Lab 3: Relationship between global cesarean delivery rates and GDP

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Instructions

- Due date: Wednesday, July 12th by 10:00pm PT with 2 hour grace period.
- Late penalty: 50% late penalty if submitted within 24 hours of due date, no marks for assignments submitted thereafter.
- This assignment is graded on **correct completion**, all or nothing. You must pass all public tests and submit the assignment for credit.
- Submission process: Follow the submission instructions on the final page. Make sure you do not remove any `\newpage` tags or rename this file, as this will break the submission.

Start by loading the required libraries, reading in the data and adding on a variable:

```r
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(ggplot2)
library(readr)
library(broom)
library(testthat)
```

```
##
## Attaching package: 'testthat'

## The following objects are masked from 'package:readr':
##
##     edition_get, local_edition
## The following object is masked from ’package:dplyr’:
##
##     matches
```

```
CS_data <- read_csv("data/cesarean.csv")
```

```
## Rows: 137 Columns: 7
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (4): Country_Name, CountryCode, Income_Group, Region
## dbl (3): Births_Per_1000, GDP_2006, CS_rate
##
## i Use ‘spec()‘ to retrieve the full column specification for this data.
## i Specify the column types or set ‘show_col_types = FALSE‘ to quiet this message.
```

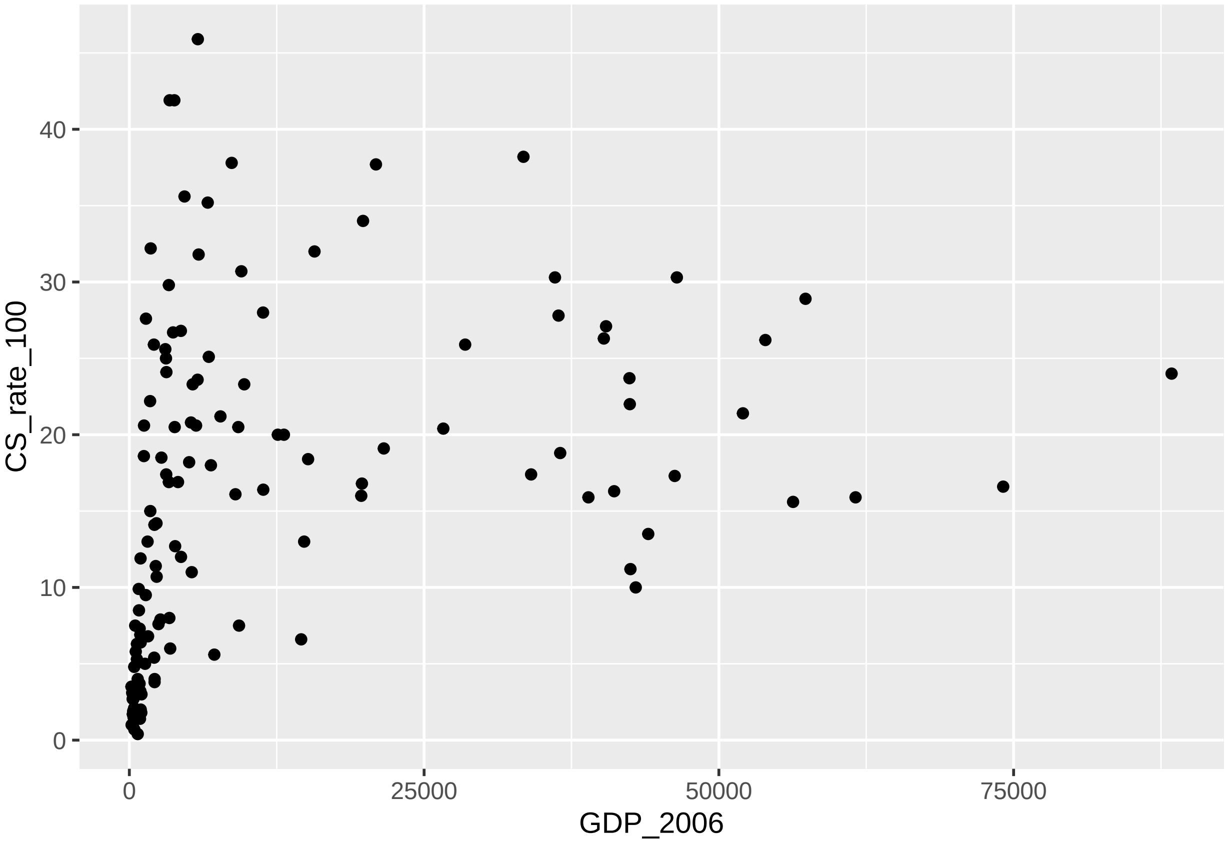
```
# The code below re-orders the variable Income_Group in the specified order.
# Note that it *does not* change the order of the data frame (like arrange() does)
# Rather, it specifies the order the data will be plotted.
# This will make more sense when we plot the data using Income_Group, and then again using Income_Group
CS_data$Income_Group <- forcats::fct_relevel(CS_data$Income_Group,
                                         "Low income", "Lower middle income",
                                 "Upper middle income", "High income: nonOECD",
                                            "High income: OECD")

CS_data <- CS_data %>% mutate(CS_rate_100 = CS_rate*100)
CS_data
```

```
## # A tibble: 137 x 8
##    Country_Name CountryCode Births_Per_1000 Income_Group Region GDP_2006 CS_rate
##    <chr>        <chr>                 <dbl> <fct>        <chr>     <dbl>   <dbl>
##  1 Albania      ALB                      46 Upper middl~ Europ~    3052.   0.256
##  2 Andorra      AND                       1 High income~ Europ~   42417.   0.237
##  3 United Arab~ ARE                      63 High income~ Middl~   42950.   0.1
##  4 Argentina    ARG                     689 High income~ Latin~    6649.   0.352
##  5 Armenia      ARM                      47 Lower middl~ Europ~    2127.   0.141
##  6 Australia    AUS                     267 High income~ East ~   36101.   0.303
##  7 Austria      AUT                      76 High income~ Europ~   40431.   0.271
##  8 Azerbaijan   AZE                     166 Upper middl~ Europ~    2473.   0.076
##  9 Belgium      BEL                     119 High income~ Europ~   38936.   0.159
## 10 Benin        BEN                     342 Low income   Sub-S~     557.   0.036
## # i 127 more rows
## # i 1 more variable: CS_rate_100 <dbl>
```

1. [1 point] Make a scatter plot between `CS_rate_100` and `GDP_2006`.

```
p1 <- ggplot(CS_data, aes(x = GDP_2006, y = CS_rate_100)) +
      geom_point()
p1
```



```
. = ottr::check("tests/p1.R")
```

```
##
## All tests passed!
```

In your plot, you might notice that many of the points are condensed towards the lower left corner. And you might recall from the lab and assignment that the distributions of both cesarean delivery rate and GDP covered a wide range of values. Both of these variables are good candidates for log transformations to spread out the range of data at the lowest levels.

2. [1 point] **Using the `mutate()` function, add two new logged variables to the `CS_data` dataset and assign this new dataset to `CS_data_log`. Call the variables `log_CS` and `log_GDP`. Use base e, also known as the natural logarithm, to create the logged variables.**

```
CS_data_log <- CS_data %>% mutate (log_CS = log(CS_rate_100),
                                   log_GDP= log (GDP_2006))
CS_data_log
```

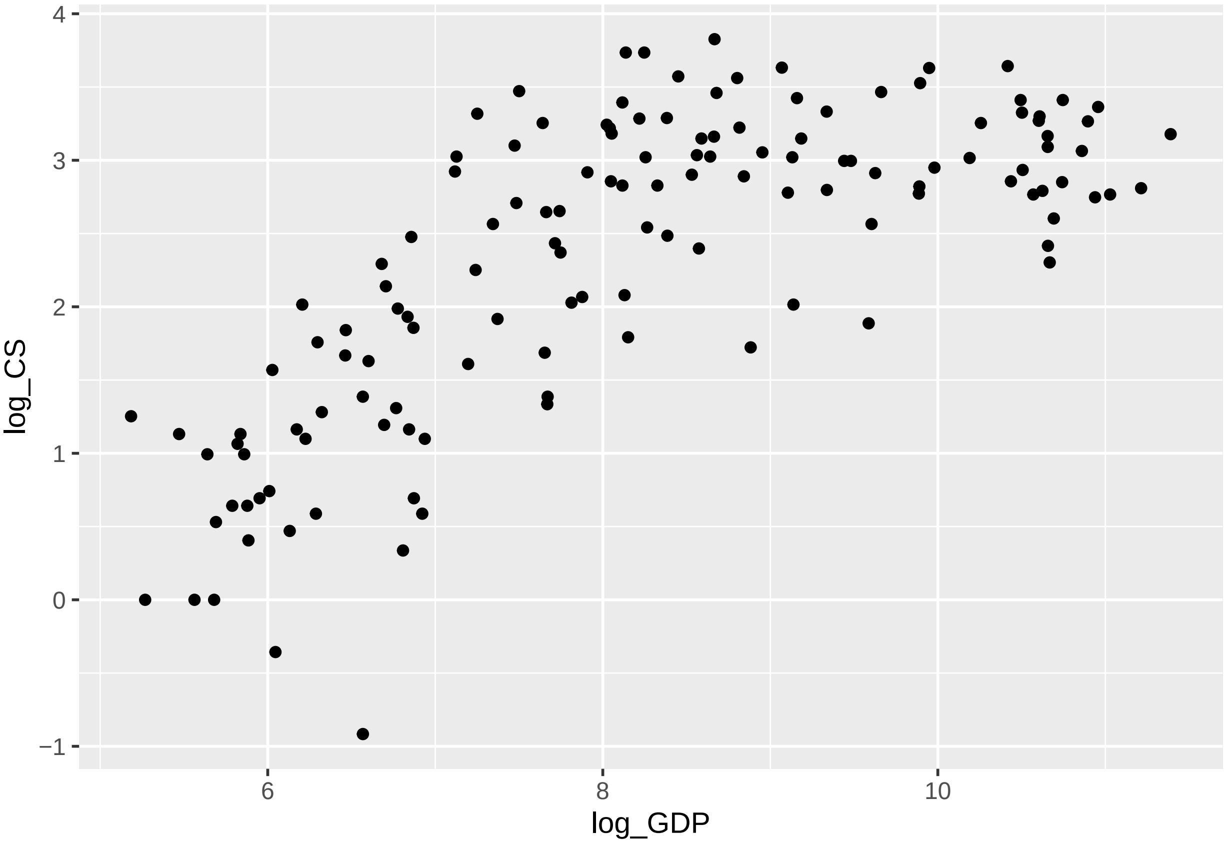
```
## # A tibble: 137 x 10
##    Country_Name CountryCode Births_Per_1000 Income_Group Region GDP_2006 CS_rate
##    <chr>        <chr>                 <dbl> <fct>        <chr>     <dbl>   <dbl>
##  1 Albania      ALB                      46 Upper middl~ Europ~    3052.   0.256
##  2 Andorra      AND                       1 High income~ Europ~   42417.   0.237
##  3 United Arab~ ARE                      63 High income~ Middl~   42950.   0.1
##  4 Argentina    ARG                     689 High income~ Latin~    6649.   0.352
##  5 Armenia      ARM                      47 Lower middl~ Europ~    2127.   0.141
##  6 Australia    AUS                     267 High income~ East ~   36101.   0.303
##  7 Austria      AUT                      76 High income~ Europ~   40431.   0.271
##  8 Azerbaijan   AZE                     166 Upper middl~ Europ~    2473.   0.076
##  9 Belgium      BEL                     119 High income~ Europ~   38936.   0.159
## 10 Benin        BEN                     342 Low income   Sub-S~     557.   0.036
## # i 127 more rows
## # i 3 more variables: CS_rate_100 <dbl>, log_CS <dbl>, log_GDP <dbl>
```

```
. = ottr::check("tests/p2.R")
```

```
##
## All tests passed!
```

3. [1 point] Remake the scatter plot using the logged variables.

```
p3 <-ggplot(CS_data_log, aes(x = log_GDP, y = log_CS)) +
       geom_point()
p3
```



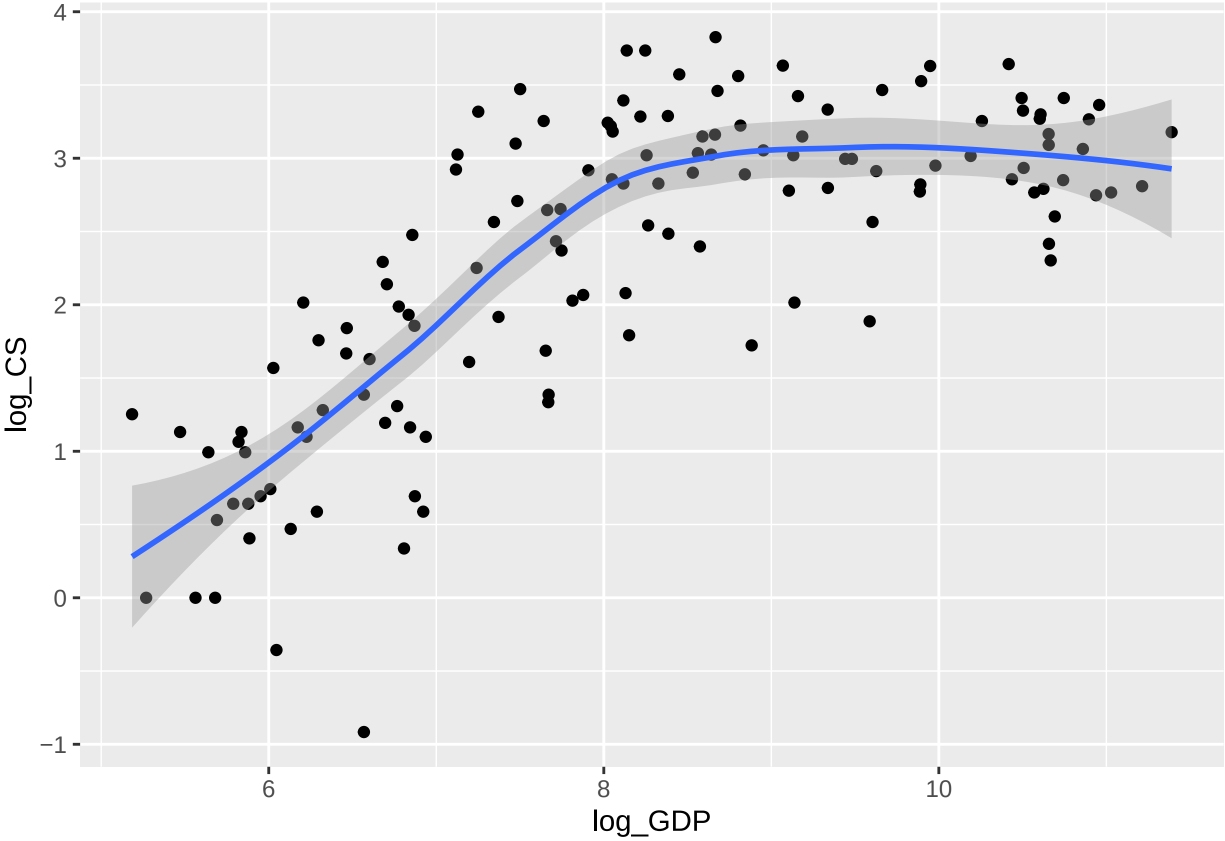
```
. = ottr::check("tests/p3.R")
```

```
##
## All tests passed!
```

4. [1 point] A geom that you have not yet learned is geom_smooth(). This geom can fit a curve to the data. Extend your ggplot() code by adding geom_smooth() to it.

```
p4 <- ggplot(CS_data_log, aes(x = log_GDP, y = log_CS)) +
       geom_point() + geom_smooth()
p4
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
. = ottr::check("tests/p4.R")
```

```
##
## All tests passed!
```

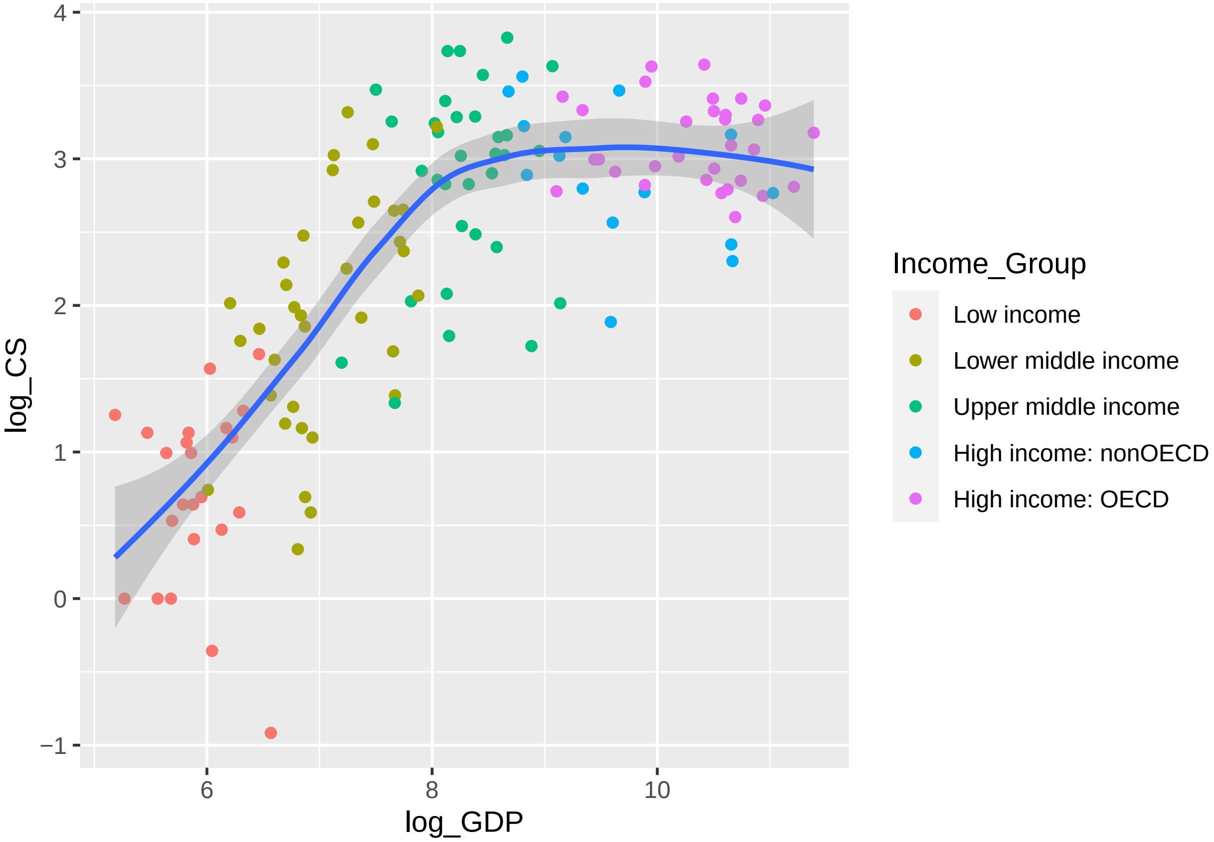
5. Does the relationship between logged GDP and logged CS look linear?

No. It appears to be curved around avalue of 8 for the log_GDP .

6. [1 point] Modify your scatter plot by linking the color of the points to the variableIncome_Group.

```
p6 <- ggplot(CS_data_log, aes(x = log_GDP, y = log_CS)) +
       geom_point(aes(color = Income_Group)) + geom_smooth()
p6
```

```
## `geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



```
. = ottr::check("tests/p6.R")
```

```
##
## All tests passed!
```

Does a linear relationship hold for any part of the data? What pattern do you notice? Only for high income group group and not the other groups

7. [1 point] For this lab, we would like to use linear regression. To do this, use a dplyr function to make a new dataset called CS_data_sub that only contains the low-, lower-middle, and upper-middle income countries (hint: You might want to look at the data to see exactly what these levels are called in the data set).

```r
CS_data_sub <- CS_data_log %>%
  filter(Income_Group %in% c ('Low income', 'Lower middle income', 'Upper middle income'))
CS_data_sub
```

```
## # A tibble: 91 x 10
##    Country_Name CountryCode Births_Per_1000 Income_Group Region GDP_2006 CS_rate
##    <chr>        <chr>                 <dbl> <fct>        <chr>     <dbl>   <dbl>
##  1 Albania      ALB                      46 Upper middl~ Europ~    3052.   0.256
##  2 Armenia      ARM                      47 Lower middl~ Europ~    2127.   0.141
##  3 Azerbaijan   AZE                     166 Upper middl~ Europ~    2473.   0.076
##  4 Benin        BEN                     342 Low income   Sub-S~     557.   0.036
##  5 Burkina Faso BFA                     721 Low income   Sub-S~     422.   0.007
##  6 Bangladesh   BGD                    3430 Lower middl~ South~     496.   0.075
##  7 Bulgaria     BGR                      73 Upper middl~ Europ~    4371.   0.268
##  8 Belarus      BLR                      96 Upper middl~ Europ~    3849.   0.205
##  9 Bolivia      BOL                     263 Lower middl~ Latin~    1234.   0.186
## 10 Brazil       BRA                    3105 Upper middl~ Latin~    5809.   0.459
## # i 81 more rows
## # i 3 more variables: CS_rate_100 <dbl>, log_CS <dbl>, log_GDP <dbl>
```

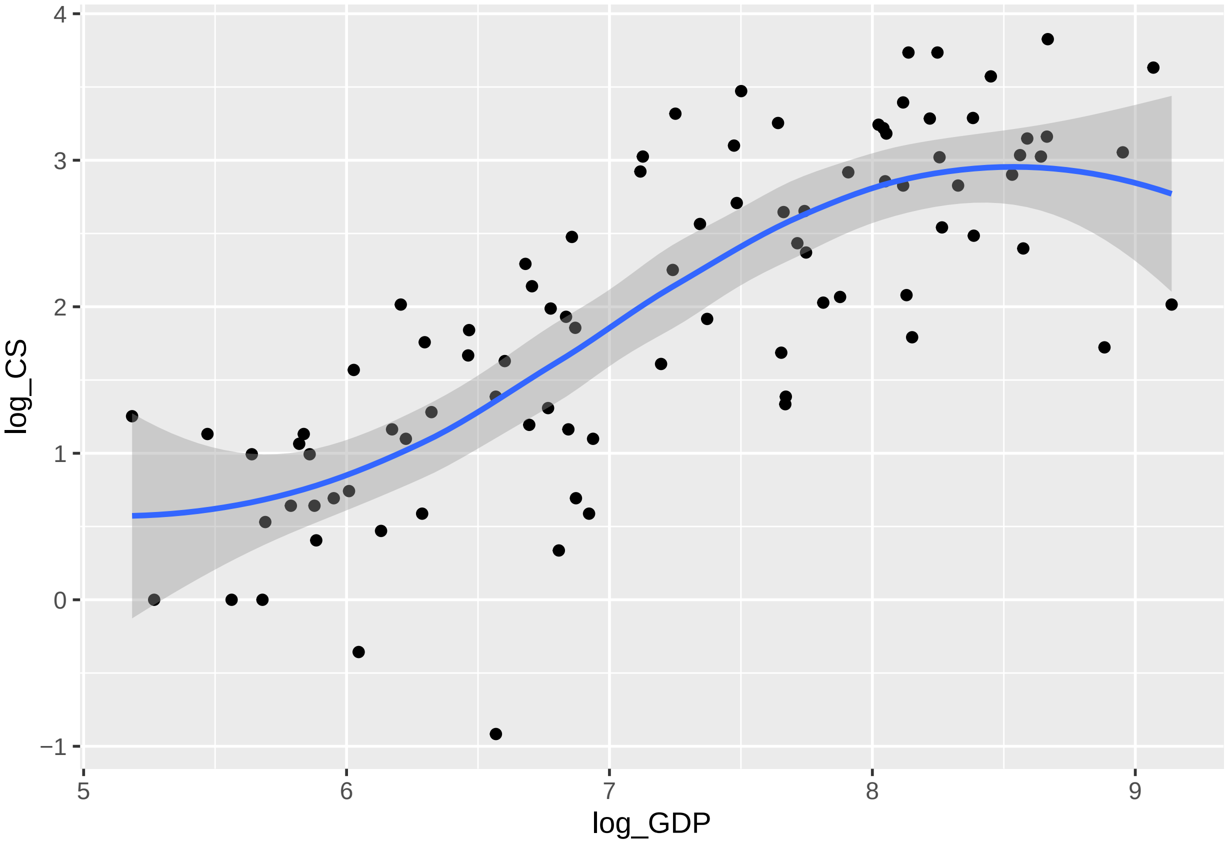
```r
. = ottr::check("tests/p7.R")
```

```
##
## All tests passed!
```

8. [1 point] Remake the last scatter plot, this time using `CS_data_sub` to see if the relationship between the logged variables looks approximately linear.

```
p8 <- ggplot(CS_data_sub, aes(x = log_GDP, y = log_CS)) +
       geom_point() + geom_smooth()
p8
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
. = ottr::check("tests/p8.R")
```

```
##
## All tests passed!
```

9. [1 point] Given that the relationship is approximately linear, use linear regression to model the relationship between `log_CS` as the response variable and `log_GDP` as the explanatory variable. Don't forget to specify the correct dataset!

```
p9 <- lm(log_CS ~ log_GDP, data = CS_data_sub)
p9
```

```
##
## Call:
## lm(formula = log_CS ~ log_GDP, data = CS_data_sub)
```

```
##
## Coefficients:
## (Intercept)      log_GDP
##     -3.9405       0.8193
```

```
. = ottr::check("tests/p9.R")
```

```
##
## All tests passed!
```

10. Interpret the slope estimate in the context of the problem.

The slope can be interpreted as: for every one unit increase in Log GDP, the log CS Delivery rate is expected to increase by 0.8193

11. Estimate what the cesarean delivery rate would be for a country with a GDP of 2000. Outline the steps you take to calculate your answer and provide an interpretation. Round your final answer to one decimal place.

The cesarean delivery rate would be 9.8 units for a country with GDP of 2000.

```
#Log_CS = intercept + slope(Log_GDP)

#calculated_output
-3.9405 + 0.8193* log(2000)
```

```
## [1] 2.286919
```

```
#transformed_output
exp (2.286919)
```

```
## [1] 9.84456
```

12. Is it appropriate to use the model to predict the cesarean delivery rate for a country with a GDP of 50,000? Why or why not? Based on the relationship in the full dataset, would you expect the linear model to over- or under-predict? The cesarean delivery rate would be 137.57 units for a country with GDP of 50000. The linear model is over-predicted based on the relationship in the full data set.

```
#Log_CS = intercept + slope(Log_GDP)

#calculated_output
log_CS = -3.9405 + 0.8193* log(50000)

#transformed_output
exp (4.924144)
```

```
## [1] 137.5715
```

Submission

For assignments in this class, you'll be submitting using the **Terminal** tab in the pane below. In order for the submission to work properly, make sure that:

1. Any image files you add that are needed to knit the file are in the `src` folder and file paths are specified accordingly.
2. You **have not changed the file name** of the assignment.
3. The file knits properly.

Once you have checked these items, you can proceed to submit your assignment.

1. Click on the **Terminal** tab in the pane below.
2. Copy-paste the following line of code into the terminal and press enter.

cd; cd ph142-su23/lab/lab03; python3 turn_in.py

3. Follow the prompts to enter your Gradescope username and password.
4. If the submission is successful, you should see "Submission successful!" appear as the output. **Check your submission on the Gradescope website to ensure that the autograder worked properly and you received credit for your correct answers. If you think the autograder is incorrectly grading your work, please post on piazza!**
5. If the submission fails, try to diagnose the issue using the error messages–if you have problems, post on Piazza under the post "Datahub Issues".

The late policy will be strictly enforced, **no matter the reason**, including submission issues, so be sure to submit early enough to have time to diagnose issues if problems arise.

Submission

Make sure you have run all cells in your notebook in order before running the cell below, so that all images/graphs appear in the output. The cell below will generate a zip file for you to submit. **Please save before exporting!**