Lab 3: Relationship between global cesarean delivery rates and GDP

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Instructions

- Due date: Friday, September 11 at 11:59pm PST.
- 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:

```
library(dplyr)
library(ggplot2)
library(readr)
library(broom)

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

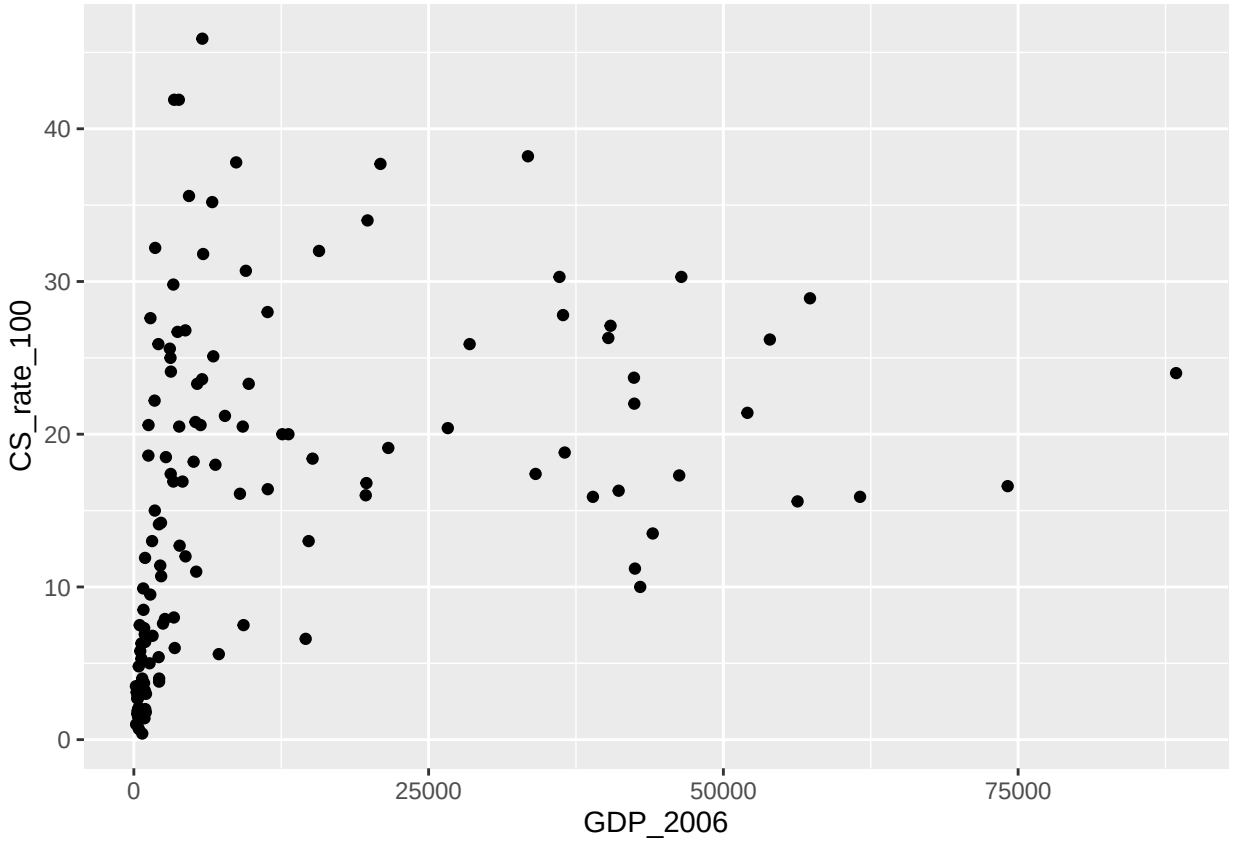
```
## Parsed with column specification:
## cols(
##   Country_Name = col_character(),
##   CountryCode = col_character(),
##   Births_Per_1000 = col_double(),
##   Income_Group = col_character(),
##   Region = col_character(),
##   GDP_2006 = col_double(),
##   CS_rate = col_double()
## )
```

```
# This code 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_order
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")
```

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

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
```




```
check_problem1()
```

```
## [1] "Checkpoint 1 Passed: A ggplot has been defined"
## [1] "Checkpoint 2 Passed: You are using the correct dataset!"
## [1] "Checkpoint 3 Passed: Correct variable plotted!"
## [1] "Checkpoint 4 Passed: Correct variable plotted!"
## [1] "Checkpoint 5 Passed: You defined a scatterplot!"
##
## Problem 1
## Checkpoints Passed: 5
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: 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.

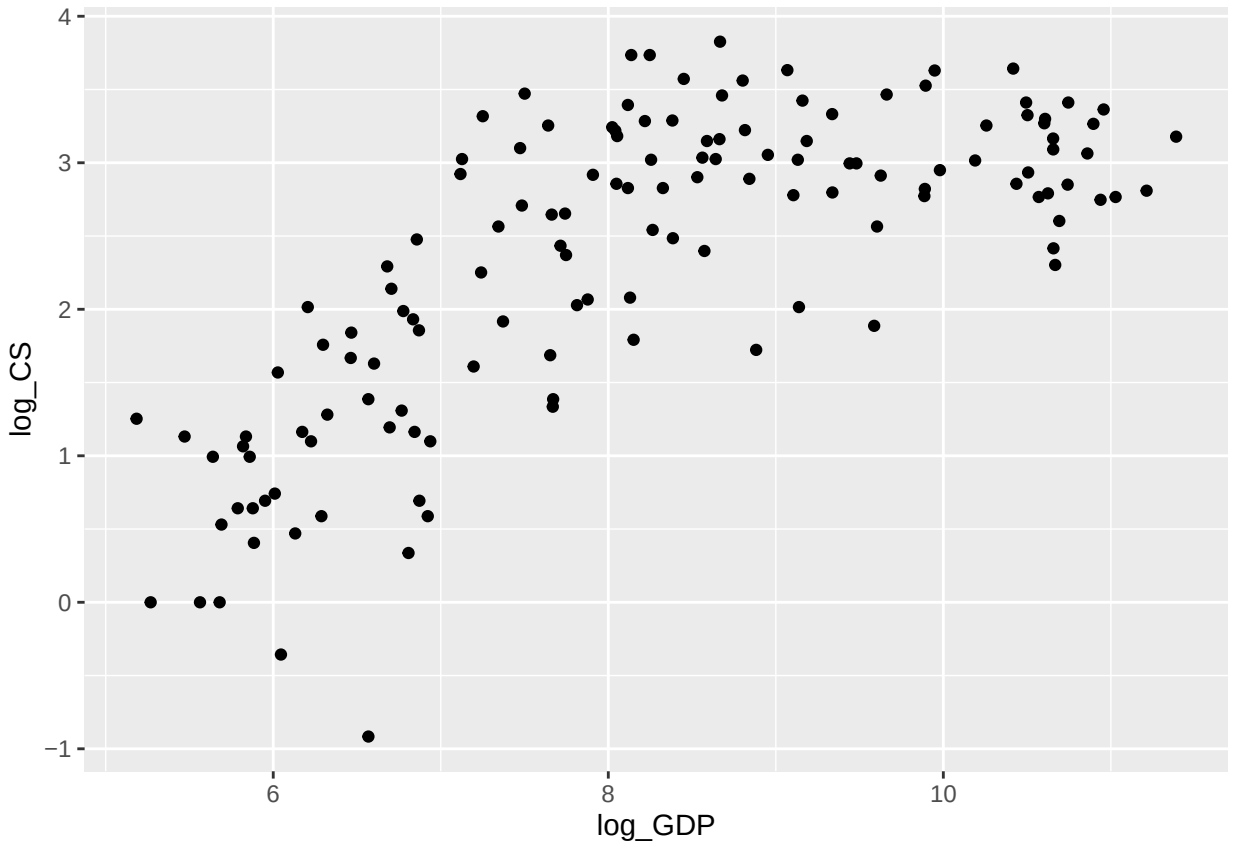
2.[1 point] Using the `mutate()` function, add two new logged variables to the data set `CS_data` and assign this new data set to `CS_data_log`. Call the variables `log_CS` and `log_GDP`. Use base e, also known as natural logarithms, to create the logged variables:

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


check_problem2()
```

```
## [1] "Checkpoint 1 Passed: You correctly named you dataset!"
## [1] "Checkpoint 2 Passed: You correctly transformed CS_rate_100!"
## [1] "Checkpoint 3 Passed: You correctly transformed GDP_2006!"
##
## Problem 2
## Checkpoints Passed: 3
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: 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
```



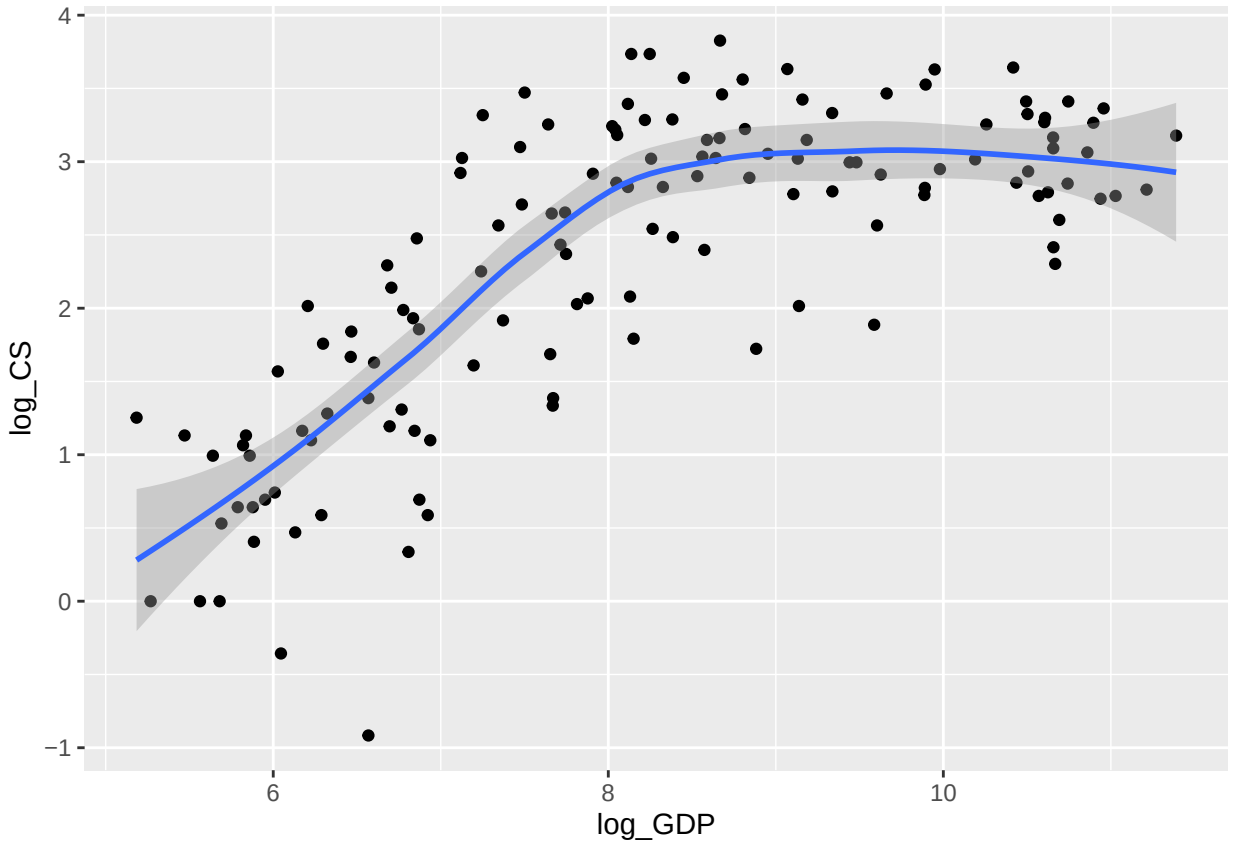

```
check_problem3()
```

```
## [1] "Checkpoint 1 Passed: A ggplot has been defined"
## [1] "Checkpoint 2 Passed: You've used the right dataset!"
## [1] "Checkpoint 3 Passed: You plotted the right variable!"
## [1] "Checkpoint 4 Passed: You've plotted the right variable!"
## [1] "Checkpoint 5 Passed: You correctly defined a scatter ggplot!"
##
## Problem 3
## Checkpoints Passed: 5
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

4. [1 point] A geom that you have not yet learnt 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'
```




```
check_problem4()
```

```
## [1] "Checkpoint 1 Passed: A ggplot has been defined"
## [1] "Checkpoint 2 Passed: You used the correct dataset!"
## [1] "Checkpoint 3 Passed: You plotted the correct variable!"
## [1] "Checkpoint 4 Passed: You plotted the correct variable!"
## [1] "Checkpoint 5 Passed: You've defined a scatterplot in ggplot!"
## [1] "Checkpoint 6 Passed: You've defined a geom_smooth in ggplot!"
##
## Problem 4
## Checkpoints Passed: 6
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

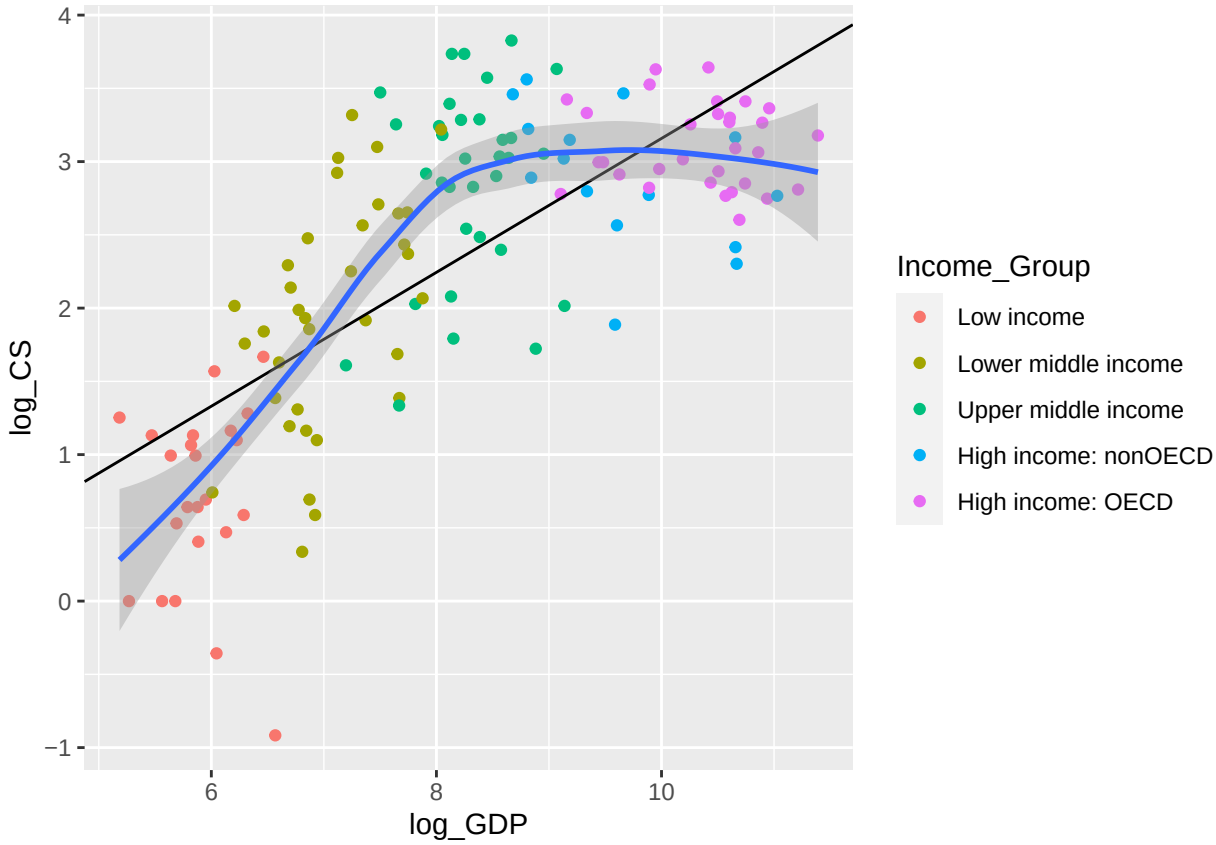
Does the relationship between logged GDP and logged CS look linear?

The relationship between logged GDP and logged CS is linear for the first 60% of our data. The points start to plateau after a log_GDP of 8.

5. [1 point] Modify your scatter plot by linking the color of the points to the variable `Income_Group`.

```
p5 <- ggplot(CS_data_log, aes(x = log_GDP, y = log_CS)) +
  geom_point(aes(col = Income_Group)) +
  geom_abline(slope = 0.457, intercept = -1.412) +
  geom_smooth()
p5
```

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




```
check_problem5()
```

```
## [1] "Checkpoint 1 Passed: A ggplot has been defined"
## [1] "Checkpoint 2 Passed: You used the correct dataset!"
## [1] "Checkpoint 3 Passed: You plotted the correct variable!"
## [1] "Checkpoint 4 Passed: You plotted the correct variable!"
## [1] "Checkpoint 5 Passed: You've defined a scatterplot!"
## [1] "Checkpoint 6 Error: Did you define a geom_smooth in ggplot?"
## [1] "Checkpoint 7 Passed: You've set the plot to color by Income_Group!"
##
## Problem 5
## Checkpoints Passed: 6
## Checkpoints Errored: 1
## 85.71% passed
```

```
## --------
## Test: FAILED
```

Based on this colored scatter plot, it looks like the relationship is linear for those countries that are not categorized as one of the two high income categories.

```
lm(log_CS ~ log_GDP, CS_data_log)
```

```
##
## Call:
## lm(formula = log_CS ~ log_GDP, data = CS_data_log)
##
## Coefficients:
## (Intercept)      log_GDP
##      -1.412        0.457
```

6. [1 point] For this lab, we would like to use linear regression. To do this, use a `dplyr` function to make a new data set 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):

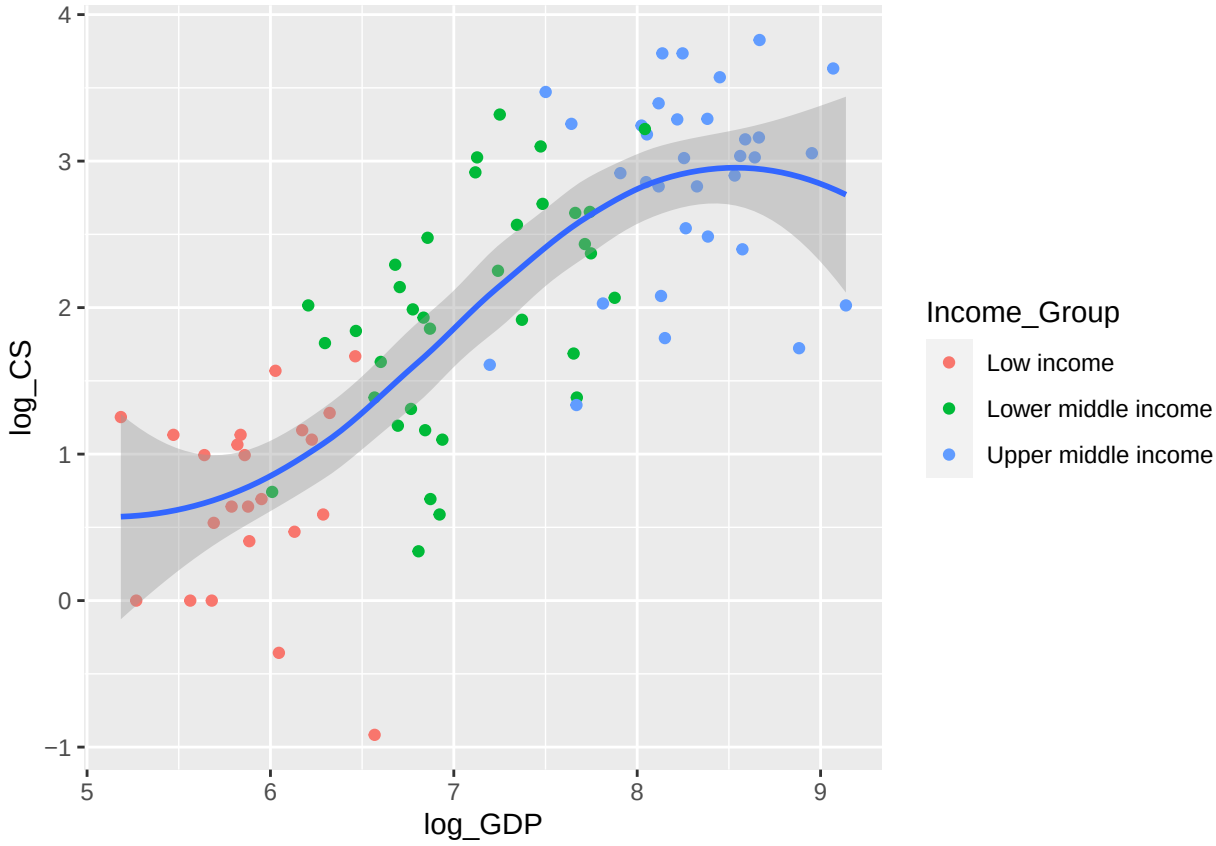
```
CS_data_sub <- CS_data_log %>% filter(Income_Group %in% c("Low income", "Lower middle income", "Upper mi

#CS_data_sub <- CS_data_log %>% filter(!(Income_Group %in% c("High income: nonOECD", "High income: OECD


check_problem6()
```

```
## [1] "Checkpoint 1 Passed: You've named your new dataset correctly!"
## [1] "Checkpoint 2 Passed: You've filtered Low income Group correctly!"
## [1] "Checkpoint 3 Passed: You've filtered Lower middle income Group correctly!"
## [1] "Checkpoint 4 Passed: You've filtered Upper middle income Group correctly!"
## [1] "Checkpoint 5 Passed: You've excluded High income: nonOECD group correctly!"
## [1] "Checkpoint 6 Passed: You've excluded High income: OECD group correctly!"
##
## Problem 6
## Checkpoints Passed: 6
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

7. [1 point] Remake the last scatter plot, this time using `CS_data_sub` to see if the relationship looks approximately linear between the logged variables:

```
p7 <- ggplot(CS_data_sub, aes(x = log_GDP, y = log_CS)) +
  geom_point(aes(col = Income_Group)) +
  geom_smooth()
p7
```

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




```
check_problem7()
```

```
## [1] "Checkpoint 1 Passed: A ggplot has been defined"
## [1] "Checkpoint 2 Passed: You've used the right dataset!"
## [1] "Checkpoint 3 Passed: You've plotted the right variable!"
## [1] "Checkpoint 4 Passed: You've plotted the right variable!"
## [1] "Checkpoint 5 Passed: You've defined a scatterplot in ggplot!"
## [1] "Checkpoint 6 Passed: You've defined a geom_smooth in ggplot!"
## [1] "Checkpoint 7 Passed: You've set the plot to color by Income_Group!"
##
## Problem 7
## Checkpoints Passed: 7
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

8. [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 data set!:

```
p8 <- lm(formula = log_CS ~ log_GDP, data = CS_data_sub)
tidy(p8)
```

```
## # A tibble: 2 x 5
##   term        estimate std.error statistic  p.value
##   <chr>          <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)   -3.94     0.515      -7.66 2.18e-11
## 2 log_GDP        0.819    0.0706     11.6  1.72e-19
```

```
check_problem8()
```

```
## [1] "Checkpoint 1 Passed: You've chosen the correct variable for the model!"
## [1] "Checkpoint 2 Passed: You've chosen the correct variable for the model!"
##
## Problem 8
## Checkpoints Passed: 2
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

9.Interpret the slope estimate:

A one unit increase in the natural log of GDP is associated with a 0.82 unit increase in the natural log of the cesarean delivery rate.

10.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.

We first need to convert the GDP onto the log (base e) scale. We can use the 'log()' function in R to take the logarithm of 2000 using base e. To use base 10, we can use the log10() function instead.

logCS = logGDP * slope + Intercept

- Step 1: Take the natrual log of GDP of 2000: log(2000) = 7.600902
- Step 2: Plug the logged GDP into the line of best fit formula:
  - logCS = logGDP * slope + Intercept
  - logCS = 7.600902 * slope + Intercept
  - logCS = 7.600902 * (0.819335) - 3.9404856
  - logCS = 2.287199
- Step 3: Exponentiate both sides of the equation to get back to the cesarean delivery rate.
  - exp(logCS) = exp(2.287199)
  - CS_rate = 9.847317% = 9.8%

Interpretation: A country with a GDP of 2000 is expected to have a cesarean delivery rate of 9.8%

11. 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 data set, would you expect the linear model to over or under predict?

A GDP of 50,000 corresponds to a logged GDP of 10.82. This value is outside of the range of our data that was used for the linear model. Because of this, we should NOT use the model to make this prediction because then we would be extrapolating data. If we did use the model, it would likely over-predict the country's cesarean delivery rate because the relationship between GDP and cesarean delivery rate is less steep for high income countries (more accurately, it plateaus after a log_GDP of around 8).

Check your score

Click on the middle icon on the top right of this code chunk (with the downwards gray arrow and green bar) to run all your code in order. Then, run this chunk to check your score.

```
# Just run this chunk.
total_score()
```

```
##              Test Points_Possible       Type
## Problem 1  PASSED               1 autograded
## Problem 2  PASSED               1 autograded
## Problem 3  PASSED               1 autograded
## Problem 4  PASSED               1 autograded
## Problem 5  FAILED               1 autograded
## Problem 6  PASSED               1 autograded
## Problem 7  PASSED               1 autograded
## Problem 8  PASSED               1 autograded
## Problem 9  FAILED               0 autograded
## Problem 10 FAILED               0 autograded
## Problem 11 FAILED               0 autograded
```

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-fa20/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 output.
5. If the submission fails, try to diagnose the issue using the error messages–if you have problems, post on Piazza under the post "Submission 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.