



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

CREATE CHANGE

ECON2300 - Introductory Econometrics

Tutorial 6: Nonlinear Regression Functions

Tutor: Francisco Tavares Garcia

R Exercise 3 is available!

Dear ECON2300 Students,

R-Exercise 3 is now available in the "R-Exercises: Analysis of Data and Short Report" folder, which you can access via the Assessment tab.

The due date for R-Exercise 3 is **Friday, September 8, 2023, 4pm**

Please read all instructions carefully before commencing the R-Exercise. For convenience, a copy of the R-Exercise instructions has been presented below.

=====

Instructions:

Please pay close attention to the number of decimal places required (if any) for each answer. The required number of decimal places may differ from question to question.

Avoid rounding during intermediate calculations where possible.

This R-Exercise is not timed. This means that you can open the R-Exercise and return to it as many times as you need to (provided that you do not click submit).

There is only one attempt for this R-Exercise.

The R-Exercise is marked out of 7, but will contribute 10% towards your final grade if it is among the highest 3 of your 5 R-Exercise scores across the semester.

The closing time for this R-Exercise is **4pm on Friday, September 8, 2023**. Please make sure that you have submitted your answers by this time. Remember that **you must click submit** before the deadline for your R-Exercise to be marked.

Please Note: If you encounter any technical issues with the R-Exercise, please email the CML coordinator at cml.2300@uq.edu.au. Do not email R-Exercise issues to the Course Coordinator or Course Administrator. Otherwise there may be a delay in responding to your enquiry.

Project 1 is available!

Project 1 Now Available

Posted on: Monday, 28 August 2023 06:00:00 o'clock AEST

Dear ECON2300 Students

Project 1 is now available via the Assessment folder. It is due at 4pm on Monday, 18 September 2023.

Posted by: Dominic Byrne

Posted to: [ECON2300] Introductory Econometrics (St Lucia & external). Semester 2, 2023 ECON2300S_7360_61825

ECON 2300: INTRODUCTORY ECONOMETRICS

Coordinator: Professor Rodney Strachan

Research Project 1

Due: 4 pm on 18 September 2023

Background

You are interested in estimating the effect of education on earnings using data on **wage** and **educ**. Here, **wage** is measured in dollars per hour. Thus, for a particular person, if **wage** = 6.75, the hourly **wage** is \$6.75. Also, **educ** denotes years of schooling; for example, **educ** = 12 corresponds to a complete high school education. The data file **wage4hw1.xlsx** contains 526 individuals, who were randomly drawn from the population of people in the US workforce in 1976. The dataset has additional variables.

- **exper**: years potential experience
- **tenure**: years with current employer
- **profocc**: =1 if in professional occupation
- **clerocc**: =1 if in clerical occupation
- **servocc**: =1 if in service occupation

Research tasks

1. (7 points) You are given a dataset in an Excel format. Figure out how to load this dataset in *R*. Provide your *R*-commands to load the data. In particular, be clear about which *R*-package you install and use. (Hint: use the Internet. There are several different ways of doing it.)
2. (15 points) Obtain summary statistics and histograms for the variables **wage** and **educ** and scatter diagram of those two variables. For the diagrams, give informative titles and variable names instead of just using the default titles and variable names. For example, you could use **Years of Education** in place of **educ**. Discuss the data characteristics.
3. (9 points) Estimate the linear regression

$$\text{wage}_i = \beta_1 + \beta_2 \text{educ}_i + u_i,$$

where u_i is the error and β_1 and β_2 are the unknown population coefficients. Assuming that $E[u|\text{educ}] = 0$, interpret the estimated coefficient on **educ** (3 points) and test whether or not the population coefficient is zero at the 1 % significance level (3 points). What is the predicted wage of a person with eight years of education (3 points)

4. (8 points) Estimate the linear regression


$$\ln(\text{wage}_i) = \beta_1 + \beta_2 \text{educ}_i + u_i,$$

where u_i is the error and β_1 and β_2 are the unknown population coefficients. Assuming that $E[u|\text{educ}] = 0$, and using the estimates, what is the predicted change of **wage** for every additional

Submission of your report






Your report must be single-spaced and in **12 Font size**. You should give your answer to each of the following questions following a similar format of the solutions to the tutorial problem sets. When you are required to use *R*, you must show your *R* command and *R* outputs (screenshots or figures generated from *R*). You will lose **2 points** whenever you fail to provide **R commands and outputs**. For each question, when you are asked to discuss or interpret, your answer has to be brief and compact. You will lose **2 points** if your answer is needlessly wordy. You must upload your assignment on the course webpage (Blackboard) **in PDF format**. (Do not submit a hard copy.)

- Download the files for tutorial 06 from Blackboard,
- save them into a folder for this tutorial.



Tutorial 6 [Week 7] Nonlinear Regression Functions

Attached Files:

-  [Lead_Mortality_Description.pdf](#) (76.299 KB)
-  [lead_mortality.csv](#) (19.463 KB)
-  [cps12.csv](#) (155.882 KB)
-  [CPS12_Description.pdf](#) (64.449 KB)
-  [tutorial6.pdf](#) (71.147 KB)

In Week 7, tutors will aim to cover **E8.1a)-b) and E8.2a)-g)**

- Copy the code from Codeshare,
- <https://codeshare.io/tut06>
- Paste the code in a new script in RStudio,
- Save the script in the same folder as the data.

E8.1 Lead is toxic, particularly for young children, and for this reason government regulations severely restrict the amount of lead in our environment. But this was not always the case. In the early part of the 20th century, the underground water pipes in many U.S. cities contained lead, and lead from these pipes leached into drinking water. In this exercise you will investigate the effect of these lead water pipes on infant mortality using the dataset, `lead_mortality.csv`, which contains data on infant mortality, type of water pipes (lead or non-lead), water acidity (pH), and several demographic variables for 172 U.S cities in 1900; see also `Lead_Mortality_Description.pdf`.

Variable Name	Description
<i>infrate</i>	Infant mortality rate (deaths per 100 in population)
<i>lead</i>	Indicator =1 if city had lead pipes. (These are “lead-only” or “mixed-lead” cities.)
<i>ph</i>	Water pH
<i>hardness</i>	Water hardness index
<i>population</i>	City population (in 100s)
<i>typhoid_rate</i>	Typhoid death rate
<i>np_tub_rate</i>	Non-pulmonary tuberculosis death rate
<i>mom_rate</i>	Fraction of population who are women of child-bearing age
<i>age</i>	Average Age
<i>foreign_share</i>	Fraction of population who are foreign born
<i>precipitation</i>	Average precipitation in state
<i>temperature</i>	Average temperature in state
<i>city</i>	City
<i>state</i>	State
<i>year</i>	Year

The pH Scale



- (a) Compute the average infant mortality rate, `infrate`, for cities with lead pipes and for cities with non-lead pipes. Is there a statistically significant difference in the average?

```
rm(list = ls())
setwd("/Users/uqdkim7/Dropbox/Teaching/R tutorials/Data")
LM <- read_csv("lead_mortality.csv") %>%
  mutate(lead_ph = lead*ph, lead_ph_65 = lead*(ph - 6.5))
attach(LM)

reg1 = lm_robust(infrate ~ lead, data = LM, se_type = "stata")
reg2 = lm_robust(infrate ~ lead + ph + lead_ph, data = LM, se_type = "stata")
reg3 = lm_robust(infrate ~ lead + ph + lead_ph_65, data = LM, se_type = "stata")

texreg(list(reg1, reg2, reg3), include.ci = F, caption.above = T,
       digits = 3, caption = "Lead and Infant Mortality",
       custom.model.names = c("(1)", "(2)", "(3)"))
```


- (a) Compute the average infant mortality rate, `infrate`, for cities with lead pipes and for cities with non-lead pipes. Is there a statistically significant difference in the average?

Table 1: Lead and Infant Mortality

	(1)	(2)	(3)
(Intercept)	0.381*** (0.020)	0.919*** (0.150)	0.919*** (0.150)
lead	0.022 (0.024)	0.462* (0.208)	0.092** (0.033)
ph		-0.075*** (0.021)	-0.075*** (0.021)
lead_ph		-0.057* (0.028)	
lead_ph_65			-0.057* (0.028)
R ²	0.005	0.272	0.272
Adj. R ²	-0.001	0.259	0.259
Num. obs.	172	172	172
RMSE	0.151	0.130	0.130

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

Column (1) of Table 1 shows that the sample mean of `infrate` for cities with non-lead pipes and cities with lead pipes are 0.381 and 0.403, respectively. The difference in the sample means is 0.022 with a standard error of 0.024. The estimate implies that cities with lead pipes have a higher infant mortality rate (by 0.022 deaths per 100 people in the population), but the standard error is comparatively large (0.024) and so the difference is not statistically significant (t -statistic= 0.91).

- (b) The amount of lead leached from lead pipes depends on the chemistry of the water running through the pipes. The more acidic the water (that is, the lower its pH), the more lead is leached. Run a regression of `infrate` on `lead`, `ph`, and the interaction term `lead × ph`.
- i. The regression includes four coefficients (the intercept and the three coefficients multiplying the regressors). Explain what each coefficient measures.

Table 1: Lead and Infant Mortality

	(1)	(2)	(3)
(Intercept)	0.381*** (0.020)	0.919*** (0.150)	0.919*** (0.150)
lead	0.022 (0.024)	0.462* (0.208)	0.092** (0.033)
ph		−0.075*** (0.021)	−0.075*** (0.021)
lead_ph		−0.057* (0.028)	
lead_ph_65			−0.057* (0.028)
R ²	0.005	0.272	0.272
Adj. R ²	−0.001	0.259	0.259
Num. obs.	172	172	172
RMSE	0.151	0.130	0.130

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

- i. The regression includes four coefficients (the intercept and the three coefficients multiplying the regressors). Explain what each coefficient measures.

- i The first coefficient is the intercept, which shows the level of `infrate` when `lead` = 0 and `ph` = 0. It dictates the level of the regression line. The second and fourth coefficients measure the effect of `lead` on the infant mortality rate. Comparing 2 cities, one with lead pipes (`lead` = 1) and one without lead pipes (`lead` = 0), but the same of `ph`, the difference in predicted infant mortality rate is

$$\widehat{\text{infrate}}|_{\text{lead}=1} - \widehat{\text{infrate}}|_{\text{lead}=0} = 0.462 - 0.057 \times \text{ph}$$

The third and fourth coefficients measure the effect of `ph` on the infant mortality rate. Comparing 2 cities, one with a `ph` = 6 and the other with `ph` = 5, but the same of `lead`, the difference in predicted infant mortality rate is

$$\widehat{\text{infrate}}|_{\text{ph}=6} - \widehat{\text{infrate}}|_{\text{ph}=5} = -0.075 - 0.057 \times \text{lead}$$

so the difference is -0.075 for cities without lead pipes and -0.132 for cities with lead pipes.

- ii. Plot the estimated regression function relating `infrate` to `ph` for `lead = 0` and for `lead = 1`. Describe the differences in the regression functions and relate these differences to the coefficients you discussed in (i).

```
fig8.1 <- ggplot(LM, aes(x = ph, y = infrate, col = as.factor(lead))) +  
  labs(title = "Figure 1: Infant Mortality Rate and pH Value",  
        x = "PH Value", y = "Infant Mortality Rate") +  
  geom_smooth(data = LM, method = "lm", se = FALSE, size = 1) +  
  theme(axis.title = element_text(family = "serif"),  
        plot.title = element_text(hjust = 0.5, size = 12, family = "serif",  
                                   face = "bold"),  
        legend.position = c(0.9, 0.8),  
        legend.title = element_blank(),  
        legend.text = element_text(family = "serif", face = "bold"),  
        legend.key = element_rect(color = "transparent"),  
        legend.background = element_rect(fill = "lightgrey",  
                                          size = 0.8,  
                                          linetype="solid")) +  
  scale_color_discrete(name = "Lead", labels = c(" lead = 0", " lead = 1"))  
print(fig8.1)
```

- ii. Plot the estimated regression function relating `infrate` to `ph` for `lead = 0` and for `lead = 1`. Describe the differences in the regression functions and relate these differences to the coefficients you discussed in (i).

- ii (See Figure 1 above) The infant mortality rate is higher for cities with lead pipes, but the difference declines as the pH level increases. For example:

The 10th percentile of pH is 6.4. At this level, the difference in infant mortality rates is

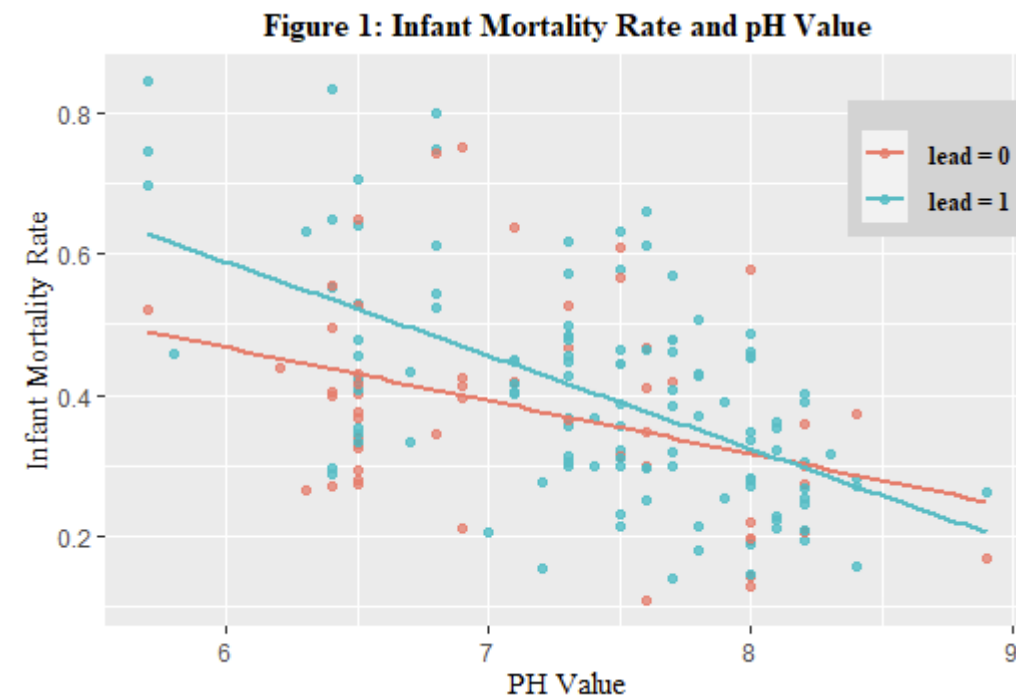
$$\widehat{\text{infrate}}|_{\text{lead}=1, \text{ph}=6.4} - \widehat{\text{infrate}}|_{\text{lead}=0, \text{ph}=6.4} = 0.462 - 0.057 \times 6.4 = 0.097$$

The 50th percentile of pH is 7.5. At this level, the difference in infant mortality rates is

$$\widehat{\text{infrate}}|_{\text{lead}=1, \text{ph}=7.5} - \widehat{\text{infrate}}|_{\text{lead}=0, \text{ph}=7.5} = 0.462 - 0.057 \times 7.5 = 0.035$$

The 90th percentile of pH is 8.2. At this level, the difference in infant mortality rates is

$$\widehat{\text{infrate}}|_{\text{lead}=1, \text{ph}=8.2} - \widehat{\text{infrate}}|_{\text{lead}=0, \text{ph}=8.2} = 0.462 - 0.057 \times 8.2 = -0.01$$



iii. Does **lead** have a statistically significant effect on infant mortality? Explain.

```
> linearHypothesis(reg2, c("lead=0", "lead_ph = 0"), test=c("F"))
Linear hypothesis test

Hypothesis:
lead = 0
lead_ph = 0

Model 1: restricted model
Model 2: infrate ~ lead + ph + lead_ph

   Res.Df Df    F    Pr(>F)
1     170    0      NA      NA
2     168  2  3.936 0.02135 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

iii The F -statistic for the coefficient on **lead** and the interaction term is 3.94, which has a p -value of 0.021, so the coefficients are jointly statistically significantly different from zero at the 5% but not the 1% significance level.

iv. Does the effect of `lead` on `infrate` depend on `ph`? Is this dependence statistically significant?

```
> summary(reg2)
```

Call:

```
lm_robust(formula = infrate ~ lead + ph + lead_ph, se_type = "stata")
```

Standard error type: HCl

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)	CI Lower	CI Upper	DF
(Intercept)	0.91890	0.15049	6.106	6.866e-09	0.62180	1.21601	168
lead	0.46180	0.20761	2.224	2.746e-02	0.05193	0.87167	168
ph	-0.07518	0.02095	-3.588	4.369e-04	-0.11654	-0.03381	168
lead_ph	-0.05686	0.02808	-2.025	4.448e-02	-0.11230	-0.00142	168

Multiple R-squared: 0.2719 , Adjusted R-squared: 0.2589

F-statistic: 20.97 on 3 and 168 DF, p-value: 1.366e-11

iv The interaction term has a t -statistic of -2.02, so the coefficient is significant at the 5% but not the 1% significance level.

- v. What is the average value of `ph` in the sample? At this pH level, what is the estimated effect of `lead` on infant mortality? What is the standard deviation of pH? Suppose that the pH level is one standard deviation lower than the average level of pH in the sample: what is the estimated effect of `lead` on infant mortality? What if pH level is one standard deviation higher than the average value?

- v The mean of pH is 7.32. At this level, the difference in infant mortality rates is

$$\widehat{\text{infrate}}|_{\text{lead}=1, \text{ph}=7.32} - \widehat{\text{infrate}}|_{\text{lead}=0, \text{ph}=7.32} = 0.462 - 0.057 \times 7.32 = 0.045$$

The standard deviation of pH is 0.69 (`sd(ph)`), so that the mean plus 1 standard deviation is 8.01 and the mean minus 1 standard deviation is 6.63. The infant mortality rates at the pH levels are:

$$\widehat{\text{infrate}}|_{\text{lead}=1, \text{ph}=8.01} - \widehat{\text{infrate}}|_{\text{lead}=0, \text{ph}=8.01} = 0.462 - 0.057 \times 8.01 = 0.005$$

$$\widehat{\text{infrate}}|_{\text{lead}=1, \text{ph}=6.63} - \widehat{\text{infrate}}|_{\text{lead}=0, \text{ph}=6.63} = 0.462 - 0.057 \times 6.63 = 0.084$$

- vi. Construct a 95% confidence interval for the effect of `lead` on infant mortality when `pH` = 6.5.

```
> confint(gllht(reg2, linct = c("lead + 6.5*lead_ph=0")))

Simultaneous Confidence Intervals

Fit: lm_robust(formula = infrate ~ lead + ph + lead_ph, se_type = "stata")

Quantile = 1.96
95% family-wise confidence level

Linear Hypotheses:

```

	Estimate	lwr	upr
lead + 6.5 * lead_ph == 0	0.09219	0.02779	0.15660

- vi Write the regression as

$$\text{infrate} = \beta_0 + \beta_1 \text{lead} + \beta_2 \text{ph} + \beta_3 \text{lead} \times \text{ph} + u$$

so the effect of `lead` on `infrate` is $\beta_1 + \beta_3 \times \text{ph}$. Thus, we want to construct a 95% confidence interval (CI) for $\beta_1 + 6.5\beta_3$. This CI can be easily computed using the functions `confint` and `gllht`. The resulting CI is [0.028, 0.157]. Equivalently, we can also use method 2 of Section 7.3, add and subtract $6.5\beta_3$ lead to the regression to obtain:

$$\begin{aligned} \text{infrate} &= \beta_0 + (\beta_1 + 6.5\beta_3) \times \text{lead} + \beta_2 \times \text{ph} + \beta_3 \times (\text{lead} \times \text{ph} - 6.5 \times \text{lead}) + u \\ &= \beta_0 + \gamma \times \text{lead} + \beta_2 \times \text{ph} + \beta_3 \text{lead} \times (\text{ph} - 6.5) + u \end{aligned}$$

So, the 95% CI for $\beta_1 + 6.5\beta_3$ is equal to the 95% CI for γ , which can be constructed using results presented in column (3) of Table 1.

- (c) The analysis in (b) may suffer from omitted variable bias because it neglects factors that affect infant mortality and that might potentially be correlated with `lead` and `ph`. Investigate this concern, using the other variables in the dataset. `[self-study, no solution]`

E8.2 In this exercise, you will investigate the relationship between a worker's age and earnings using the sample `cps12.csv`, which contains data for full-time, full-year workers, ages 25–34, with a high school diploma or B.A./B.S. as their highest degree; see also `CPS12_Description.pdf`.

	A	B	C	D	E
1	year	ahe	bachelor	female	age
2	2012	19.23077	0	0	30
3	2012	17.54808	0	0	29
4	2012	8.547009	0	0	27
5	2012	16.82692	0	1	25
6	2012	16.34615	1	1	27
7	2012	16.10577	1	0	30
8	2012	15.81197	0	0	31
9	2012	3.525641	1	0	29
10	2012	14.42308	0	0	29

Series in Data Set:

FEMALE: 1 if female; 0 if male

YEAR: Year

AHE : Average Hourly Earnings

BACHELOR: 1 if worker has a bachelor's degree;
0 if worker has a high school degree

E8.2 In this exercise, you will investigate the relationship between a worker's age and earnings using the sample `cps12.csv`, which contains data for full-time, full-year workers, ages 25–34, with a high school diploma or B.A./B.S. as their highest degree; see also `CPS12_Description.pdf`.

```
rm(list = ls())
setwd("/Users/uqdkim7/Dropbox/Teaching/R tutorials/Data")
CPS12 <- read_csv("cps12.csv") %>%
  mutate(ln_ahe = log(ahe),
         ln_age = log(age),
         age2 = age*age,
         fem_bac = female*bachelor,
         fem_age = female*age,
         fem_age2= female*age2,
         bac_age = bachelor*age,
         bac_age2= bachelor*age2)
attach(CPS12)
```

- (a) Run a regression of average hourly earnings (`ahe`) on age (`age`), gender (`female`), and education (`bachelor`). If `age` increases from 25 to 26, how are earnings expected to change? If `age` increases from 33 to 34, how are earnings expected to change?

```
reg1 = lm_robust(ahe ~ age + female + bachelor, data = CPS12, se_type = "stata")
reg2 = lm_robust(ln_ahe ~ age + female + bachelor, data = CPS12, se_type = "stata")
reg3 = lm_robust(ln_ahe ~ ln_age + female + bachelor, data = CPS12, se_type = "stata")
reg4 = lm_robust(ln_ahe ~ age + age2 + female + bachelor,
                 data = CPS12, se_type = "stata")
reg5 = lm_robust(ln_ahe ~ age + age2 + female + bachelor + fem_bac,
                 data = CPS12, se_type = "stata")
reg6 = lm_robust(ln_ahe ~ age + age2 + fem_age + fem_age2 + female +
                 bachelor + fem_bac, data = CPS12, se_type = "stata")
reg7 = lm_robust(ln_ahe ~ age + age2 + bac_age + bac_age2 + female +
                 bachelor + fem_bac, data = CPS12, se_type = "stata")

reg8 = lm_robust(ln_ahe ~ age + age2 + fem_age + fem_age2
                 + bac_age + bac_age2 + female + bachelor + fem_bac,
                 data = CPS12, se_type = "stata")

texreg(list(reg1, reg2, reg3, reg4, reg5, reg6, reg7, reg8),
       include.ci = F, caption.above = T,
       digits = 3, caption = "Earnings and Age, 2012",
       custom.model.names = c("(1)", "(2)", "(3)", "(4)", "(5)", "(6)", "(7)", "(8)"))
```

- (a) Run a regression of average hourly earnings (**ahe**) on age (**age**), gender (**female**), and education (**bachelor**). If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 33 to 34, how are earnings expected to change?

Table 2: Earnings and Age, 2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)	0.804 (0.671)	1.987* (0.883)	1.810 (0.949)	2.715* (1.069)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)	0.104* (0.046)	0.020 (0.060)	0.037 (0.065)	-0.027 (0.073)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)	-0.242*** (0.017)	-2.949* (1.356)	-0.242*** (0.017)	-2.672 (1.367)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)	0.400*** (0.015)	0.401*** (0.015)	-1.529 (1.340)	-1.223 (1.351)
ln_age			0.753*** (0.058)					
age2				-0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.001 (0.001)
fem_bac					0.090*** (0.023)	0.089*** (0.023)	0.090*** (0.023)	0.089*** (0.023)
fem_age						0.193* (0.092)		0.174 (0.093)
fem_age2						-0.003* (0.002)		-0.003* (0.002)
bac_age							0.128 (0.091)	0.106 (0.092)
bac_age2							-0.002 (0.002)	-0.002 (0.002)
R ²	0.180	0.196	0.197	0.197	0.198	0.199	0.199	0.200
Adj. R ²	0.180	0.196	0.196	0.196	0.198	0.199	0.198	0.199
Statistic	539.537	623.312	624.311	469.238	382.921	275.770	273.657	214.586
Num. obs	7440	7440	7440	7440	7440	7440	7440	7440
RMSE	9.678	0.478	0.478	0.478	0.478	0.477	0.478	0.478

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

- (a) Run a regression of average hourly earnings (**ahe**) on age (**age**), gender (**female**), and education (**bachelor**). If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 33 to 34, how are earnings expected to change?

	(1)
(Intercept)	1.866 (1.175)
age	0.510*** (0.040)
female	-3.810*** (0.224)
bachelor	8.319*** (0.224)

Table 2: Earnings and Age, 2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)	0.804 (0.671)	1.987* (0.883)	1.810 (0.949)	2.715* (1.069)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)	0.104* (0.046)	0.020 (0.060)	0.037 (0.065)	-0.027 (0.073)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)	-0.242*** (0.017)	-2.949* (1.356)	-0.242*** (0.017)	-2.672 (1.367)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)	0.400*** (0.015)	0.401*** (0.015)	-1.529 (1.340)	-1.223 (1.351)
ln_age			0.753*** (0.058)					
age2				-0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.001 (0.001)
fem_bac						0.090*** (0.023)	0.089*** (0.023)	0.089*** (0.023)
fem_age						0.193* (0.092)		0.174 (0.093)
fem_age2						-0.003* (0.002)		-0.003* (0.002)
bac_age							0.128 (0.091)	0.106 (0.092)
bac_age2							-0.002 (0.002)	-0.002 (0.002)
R ²	0.180	0.196	0.197	0.197	0.198	0.199	0.199	0.200
Adj. R ²	0.180	0.196	0.196	0.196	0.198	0.199	0.198	0.199
Statistic	539.537	623.312	624.311	469.238	382.921	275.770	273.657	214.586
Num. obs	7440	7440	7440	7440	7440	7440	7440	7440
RMSE	9.678	0.478	0.478	0.478	0.478	0.477	0.478	0.478

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

The regression results for this question are shown in column (1) of Table 2. If **age** increases from 25 to 26, earnings are predicted to increase by \$0.510 per hour. If **age** increases from 33 to 34, earnings are predicted to increase by \$0.510 per hour. These values are the same because the regression is a linear function relating **ahe** and **age**.

- (b) Run a regression of the logarithm of average hourly earnings, $\ln(\text{ahe})$, on **age**, **female**, and **bachelor**. If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 34 to 35, how are earnings expected to change?

Case II: Log-linear population regression function

- ▶ Compute Y “before” and “after” changing X :

$$\ln(Y) = \beta_0 + \beta_1 X \quad (\text{“before”})$$

- ▶ New change X :

$$\ln(Y + \Delta Y) = \beta_0 + \beta_1 (X + \Delta X) \quad (\text{“after”})$$

- ▶ Subtract (“after”) - (“before”):

$$\underbrace{\ln(Y + \Delta Y) - \ln(Y)}_{\approx \Delta Y / Y} = \beta_1 \Delta X \implies \frac{\Delta Y}{Y} \approx \beta_1 \Delta X$$

- ▶ If X changes by one unit, i.e. $\Delta X = 1$, then $\frac{\Delta Y}{Y}$ changes by β_1 .
- ▶ A one-unit change in X is associated with a $\beta_1 \times 100\%$ change in Y

(b) Run a regression of the logarithm of average hourly earnings, $\ln(\text{ahe})$, on **age**, **female**, and **bachelor**. If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 34 to 35, how are earnings expected to change?

T

	(1)	(2)
(Intercept)	1.866 (1.175)	1.941*** (0.059)
age	0.510*** (0.040)	0.026*** (0.002)
female	-3.810*** (0.224)	-0.192*** (0.011)
bachelor	8.319*** (0.224)	0.438*** (0.011)

Table 2: Earnings and Age, 2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)	0.804 (0.671)	1.987* (0.883)	1.810 (0.949)	2.715* (1.069)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)	0.104* (0.046)	0.020 (0.060)	0.037 (0.065)	-0.027 (0.073)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)	-0.242*** (0.017)	-2.949* (1.356)	-0.242*** (0.017)	-2.672 (1.367)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)	0.400*** (0.015)	0.401*** (0.015)	-1.529 (1.340)	-1.223 (1.351)
ln_age			0.753*** (0.058)					
age2				-0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.001 (0.001)
fem_bac					0.090*** (0.023)	0.089*** (0.023)	0.090*** (0.023)	0.089*** (0.023)
fem_age						0.193* (0.092)		0.174 (0.093)
fem_age2						-0.003* (0.002)		-0.003* (0.002)
bac_age							0.128 (0.091)	0.106 (0.092)
bac_age2							-0.002 (0.002)	-0.002 (0.002)
R ²	0.180	0.196	0.197	0.197	0.198	0.199	0.199	0.200
Adj. R ²	0.180	0.196	0.196	0.196	0.198	0.199	0.198	0.199
Statistic	539.537	623.312	624.311	469.238	382.921	275.770	273.657	214.586
Num. obs	7440	7440	7440	7440	7440	7440	7440	7440
RMSE	9.678	0.478	0.478	0.478	0.478	0.477	0.478	0.478

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

The regression results for this question are shown in column(2) of Table 2. If **age** increases from 25 to 26, $\ln(\text{ahe})$ is predicted to increase by 0.026, so earnings are predicted to increase **by 2.6%**. If **age** increases from 34 to 35, $\ln(\text{ahe})$ is predicted to increase by 0.026, earnings are predicted to increase **by 2.6%**. These values, in percentage terms, are the same because the regression is a linear function relating $\ln(\text{ahe})$ and **age**.

- (c) Run a regression of the logarithm of average hourly earnings, $\ln(\text{ahe})$, on $\ln(\text{age})$, **female**, and **bachelor**. If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 34 to 35, how are earnings expected to change?

Case III: Log-log population regression function

- ▶ Compute Y “before” and “after” changing X :

$$\ln(Y) = \beta_0 + \beta_1 \ln(X) \quad (\text{“before”})$$

- ▶ New change X :

$$\ln(Y + \Delta Y) = \beta_0 + \beta_1 \ln(X + \Delta X) \quad (\text{“after”})$$

- ▶ Subtract (“after”) - (“before”):

$$\underbrace{\ln(Y + \Delta Y) - \ln(Y)}_{\approx \Delta Y / Y} = \beta_1 \underbrace{[\ln(X + \Delta X) - \ln(X)]}_{\approx \Delta X / X}$$

- ▶ So,

$$\beta_1 \approx \frac{\Delta Y / Y}{\Delta X / X} = \frac{\text{percentage change in } Y}{\text{percentage change in } X} = \text{Elasticity of } Y \text{ to } X$$

- (c) Run a regression of the logarithm of average hourly earnings, $\ln(\text{ahe})$, on $\ln(\text{age})$, **female**, and **bachelor**. If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 34 to 35, how are earnings expected to change?

Table 2: Earn

	(1)	(2)	(3)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)
age	0.510*** (0.040)	0.026*** (0.002)	
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)
\ln_age			0.753*** (0.058)

Table 2: Earnings and Age, 2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)	0.804 (0.671)	1.987* (0.883)	1.810 (0.949)	2.715* (1.069)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)	0.104* (0.046)	0.020 (0.060)	0.037 (0.065)	-0.027 (0.073)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)	-0.242*** (0.017)	-2.949* (1.356)	-0.242*** (0.017)	-2.672 (1.367)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)	0.400*** (0.015)	0.401*** (0.015)	-1.529 (1.340)	-1.223 (1.351)
\ln_age			0.753*** (0.058)					
age2				-0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.001 (0.001)
fem_bac					0.090*** (0.023)	0.089*** (0.023)	0.090*** (0.023)	0.089*** (0.023)
fem_age						0.193* (0.092)		0.174 (0.093)
fem_age2						-0.003* (0.002)		-0.003* (0.002)
bac_age							0.128 (0.091)	0.106 (0.092)
bac_age2							-0.002 (0.002)	-0.002 (0.002)
R ²	0.180	0.196	0.197	0.197	0.198	0.199	0.199	0.200
Adj. R ²	0.180	0.196	0.196	0.196	0.198	0.199	0.198	0.199
Statistic	539.537	623.312	624.311	469.238	382.921	275.770	273.657	214.586
Num. obs	7440	7440	7440	7440	7440	7440	7440	7440
RMSE	9.678	0.478	0.478	0.478	0.478	0.477	0.478	0.478

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

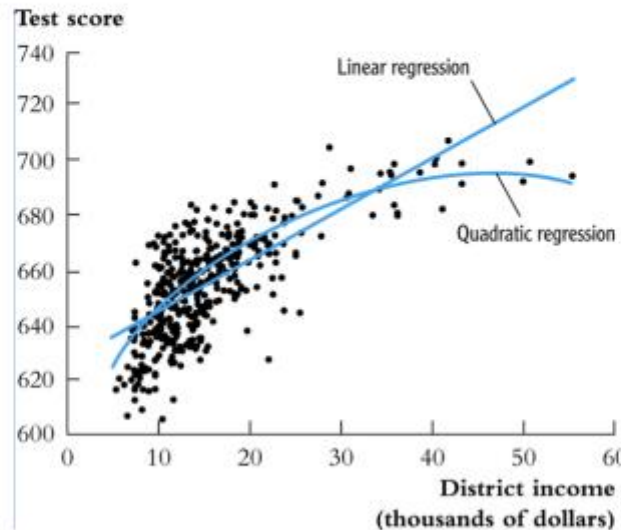
The regression results for this question are shown in column (3) of Table 2. If **age** increases from 25 to 26, then $\ln(\text{age})$ has increased by $\ln(26) - \ln(25) = 0.0392$ (or 3.92%). The predicted increase in $\ln(\text{ahe})$ is $0.75 \times 0.0392 = 0.029$. This means that earnings are predicted to increase by 2.9%. If **age** increases from 34 to 35, then $\ln(\text{age})$ has increased by $\ln(35) - \ln(34) = 0.0290$ (or 2.90%). The predicted increase in $\ln(\text{ahe})$ is $0.75 \times 0.0290 = 0.021$. This means that earnings are predicted to increase by 2.1%.

- (d) Run a regression of the logarithm of average hourly earnings, $\ln(\text{ahe})$, on **age**, age^2 , **female**, and **bachelor**. If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 34 to 35, how are earnings expected to change?

Interpreting the estimated regression function:

(a) Plot the predicted values;

$$\text{TestScore}_i = \underset{(2.9)}{607.3} + \underset{(0.27)}{3.85 \text{Income}_i} - \underset{(0.0048)}{0.0423(\text{Income}_i)^2}$$



- (d) Run a regression of the logarithm of average hourly earnings, $\ln(\text{ahe})$, on **age**, age^2 , **female**, and **bachelor**. If **age** increases from 25 to 26, how are earnings expected to change? If **age** increases from 34 to 35, how are earnings expected to change?

Table 2: Earnings and Age

	(1)	(2)	(3)	(4)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)
ln_age			0.753*** (0.058)	
age2				-0.001 (0.001)

The regression results for this question are shown in column (4) of Table 2. When **age** increases from 25 to 26, the predicted change in $\ln(\text{ahe})$ is

$$(0.104 \times 26 - 0.0013 \times 26^2) - (0.104 \times 25 - 0.0013 \times 25^2) = 0.036.$$

This means that earnings are predicted to increase by 3.6%. When **age** increases from 34 to 35, the predicted change in $\ln(\text{ahe})$ is

$$(0.104 \times 35 - 0.0013 \times 35^2) - (0.104 \times 34 - 0.0013 \times 34^2) = 0.012.$$

This means that earnings are predicted to increase by 1.2%.

(e) Do you prefer the regression in (c) to the regression in (b)? Explain.

The regressions differ in their choice of one of the regressors. The two sets of estimates are overall very similar. They can be compared on the basis of the \bar{R}^2 . The regression in (c) has a (marginally) higher \bar{R}^2 (0.1962 vs. 0.1961), so it is preferred.

(f) Do you prefer the regression in (d) to the regression in (b)? Explain.

The regression in (d) adds the variable age^2 to regression (b). The coefficient on age^2 is not statistically significant at the 5% level and the estimated coefficient is very close to zero. This suggests that the regression in (b) is preferred to that in (d). However, the regressions are so similar that either may be used.

(g) Do you prefer the regression in (d) to the regression in (c)? Explain.

The regressions differ in their choice of the regressors ($\ln(\text{age})$ in (c) and age and age^2 in (d)). They can be compared on the basis of the \bar{R}^2 . The regression in (d) has a (marginally) higher \bar{R}^2 (0.1963 vs. 0.1962), so it is preferred.

- (h) Plot the regression relation between **age** and $\ln(\text{ahe})$ from (b), (c), and (d) for males with a high school diploma. Describe the similarities and differences between the estimated regression functions. Would your answer change if you plotted the regression function for females with college degrees?

```
age <- seq(25, 34, by = 1)
ln_ageb <- 1.941 + 0.0255*age
ln_agec <- 0.150 + 0.753*log(age)
ln_aged <- 0.792 + 0.104*age - 0.00133*age^2

datab <- data.frame(ln_age = ln_ageb, age = age, data = "b")
datac <- data.frame(ln_age = ln_agec, age = age, data = "c")
datad <- data.frame(ln_age = ln_aged, age = age, data = "d")
data.bcd <- rbind.data.frame(datab, datac, datad)
```

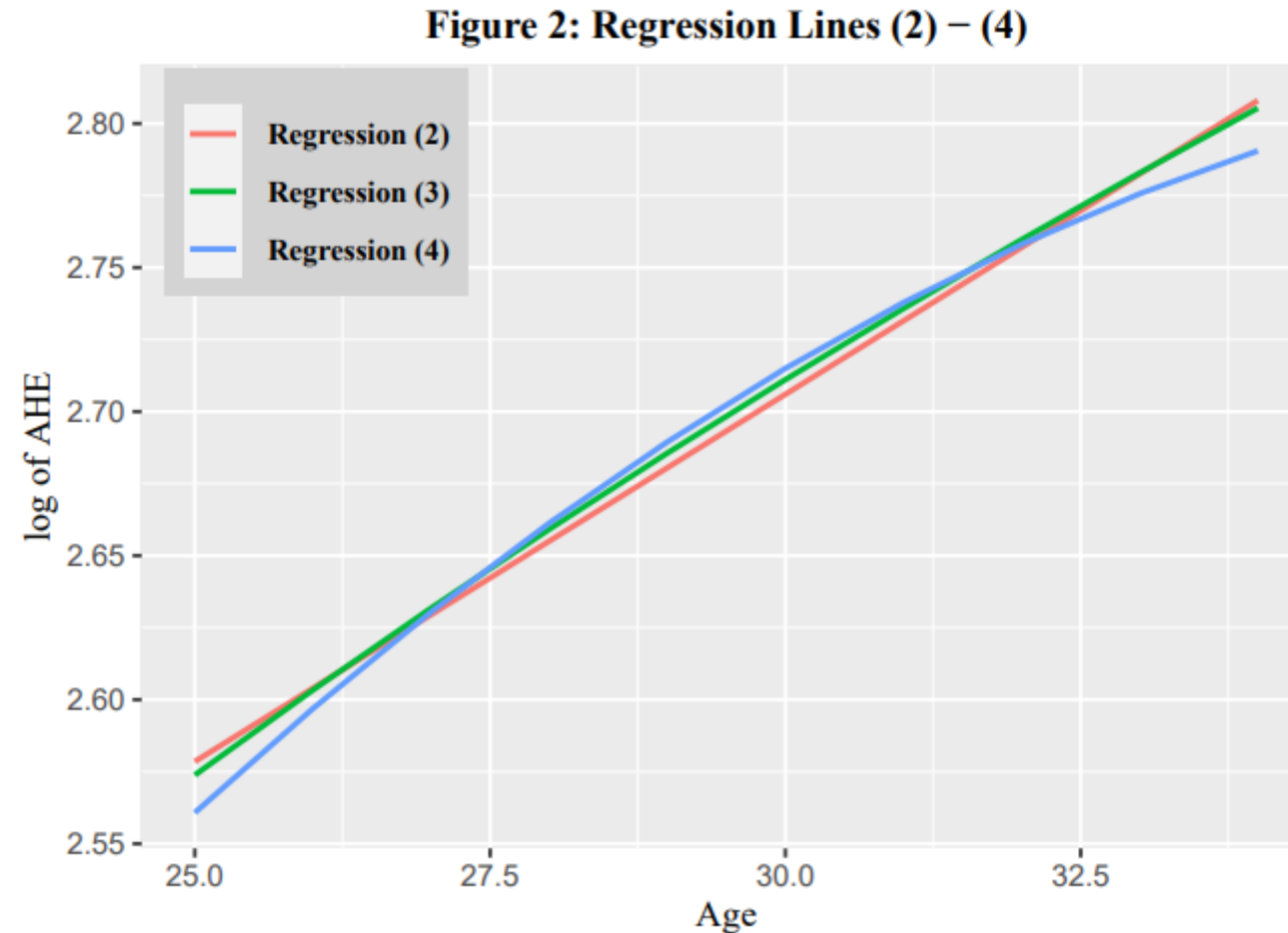
Table 2: Earnings and Age

	(1)	(2)	(3)	(4)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)
ln_age			0.753*** (0.058)	
age2				-0.001 (0.001)

- (h) Plot the regression relation between **age** and $\ln(\text{ahe})$ from (b), (c), and (d) for males with a high school diploma. Describe the similarities and differences between the estimated regression functions. Would your answer change if you plotted the regression function for females with college degrees?

```
fig8.2 <- ggplot(data.bcd, aes(x = age, y = ln_age)) +  
  geom_line(aes(col = data), size = 0.8) +  
  labs(title = "Figure 2: Regression Lines (2) - (4)",  
       x = "Age", y = "log of AHE") +  
  theme(axis.title = element_text(family = "serif"),  
        plot.title = element_text(hjust = 0.5, size = 12, family = "serif",  
                                   face = "bold"),  
        legend.position = c(0.15, 0.85),  
        legend.title = element_blank(),  
        legend.text = element_text(family = "serif", face = "bold"),  
        legend.key = element_rect(color = "transparent"),  
        legend.background = element_rect(fill = "lightgrey",  
                                          size = 0.8,  
                                          linetype="solid")) +  
  scale_color_discrete(name = "Model", labels = c(" Regression (2)",  
                                                  " Regression (3)",  
                                                  " Regression (4)"))  
  
print(fig8.2)
```


- (h) Plot the regression relation between **age** and $\ln(\mathbf{ahe})$ from (b), (c), and (d) for males with a high school diploma. Describe the similarities and differences between the estimated regression functions. Would your answer change if you plotted the regression function for females with college degrees?



- (h) Plot the regression relation between **age** and $\ln(\mathbf{ahe})$ from (b), (c), and (d) for males with a high school diploma. Describe the similarities and differences between the estimated regression functions. Would your answer change if you plotted the regression function for females with college degrees?

See Figure 2. The regression functions are very similar. The quadratic regression shows somewhat more curvature than the log-log regression, but the difference is small. The regression functions for a female with a high school diploma will look just like these, but they will be shifted by the amount of the coefficient on the binary regressor **female**. The regression functions for workers with a bachelor degree will also look just like these, but they would be shifted by the amount of the coefficient on the binary variable **bachelor**.

- (i) Run a regression of $\ln(\text{ahe})$ on age , age^2 , female , bachelor , and the interaction term $\text{female} \times \text{bachelor}$. What does the coefficient on the interaction term measure? Alexis is a 30-year-old female with a bachelor's degree. What does the regression predict for her value of $\ln(\text{ahe})$? Jane is a 30-year-old female with a high school diploma. What does the regression predict for her value of $\ln(\text{ahe})$? What is the predicted difference between Alexis's and Jane's earnings? Bob is a 30-year-old male with a bachelor's degree. What does the regression predict for his value of $\ln(\text{ahe})$? Jim is a 30-year-old male with a high school diploma. What does the regression predict for his value of $\ln(\text{ahe})$? What is the predicted difference between Bob's and Jim's earnings?

Table 2: Earnings and Age, 2012

	(1)	(2)	(3)	(4)	(5)
(Intercept)	1.866 (1.175)	1.941*** (0.059)	0.150 (0.195)	0.792 (0.671)	0.804 (0.671)
age	0.510*** (0.040)	0.026*** (0.002)		0.104* (0.046)	0.104* (0.046)
female	-3.810*** (0.224)	-0.192*** (0.011)	-0.192*** (0.011)	-0.192*** (0.011)	-0.242*** (0.017)
bachelor	8.319*** (0.224)	0.438*** (0.011)	0.438*** (0.011)	0.437*** (0.011)	0.400*** (0.015)
ln_age			0.753*** (0.058)		
age2				-0.001 (0.001)	-0.001 (0.001)
fem_bac					0.090*** (0.023)

- (i) Run a regression of $\ln(\text{ahe})$ on age , age^2 , female , bachelor , and the interaction term $\text{female} \times \text{bachelor}$. What does the coefficient on the interaction term measure? Alexis is a 30-year-old female with a bachelor's degree. What does the regression predict for her value of $\ln(\text{ahe})$? Jane is a 30-year-old female with a high school diploma. What does the regression predict for her value of $\ln(\text{ahe})$? What is the predicted difference between Alexis's and Jane's earnings? Bob is a 30-year-old male with a bachelor's degree. What does the regression predict for his value of $\ln(\text{ahe})$? Jim is a 30-year-old male with a high school diploma. What does the regression predict for his value of $\ln(\text{ahe})$? What is the predicted difference between Bob's and Jim's earnings?

```
> (Alexis <- predict(reg5, newdata = data.frame(
+   age = 30,
+   age2 = 30^2,
+   female = 1,
+   bachelor = 1,
+   fem_bac = 1
+ )))
      1
2.982923
> (Jane <- predict(reg5, newdata = data.frame(
+   age = 30,
+   age2 = 30^2,
+   female = 1,
+   bachelor = 0,
+   fem_bac = 0
+ )))
      1
2.492619
> Alexis - Jane
      1
0.4903034
```

```
> (Bob <- predict(reg5, newdata = data.frame(
+   age = 30,
+   age2 = 30^2,
+   female = 0,
+   bachelor = 1,
+   fem_bac = 0
+ )))
      1
3.135439
> (Jim <- predict(reg5, newdata = data.frame(
+   age = 30,
+   age2 = 30^2,
+   female = 0,
+   bachelor = 0,
+   fem_bac = 0
+ )))
      1
2.734993
> Bob - Jim
      1
0.4004463
```


- (i) Run a regression of $\ln(\text{ahe})$ on age , age^2 , female , bachelor , and the interaction term $\text{female} \times \text{bachelor}$. What does the coefficient on the interaction term measure? Alexis is a 30-year-old female with a bachelor's degree. What does the regression predict for her value of $\ln(\text{ahe})$? Jane is a 30-year-old female with a high school diploma. What does the regression predict for her value of $\ln(\text{ahe})$? What is the predicted difference between Alexis's and Jane's earnings? Bob is a 30-year-old male with a bachelor's degree. What does the regression predict for his value of $\ln(\text{ahe})$? Jim is a 30-year-old male with a high school diploma. What does the regression predict for his value of $\ln(\text{ahe})$? What is the predicted difference between Bob's and Jim's earnings?

This regression is shown in column (5) of Table 2. The coefficient on the interaction term $\text{female} \times \text{bachelor}$ shows the “extra effect” of bachelor on $\ln(\text{ahe})$ for women relative the effect for men.

Predicted values of $\ln(\text{ahe})$:

$$\text{Alexis} : 0.104 \times 30 - 0.0013 \times 30^2 - 0.24 \times 1 + 0.40 \times 1 + 0.090 \times 1 + 0.80 = 3.00$$

$$\text{Jane} : 0.104 \times 30 - 0.0013 \times 30^2 - 0.24 \times 1 + 0.40 \times 0 + 0.090 \times 0 + 0.80 = 2.51$$

$$\text{Bob} : 0.104 \times 30 - 0.0013 \times 30^2 - 0.24 \times 0 + 0.40 \times 1 + 0.090 \times 0 + 0.80 = 3.15$$

$$\text{Jim} : 0.104 \times 30 - 0.0013 \times 30^2 - 0.24 \times 0 + 0.40 \times 0 + 0.090 \times 0 + 0.80 = 2.75$$

Difference in $\ln(\text{ahe})$: Alexis - Jane = $3.00 - 2.51 = 0.49$. \ Difference in $\ln(\text{ahe})$: Bob - Jim = $3.15 - 2.75 = 0.40$

Notice that the difference in the differences of the predicted effects is $0.49 - 0.40 = 0.09$, which is the value of the **coefficient** on the **interaction term**.

- (j) Is the effect of `age` on earnings different for men than for women? Specify and estimate a regression that you can use to answer this question.

```
linearHypothesis(reg6, c("fem_age = 0", "fem_age2 = 0"), test=c("F"))

## Linear hypothesis test
##
## Hypothesis:
## fem_age = 0
## fem_age2 = 0
##
## Model 1: restricted model
## Model 2: ln_ahe ~ age + age2 + fem_age + fem_age2 + female + bachelor +
##          fem_bac
##
##   Res.Df Df       F    Pr(>F)
## 1     7434
## 2     7432  2 4.137 0.01601 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This regression is shown in column (6) of Table 2, which includes two additional regressors: the interactions of `female` and the age variables, `age` and `age2`. The F -statistic testing the restriction that the coefficients on these interaction terms is equal to zero is 4.14 with a p -value of 0.016. This implies that there is statistically significant evidence (at the 5% but not 1% level) that there is a different effect of `age` on $\ln(\text{ahe})$ for men and women.

- (k) Is the effect of **age** on earnings different for high school graduates than for college graduates? Specify and estimate a regression that you can use to answer this question.

```
linearHypothesis(reg7, c("bac_age = 0", "bac_age2 = 0"), test=c("F"))

## Linear hypothesis test
##
## Hypothesis:
## bac_age = 0
## bac_age2 = 0
##
## Model 1: restricted model
## Model 2: ln_ahe ~ age + age2 + bac_age + bac_age2 + female + bachelor +
##          fem_bac
##
##   Res.Df Df       F Pr(>F)
## 1     7434
## 2     7432  2 1.3003 0.2725
```

This regression is shown in column (7) of Table 2, which includes two additional regressors that are interactions of **bachelor** and the age variables, **age** and **age**². The *F*-statistic testing the restriction that the coefficients on these interaction terms is zero is 1.30 with a *p*-value of 0.273. This implies that there is no statistically significant evidence (at the 10% level) that there is a different effect of **age** on $\ln(\text{ahe})$ for high school and college graduates.

- (1) After running all these regressions (and any others that you want to run), summarise the effect of age on earnings for young workers.

Table 3: Results using (8) from the 2012 Data

Gender, Education	Predicted Value of $\ln(\text{ahe})$ at Age			Predicted Increase in $\ln(\text{ahe})$ Percent per year	
	25	32	34	25 to 32	32 to 34
Female, High School	2.36	2.52	2.53	2.3	0.4
Male, High School	2.60	2.78	2.84	2.5	3.3
Female, BA	2.81	3.03	3.02	3.1	-0.4
Male, BA	2.96	3.19	3.24	3.3	2.6

The table3 summarizes the regressions predictions for increases in earnings as a person ages from 25 to 32 and 32 to 34.

The estimated regressions suggest that earnings increase as workers age from 25–35, the range of age studied in this sample. Gender and education are significant predictors of earnings, and there are statistically significant interaction effects between age and gender and between gender and and education.

Earnings for those with a college education are higher than those with a high school degree, and earnings of the college educated increase more rapidly early in their careers (age 25–34). Earnings for men are higher than those of women, and earnings of men increase more rapidly early in their careers (age 25–34). For all categories of workers (men/women, high school/college) earnings increase more rapidly from age 25–32 than from 32–34. While the percentage increase in women's earning is similar to the percentage increase for men from age 25–32, women's earning tend to stagnate from age 32–34, while men's continues to increase.



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

CREATE CHANGE

Thank you

Francisco Tavares Garcia

Academic Tutor | School of Economics

tavaresgarcia.github.io

Reference

Stock, J. H., & Watson, M. W. (2019). Introduction to Econometrics, Global Edition, 4th edition. Pearson Education Limited.