

(2019) R

2024-05-02

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(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

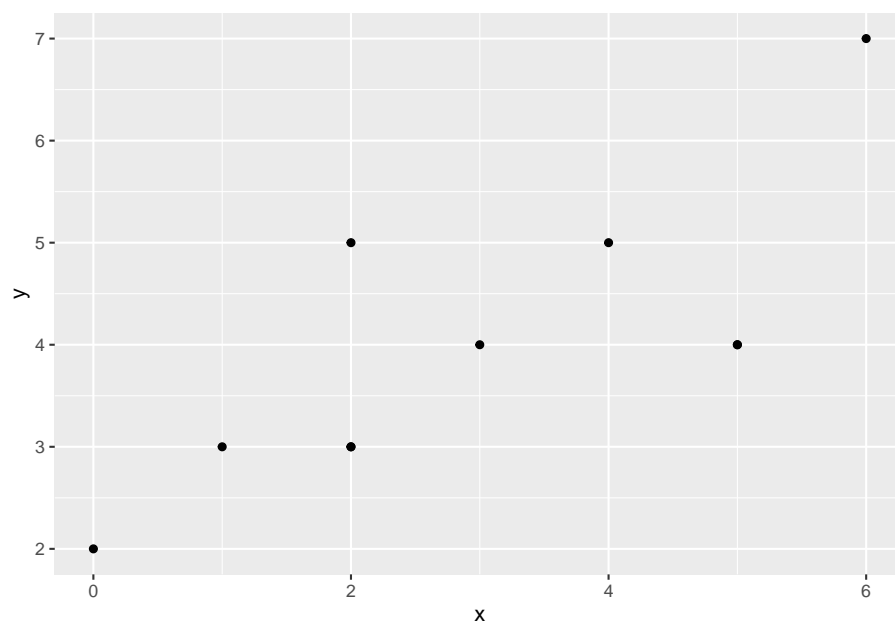
Mode <- function(x) {
  ux <- unique(x)
  tab <- tabulate(match(x, ux))
  ux[tab == max(tab)]
}

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 = "stata")
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$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <ae>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <9f>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <e8>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <b3>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <aa>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <e8>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <b3>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <83>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <e9>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <87>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <91>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <e5>
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    ()' in 'mbsToSbcs': dot substituted for <86>

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

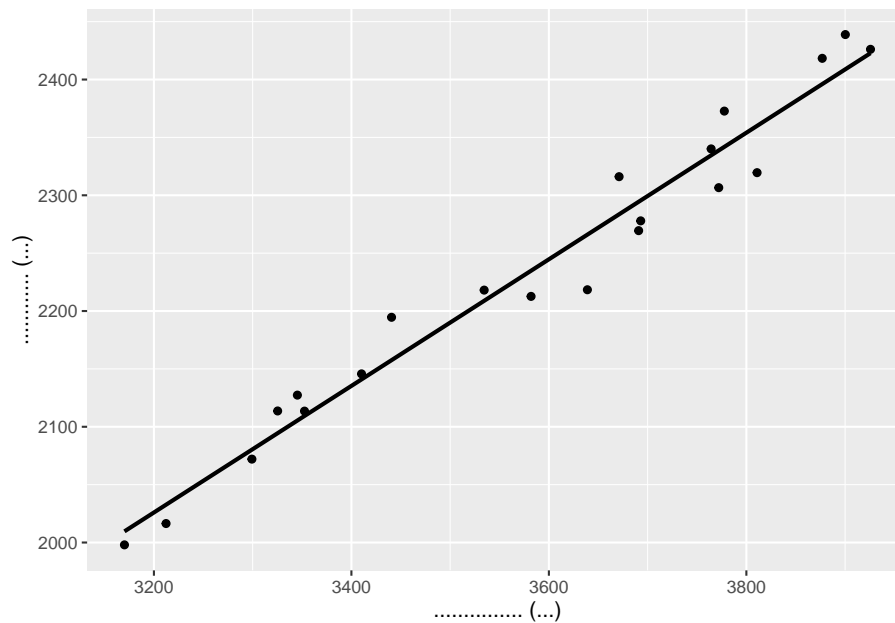
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on '    (' in 'mbcsToSbcs': dot substituted for
## <86>

```



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

[illegible]



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) $H_0: \beta_1 = 1$, $t = \frac{\hat{\beta}_1 - \beta_1}{SE(\hat{\beta}_1)} = 2.62773$. $n - 2 = 45$,
 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) $\text{Var}(u) = \frac{\sum_{i=1}^n \hat{u}_i^2}{n-2} = 0.02245859$. $\ln(\)$ $\text{var}()$, 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 []

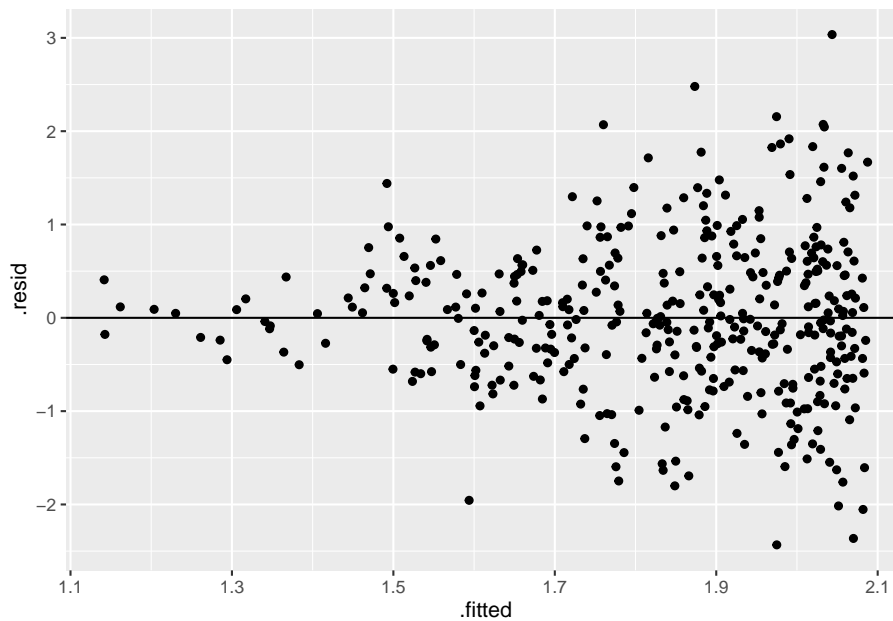
(1) , β_1 . , $\text{Cov}(u_i, X_i) = 0$.

```
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) $E(u_i^2|X_i) = 0.690318 \neq 0$. , \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() ,  $\beta_1$  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 = "stata")
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 = "stata")
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

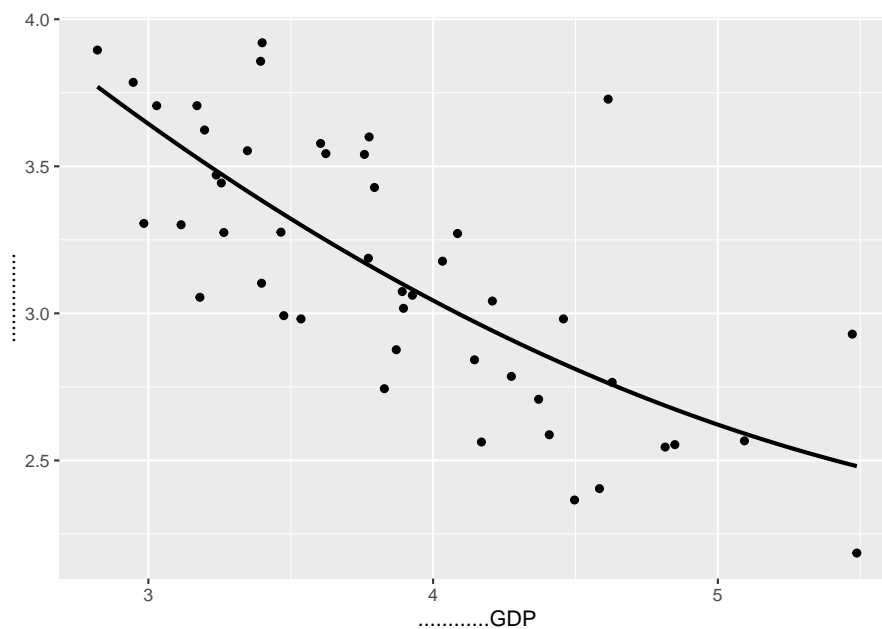
```
youdou_515 <- lm_robust(growthrate8099 ~ y80 + I(y80^2), data = youdou, se_type = "stata")
summary(youdou_515)
##
## Call:
## lm_robust(formula = growthrate8099 ~ y80 + I(y80^2), data = youdou,
##          se_type = "stata")
##
## Standard error type: HC1
##
## Coefficients:
##              Estimate 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 'mbsToSbcs': dot substituted for <e7>
```



```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' ' in 'mbcsToSbcs': dot substituted for <88>
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$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 = "stata"),
  "(5)" = lm_robust(growthrate8099 ~ norm80 + lny80 + education80, data = youdou, se_type = "stata"),
  "(6)" = lm_robust(growthrate8099 ~ trust80 + norm80 + lny80 + education80, data = youdou, se_type = "stata"),
# 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 = "stat",
  "(2)" = lm_robust(stndfnl ~ atndrte + priGPA + ACT + frosh + soph, data = attend, se_type = "stat",
  "(3)" = lm_robust(stndfnl ~ atndrte * priGPA + ACT + frosh + soph, data = attend, se_type = "stat",
  "(4)" = lm_robust(stndfnl ~ atndrte + priGPA + I(priGPA^2) + ACT + I(ACT^2) + frosh + soph, data = attend, se_type = "stat",
  "(5)" = lm_robust(stndfnl ~ atndrte * priGPA + atndrte * I(priGPA^2) + ACT + I(ACT^2) + frosh + soph, data = attend, se_type = "stat",

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

```

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

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

```

## 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^2)"))
## 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$residuals, data = youdou, se_type = "HC")
summary(practice514c_2)$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 = "HC")
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 = "HC")
practice5_15_c <- lm_robust(mathscore ~ gender*agese_q2 + gender*agese_q3 + gender*agese_q4, data = timss, se_type = "HC")
practice5_15_d <- lm_robust(mathscore ~ agese_q2 + agese_q3 + agese_q4 + comu_1 + comu_2 + comu_3, data = timss, se_type = "HC")
practice5_15_ea <- lm_robust(science_score ~ agese_q2 + agese_q3 + agese_q4, data = timss, se_type = "HC")
practice5_15_ec <- lm_robust(science_score ~ gender*agese_q2 + gender*agese_q3 + gender*agese_q4, data = timss, se_type = "HC")
practice5_15_ed <- lm_robust(science_score ~ agese_q2 + agese_q3 + agese_q4 + comu_1 + comu_2 + comu_3, data = timss, se_type = "HC")

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


8

```
#
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 .")
}
```


11

```
#
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 .")
}
```