Clustering for Pairs

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Objective

In this markdown, we look at housing variables by census tract to determine which census tracts are similar to one another. We will be deploying KMeans algorithm to some selected for some selected variables

Libraries

```
require(rio) #For loading data sets
```

```
## Loading required package: rio
```

```
## Warning: package 'rio' was built under R version 3.3.2
```

```
require(cluster) #clustering algorithms
```

```
## Loading required package: cluster
```

```
require(factoextra) #clustering algorithms & visualization
```

```
## Loading required package: factoextra
```

```
## Warning: package 'factoextra' was built under R version 3.3.2
```

```
## Loading required package: ggplot2
```

```
## Warning: package 'ggplot2' was built under R version 3.3.2
```

```
## Welcome! Related Books: `Practical Guide To Cluster Analysis in R` at https://goo.gl/13EFCZ
```

```
require(tidyr) #For data manipulation
```

```
## Loading required package: tidyr
```

```
## Warning: package 'tidyr' was built under R version 3.3.2
```

```
library(mi) #For data missingness analysis
```

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'Matrix'
```

```
## The following object is masked from 'package:tidyr':
##
##     expand
```

```
## Loading required package: stats4
```

```
## mi (Version 1.0, packaged: 2015-04-16 14:03:10 UTC; goodrich)
```

```
## mi  Copyright (C) 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 Trustees of Columbia University
```

```
## This program comes with ABSOLUTELY NO WARRANTY.
```

```
## This is free software, and you are welcome to redistribute it
```

```
## under the General Public License version 2 or later.
```

```
## Execute RShowDoc('COPYING') for details.
```

```
##
## Attaching package: 'mi'

## The following object is masked from 'package:tidyr':
##
##     complete
```

```
require(NbClust)
```

```
## Loading required package: NbClust
```

Loading Cleaned data from Monica

```
ct_housingdata <- import("../data/processing/CT_HHinfo_Full.csv")
```

Initial Explorations

```
head(ct_housingdata)
```

```
##   V1  CT_id_full med_rent_00 med_rent_10 med_rent_15 hhinc_all_00
## 1  1 36005000100          NA          NA          NA           NA
## 2  2 36005000200   1000.0000    1383.696        1358     54420.55
## 3  3 36005000400    876.7123    1445.652        1448     49026.03
## 4  4 36005000500          NA          NA          NA           NA
## 5  5 36005001100    660.2740          NA          NA     35508.22
## 6  6 36005001500    993.1507          NA          NA     35958.90
##   hhinc_owners_00 hhinc_renters_00 hhinc_all_10 hhinc_owners_10
## 1              NA               NA          NA              NA
## 2        69064.38         37227.40     65028.26        87677.17
## 3        65924.66         30620.55     78226.09        99789.13
## 4              NA               NA          NA              NA
## 5        76565.75         23845.21          NA              NA
## 6              NA         35958.90          NA              NA
##   hhinc_renters_10 hhinc_all_15 hhinc_owners_15 hhinc_renters_15
## 1               NA           NA              NA               NA
## 2         47894.57        72034          104091            42566
## 3         53419.57        74836           85293            27500
## 4               NA           NA              NA               NA
## 5               NA           NA              NA               NA
## 6               NA           NA              NA               NA
##   pct_inc_rent_00 pct_inc_rent_10 pct_inc_rent_15 total_hh_00 owner_hh_00
## 1             0.0              NA              NA          0           0
## 2            25.5            34.1            42.0       1105         672
## 3            33.5            29.8            39.2       1074         600
## 4             0.0              NA              NA          0           0
## 5            31.5              NA              NA        150          60
## 6            32.5              NA              NA         10           0
##   renter_hh_00 own_rate_00 owner_1ymoved_00 renter_1ymoved_00
## 1            0          NA                0                 0
## 2          433   0.6081448               48               114
## 3          474   0.5586592               70               114
## 4            0          NA                0                 0
## 5           90   0.4000000                0                23
## 6           10   0.0000000                0                 0
##   tot_1ymoved_00 sh_1ymoved_00 owner_5ymoved_00 renter_5ymoved_00
```

```
## 1              0           NA               0                0
## 2            162     0.1466063             185              258
## 3            184     0.1713222             233              334
## 4              0           NA               0                0
## 5             23     0.1533333               5               54
## 6              0     0.0000000               0                0
##   tot_5ymoved_00 sh_5ymoved_00 total_hh_10 owner_hh_10 renter_hh_10
## 1              0           NA          0           0            0
## 2            443     0.1466063       1297         784          513
## 3            567     0.1713222       1531         939          592
## 4              0           NA         NA          NA           NA
## 5             59     0.1533333         NA          NA           NA
## 6              0     0.0000000         NA          NA           NA
##   own_rate_10 owner_1ymoved_10 renter_1ymoved_10 tot_1ymoved_10
## 1          NA                0                 0              0
## 2   0.6044719              166               299            465
## 3   0.6133246              206               336            542
## 4          NA               NA                NA             NA
## 5          NA               NA                NA             NA
## 6          NA               NA                NA             NA
##   sh_1ymoved_10 owner_5ymoved_10 renter_5ymoved_10 tot_5ymoved_10
## 1            NA                0                 0              0
## 2     0.3585197              343               422            765
## 3     0.3540170              388               497            885
## 4            NA               NA                NA             NA
## 5            NA               NA                NA             NA
## 6            NA               NA                NA             NA
##   sh_5ymoved_10 total_hh_15 owner_hh_15 renter_hh_15 own_rate_15
## 1            NA          0           0            0          NA
## 2     0.3585197       1379         696          683   0.5047136
## 3     0.3540170       1921        1403          518   0.7303488
## 4            NA         NA          NA           NA          NA
## 5            NA         NA          NA           NA          NA
## 6            NA         NA          NA           NA          NA
##   owner_1ymoved_15 renter_1ymoved_15 tot_1ymoved_15 sh_1ymoved_15
## 1                0                 0              0            NA
## 2                0                 0              0             0
## 3                0                 0              0             0
## 4               NA                NA             NA            NA
## 5               NA                NA             NA            NA
## 6               NA                NA             NA            NA
##   owner_5ymoved_15 renter_5ymoved_15 tot_5ymoved_15 sh_5ymoved_15
## 1                0                 0              0            NA
## 2               27               285            312             0
## 3              195               183            378             0
## 4               NA                NA             NA            NA
## 5               NA                NA             NA            NA
## 6               NA                NA             NA            NA
##   shwhite_hh_00 shblack_hh_00 shasian_hh_00 shother_hh_00 shwhite_hh_10
## 1            NA           NA           NA           NA           NA
## 2     0.3529412    0.2841629   0.00000000    0.3628959    0.1210486
## 3     0.3342644    0.2914339   0.02979516    0.3445065    0.1293272
## 4            NA           NA           NA           NA           NA
## 5     0.5866667    0.2066667   0.00000000    0.2066667           NA
```

```
## 6     0.0000000     1.0000000    0.00000000     0.0000000           NA
##   shblack_hh_10 shasian_hh_10 shother_hh_10 shwhite_hh_15 shblack_hh_15
## 1            NA            NA            NA            NA           NA
## 2     0.2837317    0.05551272            NA     0.4118927    0.2414793
## 3     0.2638798    0.01632920            NA     0.3529412    0.3675169
## 4            NA            NA            NA            NA           NA
## 5            NA            NA            NA            NA           NA
## 6            NA            NA            NA            NA           NA
##   shasian_hh_15 shother_hh_15   ed1_ns_00 ed2_hs_00 ed3_sc_00  ed4_bc_00
## 1            NA            NA 0.004768097 0.8634590 0.1317729 0.00000000
## 2    0.03408267            NA 0.023156900 0.6526465 0.2410208 0.08317580
## 3    0.01353462            NA 0.023413111 0.5863684 0.2710718 0.11914672
## 4            NA            NA          NA        NA        NA         NA
## 5            NA            NA 0.089411765 0.6494118 0.2282353 0.03294118
## 6            NA            NA 0.000000000 0.0000000 1.0000000 0.00000000
##     ed1_ns_10 ed2_hs_10 ed3_sc_10  ed4_bc_10   ed1_ns_15 ed2_hs_15
## 1 0.013848672 0.8618910 0.1012212 0.02303915 0.016489765 0.8402199
## 2 0.004419446 0.5717155 0.2812374 0.14262756 0.034055728 0.5164650
## 3 0.036624204 0.4156051 0.2907643 0.25700637 0.005438813 0.3982695
## 4          NA        NA        NA         NA          NA        NA
## 5          NA        NA        NA         NA          NA        NA
## 6          NA        NA        NA         NA          NA        NA
##   ed3_sc_15  ed4_bc_15
## 1 0.1305914 0.01269901
## 2 0.2921475 0.15733183
## 3 0.3644005 0.23189122
## 4        NA         NA
## 5        NA         NA
## 6        NA         NA
```

```
print(dim(ct_housingdata))
```

```
## [1] 2217   77
```

There appears to be data missing problems. K-Means cannot handle clustering with missing data. We will either have to remove it or impute it later. For now, let's look at the pattern of missingness. Before that, let's only pare the data frame down to the variables of interest for us.

Puning the data frame to Variable of Interest

Of the 25 variables for each year, we are focused on **continuous** variables for initial clustering from the year 2000. Below are the variables we have picked with a short description of the variables.

- med_rent_00 : median rent income in year 2000
- hhinc_all_00 : household income all in year 2000
- hhinc_owners_00 : household income owners in year 2000 **NOT INCLUDED FOR NOW**
- hhinc_renters_00 : household income renters in year 2000 **NOT INCLUDED FOR NOW**
- pct_inc_rent_00 : percent of income to rent in year 2000
- own_rate_00 : percentage of owner of households in year 2000
- owner_hh_00 : number of owner household in year 2000 **NOT INCLUDED FOR NOW**
- renter_hh_00 : number of renter household in year 2000 **NOT INCLUDED FOR NOW**
- shwhite_hh_00 : percentage of white household in year 2000
- shblack_hh_00 : percentage of black household in year 2000 **NOT INCLUDED FOR NOW**
- shasian_hh_00 : percentage of asian household in year 2000 **NOT INCLUDED FOR NOW**
- ed1_ns_00 : percentage of education no school in year 2000

- ed2_hs_00 : percentage of education high school in year 2000 **NOT INCLUDED FOR NOW**
- ed3_sc_00 : percentage of some college education in year 2000 **NOT INCLUDED FOR NOW**
- ed4_bc_00 : percentage of bachelor college in year 2000 **NOT INCLUDED FOR NOW**

Extracting Household data of selected variables for year 2000

```
colnames(ct_housingdata)
```

```
##  [1] "V1"               "CT_id_full"        "med_rent_00"
##  [4] "med_rent_10"      "med_rent_15"       "hhinc_all_00"
##  [7] "hhinc_owners_00"  "hhinc_renters_00"  "hhinc_all_10"
## [10] "hhinc_owners_10"  "hhinc_renters_10"  "hhinc_all_15"
## [13] "hhinc_owners_15"  "hhinc_renters_15"  "pct_inc_rent_00"
## [16] "pct_inc_rent_10"  "pct_inc_rent_15"   "total_hh_00"
## [19] "owner_hh_00"      "renter_hh_00"      "own_rate_00"
## [22] "owner_1ymoved_00" "renter_1ymoved_00" "tot_1ymoved_00"
## [25] "sh_1ymoved_00"    "owner_5ymoved_00"  "renter_5ymoved_00"
## [28] "tot_5ymoved_00"   "sh_5ymoved_00"     "total_hh_10"
## [31] "owner_hh_10"      "renter_hh_10"      "own_rate_10"
## [34] "owner_1ymoved_10" "renter_1ymoved_10" "tot_1ymoved_10"
## [37] "sh_1ymoved_10"    "owner_5ymoved_10"  "renter_5ymoved_10"
## [40] "tot_5ymoved_10"   "sh_5ymoved_10"     "total_hh_15"
## [43] "owner_hh_15"      "renter_hh_15"      "own_rate_15"
## [46] "owner_1ymoved_15" "renter_1ymoved_15" "tot_1ymoved_15"
## [49] "sh_1ymoved_15"    "owner_5ymoved_15"  "renter_5ymoved_15"
## [52] "tot_5ymoved_15"   "sh_5ymoved_15"     "shwhite_hh_00"
## [55] "shblack_hh_00"    "shasian_hh_00"     "shother_hh_00"
## [58] "shwhite_hh_10"    "shblack_hh_10"     "shasian_hh_10"
## [61] "shother_hh_10"    "shwhite_hh_15"     "shblack_hh_15"
## [64] "shasian_hh_15"    "shother_hh_15"     "ed1_ns_00"
## [67] "ed2_hs_00"        "ed3_sc_00"         "ed4_bc_00"
## [70] "ed1_ns_10"        "ed2_hs_10"         "ed3_sc_10"
## [73] "ed4_bc_10"        "ed1_ns_15"         "ed2_hs_15"
## [76] "ed3_sc_15"        "ed4_bc_15"
```

Household data extract for Year 2000

```
ct_housing_2000 <- ct_housingdata[,c(2,3,6,15,21,54,66)]
row.names(ct_housing_2000) <- ct_housing_2000$CT_id_full
ct_housing_2000 <- ct_housing_2000[,-1]
head(ct_housing_2000)
```

```
##             med_rent_00 hhinc_all_00 pct_inc_rent_00 own_rate_00
## 36005000100          NA           NA            0.0          NA
## 36005000200   1000.0000     54420.55           25.5   0.6081448
## 36005000400    876.7123     49026.03           33.5   0.5586592
## 36005000500          NA           NA            0.0          NA
## 36005001100    660.2740     35508.22           31.5   0.4000000
## 36005001500    993.1507     35958.90           32.5   0.0000000
##             shwhite_hh_00   ed1_ns_00
## 36005000100            NA 0.004768097
## 36005000200     0.3529412 0.023156900
## 36005000400     0.3342644 0.023413111
## 36005000500            NA          NA
## 36005001100     0.5866667 0.089411765
```

```
## 36005001500     0.0000000 0.000000000
```

Missingness examiniations

```
mdf = missing_data.frame(ct_housing_2000)
```

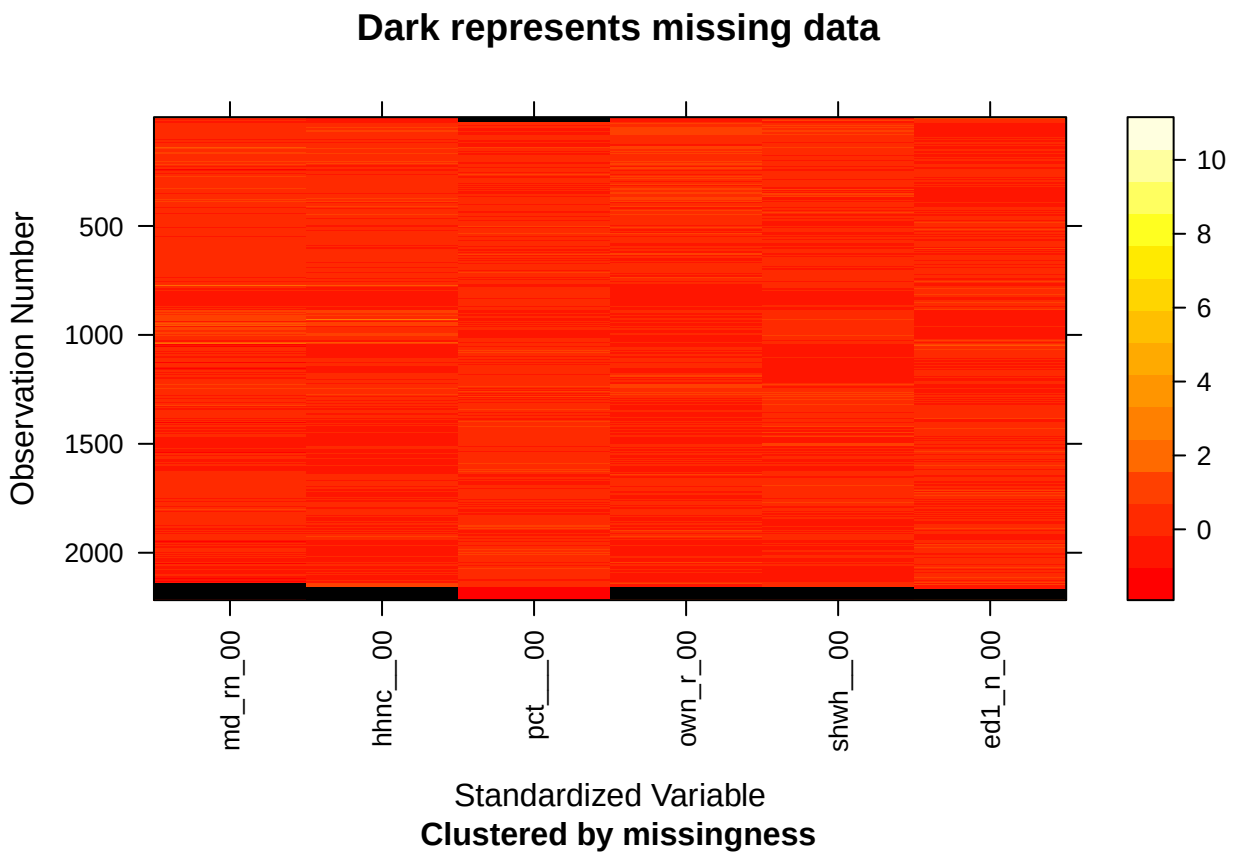
```
## Loading required namespace: betareg
```

```
## NOTE: In the following pairs of variables, the missingness pattern of the second is a subset of the f
##  Please verify whether they are in fact logically distinct variables.
##      [,1]            [,2]
## [1,] "med_rent_00"   "own_rate_00"
## [2,] "med_rent_00"   "shwhite_hh_00"
## [3,] "med_rent_00"   "ed1_ns_00"
## [4,] "hhinc_all_00"  "own_rate_00"
## [5,] "hhinc_all_00"  "shwhite_hh_00"
## [6,] "hhinc_all_00"  "ed1_ns_00"
## [7,] "own_rate_00"   "ed1_ns_00"
## [8,] "shwhite_hh_00" "ed1_ns_00"
```

Some of the variable missingness patterns seems to be correlated with each other. What does median income of household has to do with the percentage white in that census tract? There needs to be a narrative to this story that we may want to include in the final report.

Visualizing missingness across variables

```
image(mdf)
```



The image demonstrates as wite the note above that the missingness across variables are correlated. However,

the good news is that they are clumped to certain census tracts. We can effectively remove them.

Removing the missing data

```
ct_housing_2000_no_missing <- ct_housing_2000[complete.cases(ct_housing_2000),]
print(sum(is.na(ct_housing_2000_no_missing)))
```

```
## [1] 0
```

Applying K Means Clustering

Scaling the continuous variables first

```
ct_housing_2000_no_missing <- scale(ct_housing_2000_no_missing)
print(dim(ct_housing_2000_no_missing))
```

```
## [1] 2115    6
```

```
head(ct_housing_2000_no_missing)
```

```
##             med_rent_00 hhinc_all_00 pct_inc_rent_00 own_rate_00
## 36005000200 -0.07983982  -0.02808952      -0.3879183   1.0644996
## 36005000400 -0.48261494  -0.24050901       1.1136667   0.8620157
## 36005001100 -1.18970902  -0.77279838       0.7382704   0.2128178
## 36005001500 -0.10221622  -0.75505181       0.9259686  -1.4238922
## 36005001600 -0.84958782  -0.83164797      -0.1063711  -0.7882545
## 36005001700 -1.36424490  -1.01483146       1.8081498  -0.8954342
##             shwhite_hh_00  ed1_ns_00
## 36005000200    -0.3893844 -0.2642038
## 36005000400    -0.4473174 -0.2549543
## 36005001100     0.3356038  2.1276667
## 36005001500    -1.4841653 -1.1001923
## 36005001600    -0.3131886 -0.4255131
## 36005001700    -0.9462010  1.9428084
```

Essentially, there is exactly 2115 Census Tract groups we are trying to cluster.

Implementing K-Means Cluster referencing this site: https://uc-r.github.io/kmeans_clustering

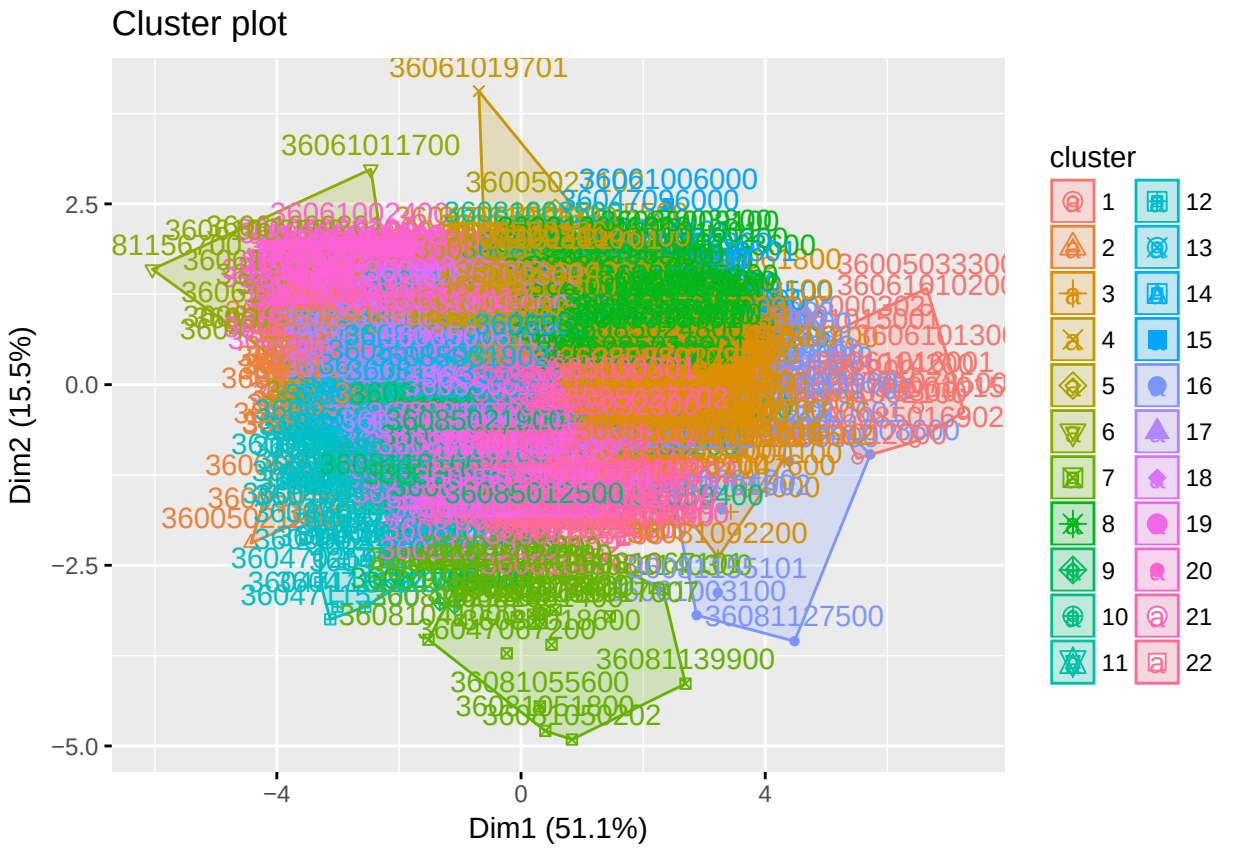
Let's assume we want around 22 clusters. We can change the size of the clusters later on. There is a method to apply to pick the optimal clusters. It will be implemented later on.

```
k22 <- kmeans(ct_housing_2000_no_missing, centers = 22, nstart = 25, iter.max = 30)
```

Visualizing the Clusters

The Census Tracts strings are very long and not visually appealing. We can maybe map them to single digits to make it more appealing on the visual plot

```
fviz_cluster(k22, data = ct_housing_2000_no_missing)
```



Examining the Clustering Structure

```
str(k22)
```

```
## List of 9
##  $ cluster     : Named int [1:2115] 14 19 2 13 18 2 20 20 2 20 ...
##   ..- attr(*, "names")= chr [1:2115] "36005000200" "36005000400" "36005001100" "36005001500" ...
##  $ centers     : num [1:22, 1:6] 3.27023 -0.69337 0.82736 -0.00147 -0.40744 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:22] "1" "2" "3" "4" ...
##   .. ..$ : chr [1:6] "med_rent_00" "hhinc_all_00" "pct_inc_rent_00" "own_rate_00" ...
##  $ totss       : num 12684
##  $ withinss    : num [1:22] 68.6 111.1 159.3 239.7 92.2 ...
##  $ tot.withinss: num 2628
##  $ betweenss   : num 10056
##  $ size        : int [1:22] 14 64 105 233 94 14 26 147 88 70 ...
##  $ iter        : int 6
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"
```

```
#Of particular interest to us would be the cluster and centers!
```

```
print(k22)
```

```
## K-means clustering with 22 clusters of sizes 14, 64, 105, 233, 94, 14, 26, 147, 88, 70, 103, 71, 137
##
## Cluster means:
```

```
##     med_rent_00 hhinc_all_00 pct_inc_rent_00 own_rate_00 shwhite_hh_00
## 1   3.270226190   5.10275897    -1.729959956  1.45623260     1.3326333
## 2  -0.693372608  -0.97936781     0.754400737 -0.99237740    -0.5331103
## 3   0.827363167   1.46422253    -0.531462717  1.76244711     1.1490679
## 4  -0.001474423   0.05866028    -0.550321527 -0.21771590     0.9318241
## 5  -0.407439771  -0.30329801    -0.687636308 -0.53646667    -1.0868992
## 6  -1.354655021  -1.06600987    -0.335631004 -0.91264465    -0.6080453
## 7   0.663056494   0.48665659     2.692496710  1.53858908    -0.6549563
## 8   0.176864616   0.71376965    -1.184166997  1.06215902     1.1458462
## 9  -0.095249024  -0.61942033     1.536200767 -0.21839431     0.8748214
## 10  0.360719430   0.79364549    -1.039767124  1.47498774    -1.1663636
## 11  0.041948594  -0.19164322    -0.004503911 -0.08897566     0.1926195
## 12 -0.582835974  -1.11181274     2.180373653 -0.74747204    -0.8980569
## 13 -0.703700254  -0.84025883     0.429322051 -0.75327999    -1.2565307
## 14  0.238934301   0.28834055    -0.358825130  0.43725203    -0.4297792
## 15  1.510085926   1.30695069    -0.831094475 -0.41018009     1.0528432
## 16  3.456663364   2.24127296    -0.356635318  0.09546535     1.0643833
## 17 -0.562281736  -0.83472672     0.361727925 -0.97300697    -0.7945082
## 18 -0.124054448  -0.43683942     0.014682266 -0.78067515     0.1737768
## 19  0.132809698  -0.26739591     1.150793788  0.37311270    -0.6843787
## 20 -1.824764476  -1.32459868    -0.223052148 -1.16867667    -0.7960901
## 21  0.246429328   0.41973602     0.355008728  1.07282007     0.9076850
## 22  0.249551496   0.49597938     0.428229304  1.38468521    -1.2563235
##      ed1_ns_00
## 1  -0.90009278
## 2   2.59449639
## 3  -0.68285384
## 4  -0.37332904
## 5  -0.43840808
## 6   5.27857843
## 7  -0.18680378
## 8  -0.64820057
## 9   0.28593088
## 10 -0.54697642
## 11  1.31377893
## 12  0.65196682
## 13 -0.32115211
## 14 -0.27332106
## 15 -0.85482737
## 16 -0.95523226
## 17  0.97988679
## 18 -0.04634857
## 19 -0.18486415
## 20  0.71096825
## 21 -0.37582059
## 22 -0.66161005
##
## Clustering vector:
## 36005000200 36005000400 36005001100 36005001500 36005001600 36005001700
##          14          19           2          13          18           2
## 36005002000 36005002300 36005002500 36005002701 36005002702 36005002800
##          20          20           2          20           2           5
## 36005003100 36005003300 36005003500 36005003600 36005003700 36005003800
##          17          20          20           5           2          14
```

```
## 36005003900 36005004001 36005004100 36005004300 36005004400 36005004600
##           2          19          20          20          20          20
## 36005004700 36005004800 36005004900 36005005000 36005005200 36005005302
##          20           2           2          12          20          17
## 36005005400 36005005600 36005005700 36005005901 36005005902 36005006000
##          17          12           5          17          13          18
## 36005006100 36005006200 36005006400 36005006500 36005006600 36005006700
##           5          20          17          17          12          20
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##          15          15          15          16          15          15
## 36061006400 36061006500 36061006600 36061006700 36061006800 36061007000
##          15          15           4          15          15          15
```

```
## 36061007100 36061007200 36061007300 36061007400 36061007500 36061007600
##          15          16          15          16          15          18
## 36061007700 36061007800 36061007900 36061008000 36061008100 36061008200
##          15          16          15          15          15          16
## 36061008300 36061008400 36061008600 36061008700 36061008800 36061008900
##          18          16          16          15          15          15
## 36061009000 36061009100 36061009200 36061009300 36061009400 36061009500
##          16          15          15           4          12          15
## 36061009600 36061009700 36061009800 36061009900 36061010000 36061010100
##          15           4          15          15          15          16
## 36061010200 36061010300 36061010400 36061010601 36061010602 36061010800
##           1          15          15          16          16          16
## 36061010900 36061011000 36061011100 36061011201 36061011202 36061011203
##          15          16           4          16           3          16
## 36061011300 36061011402 36061011500 36061011600 36061011700 36061011800
##           4          15          18           4           6          16
## 36061011900 36061012000 36061012100 36061012200 36061012400 36061012600
##          18           1           4          16          15          16
## 36061012700 36061012800 36061012900 36061013000 36061013100 36061013200
##           4           1          15           1          15          15
## 36061013300 36061013400 36061013500 36061013600 36061013700 36061013800
##           4          15          17          15          16          15
## 36061013900 36061014000 36061014200 36061014401 36061014402 36061014601
##          15          16           1          16          15          15
## 36061014602 36061014700 36061014801 36061014802 36061014900 36061015001
##          15          15          16          16          16           1
## 36061015002 36061015100 36061015200 36061015300 36061015400 36061015500
##           1          18           4          16          15           3
## 36061015601 36061015602 36061015700 36061015801 36061015802 36061015900
##          15          13          15          16          15          15
## 36061016001 36061016002 36061016100 36061016200 36061016300 36061016400
##           1           4          15          20          15          20
## 36061016500 36061016600 36061016700 36061016800 36061016900 36061017000
##          15          17          16          20          15          17
## 36061017100 36061017201 36061017202 36061017300 36061017401 36061017402
##          15          20          17          15          20          13
## 36061017500 36061017700 36061017800 36061017900 36061018000 36061018100
##          15           4          17          15          20           4
## 36061018200 36061018300 36061018400 36061018500 36061018600 36061018700
##          20          15          20           4          20          15
## 36061018800 36061018900 36061019000 36061019100 36061019200 36061019300
##          17          20          13          15          20          18
## 36061019400 36061019500 36061019600 36061019701 36061019702 36061019800
##          20           4          20           4          13          13
## 36061019900 36061020000 36061020101 36061020102 36061020200 36061020300
##           4          17          15          17          17          18
## 36061020400 36061020500 36061020600 36061020701 36061020702 36061020800
##          20          15          13          18          13          13
## 36061020901 36061020902 36061021000 36061021100 36061021200 36061021301
##          20          12           5          18           5          13
## 36061021302 36061021400 36061021600 36061021701 36061021702 36061021800
##          12           5          17           5          13          20
## 36061021900 36061022000 36061022101 36061022102 36061022200 36061022301
##          20          20          13          13          13          17
```

```
## 36061022302 36061022400 36061022500 36061022600 36061022701 36061022702
##          17          20          17          13          13          13
## 36061022800 36061022900 36061023000 36061023101 36061023102 36061023200
##          13          13          13          13           2          20
## 36061023300 36061023400 36061023501 36061023502 36061023600 36061023700
##          13          13          17           2           5          17
## 36061023800 36061023900 36061024100 36061024301 36061024302 36061024500
##          15          17          17          13          20          17
## 36061024700 36061024900 36061025100 36061025300 36061025500 36061026100
##          17          17          17           2          18           2
## 36061026300 36061026500 36061026700 36061026900 36061027100 36061027300
##          17          18          18          17          17           4
## 36061027500 36061027700 36061027900 36061028100 36061028300 36061028500
##           8           2          17           4          18           2
## 36061028700 36061028900 36061029100 36061029300 36061029500 36061030300
##          18          20          17          17          18          18
## 36061030700 36061030900 36061031300 36061031701 36081000100 36081000200
##           4          13          16          16           3          19
## 36081000400 36081000600 36081000700 36081000800 36081001000 36081001200
##          14          11           4          21          14          21
## 36081001400 36081001600 36081001800 36081001900 36081002000 36081002200
##           4           8          21           4          21           4
## 36081002400 36081002500 36081002600 36081002700 36081002800 36081002900
##          14          20          14           2          14           2
## 36081003000 36081003100 36081003200 36081003400 36081003500 36081003600
##          11          11          21          11          11          14
## 36081003700 36081003800 36081003900 36081004001 36081004002 36081004100
##          20           4          18           4          19          18
## 36081004200 36081004300 36081004401 36081004402 36081004500 36081004700
##           9          20          19           8           8          18
## 36081004900 36081005000 36081005100 36081005200 36081005300 36081005400
##          11           5          18          19          18          21
## 36081005500 36081005700 36081005800 36081005900 36081006100 36081006200
##          18          18          21           4          18           8
## 36081006300 36081006500 36081006700 36081006900 36081007100 36081007300
##          11          18           4          18          18           4
## 36081007500 36081007700 36081007900 36081008100 36081008300 36081008600
##           4           4          18           9          18          21
## 36081008700 36081008800 36081009100 36081009400 36081009500 36081009600
##          20          21          21          19           4          14
## 36081009700 36081009800 36081010000 36081010100 36081010200 36081010300
##           4          14          14           4          14           4
## 36081010400 36081010500 36081010600 36081010800 36081011000 36081011100
##          19          11          14          14          19           4
## 36081011200 36081011300 36081011400 36081011500 36081011600 36081011700
##          14          18          19          18          14           4
## 36081011800 36081011900 36081012000 36081012100 36081012200 36081012300
##          19           4          19           4          14           4
## 36081012400 36081012601 36081012602 36081012800 36081013000 36081013200
##          14          19          19           4          19          18
## 36081013400 36081013500 36081013600 36081013700 36081013800 36081014000
##           4          21           4           9           4           4
## 36081014100 36081014201 36081014202 36081014300 36081014400 36081014500
##           9          19          11          18          19           4
```

```
## 36081014700 36081014800 36081014900 36081015000 36081015100 36081015200
##           4          19           4          19           4           7
## 36081015300 36081015400 36081015500 36081015600 36081015700 36081015800
##           4          14          18          19          18          11
## 36081015900 36081016100 36081016300 36081016400 36081016600 36081016800
##          18          11          20          10          11          22
## 36081016900 36081017000 36081017200 36081017400 36081017600 36081017800
##           4          22           7          22          19          22
## 36081017900 36081018000 36081018100 36081018300 36081018401 36081018402
##          18          10          18           4          13           7
## 36081018500 36081018600 36081018700 36081018800 36081018900 36081019000
##           4           7          11          22          18           7
## 36081019200 36081019401 36081019402 36081019600 36081019700 36081019800
##          22           7          22          19           4           5
## 36081020200 36081020400 36081020501 36081020502 36081020600 36081020800
##          10          19          14           4          10          14
## 36081021200 36081021400 36081021600 36081021900 36081022001 36081022002
##          12          14           4          15           4           4
## 36081023000 36081023200 36081023500 36081023600 36081023800 36081024000
##           8          14          11           5          17          17
## 36081024300 36081024500 36081024700 36081024800 36081024900 36081025100
##          19           4           4          22          18          11
## 36081025200 36081025300 36081025500 36081025700 36081025800 36081025900
##          13          18          14          18          19          18
## 36081026000 36081026100 36081026200 36081026300 36081026400 36081026500
##          13          17          10          18          22          18
## 36081026600 36081026700 36081026900 36081027000 36081027100 36081027200
##          13          18          17          22          18          19
## 36081027300 36081027400 36081027500 36081027700 36081027800 36081027900
##          11          10          11          11          13           4
## 36081028000 36081028100 36081028200 36081028300 36081028400 36081028500
##          22           4           7          18          22           8
## 36081028700 36081028800 36081028900 36081029100 36081029200 36081029300
##           4          22           4          18          10           7
## 36081029500 36081029700 36081030400 36081030901 36081030902 36081031700
##           4          21          22          14           4          21
## 36081032000 36081032700 36081032800 36081032900 36081033000 36081033401
##          22          11          10          21          10          22
## 36081033402 36081033700 36081033900 36081034700 36081035100 36081035200
##           5          11          19          14          11          10
## 36081035300 36081035500 36081035800 36081036100 36081036300 36081036500
##          19          22          10          19          11          19
## 36081036600 36081036700 36081036800 36081036900 36081037100 36081037300
##          22          22           7          10          22          11
## 36081037500 36081037600 36081037700 36081037900 36081038100 36081038300
##          11          22          12           2          11          14
## 36081038400 36081039400 36081039800 36081039900 36081040100 36081040200
##          10          22          10          11          11          10
## 36081040300 36081040400 36081040500 36081040700 36081040900 36081041000
##          11          22           2          11          11           7
## 36081041100 36081041300 36081041400 36081041500 36081042000 36081042200
##          14          18          19          18          10          10
## 36081042700 36081043200 36081043400 36081043700 36081043900 36081044000
##           9          22          22          19           9          19
```

```
## 36081044200 36081044300 36081044601 36081044602 36081044800 36081045000
##          13          17          17          13          14          11
## 36081045200 36081045400 36081045500 36081045600 36081045700 36081045800
##          14          14           5          22          11          14
## 36081045900 36081046000 36081046100 36081046200 36081046300 36081046400
##          11          17          11           5           2          14
## 36081046500 36081046600 36081046700 36081046800 36081046900 36081047000
##          11          14          17          14          18          14
## 36081047100 36081047200 36081047300 36081047500 36081047600 36081047800
##          12          14          14          14           3          14
## 36081047900 36081048000 36081048100 36081048200 36081048300 36081048400
##          19          10          18          10          11          22
## 36081048500 36081048900 36081049200 36081049301 36081049302 36081049500
##          19           9           5           4           4           8
## 36081049600 36081049700 36081049900 36081050000 36081050201 36081050202
##          10          21          14           5          22           7
## 36081050400 36081050500 36081050600 36081050700 36081050800 36081051000
##          22          14          22           8          22          22
## 36081051100 36081051200 36081051300 36081051500 36081051600 36081051700
##           8          22          21           4          10           4
## 36081051800 36081052000 36081052100 36081052200 36081052400 36081052500
##           7          22           8          10          10           4
## 36081052600 36081052700 36081052800 36081052900 36081053000 36081053200
##          22           4          10          11          22          22
## 36081053400 36081053500 36081053600 36081053800 36081053900 36081054000
##          22          11           7          10          14          10
## 36081054200 36081054500 36081054700 36081054800 36081054900 36081055100
##          22           9          17          10          17          18
## 36081055200 36081055300 36081055400 36081055500 36081055600 36081055700
##          14          18           8          18           7          18
## 36081055800 36081055900 36081056000 36081056200 36081056400 36081056500
##           3          18          21          10          14           9
## 36081056600 36081056700 36081056800 36081057700 36081057800 36081057900
##          19           8          14           4          22           4
## 36081058000 36081058100 36081058300 36081058500 36081058700 36081058800
##          10           4           4           4           4          10
## 36081058900 36081059000 36081059100 36081059200 36081059300 36081059400
##          18          10           4          22           4          10
## 36081059500 36081059600 36081059800 36081059900 36081060000 36081060100
##           4          10          10          21          10           8
## 36081060300 36081060400 36081060600 36081060700 36081060800 36081061000
##           8          22          22          21          10          10
## 36081061200 36081061300 36081061400 36081061601 36081061602 36081061800
##          22           4          22          22          10          22
## 36081061900 36081062000 36081062100 36081062300 36081062400 36081062500
##           4          10           4           8          22           8
## 36081062600 36081062700 36081062900 36081063000 36081063200 36081063301
##          22           4           4          10          22           8
## 36081063302 36081063500 36081063700 36081063800 36081063900 36081064101
##           8          21          21          10           8           8
## 36081064102 36081064500 36081064600 36081065000 36081065400 36081065500
##          21           8          22          22          10           8
## 36081065600 36081065701 36081065702 36081065900 36081066000 36081066100
##          22           8           8           8          10           8
```

```
## 36081066300 36081066400 36081066500 36081066700 36081066900 36081067101
##           3          10           8           8           8           7
## 36081067102 36081067700 36081067900 36081068000 36081068200 36081068300
##           8           3           4          10          10          18
## 36081068700 36081069000 36081069300 36081069400 36081069500 36081069701
##           4          10           4          10           4          18
## 36081069702 36081070300 36081070700 36081070900 36081071100 36081071301
##           8          21           3           8           8           4
## 36081071302 36081071700 36081071900 36081072100 36081072700 36081072900
##           4           4           9           4           3          21
## 36081073100 36081073300 36081073500 36081073700 36081073900 36081074100
##           3           1           1           4          15           8
## 36081074300 36081074500 36081074700 36081075700 36081076800 36081076901
##          18          18          14           8          10          15
## 36081076902 36081077300 36081077500 36081077901 36081077902 36081077903
##           4          15           4          18           3           4
## 36081077904 36081077905 36081078800 36081079000 36081079200 36081079700
##          14           8          22          19          22          11
## 36081079900 36081080301 36081080302 36081080900 36081081400 36081081800
##          11          11          21           8           7          22
## 36081083700 36081083800 36081084000 36081084500 36081084601 36081084602
##          21          10          14          18          21           3
## 36081085100 36081085300 36081085500 36081085700 36081085900 36081086100
##          17          17          17          17          11          14
## 36081086300 36081086400 36081086500 36081086700 36081087100 36081087500
##          18          14          12          19           2          19
## 36081088400 36081088901 36081088902 36081089200 36081090700 36081091601
##           8          14           5           8          21           8
## 36081091900 36081092200 36081092500 36081092800 36081092900 36081093400
##           4           3           4           3           8           4
## 36081093800 36081093900 36081094201 36081094202 36081094203 36081094500
##           4          21          18          20           4           3
## 36081094700 36081095200 36081096200 36081096400 36081097201 36081097202
##           8          20          19          22          20          13
## 36081097300 36081098100 36081098700 36081099100 36081099200 36081099701
##           3          21          21           3           5           8
## 36081099702 36081099800 36081100800 36081101001 36081101002 36081101700
##           3          18          14          17           9           8
## 36081102900 36081103201 36081103202 36081103300 36081103900 36081104700
##           8          13          18           3           3          21
## 36081105900 36081107201 36081108101 36081108102 36081108300 36081109100
##           3           3           3           8           8           3
## 36081109700 36081109900 36081111300 36081112300 36081112900 36081113300
##           3           8           3          11           3           8
## 36081113900 36081114100 36081114700 36081115100 36081115500 36081115700
##           8           3           3           3           4          14
## 36081115900 36081116100 36081116300 36081116700 36081117100 36081117500
##          14          11          17          19           9          21
## 36081118100 36081118500 36081118700 36081118900 36081119100 36081119300
##           4          18          19          19          14          19
## 36081119500 36081119900 36081120100 36081120300 36081120500 36081120700
##           3           8          19          14          19          21
## 36081121500 36081122300 36081122701 36081122702 36081124100 36081124700
##          21          21           4          18           3           3
```

```
## 36081125700 36081126500 36081126700 36081127500 36081129101 36081129102
##          19          14          21          16           8          21
## 36081130100 36081133300 36081133900 36081134100 36081134700 36081136700
##          21           3          16           3           4           8
## 36081137700 36081138501 36081139900 36081140300 36081140901 36081140902
##          21          16           7           7           3           3
## 36081141701 36081141702 36081142900 36081143500 36081144100 36081144700
##           3          14           3           3           8          19
## 36081145101 36081145102 36081145900 36081146300 36081146700 36081147100
##           3          21          21          11           4           3
## 36081147900 36081148300 36081150701 36081150702 36081152901 36081152902
##           3           3           3           3           3           8
## 36081155101 36081155102 36081156700 36081157101 36081157102 36081157901
##          16           8           6           3           3           8
## 36081157902 36081157903 36081161700 36081162100 36085000300 36085000600
##           3          21           3           8          18           4
## 36085000700 36085000800 36085000900 36085001100 36085001500 36085001700
##           5          21          18          18          21           4
## 36085001800 36085002001 36085002002 36085002100 36085002700 36085002900
##           4           8           8          14          19          13
## 36085003300 36085003600 36085003900 36085004000 36085004700 36085005000
##           8          21           4          20           8           8
## 36085005900 36085006400 36085006500 36085007000 36085007400 36085007500
##           8           4           8           8           4           4
## 36085007700 36085008100 36085009100 36085009601 36085009602 36085009700
##          19          18           8           8           8          14
## 36085010500 36085011201 36085011202 36085011401 36085011402 36085012100
##          21           8          21           4          21           3
## 36085012200 36085012500 36085012803 36085012804 36085013201 36085013203
##           8           9          21          21           3           3
## 36085013204 36085013301 36085013302 36085013400 36085013800 36085014100
##           3          20          19           8           3           4
## 36085014603 36085014604 36085014605 36085014606 36085014700 36085015100
##           3           3           3           3           3           8
## 36085015601 36085015602 36085015603 36085016901 36085016902 36085017005
##           3           3           3           3           1           3
## 36085017006 36085017007 36085017008 36085017009 36085017010 36085017300
##           3           7           3           3           3           4
## 36085017600 36085017700 36085017900 36085018500 36085018701 36085018702
##           3           3           3          20           8           8
## 36085018901 36085018902 36085019600 36085019700 36085020100 36085020700
##           8           3           3           3           8          19
## 36085020801 36085020803 36085020804 36085021300 36085021900 36085022300
##           3           3           3           8           9           7
## 36085022600 36085023100 36085023900 36085024400 36085024700 36085024800
##           8          21          21           8          21           8
## 36085025100 36085027301 36085027302 36085027702 36085027703 36085027704
##           8           8           3          21           8           8
## 36085027900 36085029102 36085029103 36085029104 36085030301 36085030302
##           3           3           3           3          21          21
## 36085031901 36085031902 36085032300
##          20          13          21
##
## Within cluster sum of squares by cluster:
```

```
##  [1]  68.60380 111.07809 159.33247 239.70418  92.23268  50.72821  79.12717
##  [8] 166.77604 129.31171  91.37012 145.30988 114.20461 108.12356  95.39433
## [15] 131.77819 125.06776 111.25216 141.26834 105.04805 140.71143 129.65299
## [22]  91.86108
##  (between_SS / total_SS =  79.3 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"
## [5] "tot.withinss" "betweenss"    "size"         "iter"
## [9] "ifault"
```

Applying the Clustering Vector to the data set to generate output data

```
cluster_ct_house_2000 <- cbind(ct_housing_2000_no_missing, clusterNum = k22$cluster)
cluster_ct_house_2000 <- cluster_ct_house_2000[, c(7,1:6)]
head(cluster_ct_house_2000)
```

```
##             clusterNum med_rent_00 hhinc_all_00 pct_inc_rent_00
## 36005000200         14 -0.07983982  -0.02808952      -0.3879183
## 36005000400         19 -0.48261494  -0.24050901       1.1136667
## 36005001100          2 -1.18970902  -0.77279838       0.7382704
## 36005001500         13 -0.10221622  -0.75505181       0.9259686
## 36005001600         18 -0.84958782  -0.83164797      -0.1063711
## 36005001700          2 -1.36424490  -1.01483146       1.8081498
##             own_rate_00 shwhite_hh_00  ed1_ns_00
## 36005000200   1.0644996    -0.3893844 -0.2642038
## 36005000400   0.8620157    -0.4473174 -0.2549543
## 36005001100   0.2128178     0.3356038  2.1276667
## 36005001500  -1.4238922    -1.4841653 -1.1001923
## 36005001600  -0.7882545    -0.3131886 -0.4255131
## 36005001700  -0.8954342    -0.9462010  1.9428084
```

Writing Out the Data File

```
write.csv(cluster_ct_house_2000, "../data/final/cluster_ct_house_2000.csv")
```

Next Steps (not necessarily in this order. Maybe an iterative process)

- Determining optimal cluster size using Elbow method and deploying it
- Determining if **K-Means** is the best Clustering Algorithm choice
- Determining if we have used all the **right** variables in the feature selection for K-Means
- After we have created the clustering pairs we need to layer the Census Tracts with those that have BiDs vs Non-BiDs

Don't have enough domain expertise to see what might be the problems in these comparisons but, looking forward to resolve them!