Example 10-3

September 11, 2020

```
[ ]: # install the following packages and libraries
     install.packages("pder")
     install.packages("plm")
     install.packages("splm")

     library(spData)
     install.packages("spDataLarge")
     library("pder")
     library("plm")
     library("splm")
```

```
[3]: ##--------------------------------Block 1--------------------------------

     #### Example 10-3 ####

     ## -------------------------------------------------------------------
     data("Cigar", package = "plm")

     # fixed effects model with spatially lagged explanatory variables
     fm <- log(sales) ~ log(price) + log(pimin) + log(ndi / cpi)
     femod <- plm(fm, Cigar)
     library("lmtest")
     coeftest(femod)
```

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
log(price)   -0.751306   0.046169 -16.273 < 2.2e-16 ***
log(pimin)    0.494602   0.045617  10.843 < 2.2e-16 ***
log(ndi/cpi)  0.680070   0.036753  18.504 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
[5]: ##--------------------------------Block 2--------------------------------
```

```
# checking th row of the relevant W matrix for the spatial lag operator sums to␣
 ↪1
wcig <- usaw46 / apply(usaw46, 1, sum)
summary(apply(wcig, 1, sum))
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
      1       1       1       1       1       1
```

[6]:
```
##--------------------------------Block 3--------------------------------

# constructing spatial lags using the W matrix and adding them to the data set
cig <- Cigar[order(Cigar$year, Cigar$state), ]
wp <- kronecker(diag(1, 30), wcig) %*% cig$price
Cigar$wp <- wp[order(cig$state, cig$year)]

## -----------------------------------------------------------------------

# alternatively can construct the lags by reversing the Kronecker product
Cigar$wp <- kronecker(wcig, diag(1,30)) %*% Cigar$price

## -----------------------------------------------------------------------

# fixed effects model with spatial lags
fm2 <- update(fm, . ~ . - log(pimin) + log(wp))
femod2 <- plm(fm2, Cigar)
coeftest(femod2)
```

```
t test of coefficients:

             Estimate Std. Error t value  Pr(>|t|)
log(price)   -0.829249   0.052807 -15.703 < 2.2e-16 ***
log(ndi/cpi)  0.629425   0.037093  16.969 < 2.2e-16 ***
log(wp)       0.587352   0.053739  10.930 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

[7]:
```
##--------------------------------Block 4--------------------------------

# automation of the construction of spatial panel lags using the slag() function
lwcig <- mat2listw(wcig)
fm3 <- update(fm, . ~ . - log(pimin) +
                      log(slag(price, listw=lwcig)))

## -----------------------------------------------------------------------
```

```
# alternative to the above. here there is no need to specify W.
wx <- function(x) slag(x, listw = lwcig)
fm3.alt <- update(fm, . ~ . - log(pimin) + log(wx(price)))
```