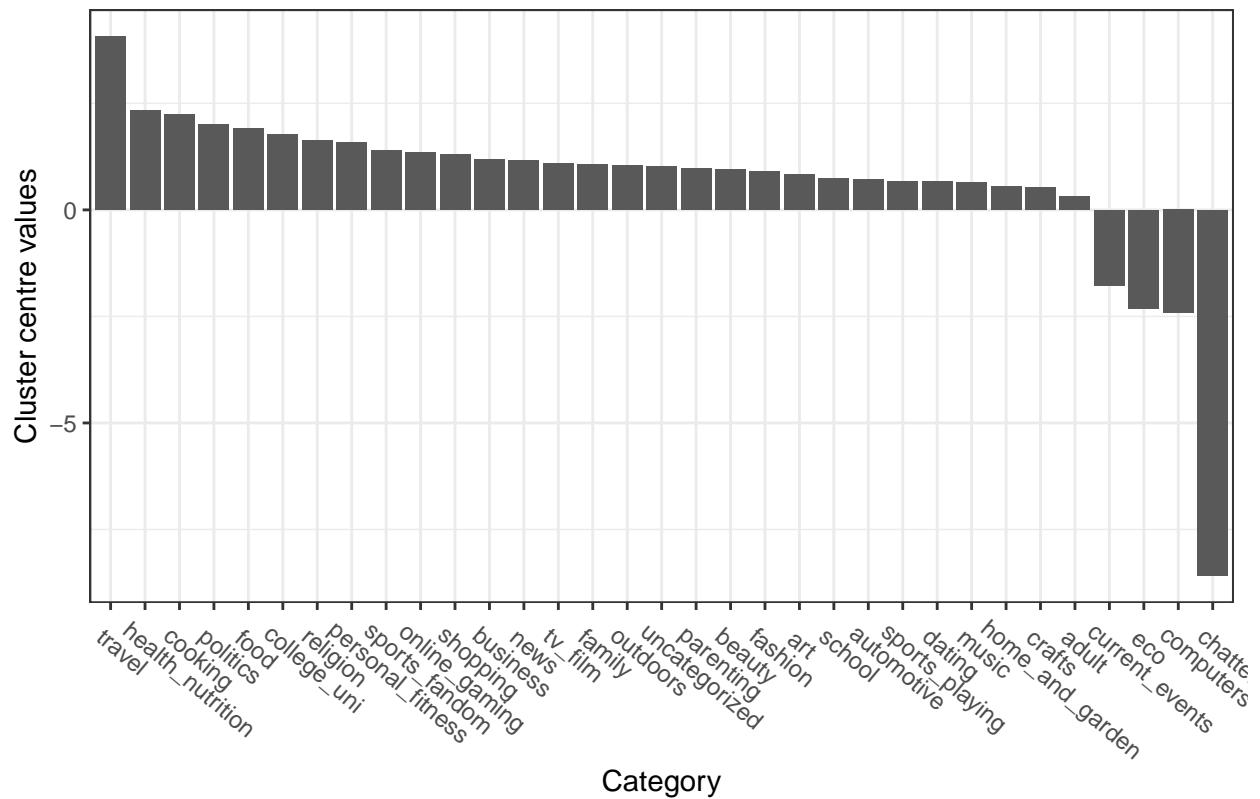
Plotting the clusters

Calculatig mu and sigma

```
##      Cluster_1      Cluster_2      Cluster_3      Cluster_4
##  Min.   :-8.5850  Min.   :-6.7400  Min.   :0.3580  Min.   :-0.5059
##  1st Qu.: 0.6585  1st Qu.: 0.3261  1st Qu.:0.7029  1st Qu.: 0.6532
##  Median : 1.0128  Median : 0.7025  Median :1.0468  Median : 1.0088
##  Mean   : 0.6524  Mean   : 0.4617  Mean   :1.3363  Mean   : 1.1833
##  3rd Qu.: 1.4036  3rd Qu.: 1.1731  3rd Qu.:1.4327  3rd Qu.: 1.3938
##  Max.   : 4.0641  Max.   : 2.5705  Max.   :8.4380  Max.   : 4.4016
##      type
##  Length:33
##  Class :character
##  Mode  :character
## 
## 
```

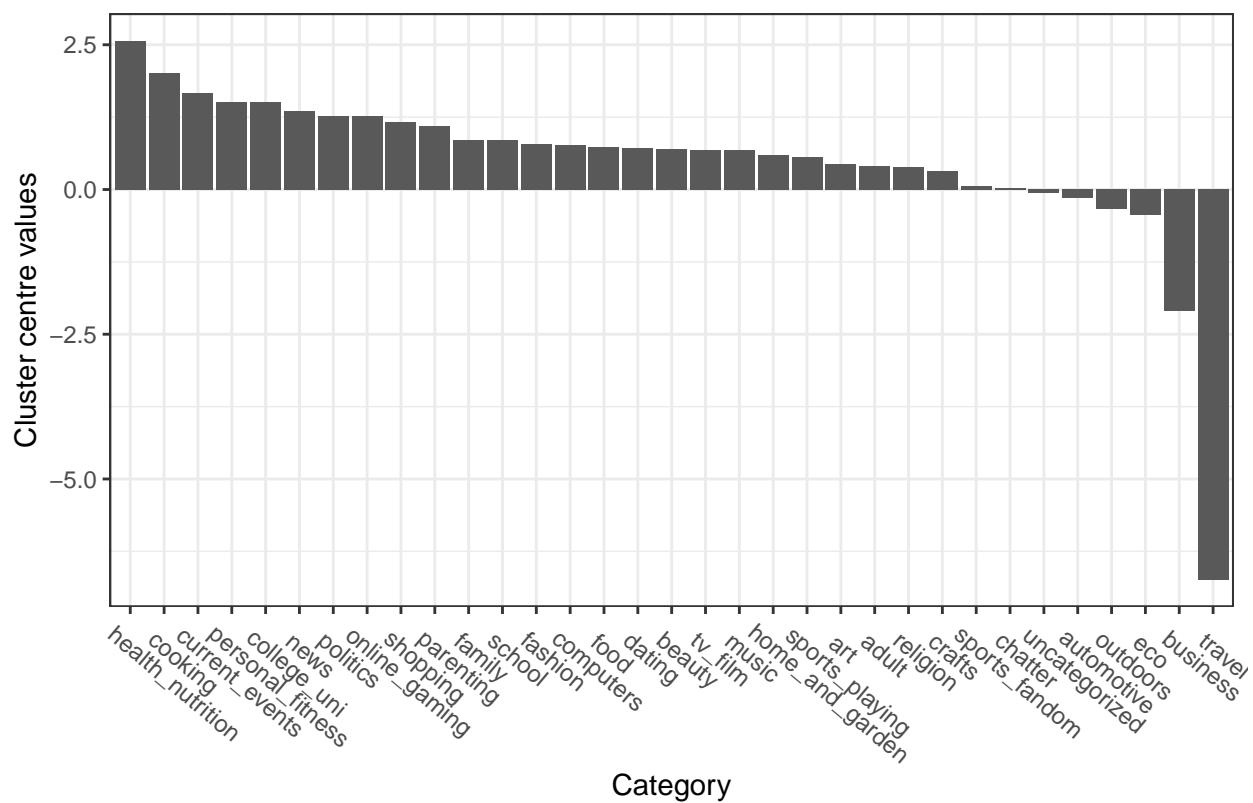
Cluster 1

Cluster 1



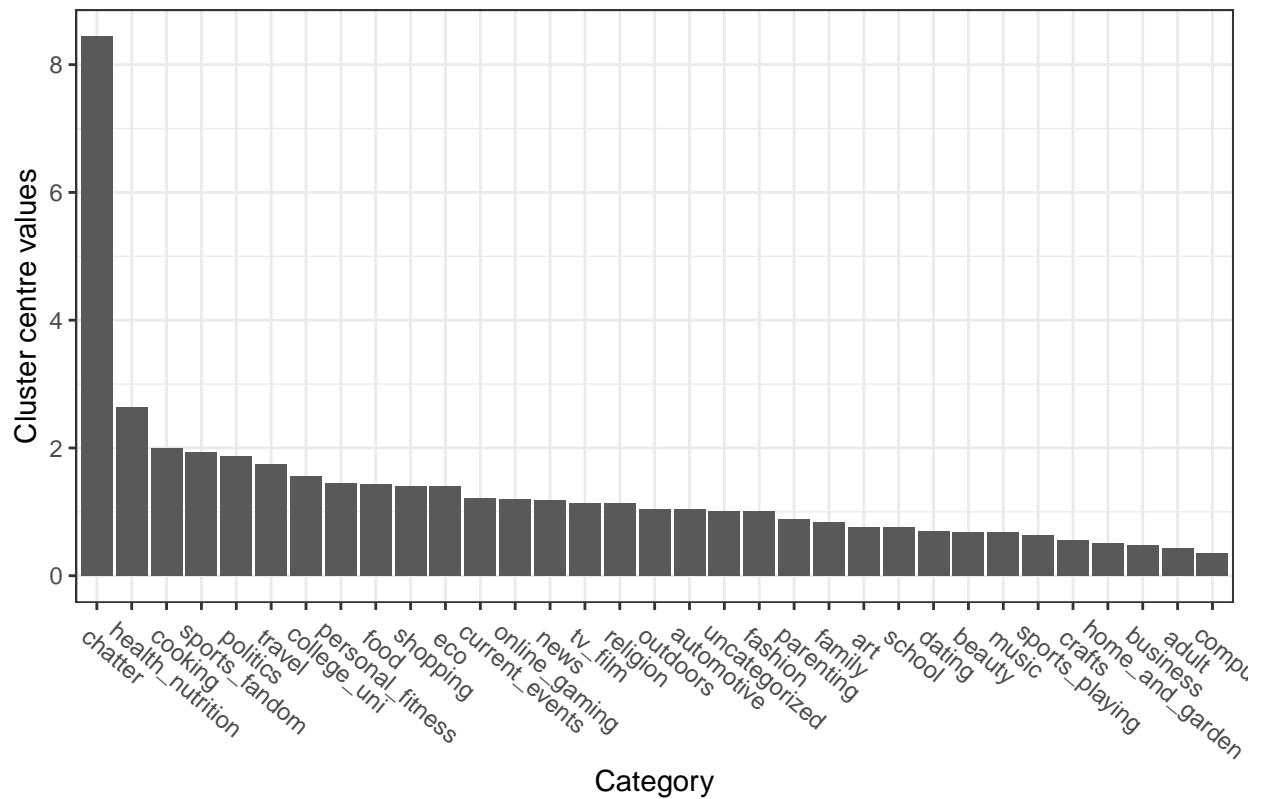
Cluster 2

Cluster 2



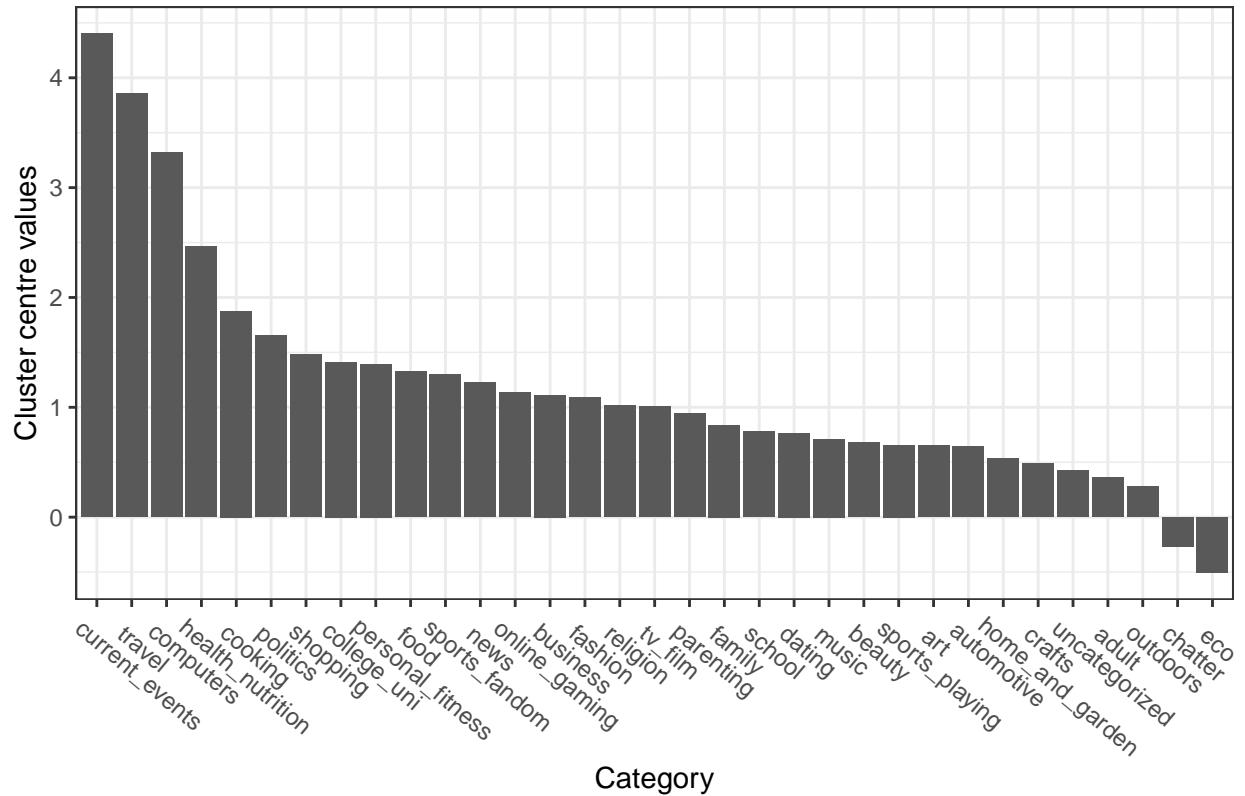
Cluster 3

Cluster 3



Cluster 4

Cluster 4



Result

Based on this analysis, we have identified the following market segments:

- 1. Current Events, Travel, Computers
- 2. Health/Nutrition, Cooking, Personal Fitness
- 3. Sports Fandom, Politics
- 4. College_uni,news,online_gaming

Following are certain inferences based on each segment:

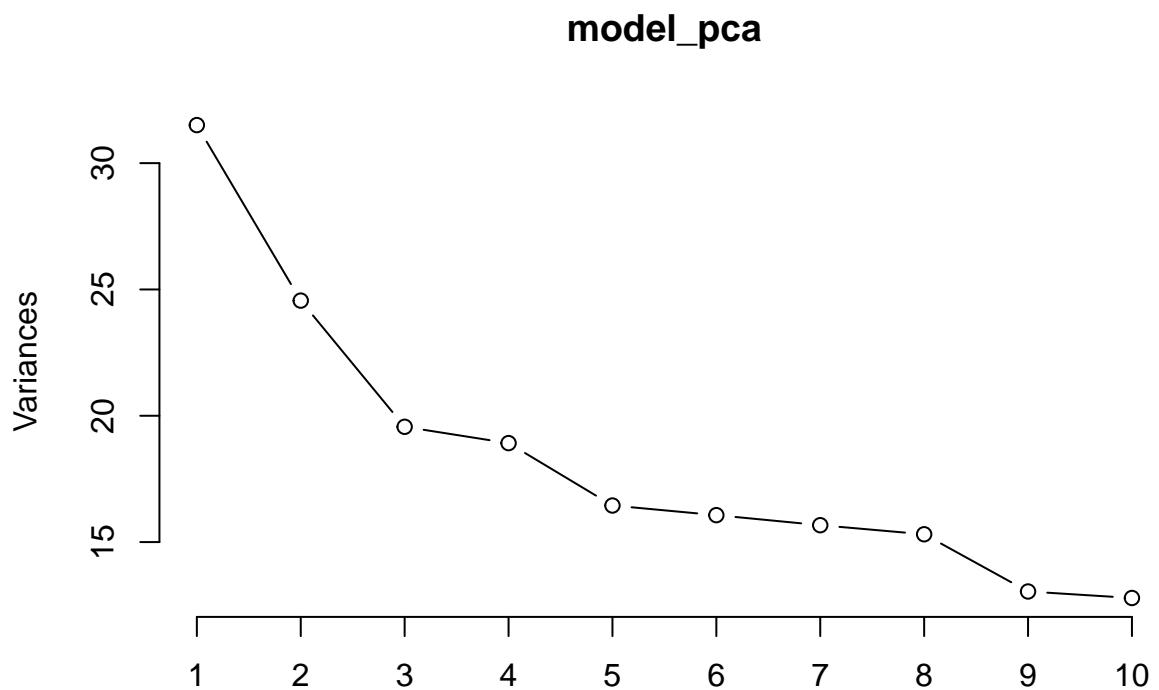
- 1. The Informed - Loves to stay ahead of things and well read about world events Middle aged
- 2. The fitness enthusiasts - Pretty self evident, like to watch their food intake and love breaking a sweat. Young.
- 3. The Average Joe - Stays out of most discussions, but can go on for a long time about their favorite team on and off the field. Middle aged to old.
- 4. The Student - College going students who like to unwind online after a day's worth of hard work. Young.

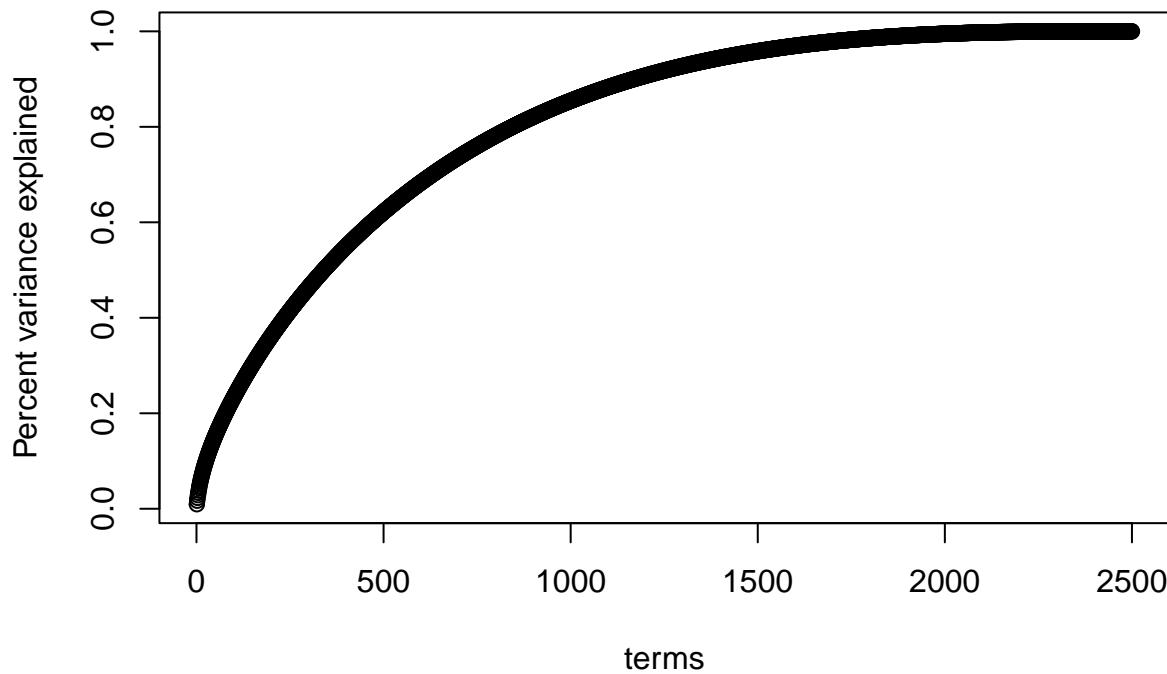
Question 5- Author Attribution

```
## <<DocumentTermMatrix (documents: 2500, terms: 32570)>>
## Non-/sparse entries: 537861/80887139
## Sparsity           : 99%
## Maximal term length: 40
## Weighting          : term frequency (tf)
```

2500 documents and 3397 terms found

2500 documents and 32574 terms found





Model 1: Naive Bayes

```
## [1] 816
## [1] "Accuracy: 32.64 percent"
```

Model 2: K-Nearest Neighbors

```
## [1] "Accuracy: 34.80 percent"
```

Model 3: Random Forest

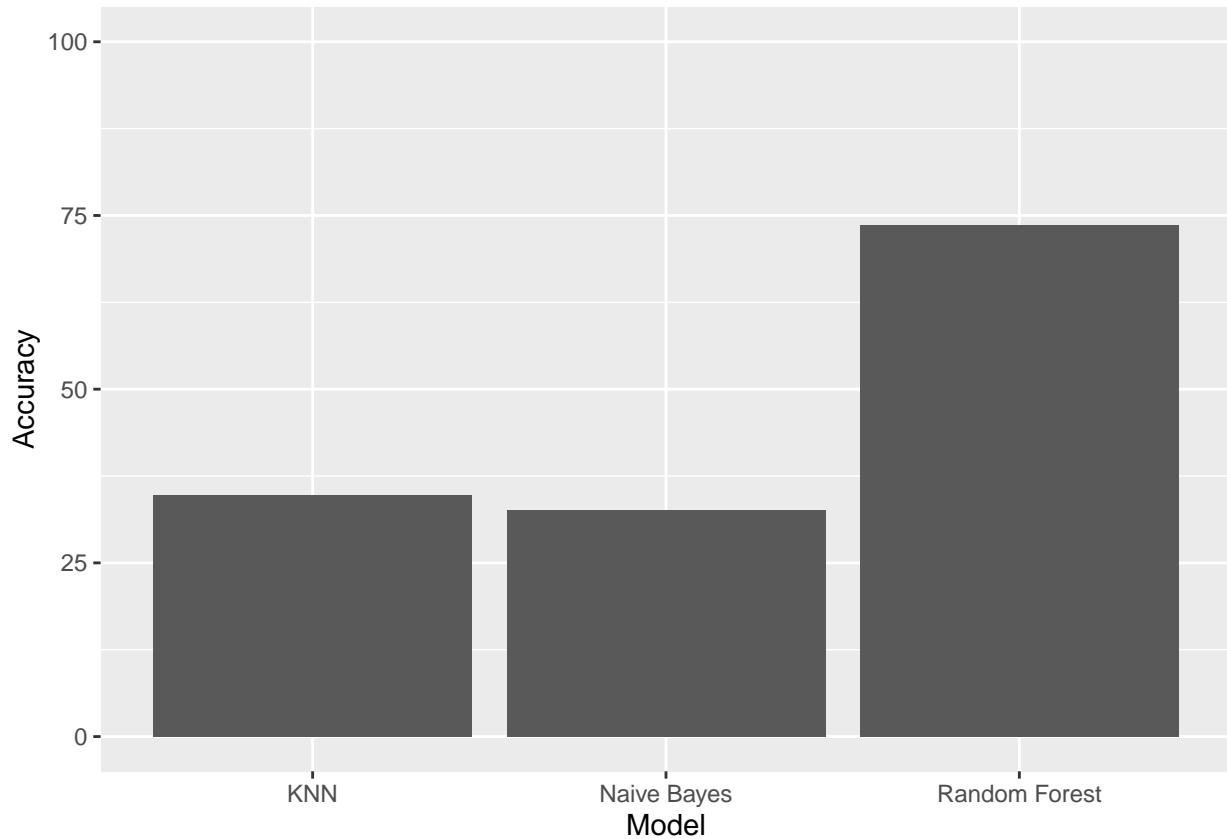
```
## [1] 1842
## [1] "Accuracy: 73.68 percent"
```

Conclusion:

We performed 3 different classification models for this dataset. Our most accurate model by far was Random Forest. Naive Bayes and KNN had significantly lower accuracies, as seen from the plot below:

Plot of Accuracies:

```
##           Model Accuracy
## 1 Random Forest     73.68
## 2          KNN      34.80
## 3   Naive Bayes    32.64
```

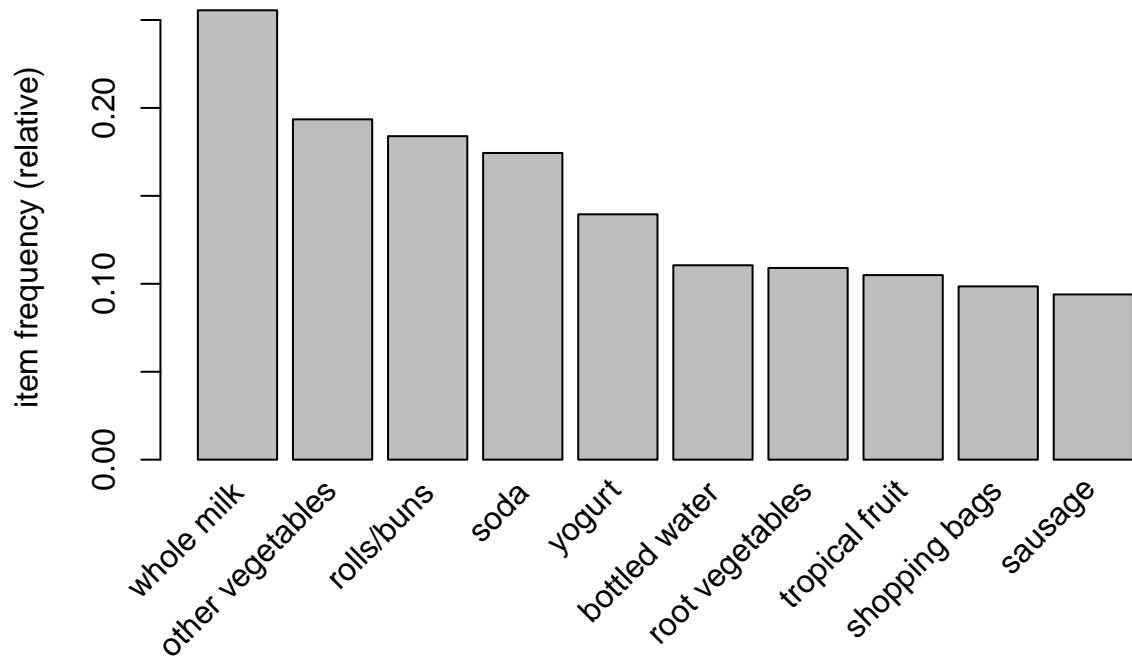


Question 6- Association Rule Mining

9835 transactions, whole milk is the most frequent item (2513 transactions) followed by other vegetables (1903 transactions)

Transaction sizes range from 1 to 32 items, with an average basket size of ~4 items

Plot of Top 10 Items



This plot shows the top 10 items purchased among all transactions, depicting our previous observations from the summary code above.

Parameter Selection 1:

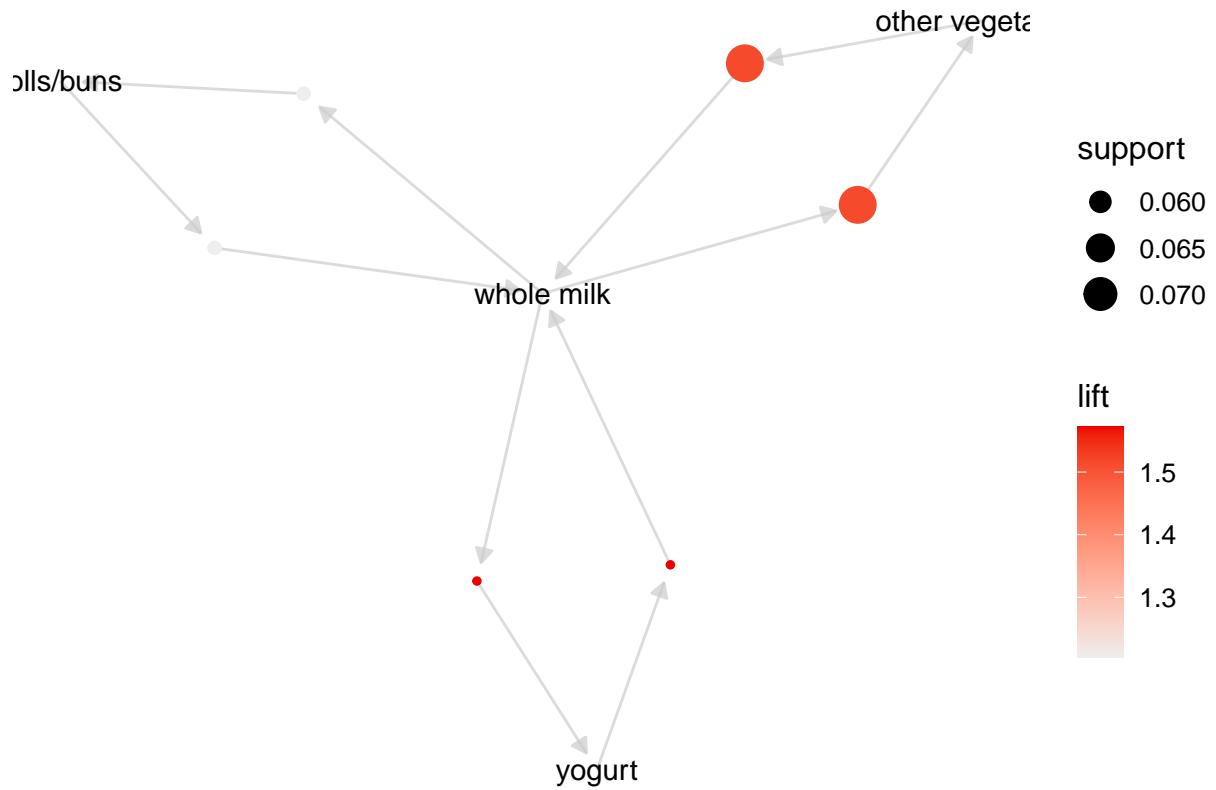
To begin, we selected a relatively high support confidence ratio and a low confidence level to see what outputs would occur.

6 rules created given the high support confidence ratio and extremely low confidence level.

```

##      lhs                  rhs          support    confidence   coverage
## [1] {yogurt}            => {whole milk} 0.05602440 0.4016035 0.1395018
## [2] {whole milk}        => {yogurt}     0.05602440 0.2192598 0.2555160
## [3] {rolls/buns}        => {whole milk} 0.05663447 0.3079049 0.1839349
## [4] {whole milk}        => {rolls/buns} 0.05663447 0.2216474 0.2555160
## [5] {other vegetables} => {whole milk}  0.07483477 0.3867578 0.1934926
## [6] {whole milk}        => {other vegetables} 0.07483477 0.2928770 0.2555160
##      lift      count
## [1] 1.571735 551
## [2] 1.571735 551
## [3] 1.205032 557
## [4] 1.205032 557
## [5] 1.513634 736
## [6] 1.513634 736

```



All relationships have whole milk; yogurt, other vegetables, and rolls/buns come up twice. This makes sense given they are all among the most frequently purchased items, as previously shown.

Parameter Selection 2:

We decreased support confidence ratio and increased confidence levels to see this impact on the output obtained.

128 rules created given the lowered support confidence ratio and slightly higher confidence level.

##	lhs	rhs	support
## [1]	{frozen vegetables}	=> {whole milk}	0.02043721
## [2]	{whole milk}	=> {frozen vegetables}	0.02043721
## [3]	{beef}	=> {whole milk}	0.02125064
## [4]	{whole milk}	=> {beef}	0.02125064
## [5]	{curd}	=> {whole milk}	0.02613116
## [6]	{whole milk}	=> {curd}	0.02613116
## [7]	{pork}	=> {other vegetables}	0.02165735
## [8]	{other vegetables}	=> {pork}	0.02165735
## [9]	{pork}	=> {whole milk}	0.02216573
## [10]	{whole milk}	=> {pork}	0.02216573
## [11]	{frankfurter}	=> {whole milk}	0.02053889
## [12]	{whole milk}	=> {frankfurter}	0.02053889
## [13]	{bottled beer}	=> {whole milk}	0.02043721
## [14]	{whole milk}	=> {bottled beer}	0.02043721
## [15]	{brown bread}	=> {whole milk}	0.02521607

```

## [16] {whole milk}          => {brown bread}      0.02521607
## [17] {margarine}          => {whole milk}       0.02419929
## [18] {whole milk}          => {margarine}        0.02419929
## [19] {butter}              => {other vegetables} 0.02003050
## [20] {other vegetables}   => {butter}           0.02003050
## [21] {butter}              => {whole milk}       0.02755465
## [22] {whole milk}          => {butter}           0.02755465
## [23] {newspapers}          => {whole milk}       0.02735130
## [24] {whole milk}          => {newspapers}        0.02735130
## [25] {domestic eggs}       => {other vegetables} 0.02226741
## [26] {other vegetables}   => {domestic eggs}     0.02226741
## [27] {domestic eggs}       => {whole milk}        0.02999492
## [28] {whole milk}          => {domestic eggs}     0.02999492
## [29] {fruit/vegetable juice}=> {other vegetables} 0.02104728
## [30] {other vegetables}   => {fruit/vegetable juice} 0.02104728
## [31] {fruit/vegetable juice}=> {whole milk}        0.02663955
## [32] {whole milk}          => {fruit/vegetable juice} 0.02663955
## [33] {whipped/sour cream}  => {yogurt}           0.02074225
## [34] {yogurt}              => {whipped/sour cream} 0.02074225
## [35] {whipped/sour cream}  => {other vegetables} 0.02887646
## [36] {other vegetables}   => {whipped/sour cream} 0.02887646
## [37] {whipped/sour cream}  => {whole milk}        0.03223183
## [38] {whole milk}          => {whipped/sour cream} 0.03223183
## [39] {pip fruit}           => {tropical fruit}    0.02043721
## [40] {tropical fruit}     => {pip fruit}         0.02043721
## [41] {pip fruit}           => {other vegetables} 0.02613116
## [42] {other vegetables}   => {pip fruit}         0.02613116
## [43] {pip fruit}           => {whole milk}        0.03009659
## [44] {whole milk}          => {pip fruit}         0.03009659
## [45] {pastry}              => {soda}             0.02104728
## [46] {soda}                 => {pastry}           0.02104728
## [47] {pastry}              => {rolls/buns}       0.02094560
## [48] {rolls/buns}          => {pastry}           0.02094560
## [49] {pastry}              => {other vegetables} 0.02257245
## [50] {other vegetables}   => {pastry}           0.02257245
## [51] {pastry}              => {whole milk}       0.03324860
## [52] {whole milk}          => {pastry}           0.03324860
## [53] {citrus fruit}        => {yogurt}           0.02165735
## [54] {yogurt}               => {citrus fruit}     0.02165735
## [55] {citrus fruit}        => {other vegetables} 0.02887646
## [56] {other vegetables}   => {citrus fruit}     0.02887646
## [57] {citrus fruit}        => {whole milk}       0.03050330
## [58] {whole milk}          => {citrus fruit}     0.03050330
## [59] {shopping bags}       => {soda}             0.02460600
## [60] {soda}                 => {shopping bags}    0.02460600
## [61] {shopping bags}       => {other vegetables} 0.02318251
## [62] {other vegetables}   => {shopping bags}    0.02318251
## [63] {shopping bags}       => {whole milk}       0.02450432
## [64] {whole milk}          => {shopping bags}    0.02450432
## [65] {sausage}              => {soda}             0.02430097
## [66] {soda}                 => {sausage}          0.02430097
## [67] {sausage}              => {rolls/buns}       0.03060498
## [68] {rolls/buns}          => {sausage}          0.03060498
## [69] {sausage}              => {other vegetables} 0.02694459

```

```

## [70] {other vegetables}          => {sausage}           0.02694459
## [71] {sausage}                 => {whole milk}        0.02989324
## [72] {whole milk}              => {sausage}           0.02989324
## [73] {bottled water}           => {soda}               0.02897814
## [74] {soda}                     => {bottled water}      0.02897814
## [75] {bottled water}           => {yogurt}             0.02297916
## [76] {yogurt}                  => {bottled water}      0.02297916
## [77] {bottled water}           => {rolls/buns}         0.02419929
## [78] {rolls/buns}              => {bottled water}      0.02419929
## [79] {bottled water}           => {other vegetables} 0.02480935
## [80] {other vegetables}        => {bottled water}      0.02480935
## [81] {bottled water}           => {whole milk}          0.03436706
## [82] {whole milk}              => {bottled water}      0.03436706
## [83] {tropical fruit}          => {root vegetables}   0.02104728
## [84] {root vegetables}         => {tropical fruit}     0.02104728
## [85] {tropical fruit}          => {soda}                0.02084392
## [86] {soda}                     => {tropical fruit}     0.02084392
## [87] {tropical fruit}          => {yogurt}              0.02928317
## [88] {yogurt}                  => {tropical fruit}     0.02928317
## [89] {tropical fruit}          => {rolls/buns}          0.02460600
## [90] {rolls/buns}              => {tropical fruit}     0.02460600
## [91] {tropical fruit}          => {other vegetables} 0.03589222
## [92] {other vegetables}        => {tropical fruit}     0.03589222
## [93] {tropical fruit}          => {whole milk}          0.04229792
## [94] {whole milk}              => {tropical fruit}     0.04229792
## [95] {root vegetables}         => {yogurt}              0.02582613
## [96] {yogurt}                  => {root vegetables}   0.02582613
## [97] {root vegetables}         => {rolls/buns}          0.02430097
## [98] {rolls/buns}              => {root vegetables}   0.02430097
## [99] {root vegetables}         => {other vegetables} 0.04738180
## [100] {other vegetables}       => {root vegetables}   0.04738180
## [101] {root vegetables}       => {whole milk}          0.04890696
## [102] {whole milk}             => {root vegetables}   0.04890696
## [103] {root vegetables}       => {yogurt}              0.02735130
## [104] {yogurt}                 => {soda}                0.02735130
## [105] {soda}                   => {rolls/buns}          0.03833249
## [106] {rolls/buns}             => {soda}                0.03833249
## [107] {soda}                   => {other vegetables} 0.03274021
## [108] {other vegetables}       => {soda}                0.03274021
## [109] {soda}                   => {whole milk}          0.04006101
## [110] {whole milk}             => {soda}                0.04006101
## [111] {soda}                   => {rolls/buns}          0.03436706
## [112] {rolls/buns}             => {yogurt}              0.03436706
## [113] {yogurt}                 => {other vegetables} 0.04341637
## [114] {other vegetables}       => {yogurt}              0.04341637
## [115] {yogurt}                 => {whole milk}          0.05602440
## [116] {whole milk}             => {yogurt}              0.05602440
## [117] {yogurt}                 => {other vegetables} 0.04260295
## [118] {other vegetables}       => {rolls/buns}          0.04260295
## [119] {rolls/buns}             => {whole milk}          0.05663447
## [120] {whole milk}             => {rolls/buns}          0.05663447
## [121] {rolls/buns}             => {whole milk}          0.07483477
## [122] {whole milk}             => {other vegetables} 0.07483477
## [123] {other vegetables,root vegetables} => {whole milk} 0.02318251

```

```

## [124] {root vegetables,whole milk}      => {other vegetables}    0.02318251
## [125] {other vegetables,whole milk}    => {root vegetables}    0.02318251
## [126] {other vegetables,yogurt}       => {whole milk}        0.02226741
## [127] {whole milk,yogurt}             => {other vegetables}  0.02226741
## [128] {other vegetables,whole milk}    => {yogurt}            0.02226741
##   confidence coverage   lift      count
## [1]  0.42494715 0.04809354 1.6630940 201
## [2]  0.07998408 0.25551601 1.6630940 201
## [3]  0.40503876 0.05246568 1.5851795 209
## [4]  0.08316753 0.25551601 1.5851795 209
## [5]  0.49045802 0.05327911 1.9194805 257
## [6]  0.10226821 0.25551601 1.9194805 257
## [7]  0.37566138 0.05765125 1.9414764 213
## [8]  0.111192853 0.19349263 1.9414764 213
## [9]  0.38447972 0.05765125 1.5047187 218
## [10] 0.08674891 0.25551601 1.5047187 218
## [11] 0.34827586 0.05897306 1.3630295 202
## [12] 0.08038201 0.25551601 1.3630295 202
## [13] 0.25378788 0.08052872 0.9932367 201
## [14] 0.07998408 0.25551601 0.9932367 201
## [15] 0.38871473 0.06487036 1.5212930 248
## [16] 0.09868683 0.25551601 1.5212930 248
## [17] 0.41319444 0.05856634 1.6170980 238
## [18] 0.09470752 0.25551601 1.6170980 238
## [19] 0.36146789 0.05541434 1.8681223 197
## [20] 0.10352076 0.19349263 1.8681223 197
## [21] 0.49724771 0.05541434 1.9460530 271
## [22] 0.10783924 0.25551601 1.9460530 271
## [23] 0.34267516 0.07981698 1.3411103 269
## [24] 0.10704337 0.25551601 1.3411103 269
## [25] 0.35096154 0.06344687 1.8138238 219
## [26] 0.11508145 0.19349263 1.8138238 219
## [27] 0.47275641 0.06344687 1.8502027 295
## [28] 0.11738957 0.25551601 1.8502027 295
## [29] 0.29113924 0.07229283 1.5046529 207
## [30] 0.10877562 0.19349263 1.5046529 207
## [31] 0.36849508 0.07229283 1.4421604 262
## [32] 0.10425786 0.25551601 1.4421604 262
## [33] 0.28936170 0.07168277 2.0742510 204
## [34] 0.14868805 0.13950178 2.0742510 204
## [35] 0.40283688 0.07168277 2.0819237 284
## [36] 0.14923805 0.19349263 2.0819237 284
## [37] 0.44964539 0.07168277 1.7597542 317
## [38] 0.12614405 0.25551601 1.7597542 317
## [39] 0.27016129 0.07564820 2.5746476 201
## [40] 0.19476744 0.10493137 2.5746476 201
## [41] 0.34543011 0.07564820 1.7852365 257
## [42] 0.13504992 0.19349263 1.7852365 257
## [43] 0.39784946 0.07564820 1.5570432 296
## [44] 0.11778750 0.25551601 1.5570432 296
## [45] 0.23657143 0.08896797 1.3566647 207
## [46] 0.12069971 0.17437722 1.3566647 207
## [47] 0.23542857 0.08896797 1.2799558 206
## [48] 0.11387507 0.18393493 1.2799558 206

```

```

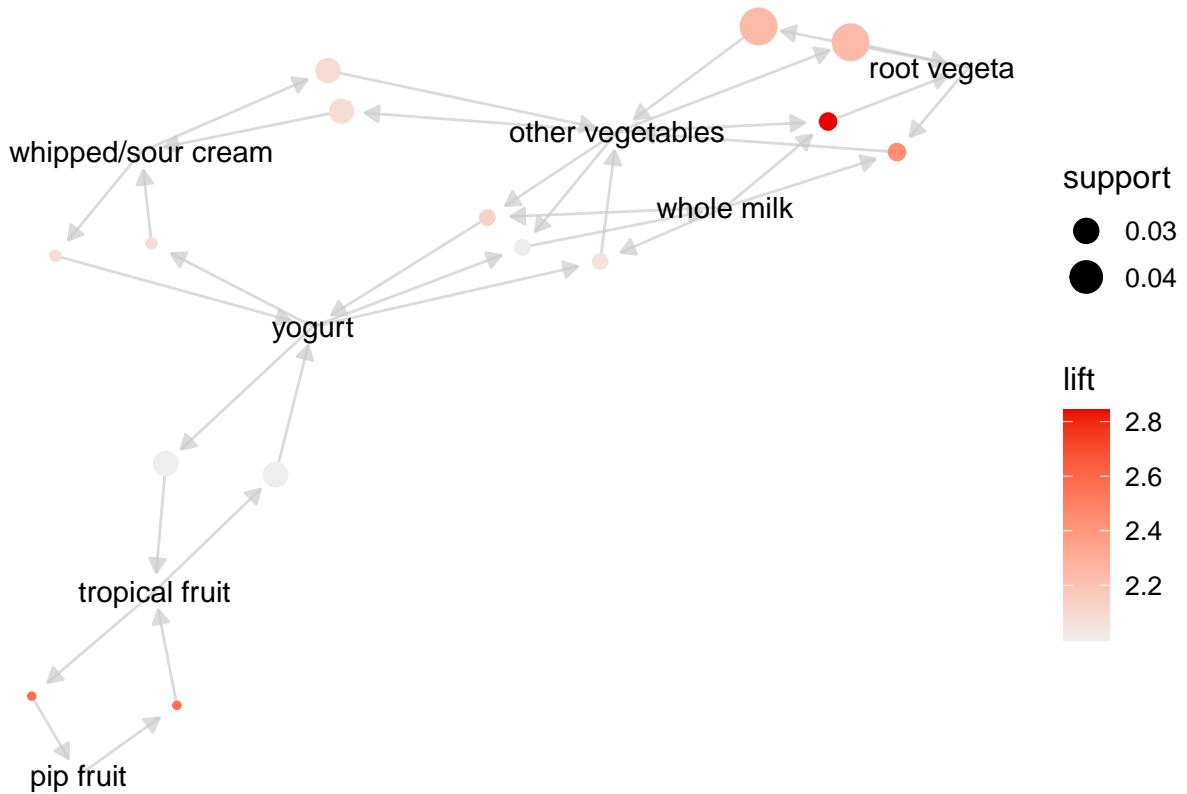
## [49] 0.25371429 0.08896797 1.3112349 222
## [50] 0.11665791 0.19349263 1.3112349 222
## [51] 0.37371429 0.08896797 1.4625865 327
## [52] 0.13012336 0.25551601 1.4625865 327
## [53] 0.26167076 0.08276563 1.8757521 213
## [54] 0.15524781 0.13950178 1.8757521 213
## [55] 0.34889435 0.08276563 1.8031403 284
## [56] 0.14923805 0.19349263 1.8031403 284
## [57] 0.36855037 0.08276563 1.4423768 300
## [58] 0.11937923 0.25551601 1.4423768 300
## [59] 0.24974200 0.09852567 1.4321939 242
## [60] 0.14110787 0.17437722 1.4321939 242
## [61] 0.23529412 0.09852567 1.2160366 228
## [62] 0.11981083 0.19349263 1.2160366 228
## [63] 0.24871001 0.09852567 0.9733637 241
## [64] 0.09590131 0.25551601 0.9733637 241
## [65] 0.25865801 0.09395018 1.4833245 239
## [66] 0.13935860 0.17437722 1.4833245 239
## [67] 0.32575758 0.09395018 1.7710480 301
## [68] 0.16639027 0.18393493 1.7710480 301
## [69] 0.28679654 0.09395018 1.4822091 265
## [70] 0.13925381 0.19349263 1.4822091 265
## [71] 0.31818182 0.09395018 1.2452520 294
## [72] 0.11699164 0.25551601 1.2452520 294
## [73] 0.26218951 0.11052364 1.5035766 285
## [74] 0.16618076 0.17437722 1.5035766 285
## [75] 0.20791168 0.11052364 1.4903873 226
## [76] 0.16472303 0.13950178 1.4903873 226
## [77] 0.21895124 0.11052364 1.1903734 238
## [78] 0.13156440 0.18393493 1.1903734 238
## [79] 0.22447102 0.11052364 1.1601012 244
## [80] 0.12821860 0.19349263 1.1601012 244
## [81] 0.31094756 0.11052364 1.2169396 338
## [82] 0.13450060 0.25551601 1.2169396 338
## [83] 0.20058140 0.10493137 1.8402220 207
## [84] 0.19309701 0.10899847 1.8402220 207
## [85] 0.19864341 0.10493137 1.1391592 205
## [86] 0.11953353 0.17437722 1.1391592 205
## [87] 0.27906977 0.10493137 2.0004746 288
## [88] 0.20991254 0.13950178 2.0004746 288
## [89] 0.23449612 0.10493137 1.2748863 242
## [90] 0.13377557 0.18393493 1.2748863 242
## [91] 0.34205426 0.10493137 1.7677896 353
## [92] 0.18549658 0.19349263 1.7677896 353
## [93] 0.40310078 0.10493137 1.5775950 416
## [94] 0.16553920 0.25551601 1.5775950 416
## [95] 0.23694030 0.10899847 1.6984751 254
## [96] 0.18513120 0.13950178 1.6984751 254
## [97] 0.22294776 0.10899847 1.2121013 239
## [98] 0.13211719 0.18393493 1.2121013 239
## [99] 0.43470149 0.10899847 2.2466049 466
## [100] 0.24487651 0.19349263 2.2466049 466
## [101] 0.44869403 0.10899847 1.7560310 481
## [102] 0.19140470 0.25551601 1.7560310 481

```

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## [103] 0.15685131 0.17437722 1.1243678 269
## [104] 0.19606414 0.13950178 1.1243678 269
## [105] 0.21982507 0.17437722 1.1951242 377
## [106] 0.20840243 0.18393493 1.1951242 377
## [107] 0.18775510 0.17437722 0.9703476 322
## [108] 0.16920652 0.19349263 0.9703476 322
## [109] 0.22973761 0.17437722 0.8991124 394
## [110] 0.15678472 0.25551601 0.8991124 394
## [111] 0.24635569 0.13950178 1.3393633 338
## [112] 0.18684356 0.18393493 1.3393633 338
## [113] 0.31122449 0.13950178 1.6084566 427
## [114] 0.22438255 0.19349263 1.6084566 427
## [115] 0.40160350 0.13950178 1.5717351 551
## [116] 0.21925985 0.25551601 1.5717351 551
## [117] 0.23161968 0.18393493 1.1970465 419
## [118] 0.22017867 0.19349263 1.1970465 419
## [119] 0.30790492 0.18393493 1.2050318 557
## [120] 0.22164743 0.25551601 1.2050318 557
## [121] 0.38675775 0.19349263 1.5136341 736
## [122] 0.29287704 0.25551601 1.5136341 736
## [123] 0.48927039 0.04738180 1.9148326 228
## [124] 0.47401247 0.04890696 2.4497702 228
## [125] 0.30978261 0.07483477 2.8420820 228
## [126] 0.51288056 0.04341637 2.0072345 219
## [127] 0.39745917 0.05602440 2.0541308 219
## [128] 0.29755435 0.07483477 2.1329789 219

```

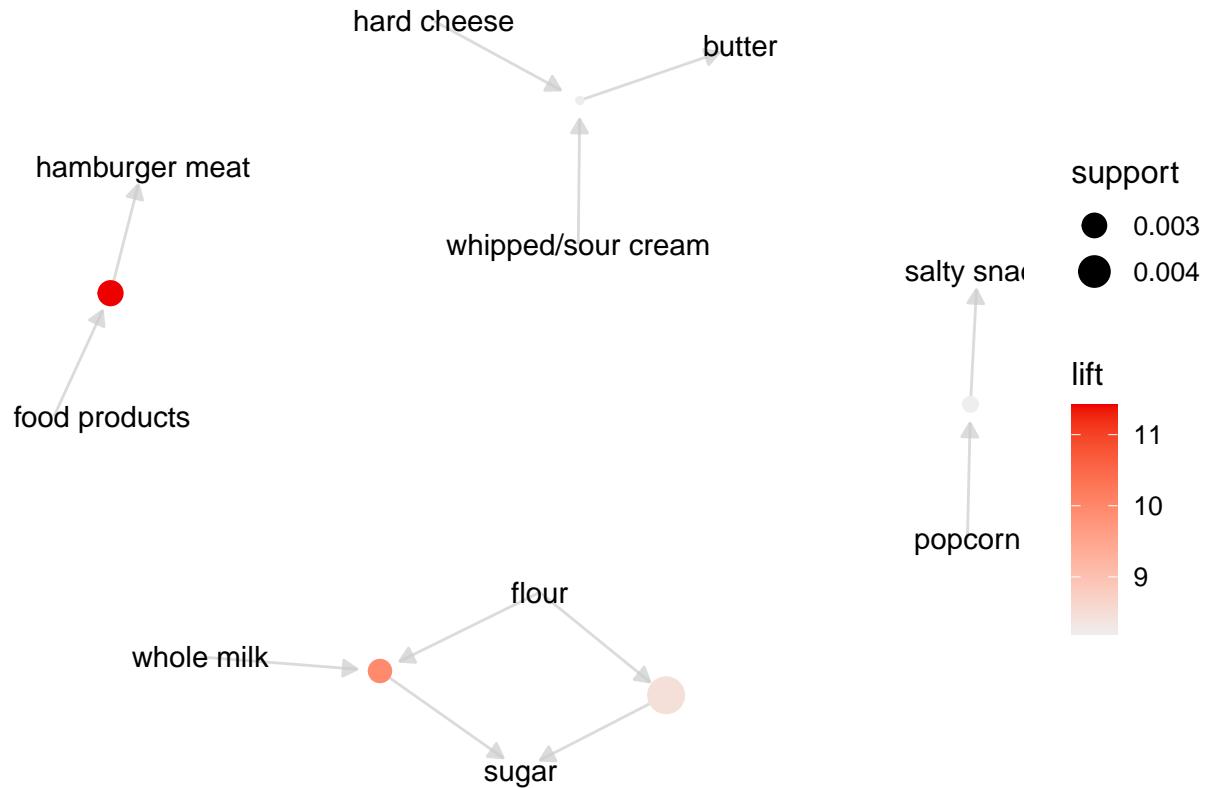


More items are included in this output as a result, but whole milk, yogurt, and other vegetables are still highly present, as shown in this plot.

Parameter Selection 3:

We further decreased support confidence ratio and further increased confidence levels to see the magnified impact of these parameters on a larger scale.

5111 rules created given the even lower support confidence ratio and significantly higher confidence level.



This graph shows that transactions that include whole milk are likely to include other baking supplies. Also shows transactions containing a dairy product like hard cheese will likely include other dairy products. Depicted is also a relationship between transactions containing salty snacks and popcorn, as well as hamburger meat with instant meals. These relationships all make sense given the similarities of the items and their respective food categories.