(2019) R

2024-05-02

Contents

(2019) ( ) R .

R :

```
install.packages("tidyverse")
install.packages("openxlsx")
install.packages("haven")
install.packages("wooldridge")
install.packages("fixest")
install.packages("car")
install.packages("knitr")
install.packages("modelsummary")
install.packages("estimatr")
```

- `estimatr::lm_robust()` .
- `modelsummary`, `gt` , HTML, LaTeX .
- `tidyverse` , `ggplot2` .

, ( ).

- (2020) R (https://ritsu1997.github.io/r-for-nlas-econometrics/)[1].
- @kpd0605( ) (2024) (https://qiita.com/kpd0605/items/28ca24fe8b192612e67c).

[1] , .

2

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support02.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support02.zip"
download.file(curl, cdestfile)
#          ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R        Linux
# Windows        .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support02.zip", "./data"))
} else {
    print("Windows         .")
}
```

.

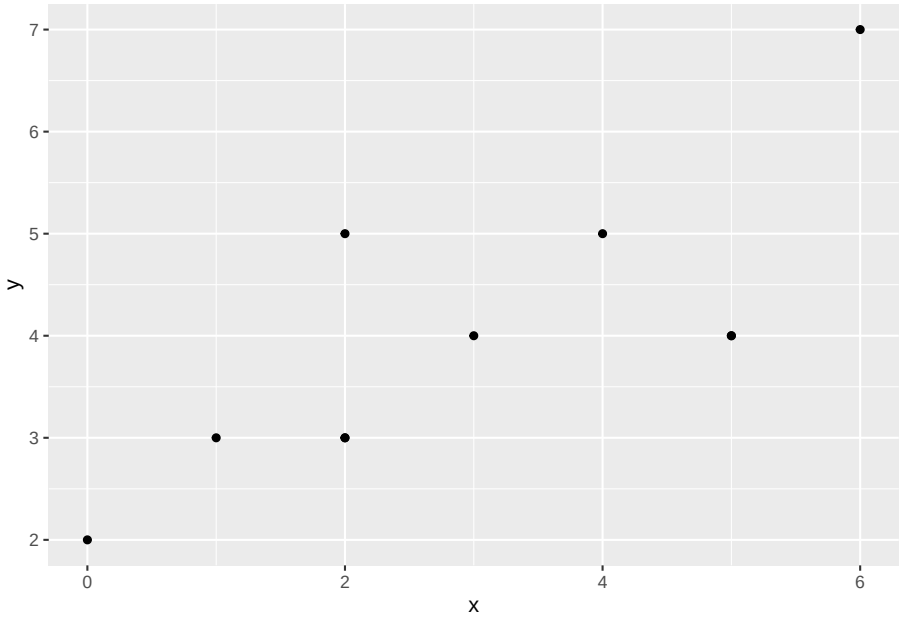
```
library(tidyverse)
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.0     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become
```

2-1 [ ]

R , Mode() .

```
data21 <- read.table("data/02_ 2 /02_practice_01.csv")

mean(data21$V1)
## [1] 10
var(data21$V1)
## [1] 18.10526
median(data21$V1)
## [1] 10

Mode <- function(x) {
    ux <- unique(x)
    tab <- tabulate(match(x, ux))
    ux[tab == max(tab)]
}

Mode(data21$V1)
## [1] 10
```

```
data23 <- read.table("data/02_ 2 /02_practice_03.csv", sep=",")

x <- data23$V1
y <- data23$V2

data23 %>%
    ggplot(aes(x = x, y = y)) +
    geom_point()
```




```
cov(x, y)
## [1] 2.111111
cor(x, y)
## [1] 0.7680295
```

3

3 2 . 3 , 2-1 , 2-3 .

.

```
library(tidyverse)
```

3-2 [ ]

2 2-1 t . $\alpha = 0.10$ 90% $[8.354811, 11.645189]$, 8 .
$\alpha = 0.01$ 99% $[7.277955, 12.722045]$ 8 , .

```
data32 <- read.csv("data/02_ 2 /02_practice_01.csv", header = FALSE)
x <- data32$V1

t.test(x, alternative = "two.sided", mu = 8, conf.level = 0.90)
##
##  One Sample t-test
##
## data:  x
## t = 2.102, df = 19, p-value = 0.04911
## alternative hypothesis: true mean is not equal to 8
## 90 percent confidence interval:
##   8.354811 11.645189
## sample estimates:
## mean of x
##        10

t.test(x, alternative = "two.sided", mu = 8, conf.level = 0.99)
##
##  One Sample t-test
##
## data:  x
## t = 2.102, df = 19, p-value = 0.04911
## alternative hypothesis: true mean is not equal to 8
```

```
## 99 percent confidence interval:
##   7.277955 12.722045
## sample estimates:
## mean of x
##        10
```

4

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support04.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support04.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support04.zip", "./data"))
} else {
    print("Windows          .")
}
```

.

```
library(tidyverse)
library(openxlsx)
library(estimatr)
```

4.1

p.128 $N = 22$ $N = 21$.

```
ch04_wage <- read.csv("data/04_ 4 /ch04_wage.csv")
ch04_wage_model <- lm(wage ~ productivity, data = ch04_wage)
summary(ch04_wage_model)
```

```
##
## Call:
## lm(formula = wage ~ productivity, data = ch04_wage)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -47.618 -17.612   4.186  21.946  37.052
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  276.12961   87.61057   3.152  0.00525 **
## productivity   0.54682    0.02442  22.395 4.04e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 25.77 on 19 degrees of freedom
## Multiple R-squared:  0.9635, Adjusted R-squared:  0.9616
## F-statistic: 501.5 on 1 and 19 DF,  p-value: 4.037e-15
```

R lm() . , estimatr::lm_robust() , se_type = "stata" .

```
ch04_wage_model_robust <- lm_robust(wage ~ productivity, data = ch04_wage, se_type = "s
summary(ch04_wage_model_robust)
##
## Call:
## lm_robust(formula = wage ~ productivity, data = ch04_wage, se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##              Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)  276.1296   71.25559   3.875 1.019e-03  126.990 425.2693 19
## productivity   0.5468    0.02046  26.722 1.553e-16    0.504   0.5896 19
##
## Multiple R-squared:  0.9635 ,    Adjusted R-squared:  0.9616
## F-statistic: 714.1 on 1 and 19 DF,  p-value: < 2.2e-16
```

4-1

geom_smooth() .

```
ch04_wage %>%
    ggplot(aes(x = productivity, y = wage)) +
    geom_point() +
```

```
    xlab("    ( )") +
    ylab("    ( )") +
    geom_smooth(method = "lm", se = FALSE, color = "black")
## `geom_smooth()` using formula = 'y ~ x'
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <ae>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <9f>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <e8>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <b3>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <aa>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <e8>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <b3>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <83>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <e9>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <87>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <91>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <86>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for <86>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for
## <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for
## <8a>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ( )' in 'mbcsToSbcs': dot substituted for
## <b4>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
```

```
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <83>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <8d>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <e7>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <94>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <9f>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <e7>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <94>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <a3>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <e6>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <80>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <a7>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <86>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <86>
```

```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <e5>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <8a>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <b4>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
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## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for
## <86>
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## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for <e5>
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## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for <ae>
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## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for <9f>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
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## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for <87>
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## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for <91>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
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## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbcsToSbcs': dot substituted for <86>
```
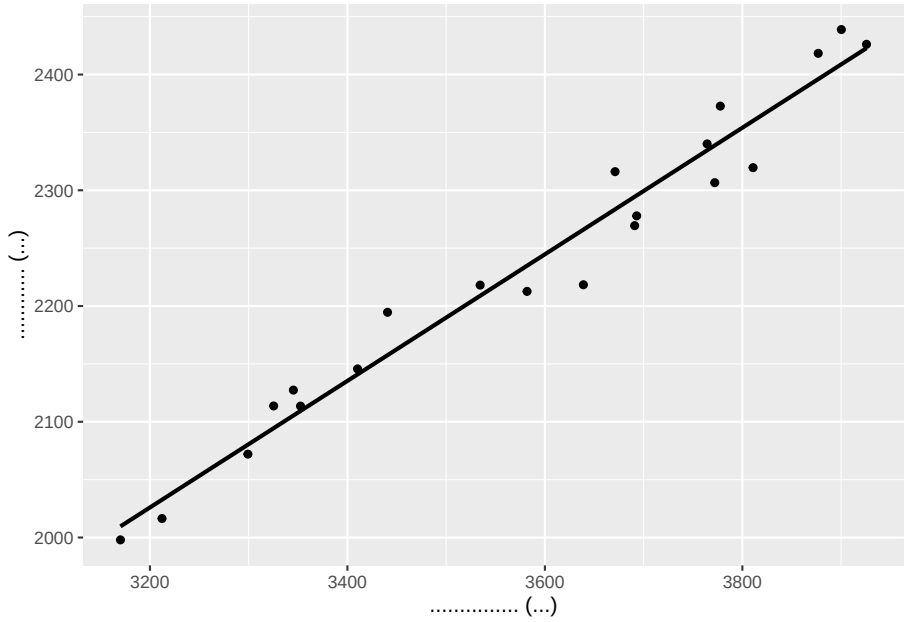



4-2 [ ]

(1) , . Excel openxlsx::read.xlsx() . , . $gdp2013\_ln = \beta_0 + \beta_1 pop2013\_ln$, $\hat{\beta}_0 = 7.623, \hat{\beta}_1 = 1.075$.

```
data42 <- read.xlsx("data/04_ 4 /data for chap 4 exercise 2.xlsx")
colnames(data42) <- c("pref", "pop2013", "gdp2013", "pop2013_ln", "gdp2013_ln")

model42 <- lm(gdp2013_ln ~ pop2013_ln, data = data42)
model42
##
## Call:
## lm(formula = gdp2013_ln ~ pop2013_ln, data = data42)
##
## Coefficients:
## (Intercept)   pop2013_ln
##       7.623        1.075
```

(2) H_0: $\beta_1 = 1$, $t = \frac{\hat{\beta}_1 - \beta_1}{\mathrm{SE}(\hat{\beta}_1)} = 2.62773$. $n - 2 = 45$, 5% t $(\infty, -2.014103], [2.014103, \infty)$.

```
beta1 <- model42$coefficients[2]
sebeta1 <- summary(model42)$coefficients[2, 2]
n <- dim(data42)[1]
```

```
t <- (beta1 - 1)/sebeta1
t
## pop2013_ln
##    2.62773
qt(0.975, n-2) # 2.014103
## [1] 2.014103
```

(3) confint() .

```
confint(model42, '(Intercept)', level=0.90)
##                    5 %     95 %
## (Intercept) 7.257252 7.988132
```

(4) 1% , GDP $\beta_1 = 1.075\%$.

(5) $\mathrm{Var}(u) = \frac{\sum_{i=1}^{n} \hat{u}_i^2}{n-2} = 0.02245859$. ln( ) var() , 0.5964525 .

```
sum(model42$residuals^2)/(n-2)
## [1] 0.02245859

var_pop2013_ln <- var(data42$pop2013_ln)
var_pop2013_ln
## [1] 0.5964525
```

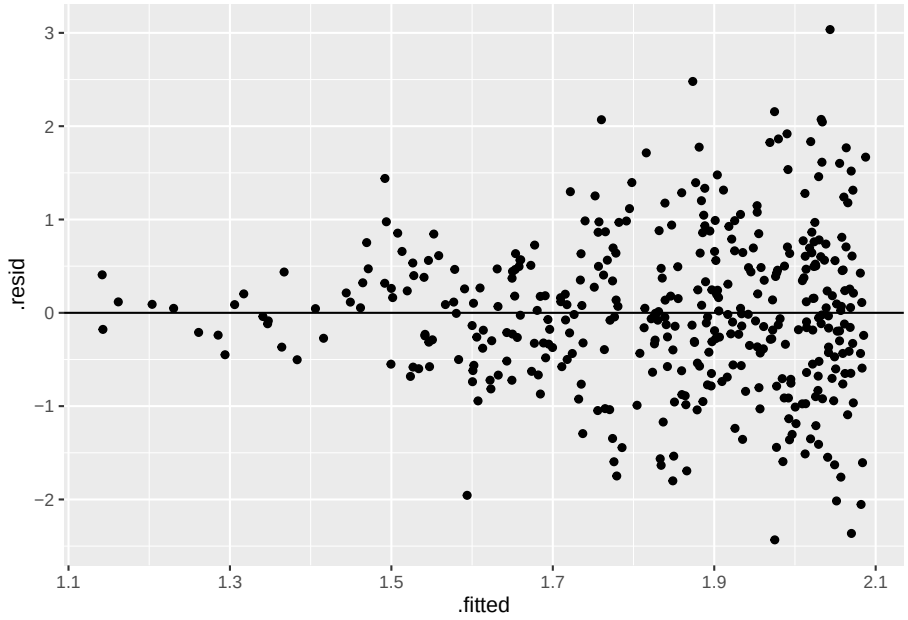
4-10 [ ]

(1) , β_1 . , $\mathrm{Cov}(u_i, X_i) = 0$.

```
data410 <- read.xlsx("data/04_ 4 /data for chap 4 exercise 10.xlsx") %>% data.frame()
model410 <- lm(Y ~ X, data = data410)
cov(model410$residuals, data410$X)
## [1] 4.392411e-18
```

(2) $\mathrm{E}(u_i^2|X_i) = 0.690318 \neq 0.$, $\hat{Y}_i$.

```
mean(model410$residuals^2)
## [1] 0.690318

model410 %>%
    ggplot(aes(x = .fitted, y = .resid)) +
    geom_point() +
    geom_hline(yintercept = 0)
```



(3) estimatr::lm_robust() .

```
model410_robust <- lm_robust(Y ~ X, data = data410)
summary(model410_robust)
##
## Call:
## lm_robust(formula = Y ~ X, data = data410)
##
## Standard error type:  HC2
##
## Coefficients:
##             Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper  DF
## (Intercept)   0.8103     0.1583   5.119 4.803e-07   0.4991    1.122 398
## X             1.2773     0.2158   5.918 7.035e-09   0.8530    1.702 398
##
## Multiple R-squared:  0.05683 ,   Adjusted R-squared:  0.05446
## F-statistic: 35.02 on 1 and 398 DF,  p-value: 7.035e-09
```

summary() , β_1 95% 0.8 , .

(4) estimatr::lm_robust() .

```
confint(model410)
##                 2.5 %   97.5 %
## (Intercept) 0.3912772 1.229412
## X           0.7645056 1.790022
```

`summary()` , β_1 95% 0.8 , .

(5) , .

5

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support05.zip"
#             ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support05.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support05.zip", "./data"))
} else {
    print("Windows          .")
}
```

.

```
library(tidyverse)
library(estimatr)
library(knitr)
library(modelsummary)
## `modelsummary` 2.0.0 now uses `tinytable` as its default table-drawing
##   backend. Learn more at: https://vincentarelbundock.github.io/tinytable/
##
## Revert to `kableExtra` for one session:
##
##   options(modelsummary_factory_default = 'kableExtra')
##
```

```
## Change the default backend persistently:
##
##   config_modelsummary(factory_default = 'gt')
##
## Silence this message forever:
##
##   config_modelsummary(startup_message = FALSE)
library(gt)
library(car)
## Loading required package: carData
##
## Attaching package: 'car'
## The following object is masked from 'package:dplyr':
##
##     recode
## The following object is masked from 'package:purrr':
##
##     some
library(wooldridge)
library(haven)
```

(5.1), (5.2)

, . , estimatr::lm_robust() .

```
youdou <- read.csv("data/05_ 5 /youdou.csv")
youdou <- youdou %>%
    mutate(lny80 = log(y80)) %>%
    mutate(lny99 = log(y99)) %>%
    mutate(lny90 = log(y90)) %>%
    mutate(growthrate8099 = (lny99-lny80)/19*100) %>%
    mutate(growthrate8090 = (lny90-lny80)/10)
youdou_51 <- lm_robust(growthrate8099 ~ trust80, data = youdou, se_type = "stata")
summary(youdou_51)
##
## Call:
## lm_robust(formula = growthrate8099 ~ trust80, data = youdou,
##     se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##             Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)   3.1394    0.06044  51.943 8.188e-42  3.01763   3.2611 45
## trust80       0.2247    0.06640   3.384 1.491e-03  0.09094   0.3584 45
```

```
##
## Multiple R-squared:  0.179 , Adjusted R-squared:  0.1608
## F-statistic: 11.45 on 1 and 45 DF,  p-value: 0.001491
youdou_52 <- lm_robust(growthrate8099 ~ norm80, data = youdou, se_type = "stata")
summary(youdou_52)
##
## Call:
## lm_robust(formula = growthrate8099 ~ norm80, data = youdou, se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##             Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)   3.0905    0.04826  64.033 7.544e-46   2.9933   3.1878 45
## norm80        0.5597    0.07058   7.931 4.348e-10   0.4176   0.7019 45
##
## Multiple R-squared:  0.4563 ,    Adjusted R-squared:  0.4442
## F-statistic:  62.9 on 1 and 45 DF,  p-value: 4.348e-10
```

5.1

```
youdou_55 <- lm_robust(growthrate8099 ~ trust80 + education80 + lny80, data = youdou, se_type = '
summary(youdou_55)
##
## Call:
## lm_robust(formula = growthrate8099 ~ trust80 + education80 +
##     lny80, data = youdou, se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##             Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)  6.04885    0.42643 14.1849 8.041e-18    5.189   6.9088 43
## trust80      0.02058    0.07564  0.2721 7.868e-01   -0.132   0.1731 43
## education80  2.61208    2.70857  0.9644 3.403e-01   -2.850   8.0744 43
## lny80       -2.38309    0.49147 -4.8489 1.658e-05   -3.374  -1.3920 43
##
## Multiple R-squared:  0.5619 ,    Adjusted R-squared:  0.5313
## F-statistic: 20.21 on 3 and 43 DF,  p-value: 2.531e-08
youdou_55_2 <- lm_robust(growthrate8099 ~ norm80 + education80 + lny80, data = youdou, se_type =
summary(youdou_55_2)
##
## Call:
## lm_robust(formula = growthrate8099 ~ norm80 + education80 + lny80,
```

```
##     data = youdou, se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##             Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)   5.2909     0.6682   7.918 6.204e-10  3.94324   6.6385 43
## norm80        0.3383     0.1370   2.469 1.758e-02  0.06202   0.6145 43
## education80   4.3872     1.9611   2.237 3.051e-02  0.43233   8.3421 43
## lny80        -1.9911     0.5746  -3.465 1.213e-03 -3.14987  -0.8324 43
##
## Multiple R-squared:  0.6391 ,    Adjusted R-squared:  0.614
## F-statistic: 41.04 on 3 and 43 DF,  p-value: 1.11e-12
```

5.2 FWL

, formula +0 -1 ( ). , estimatr::lm_robust() lm residuals ,
( ). , lm .

```
fwl_1 <- lm(trust80 ~ education80 + lny80, data = youdou)
summary(fwl_1)
##
## Call:
## lm(formula = trust80 ~ education80 + lny80, data = youdou)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.18774 -0.48567 -0.02193  0.56490  1.41091
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2.6740     0.9493   2.817  0.00723 **
## education80 -11.2886     4.5080  -2.504  0.01606 *
## lny80        -1.0254     0.9692  -1.058  0.29584
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6555 on 44 degrees of freedom
## Multiple R-squared:  0.4246, Adjusted R-squared:  0.3985
## F-statistic: 16.24 on 2 and 44 DF,  p-value: 5.233e-06
fwl_2 <- lm(growthrate8099 ~ education80 + lny80, data = youdou)
summary(fwl_2)
##
## Call:
## lm(formula = growthrate8099 ~ education80 + lny80, data = youdou)
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.46861 -0.23426  0.00308  0.13266  1.01937
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   6.1039     0.4403  13.863  < 2e-16 ***
## education80   2.3797     2.0909   1.138    0.261
## lny80        -2.4042     0.4495  -5.348 3.03e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.304 on 44 degrees of freedom
## Multiple R-squared:  0.561,  Adjusted R-squared:  0.5411
## F-statistic: 28.12 on 2 and 44 DF,  p-value: 1.36e-08
lm(fwl_2$residuals ~ 0 + fwl_1$residuals) %>% summary()
##
## Call:
## lm(formula = fwl_2$residuals ~ 0 + fwl_1$residuals)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.45839 -0.21925 -0.00947  0.13042  1.03231
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## fwl_1$residuals  0.02058    0.06832   0.301    0.765
##
## Residual standard error: 0.2971 on 46 degrees of freedom
## Multiple R-squared:  0.00197,    Adjusted R-squared:  -0.01973
## F-statistic: 0.09078 on 1 and 46 DF,  p-value: 0.7645
```

5.3 FWL

```
lm(growthrate8099 ~ fwl_1$residuals-1, data = youdou) %>% summary()
##
## Call:
## lm(formula = growthrate8099 ~ fwl_1$residuals - 1, data = youdou)
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  2.189  2.816  3.086  3.546  3.915
##
```

```
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## fwl_1$residuals  0.02058    0.73877   0.028    0.978
##
## Residual standard error: 3.212 on 46 degrees of freedom
## Multiple R-squared:  1.688e-05,  Adjusted R-squared:  -0.02172
## F-statistic: 0.0007764 on 1 and 46 DF,  p-value: 0.9779
```

5.4

5.1 .

5.5

```
youdou_515 <- lm_robust(growthrate8099 ~ y80 + I(y80^2), data = youdou, se_type = "sta
summary(youdou_515)
##
## Call:
## lm_robust(formula = growthrate8099 ~ y80 + I(y80^2), data = youdou,
##     se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##             Estimate Std. Error t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)  6.51866    1.38538   4.705 2.535e-05  3.72662   9.3107 44
## y80         -1.22615    0.70791  -1.732 9.027e-02 -2.65285   0.2005 44
## I(y80^2)     0.08935    0.08861   1.008 3.188e-01 -0.08923   0.2679 44
##
## Multiple R-squared:  0.5503 ,    Adjusted R-squared:  0.5299
## F-statistic: 27.39 on 2 and 44 DF,  p-value: 1.879e-08
```

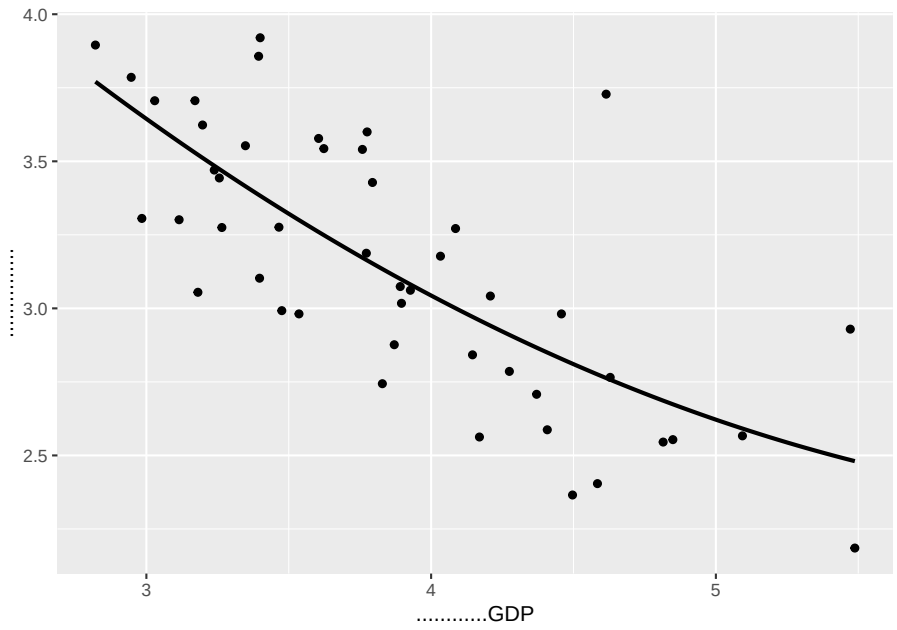
5-1

```
youdou %>%
    ggplot(aes(x = y80, y = growthrate8099)) +
    geom_point() +
    xlab("  GDP") +
    ylab("   ") +
    geom_smooth(method = "lm", formula = y ~ x + I(x^2), se = FALSE, color = "black")
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e7>
```

```
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <b5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <8c>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <b8>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <90>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e9>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <95>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <b7>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e7>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <8e>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <87>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <9d>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <9c>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <9f>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <99>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
```

```
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <82>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e7>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <82>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <b9>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e5>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <9d>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <9c>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <9f>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <99>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <82>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <e7>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <82>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '  GDP' in 'mbcsToSbcs': dot substituted for <b9>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e7>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <b5>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <8c>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e6>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <b8>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e6>
```

```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <90>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e9>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <95>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <b7>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <e7>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <8e>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '   ' in 'mbcsToSbcs': dot substituted for <87>
```



5.5

```
lm_robust(growthrate8099 ~ lny80 * education80, data = youdou, se_type = "stata") %>% summary()
##
## Call:
## lm_robust(formula = growthrate8099 ~ lny80 * education80, data = youdou,
```

```
##     se_type = "stata")
##
## Standard error type:  HC1
##
## Coefficients:
##                   Estimate Std. Error  t value  Pr(>|t|) CI Lower CI Upper DF
## (Intercept)         6.0868     1.1220  5.42485 2.492e-06    3.824   8.3496 43
## lny80              -2.3937     0.8477 -2.82364 7.167e-03   -4.103  -0.6841 43
## education80         2.5735    11.0413  0.23308 8.168e-01  -19.693  24.8405 43
## lny80:education80  -0.1211     7.1314 -0.01698 9.865e-01  -14.503  14.2608 43
##
## Multiple R-squared:  0.561 , Adjusted R-squared:  0.5304
## F-statistic: 18.45 on 3 and 43 DF,  p-value: 7.651e-08
```

5.6 GDP

urban (urban int bool). urban , lm() data filter() .

```
youdou <- youdou %>%
    mutate(urban = did > 0.4)
lm(growthrate8099 ~ urban * lny80, data = youdou) %>% summary()
##
## Call:
## lm(formula = growthrate8099 ~ urban * lny80, data = youdou)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.51040 -0.21003 -0.02406  0.16516  0.90189
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      5.74905    0.57763   9.953 9.96e-13 ***
## urbanTRUE       -0.17551    0.82444  -0.213 0.832421
## lny80           -1.91120    0.45104  -4.237 0.000117 ***
## urbanTRUE:lny80  0.06441    0.61108   0.105 0.916546
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3092 on 43 degrees of freedom
## Multiple R-squared:  0.5564, Adjusted R-squared:  0.5254
## F-statistic: 17.98 on 3 and 43 DF,  p-value: 1.041e-07
lm(growthrate8099 ~ lny80, data = (youdou %>% filter(!urban))) %>% summary()
##
## Call:
## lm(formula = growthrate8099 ~ lny80, data = (youdou %>% filter(!urban)))
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.51040 -0.22240 -0.02406  0.12827  0.90189
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   5.7491     0.6512   8.829 7.59e-09 ***
## lny80        -1.9112     0.5085  -3.759  0.00102 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3486 on 23 degrees of freedom
## Multiple R-squared:  0.3805, Adjusted R-squared:  0.3536
## F-statistic: 14.13 on 1 and 23 DF,  p-value: 0.001022
lm(growthrate8099 ~ lny80, data = (youdou %>% filter(urban))) %>% summary()
##
## Call:
## lm(formula = growthrate8099 ~ lny80, data = (youdou %>% filter(urban)))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.35740 -0.19171 -0.05236  0.17634  0.49475
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   5.5735     0.4881  11.419 3.25e-10 ***
## lny80        -1.8468     0.3421  -5.399 2.77e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2565 on 20 degrees of freedom
## Multiple R-squared:  0.593,  Adjusted R-squared:  0.5727
## F-statistic: 29.14 on 1 and 20 DF,  p-value: 2.769e-05
```

5.7 GDP

, lny80d .

```
youdou <- youdou %>%
    mutate(lny80d = lny80 > 1.4)
lm(growthrate8099 ~ urban * lny80d, data = youdou) %>% summary()
##
## Call:
## lm(formula = growthrate8099 ~ urban * lny80d, data = youdou)
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.50919 -0.25376 -0.01148  0.24475  0.85353
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           3.45474    0.07544  45.793  < 2e-16 ***
## urbanTRUE            -0.23329    0.12459  -1.872 0.067953 .
## lny80dTRUE           -0.58003    0.15400  -3.767 0.000498 ***
## urbanTRUE:lny80dTRUE  0.04725    0.20827   0.227 0.821596
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3288 on 43 degrees of freedom
## Multiple R-squared:  0.4982, Adjusted R-squared:  0.4631
## F-statistic: 14.23 on 3 and 43 DF,  p-value: 1.401e-06
```

5.8

5.5 .

5.9

5.1 . 0 . F car::linearHypothesis() .

```
linearHypothesis(youdou_55_2, c("norm80","education80"), test = "F")
## Linear hypothesis test
##
## Hypothesis:
## norm80 = 0
## education80 = 0
##
## Model 1: restricted model
## Model 2: growthrate8099 ~ norm80 + education80 + lny80
##
##   Res.Df Df      F   Pr(>F)
## 1     45
## 2     43  2 5.4375 0.007848 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

5-5

modelsummary::datasummary() . , dataframe , gt .

```
#
vars <- youdou %>%
    select(growthrate8099, trust80, norm80, education80, lny80)
table55 <- datasummary(All(vars) ~ N + Mean + SD + Min + Max,
             data = youdou,
             output = "data.frame",
             fmt = 3)
#
colnames(table55) <- c(" ", "    ", " ", "   ", "  ", "  ")
#
table55[,1] <- c("   ", " ", " ", "   ", "   GDP")
#
gt(table55)
```

	47	3.147	0.449	2.185	3.920
	47	0.033	0.845	-1.668	1.918
	47	0.101	0.542	-1.248	1.297
	47	0.112	0.036	0.069	0.238
GDP	47	1.341	0.167	1.037	1.703

5-6 :

modelsummary (stargazer , estimatr). modelsummary::msummary() goef_omit , $\bar{R}^2$, R^2 R2$. F , .

```
models <- list(
    "(1)" = lm_robust(growthrate8099 ~ trust80, data = youdou, se_type = "stata"),
    "(2)" = lm_robust(growthrate8099 ~ norm80, data = youdou, se_type = "stata"),
    "(3)" = lm_robust(growthrate8099 ~ trust80 + norm80, data = youdou, se_type = "stata"),
    "(4)" = lm_robust(growthrate8099 ~ trust80 + lny80 + education80, data = youdou, se_type = "s
    "(5)" = lm_robust(growthrate8099 ~ norm80 + lny80 + education80, data = youdou, se_type = "st
    "(6)" = lm_robust(growthrate8099 ~ trust80 + norm80 + lny80 + education80, data = youdou, se_

# F
attr(models[3]$`(3)`, "FTEST") <- TRUE
attr(models[6]$`(6)`, "FTEST") <- TRUE

glance_custom.lm_robust <- function(x) {
    #    , F
```

```
    if (!isTRUE(attr(x, "FTEST"))) return(NULL)

    # F
    ftest <- linearHypothesis(x, test = "F", c("trust80", "norm80"))

    # F    p   tibble
    out <- tibble(
        "F     $H_0: \\beta_{ }=0, \\beta_{ }=0$" = ftest[["F"]][2],
        "     " = sprintf("(%.3f)", ftest[["Pr(>F)"]][2]))
    return(out)
}

gm <- tribble(
    ~raw,        ~clean,          ~fmt,
    "F     $H_0: \\beta_{ }=0, \\beta_{ }=0$", "F     $H_0: \\beta_{ }=0, \\beta_{ }=0$
    "     ", "     ", 3,
    "adj.r.squared", "$\\bar{R}^2$", 3,
    "nobs", "    ", 0)

msummary(models,
         stars = TRUE,
         gof_omit='R2$|RMSE|AIC|BIC|Log.Lik.',
         gof_map = gm,
         coef_map = c("trust80" = " ", "norm80" = " ", "lny80" = "   GDP", "education8
```

F , , .

5-7

, R wooldridge attend .

```
data('attend')
models_57 <- list(
    "(1)" = lm_robust(stndfnl ~ atndrte + frosh + soph, data = attend, se_type = "stata
    "(2)" = lm_robust(stndfnl ~ atndrte + priGPA + ACT + frosh + soph, data = attend, s
    "(3)" = lm_robust(stndfnl ~ atndrte * priGPA + ACT + frosh + soph, data = attend, s
    "(4)" = lm_robust(stndfnl ~ atndrte + priGPA + I(priGPA^2) + ACT + I(ACT^2) + frosh
    "(5)" = lm_robust(stndfnl ~ atndrte * priGPA + atndrte * I(priGPA^2) + ACT + I(ACT

cm <- c("atndrte" = "  ",
        "priGPA" = "   GPA",
        "I(priGPA^2)" = "   GPA$^2$",
        "atndrte:priGPA" = "   $\\times$    GPA",
        "atndrte:I(priGPA^2)" = "   $\\times$    GPA$^2$",
        "ACT" = "ACT",
```

	(1)	(2)	(3)	(4)	(5)	(6)
	0.225**		0.036	0.021		−0.012
	(0.066)		(0.082)	(0.076)		(0.081)
		0.560***	0.529***		0.338*	0.342*
		(0.071)	(0.102)		(0.137)	(0.148)
GDP				−2.383***	−1.991**	−1.999**
				(0.491)	(0.575)	(0.556)
				2.612	4.387*	4.270+
				(2.709)	(1.961)	(2.237)
	3.139***	3.091***	3.092***	6.049***	5.291***	5.315**
	(0.060)	(0.048)	(0.048)	(0.426)	(0.668)	(0.603)
F $H_0: \beta_{ }=0, \beta_{ }=0$			29.874			3.460
			(0.000)			(0.041)
$\bar{R}^2$	0.161	0.444	0.435	0.531	0.614	0.605
	47	47	47	47	47	47

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

```
        "I(ACT^2)" = "ACT$^2$",
        "frosh" = "1 ",
        "soph" = "2 ",
        "(Intercept)" = "  ")

gm <- tribble(
    ~raw,            ~clean,           ~fmt,
    "adj.r.squared", "$\\bar{R}^2$",   2,
    "nobs",          "    ", 0)

#
custom_format <- function(values) {
    formatted_values <- ifelse(values < 1,
                               signif(values, digits=2),
                               round(values, digits=2))
    return(formatted_values)
}

#         ?
msummary(models_57,
         stars = TRUE,
```

```
         gof_omit='R2$|RMSE|AIC|BIC|Log.Lik.',
         coef_map = cm,
         gof_map = gm,
         fmt = custom_format)
```

F , .

```
linearHypothesis(models_57[3]$`(3)`, test = "F", c("atndrte", "atndrte:priGPA"))
## Linear hypothesis test
##
## Hypothesis:
## atndrte = 0
## atndrte:priGPA = 0
##
## Model 1: restricted model
## Model 2: stndfnl ~ atndrte * priGPA + ACT + frosh + soph
##
##   Res.Df Df      F    Pr(>F)
## 1    675
## 2    673  2 7.8085 0.0004442 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
linearHypothesis(models_57[4]$`(4)`, test = "F", c("I(priGPA^2)", "I(ACT^2)"))
## Linear hypothesis test
##
## Hypothesis:
## I(priGPA^2) = 0
## I(ACT^2) = 0
##
## Model 1: restricted model
## Model 2: stndfnl ~ atndrte + priGPA + I(priGPA^2) + ACT + I(ACT^2) + frosh +
##     soph
##
##   Res.Df Df      F    Pr(>F)
## 1    674
## 2    672  2 11.772 9.438e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
linearHypothesis(models_57[5]$`(5)`, test = "F", c("atndrte", "atndrte:priGPA", "atndr
## Linear hypothesis test
##
## Hypothesis:
## atndrte = 0
## atndrte:priGPA = 0
## atndrte:I(priGPA^2) = 0
##
```

		(1)	(2)	(3)	(4)	(5)
		0.0082***	0.0052*	−0.022*	0.0062**	0.065*
		(0.0021)	(0.0024)	(0.0088)	(0.0023)	(0.032)
GPA			0.43***	−0.56+	−1.5**	3.63
			(0.086)	(0.32)	(0.49)	(2.21)
GPA^2					0.37***	−0.82+
					(0.09)	(0.45)
$\times$	GPA			0.012**		−0.057*
				(0.0037)		(0.026)
$\times$	GPA^2					0.013*
						(0.0052)
ACT			0.084***	0.082***	−0.11	−0.11
			(0.011)	(0.011)	(0.1)	(0.1)
ACT^2					0.0042+	0.0042+
					(0.0023)	(0.0022)
1		−0.29*	−0.049	−0.063	−0.11	−0.1
		(0.11)	(0.11)	(0.1)	(0.1)	(0.1)
2		−0.12	−0.16+	−0.17+	−0.18*	−0.19*
		(0.1)	(0.089)	(0.088)	(0.087)	(0.086)
		−0.5**	−3.3***	−1	1.38	−3.9
		(0.18)	(0.3)	(0.76)	(1.24)	(2.95)
$\bar{R}^2$		0.02	0.20	0.21	0.22	0.23
		680	680	680	680	680

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

```
## Model 1: restricted model
## Model 2: stndfnl ~ atndrte * priGPA + atndrte * I(priGPA^2) + ACT + I(ACT^2) +
##     frosh + soph
##
##   Res.Df Df      F    Pr(>F)
## 1    673
## 2    670  3 6.2543 0.0003437 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
linearHypothesis(models_57[5]$`(5)`, test = "F", c("I(priGPA^2)", "atndrte:I(priGPA^2)"
## Linear hypothesis test
##
## Hypothesis:
## I(priGPA^2) = 0
## atndrte:I(priGPA^2) = 0
## I(ACT^2) = 0
##
## Model 1: restricted model
## Model 2: stndfnl ~ atndrte * priGPA + atndrte * I(priGPA^2) + ACT + I(ACT^2) +
##     frosh + soph
##
##   Res.Df Df      F    Pr(>F)
## 1    673
## 2    670  3 7.5692 5.521e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
linearHypothesis(models_57[5]$`(5)`, test = "F", c("atndrte:priGPA", "atndrte:I(priGPA
## Linear hypothesis test
##
## Hypothesis:
## atndrte:priGPA = 0
## atndrte:I(priGPA^2) = 0
##
## Model 1: restricted model
## Model 2: stndfnl ~ atndrte * priGPA + atndrte * I(priGPA^2) + ACT + I(ACT^2) +
##     frosh + soph
##
##   Res.Df Df      F   Pr(>F)
## 1    672
## 2    670  2 5.1942 0.005774 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

5-14 [ ]

a. 5-6 .

b. $\bar{R}^2$ (p.158).

$$\bar{R}^2 = 1 - \frac{N-1}{N-k-1}\frac{\sum_{i=1}^{N}\hat{u}_i^2}{\sum_{i=1}^{N}(Y_i - \bar{Y}^2)}$$

.

R^2 , k . R^2 , R^2 , .

c. . 1 , 2 .

```
practice514c_1 <- lm(trust80 ~ norm80, data = youdou)
practice514c_2 <- lm_robust(growthrate8099 ~ 0 + practice514c_1$residuals, data = youdou, se_type
summary(practice514c_2)$coefficients
##                            Estimate Std. Error    t value  Pr(>|t|)  CI Lower
## practice514c_1$residuals 0.0358709  0.7030377 0.05102272 0.9595283 -1.379271
##                           CI Upper DF
## practice514c_1$residuals 1.451012 46

practice514c_3 <- lm(growthrate8099 ~ norm80, data = youdou)
practice514c_4 <- lm(trust80 ~ 0 + norm80, data = youdou)
practice514c_5 <- lm_robust(practice514c_3$residuals ~ 0 + practice514c_4$residuals, se_type = "s
summary(practice514c_5)$coefficients
##                             Estimate Std. Error   t value  Pr(>|t|)   CI Lower
## practice514c_4$residuals 0.03566014 0.08075573 0.4415803 0.6608618 -0.1268927
##                           CI Upper DF
## practice514c_4$residuals 0.198213 46
```

5-15 [ ]

STATA .dta , R haven::read_dta() .

```
timss <- read_dta("data/05_ 5 /timss.dta")

practice5_15_a <- lm_robust(mathscore ~ agese_q2 + agese_q3 + agese_q4, data = timss, se_type = '
practice5_15_c <- lm_robust(mathscore ~ gender*agese_q2 + gender*agese_q3 + gender*agese_q4, data
practice5_15_d <- lm_robust(mathscore ~ agese_q2 + agese_q3 + agese_q4 + comu_1 + comu_2 + comu_3
practice5_15_ea <- lm_robust(sciencescore ~ agese_q2 + agese_q3 + agese_q4, data = timss, se_type
practice5_15_ec <- lm_robust(sciencescore ~ gender*agese_q2 + gender*agese_q3 + gender*agese_q4,
practice5_15_ed <- lm_robust(sciencescore ~ agese_q2 + agese_q3 + agese_q4 + comu_1 + comu_2 + co
```

modelsummary . (d) coef_map .

```
models_5_15 <- list()
models_5_15[['a']] <- practice5_15_a
models_5_15[['c']] <- practice5_15_c
models_5_15[['d']] <- practice5_15_d
models_5_15[['ea']] <- practice5_15_ea
models_5_15[['ec']] <- practice5_15_ec
models_5_15[['ed']] <- practice5_15_ed
cm <- c("agese_q2",
        "agese_q3",
        "agese_q4",
        "gender",
        "gender:agese_q2",
        "gender:agese_q3",
        "gender:agese_q4",
        "(Intercept)")
gm <- tribble(
    ~raw,            ~clean,           ~fmt,
    "adj.r.squared", "$\\bar{R}^2$",   2,
    "nobs",          "    ", 0)
msummary(models_5_15,
         coef_map = cm,
         gof_map = gm,
         stars = TRUE)
```

a. a , agese_q4 . , 4 6 .

b. 4 , . 4 6 , . 4 6 , β_{Q1}, β_{Q4} , $H_0 : \beta_{Q4} < \beta_{Q1}$.

c. c , gender . , .

d. d , agese_q4 ( ).

e. ea, ec, ed . ea, ed agese_q4 , .

	a	c	d	ea	ec	ed
agese_q2	0.174	−0.500	0.218	0.261	0.006	0.317
	(0.412)	(1.282)	(0.394)	(0.420)	(1.302)	(0.406)
agese_q3	−0.346	−1.516	−0.460	−0.543	−1.274	−0.614
	(0.415)	(1.291)	(0.395)	(0.419)	(1.274)	(0.406)
agese_q4	−1.558***	−2.935*	−1.336***	−1.717***	−1.963	−1.522***
	(0.419)	(1.289)	(0.403)	(0.428)	(1.312)	(0.413)
gender		−0.137			1.031+	
		(0.586)			(0.611)	
gender:agese_q2		0.445			0.147	
		(0.824)			(0.840)	
gender:agese_q3		0.783			0.487	
		(0.830)			(0.839)	
gender:agese_q4		0.920			0.160	
		(0.839)			(0.856)	
(Intercept)	150.363***	150.568***	146.798***	150.453***	148.915***	150.811***
	(0.293)	(0.908)	(2.392)	(0.305)	(0.923)	(1.884)
$\bar{R}^2$	0.00	0.00	0.09	0.00	0.01	0.07
	4536	4536	4536	4536	4536	4536

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support06.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support06.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support06.zip", "./data"))
} else {
    print("Windows         .")
}
```

7

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support07.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support07.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support07.zip", "./data"))
} else {
    print("Windows         .")
}
```

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.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support08.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support08.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support08.zip", "./data"))
} else {
    print("Windows         .")
}
```

9

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support09.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support09.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support09.zip", "./data"))
} else {
    print("Windows         .")
}
```

10

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support10.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support10.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support10.zip", "./data"))
} else {
    print("Windows         .")
}
```

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.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support11.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support11.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support11.zip", "./data"))
} else {
    print("Windows         .")
}
```

12 VAR

.

```
#
curl <- "https://www.yuhikaku.co.jp/static_files/05385_support12.zip"
#            ,
if(!dir.exists("downloads")){
    dir.create("downloads")
}
cdestfile <- "downloads/support12.zip"
download.file(curl, cdestfile)
#           ,
if(!dir.exists("data")){
    dir.create("data")
}
# WSL R         Linux
# Windows         .
if(.Platform$OS.type == "unix") {
    system(sprintf('unzip -n -Ocp932 %s -d %s', "downloads/support12.zip", "./data"))
} else {
    print("Windows         .")
}
```