GEOG210B Assignment3: Spatial Regression Models

Lily Cheng

```
library(spdep)
```

```
## Warning: package 'spdep' was built under R version 3.4.3

## Loading required package: sp

## Warning: package 'sp' was built under R version 3.4.3

## Loading required package: Matrix

## Loading required package: spData

## Warning: package 'spData' was built under R version 3.4.3

## To access larger datasets in this package, install the spDataLarge
## package with: `install.packages('spDataLarge')`
```

```
library(maptools)
```

```
## Checking rgeos availability: TRUE
```

```
library(leaflet)
library(RColorBrewer)
```

Read data

```
CA.poly <- readShapePoly('LPA_Pop_Char_bg.shp')
```

```
## Warning: use rgdal::readOGR or sf::st_read
```

```
class(CA.poly)
```

```
## [1] "SpatialPolygonsDataFrame"
## attr(,"package")
## [1] "sp"
```

Component 1: Data contains the variables that are used in the analysis such as number of households with zero cars, vehicle miles of travel. remember these are at the block group level

```
str(slot(CA.poly, "data"))
```

```
## 'data.frame':    23198 obs. of  105 variables:
##  $ OBJECTID  : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ STATEFP   : Factor w/ 1 level "06": 1 1 1 1 1 1 1 1 1 1 ...
##  $ COUNTYFP  : Factor w/ 58 levels "001","003","005",..: 42 37 30 12 19 30 30 19 19 33 ...
##  $ TRACTCE   : Factor w/ 6521 levels "000100","000101",..: 319 1482 2412 1083 5937 2492 1898 3170 375
##  $ BLKGRPCE  : Factor w/ 10 levels "0","1","2","3",..: 2 3 3 2 2 3 6 2 2 2 ...
##  $ AFFGEOID  : Factor w/ 23198 levels "1500000US060014001001",..: 19731 17394 11471 2765 8865 11726 
##  $ NAME      : Factor w/ 10 levels "0","1","2","3",..: 2 3 3 2 2 3 6 2 2 2 ...
##  $ LSAD      : Factor w/ 1 level "BG": 1 1 1 1 1 1 1 1 1 1 ...
##  $ ALAND     : num  6.70e+06 3.80e+06 2.89e+05 8.03e+08 2.61e+05 ...
##  $ AWATER    : num  502651 2039168 0 1577551 2184908 ...
##  $ GEO_ID2   : num  6.08e+10 6.07e+10 6.06e+10 6.02e+10 6.04e+10 ...
##  $ GEOID_1   : num  6.08e+10 6.07e+10 6.06e+10 6.02e+10 6.04e+10 ...
##  $ HHAGE1    : num  3 14 0 21 50 5 7 4 6 11 ...
##  $ HHAGE2    : num  12 87 0 81 206 82 105 20 31 45 ...
```

```
##  $ HHAGE3   : num  34 180 0 67 117 73 193 63 51 57 ...
##  $ HHAGE4   : num  103 225 6 113 80 96 75 75 49 82 ...
##  $ HHAGE5   : num  67 96 20 68 27 59 22 52 30 50 ...
##  $ HHAGE6   : num  57 97 18 79 22 43 27 40 11 85 ...
##  $ HHAGE7   : num  99 119 107 59 16 45 15 39 18 256 ...
##  $ HHAGE8   : num  60 67 221 48 7 25 8 16 7 187 ...
##  $ HHAGE9   : num  28 39 105 7 4 9 1 16 2 52 ...
##  $ HHCHILD1 : num  336 643 477 431 477 409 199 210 92 706 ...
##  $ HHCHILD2 : num  127 281 0 112 52 28 254 115 113 119 ...
##  $ HHSIZE1  : num  80 219 250 196 322 238 80 68 18 415 ...
##  $ HHSIZE2  : num  218 343 210 214 155 165 107 90 31 271 ...
##  $ HHSIZE3  : num  67 153 17 64 31 25 100 55 32 68 ...
##  $ HHSIZE4  : num  47 144 0 38 15 9 110 62 35 32 ...
##  $ HHSIZE5  : num  33 50 0 24 6 0 44 26 30 23 ...
##  $ HHSIZE6  : num  10 15 0 3 0 0 10 12 15 12 ...
##  $ HHSIZE7  : num  8 0 0 4 0 0 2 12 44 4 ...
##  $ rHHINC1  : num  11 60 0 82 11 17 0 0 0 37 ...
##  $ rHHINC2  : num  11 129 62 136 76 58 0 0 50 255 ...
##  $ rHHINC3  : num  50 39 130 144 114 23 0 49 32 47 ...
##  $ rHHINC4  : num  16 67 179 105 168 6 12 17 39 178 ...
##  $ rHHINC5  : num  36 69 42 76 48 101 12 95 26 114 ...
##  $ rHHINC6  : num  61 173 47 0 63 50 73 67 27 55 ...
##  $ rHHINC7  : num  79 121 9 0 25 40 173 60 31 34 ...
##  $ rHHINC8  : num  67 75 0 0 0 81 67 0 0 39 ...
##  $ rHHINC9  : num  132 191 8 0 24 61 116 37 0 66 ...
##  $ n_hh     : num  463 924 477 543 529 437 453 325 205 825 ...
##  $ AGE1     : num  163 408 0 138 63 33 447 172 227 153 ...
##  $ AGE2     : num  139 174 1 93 86 25 73 109 172 101 ...
##  $ AGE3     : num  88 409 1 202 390 211 436 155 206 153 ...
##  $ AGE4     : num  136 385 9 140 119 110 216 158 127 116 ...
##  $ AGE5     : num  350 524 99 381 116 190 117 224 101 310 ...
##  $ AGE6     : num  315 380 611 180 41 110 40 135 52 673 ...
##  $ SEX1     : num  563 1077 258 495 402 ...
##  $ SEX2     : num  628 1203 463 639 413 ...
##  $ n_pr     : num  1191 2280 721 1134 815 ...
##  $ Shape_Leng: num  0.1822 0.1509 0.023 2.9636 0.0367 ...
##  $ Shape_Area: num  6.64e-04 3.92e-04 2.81e-05 8.61e-02 2.33e-05 ...
##  $ FID_     : int  0 1 2 3 4 5 6 7 8 9 ...
##  $ STATEFP_1 : Factor w/ 1 level "06": 1 1 1 1 1 1 1 1 1 1 ...
##  $ COUNTYFP_1: Factor w/ 58 levels "001","003","005",..: 42 37 30 12 19 30 30 19 19 33 ...
##  $ TRACTCE_1 : Factor w/ 6521 levels "000100","000101",..: 319 1482 2412 1083 5937 2492 1898 3170 375
##  $ BLKGRPCE_1: Factor w/ 10 levels "0","1","2","3",..: 2 3 3 2 2 3 6 2 2 2 ...
##  $ AFFGEOID_1: Factor w/ 23198 levels "1500000US060014001001",..: 19731 17394 11471 2765 8865 11726 
##  $ ALAND_1  : num  6.70e+06 3.80e+06 2.89e+05 8.03e+08 2.61e+05 ...
##  $ AWATER_1 : num  502651 2039168 0 1577551 2184908 ...
##  $ Shape_Ar_1: num  6.64e-04 3.92e-04 2.81e-05 8.61e-02 2.33e-05 ...
##  $ GEO_ID2_1 : num  6.08e+10 6.07e+10 6.06e+10 6.02e+10 6.04e+10 ...
##  $ pumano   : int  8303 7304 5904 2300 3765 5903 5915 3724 3745 6515 ...
##  $ countyname: Factor w/ 58 levels "Alameda","Alpine",..: 42 37 30 12 19 30 30 19 19 33 ...
##  $ GEOID    : num  6.08e+10 6.07e+10 6.06e+10 6.02e+10 6.04e+10 ...
##  $ n_hh_1   : num  463 924 477 543 529 437 453 325 205 825 ...
##  $ n_pr_1   : num  1191 2280 721 1134 815 ...
##  $ walkM    : num  181 452 67 160 418 ...
##  $ bikeM    : num  232.6 186.2 34 37.5 384.9 ...
```

```
##  $ drvalM   : num  14067 25300 5429 11066 9466 ...
##  $ drvothM  : num  6583 13495 4246 8737 3667 ...
##  $ passM    : num  7720 19778 3538 10707 4177 ...
##  $ planeM   : num  922 838 0 335 0 ...
##  $ otherM   : num  643 4394 439 598 2144 ...
##  $ allM     : num  30348 64443 13754 31640 20256 ...
##  $ walkD    : num  3972 11498 2992 2865 10470 ...
##  $ bikeD    : num  1812 2448 304 289 2910 ...
##  $ drvalD   : num  34663 60042 14727 23800 28254 ...
##  $ drvothD  : num  14518 28376 8600 17921 8804 ...
##  $ passD    : num  17764 40452 7514 22878 10399 ...
##  $ planeD   : num  1577 4256 0 1200 0 ...
##  $ otherD   : num  1917 9406 1195 1946 6084 ...
##  $ allD     : num  76223 156478 35332 70899 66921 ...
##  $ walkT    : num  281 879 174 180 848 388 498 287 566 566 ...
##  $ bikeT    : num  44 135 10 10 126 18 46 48 17 59 ...
##  $ drvalT   : num  1725 2887 905 1099 1379 ...
##  $ drvothT  : num  687 1347 342 680 407 ...
##  $ passT    : num  865 1780 299 882 459 254 1990 761 833 889 ...
##  $ planeT   : num  11 11 0 4 0 3 18 4 1 11 ...
##  $ otherT   : num  67 282 52 50 249 171 136 72 99 166 ...
##  $ allT     : num  3680 7321 1782 2905 3468 ...
##  $ VMT_drv  : num  20650 38795 9675 19802 13132 ...
##  $ VMT_pas  : num  7720 19778 3538 10707 4177 ...
##  $ VMT      : num  28370 58573 13214 30509 17309 ...
##  $ pr_LDTrips: num 86 170 60 133 39 74 197 131 26 155 ...
##  $ HHVEH0   : num  6 61 33 24 91 34 5 4 18 92 ...
##  $ HHVEH1   : num  102 264 300 248 310 210 94 88 81 413 ...
##  $ HHVEH2   : num  244 411 130 194 114 159 233 152 53 246 ...
##  $ HHVEH3   : num  87 136 11 57 14 23 93 62 34 50 ...
##  $ HHVEH4   : num  17 41 1 16 0 7 23 16 13 17 ...
##   [list output truncated]
##  - attr(*, "data_types")= chr  "N" "C" "C" "C" ...
```

```r
summary(slot(CA.poly, "data"))
```

```
##     OBJECTID       STATEFP        COUNTYFP       TRACTCE         BLKGRPCE
##  Min.   :    1   06:23198   037    :6423   000200 :   71   1      :8036
##  1st Qu.: 5800              059    :1822   000300 :   70   2      :7353
##  Median :11600             073    :1794   000400 :   68   3      :4736
##  Mean   :11600             071    :1092   000600 :   56   4      :2139
##  3rd Qu.:17399             085    :1075   000800 :   55   5      : 710
##  Max.   :23198             001    :1047   000100 :   51   6      : 169
##                           (Other):9945   (Other):22827   (Other):  55
##                    AFFGEOID           NAME        LSAD
##  1500000US060014001001:    1   1      :8036   BG:23198
##  1500000US060014002001:    1   2      :7353
##  1500000US060014002002:    1   3      :4736
##  1500000US060014003001:    1   4      :2139
##  1500000US060014003002:    1   5      : 710
##  1500000US060014003003:    1   6      : 169
##  (Other)              :23192   (Other):  55
##     ALAND              AWATER            GEO_ID2
##  Min.   :0.000e+00   Min.   :0.000e+00   Min.   :6.001e+10
##  1st Qu.:2.988e+05   1st Qu.:0.000e+00   1st Qu.:6.037e+10
```

```
## Median :5.461e+05   Median :0.000e+00   Median :6.059e+10
## Mean   :1.739e+07   Mean   :5.722e+05   Mean   :6.055e+10
## 3rd Qu.:1.296e+06   3rd Qu.:0.000e+00   3rd Qu.:6.073e+10
## Max.   :1.610e+10   Max.   :2.406e+09   Max.   :6.115e+10
##
##    GEOID_1              HHAGE1              HHAGE2              HHAGE3
## Min.   :0.000e+00   Min.   :   0.00   Min.   :   0.00   Min.   :   0.0
## 1st Qu.:6.037e+10   1st Qu.:   5.00   1st Qu.:  36.00   1st Qu.:  63.0
## Median :6.059e+10   Median :  12.00   Median :  63.00   Median :  91.0
## Mean   :6.039e+10   Mean   :  21.89   Mean   :  85.11   Mean   : 107.9
## 3rd Qu.:6.073e+10   3rd Qu.:  25.00   3rd Qu.: 107.00   3rd Qu.: 133.0
## Max.   :6.115e+10   Max.   :2130.00   Max.   :2879.00   Max.   :1878.0
##
##    HHAGE4              HHAGE5              HHAGE6              HHAGE7
## Min.   :   0.0   Min.   :   0.00   Min.   :   0.0   Min.   :   0.0
## 1st Qu.:  76.0   1st Qu.:  33.00   1st Qu.:  27.0   1st Qu.:  31.0
## Median : 105.0   Median :  46.00   Median :  39.0   Median :  48.0
## Mean   : 119.6   Mean   :  52.21   Mean   :  44.8   Mean   :  57.3
## 3rd Qu.: 147.0   3rd Qu.:  65.00   3rd Qu.:  56.0   3rd Qu.:  72.0
## Max.   :1361.0   Max.   : 381.00   Max.   : 454.0   Max.   : 828.0
##
##    HHAGE8              HHAGE9              HHCHILD1             HHCHILD2
## Min.   :   0.0   Min.   :   0.00   Min.   :   0.0   Min.   :   0
## 1st Qu.:  17.0   1st Qu.:   5.00   1st Qu.: 197.0   1st Qu.: 116
## Median :  28.0   Median :  10.00   Median : 291.0   Median : 174
## Mean   :  36.8   Mean   :  16.48   Mean   : 339.1   Mean   : 203
## 3rd Qu.:  46.0   3rd Qu.:  19.00   3rd Qu.: 428.0   3rd Qu.: 254
## Max.   : 781.0   Max.   : 510.00   Max.   :3363.0   Max.   :4664
##
##    HHSIZE1              HHSIZE2              HHSIZE3              HHSIZE4
## Min.   :   0.0   Min.   :   0.0   Min.   :   0.0   Min.   :   0.00
## 1st Qu.:  54.0   1st Qu.:  88.0   1st Qu.:  54.0   1st Qu.:  47.00
## Median :  92.0   Median : 136.0   Median :  77.0   Median :  69.00
## Mean   : 126.1   Mean   : 157.5   Mean   :  88.2   Mean   :  81.28
## 3rd Qu.: 159.0   3rd Qu.: 202.0   3rd Qu.: 110.0   3rd Qu.: 101.00
## Max.   :1884.0   Max.   :1519.0   Max.   :1678.0   Max.   :1770.00
##
##    HHSIZE5              HHSIZE6              HHSIZE7              rHHINC1
## Min.   :   0.00   Min.   :   0.00   Min.   :   0.00   Min.   :   0.00
## 1st Qu.:  23.00   1st Qu.:   8.00   1st Qu.:   4.00   1st Qu.:   0.00
## Median :  38.00   Median :  17.00   Median :  12.00   Median :  17.00
## Mean   :  44.93   Mean   :  22.01   Mean   :  22.11   Mean   :  28.75
## 3rd Qu.:  58.00   3rd Qu.:  30.00   3rd Qu.:  32.00   3rd Qu.:  41.00
## Max.   : 830.00   Max.   : 412.00   Max.   : 418.00   Max.   : 722.00
##
##    rHHINC2              rHHINC3              rHHINC4              rHHINC5
## Min.   :   0.00   Min.   :   0.0   Min.   :   0.00   Min.   :   0.00
## 1st Qu.:  26.00   1st Qu.:  16.0   1st Qu.:  29.00   1st Qu.:  47.00
## Median :  59.00   Median :  39.0   Median :  56.00   Median :  81.00
## Mean   :  78.56   Mean   :  49.3   Mean   :  68.37   Mean   :  95.38
## 3rd Qu.: 110.00   3rd Qu.:  71.0   3rd Qu.:  95.00   3rd Qu.: 127.00
## Max.   :1018.00   Max.   : 713.0   Max.   :1598.00   Max.   :1611.00
##
##    rHHINC6              rHHINC7              rHHINC8              rHHINC9
```

```
## Min.   :   0.00   Min.   :   0.00   Min.   :   0.00   Min.   :   0.00
## 1st Qu.:  29.00   1st Qu.:  28.00   1st Qu.:   0.00   1st Qu.:   0.00
## Median :  56.00   Median :  64.00   Median :  19.00   Median :  11.00
## Mean   :  69.41   Mean   :  81.93   Mean   :  34.87   Mean   :  35.54
## 3rd Qu.:  95.00   3rd Qu.: 114.00   3rd Qu.:  50.00   3rd Qu.:  45.00
## Max.   :1201.00   Max.   :1415.00   Max.   :668.00    Max.   :1270.00
##
##      n_hh            AGE1            AGE2            AGE3
## Min.   :   0.0   Min.   :   0.0   Min.   :   0.0   Min.   :   0.0
## 1st Qu.: 350.0   1st Qu.: 166.0   1st Qu.: 122.0   1st Qu.: 181.0
## Median : 480.0   Median : 261.0   Median : 193.0   Median : 276.0
## Mean   : 542.1   Mean   : 315.4   Mean   : 224.7   Mean   : 326.9
## 3rd Qu.: 665.0   3rd Qu.: 403.0   3rd Qu.: 288.0   3rd Qu.: 410.0
## Max.   :6016.0   Max.   :4934.0   Max.   :9156.0   Max.   :6244.0
##
##      AGE4            AGE5            AGE6            SEX1
## Min.   :   0.0   Min.   :   0.0   Min.   :   0.0   Min.   :    0.0
## 1st Qu.: 138.0   1st Qu.: 180.0   1st Qu.: 100.0   1st Qu.:  480.0
## Median : 194.0   Median : 247.0   Median : 151.0   Median :  666.0
## Mean   : 221.6   Mean   : 279.7   Mean   : 184.1   Mean   :  748.9
## 3rd Qu.: 271.0   3rd Qu.: 343.0   3rd Qu.: 230.0   3rd Qu.:  919.0
## Max.   :3270.0   Max.   :2320.0   Max.   :2689.0   Max.   :11511.0
##
##      SEX2            n_pr          Shape_Leng        Shape_Area
## Min.   :    0.0   Min.   :    0   Min.   :0.000039   Min.   :0.0000000
## 1st Qu.:  518.0   1st Qu.: 1001   1st Qu.:0.024613   1st Qu.:0.0000297
## Median :  715.0   Median : 1380   Median :0.034106   Median :0.0000549
## Mean   :  803.5   Mean   : 1552   Mean   :0.088440   Mean   :0.0017962
## 3rd Qu.:  980.0   3rd Qu.: 1895   3rd Qu.:0.058370   3rd Qu.:0.0001306
## Max.   :10054.0   Max.   :20885   Max.   :8.865723   Max.   :1.5939843
##
##      FID_         STATEFP_1    COUNTYFP_1     TRACTCE_1        BLKGRPCE_1
## Min.   :    0   06:23198    037    :6423   000200 :   71   1      :8036
## 1st Qu.: 5799               059    :1822   000300 :   70   2      :7353
## Median :11598               073    :1794   000400 :   68   3      :4736
## Mean   :11598               071    :1092   000600 :   56   4      :2139
## 3rd Qu.:17398               085    :1075   000800 :   55   5      : 710
## Max.   :23197               001    :1047   000100 :   51   6      : 169
##                             (Other):9945   (Other):22827   (Other):  55
##               AFFGEOID_1        ALAND_1           AWATER_1
## 1500000US060014001001:    1   Min.   :0.000e+00   Min.   :0.000e+00
## 1500000US060014002001:    1   1st Qu.:2.988e+05   1st Qu.:0.000e+00
## 1500000US060014002002:    1   Median :5.461e+05   Median :0.000e+00
## 1500000US060014003001:    1   Mean   :1.739e+07   Mean   :5.722e+05
## 1500000US060014003002:    1   3rd Qu.:1.296e+06   3rd Qu.:0.000e+00
## 1500000US060014003003:    1   Max.   :1.610e+10   Max.   :2.406e+09
## (Other)              :23192
##   Shape_Ar_1         GEO_ID2_1           pumano
## Min.   :0.0000000   Min.   :6.001e+10   Min.   :    0
## 1st Qu.:0.0000297   1st Qu.:6.037e+10   1st Qu.: 3723
## Median :0.0000549   Median :6.059e+10   Median : 5905
## Mean   :0.0017962   Mean   :6.055e+10   Mean   : 5425
## 3rd Qu.:0.0001306   3rd Qu.:6.073e+10   3rd Qu.: 7316
## Max.   :1.5939843   Max.   :6.115e+10   Max.   :11300
```

```
## 
##        countyname        GEOID              n_hh_1          n_pr_1     
##  Los Angeles   :6423  Min.   :0.000e+00  Min.   :   0.0  Min.   :    0  
##  Orange        :1822  1st Qu.:6.037e+10  1st Qu.: 350.0  1st Qu.: 1001  
##  San Diego     :1794  Median :6.059e+10  Median : 480.0  Median : 1380  
##  San Bernadino :1092  Mean   :6.039e+10  Mean   : 542.1  Mean   : 1552  
##  Santa Clara   :1075  3rd Qu.:6.073e+10  3rd Qu.: 665.0  3rd Qu.: 1895  
##  Alameda       :1047  Max.   :6.115e+10  Max.   :6016.0  Max.   :20885  
##  (Other)       :9945                                                    
##      walkM            bikeM            drvalM          drvothM      
##  Min.   :   0.0   Min.   :   0.00   Min.   :     0   Min.   :     0  
##  1st Qu.: 206.7   1st Qu.:  72.41   1st Qu.:  8560   1st Qu.:  5180  
##  Median : 330.6   Median : 127.06   Median : 12131   Median :  7482  
##  Mean   : 398.1   Mean   : 163.46   Mean   : 14282   Mean   :  8926  
##  3rd Qu.: 511.1   3rd Qu.: 210.11   3rd Qu.: 17503   3rd Qu.: 10852  
##  Max.   :3697.9   Max.   :4100.94   Max.   :205090   Max.   :266464  
## 
##      passM            planeM            otherM           allM        
##  Min.   :     0   Min.   :    0.00   Min.   :    0   Min.   :      0  
##  1st Qu.:  7031   1st Qu.:   83.78   1st Qu.: 1157   1st Qu.:  24198  
##  Median : 10824   Median :  335.11   Median : 1819   Median :  34459  
##  Mean   : 14608   Mean   :  633.93   Mean   : 2168   Mean   :  41180  
##  3rd Qu.: 17316   3rd Qu.:  837.77   3rd Qu.: 2744   3rd Qu.:  49962  
##  Max.   :676613   Max.   :16839.22   Max.   :38781   Max.   :1167862  
## 
##      walkD            bikeD           drvalD          drvothD      
##  Min.   :     0   Min.   :    0   Min.   :     0   Min.   :     0  
##  1st Qu.:  5017   1st Qu.:  689   1st Qu.: 21739   1st Qu.: 11866  
##  Median :  8116   Median : 1169   Median : 30139   Median : 16733  
##  Mean   :  9850   Mean   : 1496   Mean   : 34575   Mean   : 19379  
##  3rd Qu.: 12692   3rd Qu.: 1912   3rd Qu.: 42305   3rd Qu.: 23536  
##  Max.   :128210   Max.   :29851   Max.   :421362   Max.   :314652  
## 
##      passD             planeD          otherD           allD        
##  Min.   :      0   Min.   :    0   Min.   :    0   Min.   :      0  
##  1st Qu.:  17602   1st Qu.:  170   1st Qu.: 3692   1st Qu.:  66732  
##  Median :  26111   Median :  805   Median : 5760   Median :  92364  
##  Mean   :  31697   Mean   : 1426   Mean   : 6797   Mean   : 105219  
##  3rd Qu.:  38562   3rd Qu.: 2034   3rd Qu.: 8756   3rd Qu.: 127822  
##  Max.   :1035072   Max.   :25910   Max.   :72248   Max.   :1897854  
## 
##      walkT            bikeT           drvalT         drvothT       
##  Min.   :   0.0   Min.   :   0.00   Min.   :    0   Min.   :    0.0  
##  1st Qu.: 391.0   1st Qu.:  34.00   1st Qu.: 1036   1st Qu.:  573.0  
##  Median : 646.5   Median :  60.00   Median : 1435   Median :  802.0  
##  Mean   : 798.4   Mean   :  76.72   Mean   : 1639   Mean   :  919.3  
##  3rd Qu.:1038.0   3rd Qu.: 100.00   3rd Qu.: 2011   3rd Qu.: 1126.0  
##  Max.   :8072.0   Max.   :1461.00   Max.   :19585   Max.   :11940.0  
## 
##      passT           planeT          otherT          allT        
##  Min.   :    0   Min.   : 0.00   Min.   :   0.0   Min.   :    0  
##  1st Qu.:  799   1st Qu.: 1.00   1st Qu.: 128.0   1st Qu.: 3240  
##  Median : 1159   Median : 4.00   Median : 208.0   Median : 4482  
##  Mean   : 1352   Mean   : 7.42   Mean   : 256.1   Mean   : 5048  
```
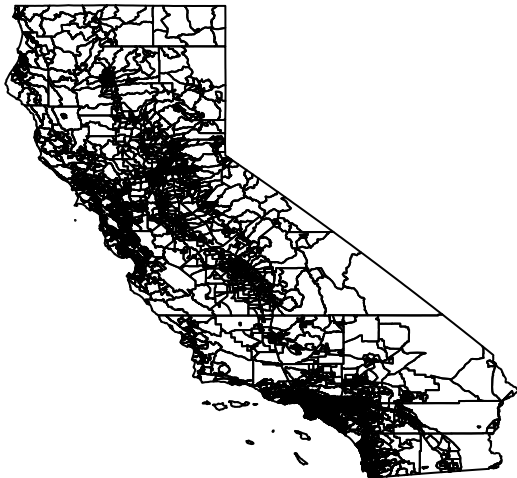
```
## 3rd Qu.: 1665    3rd Qu.:  10.00    3rd Qu.: 335.0    3rd Qu.:  6192
## Max.   :18865    Max.   :201.00    Max.   :2975.0    Max.   :59499
##
##     VMT_drv          VMT_pas            VMT            pr_LDTrips
## Min.   :     0    Min.   :     0    Min.   :      0    Min.   :   0.0
## 1st Qu.: 14022    1st Qu.:  7031    1st Qu.:  21738    1st Qu.:  67.0
## Median : 19696    Median : 10824    Median :  31288    Median : 105.0
## Mean   : 23208    Mean   : 14608    Mean   :  37816    Mean   : 131.6
## 3rd Qu.: 28201    3rd Qu.: 17316    3rd Qu.:  45815    3rd Qu.: 164.0
## Max.   :471555    Max.   :676613    Max.   :1148168    Max.   :5039.0
##
##     HHVEH0           HHVEH1            HHVEH2            HHVEH3
## Min.   :  0.00    Min.   :   0.0    Min.   :   0.0    Min.   :   0.00
## 1st Qu.: 12.00    1st Qu.: 102.0    1st Qu.: 131.0    1st Qu.:  42.00
## Median : 27.00    Median : 153.0    Median : 183.0    Median :  63.00
## Mean   : 39.65    Mean   : 183.8    Mean   : 212.3    Mean   :  76.62
## 3rd Qu.: 53.00    3rd Qu.: 233.0    3rd Qu.: 260.0    3rd Qu.:  94.00
## Max.   :760.00    Max.   :1824.0    Max.   :2997.0    Max.   :1620.00
##
##     HHVEH4           HHVEH5            HHVEH6            HHVEH7
## Min.   :  0.00    Min.   :   0.00    Min.   : 0.000    Min.   : 0.0000
## 1st Qu.: 10.00    1st Qu.:   1.00    1st Qu.: 0.000    1st Qu.: 0.0000
## Median : 17.00    Median :   3.00    Median : 1.000    Median : 0.0000
## Mean   : 21.09    Mean   :   4.95    Mean   : 2.787    Mean   : 0.7652
## 3rd Qu.: 27.00    3rd Qu.:   6.00    3rd Qu.: 3.000    3rd Qu.: 1.0000
## Max.   :320.00    Max.   :149.00    Max.   :72.000    Max.   :24.0000
##
##     HHVEH8           notrav            LPAgrp
## Min.   : 0.0000    Min.   :   0.0    Min.   :0.000
## 1st Qu.: 0.0000    1st Qu.: 226.0    1st Qu.:3.000
## Median : 0.0000    Median : 321.0    Median :3.000
## Mean   : 0.1916    Mean   : 359.6    Mean   :3.178
## 3rd Qu.: 0.0000    3rd Qu.: 447.0    3rd Qu.:4.000
## Max.   :38.0000    Max.   :3763.0    Max.   :4.000
##
```

Component 2: This is the polygon slot and contains the shape information.

```
plot(CA.poly)
```

Define the dependent variable to number of miles drive alone per household per person

```
YCOUNTY <- CA.poly[CA.poly@data$countyname== c("Riverside"), ]
YCOUNTY@data$drvalM = YCOUNTY@data$drvalM/YCOUNTY@data$n_pr
YCOUNTY@data$drvalM[is.na(YCOUNTY@data$drvalM)] <- 0
summary(YCOUNTY@data)
```

```
##    OBJECTID      STATEFP     COUNTYFP      TRACTCE        BLKGRPCE
## Min.   :   10   06:1030   065    :1030   030200 :   5   1      :453
## 1st Qu.: 6443             001    :   0   030300 :   5   2      :375
## Median :12539             003    :   0   030400 :   5   3      :142
## Mean   :12431             005    :   0   030700 :   5   4      : 44
## 3rd Qu.:17718             007    :   0   030800 :   5   5      : 16
## Max.   :23166             009    :   0   031100 :   5   0      :  0
##                           (Other):   0   (Other):1000   (Other):  0
##                    AFFGEOID           NAME     LSAD          ALAND
## 1500000US060650301011:   1   1      :453   BG:1030   Min.   :1.142e+05
## 1500000US060650301031:   1   2      :375             1st Qu.:6.798e+05
## 1500000US060650301032:   1   3      :142             Median :1.308e+06
## 1500000US060650301041:   1   4      : 44             Mean   :1.812e+07
## 1500000US060650301042:   1   5      : 16             3rd Qu.:2.984e+06
## 1500000US060650301043:   1   0      :  0             Max.   :9.860e+09
## (Other)              :1024   (Other):  0
##     AWATER            GEO_ID2            GEOID_1
## Min.   :        0   Min.   :6.065e+10   Min.   :0.000e+00
## 1st Qu.:        0   1st Qu.:6.065e+10   1st Qu.:6.065e+10
## Median :        0   Median :6.065e+10   Median :6.065e+10
## Mean   :   243646   Mean   :6.065e+10   Mean   :6.059e+10
## 3rd Qu.:        0   3rd Qu.:6.065e+10   3rd Qu.:6.065e+10
## Max.   :161997930   Max.   :6.066e+10   Max.   :6.066e+10
##
##     HHAGE1           HHAGE2           HHAGE3          HHAGE4
## Min.   :  0.00   Min.   :  0.00   Min.   :  0.0   Min.   :  0.00
## 1st Qu.:  7.00   1st Qu.: 44.00   1st Qu.: 71.0   1st Qu.: 91.25
## Median : 15.00   Median : 78.50   Median :111.0   Median :130.00
## Mean   : 24.36   Mean   : 96.99   Mean   :134.7   Mean   :146.67
## 3rd Qu.: 28.00   3rd Qu.:128.00   3rd Qu.:171.0   3rd Qu.:186.00
## Max.   :653.00   Max.   :728.00   Max.   :906.0   Max.   :580.00
##
##     HHAGE5           HHAGE6           HHAGE7           HHAGE8
## Min.   :  0.0   Min.   :  0.00   Min.   :  0.00   Min.   :  0.00
## 1st Qu.: 37.0   1st Qu.: 30.00   1st Qu.: 35.00   1st Qu.: 16.00
## Median : 54.0   Median : 46.00   Median : 53.00   Median : 28.00
## Mean   : 59.4   Mean   : 53.14   Mean   : 78.96   Mean   : 52.15
## 3rd Qu.: 78.0   3rd Qu.: 68.75   3rd Qu.: 97.00   3rd Qu.: 56.00
## Max.   :188.0   Max.   :217.00   Max.   :688.00   Max.   :781.00
##
##     HHAGE9          HHCHILD1         HHCHILD2          HHSIZE1
## Min.   :  0.00   Min.   :   0.0   Min.   :   0.0   Min.   :  0.0
## 1st Qu.:  4.00   1st Qu.: 210.0   1st Qu.: 155.0   1st Qu.: 49.0
## Median :  9.00   Median : 316.0   Median : 253.0   Median : 88.0
## Mean   : 19.85   Mean   : 380.6   Mean   : 285.7   Mean   :128.4
## 3rd Qu.: 19.00   3rd Qu.: 495.2   3rd Qu.: 369.8   3rd Qu.:166.0
## Max.   :288.00   Max.   :1933.0   Max.   :1856.0   Max.   :726.0
##
```

```
##     HHSIZE2            HHSIZE3            HHSIZE4            HHSIZE5
##  Min.   :   0.0    Min.   :  0.0     Min.   :  0.0     Min.   :  0.00
##  1st Qu.:  96.0    1st Qu.: 60.0     1st Qu.: 57.0     1st Qu.: 35.00
##  Median :  152.0   Median : 90.0     Median : 90.0     Median : 60.50
##  Mean   :  188.7   Mean   :101.7     Mean   :105.8     Mean   : 69.61
##  3rd Qu.:  246.0   3rd Qu.:129.8     3rd Qu.:137.0     3rd Qu.: 92.00
##  Max.   :1244.0    Max.   :415.0     Max.   :588.0     Max.   :538.00
##
##     HHSIZE6            HHSIZE7            rHHINC1            rHHINC2
##  Min.   :  0.00    Min.   :  0.0     Min.   :  0.00    Min.   :  0.0
##  1st Qu.: 16.00    1st Qu.: 12.0     1st Qu.:  0.00    1st Qu.: 33.0
##  Median : 32.00    Median : 28.0     Median : 21.00    Median : 73.0
##  Mean   : 36.37    Mean   : 35.7     Mean   : 31.39    Mean   : 99.2
##  3rd Qu.: 50.00    3rd Qu.: 50.0     3rd Qu.: 46.00    3rd Qu.:138.8
##  Max.   :273.00    Max.   :281.0     Max.   :307.00    Max.   :518.0
##
##     rHHINC3            rHHINC4            rHHINC5            rHHINC6
##  Min.   :  0.0     Min.   :  0.00    Min.   :  0.00    Min.   :  0.00
##  1st Qu.: 23.0     1st Qu.: 40.00    1st Qu.: 65.25    1st Qu.: 40.00
##  Median : 53.0     Median : 74.50    Median :109.00    Median : 76.00
##  Mean   : 66.5     Mean   : 88.33    Mean   :125.22    Mean   : 91.54
##  3rd Qu.: 94.0     3rd Qu.:121.00    3rd Qu.:165.00    3rd Qu.:125.00
##  Max.   :462.0     Max.   :419.00    Max.   :691.00    Max.   :726.00
##
##     rHHINC7            rHHINC8            rHHINC9             n_hh
##  Min.   :  0.00    Min.   :  0.0     Min.   :  0.00    Min.   :   0.0
##  1st Qu.: 31.00    1st Qu.:  0.0     1st Qu.:  0.00    1st Qu.: 429.2
##  Median : 73.00    Median : 20.0     Median :  8.00    Median : 599.0
##  Mean   : 99.46    Mean   : 36.4     Mean   : 28.23    Mean   : 666.3
##  3rd Qu.:142.75    3rd Qu.: 55.0     3rd Qu.: 36.75    3rd Qu.: 853.0
##  Max.   :665.00    Max.   :380.0     Max.   :451.00    Max.   :2738.0
##
##      AGE1               AGE2               AGE3               AGE4
##  Min.   :   0.0    Min.   :   0.0    Min.   :   0.0    Min.   :   0.0
##  1st Qu.: 234.0    1st Qu.: 182.2    1st Qu.: 210.2    1st Qu.: 168.2
##  Median : 416.0    Median : 292.0    Median : 348.5    Median : 248.5
##  Mean   : 469.9    Mean   : 314.3    Mean   : 401.0    Mean   : 286.3
##  3rd Qu.: 620.0    3rd Qu.: 410.0    3rd Qu.: 513.0    3rd Qu.: 358.0
##  Max.   :3377.0    Max.   :1850.0    Max.   :2853.0    Max.   :1489.0
##
##      AGE5               AGE6               SEX1               SEX2
##  Min.   :   0.0    Min.   :   0.0    Min.   :   0.0    Min.   :   0.0
##  1st Qu.: 216.0    1st Qu.: 111.2    1st Qu.: 645.0    1st Qu.: 680.2
##  Median : 300.0    Median : 172.0    Median : 900.5    Median : 961.0
##  Mean   : 338.7    Mean   : 253.7    Mean   : 992.7    Mean   :1071.1
##  3rd Qu.: 441.5    3rd Qu.: 302.0    3rd Qu.:1221.8    3rd Qu.:1313.0
##  Max.   :1271.0    Max.   :2689.0    Max.   :5074.0    Max.   :5999.0
##
##      n_pr             Shape_Leng         Shape_Area           FID_
##  Min.   :   0      Min.   :0.01383   Min.   :0.0000112   Min.   :    9
##  1st Qu.: 1349     1st Qu.:0.03830   1st Qu.:0.0000664   1st Qu.: 6442
##  Median : 1856     Median :0.05333   Median :0.0001280   Median :12538
##  Mean   : 2064     Mean   :0.10159   Mean   :0.0017866   Mean   :12430
##  3rd Qu.: 2544     3rd Qu.:0.09153   3rd Qu.:0.0003004   3rd Qu.:17717
```

9

```
## Max.   :11073  Max.   :5.19552  Max.   :0.9595660  Max.   :23165
##
## STATEFP_1  COUNTYFP_1     TRACTCE_1       BLKGRPCE_1
## 06:1030    065   :1030   030200 :   5   1       :453
##            001   :  0    030300 :   5   2       :375
##            003   :  0    030400 :   5   3       :142
##            005   :  0    030700 :   5   4       : 44
##            007   :  0    030800 :   5   5       : 16
##            009   :  0    031100 :   5   0       :  0
##            (Other):  0   (Other):1000   (Other):  0
##                AFFGEOID_1        ALAND_1            AWATER_1
## 1500000US060650301011:  1  Min.   :1.142e+05  Min.   :        0
## 1500000US060650301031:  1  1st Qu.:6.798e+05  1st Qu.:        0
## 1500000US060650301032:  1  Median :1.308e+06  Median :        0
## 1500000US060650301041:  1  Mean   :1.812e+07  Mean   :   243646
## 1500000US060650301042:  1  3rd Qu.:2.984e+06  3rd Qu.:        0
## 1500000US060650301043:  1  Max.   :9.860e+09  Max.   :161997930
## (Other)              :1024
##   Shape_Ar_1         GEO_ID2_1           pumano         countyname
## Min.   :0.0000112  Min.   :6.065e+10  Min.   :6501   Riverside:1030
## 1st Qu.:0.0000664  1st Qu.:6.065e+10  1st Qu.:6504   Alameda  :   0
## Median :0.0001280  Median :6.065e+10  Median :6508   Alpine   :   0
## Mean   :0.0017866  Mean   :6.065e+10  Mean   :6508   Amador   :   0
## 3rd Qu.:0.0003004  3rd Qu.:6.065e+10  3rd Qu.:6511   Butte    :   0
## Max.   :0.9595660  Max.   :6.066e+10  Max.   :6515   Calaveras:   0
##                                                      (Other)  :   0
##     GEOID            n_hh_1           n_pr_1          walkM
## Min.   :0.000e+00  Min.   :   0.0  Min.   :    0  Min.   :   0.0
## 1st Qu.:6.065e+10  1st Qu.: 429.2  1st Qu.: 1349  1st Qu.: 233.6
## Median :6.065e+10  Median : 599.0  Median : 1856  Median : 356.8
## Mean   :6.059e+10  Mean   : 666.3  Mean   : 2064  Mean   : 405.9
## 3rd Qu.:6.065e+10  3rd Qu.: 853.0  3rd Qu.: 2544  3rd Qu.: 524.3
## Max.   :6.066e+10  Max.   :2738.0  Max.   :11073  Max.   :2348.4
##
##     bikeM            drvalM          drvothM          passM
## Min.   :  0.00   Min.   : 0.000   Min.   :    0   Min.   :     0
## 1st Qu.: 72.32   1st Qu.: 7.686   1st Qu.: 7411   1st Qu.: 10227
## Median :120.78   Median : 9.371   Median :10706   Median : 16742
## Mean   :147.72   Mean   : 9.446   Mean   :12634   Mean   : 22625
## 3rd Qu.:193.49   3rd Qu.:10.982   3rd Qu.:15756   3rd Qu.: 28712
## Max.   :710.83   Max.   :38.325   Max.   :66840   Max.   :160220
##
##     planeM           otherM           allM            walkD
## Min.   :    0.00  Min.   :    0   Min.   :     0   Min.   :    0
## 1st Qu.:   83.78  1st Qu.: 1291   1st Qu.: 33154   1st Qu.: 5586
## Median :  335.11  Median : 1988   Median : 49953   Median : 8796
## Mean   :  674.73  Mean   : 2414   Mean   : 58213   Mean   :10045
## 3rd Qu.:  837.77  3rd Qu.: 3043   3rd Qu.: 72335   3rd Qu.:13108
## Max.   :10388.38  Max.   :22676   Max.   :294702   Max.   :80304
##
##     bikeD            drvalD          drvothD          passD
## Min.   :   0.0   Min.   :    0   Min.   :    0   Min.   :    0
## 1st Qu.: 718.8   1st Qu.: 27441  1st Qu.: 16093  1st Qu.: 24370
## Median :1146.0   Median : 39642  Median : 22534  Median : 38486
```

```
##   Mean   :1404.5   Mean   : 43971   Mean   : 26368   Mean   : 46410
##   3rd Qu.:1823.8   3rd Qu.: 55152   3rd Qu.: 32608   3rd Qu.: 57512
##   Max.   :8354.0   Max.   :184975   Max.   :139435   Max.   :280673
##
##      planeD           otherD           allD            walkT
##   Min.   :    0.0   Min.   :    0   Min.   :     0   Min.   :   0.0
##   1st Qu.:  180.0   1st Qu.: 4144   1st Qu.: 86153   1st Qu.: 426.0
##   Median :  805.5   Median : 6318   Median :121196   Median : 671.0
##   Mean   : 1504.1   Mean   : 7305   Mean   :137009   Mean   : 763.1
##   3rd Qu.: 2100.8   3rd Qu.: 9532   3rd Qu.:167998   3rd Qu.: 998.0
##   Max.   :11771.0   Max.   :37658   Max.   :682010   Max.   :4768.0
##
##       bikeT            drvalT          drvothT          passT
##   Min.   :  0.00   Min.   :   0   Min.   :   0   Min.   :    0
##   1st Qu.: 34.00   1st Qu.:1302   1st Qu.: 746   1st Qu.: 1090
##   Median : 57.00   Median :1862   Median :1076   Median : 1650
##   Mean   : 70.97   Mean   :2079   Mean   :1228   Mean   : 1898
##   3rd Qu.: 92.00   3rd Qu.:2627   3rd Qu.:1526   3rd Qu.: 2392
##   Max.   :292.00   Max.   :8955   Max.   :6452   Max.   :11317
##
##      planeT           otherT            allT            VMT_drv
##   Min.   :  0.000   Min.   :   0.0   Min.   :    0   Min.   :     0
##   1st Qu.:  1.000   1st Qu.: 136.2   1st Qu.: 4028   1st Qu.: 18888
##   Median :  4.000   Median : 212.0   Median : 5642   Median : 27948
##   Mean   :  8.143   Mean   : 248.8   Mean   : 6296   Mean   : 31946
##   3rd Qu.: 10.000   3rd Qu.: 326.8   3rd Qu.: 7794   3rd Qu.: 40037
##   Max.   :124.000   Max.   :1394.0   Max.   :31623   Max.   :153460
##
##      VMT_pas            VMT           pr_LDTrips         HHVEH0
##   Min.   :     0   Min.   :     0   Min.   :   0.0   Min.   :  0.00
##   1st Qu.: 10227   1st Qu.: 30477   1st Qu.: 105.0   1st Qu.: 10.00
##   Median : 16742   Median : 46382   Median : 162.0   Median : 22.00
##   Mean   : 22625   Mean   : 54571   Mean   : 197.1   Mean   : 32.56
##   3rd Qu.: 28712   3rd Qu.: 68563   3rd Qu.: 256.0   3rd Qu.: 44.00
##   Max.   :160220   Max.   :282956   Max.   :1168.0   Max.   :216.00
##
##      HHVEH1           HHVEH2           HHVEH3           HHVEH4
##   Min.   :  0.0   Min.   :   0.0   Min.   :  0.0   Min.   :  0.00
##   1st Qu.:106.0   1st Qu.: 173.0   1st Qu.: 57.0   1st Qu.: 13.00
##   Median :164.5   Median : 251.5   Median : 91.0   Median : 24.00
##   Mean   :199.0   Mean   : 283.3   Mean   :110.1   Mean   : 30.01
##   3rd Qu.:262.8   3rd Qu.: 355.2   3rd Qu.:143.0   3rd Qu.: 40.00
##   Max.   :806.0   Max.   :1280.0   Max.   :664.0   Max.   :219.00
##
##      HHVEH5           HHVEH6           HHVEH7           HHVEH8
##   Min.   : 0.000   Min.   : 0.000   Min.   : 0.000   Min.   : 0.0000
##   1st Qu.: 2.000   1st Qu.: 0.000   1st Qu.: 0.000   1st Qu.: 0.0000
##   Median : 5.000   Median : 2.000   Median : 0.000   Median : 0.0000
##   Mean   : 7.481   Mean   : 2.734   Mean   : 0.701   Mean   : 0.2922
##   3rd Qu.:10.000   3rd Qu.: 4.000   3rd Qu.: 1.000   3rd Qu.: 0.0000
##   Max.   :75.000   Max.   :41.000   Max.   :17.000   Max.   :24.0000
##
##      notrav           LPAgrp
##   Min.   :  0.0   Min.   :1.000
```

```
##  1st Qu.: 315.2    1st Qu.:2.000
##  Median : 439.0    Median :3.000
##  Mean   : 493.3    Mean   :2.772
##  3rd Qu.: 616.8    3rd Qu.:3.000
##  Max.   :2765.0    Max.   :4.000
##
```
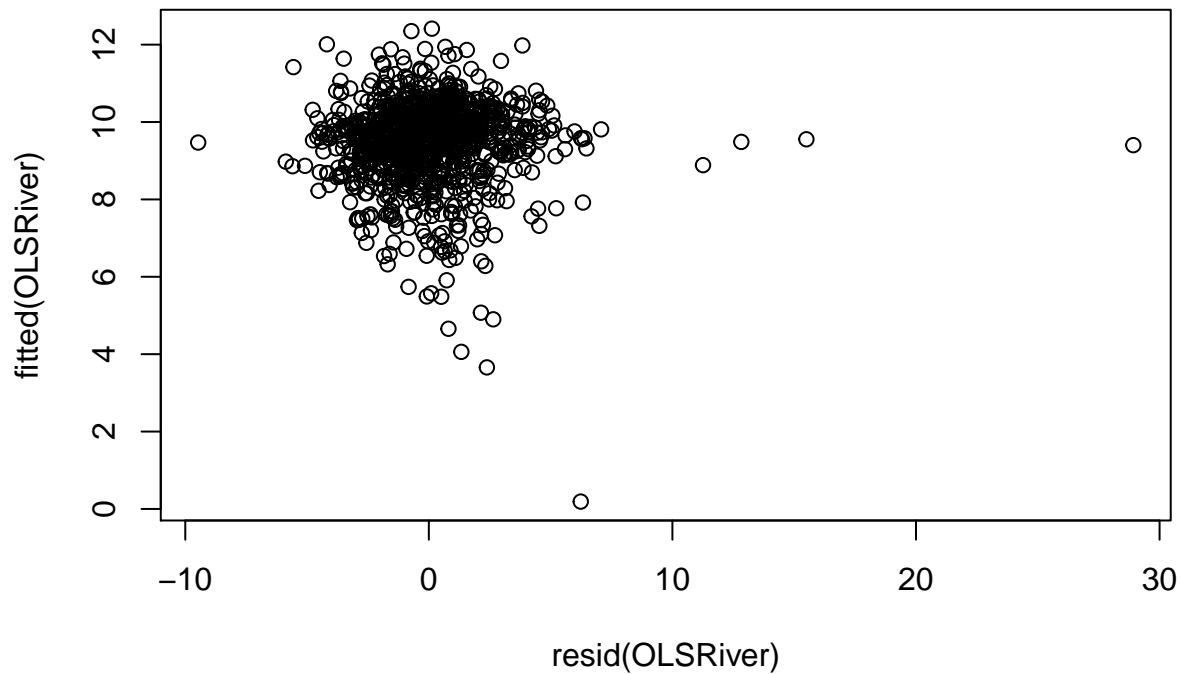
Non spatial OLS

```
OLSRiver = lm(drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 + HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data=YCOU
summary(OLSRiver)
```

```
##
## Call:
## lm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 + HHVEH4 +
##     HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY@data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.4700 -1.5109 -0.0798  1.2364 28.9223
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  9.469955   0.174907  54.143  < 2e-16 ***
## HHVEH0      -0.032975   0.003784  -8.713  < 2e-16 ***
## HHVEH1       0.002130   0.001322   1.611 0.107557
## HHVEH2       0.005519   0.001434   3.848 0.000126 ***
## HHVEH3      -0.003717   0.002984  -1.246 0.213217
## HHVEH4      -0.006927   0.006257  -1.107 0.268537
## HHVEH5      -0.009932   0.014960  -0.664 0.506897
## HHVEH6       0.009330   0.022882   0.408 0.683530
## HHVEH7      -0.388248   0.065561  -5.922 4.34e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.395 on 1021 degrees of freedom
## Multiple R-squared:  0.173,  Adjusted R-squared:  0.1666
## F-statistic: 26.71 on 8 and 1021 DF,  p-value: < 2.2e-16
```

In this model, if all the variables are 0, the number of miles drive alone per household per person is 54.143miles (p<0.001). If all the variables are not 0, then each more household has no car, the number of miles drive alone per household per person will decrease 8.713 miles (p<0.001); each more household has 2 car, the number of miles drive alone per household per person will increase 3.848 miles (p<0.001); then each more household has 7 car, the number of miles drive alone per household per person will decrease 5.922 miles (p<0.001).
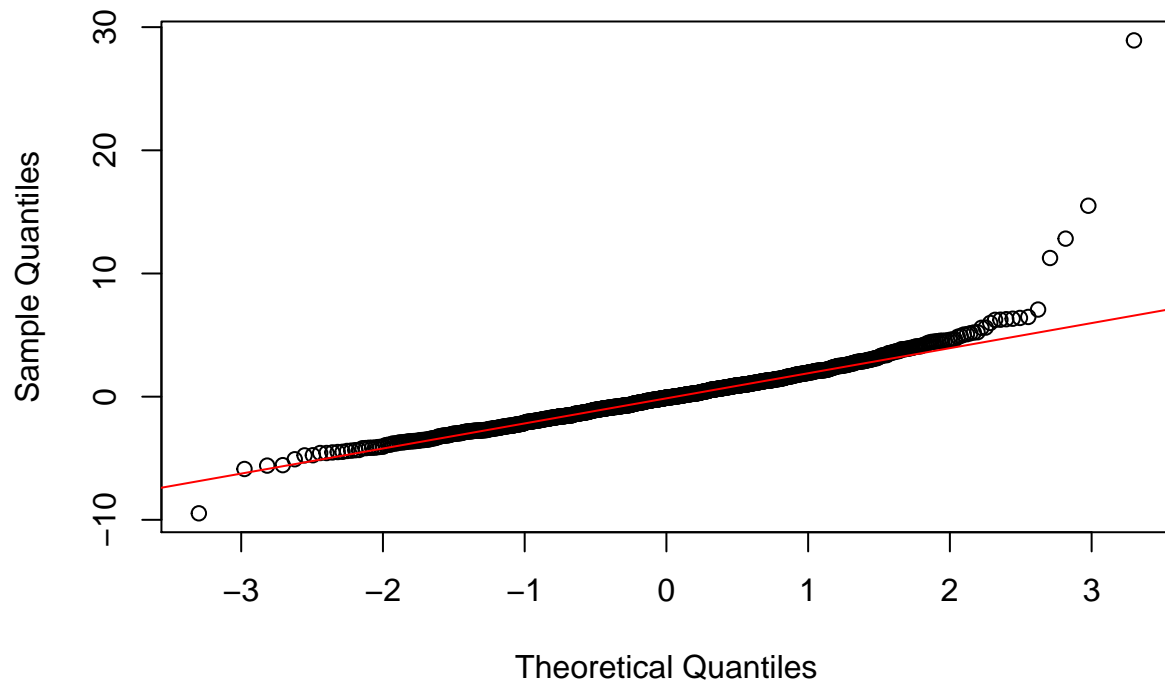
```
resOLSRiver <- resid(OLSRiver) # save the residuals
plot(resid(OLSRiver), fitted(OLSRiver)) # Tukey-Anscombe's plot
```

From the above plot, I can see that residual variability increases with fitted y when fitted y is closer to 10.

```
qqnorm(resOLSRiver)
qqline(resOLSRiver,col="red")
```
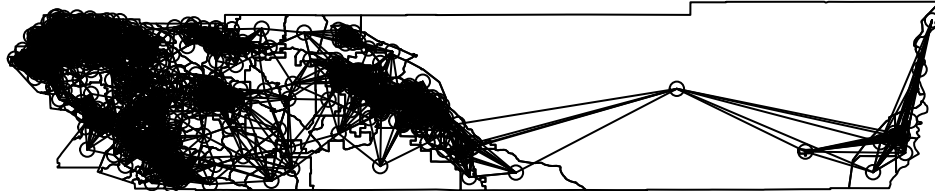
Normal Q–Q Plot

From the plot above, we can see that the quantile data of residual is not aligned with the predicted quantile distribution. Thus, there is variability in residual distribution and thus it corresponds to the plot of the residual with fitted y to look more into the variability.

Spatial weights creation and checking the data

Using neighborhoods based on the k-nearest neighbor rule

```
coords<-coordinates(YCOUNTY)
IDs<-row.names(as(YCOUNTY, "data.frame"))
plot(YCOUNTY)
sids_kn10<-knn2nb(knearneigh(coords,    k=10), row.names=IDs)
plot(sids_kn10, coords, add=T)
```



```
summary (sids_kn10)
```

```
## Neighbour list object:
## Number of regions: 1030
## Number of nonzero links: 10300
## Percentage nonzero weights: 0.9708738
## Average number of links: 10
## Non-symmetric neighbours list
## Link number distribution:
##
##    10
## 1030
## 1030 least connected regions:
## 9 101 107 134 174 318 364 420 454 493 501 520 525 533 546 563 575 628 642 670 695 699 724 742 821 82
## 1030 most connected regions:
## 9 101 107 134 174 318 364 420 454 493 501 520 525 533 546 563 575 628 642 670 695 699 724 742 821 82
```

```
sids_kn10_w<- nb2listw(sids_kn10)
summary(sids_kn10_w)
```
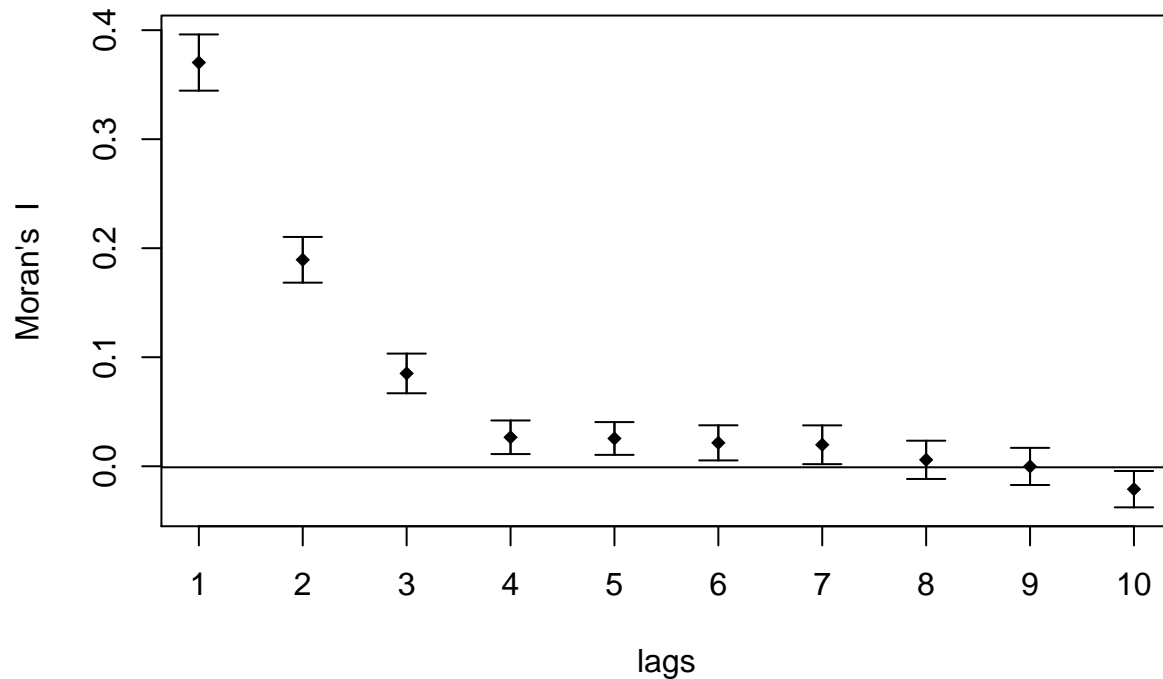
```
## Characteristics of weights list object:
## Neighbour list object:
## Number of regions: 1030
## Number of nonzero links: 10300
## Percentage nonzero weights: 0.9708738
## Average number of links: 10
## Non-symmetric neighbours list
## Link number distribution:
##
##    10
## 1030
## 1030 least connected regions:
## 9 101 107 134 174 318 364 420 454 493 501 520 525 533 546 563 575 628 642 670 695 699 724 742 821 82
## 1030 most connected regions:
## 9 101 107 134 174 318 364 420 454 493 501 520 525 533 546 563 575 628 642 670 695 699 724 742 821 82
##
## Weights style: W
## Weights constants summary:
##        n      nn    S0    S1      S2
```

```
## W 1030 1060900 1030 180.98 4232.62
```

Moran's I

```
mor10k <- sp.correlogram(sids_kn10, var=YCOUNTY@data$drvalM, order=10, method="I", zero.policy=TRUE)  #
plot(mor10k, main = "Moran I with knn10 Contiguity and Row Standardization")
```

Moran I with knn10 Contiguity and Row Standardization


```
LM<-lm.LMtests(OLSRiver, sids_kn10_w, test="all")
print(LM)
```

```
##
##  Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
## HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY@data)
## weights: sids_kn10_w
##
## LMerr = 578.6, df = 1, p-value < 2.2e-16
##
##
##  Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
## HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY@data)
## weights: sids_kn10_w
##
## LMlag = 567.75, df = 1, p-value < 2.2e-16
##
##
```

```
##  Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
## HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY@data)
## weights: sids_kn10_w
##
## RLMerr = 39.831, df = 1, p-value = 2.769e-10
##
##
##  Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
## HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY@data)
## weights: sids_kn10_w
##
## RLMlag = 28.979, df = 1, p-value = 7.318e-08
##
##
##  Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
## HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY@data)
## weights: sids_kn10_w
##
## SARMA = 607.58, df = 2, p-value < 2.2e-16
```

1. Spatial Lag Model

```
SpaLag <- lagsarlm(drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
    HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data=YCOUNTY, sids_kn10_w)
summary(SpaLag)
```

```
##
## Call:lagsarlm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
##     HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY, listw = sids_kn10_w)
##
## Residuals:
##       Min       1Q   Median       3Q      Max
## -9.88657 -1.17346 -0.14422  0.96878 26.81413
##
## Type: lag
## Coefficients: (asymptotic standard errors)
##               Estimate Std. Error z value  Pr(>|z|)
## (Intercept)  3.0734490  0.3119574  9.8521 < 2.2e-16
## HHVEH0      -0.0265920  0.0031553 -8.4277 < 2.2e-16
## HHVEH1       0.0019943  0.0010936  1.8236 0.0682094
## HHVEH2       0.0033276  0.0011866  2.8043 0.0050427
## HHVEH3      -0.0045829  0.0024703 -1.8552 0.0635615
## HHVEH4      -0.0061082  0.0051758 -1.1801 0.2379479
## HHVEH5       0.0138848  0.0123765  1.1219 0.2619166
## HHVEH6       0.0122851  0.0189295  0.6490 0.5163414
## HHVEH7      -0.2069581  0.0543321 -3.8091 0.0001395
```

```
##
## Rho: 0.71713, LR test value: 319.39, p-value: < 2.22e-16
## Asymptotic standard error: 0.028609
##     z-value: 25.067, p-value: < 2.22e-16
## Wald statistic: 628.35, p-value: < 2.22e-16
##
## Log likelihood: -2197.031 for lag model
## ML residual variance (sigma squared): 3.9246, (sigma: 1.9811)
## Number of observations: 1030
## Number of parameters estimated: 11
## AIC: 4416.1, (AIC for lm: 4733.5)
## LM test for residual autocorrelation
## test value: 10.274, p-value: 0.001349
```

The number of miles per person drives alone of a block group is a function of the neighborhood's number of miles per person drive alone. This output shows the Rho (0.71713) is significantly different than zero (p<0.001). This means the number of miles per person drives alone for each block group depends on the the number of miles per person drives alone of its neighbors.

2. Spatial Error Model

```
SpaErr<-errorsarlm(drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
    HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data=YCOUNTY, sids_kn10_w)
summary(SpaErr)
```

```
##
## Call:errorsarlm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
##      HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY, listw = sids_kn10_w)
##
## Residuals:
##       Min       1Q    Median       3Q       Max
## -10.01430  -1.18971  -0.12343   0.96141  26.68614
##
## Type: error
## Coefficients: (asymptotic standard errors)
##               Estimate Std. Error z value  Pr(>|z|)
## (Intercept) 10.2501338  0.2914705 35.1670 < 2.2e-16
## HHVEH0      -0.0294399  0.0032416 -9.0819 < 2.2e-16
## HHVEH1       0.0018576  0.0011522  1.6121  0.106936
## HHVEH2       0.0025418  0.0012054  2.1087  0.034972
## HHVEH3      -0.0035414  0.0025050 -1.4137  0.157449
## HHVEH4      -0.0045088  0.0051449 -0.8764  0.380828
## HHVEH5       0.0227143  0.0128428  1.7686  0.076954
## HHVEH6       0.0208556  0.0198502  1.0506  0.293421
## HHVEH7      -0.1730065  0.0558346 -3.0986  0.001945
##
## Lambda: 0.75625, LR test value: 323.37, p-value: < 2.22e-16
## Asymptotic standard error: 0.028703
##     z-value: 26.347, p-value: < 2.22e-16
## Wald statistic: 694.18, p-value: < 2.22e-16
##
## Log likelihood: -2195.042 for error model
## ML residual variance (sigma squared): 3.8708, (sigma: 1.9674)
## Number of observations: 1030
## Number of parameters estimated: 11
## AIC: 4412.1, (AIC for lm: 4733.5)
```

The error of a block group is a function of the neighbor's errors. From this output I find the estimated model is contradicting the robust of the simple linear model test for error dependence because Lambda (0.75625) is significantly different than zero (p<0.001). The error of a block group is influenced by the neighbor's errors.

3. SARAR model

```
SARAR<-sacsarlm(drvalM ~ HHVEH0+HHVEH1+HHVEH2+HHVEH3+HHVEH4+HHVEH5+HHVEH6+HHVEH7, data=YCOUNTY, sids_kn
summary(SARAR)
```

```
##
## Call:sacsarlm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
##      HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY, listw = sids_kn10_w)
##
## Residuals:
##       Min       1Q   Median       3Q      Max
## -9.90177 -1.23818 -0.14159  0.98737 27.29438
##
## Type: sac
## Coefficients: (asymptotic standard errors)
##                Estimate Std. Error z value  Pr(>|z|)
## (Intercept)  5.8356428  1.4637323   3.9868 6.696e-05
## HHVEH0      -0.0294653  0.0032790  -8.9860 < 2.2e-16
## HHVEH1       0.0019649  0.0011549   1.7013 0.0888846
## HHVEH2       0.0029733  0.0012202   2.4367 0.0148233
## HHVEH3      -0.0039291  0.0025374  -1.5485 0.1215036
## HHVEH4      -0.0057762  0.0052444  -1.1014 0.2707210
## HHVEH5       0.0195642  0.0129061   1.5159 0.1295476
## HHVEH6       0.0187331  0.0199356   0.9397 0.3473827
## HHVEH7      -0.1910326  0.0564385  -3.3848 0.0007123
##
## Rho: 0.43445
## Asymptotic standard error: 0.15012
##     z-value: 2.894, p-value: 0.0038038
## Lambda: 0.49564
## Asymptotic standard error: 0.1471
##     z-value: 3.3693, p-value: 0.00075362
##
## LR test value: 331.14, p-value: < 2.22e-16
##
## Log likelihood: -2191.156 for sac model
## ML residual variance (sigma squared): 3.9552, (sigma: 1.9888)
## Number of observations: 1030
## Number of parameters estimated: 12
## AIC: 4406.3, (AIC for lm: 4733.5)
```

When considering the influence of both neighbor variables and errors by using SARRAR model, I find that both Rho (0.43445, p<0.05) and lambda (0.49564, p<0.001) are significant. This means that Y (the number of miles drive alone per person) is influenced by the neighbor and the error of Y is also influenced by neighbor's error.

4. Spatial Lag with Lagged explanatory variables

```
SpaLagMix <- lagsarlm(drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
    HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data=YCOUNTY, sids_kn10_w, type="mixed")
summary(SpaLagMix)
```

```
##
```

```
## Call:lagsarlm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
##     HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY, listw = sids_kn10_w,
##     type = "mixed")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -9.83110 -1.17927 -0.13052  1.00179 26.67252
##
## Type: mixed
## Coefficients: (asymptotic standard errors)
##               Estimate Std. Error z value  Pr(>|z|)
## (Intercept)  2.9626986  0.4375517  6.7711 1.278e-11
## HHVEH0      -0.0289583  0.0032574 -8.8899 < 2.2e-16
## HHVEH1       0.0017903  0.0011589  1.5448 0.122385
## HHVEH2       0.0025184  0.0012098  2.0818 0.037365
## HHVEH3      -0.0038794  0.0025235 -1.5373 0.124223
## HHVEH4      -0.0036054  0.0052115 -0.6918 0.489057
## HHVEH5       0.0211793  0.0129163  1.6397 0.101061
## HHVEH6       0.0203622  0.0198061  1.0281 0.303912
## HHVEH7      -0.1718432  0.0559906 -3.0691 0.002147
## lag.HHVEH0   0.0193564  0.0076488  2.5306 0.011385
## lag.HHVEH1  -0.0033380  0.0028168 -1.1850 0.236009
## lag.HHVEH2   0.0037336  0.0032748  1.1401 0.254257
## lag.HHVEH3  -0.0032551  0.0070597 -0.4611 0.644746
## lag.HHVEH4   0.0144203  0.0158385  0.9105 0.362584
## lag.HHVEH5  -0.0761970  0.0358898 -2.1231 0.033747
## lag.HHVEH6  -0.0252700  0.0496959 -0.5085 0.611108
## lag.HHVEH7  -0.2023090  0.1498874 -1.3497 0.177099
##
## Rho: 0.69827, LR test value: 250.51, p-value: < 2.22e-16
## Asymptotic standard error: 0.033086
##     z-value: 21.104, p-value: < 2.22e-16
## Wald statistic: 445.4, p-value: < 2.22e-16
##
## Log likelihood: -2183.607 for mixed model
## ML residual variance (sigma squared): 3.8402, (sigma: 1.9596)
## Number of observations: 1030
## Number of parameters estimated: 19
## AIC: 4405.2, (AIC for lm: 4653.7)
## LM test for residual autocorrelation
## test value: 4.1202, p-value: 0.042374
```

In order to test if Xs are spatially correlated, I used "mixed" type in the lagsarlm. The result shows a bigger Rho (0.69827, p<0.001), which means that the Xs (number of vehicles in the neighboring household) of the neighbors influence their Ys (the number of miles drive alone per person) and contributes even more variables to the Ys.

5. SARAR with Lagged explanatory variables

```
SARARMix<-sacsarlm(drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
    HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data=YCOUNTY, sids_kn10_w, type= "sacmixed")
summary(SARARMix)
```

```
##
## Call:sacsarlm(formula = drvalM ~ HHVEH0 + HHVEH1 + HHVEH2 + HHVEH3 +
##     HHVEH4 + HHVEH5 + HHVEH6 + HHVEH7, data = YCOUNTY, listw = sids_kn10_w,
```

```
##      type = "sacmixed")
##
## Residuals:
##      Min      1Q   Median      3Q      Max
## -9.87804 -1.18146 -0.13597  1.01266 27.04046
##
## Type: sacmixed
## Coefficients: (asymptotic standard errors)
##                Estimate  Std. Error z value  Pr(>|z|)
## (Intercept)  6.47564513  2.48635871  2.6045  0.009202
## HHVEH0      -0.02933103  0.00331800 -8.8400 < 2.2e-16
## HHVEH1       0.00195298  0.00117010  1.6691  0.095103
## HHVEH2       0.00278259  0.00124525  2.2346  0.025446
## HHVEH3      -0.00398209  0.00258389 -1.5411  0.123287
## HHVEH4      -0.00431873  0.00540472 -0.7991  0.424252
## HHVEH5       0.01758356  0.01325062  1.3270  0.184509
## HHVEH6       0.01946074  0.01992847  0.9765  0.328802
## HHVEH7      -0.18609846  0.05821630 -3.1967  0.001390
## lag.HHVEH0  -0.00234306  0.01569094 -0.1493  0.881296
## lag.HHVEH1  -0.00087517  0.00421876 -0.2074  0.835661
## lag.HHVEH2   0.00630663  0.00506404  1.2454  0.212994
## lag.HHVEH3   0.00022997  0.00994496  0.0231  0.981551
## lag.HHVEH4   0.00555005  0.02234235  0.2484  0.803818
## lag.HHVEH5  -0.09942094  0.04900634 -2.0287  0.042485
## lag.HHVEH6  -0.04493152  0.07062973 -0.6362  0.524675
## lag.HHVEH7  -0.37640236  0.25765472 -1.4609  0.144049
##
## Rho: 0.30494
## Asymptotic standard error: 0.25962
##     z-value: 1.1746, p-value: 0.24016
## Lambda: 0.54095
## Asymptotic standard error: 0.20034
##     z-value: 2.7001, p-value: 0.0069312
##
## LR test value: 351.23, p-value: < 2.22e-16
##
## Log likelihood: -2181.109 for sacmixed model
## ML residual variance (sigma squared): 3.8947, (sigma: 1.9735)
## Number of observations: 1030
## Number of parameters estimated: 20
## AIC: 4402.2, (AIC for lm: 4733.5)
```

In this SARRAR model with lagged Xs, Rho is smaller (0.30494) and not significant (p= 0.24016) which means that Xs balanced out some variables of the Ys so that Rho is smaller and insignificant. Lambda (0.54095) is bigger and less significant (p<0.05), which means that Xs balanced out some errors of neighbors.