Final Term Project

Introduction to Data Science

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Section: D

Description of the Dataset:

The data set refers to clients of a wholesale distributor. It includes the annual spending in monetary units (m.u.) on diverse product categories.

Data Set Information:

Provide all relevant information about data set.

Attribute Information:

1) FRESH: annual spending (m.u.) on fresh products (Continuous);

2) MILK: annual spending (m.u.) on milk products (Continuous);

3) GROCERY: annual spending (m.u.) on grocery products (Continuous);

4) FROZEN: annual spending (m.u.) on frozen products (Continuous)

5) DETERGENTS_PAPER: annual spending (m.u.) on detergents and paper products (Continuous)

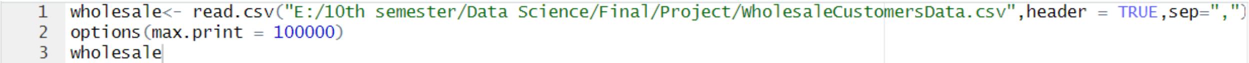
6) DELICATESSEN: annual spending (m.u.) on and delicatessen products (Continuous);

7) CHANNEL: customersâ€™ Channel - Horeca (Hotel/Restaurant/CafÃ©) or Retail channel (Nominal)

8) REGION: customersâ€™ Region â€“ Lisbon, Oporto or Other (Nominal)

Dataset Link: https://archive-beta.ics.uci.edu/dataset/292/wholesale+customers

Import the data set as csv and print the data set:



```
wholesale<- read.csv("E:/10th semester/Data Science/Final/Project/WholesaleCustomersData.csv",header = TRUE,sep=",")
options(max.print = 100000)
wholesale
```

Here is the code of import the dataset as csv file. In this code also has the location of the csv dataset file.

Output:

```
   Channel Region  Fresh  Milk Grocery Frozen Detergents_Paper Delicassen
1        2      3  12669  9656    7561    214             2674       1338
2        2      3   7057  9810    9568   1762             3293       1776
3        2      3   6353  8808    7684   2405             3516       7844
4        1      3  13265  1196    4221   6404              507       1788
5        2      3  22615  5410    7198   3915             1777       5185
6        2      3   9413  8259    5126    666             1795       1451
7        2      3  12126  3199    6975    480             3140        545
8        2      3   7579  4956    9426   1669             3321       2566
9        1      3   5963  3648    6192    425             1716        750
10       2      3   6006 11093   18881   1159             7425       2098
11       2      3   3366  5403   12974   4400             5977       1744
12       2      3  13146  1124    4523   1420              549        497
13       2      3  31714 12319   11757    287             3881       2931
14       2      3  21217  6208   14982   3095             6707        602
15       2      3  24653  9465   12091    294             5058       2168
16       1      3  10253  1114    3821    397              964        412
17       2      3   1020  8816   12121    134             4508       1080
18       1      3   5876  6157    2933    839              370       4478
19       2      3  18601  6327   10099   2205             2767       3181
20       1      3   7780  2495    9464    669             2518        501
21       2      3  17546  4519    4602   1066             2259       2124
22       1      3   5567   871    2010   3383              375        569
23       1      3  31276  1917    4469   9408             2381       4334
24       2      3  26373 36423   22019   5154             4337      16523
25       2      3  22647  9776   13792   2915             4482       5778
26       2      3  16165  4230    7595    201             4003         57
27       1      3   9898   961    2861   3151              242        833
28       1      3  14276   803    3045    485              100        518
29       2      3   4113 20484   25957   1158             8604       5206
30       1      3  43088  2100    2609   1200             1107        823
31       1      3  18815  3610   11107   1148             2134       2963
32       1      3   2612  4339    3133   2088              820        985
33       1      3  21632  1318    2886    266              918        405
34       1      3  29729  4786    7326   6130              361       1083
35       1      3   1502  1979    2262    425              483        395
36       2      3    688  5491   11091    833             4239        436
37       1      3  29955  4362    5428   1729              862       4626
38       2      3  15168 10556   12477   1920             6506        714
39       2      3   4591 15729   16709     33             6956        433
40       1      3  56159   555     902  10002              212       2916
41       1      3  24025  4332    4757   9510             1145       5864
42       1      3  19176  3065    5956   2033             2575       2802
43       2      3  10850  7555   14961    188             6899         46
44       2      3    630 11095   23998    787             9529         72
45       2      3   9670  7027   10471    541             4618         65
46       2      3   5181 22044   21531   1740             7353       4985
47       2      3   3103 14069   21955   1668             6792       1452
48       2      3  44466 54259   55571   7782            24171       6465
```

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71	1	3	16705	2037	3202	10643	116	1365
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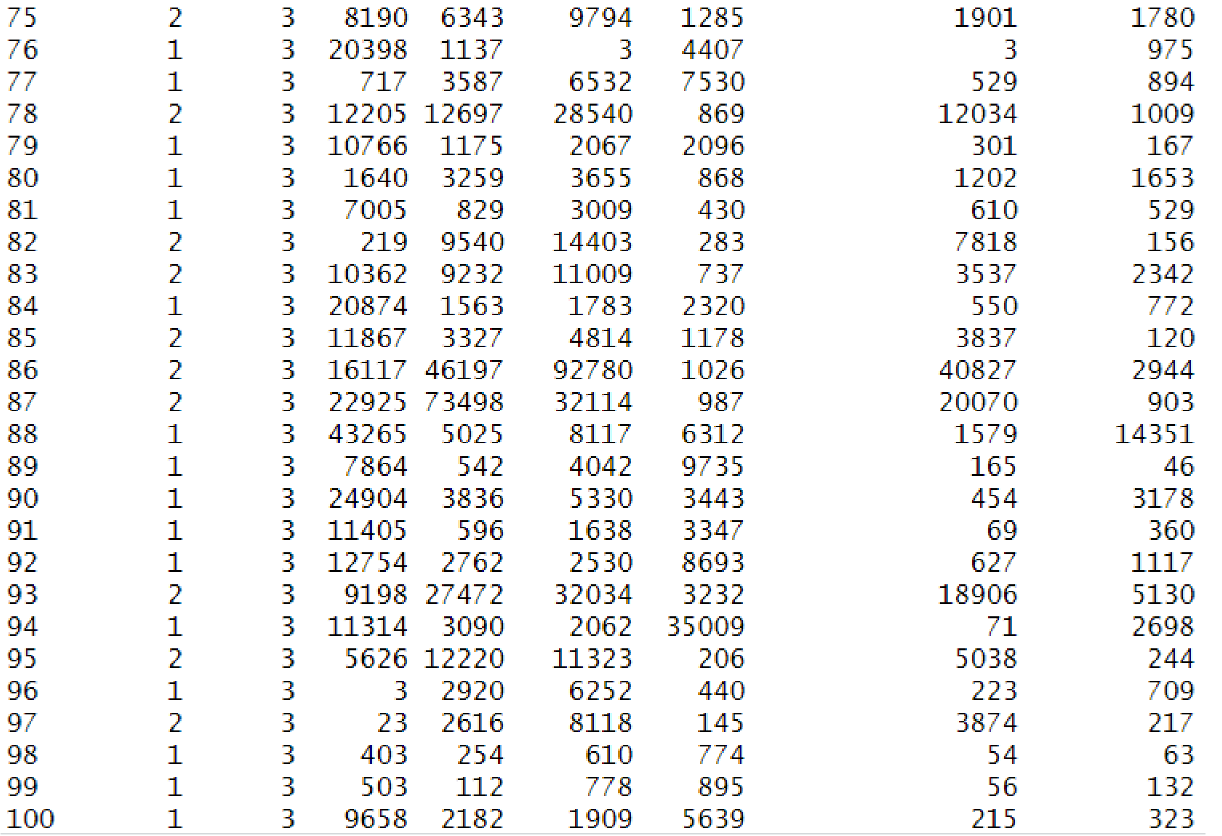

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97	2	3	23	2616	8118	145	3874	217
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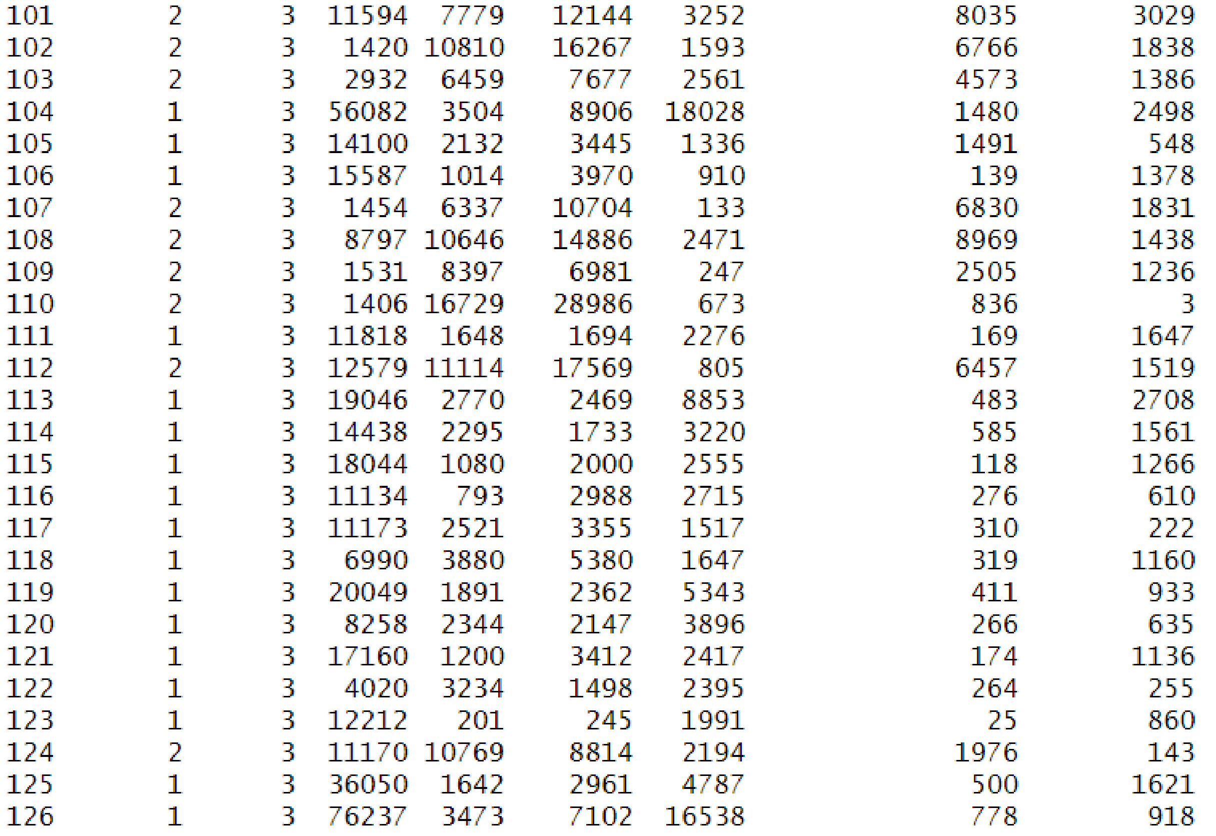

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221	1	1	14755	899	1382	1765	56	749
222	1	1	5396	7503	10646	91	4167	239
223	1	1	5041	1115	2856	7496	256	375
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230	1	1	8656	2746	2501	6845	694	980
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234	1	1	964	4984	3316	937	409	7
235	1	1	15603	2703	3833	4260	325	2563
236	1	1	1838	6380	2824	1218	1216	295
237	1	1	8635	820	3047	2312	415	225
238	1	1	18692	3838	593	4634	28	1215
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240	1	1	47493	2567	3779	5243	828	2253
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245	1	1	6202	7775	10817	1183	3143	1970
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268	1	1	20893	1222	2576	3975	737	3628
269	2	1	11908	8053	19847	1069	6374	698
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272	1	1	2083	5007	1563	1120	147	1550
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290	1	3	42786	286	471	1388	32	22
291	1	3	2708	2160	2642	502	965	1522
292	1	3	6022	3354	3261	2507	212	686
293	1	3	2838	3086	4329	3838	825	1060
294	2	2	3996	11103	12469	902	5952	741
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296	2	2	7588	1897	5234	417	2208	254
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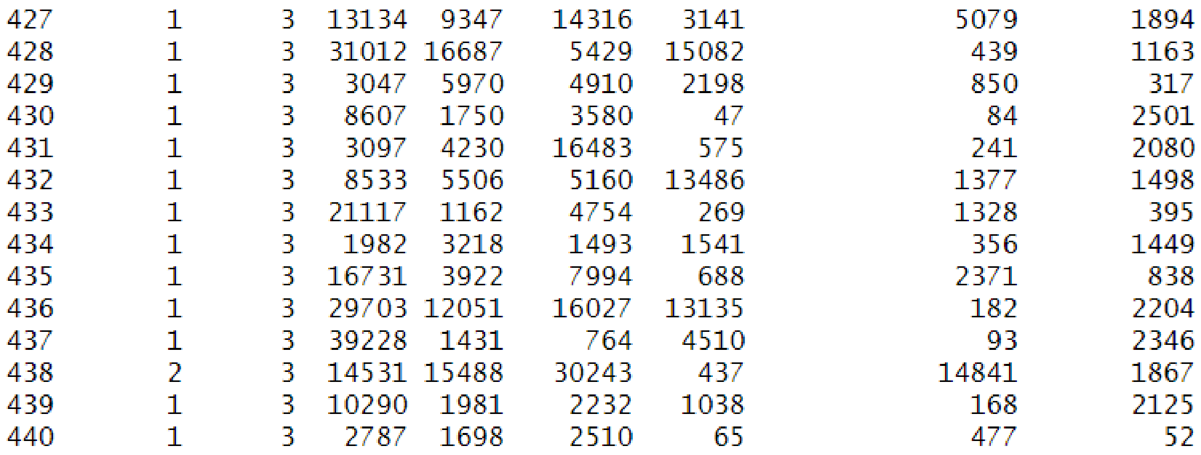
312	1	2	29635	2335	8280	3046	371	117
313	2	2	2137	3737	19172	1274	17120	142
314	1	2	9784	925	2405	4447	183	297
315	1	2	10617	1795	7647	1483	857	1233
316	2	2	1479	14982	11924	662	3891	3508
317	1	2	7127	1375	2201	2679	83	1059
318	1	2	1182	3088	6114	978	821	1637
319	1	2	11800	2713	3558	2121	706	51
320	2	2	9759	25071	17645	1128	12408	1625
321	1	2	1774	3696	2280	514	275	834
322	1	2	9155	1897	5167	2714	228	1113
323	1	2	15881	713	3315	3703	1470	229
324	1	2	13360	944	11593	915	1679	573
325	1	2	25977	3587	2464	2369	140	1092
326	1	2	32717	16784	13626	60869	1272	5609

327	1	2	4414	1610	1431	3498	387	834
328	1	2	542	899	1664	414	88	522
329	1	2	16933	2209	3389	7849	210	1534
330	1	2	5113	1486	4583	5127	492	739
331	1	2	9790	1786	5109	3570	182	1043
332	2	2	11223	14881	26839	1234	9606	1102
333	1	2	22321	3216	1447	2208	178	2602
334	2	2	8565	4980	67298	131	38102	1215
335	2	2	16823	928	2743	11559	332	3486
336	2	2	27082	6817	10790	1365	4111	2139
337	1	2	13970	1511	1330	650	146	778
338	1	2	9351	1347	2611	8170	442	868
339	1	2	3	333	7021	15601	15	550
340	1	2	2617	1188	5332	9584	573	1942
341	2	3	381	4025	9670	388	7271	1371
342	2	3	2320	5763	11238	767	5162	2158
343	1	3	255	5758	5923	349	4595	1328
344	2	3	1689	6964	26316	1456	15469	37
345	1	3	3043	1172	1763	2234	217	379
346	1	3	1198	2602	8335	402	3843	303
347	2	3	2771	6939	15541	2693	6600	1115
348	2	3	27380	7184	12311	2809	4621	1022
349	1	3	3428	2380	2028	1341	1184	665
350	2	3	5981	14641	20521	2005	12218	445
351	1	3	3521	1099	1997	1796	173	995
352	2	3	1210	10044	22294	1741	12638	3137
353	1	3	608	1106	1533	830	90	195
354	2	3	117	6264	21203	228	8682	1111
355	1	3	14039	7393	2548	6386	1333	2341
356	1	3	190	727	2012	245	184	127
357	1	3	22686	134	218	3157	9	548
358	2	3	37	1275	22272	137	6747	110
359	1	3	759	18664	1660	6114	536	4100
360	1	3	796	5878	2109	340	232	776
361	1	3	19746	2872	2006	2601	468	503
362	1	3	4734	607	864	1206	159	405
363	1	3	2121	1601	2453	560	179	712
364	1	3	4627	997	4438	191	1335	314
365	1	3	2615	873	1524	1103	514	468
366	2	3	4692	6128	8025	1619	4515	3105
367	1	3	9561	2217	1664	1173	222	447
368	1	3	3477	894	534	1457	252	342
369	1	3	22335	1196	2406	2046	101	558
370	1	3	6211	337	683	1089	41	296
371	2	3	39679	3944	4955	1364	523	2235
372	1	3	20105	1887	1939	8164	716	790
373	1	3	3884	3801	1641	876	397	4829
374	2	3	15076	6257	7398	1504	1916	3113
375	1	3	6338	2256	1668	1492	311	686
376	1	3	5841	1450	1162	597	476	70

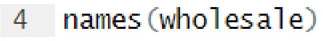
377	2	3	3136	8630	13586	5641		4666	1426
378	1	3	38793	3154	2648	1034		96	1242
379	1	3	3225	3294	1902	282		68	1114
380	2	3	4048	5164	10391	130		813	179
381	1	3	28257	944	2146	3881		600	270
382	1	3	17770	4591	1617	9927		246	532
383	1	3	34454	7435	8469	2540		1711	2893
384	1	3	1821	1364	3450	4006		397	361
385	1	3	10683	21858	15400	3635		282	5120
386	1	3	11635	922	1614	2583		192	1068
387	1	3	1206	3620	2857	1945		353	967
388	1	3	20918	1916	1573	1960		231	961
389	1	3	9785	848	1172	1677		200	406
390	1	3	9385	1530	1422	3019		227	684
391	1	3	3352	1181	1328	5502		311	1000
392	1	3	2647	2761	2313	907		95	1827
393	1	3	518	4180	3600	659		122	654
394	1	3	23632	6730	3842	8620		385	819
395	1	3	12377	865	3204	1398		149	452
396	1	3	9602	1316	1263	2921		841	290
397	2	3	4515	11991	9345	2644		3378	2213
398	1	3	11535	1666	1428	6838		64	743
399	1	3	11442	1032	582	5390		74	247
400	1	3	9612	577	935	1601		469	375
401	1	3	4446	906	1238	3576		153	1014
402	1	3	27167	2801	2128	13223		92	1902
403	1	3	26539	4753	5091	220		10	340
404	1	3	25606	11006	4604	127		632	288
405	1	3	18073	4613	3444	4324		914	715
406	1	3	6884	1046	1167	2069		593	378
407	1	3	25066	5010	5026	9806		1092	960
408	2	3	7362	12844	18683	2854		7883	553
409	2	3	8257	3880	6407	1646		2730	344
410	1	3	8708	3634	6100	2349		2123	5137
411	1	3	6633	2096	4563	1389		1860	1892
412	1	3	2126	3289	3281	1535		235	4365
413	1	3	97	3605	12400	98		2970	62
414	1	3	4983	4859	6633	17866		912	2435
415	1	3	5969	1990	3417	5679		1135	290
416	2	3	7842	6046	8552	1691		3540	1874
417	2	3	4389	10940	10908	848		6728	993
418	1	3	5065	5499	11055	364		3485	1063
419	2	3	660	8494	18622	133		6740	776
420	1	3	8861	3783	2223	633		1580	1521
421	1	3	4456	5266	13227	25		6818	1393
422	2	3	17063	4847	9053	1031		3415	1784
423	1	3	26400	1377	4172	830		948	1218
424	2	3	17565	3686	4657	1059		1803	668
425	2	3	16980	2884	12232	874		3213	249
426	1	3	11243	2408	2593	15348		108	1886



```
427        1       3  13134  9347    14316   3141             5079        1894
428        1       3  31012 16687     5429  15082              439        1163
429        1       3   3047  5970     4910   2198              850         317
430        1       3   8607  1750     3580     47               84        2501
431        1       3   3097  4230    16483    575              241        2080
432        1       3   8533  5506     5160  13486             1377        1498
433        1       3  21117  1162     4754    269             1328         395
434        1       3   1982  3218     1493   1541              356        1449
435        1       3  16731  3922     7994    688             2371         838
436        1       3  29703 12051    16027  13135              182        2204
437        1       3  39228  1431      764   4510               93        2346
438        2       3  14531 15488    30243    437            14841        1867
439        1       3  10290  1981     2232   1038              168        2125
440        1       3   2787  1698     2510     65              477          52
```

It is the output of the dataset which is import in Rstudio.

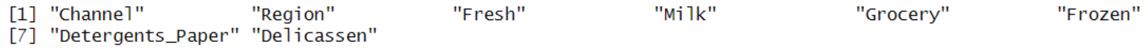
To see the column name of the data set:



```
names(wholesale)
```

This code is to see the column name of the dataset. Here with this code can see the attributes names.

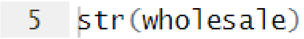
Output:



```
[1] "Channel"          "Region"           "Fresh"            "Milk"             "Grocery"          "Frozen"          
[7] "Detergents_Paper" "Delicassen"
```

The output of the name() function where we can see the attributes of the dataset.

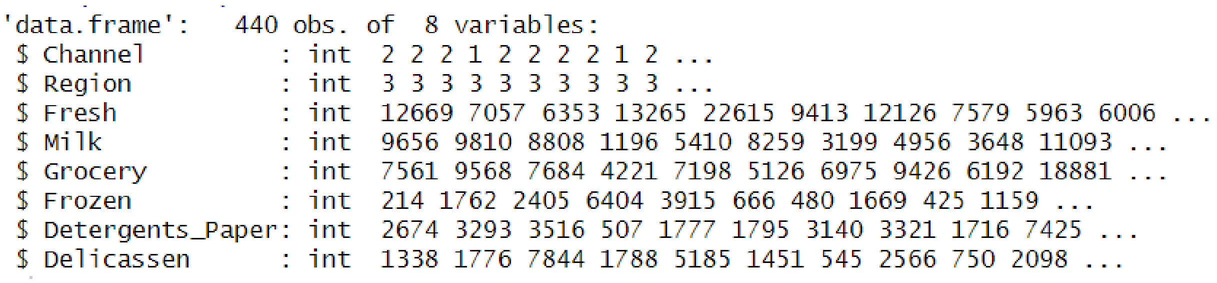
Summary of the structure of data set:



```
str(wholesale)
```

Here is the code to see the summary of the structure of dataset.

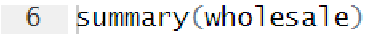
Output:



```
'data.frame':   440 obs. of  8 variables:
 $ Channel         : int  2 2 2 1 2 2 2 2 1 2 ...
 $ Region          : int  3 3 3 3 3 3 3 3 3 3 ...
 $ Fresh           : int  12669 7057 6353 13265 22615 9413 12126 7579 5963 6006 ...
 $ Milk            : int  9656 9810 8808 1196 5410 8259 3199 4956 3648 11093 ...
 $ Grocery         : int  7561 9568 7684 4221 7198 5126 6975 9426 6192 18881 ...
 $ Frozen          : int  214 1762 2405 6404 3915 666 480 1669 425 1159 ...
 $ Detergents_Paper: int  2674 3293 3516 507 1777 1795 3140 3321 1716 7425 ...
 $ Delicassen      : int  1338 1776 7844 1788 5185 1451 545 2566 750 2098 ...
```

In the output we can see the summary of the structure of the dataset. The dataset has 440 observations (rows) and 8 variables (columns). Also here is showed the data types of the dataset.

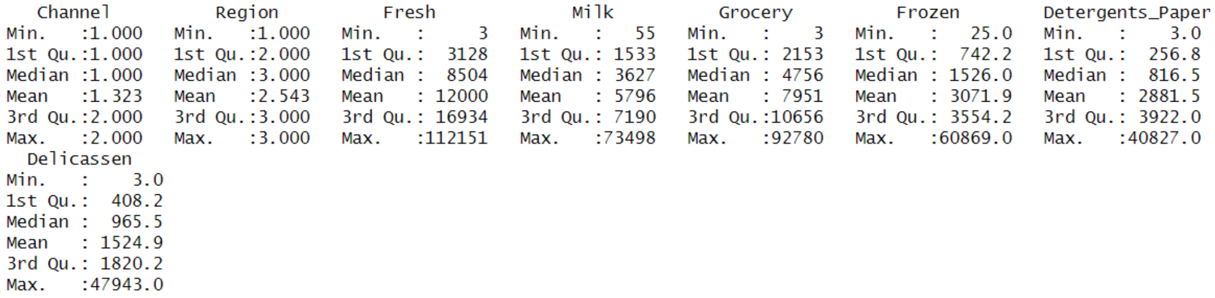
Descriptive Statistics Using summary() Function:



```
summary(wholesale)
```

Here is the code to see the descriptive Statistics. To see descriptive statistic we use the summary() function.

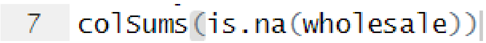
Output:



```
    Channel          Region          Fresh             Milk          Grocery          Frozen        Detergents_Paper
 Min.   :1.000   Min.   :1.000   Min.   :     3   Min.   :   55   Min.   :    3   Min.   :   25.0   Min.   :    3.0  
 1st Qu.:1.000   1st Qu.:2.000   1st Qu.:  3128   1st Qu.: 1533   1st Qu.: 2153   1st Qu.:  742.2   1st Qu.:  256.8  
 Median :1.000   Median :3.000   Median :  8504   Median : 3627   Median : 4756   Median : 1526.0   Median :  816.5  
 Mean   :1.323   Mean   :2.543   Mean   : 12000   Mean   : 5796   Mean   : 7951   Mean   : 3071.9   Mean   : 2881.5  
 3rd Qu.:2.000   3rd Qu.:3.000   3rd Qu.: 16934   3rd Qu.: 7190   3rd Qu.:10656   3rd Qu.: 3554.2   3rd Qu.: 3922.0  
 Max.   :2.000   Max.   :3.000   Max.   :112151   Max.   :73498   Max.   :92780   Max.   :60869.0   Max.   :40827.0  
   Delicassen     
 Min.   :    3.0  
 1st Qu.:  408.2  
 Median :  965.5  
 Mean   : 1524.9  
 3rd Qu.: 1820.2  
 Max.   :47943.0  
```

In the output here min, max, median, and mean are shown.

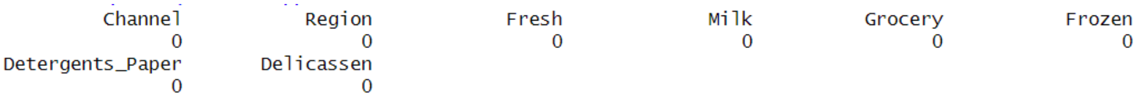
Counting number of Missing values in each column:



```
colSums(is.na(wholesale))
```

Here the code for counting number of missing values in each column.

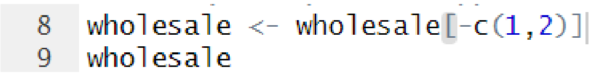
Output:



```
         Channel           Region            Fresh             Milk          Grocery           Frozen 
               0                0                0                0                0                0 
Detergents_Paper       Delicassen 
               0                0 
```

In this output we can see there is no missing value.

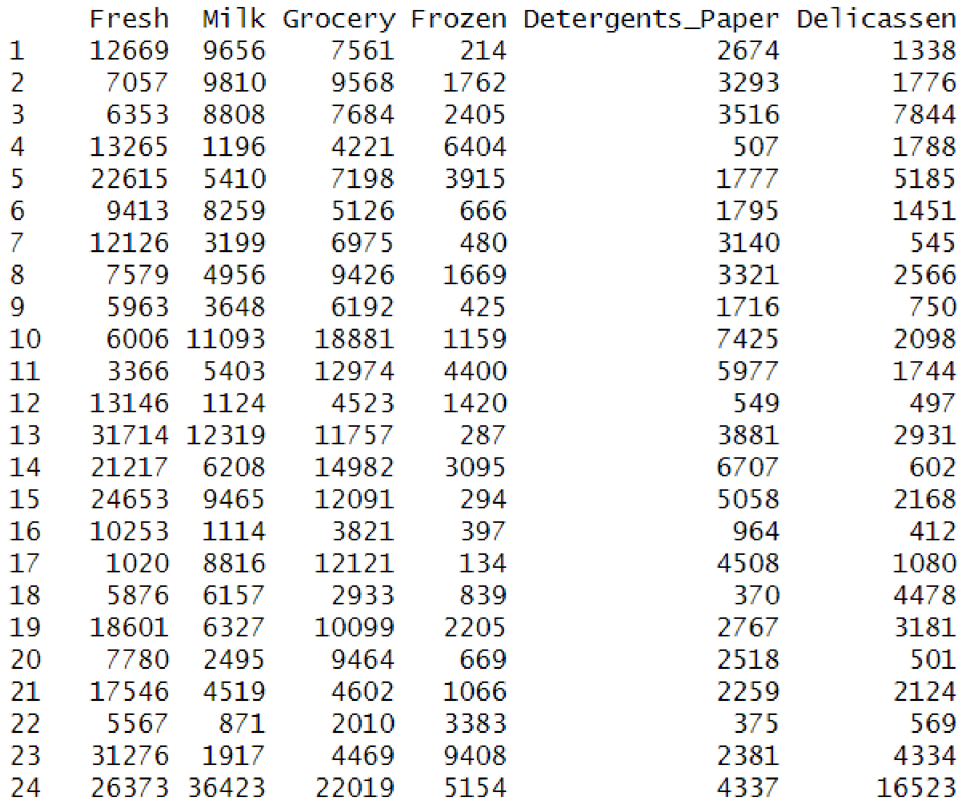
Data Preparation:



```
wholesale <- wholesale[-c(1,2)]
wholesale
```

All the attributes are of same scale except “channel” and “region”. We can ignore those attributes for clustering and normalization is not required.

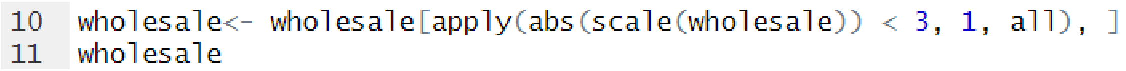
Output:



```
     Fresh  Milk Grocery Frozen Detergents_Paper Delicassen
1    12669  9656    7561    214             2674       1338
2     7057  9810    9568   1762             3293       1776
3     6353  8808    7684   2405             3516       7844
4    13265  1196    4221   6404              507       1788
5    22615  5410    7198   3915             1777       5185
6     9413  8259    5126    666             1795       1451
7    12126  3199    6975    480             3140        545
8     7579  4956    9426   1669             3321       2566
9     5963  3648    6192    425             1716        750
10    6006 11093   18881   1159             7425       2098
11    3366  5403   12974   4400             5977       1744
12   13146  1124    4523   1420              549        497
13   31714 12319   11757    287             3881       2931
14   21217  6208   14982   3095             6707        602
15   24653  9465   12091    294             5058       2168
16   10253  1114    3821    397              964        412
17    1020  8816   12121    134             4508       1080
18    5876  6157    2933    839              370       4478
19   18601  6327   10099   2205             2767       3181
20    7780  2495    9464    669             2518        501
21   17546  4519    4602   1066             2259       2124
22    5567   871    2010   3383              375        569
23   31276  1917    4469   9408             2381       4334
24   26373 36423   22019   5154             4337      16523
```

In this output we can see channel and region attribute are removed.

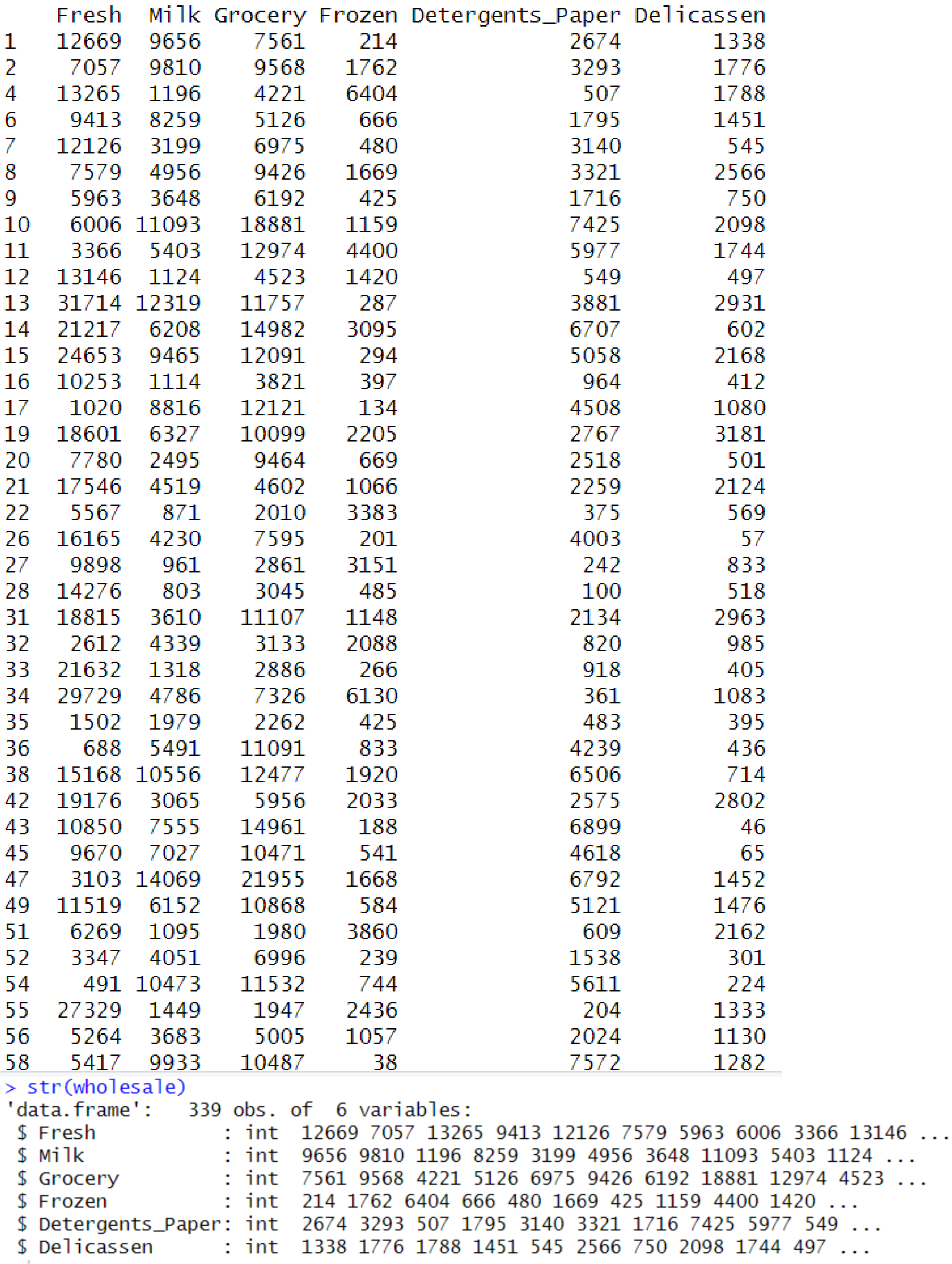
Remove Outlier:



```
wholesale<- wholesale[apply(abs(scale(wholesale)) < 3, 1, all), ]
wholesale
```

This code is use to remove outliers using z score method. Here scale normalize the data then abs is used to calculate absolute value. Rows whose z score is greater than 3 and less than -3 is removed.

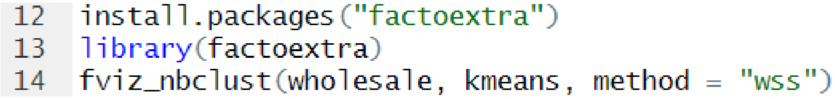
Output:



```
    Fresh   Milk Grocery Frozen Detergents_Paper Delicassen
1   12669   9656    7561    214             2674       1338
2    7057   9810    9568   1762             3293       1776
4   13265   1196    4221   6404              507       1788
6    9413   8259    5126    666             1795       1451
7   12126   3199    6975    480             3140        545
8    7579   4956    9426   1669             3321       2566
9    5963   3648    6192    425             1716        750
10   6006  11093   18881   1159             7425       2098
11   3366   5403   12974   4400             5977       1744
12  13146   1124    4523   1420              549        497
13  31714  12319   11757    287             3881       2931
14  21217   6208   14982   3095             6707        602
15  24653   9465   12091    294             5058       2168
16  10253   1114    3821    397              964        412
17   1020   8816   12121    134             4508       1080
19  18601   6327   10099   2205             2767       3181
20   7780   2495    9464    669             2518        501
21  17546   4519    4602   1066             2259       2124
22   5567    871    2010   3383              375        569
26  16165   4230    7595    201             4003         57
27   9898    961    2861   3151              242        833
28  14276    803    3045    485              100        518
31  18815   3610   11107   1148             2134       2963
32   2612   4339    3133   2088              820        985
33  21632   1318    2886    266              918        405
34  29729   4786    7326   6130              361       1083
35   1502   1979    2262    425              483        395
36    688   5491   11091    833             4239        436
38  15168  10556   12477   1920             6506        714
42  19176   3065    5956   2033             2575       2802
43  10850   7555   14961    188             6899         46
45   9670   7027   10471    541             4618         65
47   3103  14069   21955   1668             6792       1452
49  11519   6152   10868    584             5121       1476
51   6269   1095    1980   3860              609       2162
52   3347   4051    6996    239             1538        301
54    491  10473   11532    744             5611        224
55  27329   1449    1947   2436              204       1333
56   5264   3683    5005   1057             2024       1130
58   5417   9933   10487     38             7572       1282
> str(wholesale)
'data.frame':	339 obs. of  6 variables:
 $ Fresh           : int  12669 7057 13265 9413 12126 7579 5963 6006 3366 13146 ...
 $ Milk            : int  9656 9810 1196 8259 3199 4956 3648 11093 5403 1124 ...
 $ Grocery         : int  7561 9568 4221 5126 6975 9426 6192 18881 12974 4523 ...
 $ Frozen          : int  214 1762 6404 666 480 1669 425 1159 4400 1420 ...
 $ Detergents_Paper: int  2674 3293 507 1795 3140 3321 1716 7425 5977 549 ...
 $ Delicassen      : int  1338 1776 1788 1451 545 2566 750 2098 1744 497 ...
```

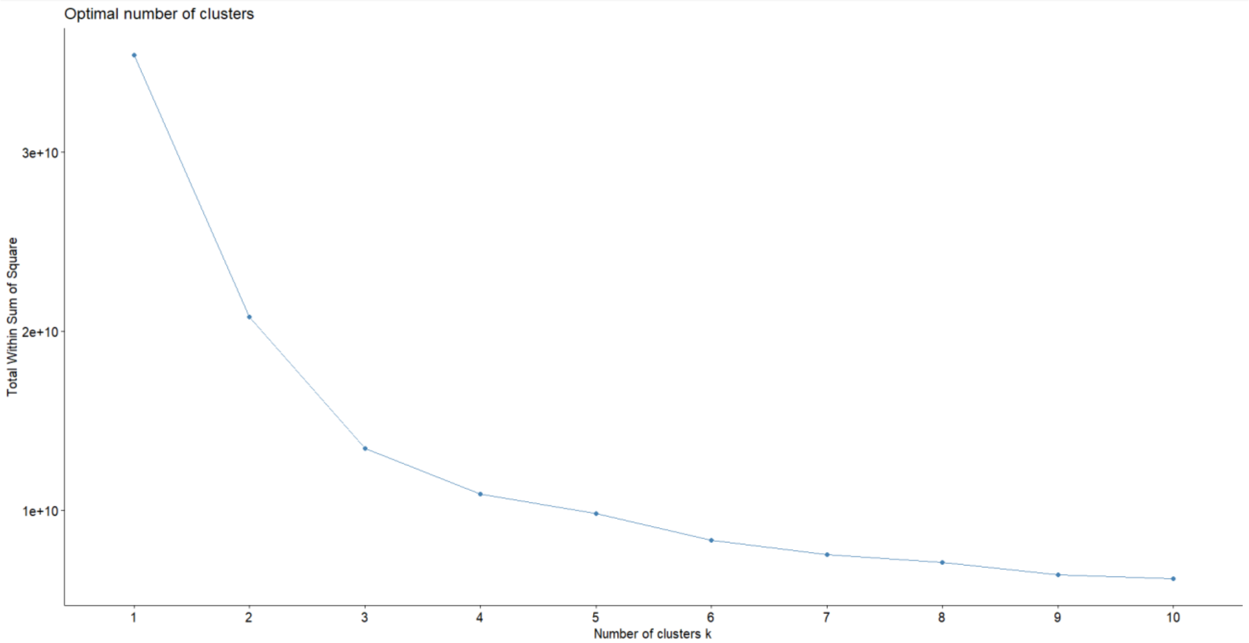
In the output after remove the outlier we found 339 instances from 440 instances.

Estimating the Optimal number of Cluster:

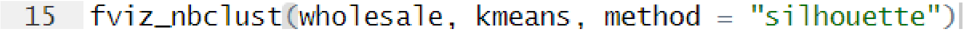


```
install.packages("factoextra")
library(factoextra)
fviz_nbclust(wholesale, kmeans, method = "wss")
```

Output:

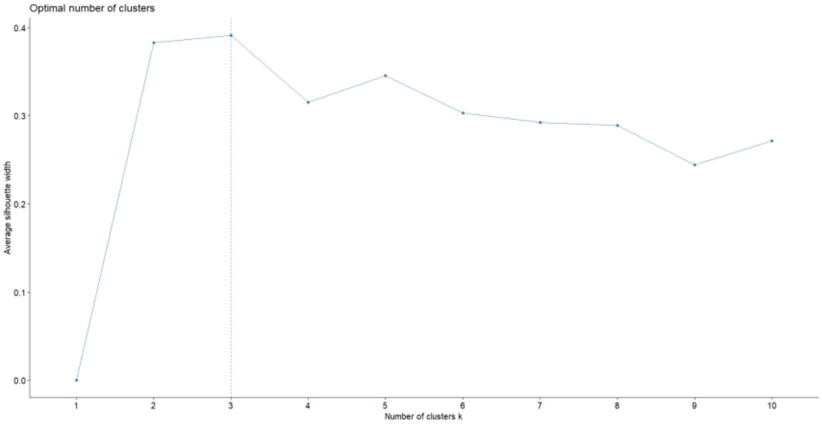


Here WSS method is used to determine the optimal number of clusters for the data. Here the plot shows the relation between the total WSS and the number of clusters. Here the bend is 5 to 4.

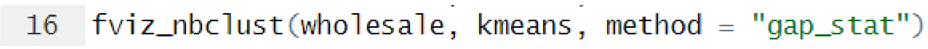


```
fviz_nbclust(wholesale, kmeans, method = "silhouette")
```

Output:

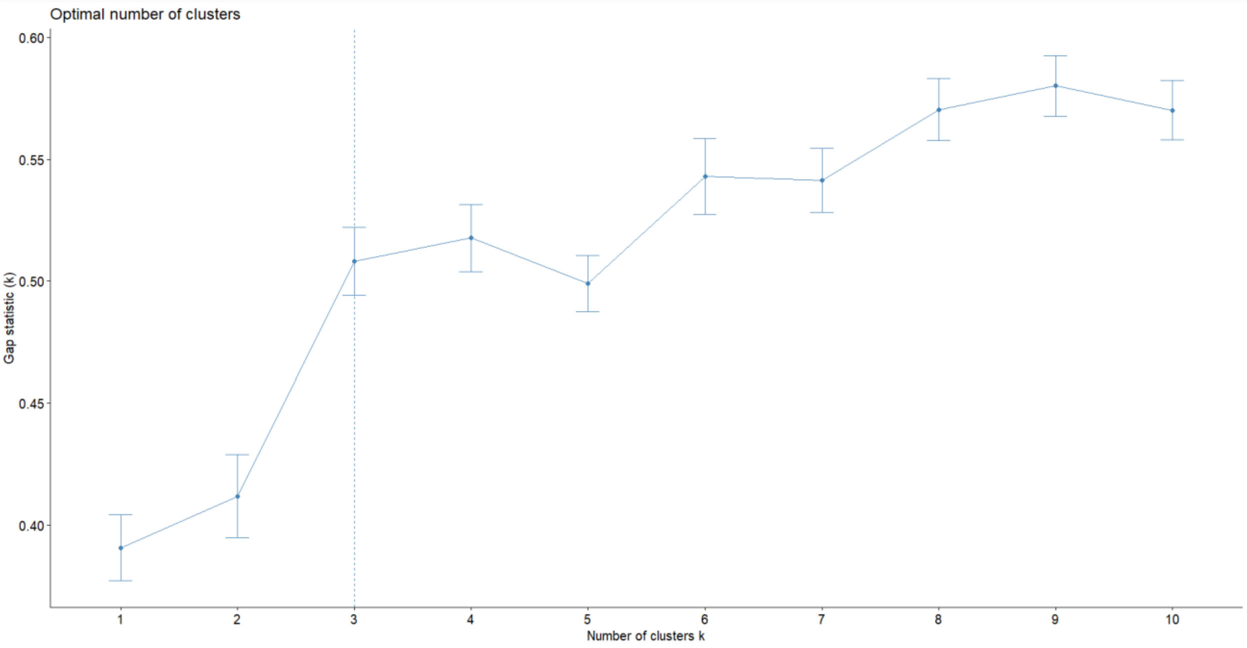


Here Silhouette method is a measure of the quality of a clustering solution that takes into account both how well each data point is assigned to its own cluster (cohesion) and how distinct the cluster is from other clusters (separation). Here the highest score is 3.



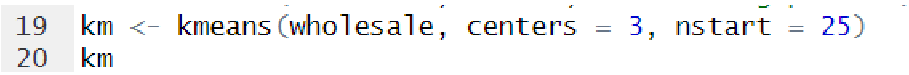
```
fviz_nbclust(wholesale, kmeans, method = "gap_stat")
```

Output:



Here the highest point is 9 and the 3 is the baseline of this plot.

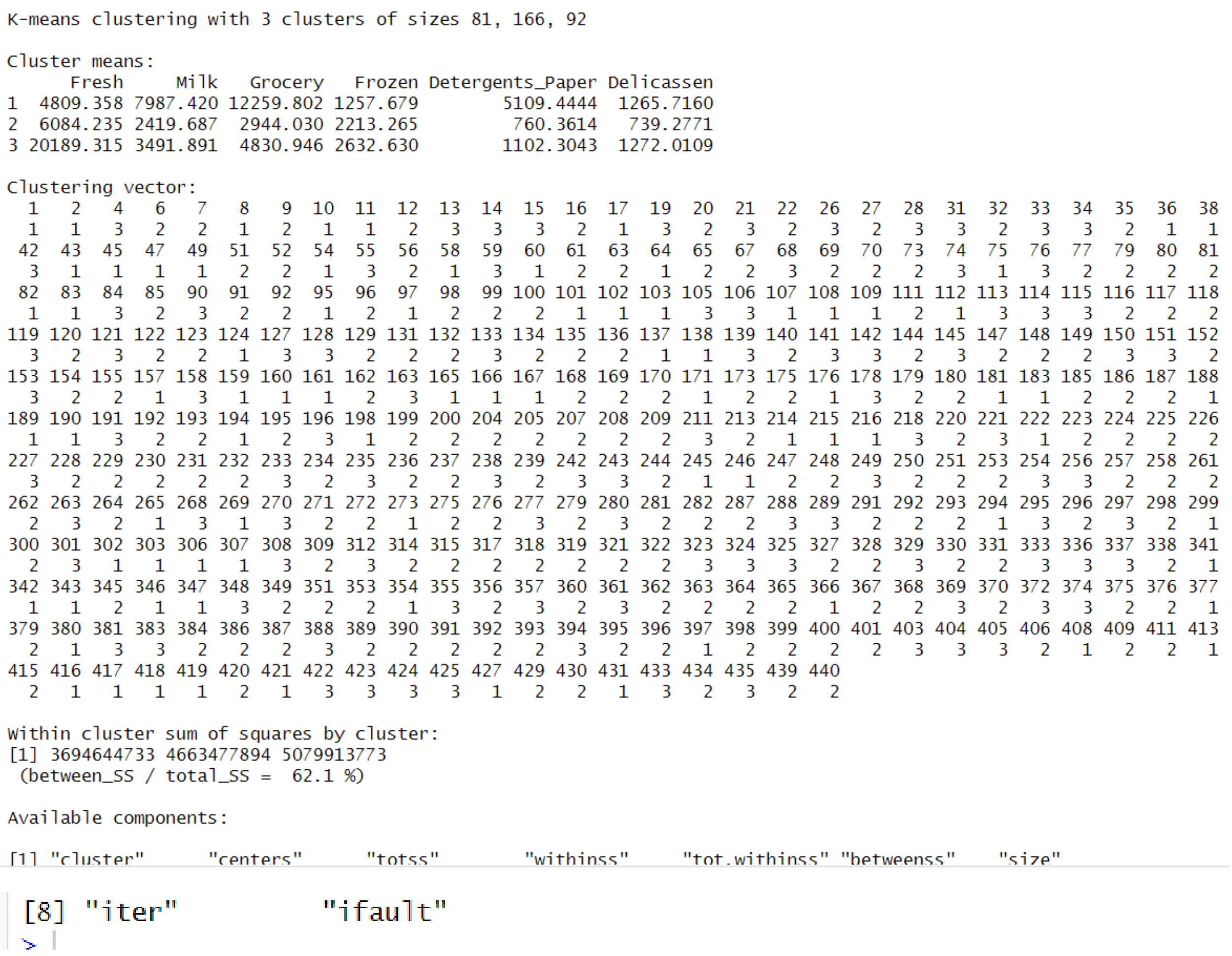
Perform K-means Clustering Algorithm on Dataset:



```
km <- kmeans(wholesale, centers = 3, nstart = 25)
km
```

Here the number of clusters set we consider is 3. The “nstart” parameter controls the number of times the clustering algorithm is run with different initial starting points.

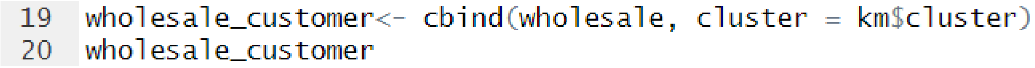
Output:



```
K-means clustering with 3 clusters of sizes 81, 166, 92

Cluster means:
      Fresh     Milk   Grocery   Frozen Detergents_Paper Delicassen
1  4809.358 7987.420 12259.802 1257.679        5109.4444  1265.7160
2  6084.235 2419.687  2944.030 2213.265         760.3614   739.2771
3 20189.315 3491.891  4830.946 2632.630        1102.3043  1272.0109

Clustering vector:
  1   2   4   6   7   8   9  10  11  12  13  14  15  16  17  19  20  21  22  26  27  28  31  32  33  34  35  36  38 
  1   1   3   2   2   1   2   1   1   2   3   3   3   2   1   3   2   3   2   3   2   3   3   2   3   3   2   1   1 
 42  43  45  47  49  51  52  54  55  56  58  59  60  61  63  64  65  67  68  69  70  73  74  75  76  77  79  80  81 
  3   1   1   1   1   2   2   1   3   2   1   3   1   2   2   1   2   2   3   2   2   2   3   1   3   2   2   2   2 
 82  83  84  85  90  91  92  95  96  97  98  99 100 101 102 103 105 106 107 108 109 111 112 113 114 115 116 117 118 
  1   1   3   2   3   2   2   1   2   1   2   2   2   1   1   1   3   3   1   1   1   2   1   3   3   3   2   2   2 
119 120 121 122 123 124 127 128 129 131 132 133 134 135 136 137 138 139 140 141 142 144 145 147 148 149 150 151 152 
  3   2   3   2   2   1   3   3   2   2   2   3   2   2   2   1   1   3   2   3   3   2   3   2   2   2   3   3   2 
153 154 155 157 158 159 160 161 162 163 165 166 167 168 169 170 171 173 175 176 178 179 180 181 183 185 186 187 188 
  3   2   2   1   3   1   1   1   2   3   1   1   1   2   2   2   1   2   2   1   3   2   2   1   1   2   2   2   1 
189 190 191 192 193 194 195 196 198 199 200 204 205 207 208 209 211 213 214 215 216 218 220 221 222 223 224 225 226 
  1   1   3   2   2   1   2   3   1   2   2   2   2   2   2   2   3   2   1   1   1   3   2   3   1   2   2   2   2 
227 228 229 230 231 232 233 234 235 236 237 238 239 242 243 244 245 246 247 248 249 250 251 253 254 256 257 258 261 
  3   2   2   2   2   2   3   2   3   2   2   3   2   3   3   2   1   1   2   2   3   2   2   2   3   3   2   2   2 
262 263 264 265 268 269 270 271 272 273 275 276 277 279 280 281 282 287 288 289 291 292 293 294 295 296 297 298 299 
  2   3   2   1   3   1   3   2   2   1   2   2   3   2   3   2   2   2   3   3   2   2   2   1   3   2   3   2   1 
300 301 302 303 306 307 308 309 312 314 315 317 318 319 321 322 323 324 325 327 328 329 330 331 333 336 337 338 341 
  2   3   1   1   1   1   3   2   3   2   2   2   2   2   2   2   3   3   3   2   2   3   2   2   3   3   3   2   1 
342 343 345 346 347 348 349 351 353 354 355 356 357 360 361 362 363 364 365 366 367 368 369 370 372 374 375 376 377 
  1   1   2   1   1   3   2   2   2   1   3   2   3   2   3   2   2   2   2   1   2   2   3   2   3   3   2   2   1 
379 380 381 383 384 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 403 404 405 406 408 409 411 413 
  2   1   3   3   2   2   2   3   2   2   2   2   2   3   2   2   1   2   2   2   2   3   3   3   2   1   2   2   1 
415 416 417 418 419 420 421 422 423 424 425 427 429 430 431 433 434 435 439 440 
  2   1   1   1   1   2   1   3   3   3   3   1   2   2   1   3   2   3   2   2 

Within cluster sum of squares by cluster:
[1] 3694644733 4663477894 5079913773
 (between_SS / total_SS =  62.1 %)

Available components:

[1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss" "betweenss"    "size"
[8] "iter"         "ifault"
> 
```

In the output we found the 3 clusters size which are 81,166,92. Here we also found the clusters mean values and sum of squares

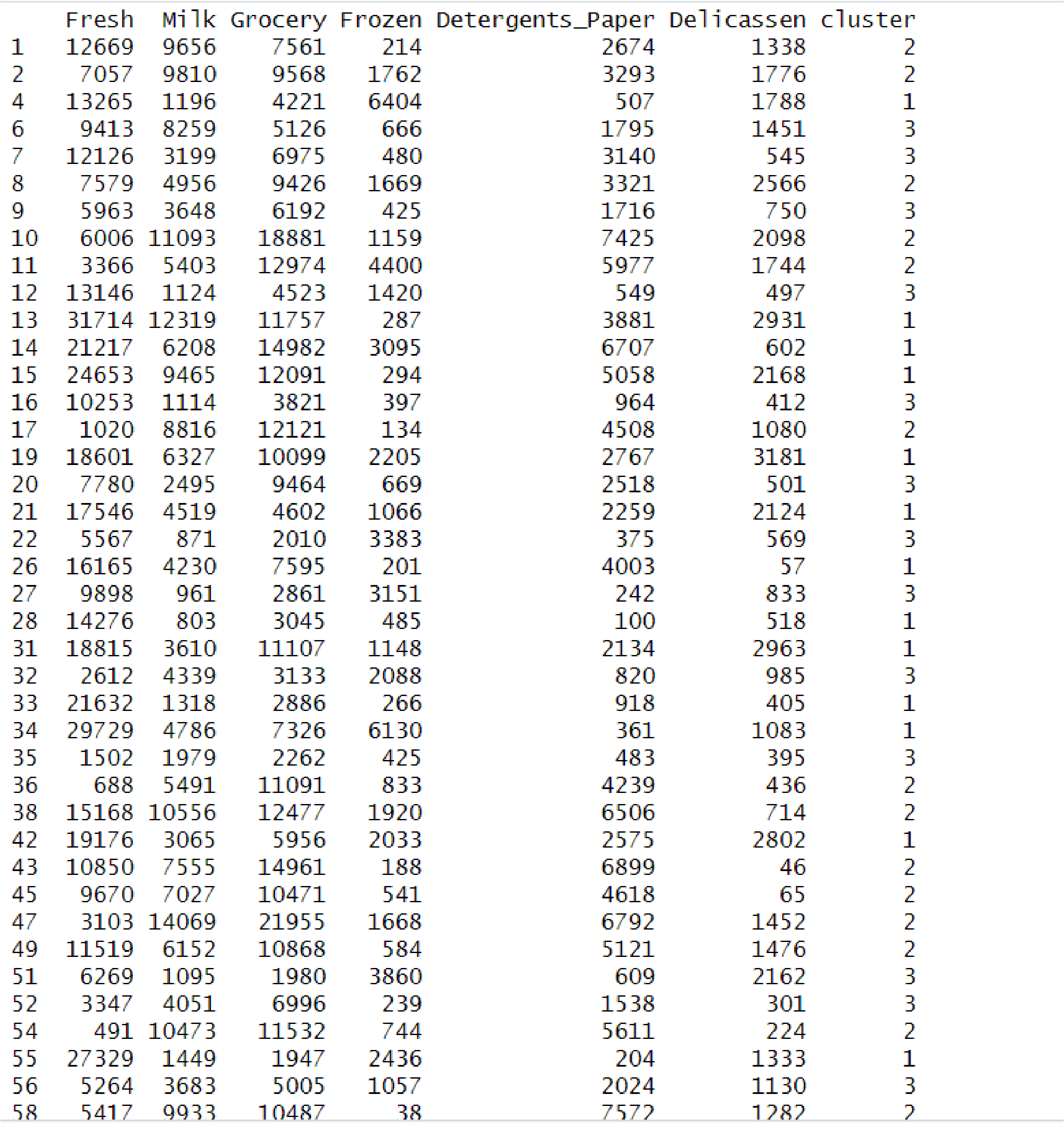
Visualize the output of K-means Clustering Algorithm:



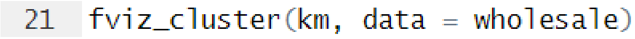
```
wholesale_customer<- cbind(wholesale, cluster = km$cluster)
wholesale_customer
```

This line of code is adding a new column to the "wholesale" dataset called "cluster". The values in this new column are determined by the cluster assignments generated by the k-means clustering algorithm stored in the km object. The cbind() function is used to combine the "wholesale" dataset with a new column containing the cluster assignments.

Output:

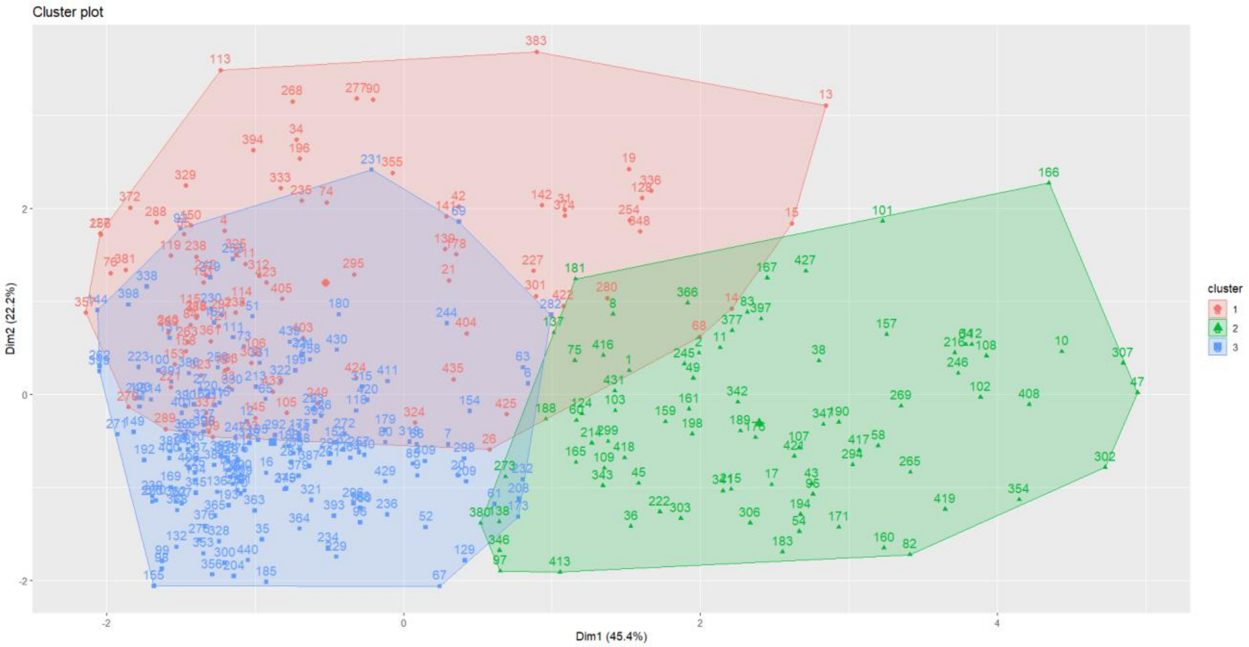


```
   Fresh  Milk Grocery Frozen Detergents_Paper Delicassen cluster
1  12669  9656    7561    214             2674       1338       2
2   7057  9810    9568   1762             3293       1776       2
4  13265  1196    4221   6404              507       1788       1
6   9413  8259    5126    666             1795       1451       3
7  12126  3199    6975    480             3140        545       3
8   7579  4956    9426   1669             3321       2566       2
9   5963  3648    6192    425             1716        750       3
10  6006 11093   18881   1159             7425       2098       2
11  3366  5403   12974   4400             5977       1744       2
12 13146  1124    4523   1420              549        497       3
13 31714 12319   11757    287             3881       2931       1
14 21217  6208   14982   3095             6707        602       1
15 24653  9465   12091    294             5058       2168       1
16 10253  1114    3821    397              964        412       3
17  1020  8816   12121    134             4508       1080       2
19 18601  6327   10099   2205             2767       3181       1
20  7780  2495    9464    669             2518        501       3
21 17546  4519    4602   1066             2259       2124       1
22  5567   871    2010   3383              375        569       3
26 16165  4230    7595    201             4003         57       1
27  9898   961    2861   3151              242        833       3
28 14276   803    3045    485              100        518       1
31 18815  3610   11107   1148             2134       2963       1
32  2612  4339    3133   2088              820        985       3
33 21632  1318    2886    266              918        405       1
34 29729  4786    7326   6130              361       1083       1
35  1502  1979    2262    425              483        395       3
36   688  5491   11091    833             4239        436       2
38 15168 10556   12477   1920             6506        714       2
42 19176  3065    5956   2033             2575       2802       1
43 10850  7555   14961    188             6899         46       2
45  9670  7027   10471    541             4618         65       2
47  3103 14069   21955   1668             6792       1452       2
49 11519  6152   10868    584             5121       1476       2
51  6269  1095    1980   3860              609       2162       3
52  3347  4051    6996    239             1538        301       3
54   491 10473   11532    744             5611        224       2
55 27329  1449    1947   2436              204       1333       1
56  5264  3683    5005   1057             2024       1130       3
58  5417  9933   10487     38             7572       1282       2
```



```
fviz_cluster(km, data = wholesale)
```

Output:



The fviz_cluster() function is used to create a visualization of the clusters generated by a clustering algorithm. Here this plots I consider 3 clusters. Here 3 clusters are overlapping with each other because here may be different clusters in terms of the types and quantities of products purchased by the customers. Here "Dim1 (45.4%)" and "Dim2 (22.2%)" in the plot means that Dim1 explains 45.4% of the total variance in the data, and Dim2 explains 22.2% of the total variance.