

# Econ 613 Assignment 2

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```
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

library(fastDummies)
library(gmm)

## Loading required package: sandwich

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

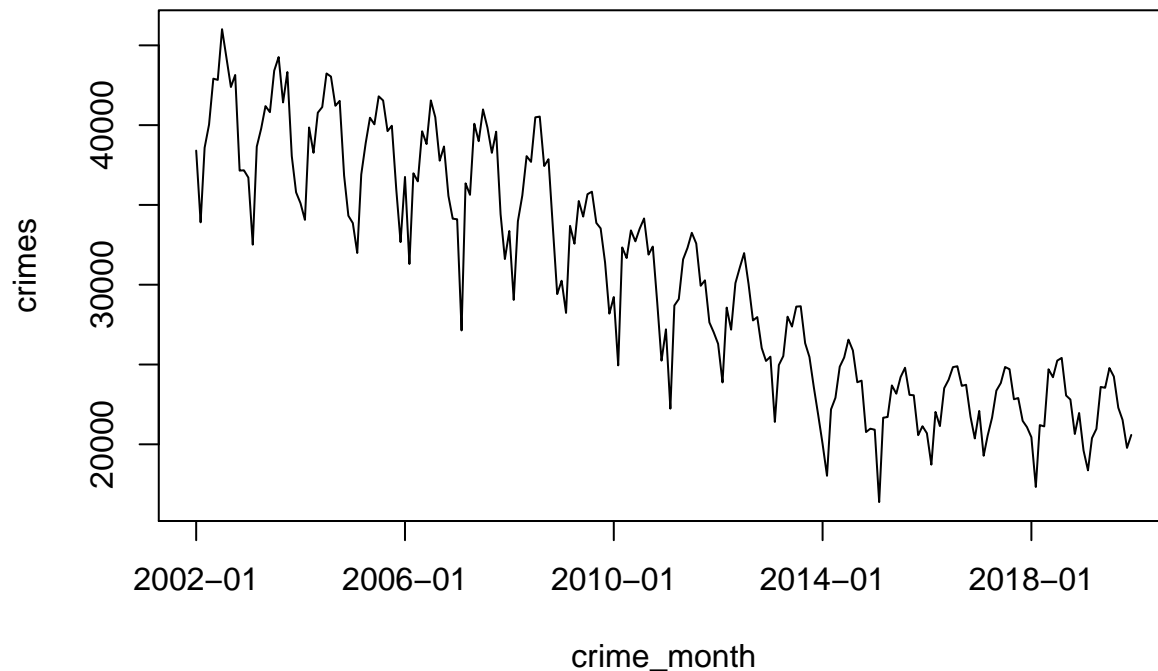
```
pop = read.csv("file:///Users/DXL/Desktop/Econ613/population.csv")
cri = read.csv("file:///Users/DXL/Desktop/Econ613/crime_long.csv")
off = read.csv("file:///Users/DXL/Desktop/Econ613/officers.csv")
```

## 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')
```

### Total Crimes Per Month



- 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` argument.

```
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)
```

```

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$hispan/df5$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  $\beta$  and  $\gamma$

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

## Exercise 4 Panel Data: More controls

- Create data df10 with district and month dummies

```
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  $\beta$ ,  $\gamma$ ,  $\psi$ , and  $\kappa$  with district and year and month dummies, whereas the base group dummies are excluded

```
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  $\beta$  is  $-3.0576539 \times 10^{-6}$ , the estimated  $\gamma$  are  $-3.154716 \times 10^{-6}$ ,  $-1.3999809 \times 10^{-6}$ , 0.2921666, 0.652668, 0.5273245, the estimated  $\psi$  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  $\kappa$  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,  $-4.915844 \times 10^{-4}$ ,  $-2.4393325 \times 10^{-4}$ , 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,  $7.0270812 \times 10^{-4}$ , 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,  $5.1556835 \times 10^{-4}$ , -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						

[illegible]



[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```
## 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			

[illegible]



[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```
## 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  $\beta$  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  $\beta$  is  $-1.7560586 \times 10^{-5}$ . Here taking the mean does not eliminate individual fixed effects, but since there are too many individuals, the calculation amount is too large if we estimate the individual fixed effects for each individual.

- First difference estimator

```
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  $\beta$  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
  - Estimate

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

- Obtain

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

```
coef6 = solve(t(X2)%*%X2)%*%t(X2)%*%Y2,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

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

```
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

$$\min_{\beta} [(Y - X\beta)'X]S_{\kappa}[X'(Y - X\beta)]$$

- Obtain

$$\hat{\beta}_{GMM} = (X'XS_{\kappa}X'X)^{-1}X'XS_{\kappa}X'Y$$

```
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  $\beta$  is 0.034327, the estimated  $\gamma$  are -0.0125792,  $-9.3030114 \times 10^{-5}$ , 11.427927, -5.7627884, 15.8779875, the estimated  $\psi$  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  $\kappa$  are -4648.7402747,  $-1.5720909 \times 10^4$ ,  $-1.0770185 \times 10^4$ ,  $-1.8773271 \times 10^4$ , 6882.0080465, 4187.1431704, 92.7673602,  $-1.5869528 \times 10^4$ , -837.183258, 6060.3290497, 3650.0219531, 7982.0851386, 6442.1367284, -7160.672517,  $1.1831375 \times 10^4$ , -8527.9742489,  $1.7217455 \times 10^4$ , 5935.9088468, 808.8681615, 373.3567247,  $1.1302311 \times 10^4$ , -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,  $-1.1225375 \times 10^4$ ,  $-1.2298408 \times 10^4$ , 3602.9920122, 6937.6344949, 3771.5645188, 1062.0216998, -1487.8646396, 1923.7791699, -184.4182187, -2692.3040992,  $-1.7145734 \times 10^4$ ,  $1.330129 \times 10^4$ , 3773.5661489, -8906.4649896,  $-1.5512831 \times 10^4$ , 5175.6766344, 3582.3241896, 6536.2838298, 5452.4518203,  $1.359897 \times 10^4$ ,  $-1.1998475 \times 10^4$ ,  $1.0685452 \times 10^4$ , -2682.5329117, 6895.6899574, -288.7476584, 517.0154226,  $1.1897068 \times 10^4$ , 8721.337217,  $-1.350147 \times 10^4$ , 469.8279665, 1845.0446036, 1467.1897827, -2383.1464035, -3843.3332761, 4646.9455575, 2722.2626014,  $1.4488496 \times 10^4$ , -8519.5777973, 3515.4986753,  $1.0638952 \times 10^4$ , -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,  $-1.0868295 \times 10^4$ ,  $-1.3514536 \times 10^4$ ,  $-1.2087499 \times 10^4$ ,  $1.2970387 \times 10^4$ , 3072.4528395, 6285.0464968, 479.1908025, -3870.3300715,  $-1.0804468 \times 10^4$ , -71.6723671, -4847.5109113, 8145.4557554, -1981.7509394,  $-1.4132138 \times 10^4$ , 1469.1382734, 3900.1817863,  $1.2036269 \times 10^4$ ,  $-1.1020757 \times 10^4$ , 3480.653435, -648.8760578, -8180.6809538, 3847.4282321,  $-2.2202234 \times 10^4$ ,  $-1.0812708 \times 10^4$ , -452.2407115, -3444.4031514, -3720.6591747, -8306.2290921,  $-1.1364297 \times 10^4$ , -8486.3543727, 9746.6072566, 9060.8262699, -3131.2230012.