Econ 613 Assignment 2

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```r
library(bayesm)
library(plyr)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:plyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(fastDummies)
library(gmm)
```

```
## Loading required package: sandwich
```

```r
library(tidyr)
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.1.0     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::arrange()   masks plyr::arrange()
## x purrr::compact()   masks plyr::compact()
## x dplyr::count()     masks plyr::count()
## x dplyr::failwith()  masks plyr::failwith()
## x dplyr::filter()    masks stats::filter()
## x dplyr::id()        masks plyr::id()
## x dplyr::lag()       masks stats::lag()
## x dplyr::mutate()    masks plyr::mutate()
## x dplyr::rename()    masks plyr::rename()
## x dplyr::summarise() masks plyr::summarise()
## x dplyr::summarize() masks plyr::summarize()
```

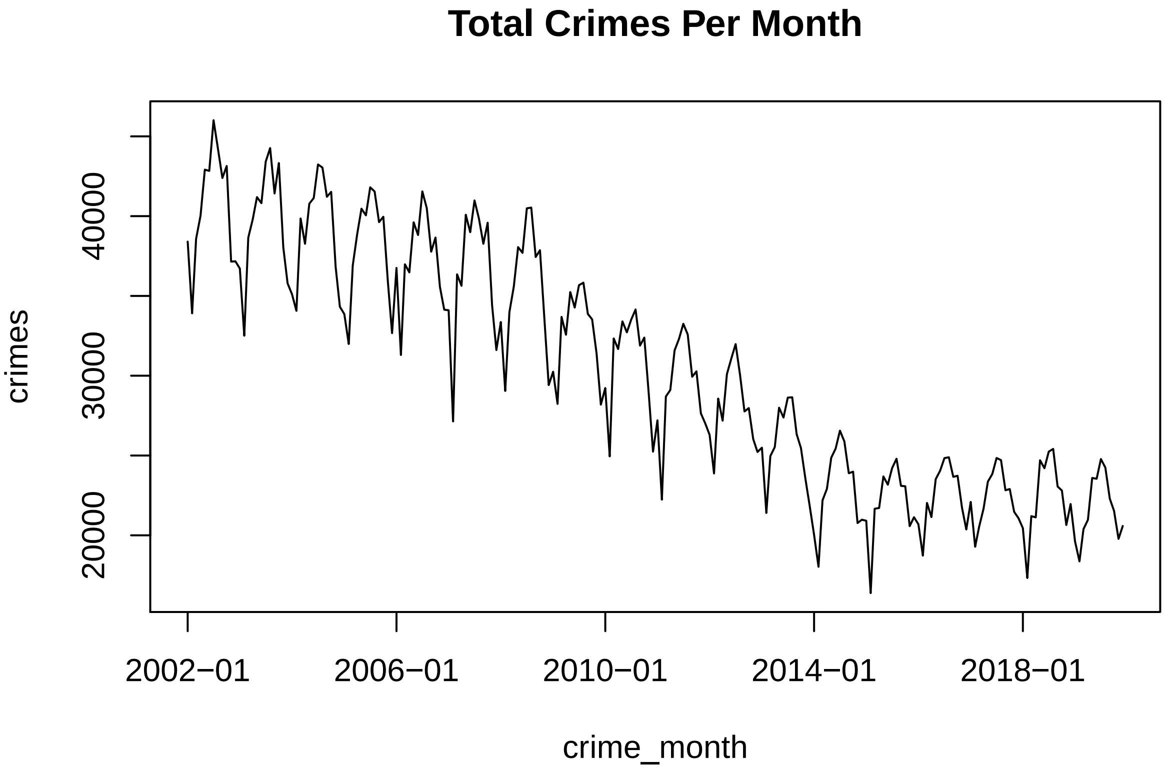
Links to the datasets

```
pop = read.csv("file:///Users/DXL/Desktop/Econ613/population.csv")
cri = read.csv("file:///Users/DXL/Desktop/Econ613/crime_long.csv")
off = read.csv("file:///Users/DXL/Desktop/Econ613/officers.csv")
```

Exercise 2 Data Manipulation

- Total Crimes Per Month

```
sum1 = cri %>% group_by(crime_month) %>%
  summarise(cripermon=sum(crimes))
month = as.Date(sum1 %>% pull(crime_month))
cripermon = sum1 %>% pull(cripermon)
plot(month,cripermon,col=1,type="l",xaxt='n',main='Total Crimes Per Month',
     xlab='crime_month',ylab='crimes',lwd=1)
axis.Date(1,at=seq(min(month),max(month),by='48 mon'),format='%Y-%m')
```



- Merged data df1

```
df1 = full_join(cri, pop,
                    by=c('crime_month'='month','district'='district'))
df1[1:10,]
```

```
##    crime_month district crime_type crimes period tot_pop tot_white tot_black
## 1   2002-01-01        1       drug    104     NA      NA        NA        NA
## 2   2002-01-01        1      other     97     NA      NA        NA        NA
## 3   2002-01-01        1      other    174     NA      NA        NA        NA
```

```
## 4   2002-01-01        1   property    658     NA      NA        NA        NA
## 5   2002-01-01        1   property    201     NA      NA        NA        NA
## 6   2002-01-01        1    violent    182     NA      NA        NA        NA
## 7   2002-01-01        1    violent     60     NA      NA        NA        NA
## 8   2002-01-01        2       drug    161     NA      NA        NA        NA
## 9   2002-01-01        2      other    112     NA      NA        NA        NA
## 10  2002-01-01        2      other    158     NA      NA        NA        NA
##    tot_hisp p50_inc
## 1        NA      NA
## 2        NA      NA
## 3        NA      NA
## 4        NA      NA
## 5        NA      NA
## 6        NA      NA
## 7        NA      NA
## 8        NA      NA
## 9        NA      NA
## 10       NA      NA
```

- Panel data df7 of unit over time with the following variables
    - Total crimes per resident
    - Violent crimes per resident
    - Property crimes per resident
    - Median income
    - Share of black, Hispanic, and white residents

```
sum2 = df1 %>% group_by(crime_month,district) %>%
  summarise(cribydis=sum(crimes),popbydis=sum(tot_pop),white=sum(tot_white),
            black=sum(tot_black),hisp=sum(tot_hisp),
            med=quantile(p50_inc,1/2,na.rm=TRUE))
```

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

```
sum3 = df1 %>% group_by(crime_month,district,crime_type) %>%
  summarise(cribytype=sum(crimes))
```

```
## `summarise()` has grouped output by 'crime_month', 'district'. You can override using the `.groups` a
```

```
popbydis = sum2 %>% pull(popbydis)
index1 = which(is.na(popbydis)==FALSE)
popbydis = popbydis[!is.na(popbydis)]
df2 = data.frame(matrix(ncol=0,nrow=length(popbydis)))
crimonth = sum2 %>% pull(crime_month)
df2$crimonth = crimonth[c(index1)]
dis = sum2 %>% pull(district)
df2$dis = dis[c(index1)]
cribydis = sum2 %>% pull(cribydis)
df2$cribydis = cribydis[c(index1)]
df2$popbydis = popbydis
white = sum2 %>% pull(white)
df2$white = white[c(index1)]
black = sum2 %>% pull(black)
df2$black = black[c(index1)]
hisp = sum2 %>% pull(hisp)
df2$hisp = hisp[c(index1)]
med = sum2 %>% pull(med)
```

```r
df2$med = med[c(index1)]
crimon = sum3 %>% pull(crime_month)
df3 = data.frame(matrix(ncol=0,nrow=length(crimon)))
df3$crimon = crimon
df3$dis = sum3 %>% pull(district)
df3$type = sum3 %>% pull(crime_type)
df3$cribytype = sum3 %>% pull(cribytype)
df4 = full_join(df3, df2,
                    by=c('crimon'='crimonth','dis'='dis'))
index2 = which(is.na(df4$cribydis)==FALSE)
df5 = df4[c(index2),]
df5$criperres = df5$cribydis/df5$popbydis
df5$typeperres = df5$cribytype/df5$popbydis
df5$shareofb = df5$black/df5$popbydis
df5$shareofh = df5$hisp/df5$popbydis
df5$shareofw = df5$white/df5$popbydis
df6 = df5[,c(1:3,5,10:15)]
df6 = subset(df6, df6$type=='violent' | df6$type=='property')
df7 = spread(df6, type, typeperres)
colnames(df7) = c('month','district','total_crime','median_income',
                  'crime_per_resident','share_of_black',
                  'share_of_hispanic','share_of_white',
                  'property_per_resident','violent_per_resident')
df7[1:10,]
```

```
##         month district total_crime median_income crime_per_resident
## 1  2005-01-01        1        1549      91084.91        0.005032881
## 2  2005-01-01        2        1351      29890.17        0.004445015
## 3  2005-01-01        3        1707      28047.56        0.003101364
## 4  2005-01-01        4        1839      39010.22        0.002109833
## 5  2005-01-01        5        1411      33146.90        0.002709876
## 6  2005-01-01        6        1742      34672.25        0.002778354
## 7  2005-01-01        7        1970      23960.59        0.003929688
## 8  2005-01-01        8        2383      49069.15        0.001376175
## 9  2005-01-01        9        1533      36323.73        0.001418394
## 10 2005-01-01       10        1395      29147.49        0.001700259
##    share_of_black share_of_hispanic share_of_white property_per_resident
## 1       0.1287430        0.06610002    0.587648160          0.0025473071
## 2       0.9466730        0.01652980    0.016582438          0.0016746947
## 3       0.9130473        0.01743631    0.040913658          0.0011010114
## 4       0.6209012        0.28418956    0.079714742          0.0008191521
## 5       0.9417751        0.03393203    0.011333082          0.0008968903
## 6       0.9745227        0.01011499    0.003449816          0.0011706726
## 7       0.9679541        0.01636506    0.003700290          0.0012726605
## 8       0.2110942        0.56535677    0.208151253          0.0006774039
## 9       0.1215997        0.61083549    0.151658031          0.0006236121
## 10      0.3373888        0.61905656    0.035867553          0.0005606590
##    violent_per_resident
## 1          0.0006888126
## 2          0.0012009107
## 3          0.0009683813
## 4          0.0007067195
## 5          0.0008354331
## 6          0.0009425988
```

```
## 7          0.0014202732
## 8          0.0003638231
## 9          0.0004200592
## 10         0.0005375014
```

Exercise 3 Panel Data: Introduction

- Create data df9 by merging the data ‘off’ with the previous panel data df7

```
df8 = full_join(off, df7,
                   by=c('month'='month','unit'='district'))
df9 = df8[,c(1:7,9:11)]
df9 = df9[rowSums(is.na(df9[,1:10]))== 0,]
df9[1:10,]
```

```
##    NUID      month unit tenure arrest total_crime median_income share_of_black
## 1     1 2007-03-01   14     18      2        1353      61849.46       0.072232
## 2     1 2007-04-01   14     19      0        1200      61849.46       0.072232
## 3     1 2007-05-01   14     20      1        1423      61849.46       0.072232
## 4     1 2007-06-01   14     21      1        1480      61849.46       0.072232
## 5     1 2007-07-01   14     22      0        1569      61849.46       0.072232
## 6     1 2007-08-01   14     23      0        1581      61849.46       0.072232
## 7     1 2007-09-01   14     24      1        1435      61849.46       0.072232
## 8     1 2007-10-01   14     25      0        1538      61849.46       0.072232
## 9     1 2007-11-01   14     26      0        1325      61849.46       0.072232
## 10    1 2007-12-01   14     27      2        1223      61849.46       0.072232
##    share_of_hispanic share_of_white
## 1          0.4608716      0.4173754
## 2          0.4608716      0.4173754
## 3          0.4608716      0.4173754
## 4          0.4608716      0.4173754
## 5          0.4608716      0.4173754
## 6          0.4608716      0.4173754
## 7          0.4608716      0.4173754
## 8          0.4608716      0.4173754
## 9          0.4608716      0.4173754
## 10         0.4608716      0.4173754
```

- Estimate β and γ

```
X1 = as.matrix(df9[,c(4,6:10)])
Y1 = as.matrix(df9[,5])
coef1 = solve(t(X1)%*%X1)%*%t(X1)%*%Y1
coef1[1:6,1]
```

```
##            tenure       total_crime     median_income    share_of_black
##      2.878869e-05     -1.364283e-05      7.210106e-07      5.028186e-01
## share_of_hispanic    share_of_white
##      5.172976e-01      5.151714e-01
```

The estimated β is `coef1[1,1]` and the estimated γ are $-1.3642833 \times 10^{-5}$, 7.210106×10^{-7}, 0.5028186, 0.5172976, 0.5151714.

Exercise 4 Panel Data: More controls

- Create data df10 with district and month dummies

```r
df10 = dummy_cols(df9, select_columns=c('unit','month'))
df10[1:10,]
```

```
##    NUID      month unit tenure arrest total_crime median_income share_of_black
## 1     1 2007-03-01   14     18      2        1353      61849.46       0.072232
## 2     1 2007-04-01   14     19      0        1200      61849.46       0.072232
## 3     1 2007-05-01   14     20      1        1423      61849.46       0.072232
## 4     1 2007-06-01   14     21      1        1480      61849.46       0.072232
## 5     1 2007-07-01   14     22      0        1569      61849.46       0.072232
## 6     1 2007-08-01   14     23      0        1581      61849.46       0.072232
## 7     1 2007-09-01   14     24      1        1435      61849.46       0.072232
## 8     1 2007-10-01   14     25      0        1538      61849.46       0.072232
## 9     1 2007-11-01   14     26      0        1325      61849.46       0.072232
## 10    1 2007-12-01   14     27      2        1223      61849.46       0.072232
##    share_of_hispanic share_of_white unit_1 unit_2 unit_3 unit_4 unit_5 unit_6
## 1          0.4608716      0.4173754      0      0      0      0      0      0
## 2          0.4608716      0.4173754      0      0      0      0      0      0
## 3          0.4608716      0.4173754      0      0      0      0      0      0
## 4          0.4608716      0.4173754      0      0      0      0      0      0
## 5          0.4608716      0.4173754      0      0      0      0      0      0
## 6          0.4608716      0.4173754      0      0      0      0      0      0
## 7          0.4608716      0.4173754      0      0      0      0      0      0
## 8          0.4608716      0.4173754      0      0      0      0      0      0
## 9          0.4608716      0.4173754      0      0      0      0      0      0
## 10         0.4608716      0.4173754      0      0      0      0      0      0
##    unit_7 unit_8 unit_9 unit_10 unit_11 unit_12 unit_13 unit_14 unit_15 unit_16
## 1       0      0      0       0       0       0       0       1       0       0
## 2       0      0      0       0       0       0       0       1       0       0
## 3       0      0      0       0       0       0       0       1       0       0
## 4       0      0      0       0       0       0       0       1       0       0
## 5       0      0      0       0       0       0       0       1       0       0
## 6       0      0      0       0       0       0       0       1       0       0
## 7       0      0      0       0       0       0       0       1       0       0
## 8       0      0      0       0       0       0       0       1       0       0
## 9       0      0      0       0       0       0       0       1       0       0
## 10      0      0      0       0       0       0       0       1       0       0
##    unit_17 unit_18 unit_19 unit_20 unit_21 unit_22 unit_23 unit_24 unit_25
## 1        0       0       0       0       0       0       0       0       0
## 2        0       0       0       0       0       0       0       0       0
## 3        0       0       0       0       0       0       0       0       0
## 4        0       0       0       0       0       0       0       0       0
## 5        0       0       0       0       0       0       0       0       0
## 6        0       0       0       0       0       0       0       0       0
## 7        0       0       0       0       0       0       0       0       0
## 8        0       0       0       0       0       0       0       0       0
## 9        0       0       0       0       0       0       0       0       0
## 10       0       0       0       0       0       0       0       0       0
##    month_2007-01-01 month_2007-02-01 month_2007-03-01 month_2007-04-01
## 1                 0                0                1                0
## 2                 0                0                0                1
```

```
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2007-05-01 month_2007-06-01 month_2007-07-01 month_2007-08-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 1                 0                 0                 0
## 4                 0                 1                 0                 0
## 5                 0                 0                 1                 0
## 6                 0                 0                 0                 1
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2007-09-01 month_2007-10-01 month_2007-11-01 month_2007-12-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 1                 0                 0                 0
## 8                 0                 1                 0                 0
## 9                 0                 0                 1                 0
## 10                0                 0                 0                 1
##    month_2008-01-01 month_2008-02-01 month_2008-03-01 month_2008-04-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2008-05-01 month_2008-06-01 month_2008-07-01 month_2008-08-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2008-09-01 month_2008-10-01 month_2008-11-01 month_2008-12-01
## 1                 0                 0                 0                 0
```

```
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2009-01-01 month_2009-02-01 month_2009-03-01 month_2009-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2009-05-01 month_2009-06-01 month_2009-07-01 month_2009-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2009-09-01 month_2009-10-01 month_2009-11-01 month_2009-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2010-01-01 month_2010-02-01 month_2010-03-01 month_2010-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2010-05-01 month_2010-06-01 month_2010-07-01 month_2010-08-01
```

```
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2010-09-01 month_2010-10-01 month_2010-11-01 month_2010-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2011-01-01 month_2011-02-01 month_2011-03-01 month_2011-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2011-05-01 month_2011-06-01 month_2011-07-01 month_2011-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2011-09-01 month_2011-10-01 month_2011-11-01 month_2011-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
```

```
##    month_2012-01-01 month_2012-02-01 month_2012-03-01 month_2012-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2012-05-01 month_2012-06-01 month_2012-07-01 month_2012-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2012-09-01 month_2012-10-01 month_2012-11-01 month_2012-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2013-01-01 month_2013-02-01 month_2013-03-01 month_2013-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2013-05-01 month_2013-06-01 month_2013-07-01 month_2013-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
```

```
## 10                0                0                0                0
##    month_2013-09-01 month_2013-10-01 month_2013-11-01 month_2013-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2014-01-01 month_2014-02-01 month_2014-03-01 month_2014-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2014-05-01 month_2014-06-01 month_2014-07-01 month_2014-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2014-09-01 month_2014-10-01 month_2014-11-01 month_2014-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2015-01-01 month_2015-02-01 month_2015-03-01 month_2015-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
```

```
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2015-05-01 month_2015-06-01 month_2015-07-01 month_2015-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2015-09-01 month_2015-10-01 month_2015-11-01 month_2015-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2016-01-01 month_2016-02-01 month_2016-03-01 month_2016-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2016-05-01 month_2016-06-01 month_2016-07-01 month_2016-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2016-09-01 month_2016-10-01 month_2016-11-01 month_2016-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
```

```
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2017-01-01 month_2017-02-01 month_2017-03-01 month_2017-04-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2017-05-01 month_2017-06-01 month_2017-07-01 month_2017-08-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
##    month_2017-09-01 month_2017-10-01 month_2017-11-01 month_2017-12-01
## 1                 0                 0                 0                 0
## 2                 0                 0                 0                 0
## 3                 0                 0                 0                 0
## 4                 0                 0                 0                 0
## 5                 0                 0                 0                 0
## 6                 0                 0                 0                 0
## 7                 0                 0                 0                 0
## 8                 0                 0                 0                 0
## 9                 0                 0                 0                 0
## 10                0                 0                 0                 0
```

- Estimate β, γ, ψ, and κ with district and year and month dummies, whereas the base group dummies are excluded

```r
X2 = as.matrix(df10[,c(4,6:34,36:166)])
Y2 = as.matrix(df10[,5])
coef2 = solve(t(X2)%*%X2)%*%t(X2)%*%Y2
coef2[1:6,1]
```

```
##            tenure       total_crime     median_income    share_of_black
##     -3.057654e-06     -3.154716e-06     -1.399981e-06      2.921666e-01
## share_of_hispanic    share_of_white
##      6.526680e-01      5.273245e-01
```

The estimated β is $-3.0576539 \times 10^{-6}$, the estimated γ are -3.154716×10^{-6}, $-1.3999809 \times 10^{-6}$, 0.2921666, 0.652668, 0.5273245, the estimated ψ are 0.2373476, 0.2415874, 0.2381178, 0.1438174, 0.241982, 0.2552244, 0.2357544, 0.0293969, 0.0461598, 0.0150121, 0.201642, 0.0842541, 0.0886341, 0.0494662, 0.2304053, 0.0698951, 0.0776787, 0.1592691, 0.1245693, 0.1322237, 0.2700504, 0.2079346, 0.1174384, 0.1446851, and the estimated κ are 0.0067746, 0.0104332, 0.0119061, 0.0021393, 0.0156336, -0.0090527, 0.0033869, -0.003256, 0.0090704, 0.0115942, 0.0100144, -0.0014133, -0.0089205, -4.915844×10^{-4}, $-2.4393325 \times 10^{-4}$, 0.0144694, 0.0251773, 0.0073657, 0.0059242, 0.0069588, 0.0157022, 0.0029276, 0.0053058, 0.0183348, 0.0012871, 0.0017783, -0.0020449, 0.0020809, 0.0050933, 0.0109603, 0.012053, 0.0018908, 0.002023, 0.0052753, 0.0019425, -0.0023136, 0.0092471, 0.0116102, -0.0018615, 0.0141911, 0.0034682, 0.0011102, -0.0066715, 0.0166472, 0.00929, 0.0044686, -0.0017094, 0.0031957, $-5.1523367 \times 10^{-4}$, 0.0029628, 0.0029337, 0.0062398, 0.0065709, 0.0071183, 0.010871, 0.0068533, -0.0039762, 0.0178219, 7.0270812×10^{-4}, 0.0080445, -0.0026028, 0.0111669, 0.0091963, 0.0140341, 0.0133939, 0.0068052, 0.0094394, 0.0039216, 0.0117029, -0.0052146, 0.0131121, -0.0071067, 0.0136071, 0.0023584, -0.0059566, 0.0133309, 0.0235331, 0.0165834, 0.0268663, 0.0065925, 0.0127283, 0.0011173, 0.0042966, 0.0136876, -0.0043429, 0.0134174, 0.0058303, -0.0084629, 0.003986, 0.0080348, 0.0151915, 0.0086063, 0.0110643, 0.0082572, 0.0019381, 0.003424, 0.0055423, 0.001851, 0.0144963, 0.0068015, 0.0033093, 0.0029972, 0.0013176, 0.0045188, 0.0091113, 0.0017915, 0.0128181, 0.0030544, 0.005143, 0.0036937, -0.0042581, 0.0202257, 0.019912, 0.0048231, $-9.5898066 \times 10^{-4}$, -0.0093592, 0.0085057, 0.0131568, -0.0036378, -0.0023411, 0.0103822, 0.0048672, 0.0165671, 0.0045999, 0.0184974, -0.0021624, 0.0037606, 0.0072453, 0.0016982, 5.1556835×10^{-4}, -0.0064252.

Exercise 5 Panel Data: Individual fixed effects

- Create data df11 with mean differences, df12 with means, and df13 with first differences

```
df11 = df10 %>% group_by(NUID) %>%
  mutate(across(!month & !unit, ~.x-mean(.x)))
df12 = df10 %>% group_by(NUID) %>%
  summarise(across(!month & !unit, list(mean)))
df13 = df10 %>% group_by(NUID) %>%
  mutate(across(!month & !unit, ~.x-lag(.x)))
df13 = df13[rowSums(is.na(df13[,1:10]))== 0,]
df11 = as.data.frame(df11)
df12 = as.data.frame(df12)
df13 = as.data.frame(df13)
df11[1:10,]
```

```
##    NUID      month unit    tenure     arrest total_crime median_income
## 1     1 2007-03-01   14 -64.73077  1.5153846    292.6615      2442.263
## 2     1 2007-04-01   14 -63.73077 -0.4846154    139.6615      2442.263
## 3     1 2007-05-01   14 -62.73077  0.5153846    362.6615      2442.263
## 4     1 2007-06-01   14 -61.73077  0.5153846    419.6615      2442.263
## 5     1 2007-07-01   14 -60.73077 -0.4846154    508.6615      2442.263
## 6     1 2007-08-01   14 -59.73077 -0.4846154    520.6615      2442.263
## 7     1 2007-09-01   14 -58.73077  0.5153846    374.6615      2442.263
## 8     1 2007-10-01   14 -57.73077 -0.4846154    477.6615      2442.263
## 9     1 2007-11-01   14 -56.73077 -0.4846154    264.6615      2442.263
## 10    1 2007-12-01   14 -55.73077  1.5153846    162.6615      2442.263
##    share_of_black share_of_hispanic share_of_white unit_1 unit_2      unit_3
## 1      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 2      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 3      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 4      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 5      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 6      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 7      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 8      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 9      -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
## 10     -0.0603778        0.04996568     0.01021265      0      0 -0.07692308
##    unit_4 unit_5 unit_6 unit_7 unit_8 unit_9 unit_10 unit_11 unit_12 unit_13
```

```
## 1       0      0      0      0      0      0       0       0       0       0
## 2       0      0      0      0      0      0       0       0       0       0
## 3       0      0      0      0      0      0       0       0       0       0
## 4       0      0      0      0      0      0       0       0       0       0
## 5       0      0      0      0      0      0       0       0       0       0
## 6       0      0      0      0      0      0       0       0       0       0
## 7       0      0      0      0      0      0       0       0       0       0
## 8       0      0      0      0      0      0       0       0       0       0
## 9       0      0      0      0      0      0       0       0       0       0
## 10      0      0      0      0      0      0       0       0       0       0
##      unit_14 unit_15     unit_16 unit_17 unit_18 unit_19 unit_20 unit_21
## 1  0.1461538       0 -0.06923077       0       0       0       0       0
## 2  0.1461538       0 -0.06923077       0       0       0       0       0
## 3  0.1461538       0 -0.06923077       0       0       0       0       0
## 4  0.1461538       0 -0.06923077       0       0       0       0       0
## 5  0.1461538       0 -0.06923077       0       0       0       0       0
## 6  0.1461538       0 -0.06923077       0       0       0       0       0
## 7  0.1461538       0 -0.06923077       0       0       0       0       0
## 8  0.1461538       0 -0.06923077       0       0       0       0       0
## 9  0.1461538       0 -0.06923077       0       0       0       0       0
## 10 0.1461538       0 -0.06923077       0       0       0       0       0
##    unit_22 unit_23 unit_24 unit_25 month_2007-01-01 month_2007-02-01
## 1        0       0       0       0                0                0
## 2        0       0       0       0                0                0
## 3        0       0       0       0                0                0
## 4        0       0       0       0                0                0
## 5        0       0       0       0                0                0
## 6        0       0       0       0                0                0
## 7        0       0       0       0                0                0
## 8        0       0       0       0                0                0
## 9        0       0       0       0                0                0
## 10       0       0       0       0                0                0
##    month_2007-03-01 month_2007-04-01 month_2007-05-01 month_2007-06-01
## 1       0.992307692     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308      0.992307692     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308      0.992307692     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308      0.992307692
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2007-07-01 month_2007-08-01 month_2007-09-01 month_2007-10-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5       0.992307692     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308      0.992307692     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308      0.992307692     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308      0.992307692
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
```

```
##    month_2007-11-01 month_2007-12-01 month_2008-01-01 month_2008-02-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9       0.992307692     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308      0.992307692     -0.007692308     -0.007692308
##    month_2008-03-01 month_2008-04-01 month_2008-05-01 month_2008-06-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2008-07-01 month_2008-08-01 month_2008-09-01 month_2008-10-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2008-11-01 month_2008-12-01 month_2009-01-01 month_2009-02-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2009-03-01 month_2009-04-01 month_2009-05-01 month_2009-06-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
```

```
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2009-07-01 month_2009-08-01 month_2009-09-01 month_2009-10-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2009-11-01 month_2009-12-01 month_2010-01-01 month_2010-02-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2010-03-01 month_2010-04-01 month_2010-05-01 month_2010-06-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2010-07-01 month_2010-08-01 month_2010-09-01 month_2010-10-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2010-11-01 month_2010-12-01 month_2011-01-01 month_2011-02-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2011-03-01 month_2011-04-01 month_2011-05-01 month_2011-06-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2011-07-01 month_2011-08-01 month_2011-09-01 month_2011-10-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2011-11-01 month_2011-12-01 month_2012-01-01 month_2012-02-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2012-03-01 month_2012-04-01 month_2012-05-01 month_2012-06-01
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## 3      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2012-07-01 month_2012-08-01 month_2012-09-01 month_2012-10-01
## 1      -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 8       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 1       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2013-03-01 month_2013-04-01 month_2013-05-01 month_2013-06-01
## 1       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2013-07-01 month_2013-08-01 month_2013-09-01 month_2013-10-01
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##    month_2013-11-01 month_2013-12-01 month_2014-01-01 month_2014-02-01
## 1       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2014-03-01 month_2014-04-01 month_2014-05-01 month_2014-06-01
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## 6       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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## 7       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2014-07-01 month_2014-08-01 month_2014-09-01 month_2014-10-01
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##    month_2014-11-01 month_2014-12-01 month_2015-01-01 month_2015-02-01
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##    month_2015-03-01 month_2015-04-01 month_2015-05-01 month_2015-06-01
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##    month_2015-07-01 month_2015-08-01 month_2015-09-01 month_2015-10-01
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##    month_2015-11-01 month_2015-12-01 month_2016-01-01 month_2016-02-01
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## 6       -0.007692308     -0.007692308     -0.007692308     -0.007692308
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##    month_2016-07-01 month_2016-08-01 month_2016-09-01 month_2016-10-01
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## 3       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10      -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2016-11-01 month_2016-12-01 month_2017-01-01 month_2017-02-01
## 1       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10      -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2017-03-01 month_2017-04-01 month_2017-05-01 month_2017-06-01
## 1       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 5       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10      -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2017-07-01 month_2017-08-01 month_2017-09-01 month_2017-10-01
## 1       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 2       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 3       -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 4       -0.007692308     -0.007692308     -0.007692308     -0.007692308
```

```
## 5      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308     -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308     -0.007692308     -0.007692308
##    month_2017-11-01 month_2017-12-01
## 1      -0.007692308     -0.007692308
## 2      -0.007692308     -0.007692308
## 3      -0.007692308     -0.007692308
## 4      -0.007692308     -0.007692308
## 5      -0.007692308     -0.007692308
## 6      -0.007692308     -0.007692308
## 7      -0.007692308     -0.007692308
## 8      -0.007692308     -0.007692308
## 9      -0.007692308     -0.007692308
## 10     -0.007692308     -0.007692308
```

```
df12[1:10,]
```

```
##    NUID  tenure_1  arrest_1 total_crime_1 median_income_1 share_of_black_1
## 1     1  82.73077 0.4846154     1060.3385        59407.20       0.13260980
## 2     2  78.23140 0.4958678     1269.9587        27940.01       0.93349592
## 3     6 157.04167 0.3333333      596.6667        52332.72       0.10655149
## 4     7 199.16667 0.4772727      990.4924        57487.19       0.11121455
## 5    16  63.38806 0.4626866     1533.8657        51768.31       0.71489015
## 6    17 246.95238 0.7380952      485.6190        63652.04       0.09979825
## 7    18 157.39000 0.4400000     1284.2000        70194.66       0.10567584
## 8    19 119.11765 0.5882353      948.3382        55060.06       0.03325003
## 9    23  24.84615 0.4615385      656.9231        55060.06       0.03325003
## 10   25  31.85185 0.7407407     1531.0370        26337.89       0.84344077
##    share_of_hispanic_1 share_of_white_1  unit_1_1 unit_2_1   unit_3_1 unit_4_1
## 1           0.41090590       0.40716270 0.0000000        0 0.07692308        0
## 2           0.03704857       0.01631036 0.0000000        0 0.00000000        0
## 3           0.18344178       0.54034104 0.0000000        0 0.00000000        0
## 4           0.33564607       0.46544887 0.0000000        0 0.00000000        0
## 5           0.02726117       0.18193889 0.3283582        0 0.00000000        0
## 6           0.09368892       0.71092904 0.0000000        0 0.00000000        0
## 7           0.25022095       0.57018921 0.0000000        0 0.00000000        0
## 8           0.43260344       0.38627632 0.0000000        0 0.00000000        0
## 9           0.43260344       0.38627632 0.0000000        0 0.00000000        0
## 10          0.11737796       0.02479407 0.0000000        0 0.00000000        0
##    unit_5_1  unit_6_1 unit_7_1 unit_8_1 unit_9_1 unit_10_1 unit_11_1 unit_12_1
## 1         0 0.0000000        0        0        0         0         0 0.0000000
## 2         0 0.0000000        0        0        0         0         0 0.0000000
## 3         0 0.0000000        0        0        0         0         0 0.0000000
## 4         0 0.0000000        0        0        0         0         0 0.6136364
## 5         0 0.6716418        0        0        0         0         0 0.0000000
## 6         0 0.0000000        0        0        0         0         0 0.0000000
## 7         0 0.0000000        0        0        0         0         0 0.0000000
## 8         0 0.0000000        0        0        0         0         0 0.0000000
## 9         0 0.0000000        0        0        0         0         0 0.0000000
## 10        0 0.0000000        0        0        0         0         1 0.0000000
##    unit_13_1 unit_14_1 unit_15_1  unit_16_1 unit_17_1 unit_18_1 unit_19_1
## 1          0 0.8538462         0 0.06923077         0      0.00 0.0000000
```

```
## 2          0 0.0000000         1 0.00000000         0      0.00 0.0000000
## 3          0 0.0000000         0 0.00000000         0      0.00 0.0000000
## 4          0 0.0000000         0 0.38636364         0      0.00 0.0000000
## 5          0 0.0000000         0 0.00000000         0      0.00 0.0000000
## 6          0 0.0000000         0 0.00000000         0      0.00 0.2619048
## 7          0 0.0000000         0 0.00000000         0      0.37 0.3300000
## 8          0 0.0000000         0 0.00000000         1      0.00 0.0000000
## 9          0 0.0000000         0 0.00000000         1      0.00 0.0000000
## 10         0 0.0000000         0 0.00000000         0      0.00 0.0000000
##    unit_20_1 unit_21_1 unit_22_1 unit_23_1 unit_24_1 unit_25_1
## 1          0         0         0 0.0000000         0       0.0
## 2          0         0         0 0.0000000         0       0.0
## 3          1         0         0 0.0000000         0       0.0
## 4          0         0         0 0.0000000         0       0.0
## 5          0         0         0 0.0000000         0       0.0
## 6          0         0         0 0.7380952         0       0.0
## 7          0         0         0 0.0000000         0       0.3
## 8          0         0         0 0.0000000         0       0.0
## 9          0         0         0 0.0000000         0       0.0
## 10         0         0         0 0.0000000         0       0.0
##    month_2007-01-01_1 month_2007-02-01_1 month_2007-03-01_1 month_2007-04-01_1
## 1         0.000000000        0.000000000        0.007692308        0.007692308
## 2         0.000000000        0.000000000        0.008264463        0.008264463
## 3         0.041666667        0.041666667        0.041666667        0.041666667
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.000000000
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2007-05-01_1 month_2007-06-01_1 month_2007-07-01_1 month_2007-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.041666667        0.041666667        0.041666667        0.041666667
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.000000000
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2007-09-01_1 month_2007-10-01_1 month_2007-11-01_1 month_2007-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.041666667        0.041666667        0.041666667        0.041666667
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.000000000
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2008-01-01_1 month_2008-02-01_1 month_2008-03-01_1 month_2008-04-01_1
```

```
## 1          0.007692308        0.007692308        0.007692308        0.007692308
## 2          0.008264463        0.008264463        0.008264463        0.008264463
## 3          0.041666667        0.041666667        0.041666667        0.041666667
## 4          0.007575758        0.007575758        0.007575758        0.007575758
## 5          0.000000000        0.000000000        0.000000000        0.000000000
## 6          0.011904762        0.011904762        0.011904762        0.011904762
## 7          0.010000000        0.010000000        0.010000000        0.010000000
## 8          0.014705882        0.014705882        0.014705882        0.014705882
## 9          0.000000000        0.000000000        0.000000000        0.000000000
## 10         0.000000000        0.000000000        0.000000000        0.000000000
##    month_2008-05-01_1 month_2008-06-01_1 month_2008-07-01_1 month_2008-08-01_1
## 1          0.007692308        0.007692308        0.007692308        0.007692308
## 2          0.008264463        0.008264463        0.008264463        0.008264463
## 3          0.041666667        0.041666667        0.041666667        0.041666667
## 4          0.007575758        0.007575758        0.007575758        0.007575758
## 5          0.000000000        0.000000000        0.000000000        0.000000000
## 6          0.011904762        0.011904762        0.011904762        0.011904762
## 7          0.010000000        0.010000000        0.010000000        0.010000000
## 8          0.014705882        0.014705882        0.014705882        0.014705882
## 9          0.000000000        0.000000000        0.000000000        0.000000000
## 10         0.000000000        0.000000000        0.000000000        0.000000000
##    month_2008-09-01_1 month_2008-10-01_1 month_2008-11-01_1 month_2008-12-01_1
## 1          0.007692308        0.007692308        0.007692308        0.007692308
## 2          0.008264463        0.008264463        0.008264463        0.008264463
## 3          0.041666667        0.041666667        0.041666667        0.041666667
## 4          0.007575758        0.007575758        0.007575758        0.007575758
## 5          0.000000000        0.000000000        0.000000000        0.000000000
## 6          0.011904762        0.011904762        0.011904762        0.011904762
## 7          0.010000000        0.010000000        0.010000000        0.010000000
## 8          0.014705882        0.014705882        0.014705882        0.014705882
## 9          0.000000000        0.000000000        0.000000000        0.000000000
## 10         0.000000000        0.000000000        0.000000000        0.000000000
##    month_2009-01-01_1 month_2009-02-01_1 month_2009-03-01_1 month_2009-04-01_1
## 1          0.007692308        0.007692308        0.007692308        0.007692308
## 2          0.008264463        0.008264463        0.008264463        0.008264463
## 3          0.000000000        0.000000000        0.000000000        0.000000000
## 4          0.007575758        0.007575758        0.007575758        0.007575758
## 5          0.000000000        0.000000000        0.000000000        0.000000000
## 6          0.011904762        0.011904762        0.011904762        0.011904762
## 7          0.010000000        0.010000000        0.010000000        0.010000000
## 8          0.014705882        0.014705882        0.014705882        0.014705882
## 9          0.000000000        0.000000000        0.000000000        0.000000000
## 10         0.000000000        0.000000000        0.000000000        0.000000000
##    month_2009-05-01_1 month_2009-06-01_1 month_2009-07-01_1 month_2009-08-01_1
## 1          0.007692308        0.007692308        0.007692308        0.007692308
## 2          0.008264463        0.008264463        0.008264463        0.008264463
## 3          0.000000000        0.000000000        0.000000000        0.000000000
## 4          0.007575758        0.007575758        0.007575758        0.007575758
## 5          0.000000000        0.000000000        0.000000000        0.000000000
## 6          0.011904762        0.011904762        0.011904762        0.011904762
## 7          0.010000000        0.010000000        0.010000000        0.010000000
## 8          0.014705882        0.014705882        0.014705882        0.014705882
## 9          0.000000000        0.000000000        0.000000000        0.000000000
## 10         0.000000000        0.000000000        0.000000000        0.000000000
```

```
##    month_2009-09-01_1 month_2009-10-01_1 month_2009-11-01_1 month_2009-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2010-01-01_1 month_2010-02-01_1 month_2010-03-01_1 month_2010-04-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2010-05-01_1 month_2010-06-01_1 month_2010-07-01_1 month_2010-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2010-09-01_1 month_2010-10-01_1 month_2010-11-01_1 month_2010-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2011-01-01_1 month_2011-02-01_1 month_2011-03-01_1 month_2011-04-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
```

```
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2011-05-01_1 month_2011-06-01_1 month_2011-07-01_1 month_2011-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2011-09-01_1 month_2011-10-01_1 month_2011-11-01_1 month_2011-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2012-01-01_1 month_2012-02-01_1 month_2012-03-01_1 month_2012-04-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2012-05-01_1 month_2012-06-01_1 month_2012-07-01_1 month_2012-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.000000000        0.000000000        0.000000000
## 8         0.014705882        0.014705882        0.014705882        0.014705882
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2012-09-01_1 month_2012-10-01_1 month_2012-11-01_1 month_2012-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.000000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
```

```
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2013-01-01_1 month_2013-02-01_1 month_2013-03-01_1 month_2013-04-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2013-05-01_1 month_2013-06-01_1 month_2013-07-01_1 month_2013-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2013-09-01_1 month_2013-10-01_1 month_2013-11-01_1 month_2013-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.000000000
## 6         0.011904762        0.011904762        0.011904762        0.011904762
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2014-01-01_1 month_2014-02-01_1 month_2014-03-01_1 month_2014-04-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.000000000
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.000000000        0.000000000        0.000000000        0.000000000
##    month_2014-05-01_1 month_2014-06-01_1 month_2014-07-01_1 month_2014-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.000000000        0.000000000        0.000000000        0.000000000
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
```

```
## 8          0.000000000          0.000000000          0.000000000          0.000000000
## 9          0.000000000          0.000000000          0.000000000          0.000000000
## 10         0.000000000          0.000000000          0.000000000          0.000000000
##    month_2014-09-01_1 month_2014-10-01_1 month_2014-11-01_1 month_2014-12-01_1
## 1          0.007692308          0.007692308          0.007692308          0.007692308
## 2          0.008264463          0.008264463          0.008264463          0.008264463
## 3          0.000000000          0.000000000          0.000000000          0.000000000
## 4          0.007575758          0.007575758          0.007575758          0.007575758
## 5          0.000000000          0.000000000          0.000000000          0.000000000
## 6          0.000000000          0.000000000          0.000000000          0.000000000
## 7          0.010000000          0.010000000          0.010000000          0.010000000
## 8          0.000000000          0.000000000          0.000000000          0.000000000
## 9          0.000000000          0.000000000          0.000000000          0.000000000
## 10         0.000000000          0.000000000          0.000000000          0.000000000
##    month_2015-01-01_1 month_2015-02-01_1 month_2015-03-01_1 month_2015-04-01_1
## 1          0.007692308          0.007692308          0.007692308          0.007692308
## 2          0.008264463          0.008264463          0.008264463          0.008264463
## 3          0.000000000          0.000000000          0.000000000          0.000000000
## 4          0.007575758          0.007575758          0.007575758          0.007575758
## 5          0.000000000          0.000000000          0.000000000          0.000000000
## 6          0.000000000          0.000000000          0.000000000          0.000000000
## 7          0.010000000          0.010000000          0.010000000          0.010000000
## 8          0.000000000          0.000000000          0.000000000          0.000000000
## 9          0.000000000          0.000000000          0.000000000          0.000000000
## 10         0.000000000          0.000000000          0.000000000          0.000000000
##    month_2015-05-01_1 month_2015-06-01_1 month_2015-07-01_1 month_2015-08-01_1
## 1          0.007692308          0.007692308          0.007692308          0.007692308
## 2          0.008264463          0.008264463          0.008264463          0.008264463
## 3          0.000000000          0.000000000          0.000000000          0.000000000
## 4          0.007575758          0.007575758          0.007575758          0.007575758
## 5          0.000000000          0.000000000          0.000000000          0.000000000
## 6          0.000000000          0.000000000          0.000000000          0.000000000
## 7          0.010000000          0.010000000          0.010000000          0.010000000
## 8          0.000000000          0.000000000          0.000000000          0.000000000
## 9          0.000000000          0.000000000          0.000000000          0.000000000
## 10         0.000000000          0.000000000          0.000000000          0.000000000
##    month_2015-09-01_1 month_2015-10-01_1 month_2015-11-01_1 month_2015-12-01_1
## 1          0.007692308          0.007692308          0.007692308          0.007692308
## 2          0.008264463          0.008264463          0.008264463          0.008264463
## 3          0.000000000          0.000000000          0.000000000          0.000000000
## 4          0.007575758          0.007575758          0.007575758          0.007575758
## 5          0.000000000          0.000000000          0.000000000          0.000000000
## 6          0.000000000          0.000000000          0.000000000          0.000000000
## 7          0.010000000          0.010000000          0.010000000          0.010000000
## 8          0.000000000          0.000000000          0.000000000          0.000000000
## 9          0.000000000          0.000000000          0.000000000          0.000000000
## 10         0.000000000          0.037037037          0.037037037          0.037037037
##    month_2016-01-01_1 month_2016-02-01_1 month_2016-03-01_1 month_2016-04-01_1
## 1          0.007692308          0.007692308          0.007692308          0.007692308
## 2          0.008264463          0.008264463          0.008264463          0.008264463
## 3          0.000000000          0.000000000          0.000000000          0.000000000
## 4          0.007575758          0.007575758          0.007575758          0.007575758
## 5          0.000000000          0.000000000          0.014925373          0.014925373
## 6          0.000000000          0.000000000          0.000000000          0.000000000
```

```
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.037037037        0.037037037        0.037037037        0.037037037
##    month_2016-05-01_1 month_2016-06-01_1 month_2016-07-01_1 month_2016-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.000000000
## 10        0.037037037        0.037037037        0.037037037        0.037037037
##    month_2016-09-01_1 month_2016-10-01_1 month_2016-11-01_1 month_2016-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.008264463
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.000000000        0.000000000        0.000000000        0.076923077
## 10        0.037037037        0.037037037        0.037037037        0.037037037
##    month_2017-01-01_1 month_2017-02-01_1 month_2017-03-01_1 month_2017-04-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.008264463        0.008264463        0.008264463        0.000000000
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.076923077        0.076923077        0.076923077        0.076923077
## 10        0.037037037        0.037037037        0.037037037        0.037037037
##    month_2017-05-01_1 month_2017-06-01_1 month_2017-07-01_1 month_2017-08-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.000000000        0.000000000        0.000000000        0.000000000
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.076923077        0.076923077        0.076923077        0.076923077
## 10        0.037037037        0.037037037        0.037037037        0.037037037
##    month_2017-09-01_1 month_2017-10-01_1 month_2017-11-01_1 month_2017-12-01_1
## 1         0.007692308        0.007692308        0.007692308        0.007692308
## 2         0.000000000        0.000000000        0.000000000        0.000000000
## 3         0.000000000        0.000000000        0.000000000        0.000000000
## 4         0.007575758        0.007575758        0.007575758        0.007575758
## 5         0.014925373        0.014925373        0.014925373        0.014925373
```

```
## 6         0.000000000        0.000000000        0.000000000        0.000000000
## 7         0.010000000        0.010000000        0.010000000        0.010000000
## 8         0.000000000        0.000000000        0.000000000        0.000000000
## 9         0.076923077        0.076923077        0.076923077        0.076923077
## 10        0.037037037        0.037037037        0.037037037        0.037037037
```

```
df13[1:10,]
```

```
##    NUID      month unit tenure arrest total_crime median_income share_of_black
## 1     1 2007-04-01   14      1     -2        -153             0              0
## 2     1 2007-05-01   14      1      1         223             0              0
## 3     1 2007-06-01   14      1      0          57             0              0
## 4     1 2007-07-01   14      1     -1          89             0              0
## 5     1 2007-08-01   14      1      0          12             0              0
## 6     1 2007-09-01   14      1      1        -146             0              0
## 7     1 2007-10-01   14      1     -1         103             0              0
## 8     1 2007-11-01   14      1      0        -213             0              0
## 9     1 2007-12-01   14      1      2        -102             0              0
## 10    1 2008-01-01   14      1     -1          53             0              0
##    share_of_hispanic share_of_white unit_1 unit_2 unit_3 unit_4 unit_5 unit_6
## 1                  0              0      0      0      0      0      0      0
## 2                  0              0      0      0      0      0      0      0
## 3                  0              0      0      0      0      0      0      0
## 4                  0              0      0      0      0      0      0      0
## 5                  0              0      0      0      0      0      0      0
## 6                  0              0      0      0      0      0      0      0
## 7                  0              0      0      0      0      0      0      0
## 8                  0              0      0      0      0      0      0      0
## 9                  0              0      0      0      0      0      0      0
## 10                 0              0      0      0      0      0      0      0
##    unit_7 unit_8 unit_9 unit_10 unit_11 unit_12 unit_13 unit_14 unit_15 unit_16
## 1       0      0      0       0       0       0       0       0       0       0
## 2       0      0      0       0       0       0       0       0       0       0
## 3       0      0      0       0       0       0       0       0       0       0
## 4       0      0      0       0       0       0       0       0       0       0
## 5       0      0      0       0       0       0       0       0       0       0
## 6       0      0      0       0       0       0       0       0       0       0
## 7       0      0      0       0       0       0       0       0       0       0
## 8       0      0      0       0       0       0       0       0       0       0
## 9       0      0      0       0       0       0       0       0       0       0
## 10      0      0      0       0       0       0       0       0       0       0
##    unit_17 unit_18 unit_19 unit_20 unit_21 unit_22 unit_23 unit_24 unit_25
## 1        0       0       0       0       0       0       0       0       0
## 2        0       0       0       0       0       0       0       0       0
## 3        0       0       0       0       0       0       0       0       0
## 4        0       0       0       0       0       0       0       0       0
## 5        0       0       0       0       0       0       0       0       0
## 6        0       0       0       0       0       0       0       0       0
## 7        0       0       0       0       0       0       0       0       0
## 8        0       0       0       0       0       0       0       0       0
## 9        0       0       0       0       0       0       0       0       0
## 10       0       0       0       0       0       0       0       0       0
##    month_2007-01-01 month_2007-02-01 month_2007-03-01 month_2007-04-01
## 1                 0                0               -1                1
## 2                 0                0                0               -1
```

```
## 3                0                0                0                0
## 4                0                0                0                0
## 5                0                0                0                0
## 6                0                0                0                0
## 7                0                0                0                0
## 8                0                0                0                0
## 9                0                0                0                0
## 10               0                0                0                0
##    month_2007-05-01 month_2007-06-01 month_2007-07-01 month_2007-08-01
## 1                0                0                0                0
## 2                1                0                0                0
## 3               -1                1                0                0
## 4                0               -1                1                0
## 5                0                0               -1                1
## 6                0                0                0               -1
## 7                0                0                0                0
## 8                0                0                0                0
## 9                0                0                0                0
## 10               0                0                0                0
##    month_2007-09-01 month_2007-10-01 month_2007-11-01 month_2007-12-01
## 1                0                0                0                0
## 2                0                0                0                0
## 3                0                0                0                0
## 4                0                0                0                0
## 5                0                0                0                0
## 6                1                0                0                0
## 7               -1                1                0                0
## 8                0               -1                1                0
## 9                0                0               -1                1
## 10               0                0                0               -1
##    month_2008-01-01 month_2008-02-01 month_2008-03-01 month_2008-04-01
## 1                0                0                0                0
## 2                0                0                0                0
## 3                0                0                0                0
## 4                0                0                0                0
## 5                0                0                0                0
## 6                0                0                0                0
## 7                0                0                0                0
## 8                0                0                0                0
## 9                0                0                0                0
## 10               1                0                0                0
##    month_2008-05-01 month_2008-06-01 month_2008-07-01 month_2008-08-01
## 1                0                0                0                0
## 2                0                0                0                0
## 3                0                0                0                0
## 4                0                0                0                0
## 5                0                0                0                0
## 6                0                0                0                0
## 7                0                0                0                0
## 8                0                0                0                0
## 9                0                0                0                0
## 10               0                0                0                0
##    month_2008-09-01 month_2008-10-01 month_2008-11-01 month_2008-12-01
## 1                0                0                0                0
```

```
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2009-01-01 month_2009-02-01 month_2009-03-01 month_2009-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2009-05-01 month_2009-06-01 month_2009-07-01 month_2009-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2009-09-01 month_2009-10-01 month_2009-11-01 month_2009-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2010-01-01 month_2010-02-01 month_2010-03-01 month_2010-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2010-05-01 month_2010-06-01 month_2010-07-01 month_2010-08-01
```

```
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2010-09-01 month_2010-10-01 month_2010-11-01 month_2010-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2011-01-01 month_2011-02-01 month_2011-03-01 month_2011-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2011-05-01 month_2011-06-01 month_2011-07-01 month_2011-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2011-09-01 month_2011-10-01 month_2011-11-01 month_2011-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
```

```
##    month_2012-01-01 month_2012-02-01 month_2012-03-01 month_2012-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2012-05-01 month_2012-06-01 month_2012-07-01 month_2012-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2012-09-01 month_2012-10-01 month_2012-11-01 month_2012-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2013-01-01 month_2013-02-01 month_2013-03-01 month_2013-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2013-05-01 month_2013-06-01 month_2013-07-01 month_2013-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
```

```
## 10                0                0                0                0
##    month_2013-09-01 month_2013-10-01 month_2013-11-01 month_2013-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2014-01-01 month_2014-02-01 month_2014-03-01 month_2014-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2014-05-01 month_2014-06-01 month_2014-07-01 month_2014-08-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2014-09-01 month_2014-10-01 month_2014-11-01 month_2014-12-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
## 9                 0                0                0                0
## 10                0                0                0                0
##    month_2015-01-01 month_2015-02-01 month_2015-03-01 month_2015-04-01
## 1                 0                0                0                0
## 2                 0                0                0                0
## 3                 0                0                0                0
## 4                 0                0                0                0
## 5                 0                0                0                0
## 6                 0                0                0                0
## 7                 0                0                0                0
## 8                 0                0                0                0
```

```
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2015-05-01 month_2015-06-01 month_2015-07-01 month_2015-08-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2015-09-01 month_2015-10-01 month_2015-11-01 month_2015-12-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2016-01-01 month_2016-02-01 month_2016-03-01 month_2016-04-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2016-05-01 month_2016-06-01 month_2016-07-01 month_2016-08-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2016-09-01 month_2016-10-01 month_2016-11-01 month_2016-12-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
```

```
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2017-01-01 month_2017-02-01 month_2017-03-01 month_2017-04-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2017-05-01 month_2017-06-01 month_2017-07-01 month_2017-08-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
##    month_2017-09-01 month_2017-10-01 month_2017-11-01 month_2017-12-01
## 1                  0                0                0                0
## 2                  0                0                0                0
## 3                  0                0                0                0
## 4                  0                0                0                0
## 5                  0                0                0                0
## 6                  0                0                0                0
## 7                  0                0                0                0
## 8                  0                0                0                0
## 9                  0                0                0                0
## 10                 0                0                0                0
```

- Within estimator

```
X3 = as.matrix(df11[,c(4,6:34,36:166)])
Y3 = as.matrix(df11[,5])
coef3 = solve(t(X3)%*%X3)%*%t(X3)%*%Y3
coef3[1,1]
```

```
##        tenure
## -0.0002767571
```

The estimated β is $-2.7675706 \times 10^{-4}$.

- Between estimator

```
X4 = as.matrix(df12[,c(2,4:32,34:164)])
Y4 = as.matrix(df12[,3])
coef4 = solve(t(X4)%*%X4,tol=1e-100)%*%t(X4)%*%Y4
coef4[1,1]
```

```
##      tenure_1
```

```
## -1.756059e-05
```

The estimated β is $-1.7560586 \times 10^{-5}$. Here taking the mean does not eliminate individual fixed effects, but since there are 10k+ individuals, the calculation amount is too large if I estimate the individual fixed effects for each individual.

- First difference estimator

```r
X5 = as.matrix(df13[,c(4,6:34,36:166)])
Y5 = as.matrix(df13[,5])
coef5 = solve(t(X5)%*%X5,tol=1e-100)%*%t(X5)%*%Y5
coef5[1,1]
```

```
##      tenure
## 0.005430383
```

The estimated β is 0.0054304. The within and between estimators are negative with small absolute value, while the first difference estimator is positive with small absolute value.

- GMM
  - Since there are 10k+ individuals, the calculation amount is too large if I estimate the individual fixed effects for each individual, so I use the data df10 and only consider district and year and month fixed effects.
  - Estimate

$$min_\beta[(Y-X\beta)^{'}X]I[X^{'}(Y-X\beta)]$$

  - Obtain

$$\hat{\beta}_1 = (X^{'}XX^{'}X)^{-1}X^{'}XX^{'}Y$$

```r
coef6 = solve(t(X2)%*%X2%*%t(X2)%*%X2,tol=1e-100)%*%t(X2)%*%X2%*%t(X2)%*%Y2
coef6[1:6,1]
```

```
##            tenure       total_crime     median_income    share_of_black
##      -0.006430752       0.044062993       0.001673600     174.105950560
## share_of_hispanic    share_of_white
##      94.058096948     -68.634474816
```

- Matrix of variance/covariance

$$\hat{\mathbb{S}}_n = \frac{1}{N}X^{'}(Y-X\hat{\beta}_1)(Y-X\hat{\beta}_1)^{'}X$$

```r
s = t(X2)%*%(Y2-X2%*%coef6)%*%t(Y2-X2%*%coef6)%*%X2/nrow(X2)
s[1:6,1:6]
```

```
##                            tenure   total_crime median_income share_of_black
## tenure                23526143.12   137065741.2    6778134879  -1.902191e+04
## total_crime          137065741.24   798559174.4   39490114336  -1.108236e+05
## median_income       6778134879.42 39490114336.1 1952853564595  -5.480417e+06
## share_of_black         -19021.91     -110823.6      -5480417   1.538004e+01
## share_of_hispanic      257208.55     1498523.6      74104550  -2.079643e+02
## share_of_white         -61835.01     -360257.2     -17815331   4.999629e+01
##                     share_of_hispanic share_of_white
## tenure                    257208.5516  -6.183501e+04
## total_crime              1498523.6044  -3.602572e+05
## median_income           74104550.2584  -1.781533e+07
## share_of_black              -207.9643   4.999629e+01
## share_of_hispanic           2812.0308  -6.760349e+02
## share_of_white              -676.0349   1.625242e+02
```

- Solve the problem
$$min_{\beta}[(Y-X\beta)^{'}X]\hat{\mathbb{S}}_n[X^{'}(Y-X\beta)]$$
- Obtain
$$\hat{\beta}_{GMM}=(X^{'}X\hat{\mathbb{S}}_nX^{'}X)^{-1}X^{'}X\hat{\mathbb{S}}_nX^{'}Y$$

```
coef7 = solve(t(X2)%*%X2%*%s%*%t(X2)%*%X2,tol=1e-100)%*%
  t(X2)%*%X2%*%s%*%t(X2)%*%Y2
coef7[1:6,1]
```

```
##            tenure       total_crime     median_income    share_of_black
##      3.432696e-02     -1.257924e-02     -9.303011e-05      1.142793e+01
## share_of_hispanic    share_of_white
##     -5.762788e+00      1.587799e+01
```

The estimated β is 0.034327, the estimated γ are -0.0125792, $-9.3030114 \times 10^{-5}$, 11.427927, -5.7627884, 15.8779875, the estimated ψ are 260.233486, -194.1593003, -660.3874518, -614.0392293, -1134.5037234, -513.4710327, -811.0630493, -821.7088625, 594.6329814, 433.3865776, -839.8880365, -25.5199352, 3194.3315104, 267.3792742, 47.4652703, 123.4081324, 263.0510671, 203.7918916, 454.2880195, 271.6729841, 238.1857325, 760.9020156, 3522.4804661, -454.6756343, and the estimated κ are -4648.7402747, -1.5720909×10^4, -1.0770185×10^4, -1.8773271×10^4, 6882.0080465, 4187.1431704, 92.7673602, -1.5869528×10^4, -837.183258, 6060.3290497, 3650.0219531, 7982.0851386, 6442.1367284, -7160.672517, 1.1831375×10^4, -8527.9742489, 1.7217455×10^4, 5935.9088468, 808.8681615, 373.3567247, 1.1302311×10^4, -1675.9619547, 2807.2671541, -309.080995, -6919.2121571, -392.2783251, -4130.8748702, -299.2683967, 3138.6946618, 1165.8274145, -3815.8554014, -2795.6676286, -6459.2994004, 9270.0084298, 2032.4076731, 5215.3853754, 2980.3530223, 3987.1701401, -1.1225375×10^4, -1.2298408×10^4, 3602.9920122, 6937.6344949, 3771.5645188, 1062.0216998, -1487.8646396, 1923.7791699, -184.4182187, -2692.3040992, -1.7145734×10^4, 1.330129×10^4, 3773.5661489, -8906.4649896, -1.5512831×10^4, 5175.6766344, 3582.3241896, 6536.2838298, 5452.4518203, 1.359897×10^4, -1.1998475×10^4, 1.0685452×10^4, -2682.5329117, 6895.6899574, -288.7476584, 517.0154226, 1.1897068×10^4, 8721.337217, -1.350147×10^4, 469.8279665, 1845.0446036, 1467.1897827, -2383.1464035, -3843.3332761, 4646.9455575, 2722.2626014, 1.4488496×10^4, -8519.5777973, 3515.4986753, 1.0638952×10^4, -2470.6275489, 9809.2188499, -321.4306651, 5076.001216, 5040.6569102, -1168.1721286, 4164.9269253, 9967.9296517, -7758.7770479, 3534.7615851, 3104.609609, -2675.6784481, 1467.1180117, 4234.7989251, 3786.0010486, -5014.2312015, -619.4009564, -2268.4093885, 8540.2972403, -6512.4650211, -1.0868295×10^4, -1.3514536×10^4, -1.2087499×10^4, 1.2970387×10^4, 3072.4528395, 6285.0464968, 479.1908025, -3870.3300715, -1.0804468×10^4, -71.6723671, -4847.5109113, 8145.4557554, -1981.7509394, -1.4132138×10^4, 1469.1382734, 3900.1817863, 1.2036269×10^4, -1.1020757×10^4, 3480.653435, -648.8760578, -8180.6809538, 3847.4282321, -2.2202234×10^4, -1.0812708×10^4, -452.2407115, -3444.4031514, -3720.6591747, -8306.2290921, -1.1364297×10^4, -8486.3543727, 9746.6072566, 9060.8262699, -3131.2230012.