SEM Preliminary

Ryan Larson - UMN

01/10/2020

```
#Multivariate Regression - when all predictors are identical across models
  #equivalent to separate OLS, but more efficient and takes into account error covariance

mv <- lm(cbind(total_ff_log, conf_days)~black+hispanic+asian+nativeam+other.race+
         male+log(age)+priors+trial_flag+felony+gross.mis+drug+alcohol.dui+hunt.fish+other.o
       data = monsanc.short)
summary(mv)
```

```
## Response total_ff_log :
##
## Call:
## lm(formula = total_ff_log ~ black + hispanic + asian + nativeam +
##     other.race + male + log(age) + priors + trial_flag + felony +
##     gross.mis + drug + alcohol.dui + hunt.fish + other.offense,
##     data = monsanc.short)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.8500 -0.3082  0.3337  0.7862  3.7230
##
## Coefficients:
##                  Estimate Std. Error  t value Pr(>|t|)
## (Intercept)     5.3595891  0.0154791  346.247  < 2e-16 ***
## black          -0.4070149  0.0034496 -117.988  < 2e-16 ***
## hispanic        0.0360669  0.0050889    7.087 1.37e-12 ***
## asian           0.0532808  0.0077086    6.912 4.79e-12 ***
## nativeam       -0.2358218  0.0063041  -37.408  < 2e-16 ***
## other.race     -0.1506906  0.0101037  -14.914  < 2e-16 ***
## male            0.0281478  0.0030714    9.164  < 2e-16 ***
## log(age)       -0.0575020  0.0041523  -13.848  < 2e-16 ***
## priors         -0.0156530  0.0001584  -98.794  < 2e-16 ***
## trial_flagTRUE -0.8260432  0.1312192   -6.295 3.07e-10 ***
## felony         -0.4924480  0.0054571  -90.240  < 2e-16 ***
## gross.mis       0.0489534  0.0049437    9.902  < 2e-16 ***
## drug            0.2527911  0.0084814   29.805  < 2e-16 ***
## alcohol.dui     0.5322846  0.0067356   79.025  < 2e-16 ***
## hunt.fish      -0.0131670  0.0151683   -0.868    0.385
## other.offense   0.2762845  0.0059851   46.162  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 1.478 on 1176431 degrees of freedom
##   (417664 observations deleted due to missingness)
## Multiple R-squared:  0.05284,    Adjusted R-squared:  0.05283
## F-statistic:  4376 on 15 and 1176431 DF,  p-value: < 2.2e-16
##
##
## Response conf_days :
##
## Call:
## lm(formula = conf_days ~ black + hispanic + asian + nativeam +
##     other.race + male + log(age) + priors + trial_flag + felony +
##     gross.mis + drug + alcohol.dui + hunt.fish + other.offense,
##     data = monsanc.short)
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  -2054    -27     -4     18  43566
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       40.0636     3.5757  11.205   <2e-16 ***
## black             18.6048     0.7969  23.348   <2e-16 ***
## hispanic          12.9544     1.1755  11.020   <2e-16 ***
## asian              2.2822     1.7807   1.282   0.2000
## nativeam          22.4647     1.4562  15.426   <2e-16 ***
## other.race         5.0686     2.3340   2.172   0.0299 *
## male              18.1920     0.7095  25.641   <2e-16 ***
## log(age)          21.5983     0.9592  22.517   <2e-16 ***
## priors             1.1877     0.0366  32.450   <2e-16 ***
## trial_flagTRUE  1513.0060    30.3116  49.915   <2e-16 ***
## felony           375.3401     1.2606 297.751   <2e-16 ***
## gross.mis        165.2418     1.1420 144.696   <2e-16 ***
## drug            -164.1286     1.9592 -83.773   <2e-16 ***
## alcohol.dui      -85.1572     1.5559 -54.731   <2e-16 ***
## hunt.fish       -139.6053     3.5039 -39.843   <2e-16 ***
## other.offense   -135.9844     1.3826 -98.357   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 341.5 on 1176431 degrees of freedom
##   (417664 observations deleted due to missingness)
## Multiple R-squared:  0.1416, Adjusted R-squared:  0.1416
## F-statistic: 1.294e+04 on 15 and 1176431 DF,  p-value: < 2.2e-16
```

```r
#multivariate fixed effects regression
mv.fe <- lm(cbind(total_ff_log, conf_days)~black+hispanic+asian+nativeam+other.race+
            male+log(age)+priors+trial_flag+felony+gross.mis+drug+alcohol.dui+hunt.fish+other.o:
            as.factor(filed_county)+as.factor(sentence_year), data = monsanc.short)
```

```
summary(mv)
```

```
## Response total_ff_log :
##
## Call:
## lm(formula = total_ff_log ~ black + hispanic + asian + nativeam +
##     other.race + male + log(age) + priors + trial_flag + felony +
##     gross.mis + drug + alcohol.dui + hunt.fish + other.offense,
##     data = monsanc.short)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.8500 -0.3082  0.3337  0.7862  3.7230
##
## Coefficients:
##                  Estimate Std. Error  t value Pr(>|t|)
## (Intercept)     5.3595891  0.0154791  346.247  < 2e-16 ***
## black          -0.4070149  0.0034496 -117.988  < 2e-16 ***
## hispanic        0.0360669  0.0050889    7.087 1.37e-12 ***
## asian           0.0532808  0.0077086    6.912 4.79e-12 ***
## nativeam       -0.2358218  0.0063041  -37.408  < 2e-16 ***
## other.race     -0.1506906  0.0101037  -14.914  < 2e-16 ***
## male            0.0281478  0.0030714    9.164  < 2e-16 ***
## log(age)       -0.0575020  0.0041523  -13.848  < 2e-16 ***
## priors         -0.0156530  0.0001584  -98.794  < 2e-16 ***
## trial_flagTRUE -0.8260432  0.1312192   -6.295 3.07e-10 ***
## felony         -0.4924480  0.0054571  -90.240  < 2e-16 ***
## gross.mis       0.0489534  0.0049437    9.902  < 2e-16 ***
## drug            0.2527911  0.0084814   29.805  < 2e-16 ***
## alcohol.dui     0.5322846  0.0067356   79.025  < 2e-16 ***
## hunt.fish      -0.0131670  0.0151683   -0.868    0.385
## other.offense   0.2762845  0.0059851   46.162  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.478 on 1176431 degrees of freedom
##   (417664 observations deleted due to missingness)
## Multiple R-squared:  0.05284,    Adjusted R-squared:  0.05283
## F-statistic:  4376 on 15 and 1176431 DF,  p-value: < 2.2e-16
##
##
## Response conf_days :
##
## Call:
## lm(formula = conf_days ~ black + hispanic + asian + nativeam +
##     other.race + male + log(age) + priors + trial_flag + felony +
##     gross.mis + drug + alcohol.dui + hunt.fish + other.offense,
```

```
##      data = monsanc.short)
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  -2054    -27     -4     18  43566
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      40.0636     3.5757  11.205   <2e-16 ***
## black            18.6048     0.7969  23.348   <2e-16 ***
## hispanic         12.9544     1.1755  11.020   <2e-16 ***
## asian             2.2822     1.7807   1.282   0.2000
## nativeam         22.4647     1.4562  15.426   <2e-16 ***
## other.race        5.0686     2.3340   2.172   0.0299 *
## male             18.1920     0.7095  25.641   <2e-16 ***
## log(age)         21.5983     0.9592  22.517   <2e-16 ***
## priors            1.1877     0.0366  32.450   <2e-16 ***
## trial_flagTRUE 1513.0060    30.3116  49.915   <2e-16 ***
## felony          375.3401     1.2606 297.751   <2e-16 ***
## gross.mis       165.2418     1.1420 144.696   <2e-16 ***
## drug           -164.1286     1.9592 -83.773   <2e-16 ***
## alcohol.dui     -85.1572     1.5559 -54.731   <2e-16 ***
## hunt.fish      -139.6053     3.5039 -39.843   <2e-16 ***
## other.offense  -135.9844     1.3826 -98.357   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 341.5 on 1176431 degrees of freedom
##   (417664 observations deleted due to missingness)
## Multiple R-squared:  0.1416, Adjusted R-squared:  0.1416
## F-statistic: 1.294e+04 on 15 and 1176431 DF,  p-value: < 2.2e-16
```

```r
#structural equation model
  #2SLS - uses pedicted value of conf days in LFO equation

#first stage
fs <- lm(conf_days~black+hispanic+asian+nativeam+other.race+
         male+log(age)+priors+trial_flag+felony+gross.mis+drug+alcohol.dui+hunt.fish+other.o
       data = monsanc.short)
summary(fs)
```

```
##
## Call:
## lm(formula = conf_days ~ black + hispanic + asian + nativeam +
##     other.race + male + log(age) + priors + trial_flag + felony +
##     gross.mis + drug + alcohol.dui + hunt.fish + other.offense,
##     data = monsanc.short)
##
```

```
## Residuals:
##    Min     1Q Median     3Q    Max
##  -2054    -27     -4     18  43566
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      40.0636     3.5757  11.205   <2e-16 ***
## black            18.6048     0.7969  23.348   <2e-16 ***
## hispanic         12.9544     1.1755  11.020   <2e-16 ***
## asian             2.2822     1.7807   1.282   0.2000
## nativeam         22.4647     1.4562  15.426   <2e-16 ***
## other.race        5.0686     2.3340   2.172   0.0299 *
## male             18.1920     0.7095  25.641   <2e-16 ***
## log(age)         21.5983     0.9592  22.517   <2e-16 ***
## priors            1.1877     0.0366  32.450   <2e-16 ***
## trial_flagTRUE 1513.0060    30.3116  49.915   <2e-16 ***
## felony          375.3401     1.2606 297.751   <2e-16 ***
## gross.mis       165.2418     1.1420 144.696   <2e-16 ***
## drug           -164.1286     1.9592 -83.773   <2e-16 ***
## alcohol.dui     -85.1572     1.5559 -54.731   <2e-16 ***
## hunt.fish      -139.6053     3.5039 -39.843   <2e-16 ***
## other.offense  -135.9844     1.3826 -98.357   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 341.5 on 1176431 degrees of freedom
##   (417664 observations deleted due to missingness)
## Multiple R-squared:  0.1416, Adjusted R-squared:  0.1416
## F-statistic: 1.294e+04 on 15 and 1176431 DF,  p-value: < 2.2e-16
```

```r
tsls <- tsls(total_ff_log~black+hispanic+asian+nativeam+other.race+
        male+log(age)+felony+gross.mis+conf_days+drug+alcohol.dui+hunt.fish+other.offense,
        ~black+hispanic+asian+nativeam+other.race+
        male+log(age)+priors+trial_flag+felony+gross.mis+drug+alcohol.dui+hunt.fish+other.o
        data = monsanc.short)

summary(tsls)
```

```
##
## 2SLS Estimates
##
## Model Formula: total_ff_log ~ black + hispanic + asian + nativeam + other.race +
##     male + log(age) + felony + gross.mis + conf_days + drug +
##     alcohol.dui + hunt.fish + other.offense
##
## Instruments: ~black + hispanic + asian + nativeam + other.race + male + log(age) +
##     priors + trial_flag + felony + gross.mis + drug + alcohol.dui +
##     hunt.fish + other.offense
```

```
## 
## Residuals:
##     Min.  1st Qu.   Median     Mean  3rd Qu.      Max.
##  -7.0835  -0.3936   0.2921   0.0000   0.7530 188.3416
## 
##                    Estimate    Std. Error    t value   Pr(>|t|)
## (Intercept)      5.5588632082  0.0219499488  253.25176 < 2.22e-16 ***
## black           -0.3673753064  0.0053145036  -69.12693 < 2.22e-16 ***
## hispanic         0.1030750500  0.0072088918   14.29832 < 2.22e-16 ***
## asian            0.0755059632  0.0107721624    7.00936 2.3954e-12 ***
## nativeam        -0.1573562910  0.0091459959  -17.20494 < 2.22e-16 ***
## other.race      -0.1353468553  0.0141342419   -9.57581 < 2.22e-16 ***
## male             0.0870959238  0.0047517629   18.32918 < 2.22e-16 ***
## log(age)         0.0151834847  0.0062821848    2.41691   0.015653 *
## felony           1.1052636573  0.0391963783   28.19811 < 2.22e-16 ***
## gross.mis        0.7482631408  0.0182867726   40.91827 < 2.22e-16 ***
## conf_days       -0.0043052125  0.0001015171  -42.40875 < 2.22e-16 ***
## drug            -0.4696818173  0.0203491732  -23.08113 < 2.22e-16 ***
## alcohol.dui      0.1803734100  0.0129239698   13.95650 < 2.22e-16 ***
## hunt.fish       -0.6043321613  0.0255945037  -23.61179 < 2.22e-16 ***
## other.offense   -0.3269718956  0.0160127895  -20.41942 < 2.22e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 2.0663268 on 1176432 degrees of freedom
```

```r
#2SLS Fixed Effects Model

#first stage
fs.fe <- lm(conf_days~black+hispanic+asian+nativeam+other.race+
        male+log(age)+priors+trial_flag+felony+gross.mis+drug+alcohol.dui+hunt.fish+other.o:
        as.factor(filed_county)+as.factor(sentence_year), data = monsanc.short)
summary(fs.fe)
```

```
## 
## Call:
## lm(formula = conf_days ~ black + hispanic + asian + nativeam +
##     other.race + male + log(age) + priors + trial_flag + felony +
##     gross.mis + drug + alcohol.dui + hunt.fish + other.offense +
##     as.factor(filed_county) + as.factor(sentence_year), data = monsanc.short)
## 
## Residuals:
##    Min     1Q Median     3Q    Max
##  -2052    -31     -5     25  43555
## 
## Coefficients:
##                                               Estimate Std. Error t value
## (Intercept)                                   59.80825    6.64507   9.000
```

```
## black                                          17.86377    0.86061   20.757
## hispanic                                        15.58409    1.19794   13.009
## asian                                            3.70379    1.81195    2.044
## nativeam                                        12.58152    1.55917    8.069
## other.race                                       5.61849    2.33897    2.402
## male                                            18.10990    0.70955   25.523
## log(age)                                        21.53302    0.96195   22.385
## priors                                           1.19811    0.03721   32.200
## trial_flagTRUE                                1503.86412   30.28397   49.659
## felony                                         374.01601    1.26543  295.565
## gross.mis                                      164.61658    1.14216  144.128
## drug                                          -163.54849    1.95908  -83.482
## alcohol.dui                                    -84.97659    1.55631  -54.601
## hunt.fish                                     -141.23483    3.54203  -39.874
## other.offense                                 -135.76069    1.38243  -98.205
## as.factor(filed_county)Anoka County            -17.20229    5.70516   -3.015
## as.factor(filed_county)Becker County            15.76336    6.66646    2.365
## as.factor(filed_county)Beltrami County           7.10791    6.19307    1.148
## as.factor(filed_county)Benton County             7.64632    7.34059    1.042
## as.factor(filed_county)Big Stone County        -24.13397   14.20036   -1.700
## as.factor(filed_county)Blue Earth County       -48.08418    6.09284   -7.892
## as.factor(filed_county)Brown County            -25.02173    7.70536   -3.247
## as.factor(filed_county)Carlton County          -24.74268    6.65685   -3.717
## as.factor(filed_county)Carver County           -55.55277    6.33466   -8.770
## as.factor(filed_county)Cass County              -3.92398    6.95143   -0.564
## as.factor(filed_county)Chippewa County         -22.42860    9.19584   -2.439
## as.factor(filed_county)Chisago County          -19.61027    6.63782   -2.954
## as.factor(filed_county)Clay County              -0.54580    6.16198   -0.089
## as.factor(filed_county)Clearwater County         1.06668   10.78448    0.099
## as.factor(filed_county)Cook County              -0.95292   12.70196   -0.075
## as.factor(filed_county)Cottonwood County        -3.67206    9.82633   -0.374
## as.factor(filed_county)Crow Wing County         -6.51225    6.19901   -1.051
## as.factor(filed_county)Dakota County           -41.79862    5.65255   -7.395
## as.factor(filed_county)Dodge County            -63.68184    8.73602   -7.290
## as.factor(filed_county)Douglas County          -14.54732    7.05308   -2.063
## as.factor(filed_county)Faribault County        -32.33383    9.01353   -3.587
## as.factor(filed_county)Fillmore County          -4.66314    8.67357   -0.538
## as.factor(filed_county)Freeborn County         -38.52701    7.06455   -5.454
## as.factor(filed_county)Goodhue County          -68.90066    6.22007  -11.077
## as.factor(filed_county)Grant County            -38.93544   13.50530   -2.883
## as.factor(filed_county)Hennepin County         -17.09599    5.57349   -3.067
## as.factor(filed_county)Houston County          -40.15677    8.18556   -4.906
## as.factor(filed_county)Hubbard County            4.06401    7.68439    0.529
## as.factor(filed_county)Isanti County           -16.70175    7.19240   -2.322
## as.factor(filed_county)Itasca County             3.53911    6.46952    0.547
## as.factor(filed_county)Jackson County          -31.52612   10.37843   -3.038
## as.factor(filed_county)Kanabec County          -25.75229    8.12518   -3.169
## as.factor(filed_county)Kandiyohi County         -7.79605    6.59546   -1.182
```

```
## as.factor(filed_county)Kittson County           -48.90774  18.31759  -2.670
## as.factor(filed_county)Koochiching County       -15.32279   9.19195  -1.667
## as.factor(filed_county)Lac qui Parle County      -31.71402  13.54334  -2.342
## as.factor(filed_county)Lake County               -18.05597  10.11621  -1.785
## as.factor(filed_county)Lake of the Woods County  -19.94395  11.75925  -1.696
## as.factor(filed_county)LeSueur County            -66.22225   7.74330  -8.552
## as.factor(filed_county)Lincoln County             18.90526  15.62445   1.210
## as.factor(filed_county)Lyon County                14.47081   7.25975   1.993
## as.factor(filed_county)Mahnomen County           -16.64294   8.50318  -1.957
## as.factor(filed_county)Marshall County             6.85574  11.52612   0.595
## as.factor(filed_county)Martin County             -15.86461   7.72657  -2.053
## as.factor(filed_county)McLeod County             -58.36794   6.94849  -8.400
## as.factor(filed_county)Meeker County             -19.08068   8.87152  -2.151
## as.factor(filed_county)Mille Lacs County           0.79520   6.87372   0.116
## as.factor(filed_county)Morrison County           -11.45322   7.27130  -1.575
## as.factor(filed_county)Mower County              -11.59122   6.69964  -1.730
## as.factor(filed_county)Murray County             -65.74258  13.03321  -5.044
## as.factor(filed_county)Nicollet County           -31.96552   7.15056  -4.470
## as.factor(filed_county)Nobles County             -17.01248   7.70364  -2.208
## as.factor(filed_county)Norman County             -10.51977  12.13172  -0.867
## as.factor(filed_county)Olmsted County            -38.59335   5.88453  -6.558
## as.factor(filed_county)Otter Tail County         -21.07440   6.58818  -3.199
## as.factor(filed_county)Pennington County          11.36221   8.47760   1.340
## as.factor(filed_county)Pine County               -21.20122   7.09738  -2.987
## as.factor(filed_county)Pipestone County          -64.86048  11.65316  -5.566
## as.factor(filed_county)Polk County                87.27244   6.81715  12.802
## as.factor(filed_county)Pope County               -32.27203  10.05986  -3.208
## as.factor(filed_county)Ramsey County             -12.92230   5.61442  -2.302
## as.factor(filed_county)Red Lake County           -22.38575  12.87107  -1.739
## as.factor(filed_county)Redwood County             -4.23564   7.78481  -0.544
## as.factor(filed_county)Renville County           -29.85729   8.09530  -3.688
## as.factor(filed_county)Rice County                -9.68835   6.48707  -1.493
## as.factor(filed_county)Rock County               -55.56214  12.67666  -4.383
## as.factor(filed_county)Roseau County             -24.89703   7.89339  -3.154
## as.factor(filed_county)Scott County              -53.10330   5.81974  -9.125
## as.factor(filed_county)Sherburne County           11.66731   6.25505   1.865
## as.factor(filed_county)Sibley County             -72.13230   8.80712  -8.190
## as.factor(filed_county)St. Louis County           -3.56764   5.74175  -0.621
## as.factor(filed_county)Stearns County             13.64362   5.80006   2.352
## as.factor(filed_county)Steele County             -13.49795   6.77525  -1.992
## as.factor(filed_county)Stevens County            -33.86285  11.86942  -2.853
## as.factor(filed_county)Swift County              -31.07559  10.00303  -3.107
## as.factor(filed_county)Todd County               -20.40863   8.19083  -2.492
## as.factor(filed_county)Traverse County           -50.77168  17.02736  -2.982
## as.factor(filed_county)Wabasha County            -60.92961   7.65130  -7.963
## as.factor(filed_county)Wadena County             -11.65283   8.32805  -1.399
## as.factor(filed_county)Waseca County             -17.57664   8.56280  -2.053
## as.factor(filed_county)Washington County          -7.99863   5.77931  -1.384
```

```
## as.factor(filed_county)Watonwan County      -33.16698    9.17156  -3.616
## as.factor(filed_county)Wilkin County         -29.57776   10.29543  -2.873
## as.factor(filed_county)Winona County         -55.11456    6.56611  -8.394
## as.factor(filed_county)Wright County         -12.56233    6.11829  -2.053
## as.factor(filed_county)Yellow Medicine County -4.18322    9.27903  -0.451
## as.factor(sentence_year)2011                  -1.67867    1.09572  -1.532
## as.factor(sentence_year)2012                  -0.14636    1.08465  -0.135
## as.factor(sentence_year)2013                  -0.79622    1.15580  -0.689
## as.factor(sentence_year)2014                  -3.21643    1.10861  -2.901
## as.factor(sentence_year)2015                  -3.67198    1.13032  -3.249
## as.factor(sentence_year)2016                   6.26621    1.51582   4.134
## as.factor(sentence_year)2017                  16.78522    2.70678   6.201
## as.factor(sentence_year)2018                   0.01902    4.23704   0.004
##                                               Pr(>|t|)
## (Intercept)                                   < 2e-16 ***
## black                                         < 2e-16 ***
## hispanic                                      < 2e-16 ***
## asian                                         0.040945 *
## nativeam                                      7.07e-16 ***
## other.race                                    0.016300 *
## male                                          < 2e-16 ***
## log(age)                                      < 2e-16 ***
## priors                                        < 2e-16 ***
## trial_flagTRUE                                < 2e-16 ***
## felony                                        < 2e-16 ***
## gross.mis                                     < 2e-16 ***
## drug                                          < 2e-16 ***
## alcohol.dui                                   < 2e-16 ***
## hunt.fish                                     < 2e-16 ***
## other.offense                                 < 2e-16 ***
## as.factor(filed_county)Anoka County           0.002568 **
## as.factor(filed_county)Becker County          0.018051 *
## as.factor(filed_county)Beltrami County        0.251084
## as.factor(filed_county)Benton County          0.297574
## as.factor(filed_county)Big Stone County       0.089219 .
## as.factor(filed_county)Blue Earth County      2.98e-15 ***
## as.factor(filed_county)Brown County           0.001165 **
## as.factor(filed_county)Carlton County         0.000202 ***
## as.factor(filed_county)Carver County          < 2e-16 ***
## as.factor(filed_county)Cass County            0.572424
## as.factor(filed_county)Chippewa County        0.014728 *
## as.factor(filed_county)Chisago County         0.003134 **
## as.factor(filed_county)Clay County            0.929420
## as.factor(filed_county)Clearwater County      0.921211
## as.factor(filed_county)Cook County            0.940197
## as.factor(filed_county)Cottonwood County      0.708630
## as.factor(filed_county)Crow Wing County       0.293474
## as.factor(filed_county)Dakota County          1.42e-13 ***
```

```
## as.factor(filed_county)Dodge County             3.11e-13 ***
## as.factor(filed_county)Douglas County           0.039156 *
## as.factor(filed_county)Faribault County         0.000334 ***
## as.factor(filed_county)Fillmore County          0.590835
## as.factor(filed_county)Freeborn County          4.94e-08 ***
## as.factor(filed_county)Goodhue County            < 2e-16 ***
## as.factor(filed_county)Grant County             0.003939 **
## as.factor(filed_county)Hennepin County          0.002160 **
## as.factor(filed_county)Houston County           9.31e-07 ***
## as.factor(filed_county)Hubbard County           0.596899
## as.factor(filed_county)Isanti County            0.020226 *
## as.factor(filed_county)Itasca County            0.584349
## as.factor(filed_county)Jackson County           0.002384 **
## as.factor(filed_county)Kanabec County           0.001527 **
## as.factor(filed_county)Kandiyohi County         0.237193
## as.factor(filed_county)Kittson County           0.007586 **
## as.factor(filed_county)Koochiching County       0.095519 .
## as.factor(filed_county)Lac qui Parle County     0.019198 *
## as.factor(filed_county)Lake County              0.074285 .
## as.factor(filed_county)Lake of the Woods County 0.089882 .
## as.factor(filed_county)LeSueur County            < 2e-16 ***
## as.factor(filed_county)Lincoln County           0.226287
## as.factor(filed_county)Lyon County              0.046230 *
## as.factor(filed_county)Mahnomen County          0.050317 .
## as.factor(filed_county)Marshall County          0.551977
## as.factor(filed_county)Martin County            0.040048 *
## as.factor(filed_county)McLeod County             < 2e-16 ***
## as.factor(filed_county)Meeker County            0.031494 *
## as.factor(filed_county)Mille Lacs County        0.907901
## as.factor(filed_county)Morrison County          0.115227
## as.factor(filed_county)Mower County             0.083608 .
## as.factor(filed_county)Murray County            4.55e-07 ***
## as.factor(filed_county)Nicollet County          7.81e-06 ***
## as.factor(filed_county)Nobles County            0.027219 *
## as.factor(filed_county)Norman County            0.385871
## as.factor(filed_county)Olmsted County           5.44e-11 ***
## as.factor(filed_county)Otter Tail County        0.001380 **
## as.factor(filed_county)Pennington County        0.180160
## as.factor(filed_county)Pine County              0.002816 **
## as.factor(filed_county)Pipestone County         2.61e-08 ***
## as.factor(filed_county)Polk County               < 2e-16 ***
## as.factor(filed_county)Pope County              0.001337 **
## as.factor(filed_county)Ramsey County            0.021356 *
## as.factor(filed_county)Red Lake County          0.081995 .
## as.factor(filed_county)Redwood County           0.586380
## as.factor(filed_county)Renville County          0.000226 ***
## as.factor(filed_county)Rice County              0.135310
## as.factor(filed_county)Rock County              1.17e-05 ***
```

```
## as.factor(filed_county)Roseau County          0.001610 **
## as.factor(filed_county)Scott County            < 2e-16 ***
## as.factor(filed_county)Sherburne County        0.062145 .
## as.factor(filed_county)Sibley County           2.61e-16 ***
## as.factor(filed_county)St. Louis County        0.534369
## as.factor(filed_county)Stearns County          0.018657 *
## as.factor(filed_county)Steele County           0.046344 *
## as.factor(filed_county)Stevens County          0.004332 **
## as.factor(filed_county)Swift County            0.001892 **
## as.factor(filed_county)Todd County             0.012715 *
## as.factor(filed_county)Traverse County         0.002866 **
## as.factor(filed_county)Wabasha County          1.68e-15 ***
## as.factor(filed_county)Wadena County           0.161746
## as.factor(filed_county)Waseca County           0.040104 *
## as.factor(filed_county)Washington County       0.166355
## as.factor(filed_county)Watonwan County         0.000299 ***
## as.factor(filed_county)Wilkin County           0.004067 **
## as.factor(filed_county)Winona County           < 2e-16 ***
## as.factor(filed_county)Wright County           0.040049 *
## as.factor(filed_county)Yellow Medicine County  0.652116
## as.factor(sentence_year)2011                   0.125515
## as.factor(sentence_year)2012                   0.892661
## as.factor(sentence_year)2013                   0.490894
## as.factor(sentence_year)2014                   0.003716 **
## as.factor(sentence_year)2015                   0.001160 **
## as.factor(sentence_year)2016                   3.57e-05 ***
## as.factor(sentence_year)2017                   5.61e-10 ***
## as.factor(sentence_year)2018                   0.996419
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 340.9 on 1176337 degrees of freedom
##   (417664 observations deleted due to missingness)
## Multiple R-squared:  0.1444, Adjusted R-squared:  0.1444
## F-statistic:  1822 on 109 and 1176337 DF,  p-value: < 2.2e-16
```

```r
tsls.fe <- tsls(total_ff_log~conf_days+black+hispanic+asian+nativeam+other.race+male+log(age)+
                felony+gross.mis+drug+alcohol.dui+hunt.fish+other.offense+
                as.factor(filed_county)+as.factor(sentence_year),
            ~priors+trial_flag+black+hispanic+asian+nativeam+other.race+
              male+log(age)+felony+gross.mis+drug+alcohol.dui+hunt.fish+other.offense+
              as.factor(filed_county)+as.factor(sentence_year),
            data = monsanc.short)

summary(tsls.fe)
```

```
##
##  2SLS Estimates
```

```
##
## Model Formula: total_ff_log ~ conf_days + black + hispanic + asian + nativeam +
##     other.race + male + log(age) + felony + gross.mis + drug +
##     alcohol.dui + hunt.fish + other.offense + as.factor(filed_county) +
##     as.factor(sentence_year)
##
## Instruments: ~priors + trial_flag + black + hispanic + asian + nativeam +
##     other.race + male + log(age) + felony + gross.mis + drug +
##     alcohol.dui + hunt.fish + other.offense + as.factor(filed_county) +
##     as.factor(sentence_year)
##
## Residuals:
##     Min.  1st Qu.  Median    Mean  3rd Qu.     Max.
##  -7.3000  -0.4395   0.2016   0.0000   0.7803 170.0594
##
##                                                Estimate    Std. Error
## (Intercept)                                  5.833397e+00  3.809991e-02
## conf_days                                   -3.898916e-03  9.609657e-05
## black                                       -1.937185e-01  5.272258e-03
## hispanic                                     1.425667e-01  6.933897e-03
## asian                                        7.414432e-02  1.029151e-02
## nativeam                                    -2.960310e-01  8.965936e-03
## other.race                                  -3.693756e-02  1.330287e-02
## male                                         9.168843e-02  4.469348e-03
## log(age)                                     3.029198e-02  5.909380e-03
## felony                                       8.668906e-01  3.697813e-02
## gross.mis                                    6.626374e-01  1.722828e-02
## drug                                        -3.615336e-01  1.920617e-02
## alcohol.dui                                  2.405514e-01  1.216077e-02
## hunt.fish                                   -6.210962e-01  2.431631e-02
## other.offense                               -2.343062e-01  1.513310e-02
## as.factor(filed_county)Anoka County         -8.829733e-01  3.245033e-02
## as.factor(filed_county)Becker County         3.092763e-01  3.791761e-02
## as.factor(filed_county)Beltrami County      -1.044940e-01  3.520338e-02
## as.factor(filed_county)Benton County        -3.272745e-01  4.172631e-02
## as.factor(filed_county)Big Stone County     -2.560978e-01  8.073609e-02
## as.factor(filed_county)Blue Earth County    -4.170413e-01  3.491695e-02
## as.factor(filed_county)Brown County         -2.236789e-01  4.384707e-02
## as.factor(filed_county)Carlton County       -2.088778e-01  3.790222e-02
## as.factor(filed_county)Carver County        -3.166156e-01  3.637164e-02
## as.factor(filed_county)Cass County          -4.620010e-01  3.950738e-02
## as.factor(filed_county)Chippewa County      -1.801175e-01  5.230191e-02
## as.factor(filed_county)Chisago County       -6.134913e-01  3.776334e-02
## as.factor(filed_county)Clay County          -4.385277e-02  3.501871e-02
## as.factor(filed_county)Clearwater County    -1.887741e-01  6.128908e-02
## as.factor(filed_county)Cook County          -4.295160e-01  7.218634e-02
## as.factor(filed_county)Cottonwood County    -1.845817e-01  5.584459e-02
## as.factor(filed_county)Crow Wing County     -2.531735e-01  3.523231e-02
```

```
## as.factor(filed_county)Dakota County               -4.390518e-01  3.234710e-02
## as.factor(filed_county)Dodge County                -9.962459e-01  5.000497e-02
## as.factor(filed_county)Douglas County              -7.025937e-02  4.010588e-02
## as.factor(filed_county)Faribault County            -1.775995e-01  5.131211e-02
## as.factor(filed_county)Fillmore County             -2.536087e-01  4.929425e-02
## as.factor(filed_county)Freeborn County             -5.392544e-01  4.030627e-02
## as.factor(filed_county)Goodhue County              -8.352072e-01  3.591433e-02
## as.factor(filed_county)Grant County                -3.617891e-01  7.684207e-02
## as.factor(filed_county)Hennepin County             -9.896043e-01  3.169296e-02
## as.factor(filed_county)Houston County              -6.237794e-01  4.669037e-02
## as.factor(filed_county)Hubbard County              -2.616271e-01  4.367297e-02
## as.factor(filed_county)Isanti County               -5.019389e-01  4.089956e-02
## as.factor(filed_county)Itasca County               -1.032483e-01  3.676901e-02
## as.factor(filed_county)Jackson County              -2.534792e-01  5.905920e-02
## as.factor(filed_county)Kanabec County              -4.239484e-01  4.623892e-02
## as.factor(filed_county)Kandiyohi County            -2.306967e-01  3.748754e-02
## as.factor(filed_county)Kittson County              -2.395769e-01  1.042158e-01
## as.factor(filed_county)Koochiching County          -8.181442e-01  5.225996e-02
## as.factor(filed_county)Lac qui Parle County        -3.288367e-01  7.702774e-02
## as.factor(filed_county)Lake County                 -3.989812e-01  5.751553e-02
## as.factor(filed_county)Lake of the Woods County -5.280315e-01  6.685369e-02
## as.factor(filed_county)LeSueur County              -5.711602e-01  4.443242e-02
## as.factor(filed_county)Lincoln County               4.447605e-02  8.881205e-02
## as.factor(filed_county)Lyon County                 -2.902579e-02  4.128351e-02
## as.factor(filed_county)Mahnomen County             -2.250422e-01  4.835097e-02
## as.factor(filed_county)Marshall County             -1.210807e-01  6.550661e-02
## as.factor(filed_county)Martin County               -4.531123e-01  4.393456e-02
## as.factor(filed_county)McLeod County               -7.841528e-01  3.984736e-02
## as.factor(filed_county)Meeker County               -1.225390e-01  5.044577e-02
## as.factor(filed_county)Mille Lacs County            9.626637e-02  3.906336e-02
## as.factor(filed_county)Morrison County             -2.063191e-01  4.133388e-02
## as.factor(filed_county)Mower County                -3.592652e-01  3.808952e-02
## as.factor(filed_county)Murray County               -2.407262e-01  7.432881e-02
## as.factor(filed_county)Nicollet County             -3.192411e-01  4.074403e-02
## as.factor(filed_county)Nobles County               -1.997824e-01  4.381290e-02
## as.factor(filed_county)Norman County               -1.619034e-01  6.895430e-02
## as.factor(filed_county)Olmsted County              -7.693420e-01  3.362631e-02
## as.factor(filed_county)Otter Tail County           -1.927706e-02  3.749671e-02
## as.factor(filed_county)Pennington County           -3.732169e-01  4.819325e-02
## as.factor(filed_county)Pine County                 -5.472059e-01  4.038102e-02
## as.factor(filed_county)Pipestone County            -3.241299e-01  6.651833e-02
## as.factor(filed_county)Polk County                  2.143514e-01  3.962212e-02
## as.factor(filed_county)Pope County                 -3.525558e-01  5.725150e-02
## as.factor(filed_county)Ramsey County               -1.177706e-01  3.191821e-02
## as.factor(filed_county)Red Lake County             -7.397201e-01  7.317805e-02
## as.factor(filed_county)Redwood County              -8.568745e-03  4.424109e-02
## as.factor(filed_county)Renville County             -9.353293e-01  4.608102e-02
## as.factor(filed_county)Rice County                 -7.289426e-02  3.687178e-02
```

```
## as.factor(filed_county)Rock County              -3.421538e-01  7.224402e-02
## as.factor(filed_county)Roseau County            -2.322212e-01  4.492214e-02
## as.factor(filed_county)Scott County             -3.833577e-01  3.342918e-02
## as.factor(filed_county)Sherburne County         -3.251696e-01  3.557067e-02
## as.factor(filed_county)Sibley County            -8.766764e-01  5.049423e-02
## as.factor(filed_county)St. Louis County         -2.773890e-01  3.263147e-02
## as.factor(filed_county)Stearns County           -5.893522e-02  3.299572e-02
## as.factor(filed_county)Steele County            -1.677333e-01  3.851686e-02
## as.factor(filed_county)Stevens County           -4.850922e-01  6.753406e-02
## as.factor(filed_county)Swift County             -2.919726e-01  5.692198e-02
## as.factor(filed_county)Todd County              -5.144849e-02  4.658833e-02
## as.factor(filed_county)Traverse County          -8.700327e-01  9.690218e-02
## as.factor(filed_county)Wabasha County           -7.927895e-01  4.385889e-02
## as.factor(filed_county)Wadena County            -9.943892e-02  4.734168e-02
## as.factor(filed_county)Waseca County            -5.676001e-01  4.868404e-02
## as.factor(filed_county)Washington County        -3.097171e-01  3.284818e-02
## as.factor(filed_county)Watonwan County          -2.143626e-01  5.221471e-02
## as.factor(filed_county)Wilkin County            -3.507625e-01  5.858539e-02
## as.factor(filed_county)Winona County            -6.150440e-01  3.769117e-02
## as.factor(filed_county)Wright County            -7.198747e-01  3.478171e-02
## as.factor(filed_county)Yellow Medicine County   -5.710908e-02  5.273404e-02
## as.factor(sentence_year)2011                     2.570152e-02  6.225087e-03
## as.factor(sentence_year)2012                     8.905847e-03  6.158332e-03
## as.factor(sentence_year)2013                     7.166608e-02  6.555205e-03
## as.factor(sentence_year)2014                     8.385216e-02  6.274193e-03
## as.factor(sentence_year)2015                     1.221721e-01  6.386679e-03
## as.factor(sentence_year)2016                     2.264179e-01  8.657987e-03
## as.factor(sentence_year)2017                     4.878084e-01  1.553361e-02
## as.factor(sentence_year)2018                     5.321935e-01  2.406351e-02
##                                                  t value   Pr(>|t|)
## (Intercept)                                      153.10788 < 2.22e-16 ***
## conf_days                                        -40.57290 < 2.22e-16 ***
## black                                            -36.74299 < 2.22e-16 ***
## hispanic                                          20.56083 < 2.22e-16 ***
## asian                                              7.20442 5.8331e-13 ***
## nativeam                                         -33.01730 < 2.22e-16 ***
## other.race                                        -2.77666 0.00549214 **
## male                                              20.51494 < 2.22e-16 ***
## log(age)                                           5.12608 2.9588e-07 ***
## felony                                            23.44333 < 2.22e-16 ***
## gross.mis                                         38.46220 < 2.22e-16 ***
## drug                                             -18.82383 < 2.22e-16 ***
## alcohol.dui                                       19.78094 < 2.22e-16 ***
## hunt.fish                                        -25.54237 < 2.22e-16 ***
## other.offense                                    -15.48303 < 2.22e-16 ***
## as.factor(filed_county)Anoka County              -27.21000 < 2.22e-16 ***
## as.factor(filed_county)Becker County               8.15653 4.4409e-16 ***
## as.factor(filed_county)Beltrami County            -2.96829 0.00299464 **
```

```
## as.factor(filed_county)Benton County                  -7.84336 4.4409e-15 ***
## as.factor(filed_county)Big Stone County              -3.17204 0.00151378 **
## as.factor(filed_county)Blue Earth County            -11.94381 < 2.22e-16 ***
## as.factor(filed_county)Brown County                  -5.10134 3.3731e-07 ***
## as.factor(filed_county)Carlton County                -5.51097 3.5695e-08 ***
## as.factor(filed_county)Carver County                 -8.70501 < 2.22e-16 ***
## as.factor(filed_county)Cass County                  -11.69404 < 2.22e-16 ***
## as.factor(filed_county)Chippewa County               -3.44380 0.00057361 ***
## as.factor(filed_county)Chisago County               -16.24569 < 2.22e-16 ***
## as.factor(filed_county)Clay County                   -1.25227 0.21047292
## as.factor(filed_county)Clearwater County             -3.08006 0.00206963 **
## as.factor(filed_county)Cook County                   -5.95010 2.6805e-09 ***
## as.factor(filed_county)Cottonwood County             -3.30527 0.00094886 ***
## as.factor(filed_county)Crow Wing County              -7.18583 6.6835e-13 ***
## as.factor(filed_county)Dakota County                -13.57314 < 2.22e-16 ***
## as.factor(filed_county)Dodge County                 -19.92294 < 2.22e-16 ***
## as.factor(filed_county)Douglas County                -1.75185 0.07980035 .
## as.factor(filed_county)Faribault County              -3.46116 0.00053787 ***
## as.factor(filed_county)Fillmore County               -5.14479 2.6786e-07 ***
## as.factor(filed_county)Freeborn County              -13.37892 < 2.22e-16 ***
## as.factor(filed_county)Goodhue County               -23.25554 < 2.22e-16 ***
## as.factor(filed_county)Grant County                  -4.70822 2.4992e-06 ***
## as.factor(filed_county)Hennepin County              -31.22474 < 2.22e-16 ***
## as.factor(filed_county)Houston County               -13.35992 < 2.22e-16 ***
## as.factor(filed_county)Hubbard County                -5.99060 2.0913e-09 ***
## as.factor(filed_county)Isanti County                -12.27248 < 2.22e-16 ***
## as.factor(filed_county)Itasca County                 -2.80803 0.00498471 **
## as.factor(filed_county)Jackson County                -4.29195 1.7712e-05 ***
## as.factor(filed_county)Kanabec County                -9.16865 < 2.22e-16 ***
## as.factor(filed_county)Kandiyohi County              -6.15396 7.5597e-10 ***
## as.factor(filed_county)Kittson County                -2.29885 0.02151340 *
## as.factor(filed_county)Koochiching County           -15.65528 < 2.22e-16 ***
## as.factor(filed_county)Lac qui Parle County          -4.26907 1.9631e-05 ***
## as.factor(filed_county)Lake County                   -6.93693 4.0092e-12 ***
## as.factor(filed_county)Lake of the Woods County      -7.89831 2.6645e-15 ***
## as.factor(filed_county)LeSueur County               -12.85458 < 2.22e-16 ***
## as.factor(filed_county)Lincoln County                 0.50079 0.61652011
## as.factor(filed_county)Lyon County                   -0.70308 0.48200329
## as.factor(filed_county)Mahnomen County               -4.65435 3.2504e-06 ***
## as.factor(filed_county)Marshall County               -1.84837 0.06454863 .
## as.factor(filed_county)Martin County                -10.31335 < 2.22e-16 ***
## as.factor(filed_county)McLeod County                -19.67891 < 2.22e-16 ***
## as.factor(filed_county)Meeker County                 -2.42912 0.01513550 *
## as.factor(filed_county)Mille Lacs County              2.46437 0.01372576 *
## as.factor(filed_county)Morrison County               -4.99153 5.9913e-07 ***
## as.factor(filed_county)Mower County                  -9.43213 < 2.22e-16 ***
## as.factor(filed_county)Murray County                 -3.23867 0.00120094 **
## as.factor(filed_county)Nicollet County               -7.83528 4.6629e-15 ***
```

```
## as.factor(filed_county)Nobles County              -4.55990 5.1183e-06 ***
## as.factor(filed_county)Norman County              -2.34798 0.01887567 *
## as.factor(filed_county)Olmsted County            -22.87917 < 2.22e-16 ***
## as.factor(filed_county)Otter Tail County          -0.51410 0.60718220
## as.factor(filed_county)Pennington County          -7.74417 9.7700e-15 ***
## as.factor(filed_county)Pine County               -13.55107 < 2.22e-16 ***
## as.factor(filed_county)Pipestone County           -4.87279 1.1005e-06 ***
## as.factor(filed_county)Polk County                 5.40989 6.3075e-08 ***
## as.factor(filed_county)Pope County                -6.15802 7.3685e-10 ***
## as.factor(filed_county)Ramsey County              -3.68976 0.00022447 ***
## as.factor(filed_county)Red Lake County           -10.10850 < 2.22e-16 ***
## as.factor(filed_county)Redwood County             -0.19368 0.84642417
## as.factor(filed_county)Renville County           -20.29750 < 2.22e-16 ***
## as.factor(filed_county)Rice County                -1.97697 0.04804569 *
## as.factor(filed_county)Rock County                -4.73608 2.1791e-06 ***
## as.factor(filed_county)Roseau County              -5.16942 2.3486e-07 ***
## as.factor(filed_county)Scott County              -11.46776 < 2.22e-16 ***
## as.factor(filed_county)Sherburne County           -9.14151 < 2.22e-16 ***
## as.factor(filed_county)Sibley County             -17.36191 < 2.22e-16 ***
## as.factor(filed_county)St. Louis County           -8.50066 < 2.22e-16 ***
## as.factor(filed_county)Stearns County             -1.78615 0.07407560 .
## as.factor(filed_county)Steele County              -4.35480 1.3320e-05 ***
## as.factor(filed_county)Stevens County             -7.18293 6.8279e-13 ***
## as.factor(filed_county)Swift County               -5.12935 2.9080e-07 ***
## as.factor(filed_county)Todd County                -1.10432 0.26945396
## as.factor(filed_county)Traverse County            -8.97846 < 2.22e-16 ***
## as.factor(filed_county)Wabasha County            -18.07591 < 2.22e-16 ***
## as.factor(filed_county)Wadena County              -2.10045 0.03568934 *
## as.factor(filed_county)Waseca County             -11.65885 < 2.22e-16 ***
## as.factor(filed_county)Washington County          -9.42874 < 2.22e-16 ***
## as.factor(filed_county)Watonwan County            -4.10541 4.0363e-05 ***
## as.factor(filed_county)Wilkin County              -5.98720 2.1355e-09 ***
## as.factor(filed_county)Winona County             -16.31798 < 2.22e-16 ***
## as.factor(filed_county)Wright County             -20.69693 < 2.22e-16 ***
## as.factor(filed_county)Yellow Medicine County     -1.08296 0.27882447
## as.factor(sentence_year)2011                       4.12870 3.6485e-05 ***
## as.factor(sentence_year)2012                       1.44615 0.14813651
## as.factor(sentence_year)2013                      10.93270 < 2.22e-16 ***
## as.factor(sentence_year)2014                      13.36461 < 2.22e-16 ***
## as.factor(sentence_year)2015                      19.12921 < 2.22e-16 ***
## as.factor(sentence_year)2016                      26.15133 < 2.22e-16 ***
## as.factor(sentence_year)2017                      31.40342 < 2.22e-16 ***
## as.factor(sentence_year)2018                      22.11621 < 2.22e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.9375378 on 1176338 degrees of freedom
```