# EDS 241: Assignment 4

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03/27/2022

```
# load packages
packages=c("stargazer", "tidyverse", "estimatr", "janitor", "car", "ivreg")
#            "dplyr","stringr", , "cowplot",
#            "ggplot2", "tinytex", "datasets", "tibble"

for (i in packages) {
  if (require(i,character.only=TRUE)==FALSE) {
    install.packages(i,repos='http://cran.us.r-project.org')
  }
  else {
    require(i,character.only=TRUE)
  }
}

#devtools::install_github('rstudio/rmarkdown')
options(scipen=999) # not scientific notation
```

```
# load data
data_raw <- read.csv("EU_sardines.csv")

data <- data_raw %>% clean_names()
```

## Question (a) (a)

*Estimate a bivariate regression of log(volume_sold_kg) on log(price euro_kg). What is the price elasticity of demand for sardines? Test the null hypothesis that the price elasticity is equal to -1.*

```
data_log <- data %>% mutate(vol_log = log(volume_sold_kg),
                            price_log = log(price_euro_kg))
```

```
model <- lm(formula = volume_sold_kg ~ price_euro_kg,
            data = data_log,
            family = binomial(link = "logit"))
summary(model)
```

```
##
## Call:
## lm(formula = volume_sold_kg ~ price_euro_kg, data = data_log,
##     family = binomial(link = "logit"))
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
##  -63059  -48396  -39281  -17317 1676231
##
## Coefficients:
##               Estimate Std. Error t value             Pr(>|t|)
## (Intercept)      64305       3088  20.822 < 0.0000000000000002 ***
## price_euro_kg   -15443       1916  -8.062 0.000000000000000986 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 128900 on 3986 degrees of freedom
## Multiple R-squared:  0.01604,    Adjusted R-squared:  0.0158
## F-statistic: 64.99 on 1 and 3986 DF,  p-value: 0.0000000000000009855
```

```
confidence_interval <- confint(model)
conf_int_low <- confidence_interval[[2]]
conf_int_high <- confidence_interval[[4]]
```

```
coeff_a <- round(model$coefficient[[2]], 2)
coeff_a
```

```
## [1] -15443.06
```

**The estimated price elasticity of demand for sardines is -15443.06. There is 95% probability that the interval [-19198.72, -11687.41] contains the true price elasticity of demand for sardines. Because this confidence interval does not contain the value -1, we reject the null hypothesis that the price elasticity is equal to -1.**

# Question (b) (b)

*Like in Lecture 8 (see the IV.R script), we will use wind_m_s as an instrument for log(price_euro_kg). To begin, estimate the first-stage regression relating log(price_euro_kg) to wind_m_s. Interpret the estimated coefficient on wind speed. Does it have the expected sign? Also test for the relevance of the instrument and whether it is a "weak" instrument by reporting the proper F-statistic.*

```
model_b <- lm_robust(formula = price_log ~ wind_m_s, data = data_log)
summary(model_b)
```

```
##
## Call:
## lm_robust(formula = price_log ~ wind_m_s, data = data_log)
##
## Standard error type:  HC2
##
## Coefficients:
##             Estimate Std. Error t value                                  Pr(>|t|)
## (Intercept) -0.30489   0.027309  -11.16 0.00000000000000000000000000000160909845
## wind_m_s     0.06735   0.005599   12.03 0.00000000000000000000000000000009379
```

```
##             CI Lower CI Upper   DF
## (Intercept) -0.35843 -0.25135 3986
## wind_m_s     0.05637  0.07832 3986
##
## Multiple R-squared:  0.0379 ,    Adjusted R-squared:  0.03766
## F-statistic: 144.7 on 1 and 3986 DF,  p-value: < 0.00000000000000022
```

```
wind_coeff <- round(model_b$coefficients[[2]], 5)
```

**The estimated coefficient on wind speed**: for each 1 unit (m/s) increase in wind speed, there is 0.06735 increase (+) in the log() of the price (euro/kg).

This positive coefficient matches intuition, as this indicates: as wind increases, conditions for fishing become more difficult; fewer sardines are caught (supply down), and therefore the price increases (demand up).

```
f_stat_model_b <- linearHypothesis(model_b, c("wind_m_s = 0"),
                                   white.adjust = "hc2")
f_stat_b <- f_stat_model_b$F[[2]]
f_stat_b # don't know why this won't knit
```

```
## NULL
```

**The F-statistic is . This value is greater than 10, indicating wind speed is a relevant and non-weak instrument.**

# Question (c) (c)

*Estimate the TSLS estimator of the price elasticity of demand for sardines using wind_m_s as an instrument for log(price_euro_kg). What is the estimated price elasticity of demand for sardines?*

```
tsls_c <- ivreg(formula = vol_log ~ price_log | wind_m_s,
                data = data_log)
summary(tsls_c)
```

```
##
## Call:
## ivreg(formula = vol_log ~ price_log | wind_m_s, data = data_log)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -8.8626 -1.9790 -0.2333  2.0950  6.2354
##
## Coefficients:
##             Estimate Std. Error t value            Pr(>|t|)
## (Intercept)  7.75534    0.04331  179.08 <0.0000000000000002 ***
## price_log   -1.08802    0.37003   -2.94               0.0033 **
##
## Diagnostic tests:
##                   df1  df2 statistic             p-value
## Weak instruments    1 3986   157.041 <0.0000000000000002 ***
```

```
## Wu-Hausman          1 3985     1.604               0.205
## Sargan              0   NA        NA                  NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.728 on 3986 degrees of freedom
## Multiple R-Squared: 0.09529, Adjusted R-squared: 0.09506
## Wald test: 8.646 on 1 and 3986 DF,  p-value: 0.003297
```

```
instrument_wind_coeff <- round(tsls_c$coefficients[[2]], 3)
instrument_wind_coeff
```

```
## [1] -1.088
```

**The estimated price elasticity of demand for sardines is -1.088. In other words, for every one euro increase in log price, there is a -1.088 unit increase in volume.**

# Question (d) (d)

*Repeat the exercise in (c), but include fixed effects for each year, month, and country. [Hint: you can use the command "as.factor(country) + as.factor(year) +as.factor(month)" to the ivreg function in R. Report the estimated price elasticity of demand and the F-statistic testing for relevant and non-weak instruments.*

```
tsls_d <- ivreg(data = data_log,
                formula = vol_log ~ price_log
                                    + as.factor(country)
                                    + as.factor(year)
                                    + as.factor(month)
                                   | wind_m_s
                                    + as.factor(country)
                                    + as.factor(year)
                                    + as.factor(month))
summary(tsls_d)
```

```
##
## Call:
## ivreg(formula = vol_log ~ price_log + as.factor(country) + as.factor(year) +
##     as.factor(month) | wind_m_s + as.factor(country) + as.factor(year) +
##     as.factor(month), data = data_log)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.2940 -1.8317 -0.1353  1.9969  6.2894
##
## Coefficients:
##                                  Estimate Std. Error t value
## (Intercept)                       7.33742    0.20781  35.309
## price_log                        -1.25004    0.46393  -2.694
## as.factor(country)Italy          -0.68925    0.12970  -5.314
## as.factor(country)Portugal        1.71563    0.34614   4.957
## as.factor(country)United Kingdom -0.07422    0.31428  -0.236
```

```
## as.factor(year)2014                0.14610    0.15281   0.956
## as.factor(year)2015                0.18487    0.15221   1.215
## as.factor(year)2016                0.21335    0.15320   1.393
## as.factor(year)2017                0.07400    0.15224   0.486
## as.factor(year)2018               -0.09137    0.15508  -0.589
## as.factor(year)2019                0.03602    0.19688   0.183
## as.factor(month)2                  0.06866    0.20972   0.327
## as.factor(month)3                  0.51583    0.20489   2.518
## as.factor(month)4                  0.91433    0.20297   4.505
## as.factor(month)5                  1.14887    0.20370   5.640
## as.factor(month)6                  1.14474    0.20164   5.677
## as.factor(month)7                  1.40047    0.21047   6.654
## as.factor(month)8                  1.26382    0.21692   5.826
## as.factor(month)9                  1.31072    0.21298   6.154
## as.factor(month)10                 0.72059    0.22958   3.139
## as.factor(month)11                 0.48128    0.22575   2.132
## as.factor(month)12                 0.06683    0.21920   0.305
##                                              Pr(>|t|)
## (Intercept)                       < 0.0000000000000002 ***
## price_log                                     0.00708 **
## as.factor(country)Italy              0.0000001129314 ***
## as.factor(country)Portugal           0.0000007476568 ***
## as.factor(country)United Kingdom             0.81332
## as.factor(year)2014                          0.33909
## as.factor(year)2015                          0.22461
## as.factor(year)2016                          0.16382
## as.factor(year)2017                          0.62692
## as.factor(year)2018                          0.55580
## as.factor(year)2019                          0.85483
## as.factor(month)2                            0.74339
## as.factor(month)3                            0.01185 *
## as.factor(month)4                    0.0000068372477 ***
## as.factor(month)5                    0.0000000181902 ***
## as.factor(month)6                    0.0000000146801 ***
## as.factor(month)7                    0.0000000000324 ***
## as.factor(month)8                    0.0000000061221 ***
## as.factor(month)9                    0.0000000008287 ***
## as.factor(month)10                           0.00171 **
## as.factor(month)11                           0.03308 *
## as.factor(month)12                           0.76049
##
## Diagnostic tests:
##                   df1  df2 statistic             p-value
## Weak instruments    1 3966    96.128 <0.0000000000000002 ***
## Wu-Hausman          1 3965     0.822               0.365
## Sargan              0   NA        NA                  NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.648 on 3966 degrees of freedom
## Multiple R-Squared: 0.1522,  Adjusted R-squared: 0.1477
## Wald test: 9.963 on 21 and 3966 DF,  p-value: < 0.00000000000000022
```

```r
tsls_wind_coeff <- round(tsls_d$coefficients[[2]], 3)
tsls_wind_coeff
```

```
## [1] -1.25
```

**The estimated price elasticity of demand is -1.25.**

```r
model_d <- lm_robust(data = data_log,
              formula = price_log ~ wind_m_s
                                  + as.factor(country)
                                  + as.factor(year)
                                  + as.factor(month))
summary(model_d)
```

```
##
## Call:
## lm_robust(formula = price_log ~ wind_m_s + as.factor(country) +
##     as.factor(year) + as.factor(month), data = data_log)
##
## Standard error type:  HC2
##
## Coefficients:
##                                  Estimate Std. Error t value
## (Intercept)                     -0.337243    0.07201 -4.6835
## wind_m_s                         0.072528    0.00823  8.8124
## as.factor(country)Italy         -0.041400    0.02601 -1.5920
## as.factor(country)Portugal       0.106499    0.05328  1.9989
## as.factor(country)United Kingdom -0.101376    0.11081 -0.9149
## as.factor(year)2014             -0.020595    0.03350 -0.6148
## as.factor(year)2015              0.012680    0.03413  0.3715
## as.factor(year)2016             -0.040329    0.03279 -1.2300
## as.factor(year)2017              0.003731    0.03361  0.1110
## as.factor(year)2018             -0.052021    0.03537 -1.4706
## as.factor(year)2019             -0.060297    0.04763 -1.2659
## as.factor(month)2                0.035241    0.05198  0.6780
## as.factor(month)3                0.065962    0.04910  1.3435
## as.factor(month)4                0.116455    0.04901  2.3763
## as.factor(month)5                0.098076    0.04754  2.0629
## as.factor(month)6                0.113646    0.04943  2.2990
## as.factor(month)7                0.143882    0.04953  2.9050
## as.factor(month)8                0.187778    0.05396  3.4802
## as.factor(month)9                0.051515    0.05098  1.0104
## as.factor(month)10              -0.111702    0.04950 -2.2565
## as.factor(month)11              -0.124349    0.05059 -2.4578
## as.factor(month)12               0.055052    0.05274  1.0439
##                                            Pr(>|t|)  CI Lower  CI Upper   DF
## (Intercept)                     0.0000029141115848442 -0.478415 -0.196070 3966
## wind_m_s                        0.0000000000000000018  0.056392  0.088664 3966
## as.factor(country)Italy         0.1114666588491880217 -0.092386  0.009585 3966
## as.factor(country)Portugal      0.0456891337729099095  0.002042  0.210956 3966
## as.factor(country)United Kingdom 0.3603171185299007817 -0.318624  0.115873 3966
## as.factor(year)2014             0.5387023187711785788 -0.086269  0.045079 3966
```

```
## as.factor(year)2015              0.7102879559973827028 -0.054237  0.079596 3966
## as.factor(year)2016              0.2187657027870113235 -0.104611  0.023953 3966
## as.factor(year)2017              0.9116041565562797988 -0.062158  0.069620 3966
## as.factor(year)2018              0.1414818001917897139 -0.121375  0.017333 3966
## as.factor(year)2019              0.2056108957538810011 -0.153680  0.033086 3966
## as.factor(month)2                0.4978021500114905296 -0.066663  0.137145 3966
## as.factor(month)3                0.1791827181697130122 -0.030295  0.162218 3966
## as.factor(month)4                0.0175335383504344328  0.020375  0.212536 3966
## as.factor(month)5                0.0391888179116848673  0.004865  0.191288 3966
## as.factor(month)6                0.0215575501159627550  0.016729  0.210563 3966
## as.factor(month)7                0.0036924577167014986  0.046778  0.240987 3966
## as.factor(month)8                0.0005064862424993734  0.081993  0.293562 3966
## as.factor(month)9                0.3123603880957656620 -0.048443  0.151472 3966
## as.factor(month)10               0.0240951788340151470 -0.208756 -0.014649 3966
## as.factor(month)11               0.0140198768764272525 -0.223539 -0.025159 3966
## as.factor(month)12               0.2966053595955305822 -0.048344  0.158447 3966
##
## Multiple R-squared:  0.06299 ,   Adjusted R-squared:  0.05802
## F-statistic: 14.45 on 21 and 3966 DF,  p-value: < 0.00000000000000022
```

```
f_stat_model_d <- linearHypothesis(model_d, c("wind_m_s = 0"),
                     white.adjust = "hc2")
f_stat_d <- round(f_stat_model_d$Chisq[[2]], digits = 3)
f_stat_d
```

```
## [1] 77.658
```

**The F-statistic is 77.658. This value is greater than 10, indicating wind speed is a relevant and non-weak instrument.**