Lecture13_2025

March 2, 2025

1 Lecture 13 - Spring 2025

Villas-Boas

This notebook does the following:

Measuring amenities, hedonic model

Standardizing

Functional forms

Selection x var, models, adjusted R squared

Study Ch 6.1 + 6.3

Today starts the material after the Midterm

Midterm review topics posted on bcourses, with tables for midterm Practice Midterm posted, with solutions and formula sheet posted

We will give you tables and formula sheet to use for the midterm.

You do not bring your sheets

Please bring a simple non scientific calculator

[2]:
```
# Load the 'pacman' package
install.packages("pacman")
library(pacman)
#packages to use load them now using the pacman "manager"
p_load(dplyr, haven, readr)
#Another great feature of p_load(): if you try to load a package that is not␣
 ↪installed on your machine, p_load() install the package for you, rather than␣
 ↪throwing an error. For instance, let's install and load one final package␣
 ↪named ggplot2.
p_load(ggplot2)

pacman::p_load(lfe, lmtest, haven, sandwich, tidyverse)
pacman::p_load(lfe, lmtest, haven, sandwich, tidyverse,psych,car)
# lfe for running fixed effects regression
# lmtest for displaying robust SE in output table
```

```
# haven for loading in dta files
# sandwich for producing robust Var-Cov matrix
# tidyverse for manipulating data and producing plots
```

```
Installing package into '/srv/r'
(as 'lib' is unspecified)

Installing package into '/srv/r'
(as 'lib' is unspecified)

also installing the dependencies 'mnormt', 'GPArotation'



psych installed
```

[3]:
```
#set scientific display off, thank you Roy
options(scipen=999)
```

[4]:
```
#read in a Stata dataset
my_data <- read_dta("Lecture13HPRICE2.dta")
head(my_data)
```

A tibble: 6 × 12

price <dbl>	crime <dbl>	nox <dbl>	rooms <dbl>	dist <dbl>	radial <dbl>	proptax <dbl>	stratio <dbl>	ppoverty <dbl>	lprice <dbl>
24000	0.006	5.38	6.57	4.09	1	29.6	15.3	4.98	10.085809
21599	0.027	4.69	6.42	4.97	2	24.2	17.8	9.14	9.980402
34700	0.027	4.69	7.18	4.97	2	24.2	17.8	4.03	10.454495
33400	0.032	4.58	7.00	6.06	3	22.2	18.7	2.94	10.416311
36199	0.069	4.58	7.15	6.06	3	22.2	18.7	5.33	10.496787
28701	0.030	4.58	6.43	6.06	3	22.2	18.7	5.21	10.264688

Source: D. Harrison and D.L. Rubinfeld (1978), "Hedonic Housing Prices and the Demand for Clean Air," Journal of Environmental Economics and Management 5, 81-102. (data Lecture13Hprice2.dta in bcourses) Unit of analysis census tract in the Boston area – Most data 1970 U.S. Census.
The data below were obtained by merging/ matching average house prices and characteristics by census tract (1 to 6) with crime (census) levels and pollution (variable 7) levels from another source. 1. price median housing price, $ 2. crime crimes committed per capita 3. ppoverty % of people in poverty' 4. rooms avg number of rooms per house 5. dist weighted dist. to 5 employ centers 6. stratio average student-teacher ratio 7. nox nitrous oxide, parts per 100 million. (EPA standard 5.3)

[5]:
```
#***summary stats of the data : price nox crime dist rooms ppoverty stratio

#summary stats of data
#one way describes all data:
describe(my_data)
```

A psych: 12 × 13

	vars <int>	n <dbl>	mean <dbl>	sd <dbl>	median <dbl>	trimmed <dbl>	ma <c
price	1	506	22511.509881	9208.8561707	21200.000000	21535.692118	60
crime	2	506	3.611536	8.5902471	0.256500	1.684084	0.3
nox	3	506	5.549783	1.1583952	5.380000	5.454138	1.2
rooms	4	506	6.284051	0.7025938	6.210000	6.252291	0.5
dist	5	506	3.795751	2.1061365	3.210000	3.539975	1.9
radial	6	506	9.549407	8.7072594	5.000000	8.733990	2.9
proptax	7	506	40.823715	16.8537110	33.000000	40.004433	10
stratio	8	506	18.459289	2.1658199	19.100000	18.667242	1.6
ppoverty	9	506	12.701482	7.2380656	11.360000	11.919631	7.1
lprice	10	506	9.941057	0.4092549	9.961757	9.949468	0.3
lnox	11	506	1.693091	0.2014101	1.682688	1.684572	0.2
lproptax	12	506	5.931405	0.3963666	5.799093	5.931281	0.3

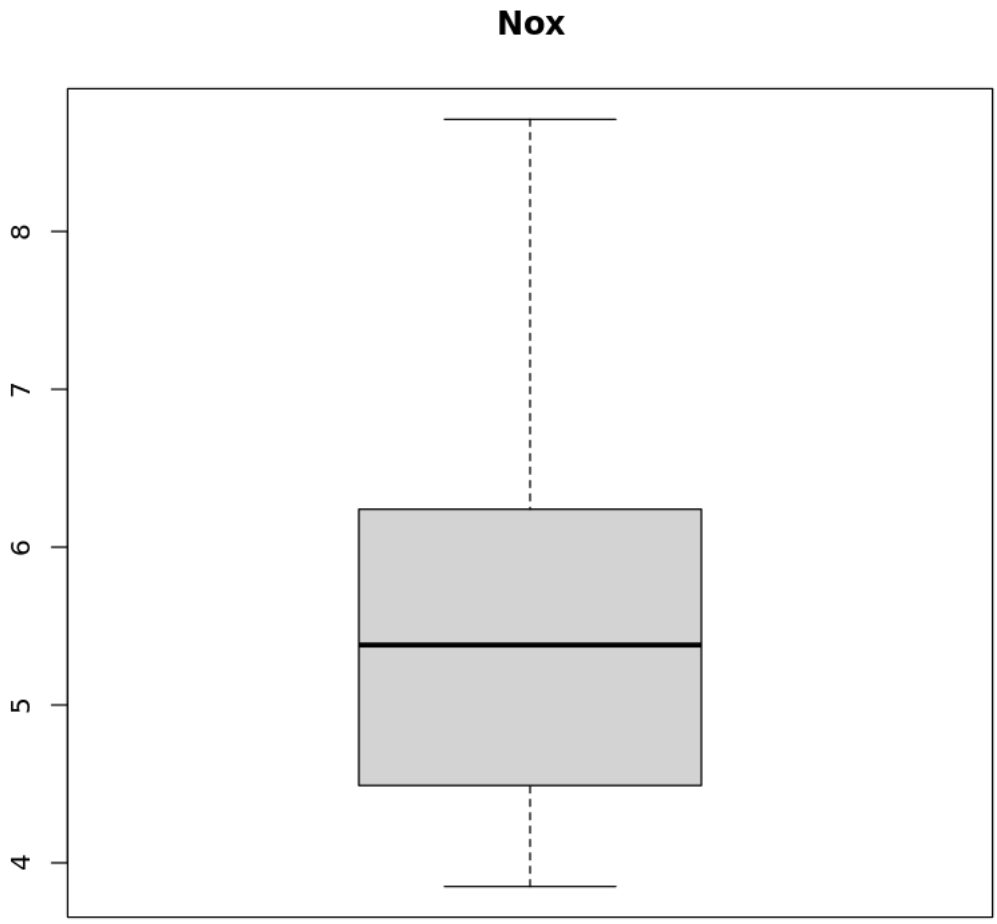
[6]:
```
#to describe only a subset
data2<-cbind(my_data$price,my_data$nox,my_data$crime,my_data$dist,my_data$rooms,my_data$ppover

##Renaming first four columns columns
colnames(data2) <- c("price", "nox", "crime", "dist", "rooms", "ppoverty",␣
 ↪"stratio")

describe(data2)
```

A psych: 7 × 13

	vars <int>	n <dbl>	mean <dbl>	sd <dbl>	median <dbl>	trimmed <dbl>	mad <dbl>
price	1	506	22511.509881	9208.8561707	21200.0000	21535.692118	6078.6
nox	2	506	5.549783	1.1583952	5.3800	5.454138	1.2750
crime	3	506	3.611536	8.5902471	0.2565	1.684084	0.3283
dist	4	506	3.795751	2.1061365	3.2100	3.539975	1.9125
rooms	5	506	6.284051	0.7025938	6.2100	6.252291	0.5114
ppoverty	6	506	12.701482	7.2380656	11.3600	11.919631	7.1683
stratio	7	506	18.459289	2.1658199	19.1000	18.667242	1.6308

[7]:
```
#box plot of NOX
boxplot(my_data$nox, main="Nox" )
# box plot for 'nox'

#/*NOX: the variable in measured in parts per 100 mill (pp100m)  nitrogen␣
 ↪dioxide
#The   EPA official annual standard is 5.3 ppm
#https://www3.epa.gov/ttn/naaqs/standards/nox/s_nox_history.html
#*/
#  /*REVIEW for MIDTERM: What do you see in terms of the data standard deviation

#and Max Min of annual NOX in US census tracts?
#  Variable | Obs        Mean    Std. Dev.       Min        Max
#nox |        506    5.549783    1.158395       3.85       8.71
```

```
#What is the average NOX among the data census tracts? What is standard error␣
 ↪of the average?


#  We know that average 5.549783
# and std dev of the data in sample is 1.158395

#Answer= std dev of average is = 1.158395/square_root(506)
#*/
```



[8]:
```
reg13 <- lm(price~nox+crime+dist+rooms+ppoverty+stratio, my_data)
summary(reg13)
```

```
Call:
lm(formula = price ~ nox + crime + dist + rooms + ppoverty +
    stratio, data = my_data)

Residuals:
     Min       1Q   Median       3Q      Max
-13163.8  -3004.4   -761.9   1872.2  28594.3

Coefficients:
            Estimate Std. Error t value             Pr(>|t|)
(Intercept) 34431.70    4732.08   7.276     0.00000000000134 ***
nox         -1757.66     331.46  -5.303     0.00000017173215 ***
crime         -80.58      30.48  -2.644              0.00846 **
dist        -1202.37     170.50  -7.052     0.00000000000591 ***
rooms        4412.58     415.85  10.611 < 0.0000000000000002 ***
ppoverty     -519.77      48.42 -10.735 < 0.0000000000000002 ***
stratio      -998.83     115.82  -8.624 < 0.0000000000000002 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5040 on 499 degrees of freedom
Multiple R-squared:  0.704,        Adjusted R-squared:  0.7005
F-statistic: 197.8 on 6 and 499 DF,  p-value: < 0.00000000000000022
```

What do you see in the output of regression above

Holding all other regressors constant will mean ceteris paribus in this notebook.

One particulate increase in nox ceteris paribus is correlated with a predicted price drop by 1757 dollars

One more crime per capita ceteris paribus is correlated with predicted housing price drops by 80 dollars

Do, for yourself, a review for midterm, t test? significance ? pvalues?

2 New :

But how do we compare the importance of these two factors as being correlated with the outcome, when those factors have different means and ranges?

Crime 0 to 89 average 3.6

Nox average 5.5 pp 100 mill and from 3.8 to 8.71?

Solution, compare them after standardizing the coefficients. And the one with the largest standardized coefficient has the biggest correlation with the outcome

[9]:
```
#New-------------------------
#But how do we compare the importance of the correlations of these two factors ␣
 ↪that have different means and ranges?

#  Crime 0 to 89 average 3.6

#nox average 5.5 pp 100 mill and from 3.8 to 8.71?

#standardize the coefficients then, to do so


#lets write a function
#coefficients:
b <- reg13$coef
X<-cbind(1,my_data$nox,my_data$crime,my_data$dist,my_data$rooms,my_data$ppoverty,my_data$strat
sx1<-sd(X[,1])
sx2<-sd(X[,2])
sx3<-sd(X[,3])
sx4<-sd(X[,4])
sx5<-sd(X[,5])
sx6<-sd(X[,6])
sx7<-sd(X[,7])
sx<-cbind(sx1,sx2,sx3,sx4,sx5,sx6,sx7)
sy<-sd(my_data$price)
beta <- b * sx/sy
#pring standardized betas:
beta
```

A matrix: 1×7 of type dbl

sx1	sx2	sx3	sx4	sx5	sx6	sx7
0	-0.2210981	-0.07516394	-0.2749917	0.3366601	-0.4085311	-0.2349146

From the above results we see that

One std dev increase in Nox ceteris paribus is correlated with a price drop by 0.22 standard dev

One std dev increase in crime ceteris paribus is correlated with a housing price drop by 0.075 std dev

This is how we compare the importance of the correlations of these two factors that have different means and ranges, using Z scores and interpreting the standardized betas

3 New:

How do we choose between two models with the same y variable but different X's on the right?

In this case, which model is preferred?

Model 1 $log(price)_i = \beta_1 + \beta_2 log(distance)_i + \epsilon_{1i}$

or

Model 2 $log(price)_i = \alpha_1 + \alpha_2 distance_i + \alpha_3 distance_i^2 + \epsilon_{2i}$

where the second model has distance and the square of distance as regressors, whereas the first model has log distance as a regressor. Both have log(price) as the dependent variable.

How do we choose between two models with the same y variable but different X's on the right?

[10]:
```
#logs specification? log of distance

lprice<-log(my_data$price)
ldist<-log(my_data$dist)
lnox<-log(my_data$nox)

reg13log<-lm(lprice~lnox+rooms+ppoverty+ldist,my_data)
summary(reg13log)
```

```
Call:
lm(formula = lprice ~ lnox + rooms + ppoverty + ldist, data = my_data)

Residuals:
    Min      1Q  Median      3Q     Max
-0.9985 -0.1154 -0.0124  0.1128  1.0021

Coefficients:
            Estimate Std. Error t value             Pr(>|t|)
(Intercept) 10.76614    0.25285  42.579 < 0.0000000000000002 ***
lnox        -0.59334    0.10424  -5.692     0.00000002138236 ***
rooms        0.13537    0.01863   7.265     0.00000000000143 ***
ppoverty    -0.03490    0.00216 -16.161 < 0.0000000000000002 ***
ldist       -0.19174    0.03788  -5.062     0.00000058438597 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2312 on 501 degrees of freedom
Multiple R-squared:  0.6834,        Adjusted R-squared:  0.6809
F-statistic: 270.4 on 4 and 501 DF,  p-value: < 0.00000000000000022
```

[11]:
```
#regress log price on distance and distance squared specification
my_data$dist2<-my_data$dist*my_data$dist
reg13sq<-lm(lprice~nox+crime+dist+dist2+rooms+ppoverty+stratio, my_data)
summary(reg13sq)
```

```
Call:
lm(formula = lprice ~ nox + crime + dist + dist2 + rooms + ppoverty +
    stratio, data = my_data)
```

```
Residuals:
     Min       1Q   Median       3Q      Max
-0.72953 -0.10903 -0.01039  0.10005  0.83580

Coefficients:
             Estimate Std. Error t value             Pr(>|t|)
(Intercept) 11.220529   0.211784  52.981 < 0.0000000000000002 ***
nox         -0.098098   0.014850  -6.606 0.000000000101772783 ***
crime       -0.010501   0.001249  -8.411 0.000000000000000433 ***
dist        -0.122620   0.024146  -5.078 0.000000539002084613 ***
dist2        0.006774   0.002030   3.337              0.00091 ***
rooms        0.113690   0.016665   6.822 0.000000000026135585 ***
ppoverty    -0.028510   0.001944 -14.668 < 0.0000000000000002 ***
stratio     -0.038550   0.004643  -8.302 0.000000000000000969 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2019 on 498 degrees of freedom
Multiple R-squared:  0.7599,        Adjusted R-squared:  0.7565
F-statistic: 225.2 on 7 and 498 DF,  p-value: < 0.00000000000000022
```

What do you see? Which MODEL REGRESSION do we choose in this case?

Adj R squared with ldist 0.68

Adj R squared with dist and dist2 0.7565

So you would choose the one with dist and dist 2 instead of the one with log distance, because it has the higher adjusted R squared

Take away

if same y and different X's then use adjusted R2 like in this lecture

how do we select between a regression of price on nox or a regression of log price on nox? different method for model selection, in a future lecture.

The end

[ ]: