**Maximum Likelihood Estimation of Spatial Error Model with Second-order Neighborhood Structure**

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Source code for ‘**Property Price**’ data analysis.

library(CARBayesdata)

library(shapefiles)

library(sf)

data(lipdata)

data(lipdbf)

data(lipshp)

data(GGHB.IZ)

data(pricedata)

library(rgdal)

#head(pricedata)

library(spdep)

library(Matrix)

library(DEoptim)

head(pricedata)

##Loading data

pricedata=pricedata%>%mutate(logprice=log(pricedata$price))

head(pricedata)

#ggpairs(data=pricedata, columns=c(8,3:7))

pricedata.sf=merge(x=GGHB.IZ, y=pricedata, by="IZ", all.x=FALSE)

pricedata.sf <- st\_transform(x=pricedata.sf,

crs='+proj=longlat +datum=WGS84 +no\_defs')

## Creating the spatial Weight Matrix

W.nb=nblag(poly2nb(pricedata.sf,queen=TRUE, row.names =

rownames(pricedata$IZ)),max=2)

## style="W" provides standardized weighted matrix

W.list=nb2listw(W.nb[[1]], style="W")

W.mat<-nb2mat(W.nb[[2]],style="W",zero.policy=TRUE)

## In case of using data from local drive

pricedata=read.csv(file="drive:folder/filename.csv",header=T,sep=",")

##(an example- filename= PropertyPrice\_270.csv, folder= Ravina, drive=D)

pricedata=read.csv(file="D:/Ravina/PropertyPrice\_270.csv",header=T,sep=",")

y=(pricedata$price)

x1=(pricedata$sales)

x2=(pricedata$driveshop)

x3=(pricedata$Crimes)

##(using saved contiguity matrix from local drive)

W=read.csv(file="D:/Ravina/pricedata.nb.csv",header=T,sep=",")

dim(W)

W1=as.matrix(W)

W1\_sp=Matrix(W1,sparse=T) ## ## taking sparse matrix

##(using saved contiguity matrix from local drive)

W2=read.csv(file="D:/Ravina/pricedata.nb2.csv",header=T,sep=",")

W2=as.matrix(W2)

W2\_sp=Matrix(W2,sparse=T) ## taking sparse matrix

m=270

I=diag(270)

I\_sp=Matrix(I,sparse=T)

## The Objective Function

SEM\_2=function(par){

b0=par[1] #intercept

b1=par[2] #slope

b2=par[3] # slope

b3=par[4] # slope

r1=par[5] #spatial parameter

r2=par[6] #spatial parameter

s=par[7] #standard deviation

A=I\_sp-r1\*W1\_sp-r2\*W2\_sp

z=b0+b1\*x1+b2\*x2+b3\*x3

L1=0.5\*m\*log(2\*pi)

L2=m\*log(s)

L3=log(det(t(A)%\*%A))

Y=y-z

L4=(t(Y)%\*%t(A) %\*%A%\*%Y)/s\*\*2

## Optimizing Negative log likelihood Function of SEM\_2model

sum=L1+L2-0.5\*L3 +0.5\*L4

as.matrix(sum)

}

## End of function

## Two vectors specifying scalar real lower and upper bounds on each parameter

## to be optimized

lower=c(-1000,-1000,-1000,-1000,0,0,0)

upper=c(1000,1000,1000,1000,1,1,1000)

## Run DEoptim

DEoptim=DEoptim(SEM\_2,lower, upper,control=DEoptim.control(itermax=2000))

## To get the optimised values at every 100 iterations

DEoptim=DEoptim(SEM\_2,lower, upper,control=DEoptim.control(itermax=2000,

trace=100))

##Estimate values

Parameters= SEM\_2$member$bestmemit

Parameters= Parameters[2000,]

Parameters

## Estimate negative likelihood value

Like=SEM\_2$member$bestmemit

Likelihood

## Plot for Convergence

Plot(SEM\_2)

## End

Note:R version: [R 4.2.1](https://cran.r-project.org/bin/windows/base/old/4.2.1) (June, 2022)

This available R code is used for implementing second order Spatial Error Model through full-likelihood which is submitted in the esteemed journal “Journal of Agricultural, Biological and Environmental Statistics”. It’s uploading here for the purpose of reproducibility.