R Data Code

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R Markdown

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Section A: Data Examination
##############################

Loading of packages required for the data analysis

```
## ── Attaching packages
─────────────────────────────────────────────────────────────────────
──────── tidyverse 1.2.1 ──

## ✔ ggplot2 3.1.0     ✔ purrr   0.2.5
## ✔ tibble  1.4.2     ✔ dplyr   0.7.8
## ✔ tidyr   0.8.2     ✔ stringr 1.3.1
## ✔ readr   1.1.1     ✔ forcats 0.3.0

## ── Conflicts
──────────────────────────────────────────────────────────────────────
──────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()

##
## Attaching package: 'scales'

## The following object is masked from 'package:purrr':
##
##     discard

## The following object is masked from 'package:readr':
##
##     col_factor
```

Loading of data into R

```
raw_stats <-
read.csv("~/Documents/Class/CKME-136/Workshop/CKME136_Capstone/Da
ta/all_energy_statistics.csv")
```

We now look at the data loaded

```
head(raw_stats)
```

```
##   country_or_area             commodity_transaction year
## 1         Austria Additives and Oxygenates - Exports 1996
## 2         Austria Additives and Oxygenates - Exports 1995
## 3         Belgium Additives and Oxygenates - Exports 2014
## 4         Belgium Additives and Oxygenates - Exports 2013
## 5         Belgium Additives and Oxygenates - Exports 2012
## 6         Belgium Additives and Oxygenates - Exports 2011
##                      unit quantity quantity_footnotes
## 1 Metric tons,  thousand        5                 NA
## 2 Metric tons,  thousand       17                 NA
## 3 Metric tons,  thousand        0                 NA
## 4 Metric tons,  thousand        0                 NA
## 5 Metric tons,  thousand       35                 NA
## 6 Metric tons,  thousand       25                 NA
##                    category
## 1 additives_and_oxygenates
## 2 additives_and_oxygenates
## 3 additives_and_oxygenates
## 4 additives_and_oxygenates
## 5 additives_and_oxygenates
## 6 additives_and_oxygenates
```

Looking further:

```
summary(raw_stats)
```

```
##       country_or_area
##  Germany      :  20422
##  United States:  19847
##  Poland       :  19802
##  Austria      :  17440
##  Romania      :  17357
##  France       :  17236
##  (Other)      :1077378
##
commodity_transaction
##  From combustible fuels – Main activity                  :
6601
##  Electricity - Gross demand                              :
5532
##  Electricity - Gross production                          :
5523
##  Electricity - net production                            :
```

```
5523
##  Electricity - Own use by electricity, heat and CHP plants:
5523
##  Electricity - total production, main activity           :
5523
##
(Other)                                                   :1155257

##       year                          unit           quantity

##  Min.   :1990   Cubic metres, thousand : 52032   Min.   :   -
864348
##  1st Qu.:1997   Kilowatt-hours, million:147741   1st Qu.:
14
##  Median :2003   Kilowatts,  thousand   : 50229   Median :
189
##  Mean   :2003   Metric Tons            :   684   Mean   :
184265
##  3rd Qu.:2009   Metric tons,  thousand :759859   3rd Qu.:
2265
##  Max.   :2014   Terajoules             :178937
Max.   :6680329000
##

##  quantity_footnotes                      category
##  Min.   :1          total_electricity        :133916
##  1st Qu.:1          gas_oil_diesel_oil       : 97645
##  Median :1          fuel_oil                 : 75132
##  Mean   :1          natural_gas_including_lng: 64161
##  3rd Qu.:1          liquified_petroleum_gas  : 62156
##  Max.   :1          motor_gasoline           : 53198
##  NA's   :1025536    (Other)                  :703274

str(raw_stats)

## 'data.frame':    1189482 obs. of  7 variables:
##  $ country_or_area      : Factor w/ 243 levels
"Afghanistan",..: 14 14 21 21 21 21 21 21 58 58 ...
##  $ commodity_transaction: Factor w/ 2452 levels "Additives and
Oxygenates - Exports",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ year                 : int  1996 1995 2014 2013 2012 2011
2010 2009 1998 1995 ...
##  $ unit                 : Factor w/ 6 levels "Cubic metres,
thousand",..: 5 5 5 5 5 5 5 5 5 5 ...
##  $ quantity             : num  5 17 0 0 35 25 22 45 1 7 ...
##  $ quantity_footnotes   : int  NA NA NA NA NA NA NA NA NA
NA ...
##  $ category             : Factor w/ 71 levels
"additives_and_oxygenates",..: 1 1 1 1 1 1 1 1 1 1 ...

anyNA(raw_stats$quantity_footnotes)
```

```
## [1] TRUE
```

```
sum(is.na(raw_stats$quantity_footnotes))
```

```
## [1] 1025536
```

```
ncol(raw_stats)
```

```
## [1] 7
```

```
nrow(raw_stats)
```

```
## [1] 1189482
```

Dataset is 7 columns x 1,189,482 rows. Lots of N/A's in "quantity footnotes variable". Check to see how many.

```
(sum(is.na(raw_stats$quantity_footnotes))/nrow(raw_stats))*100
```

```
## [1] 86.21703
```

86% N/As! We will need to drop this column. For now, we need some descriptive statistics of the individual columns. First country_or_area

```
country_detail <- raw_stats %>% group_by(country_or_area) %>%
summarise(occurences = length(country_or_area)) %>%
arrange(desc(occurences))

head(country_detail, n=10)
```

```
## # A tibble: 10 x 2
##    country_or_area occurences
##    <fct>                <int>
##  1 Germany              20422
##  2 United States        19847
##  3 Poland               19802
##  4 Austria              17440
##  5 Romania              17357
##  6 France               17236
##  7 Japan                17037
##  8 Czechia              16588
##  9 Italy                16312
## 10 Netherlands          15955
```

```
tail(country_detail, n=10)
```

```
## # A tibble: 10 x 2
##    country_or_area                          occurences
##    <fct>                                         <int>
##  1 South Sudan                                     305
##  2 Germany, Fed. R. (former)                       293
##  3 Bonaire, St Eustatius, Saba                     224
##  4 Sint Maarten (Dutch part)                       219
```

```
##  5 German Dem. R. (former)                                106
##  6 Antarctic Fisheries                                     90
##  7 Pacific Islands (former)                                68
##  8 Yemen, Dem. (former)                                    61
##  9 Yemen Arab Rep. (former)                                45
## 10 Commonwealth of Independent States (CIS)                16
```

```
anyNA(country_detail)
```

```
## [1] FALSE
```

```
str(country_detail)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    243 obs. of  2
variables:
##  $ country_or_area: Factor w/ 243 levels "Afghanistan",..: 84
229 172 14 178 77 111 58 109 153 ...
##  $ occurences     : int  20422 19847 19802 17440 17357 17236
17037 16588 16312 15955 ...
```

```
summary(country_detail)
```

```
##        country_or_area   occurences
##  Afghanistan   :  1    Min.   :   16
##  Albania       :  1    1st Qu.: 1914
##  Algeria       :  1    Median : 3406
##  American Samoa:  1    Mean   : 4895
##  Andorra       :  1    3rd Qu.: 5890
##  Angola        :  1    Max.   :20422
##  (Other)       :237
```

Commodity transaction stats:

```
commodity_detail <- raw_stats %>% group_by(commodity_transaction)
%>% summarise(occurences = length(commodity_transaction)) %>%
arrange(desc(occurences))
```

```
head(commodity_detail, n=10)
```

```
## # A tibble: 10 x 2
##    commodity_transaction
occurences
##    <fct>
<int>
##  1 From combustible fuels – Main activity
6601
##  2 Electricity - Gross demand
5532
##  3 Electricity - Gross production
5523
##  4 Electricity - net production
5523
```

```
##  5 Electricity - Own use by electricity, heat and CHP plants
5523
##  6 Electricity - total production, main activity
5523
##  7 Electricity - total net installed capacity of electric
powe…       5521
##  8 Electricity - total net installed capacity of electric
powe…       5521
##  9 Electricity - Final energy consumption
5499
## 10 Electricity - Consumption by other
5491
```

```
tail(commodity_detail, n=10)
```

```
## # A tibble: 10 x 2
##    commodity_transaction
occurences
##    <fct>
<int>
##  1 Refinery gas - Transformation in coke ovens
1
##  2 "Vegetal waste - Consumption by construction "
1
##  3 "Vegetal waste - Consumption by mining and quarrying "
1
##  4 "White spirit and special boiling point industrial spirits
…           1
##  5 "White spirit and special boiling point industrial spirits
…           1
##  6 "White spirit and special boiling point industrial spirits
…           1
##  7 White spirit and special boiling point industrial spirits -
…           1
##  8 "White spirit and special boiling point industrial spirits
…           1
##  9 "White spirit and special boiling point industrial spirits
…           1
## 10 "White spirit and special boiling point industrial spirits
…           1
```

```
anyNA(commodity_detail)
```

```
## [1] FALSE
```

```
str(commodity_detail)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    2452 obs. of  2
variables:
##  $ commodity_transaction: Factor w/ 2452 levels "Additives and
Oxygenates - Exports",..: 832 719 720 737 744 766 758 759 718 702
```

```
...
##  $ occurences           : int  6601 5532 5523 5523 5523 5523
5521 5521 5499 5491 ...
```

```
summary(commodity_detail)
```

```
##
commodity_transaction
##  Additives and Oxygenates - Exports                    :   1
##  Additives and Oxygenates - Imports                    :   1
##  Additives and Oxygenates - Production                 :   1
##  Additives and Oxygenates - Receipts from other sources:   1
##  Additives and Oxygenates - Stock changes              :   1
##  Additives and Oxygenates - Total energy supply        :   1
##  (Other)                                               :2446
##    occurences
##  Min.   :   1.0
##  1st Qu.:  23.0
##  Median :  99.0
##  Mean   : 485.1
##  3rd Qu.: 476.0
##  Max.   :6601.0
##
```

Year is pretty straightforward.

```
year_detail <- raw_stats %>% group_by(year) %>%
summarise(occurences = length(year)) %>%
arrange(desc(occurences))
```

```
year_detail
```

```
## # A tibble: 25 x 2
##     year occurences
##    <int>      <int>
##  1  2014      56264
##  2  2013      56109
##  3  2012      55838
##  4  2011      55214
##  5  2010      54544
##  6  2008      53852
##  7  2009      53769
##  8  2007      52248
```

```
##  9  2006      49397
## 10  2005      49203
## # ... with 15 more rows
```

```
anyNA(year_detail)
```

```
## [1] FALSE
```

```
str(year_detail)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    25 obs. of  2
variables:
##  $ year      : int  2014 2013 2012 2011 2010 2008 2009 2007
2006 2005 ...
##  $ occurences: int  56264 56109 55838 55214 54544 53852 53769
52248 49397 49203 ...
```

```
summary(year_detail)
```

```
##       year        occurences
##  Min.   :1990   Min.   :36280
##  1st Qu.:1996   1st Qu.:43550
##  Median :2002   Median :46520
##  Mean   :2002   Mean   :47579
##  3rd Qu.:2008   3rd Qu.:53769
##  Max.   :2014   Max.   :56264
```

Unit column:

```
unit_detail <- raw_stats %>% group_by(unit) %>%
summarise(occurences = length(unit)) %>%
arrange(desc(occurences))

unit_detail
```

```
## # A tibble: 6 x 2
##   unit                     occurences
##   <fct>                         <int>
## 1 Metric tons,  thousand       759859
## 2 Terajoules                   178937
## 3 Kilowatt-hours, million      147741
## 4 Cubic metres, thousand        52032
## 5 Kilowatts,  thousand          50229
## 6 Metric Tons                     684
```

```
anyNA(unit_detail)
```

```
## [1] FALSE
```

```
str(unit_detail)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    6 obs. of  2
variables:
```

```
##  $ unit      : Factor w/ 6 levels "Cubic metres, thousand",..:
5 6 2 1 3 4
##  $ occurences: int  759859 178937 147741 52032 50229 684
```

```
summary(unit_detail)
```

```
##                        unit     occurences
##  Cubic metres, thousand :1   Min.   :   684
##  Kilowatt-hours, million:1   1st Qu.: 50680
##  Kilowatts,  thousand   :1   Median : 99886
##  Metric Tons            :1   Mean   :198247
##  Metric tons,  thousand :1   3rd Qu.:171138
##  Terajoules             :1   Max.   :759859
```

Quantity column:

```
anyNA(raw_stats$quantity)
```

```
## [1] FALSE
```

```
str(raw_stats$quantity)
```

```
##  num [1:1189482] 5 17 0 0 35 25 22 45 1 7 ...
```

```
summary(raw_stats$quantity)
```

```
##       Min.    1st Qu.     Median       Mean    3rd Qu.
Max.
##    -864348         14        189     184265       2265
6680329000
```

We already know about quantity_footnotes so next up is the category column:

```
category_detail <- raw_stats %>% group_by(category) %>%
summarise(occurences = length(category)) %>%
arrange(desc(occurences))

head(category_detail, n=10)
```

```
## # A tibble: 10 x 2
##    category
occurences
##    <fct>
<int>
##  1 total_electricity
133916
##  2 gas_oil_diesel_oil
97645
##  3 fuel_oil
75132
##  4 natural_gas_including_lng
64161
```

```
##  5 liquified_petroleum_gas
62156
##  6 motor_gasoline
53198
##  7 fuelwood
52032
##  8 electricity_net_installed_capacity_of_electric_power_plants
50229
##  9 other_kerosene
43466
## 10 hard_coal
42307
```

```
tail(category_detail, n=10)
```

```
## # A tibble: 10 x 2
##    category                         occurences
##    <fct>                                 <int>
##  1 gasoline_type_jet_fuel                 1293
##  2 falling_water                           962
##  3 solar_electricity                       953
##  4 nuclear_electricity                     756
##  5 oil_shale_oil_sands                     756
##  6 uranium                                 684
##  7 geothermal                              496
##  8 gas_coke                                365
##  9 other_coal_products                     105
## 10 tide_wave_and_ocean_electricity          58
```

```
anyNA(category_detail)
```

```
## [1] FALSE
```

```
str(category_detail)
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    71 obs. of  2
variables:
##  $ category  : Factor w/ 71 levels
"additives_and_oxygenates",..: 67 27 24 42 37 39 25 21 51 31 ...
##  $ occurences: int  133916 97645 75132 64161 62156 53198 52032
50229 43466 42307 ...
```

```
summary(category_detail)
```

```
##                      category    occurences
##  additives_and_oxygenates: 1   Min.   :    58
##  animal_waste            : 1   1st Qu.:  2208
##  anthracite              : 1   Median :  6470
##  aviation_gasoline       : 1   Mean   : 16753
##  bagasse                 : 1   3rd Qu.: 20236
##  biodiesel               : 1   Max.   :133916
##  (Other)                 :65
```

We do some cleanup.

```
rm(category_detail)

rm(commodity_detail)

rm(country_detail)

rm(unit_detail)

rm(year_detail)
```

Lastly we drop the quantity footnotes column and use the raw statistics as a tibble dataframe going forward.

```
test_data <- as_tibble(raw_stats)

class(test_data)

## [1] "tbl_df"     "tbl"        "data.frame"

test_data <- test_data %>% select(-quantity_footnotes)
```

Section B: Data Analysis
################################## Part 1: Hard Coal
————————–

We filter the categories of interest, beginning with ‘Hard coal’. We drop columns we don’t need, group the countries together, and sort the results in ascending order by country followed by year. Lastly we nest the result by the grouped country.

```
hard_coal <- test_data %>% filter(commodity_transaction == "Hard
coal - transformation in electricity, CHP and heat plants") %>%
select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest()

head(hard_coal)

## # A tibble: 6 x 2
##   country_or_area data
##   <fct>           <list>
## 1 Afghanistan     <tibble [16 × 3]>
## 2 Argentina       <tibble [25 × 3]>
## 3 Australia       <tibble [25 × 3]>
## 4 Austria         <tibble [25 × 3]>
## 5 Bangladesh      <tibble [19 × 3]>
## 6 Belarus         <tibble [9 × 3]>
```

```
# Check to see the structure of the 'data' tibble - say
Afghanistan
pluck(hard_coal, "data") %>% pluck(1) %>% head()
```

```
## # A tibble: 6 x 3
##    year unit                    quantity
##   <int> <fct>                      <dbl>
## 1  1990 Metric tons,  thousand       40
## 2  1991 Metric tons,  thousand       40
## 3  2001 Metric tons,  thousand       20
## 4  2002 Metric tons,  thousand       20
## 5  2003 Metric tons,  thousand       30
## 6  2004 Metric tons,  thousand       30
```

We create new data columns using the ‘mutate’ and ‘map’ commands. From the data we extract the following information: - initial_year: (first recorded year of transforming this resource), initial_transformation (recorded units of transformation in first recorded year) - linear model: (derived linear model of transformation units as described by year) - slope: (slope of linear model: +ve/-ve) - r_squared: (statistical measure of how close the model data is to the fitted regression line)

```
hard_coal <- test_data %>% filter(commodity_transaction == "Hard
coal - transformation in electricity, CHP and heat plants") %>%
select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest() %>% mutate(initial_year = map_int((map(data, "year")), 1),
initial_transformation = map_dbl((map(data, "quantity")), 1),
model = map(data, ~lm(quantity ~ year, data =  .)), slope =
map_dbl(model, ~pluck(coef(.), "year")), r_squared =
map_dbl(model, ~pluck(glance(.), "r.squared")), adj_r_squared =
map_dbl(model, ~pluck(glance(.), "adj.r.squared")) )

head(hard_coal)
```

```
## # A tibble: 6 x 8
##   country_or_area data  initial_year initial_transfo… model
slope
##   <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
## 1 Afghanistan     <tib…         1990               40 <S3:…
0.707
## 2 Argentina       <tib…         1990              205 <S3:…
23.3
## 3 Australia       <tib…         1990            23913 <S3:… -
139.
## 4 Austria         <tib…         1990             1421 <S3:…
19.1
## 5 Bangladesh      <tib…         1990                0 <S3:…
```

```
26.6
## 6 Belarus         <tib…         2006               73 <S3:…
-7.12
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>

# Descriptive statistics on our output data
summary(hard_coal$initial_year)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1990    1990    1990    1993    1992    2012

summary(hard_coal$slope)

##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.     NA's

## -5766.27   -11.41     3.31  1193.27    44.13 81557.11        2

summary(hard_coal$r_squared)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.0000  0.1824  0.5720  0.5053  0.7738  0.9908
```

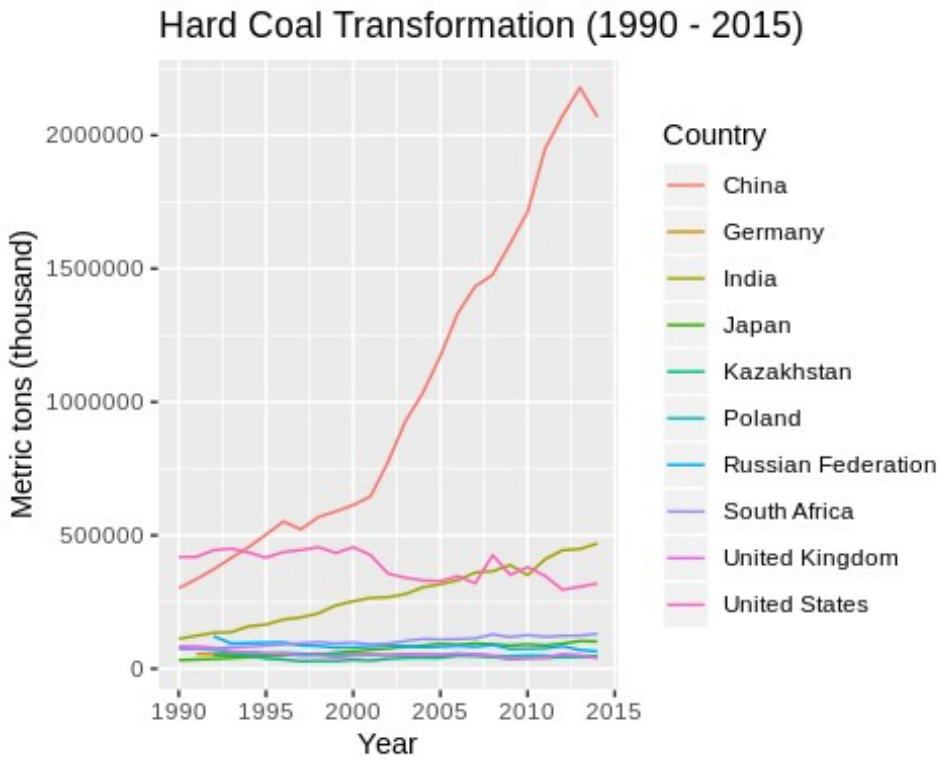
We can now begin our analysis on this data. We obtain the a list of the top 10 countries that began with the highest transformtion of coal into electricity.

```
hard_coal %>% arrange(desc(initial_transformation)) %>% head(10)

## # A tibble: 10 x 8
##    country_or_area data  initial_year initial_transfo… model
slope
##    <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
##  1 United States   <tib…         1990           418513 <S3:…
-5766.
##  2 China           <tib…         1990           301998 <S3:…
81557.
##  3 Russian Federa… <tib…         1992           121629 <S3:…
-1343.
##  4 India           <tib…         1990           111940 <S3:…
14854.
##  5 United Kingdom  <tib…         1990            84014 <S3:…
-1218.
##  6 Poland          <tib…         1990            77554 <S3:…
-1010.
##  7 South Africa    <tib…         1990            74186 <S3:…
2371.
##  8 Germany         <tib…         1991            55723 <S3:…
-622.
##  9 Kazakhstan      <tib…         1992            52140 <S3:…
197.
```

```
## 10 Japan           <tib…         1990            31785 <S3:…
3103.
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

At this point we can generate a chart to see how these countries hard coal transformation into electricity change over time.

```
hard_coal %>% arrange(desc(initial_transformation)) %>% head(10)
%>% unnest(data) %>% ggplot(country_or_area, mapping = aes(x =
year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area)) +labs(y= "Metric tons (thousand)", x = "Year")
+ ggtitle("Hard Coal Transformation (1990 - 2015)")+ labs(colour
= "Country")
```



Part 2: Brown Coal

Same code as before but different variable.

```
brown_coal <- test_data %>% filter(commodity_transaction ==
"Brown coal - Transformation in electricity, CHP and heat
plants") %>% select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest()

head(brown_coal)
```

```
## # A tibble: 6 x 2
##   country_or_area        data
##   <fct>                  <list>
## 1 Australia              <tibble [25 × 3]>
## 2 Austria                <tibble [17 × 3]>
## 3 Belgium                <tibble [15 × 3]>
## 4 Bosnia and Herzegovina <tibble [23 × 3]>
## 5 Bulgaria               <tibble [25 × 3]>
## 6 Cambodia               <tibble [7 × 3]>
```

```
pluck(brown_coal, "data") %>% pluck(1) %>% head()
```

```
## # A tibble: 6 x 3
##    year unit                    quantity
##   <int> <fct>                      <dbl>
## 1  1990 Metric tons,  thousand    58421
## 2  1991 Metric tons,  thousand    62332
## 3  1992 Metric tons,  thousand    64012
## 4  1993 Metric tons,  thousand    61619
## 5  1994 Metric tons,  thousand    64849
## 6  1995 Metric tons,  thousand    66407
```

```
brown_coal <- test_data %>% filter(commodity_transaction ==
"Brown coal - Transformation in electricity, CHP and heat
plants") %>% select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest() %>% mutate(initial_year = map_int((map(data, "year")), 1),
initial_transformation = map_dbl((map(data, "quantity")), 1),
model = map(data, ~lm(quantity ~ year, data =  .)), slope =
map_dbl(model, ~pluck(coef(.), "year")), r_squared =
map_dbl(model, ~pluck(glance(.), "r.squared")), adj_r_squared =
map_dbl(model, ~pluck(glance(.), "adj.r.squared")) )
```

```
head(brown_coal)
```

```
## # A tibble: 6 x 8
##   country_or_area data  initial_year initial_transfo… model
slope
##   <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
## 1 Australia       <tib…         1990            58421 <S3:…
1780.
## 2 Austria         <tib…         1990             2133 <S3:…
-43.7
## 3 Belgium         <tib…         1990              936 <S3:…
-56.3
## 4 Bosnia and Her… <tib…         1992             7317 <S3:…
389.
## 5 Bulgaria        <tib…         1990            26211 <S3:…
213.
## 6 Cambodia        <tib…         2008                0 <S3:…
```

```
58.4
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

```
# Descriptive statistics
summary(brown_coal$initial_year)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1990    1990    1990    1994    1992    2013
```

```
summary(brown_coal$slope)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.     NA's

## -985.537  -60.167   -0.141  260.827  185.274 8598.847        2
```

```
summary(brown_coal$r_squared)
```

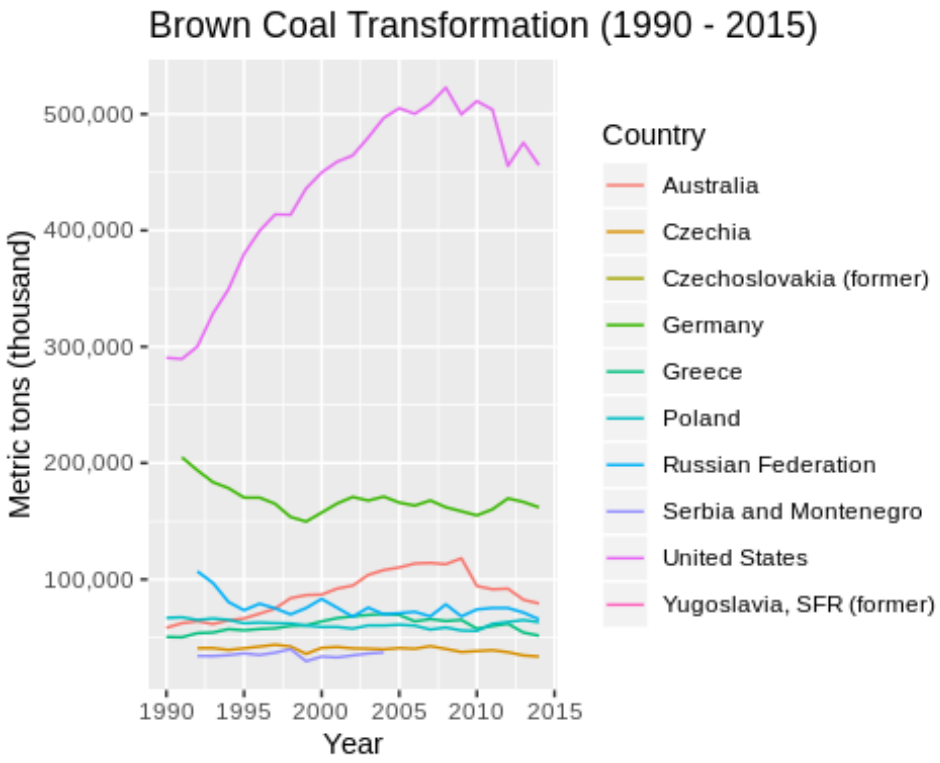
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.0000  0.1214  0.3927  0.4361  0.7529  1.0000
```

Analysis and charts

```
brown_coal %>% arrange(desc(initial_transformation)) %>% head(10)
```

```
## # A tibble: 10 x 8
##    country_or_area data  initial_year initial_transfo… model
slope
##    <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
##  1 United States   <tib…         1990           290523 <S3:…
8599.
##  2 Germany         <tib…         1991           204903 <S3:…
-986.
##  3 Russian Federa… <tib…         1992           106834 <S3:…
-830.
##  4 Poland          <tib…         1990            66915 <S3:…
-234.
##  5 Czechoslovakia… <tib…         1990            63000 <S3:…
NA
##  6 Yugoslavia, SF… <tib…         1990            60458 <S3:…
NA
##  7 Australia       <tib…         1990            58421 <S3:…
1780.
##  8 Greece          <tib…         1990            50531 <S3:…
302.
##  9 Czechia         <tib…         1992            40889 <S3:…
-224.
## 10 Serbia and Mon… <tib…         1992            34158 <S3:…
41.7
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

```
brown_coal %>% arrange(desc(initial_transformation)) %>% head(10)
%>% unnest(data) %>% ggplot(country_or_area, mapping = aes(x =
year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area)) + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Year") +
ggtitle("Brown Coal Transformation (1990 - 2015)")+ labs(colour =
"Country")
```



Part 3: Fuel Oil

```
fuel_oil <- test_data %>% filter(commodity_transaction == "Fuel
oil - Transformation in electricity, CHP and heat plants") %>%
select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest()

head(fuel_oil)
```

```
## # A tibble: 6 x 2
##   country_or_area     data
##   <fct>               <list>
## 1 Afghanistan         <tibble [24 × 3]>
## 2 Albania             <tibble [18 × 3]>
## 3 Algeria             <tibble [8 × 3]>
## 4 Angola              <tibble [25 × 3]>
## 5 Antigua and Barbuda <tibble [25 × 3]>
## 6 Argentina           <tibble [25 × 3]>
```

```r
pluck(fuel_oil, "data") %>% pluck(1) %>% head()
```

```
## # A tibble: 6 x 3
##    year unit                    quantity
##   <int> <fct>                      <dbl>
## 1  1990 Metric tons,  thousand        4
## 2  1991 Metric tons,  thousand        3
## 3  1992 Metric tons,  thousand        2
## 4  1993 Metric tons,  thousand        2
## 5  1994 Metric tons,  thousand        2
## 6  1995 Metric tons,  thousand        2
```

```r
fuel_oil <- test_data %>% filter(commodity_transaction == "Fuel
oil - Transformation in electricity, CHP and heat plants") %>%
select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest() %>% mutate(initial_year = map_int((map(data, "year")), 1),
initial_transformation = map_dbl((map(data, "quantity")), 1),
model = map(data, ~lm(quantity ~ year, data =  .)), slope =
map_dbl(model, ~pluck(coef(.), "year")), r_squared =
map_dbl(model, ~pluck(glance(.), "r.squared")), adj_r_squared =
map_dbl(model, ~pluck(glance(.), "adj.r.squared")) )
```

```
## Warning in stats::summary.lm(x): essentially perfect fit:
summary may be
## unreliable

## Warning in stats::summary.lm(x): essentially perfect fit:
summary may be
## unreliable
```

```r
head(fuel_oil)
```

```
## # A tibble: 6 x 8
##   country_or_area data  initial_year initial_transfo… model
slope
##   <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
## 1 Afghanistan     <tib…         1990                4 <S3:…  -
0.0818
## 2 Albania         <tib…         1990              169 <S3:…  -
6.77
## 3 Algeria         <tib…         1990                0 <S3:…  -
0.0357
## 4 Angola          <tib…         1990               40 <S3:…
6.96
## 5 Antigua and Ba… <tib…         1990                9 <S3:…
1.26
## 6 Argentina       <tib…         1990             1800 <S3:…
67.1
```

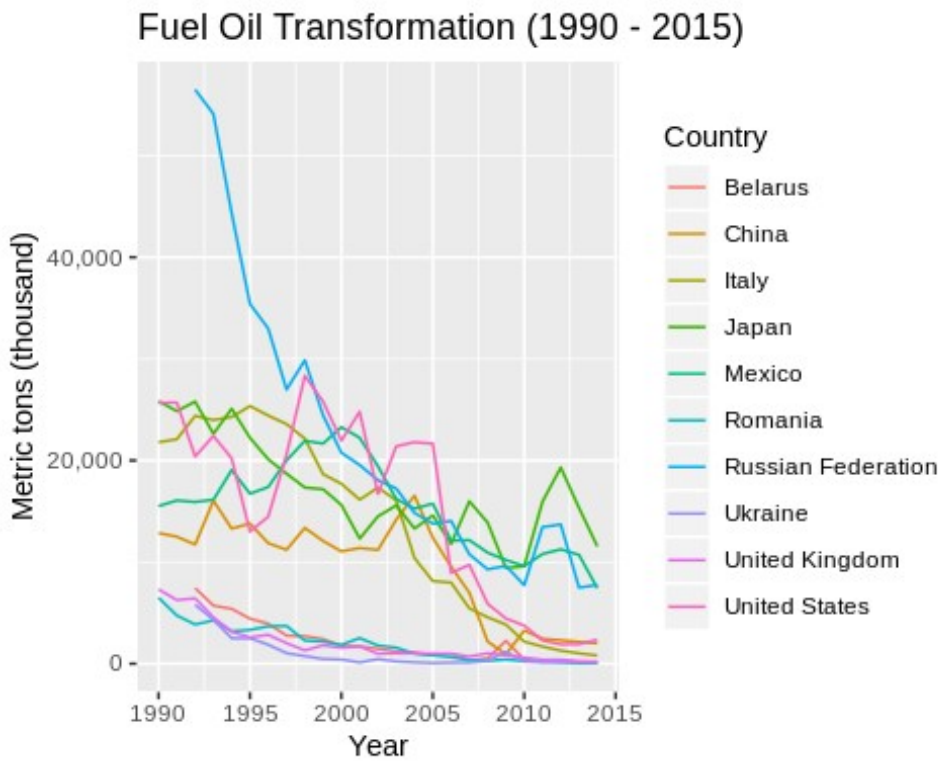
```
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>

# Descriptive statistics on our output data
summary(fuel_oil$initial_year)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1990    1990    1990    1993    1992    2012

summary(fuel_oil$slope)

##       Min.    1st Qu.     Median       Mean    3rd Qu.
Max.
## -1904.6690   -25.0378    -0.2062   -44.9352     3.6897
335.8062
##       NA's
##          2

summary(fuel_oil$r_squared)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##  0.0000  0.2210  0.5144  0.4959  0.7486  1.0000       1
```

Analysis and charts

```
fuel_oil %>% arrange(desc(initial_transformation)) %>% head(10)

## # A tibble: 10 x 8
##    country_or_area data  initial_year initial_transfo… model
slope
##    <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
##  1 Russian Federa… <tib…         1992            56504 <S3:… -
1905.
##  2 Japan           <tib…         1990            25834 <S3:…
-536.
##  3 United States   <tib…         1990            25666 <S3:…
-999.
##  4 Italy           <tib…         1990            21798 <S3:… -
1197.
##  5 Mexico          <tib…         1990            15508 <S3:…
-407.
##  6 China           <tib…         1990            12856 <S3:…
-547.
##  7 Belarus         <tib…         1992             7434 <S3:…
-264.
##  8 United Kingdom  <tib…         1990             7313 <S3:…
-235.
##  9 Romania         <tib…         1990             6492 <S3:…
-229.
## 10 Ukraine         <tib…         1992             5800 <S3:…
-159.
```

```
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

```
fuel_oil %>% arrange(desc(initial_transformation)) %>% head(10)
%>% unnest(data) %>% ggplot(country_or_area, mapping = aes(x =
year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area)) + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) + scale_x_continuous(name="Year") +
ggtitle("Fuel Oil Transformation (1990 - 2015)")+ labs(colour =
"Country")
```



Part 4: Gas Oil/Diesel Oil

```
gasdiesel_oil <- test_data %>% filter(commodity_transaction ==
"Gas Oil/ Diesel Oil - Transformation in electricity, CHP and
heat plants") %>% select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest()
```

```
head(gasdiesel_oil)
```

```
## # A tibble: 6 x 2
##   country_or_area     data
##   <fct>               <list>
## 1 Afghanistan         <tibble [25 × 3]>
## 2 Albania             <tibble [3 × 3]>
## 3 Algeria             <tibble [25 × 3]>
## 4 Angola              <tibble [18 × 3]>
```

```
## 5 Anguilla            <tibble [25 × 3]>
## 6 Antigua and Barbuda <tibble [25 × 3]>
```

```
pluck(gasdiesel_oil, "data") %>% pluck(1) %>% head()
```

```
## # A tibble: 6 x 3
##    year unit                   quantity
##   <int> <fct>                     <dbl>
## 1  1990 Metric tons,  thousand       50
## 2  1991 Metric tons,  thousand       50
## 3  1992 Metric tons,  thousand       50
## 4  1993 Metric tons,  thousand       50
## 5  1994 Metric tons,  thousand       50
## 6  1995 Metric tons,  thousand       50
```

```
gasdiesel_oil <- test_data %>% filter(commodity_transaction ==
"Gas Oil/ Diesel Oil - Transformation in electricity, CHP and
heat plants") %>% select(-commodity_transaction, -category) %>%
group_by(country_or_area) %>% arrange(country_or_area, year) %>%
nest() %>% mutate(initial_year = map_int((map(data, "year")), 1),
initial_transformation = map_dbl((map(data, "quantity")), 1),
model = map(data, ~lm(quantity ~ year, data =  .)), slope =
map_dbl(model, ~pluck(coef(.), "year")), r_squared =
map_dbl(model, ~pluck(glance(.), "r.squared")), adj_r_squared =
map_dbl(model, ~pluck(glance(.), "adj.r.squared")) )
```

```
## Warning in stats::summary.lm(x): essentially perfect fit:
summary may be
## unreliable
```

```
## Warning in stats::summary.lm(x): essentially perfect fit:
summary may be
## unreliable
```

```
head(gasdiesel_oil)
```

```
## # A tibble: 6 x 8
##   country_or_area data  initial_year initial_transfo… model
slope
##   <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
## 1 Afghanistan     <tib…         1990               50 <S3:…  -
1.58
## 2 Albania         <tib…         2000               21 <S3:…  -
7.5
## 3 Algeria         <tib…         1990              125 <S3:…
25.2
## 4 Angola          <tib…         1997               51 <S3:…
42.1
## 5 Anguilla        <tib…         1990                4 <S3:…
0.807
```

```
## 6 Antigua and Ba… <tib…          1990                24 <S3:…
1.68
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

```
# Descriptive statistics
summary(gasdiesel_oil$initial_year)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1990    1990    1990    1992    1990    2012
```

```
summary(gasdiesel_oil$slope)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
## -138.9125   -0.3634    0.3531   15.8313    3.2729 1559.5000
```

```
summary(gasdiesel_oil$r_squared)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
NA's
## 0.0000123 0.1509958 0.4642213 0.4668467 0.7596032 0.9847941
1
```

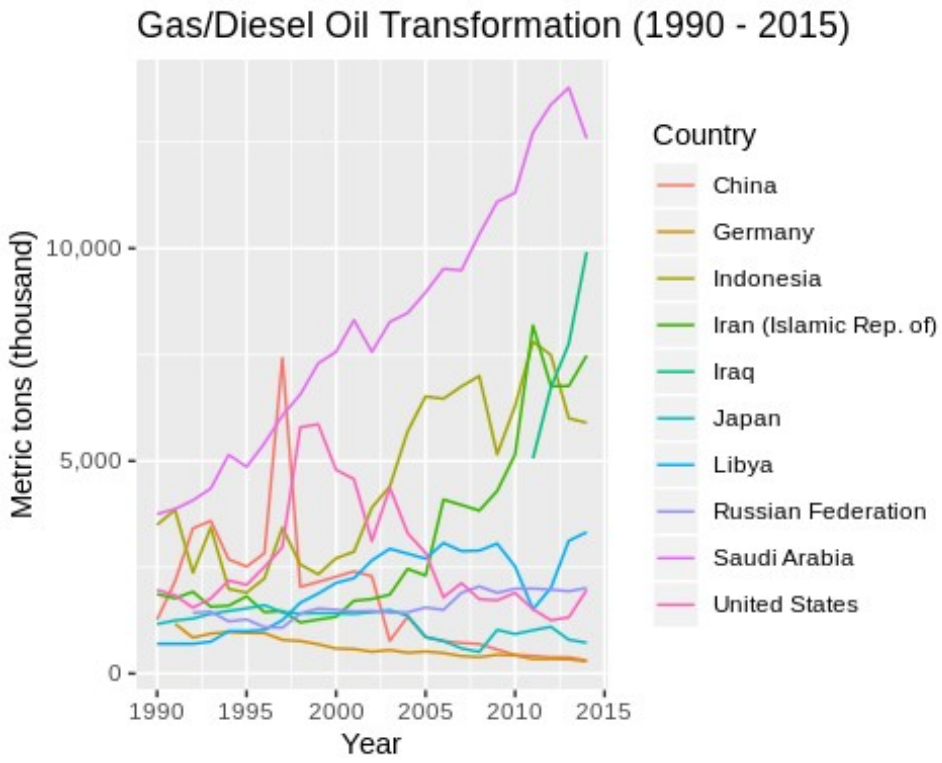
Analysis and charts

```
gasdiesel_oil %>% arrange(desc(initial_transformation)) %>%
head(10)
```

```
## # A tibble: 10 x 8
##    country_or_area data  initial_year initial_transfo… model
slope
##    <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
##  1 Iraq            <tib…         2011             5061 <S3:…
1559.
##  2 Saudi Arabia    <tib…         1990             3752 <S3:…
417.
##  3 Indonesia       <tib…         1990             3500 <S3:…
216.
##  4 United States   <tib…         1990             1969 <S3:…
-40.7
##  5 Iran (Islamic … <tib…         1990             1868 <S3:…
246.
##  6 Russian Federa… <tib…         1992             1430 <S3:…
39.3
##  7 China           <tib…         1990             1269 <S3:…
-139.
##  8 Germany         <tib…         1991             1172 <S3:…
-33.6
##  9 Japan           <tib…         1990             1163 <S3:…
-29.7
## 10 Libya           <tib…         1990              700 <S3:…
```

```
103.
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

```
gasdiesel_oil %>% arrange(desc(initial_transformation)) %>%
head(10) %>% unnest(data) %>% ggplot(country_or_area, mapping =
aes(x = year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area)) + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Year") +
ggtitle("Gas/Diesel Oil Transformation (1990 - 2015)")+
labs(colour = "Country")
```



Part 5: Natural Gas (including LNG)

```
natural_gas <- test_data %>% filter(commodity_transaction ==
"Natural gas (including LNG) - transformation in electricity, CHP
and heat plants") %>% select(-commodity_transaction, -category)
%>% group_by(country_or_area) %>% arrange(country_or_area, year)
%>% nest()

head(natural_gas)
```

```
## # A tibble: 6 x 2
##   country_or_area data
##   <fct>           <list>
## 1 Algeria         <tibble [25 × 3]>
## 2 Argentina       <tibble [25 × 3]>
## 3 Armenia         <tibble [23 × 3]>
```

```
## 4 Australia       <tibble [25 × 3]>
## 5 Austria         <tibble [25 × 3]>
## 6 Azerbaijan      <tibble [23 × 3]>
```

```
pluck(natural_gas, "data") %>% pluck(1) %>% head()
```

```
## # A tibble: 6 x 3
##    year unit       quantity
##   <int> <fct>         <dbl>
## 1  1990 Terajoules   179712
## 2  1991 Terajoules   192337
## 3  1992 Terajoules   200313
## 4  1993 Terajoules   237719
## 5  1994 Terajoules   252618
## 6  1995 Terajoules   259020
```

```
natural_gas <- test_data %>% filter(commodity_transaction ==
"Natural gas (including LNG) - transformation in electricity, CHP
and heat plants") %>% select(-commodity_transaction, -category)
%>% group_by(country_or_area) %>% arrange(country_or_area, year)
%>% nest() %>% mutate(initial_year = map_int((map(data, "year")),
1), initial_transformation = map_dbl((map(data, "quantity")), 1),
model = map(data, ~lm(quantity ~ year, data =  .)), slope =
map_dbl(model, ~pluck(coef(.), "year")), r_squared =
map_dbl(model, ~pluck(glance(.), "r.squared")), adj_r_squared =
map_dbl(model, ~pluck(glance(.), "adj.r.squared")) )

head(natural_gas)
```

```
## # A tibble: 6 x 8
##   country_or_area data  initial_year initial_transfo… model
slope
##   <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
## 1 Algeria         <tib…         1990           179712 <S3:…
1.64e4
## 2 Argentina       <tib…         1990           243136 <S3:…
1.99e4
## 3 Armenia         <tib…         1992            22800 <S3:… -
3.06e1
## 4 Australia       <tib…         1990           161478 <S3:…
1.76e4
## 5 Austria         <tib…         1990            82181 <S3:…
3.44e2
## 6 Azerbaijan      <tib…         1992           117775 <S3:…
7.82e3
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>
```

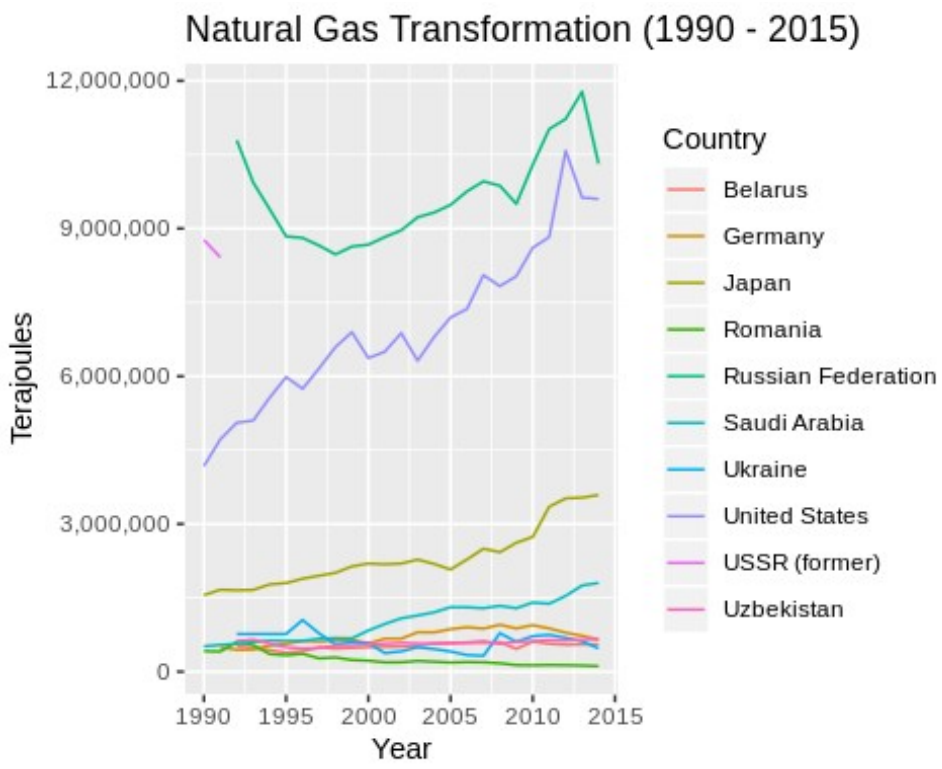
```
# Descriptive statistics on our output data
summary(natural_gas$initial_year)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1990    1990    1990    1993    1993    2011

summary(natural_gas$slope)

##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
NA's
## -350937.0     216.1    2794.5    9065.1   14219.6  210181.2
2

summary(natural_gas$r_squared)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.0000  0.2685  0.6901  0.5759  0.8518  1.0000
```

Analysis and charts

```
natural_gas %>% arrange(desc(initial_transformation)) %>%
head(10)

## # A tibble: 10 x 8
##    country_or_area data  initial_year initial_transfo… model
slope
##    <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
##  1 Russian Federa… <tib…         1992         10794027 <S3:…
7.88e4
##  2 USSR (former)   <tib…         1990          8765937 <S3:… -
3.51e5
##  3 United States   <tib…         1990          4175718 <S3:…
2.10e5
##  4 Japan           <tib…         1990          1555133 <S3:…
7.63e4
##  5 Ukraine         <tib…         1992           765500 <S3:… -
9.35e3
##  6 Uzbekistan      <tib…         1992           622140 <S3:…
4.58e3
##  7 Saudi Arabia    <tib…         1990           516377 <S3:…
5.30e4
##  8 Belarus         <tib…         1992           511257 <S3:…
6.30e3
##  9 Germany         <tib…         1991           496505 <S3:…
1.77e4
## 10 Romania         <tib…         1990           417957 <S3:… -
1.58e4
## # ... with 2 more variables: r_squared <dbl>, adj_r_squared
<dbl>

natural_gas %>% arrange(desc(initial_transformation)) %>%
head(10) %>% unnest(data) %>% ggplot(country_or_area, mapping =
aes(x = year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area)) + scale_y_continuous(name="Terajoules", labels
```

```
= comma) +  scale_x_continuous(name="Year") + ggtitle("Natural
Gas Transformation (1990 - 2015)")+ labs(colour = "Country")
```



Section 3: Further Analysis
##

We load additional data for further investigations.

```
###################################
# First we do population data:
###################################
population <-
read.csv("~/Documents/Class/CKME-136/Workshop/CKME136_Capstone/Da
ta/population-by-country-gapminder+un.csv")

head(population)

##        Entity Code Year
## 1 Afghanistan  AFG 1800
## 2 Afghanistan  AFG 1820
## 3 Afghanistan  AFG 1870
## 4 Afghanistan  AFG 1913
## 5 Afghanistan  AFG 1950
## 6 Afghanistan  AFG 1951
##   Total.population..Gapminder..UN.Population.Division.
## 1                                              3280000
## 2                                              3280000
```

```
## 3                                                    4207000
## 4                                                    5730000
## 5                                                    7752118
## 6                                                    7839510
```

```
tail(population)
```

```
##         Entity Code Year
## 21481 Zimbabwe  ZWE 2011
## 21482 Zimbabwe  ZWE 2012
## 21483 Zimbabwe  ZWE 2013
## 21484 Zimbabwe  ZWE 2014
## 21485 Zimbabwe  ZWE 2015
## 21486 Zimbabwe  ZWE 2016
##       Total.population..Gapminder..UN.Population.Division.
## 21481                                              14386649
## 21482                                              14710826
## 21483                                              15054506
## 21484                                              15411675
## 21485                                              15777451
## 21486                                              16150362
```

```
anyNA(population)
```

```
## [1] FALSE
```

```
summary(population)
```

```
##              Entity           Code            Year
##  Sweden         :  235   SWE    :  235   Min.   :1700
##  United Kingdom:  203   GBR    :  203   1st Qu.:1942
##  Australia      :  199   AUS    :  199   Median :1970
##  Austria        :  199   AUT    :  199   Mean   :1958
##  Belgium        :  199   BEL    :  199   3rd Qu.:1993
##  China          :  199   CHE    :  199   Max.   :2016
##  (Other)        :20252   (Other):20252
##  Total.population..Gapminder..UN.Population.Division.
##  Min.   :0.000e+00
##  1st Qu.:4.403e+05
##  Median :3.408e+06
##  Mean   :3.552e+07
##  3rd Qu.:1.126e+07
##  Max.   :7.467e+09
##
```

```
colnames(population)
```

```
## [1] "Entity"
## [2] "Code"
## [3] "Year"
## [4] "Total.population..Gapminder..UN.Population.Division."
```

```r
# One problem with this data is that we need to rename "Russia"
to "Russian Federation" for consistency. Also with "Iran" to
"Iran (Islamic Rep. of)"
length(grep("\\<Russia\\>", population$Entity))
```

```
## [1] 69
```

```r
length(grep("\\<Iran\\>", population$Entity))
```

```
## [1] 72
```

```r
# 69 Occurrences of Russia in this data - we need to rename these
population$Entity <- as.character(population$Entity)
population$Entity[population$Entity == "Russia"] <- "Russian
Federation"
population$Entity[population$Entity == "Iran"] <- "Iran (Islamic
Rep. of)"
population$Entity <- as.factor(population$Entity)

# We also need to rename the column headings to that of our
prepared data for merging.

names(population) <- c("country_or_area", "code", "year",
"population")

#####################################
# Similarly, we do GDP data
#####################################
gdp <-
read.csv("~/Documents/Class/CKME-136/Workshop/CKME136_Capstone/Da
ta/real-gdp-per-capita-PWT.csv")

head(gdp)
```

```
##    Entity Code Year
## 1 Albania  ALB 1970
## 2 Albania  ALB 1971
## 3 Albania  ALB 1972
## 4 Albania  ALB 1973
## 5 Albania  ALB 1974
## 6 Albania  ALB 1975
##   GDP.per.capita..2011.international....PPP.adjusted.US...
## 1                                                 3345.638
## 2                                                 3398.699
## 3                                                 3454.167
## 4                                                 3510.072
## 5                                                 3571.006
## 6                                                 3633.953
```

```r
tail(gdp)
```

```
##        Entity Code Year
## 9434 Zimbabwe  ZWE 2009
## 9435 Zimbabwe  ZWE 2010
## 9436 Zimbabwe  ZWE 2011
## 9437 Zimbabwe  ZWE 2012
## 9438 Zimbabwe  ZWE 2013
## 9439 Zimbabwe  ZWE 2014
##      GDP.per.capita..2011.international....PPP.adjusted.US...
## 9434                                                  1518.454
## 9435                                                  1477.950
## 9436                                                  1453.495
## 9437                                                  1627.729
## 9438                                                  1813.117
## 9439                                                  1869.069
```

```
anyNA(gdp)
```

```
## [1] FALSE
```

```
summary(gdp)
```

```
##        Entity          Code           Year
##  Argentina:  65   ARG    :  65   Min.   :1950
##  Australia:  65   AUS    :  65   1st Qu.:1973
##  Austria  :  65   AUT    :  65   Median :1988
##  Belgium  :  65   BEL    :  65   Mean   :1987
##  Bolivia  :  65   BOL    :  65   3rd Qu.:2002
##  Brazil   :  65   BRA    :  65   Max.   :2014
##  (Other)  :9049   (Other):9049
##  GDP.per.capita..2011.international....PPP.adjusted.US...
##  Min.   :   142.4
##  1st Qu.:  2028.5
##  Median :  5368.6
##  Mean   : 11305.7
##  3rd Qu.: 14044.6
##  Max.   :245077.8
##
```

```
colnames(gdp)
```

```
## [1] "Entity"
## [2] "Code"
## [3] "Year"
## [4] "GDP.per.capita..2011.international....PPP.adjusted.US..."
```

```
# We need to do the same renaming with this data
length(grep("\\<Russia\\>", gdp$Entity))
```

```
## [1] 25
```

```
length(grep("\\<Iran\\>", gdp$Entity))
```

```
## [1] 60

# Renaming
gdp$Entity <- as.character(gdp$Entity)
gdp$Entity[gdp$Entity == "Russia"] <- "Russian Federation"
gdp$Entity[gdp$Entity == "Iran"] <- "Iran (Islamic Rep. of)"
gdp$Entity <- as.factor(gdp$Entity)

# Now the column headings for merging.
names(gdp) <- c("country_or_area", "code", "year",
"gdp_per_capita")
```

We prepare the tables of top 10 of all the energy transformations in our five categories to merge.

```
hard_coal_10 <- hard_coal %>%
arrange(desc(initial_transformation)) %>% head(10) %>% select(-
c(initial_year, initial_transformation, model, slope, r_squared))
%>% unnest(data)

brown_coal_10 <- brown_coal %>%
arrange(desc(initial_transformation)) %>% head(10) %>% select(-
c(initial_year, initial_transformation, model, slope, r_squared))
%>% unnest(data)

fuel_oil_10 <- fuel_oil %>% arrange(desc(initial_transformation))
%>% head(10) %>% select(-c(initial_year, initial_transformation,
model, slope, r_squared)) %>% unnest(data)

gasdiesel_10 <- gasdiesel_oil %>%
arrange(desc(initial_transformation)) %>% head(10) %>% select(-
c(initial_year, initial_transformation, model, slope, r_squared))
%>% unnest(data)

natural_gas_10 <- natural_gas %>%
arrange(desc(initial_transformation)) %>% head(10) %>% select(-
c(initial_year, initial_transformation, model, slope, r_squared))
%>% unnest(data)
```

Next we begin our joins on our energy transformations against population, GDP per capita, and average temperature

```
## Population first
hard_coal_10_pop <- inner_join(hard_coal_10, population, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector
```

```r
brown_coal_10_pop <- inner_join(brown_coal_10, population, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

fuel_oil_10_pop <- inner_join(fuel_oil_10, population, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

gasdiesel_10_pop <- inner_join(gasdiesel_10, population, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

natural_gas_10_pop <- inner_join(natural_gas_10, population, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
arrange(country_or_area, year) %>% nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

## GDP Per Capita next
hard_coal_10_gdp <- inner_join(hard_coal_10, gdp, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

brown_coal_10_gdp <- inner_join(brown_coal_10, gdp, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

fuel_oil_10_gdp <- inner_join(fuel_oil_10, gdp, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()
```

```
## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector
```

```
gasdiesel_10_gdp <- inner_join(gasdiesel_10, gdp, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()
```

```
## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector
```

```
natural_gas_10_gdp <- inner_join(natural_gas_10, gdp, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()
```

```
## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector
```

Part 1: Energy Transformations against Population

```
# We need to consider each of the individual countries in our
energy transformation groupings and perform correlation analyses
to determine if there is an associative link between
transformation and population.

# First we load the ggpubr package.
library("ggpubr")
```

```
## Loading required package: magrittr
```

```
##
## Attaching package: 'magrittr'
```

```
## The following object is masked from 'package:purrr':
##
##     set_names
```

```
## The following object is masked from 'package:tidyr':
##
##     extract
```

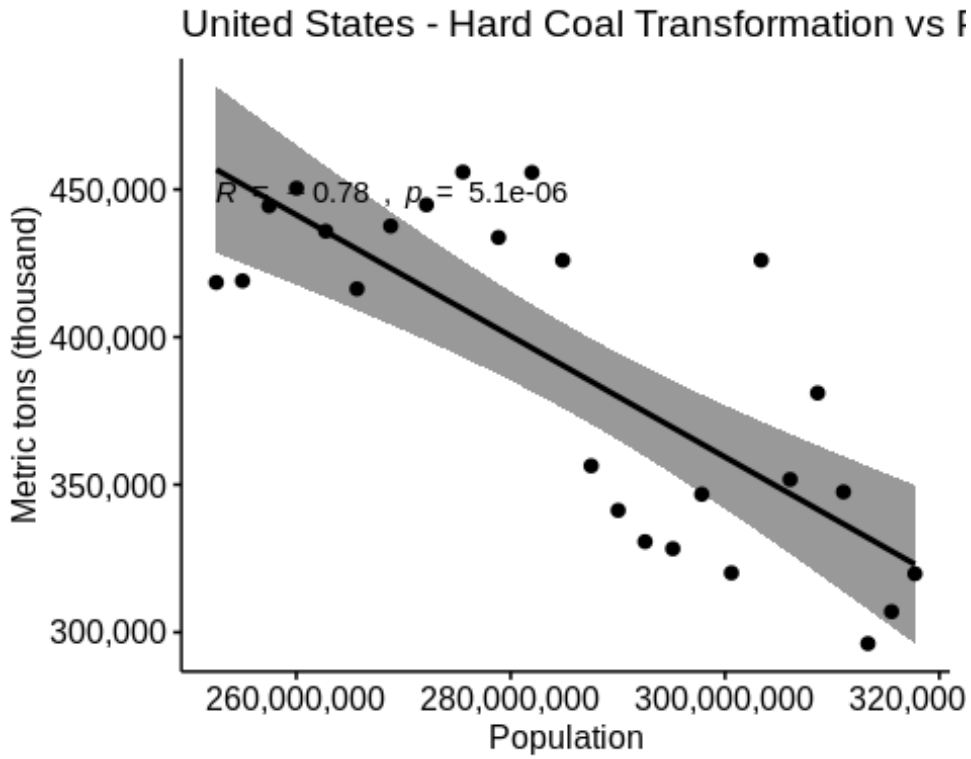
(i) Hard Coal

```
# Now we look at our hard coal data more closely


hard_coal_10_pop
```

```
## # A tibble: 10 x 2
##    country_or_area    data
```

```
##    <chr>              <list>
##  1 United States      <tibble [25 × 6]>
##  2 China              <tibble [25 × 6]>
##  3 Russian Federation <tibble [23 × 6]>
##  4 India              <tibble [25 × 6]>
##  5 United Kingdom     <tibble [25 × 6]>
##  6 Poland             <tibble [25 × 6]>
##  7 South Africa       <tibble [25 × 6]>
##  8 Germany            <tibble [24 × 6]>
##  9 Kazakhstan         <tibble [23 × 6]>
## 10 Japan              <tibble [25 × 6]>
```

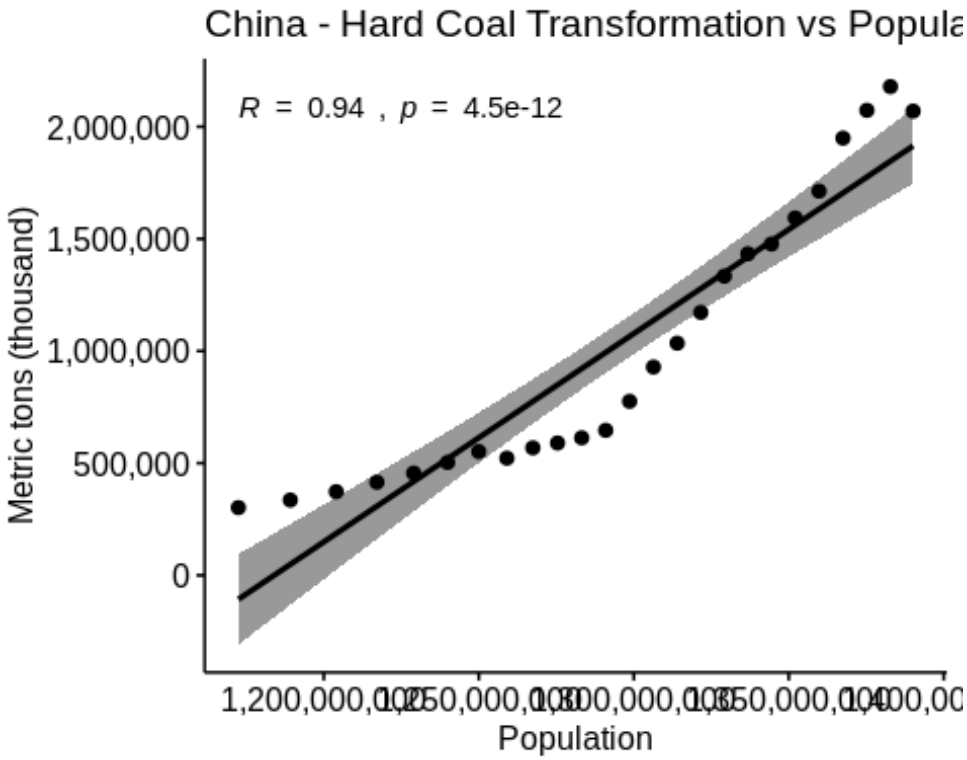
```
# These are the 10 countries that we need to investigate.

# 1: United States
hard_coal_10_pop %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("United States - Hard Coal Transformation vs
Population (1990 - 2015)")
```




```
hc_01 <- hard_coal_10_pop %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(hc_01$population, hc_01$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_01$population and hc_01$quantity
## t = -5.9042, df = 23, p-value = 5.106e-06
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8964032 -0.5496450
## sample estimates:
##       cor
## -0.7761996
```

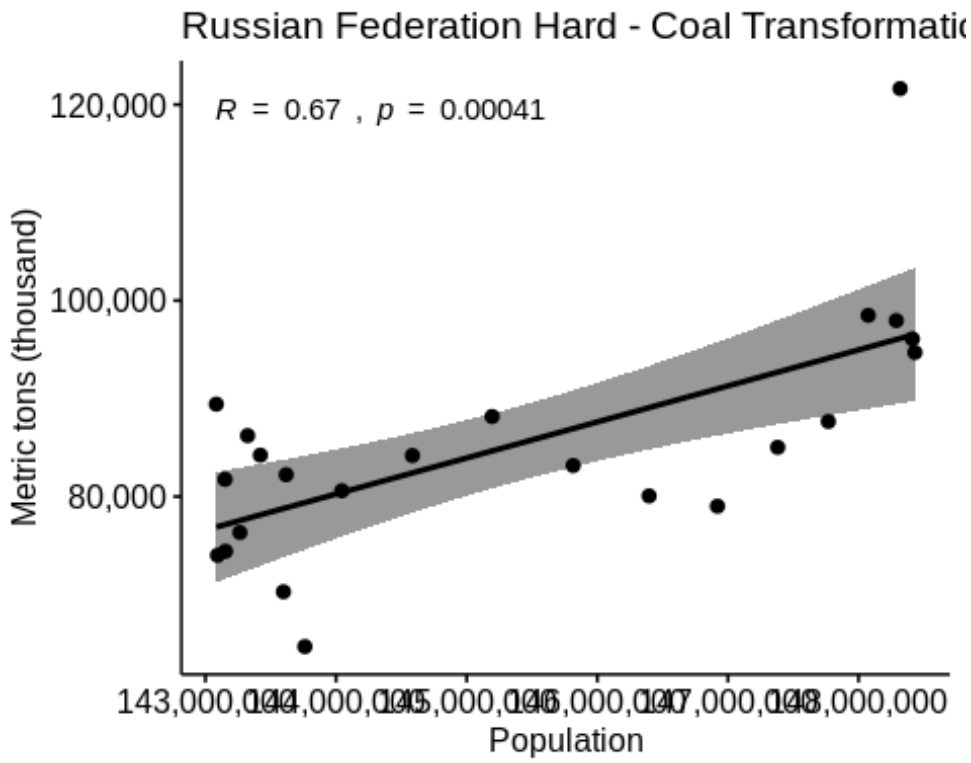
```
# 2: China
hard_coal_10_pop %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("China - Hard Coal Transformation vs Population
(1990 - 2015)")
```




```
hc_02 <- hard_coal_10_pop %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(hc_02$population, hc_02$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_02$population and hc_02$quantity
## t = 12.99, df = 23, p-value = 4.474e-12
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8627865 0.9726860
## sample estimates:
##       cor
## 0.9381047
```

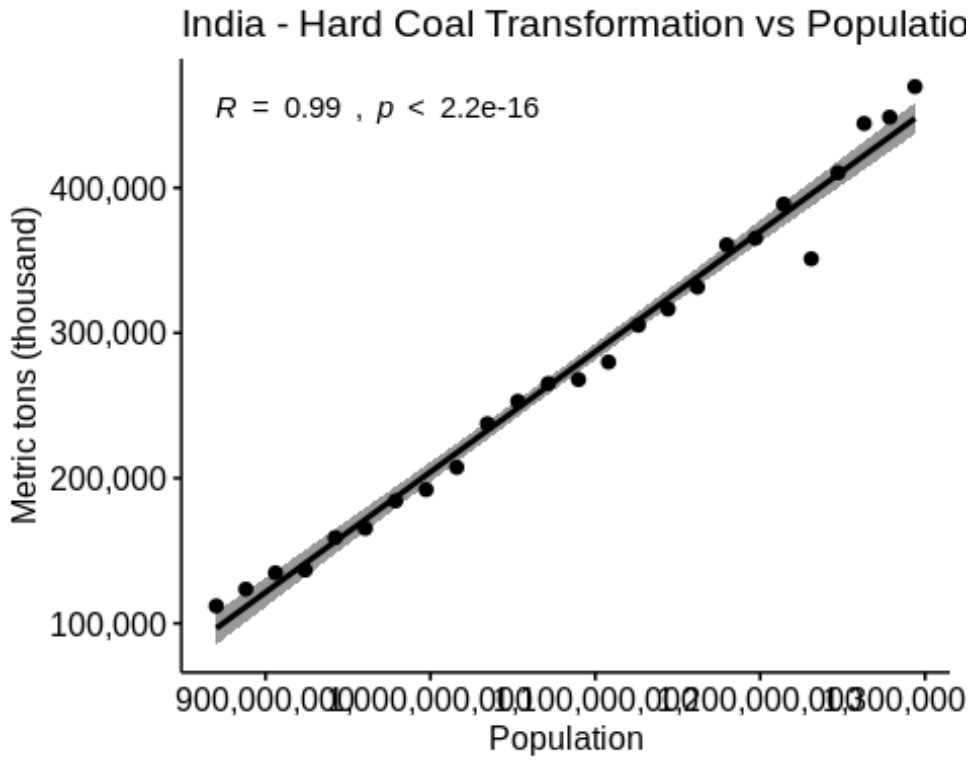
```
# 3: Russian Federation
hard_coal_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "population", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +
scale_x_continuous(name="Population", labels = comma)+
ggtitle("Russian Federation Hard - Coal Transformation vs
Population (1990 - 2015)")
```




```
hc_03 <- hard_coal_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(hc_03$population, hc_03$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_03$population and hc_03$quantity
## t = 4.188, df = 21, p-value = 0.0004145
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.3634904 0.8503525
## sample estimates:
##       cor
## 0.6746141
```

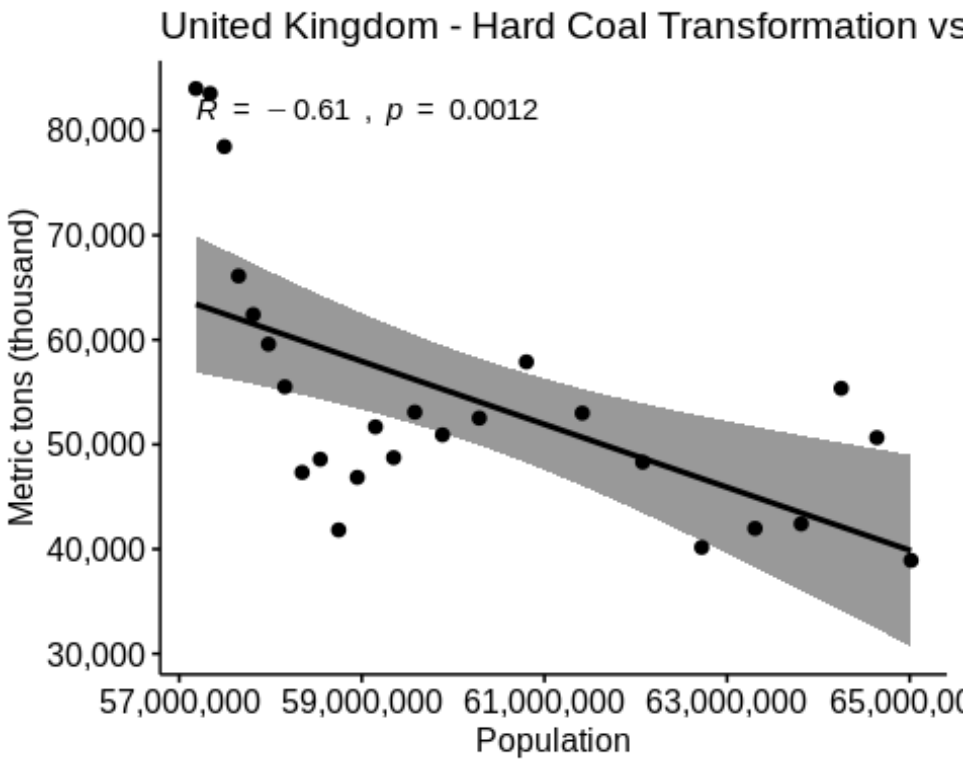
```
# 4: India
hard_coal_10_pop %>% filter(country_or_area == "India") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("India - Hard Coal Transformation vs Population
(1990 - 2015)")
```




```
hc_04 <- hard_coal_10_pop %>% filter(country_or_area == "India")
%>% unnest(data)

cor.test(hc_04$population, hc_04$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_04$population and hc_04$quantity
## t = 38.507, df = 23, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9824054 0.9966689
## sample estimates:
##       cor
## 0.9923335
```

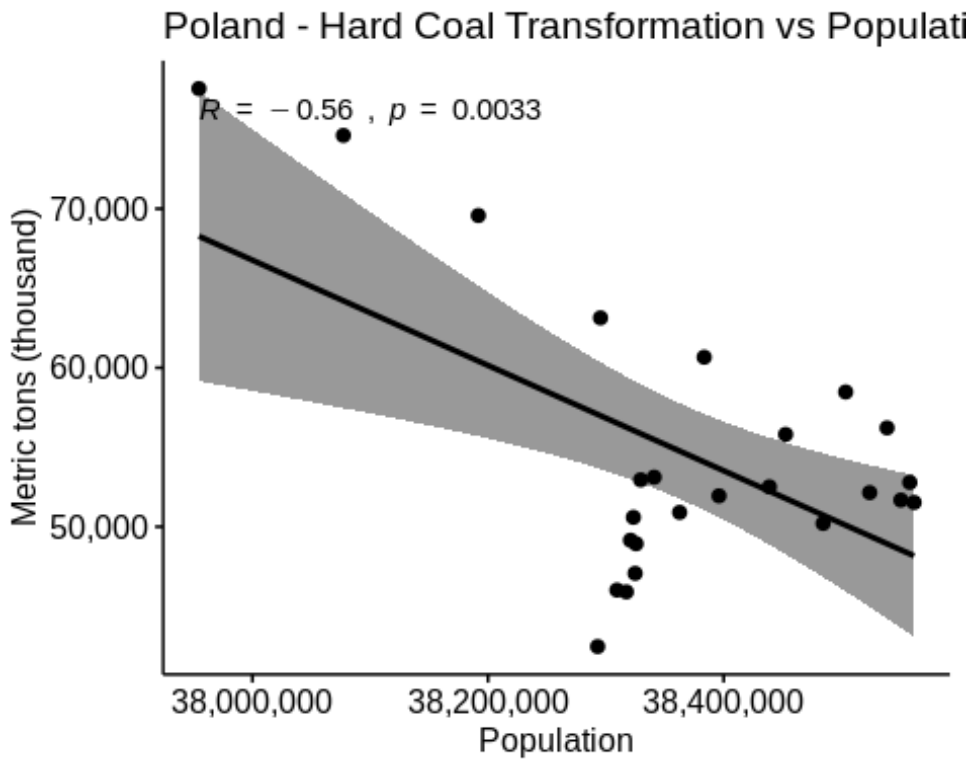
```
# 5: United Kingdom
hard_coal_10_pop %>% filter(country_or_area == "United Kingdom")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("United Kingdom - Hard Coal Transformation vs
Population (1990 - 2015)")
```




```
hc_05 <- hard_coal_10_pop %>% filter(country_or_area == "United
Kingdom") %>% unnest(data)

cor.test(hc_05$population, hc_05$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_05$population and hc_05$quantity
## t = -3.6904, df = 23, p-value = 0.00121
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8098306 -0.2828756
## sample estimates:
##       cor
## -0.6098427
```

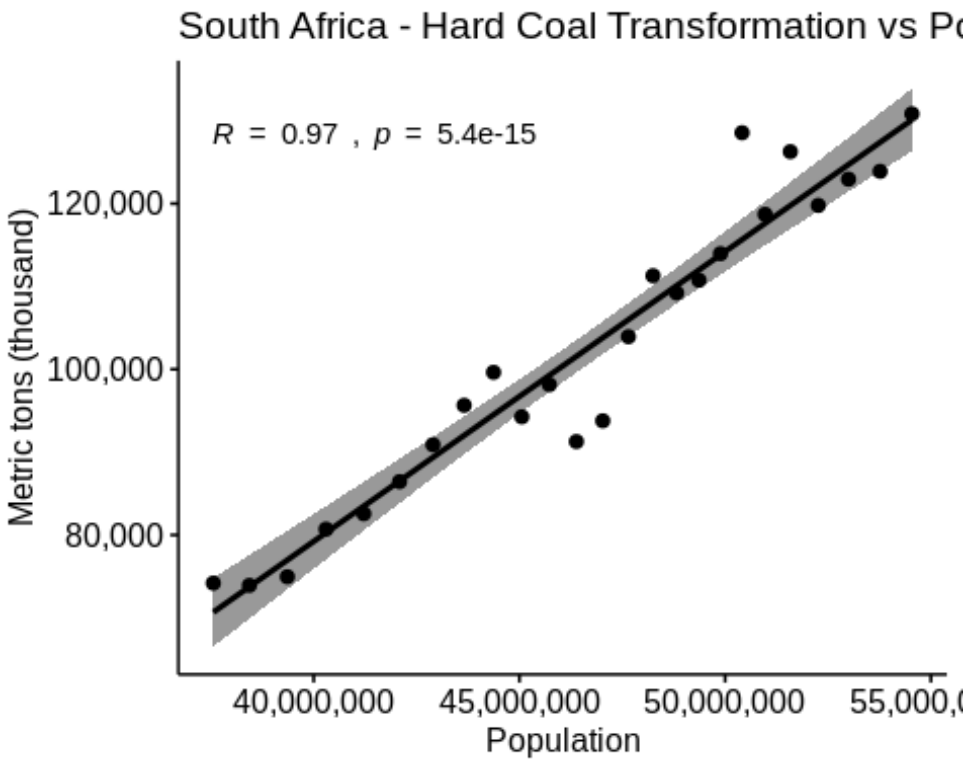
```
# 6: Poland
hard_coal_10_pop %>% filter(country_or_area == "Poland") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Poland - Hard Coal Transformation vs Population
(1990 - 2015)")
```




```
hc_06 <- hard_coal_10_pop %>% filter(country_or_area == "Poland")
%>% unnest(data)

cor.test(hc_06$population, hc_06$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_06$population and hc_06$quantity
## t = -3.2759, df = 23, p-value = 0.003317
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7843613 -0.2173512
## sample estimates:
##       cor
## -0.564041
```

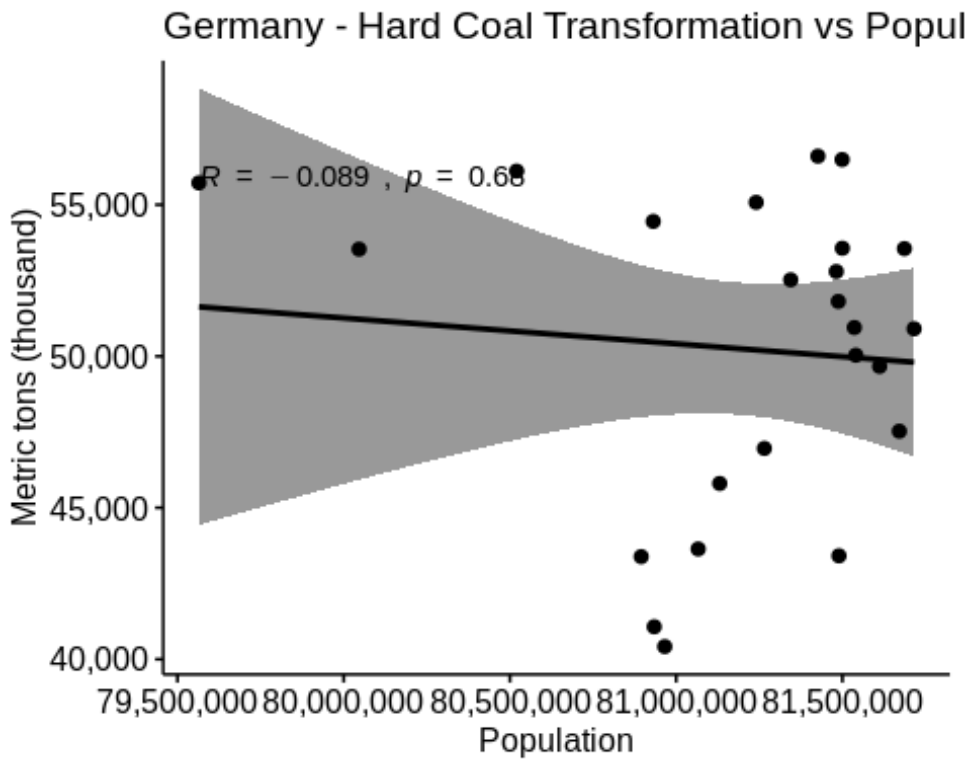
```
# 7: South Africa
hard_coal_10_pop %>% filter(country_or_area == "South Africa") %>
% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("South Africa - Hard Coal Transformation vs
Population (1990 - 2015)")
```




```
hc_07 <- hard_coal_10_pop %>% filter(country_or_area == "South
Africa") %>% unnest(data)

cor.test(hc_07$population, hc_07$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_07$population and hc_07$quantity
## t = 17.897, df = 23, p-value = 5.366e-15
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9231111 0.9850813
## sample estimates:
##       cor
## 0.9659221
```

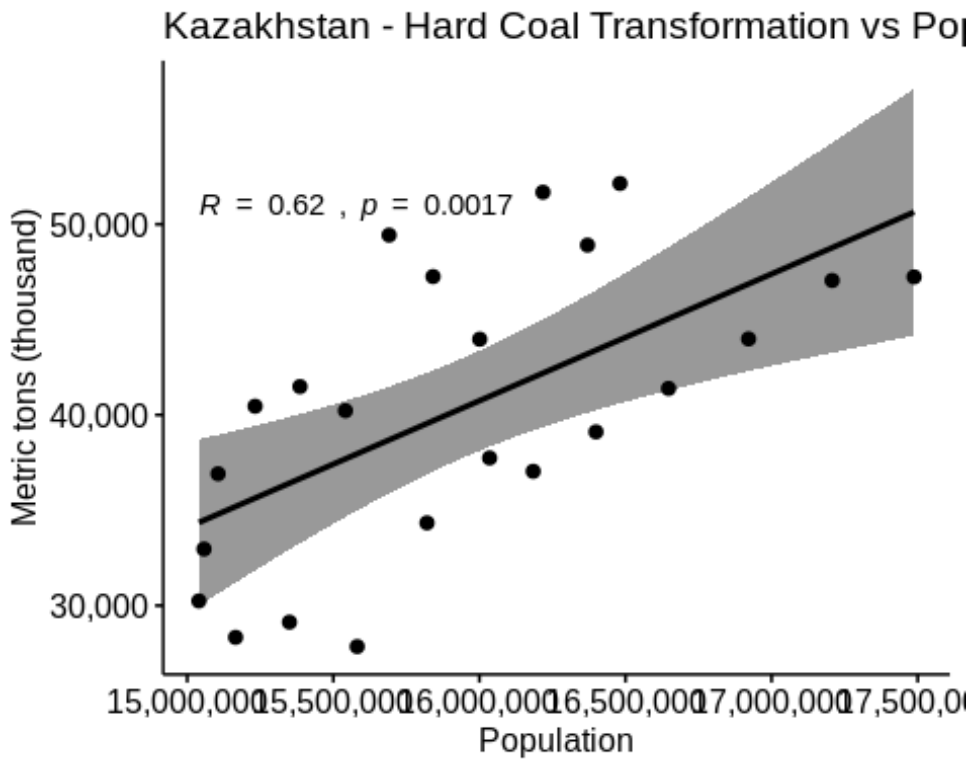
```
# 8: Germany
hard_coal_10_pop %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Germany - Hard Coal Transformation vs Population
(1990 - 2015)")
```




```
hc_08 <- hard_coal_10_pop %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(hc_08$population, hc_08$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_08$population and hc_08$quantity
## t = -0.41733, df = 22, p-value = 0.6805
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.4750393  0.3264415
## sample estimates:
##         cor
## -0.08862592
```

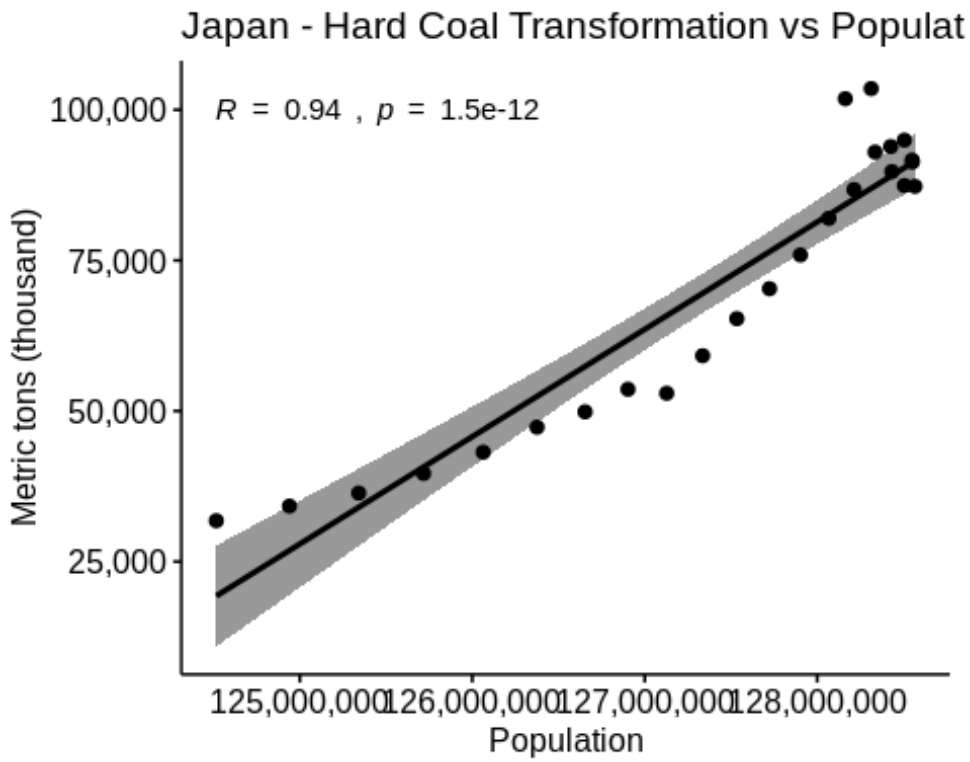
```
# 9: Kazakhstan
hard_coal_10_pop %>% filter(country_or_area == "Kazakhstan") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Kazakhstan - Hard Coal Transformation vs
Population (1990 - 2015)")
```




```
hc_09 <- hard_coal_10_pop %>% filter(country_or_area ==
"Kazakhstan") %>% unnest(data)

cor.test(hc_09$population, hc_09$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  hc_09$population and hc_09$quantity
## t = 3.5986, df = 21, p-value = 0.001689
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2755590 0.8208417
## sample estimates:
##       cor
## 0.6176094
```

```
# 10: Japan
hard_coal_10_pop %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Japan - Hard Coal Transformation vs Population
(1990 - 2015)")
```




```
hc_10 <- hard_coal_10_pop %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(hc_10$population, hc_10$quantity, method = "pearson")
```

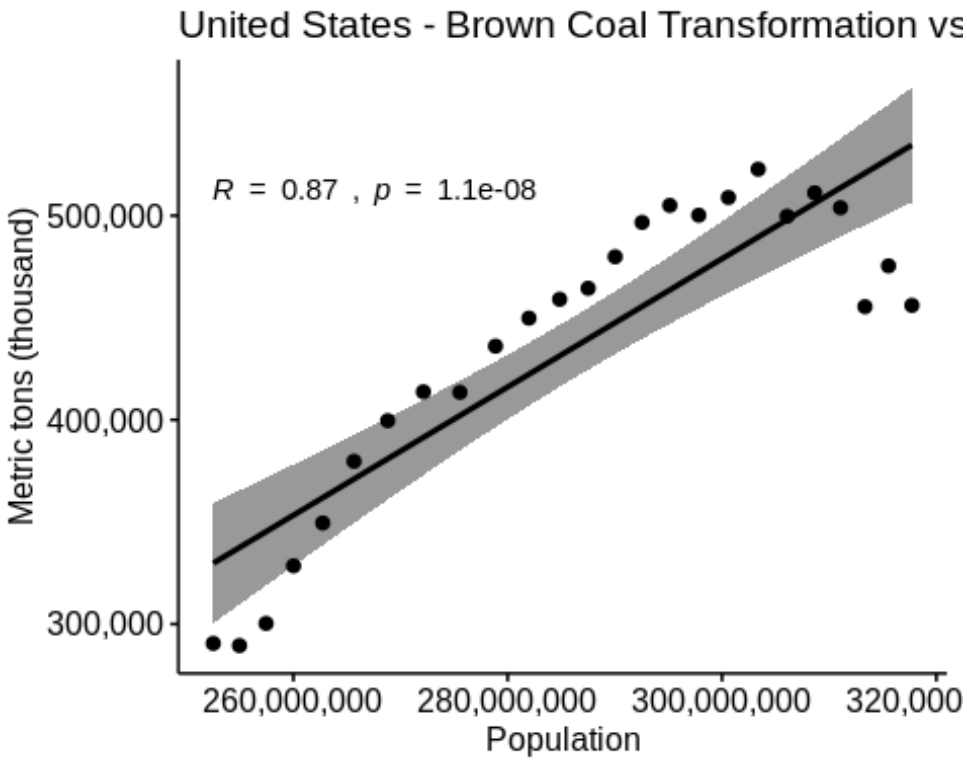
```
##
##  Pearson's product-moment correlation
##
## data:  hc_10$population and hc_10$quantity
## t = 13.714, df = 23, p-value = 1.473e-12
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8752743 0.9753045
## sample estimates:
##       cor
## 0.9439441
```

(ii) Brown Coal

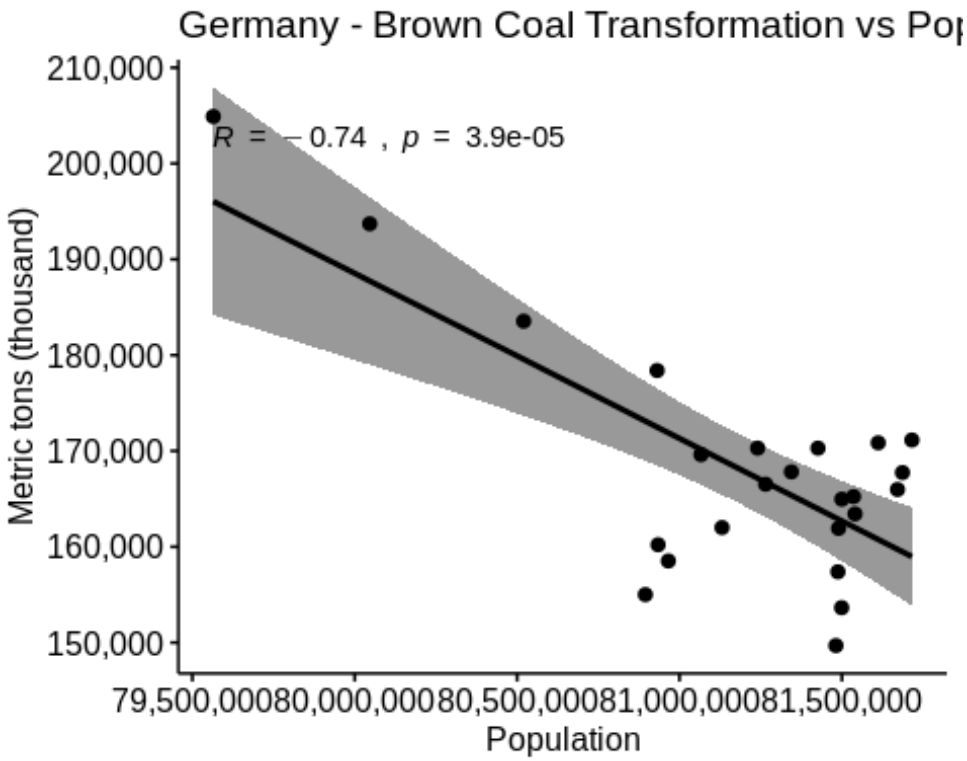
```
# Now we look at brown coal:

brown_coal_10_pop
```

```
## # A tibble: 6 x 2
##   country_or_area    data
##   <chr>              <list>
## 1 United States      <tibble [25 × 6]>
## 2 Germany            <tibble [24 × 6]>
## 3 Russian Federation <tibble [23 × 6]>
## 4 Poland             <tibble [25 × 6]>
## 5 Australia          <tibble [25 × 6]>
## 6 Greece             <tibble [25 × 6]>
```

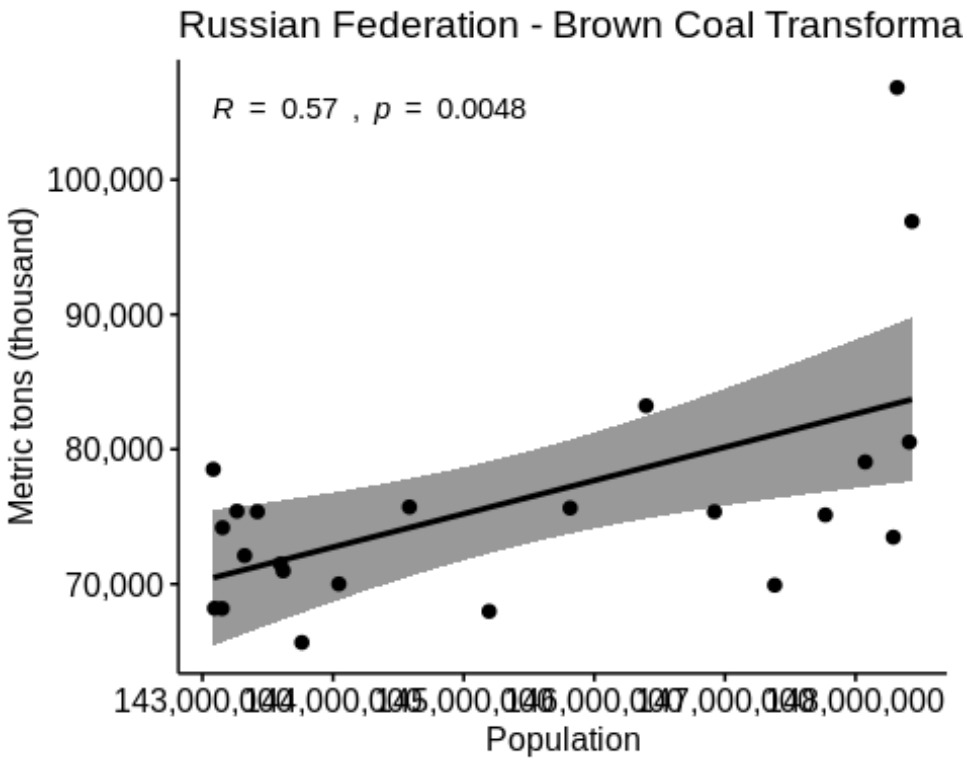
```
# These are the 6 countries that we need to investigate.

# 1: United States
brown_coal_10_pop %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("United States - Brown Coal Transformation vs
Population (1990 - 2015)")
```



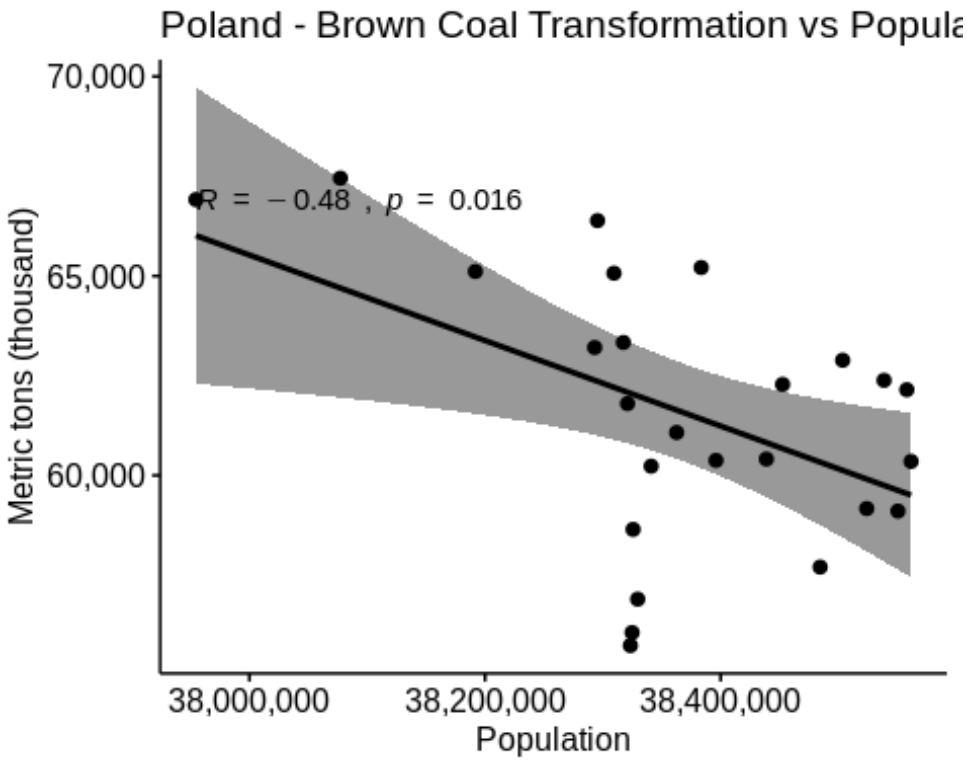

```
bc_01 <- brown_coal_10_pop %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(bc_01$population, bc_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bc_01$population and bc_01$quantity
## t = 8.6506, df = 23, p-value = 1.093e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7326412 0.9436244
## sample estimates:
##       cor
## 0.8745883

# 2: Germany
brown_coal_10_pop %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Germany - Brown Coal Transformation vs
Population (1990 - 2015)")
```



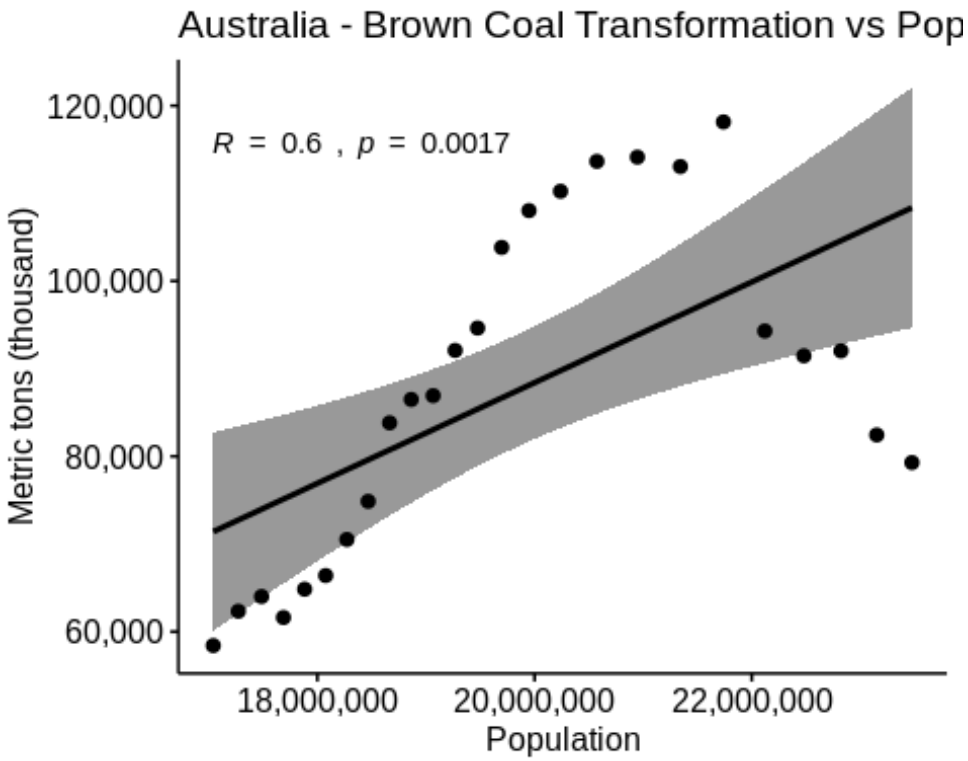

```r
bc_02 <- brown_coal_10_pop %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(bc_02$population, bc_02$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bc_02$population and bc_02$quantity
## t = -5.1263, df = 22, p-value = 3.883e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8794366 -0.4760601
## sample estimates:
##       cor
## -0.7377739

# 3: Russian Federation
brown_coal_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "population", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +
scale_x_continuous(name="Population", labels = comma)+
ggtitle("Russian Federation - Brown Coal Transformation vs
Population (1990 - 2015)")
```



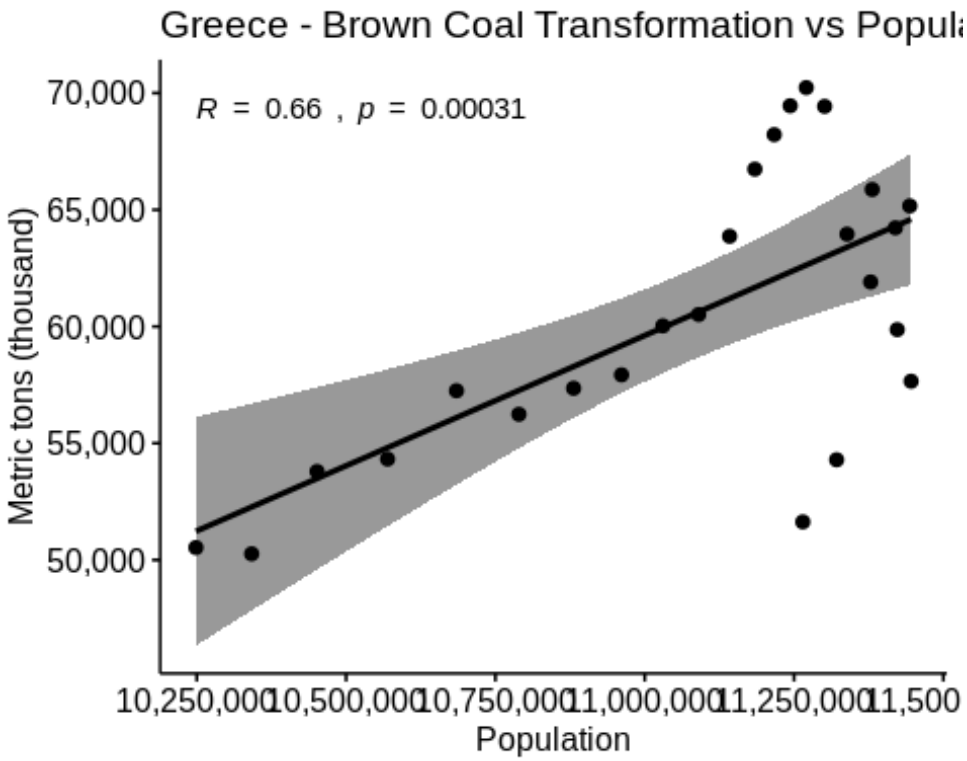

```
bc_03 <- brown_coal_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(bc_03$population, bc_03$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bc_03$population and bc_03$quantity
## t = 3.1496, df = 21, p-value = 0.004836
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2011879 0.7933818
## sample estimates:
##       cor
## 0.5664171

# 4: Poland
brown_coal_10_pop %>% filter(country_or_area == "Poland") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Poland - Brown Coal Transformation vs Population
(1990 - 2015)")
```




```
bc_04 <- brown_coal_10_pop %>% filter(country_or_area ==
"Poland") %>% unnest(data)

cor.test(bc_04$population, bc_04$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bc_04$population and bc_04$quantity
## t = -2.6073, df = 23, p-value = 0.01575
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7342030 -0.1017009
## sample estimates:
##       cor
## -0.4776378

# 5: Australia
brown_coal_10_pop %>% filter(country_or_area == "Australia") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Australia - Brown Coal Transformation vs
Population (1990 - 2015)")
```




```
bc_05 <- brown_coal_10_pop %>% filter(country_or_area ==
"Australia") %>% unnest(data)

cor.test(bc_05$population, bc_05$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bc_05$population and bc_05$quantity
## t = 3.5631, df = 23, p-value = 0.001653
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2632873 0.8024192
## sample estimates:
##       cor
## 0.5963755

# 6: Greece
brown_coal_10_pop %>% filter(country_or_area == "Greece") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Greece - Brown Coal Transformation vs Population
(1990 - 2015)")
```



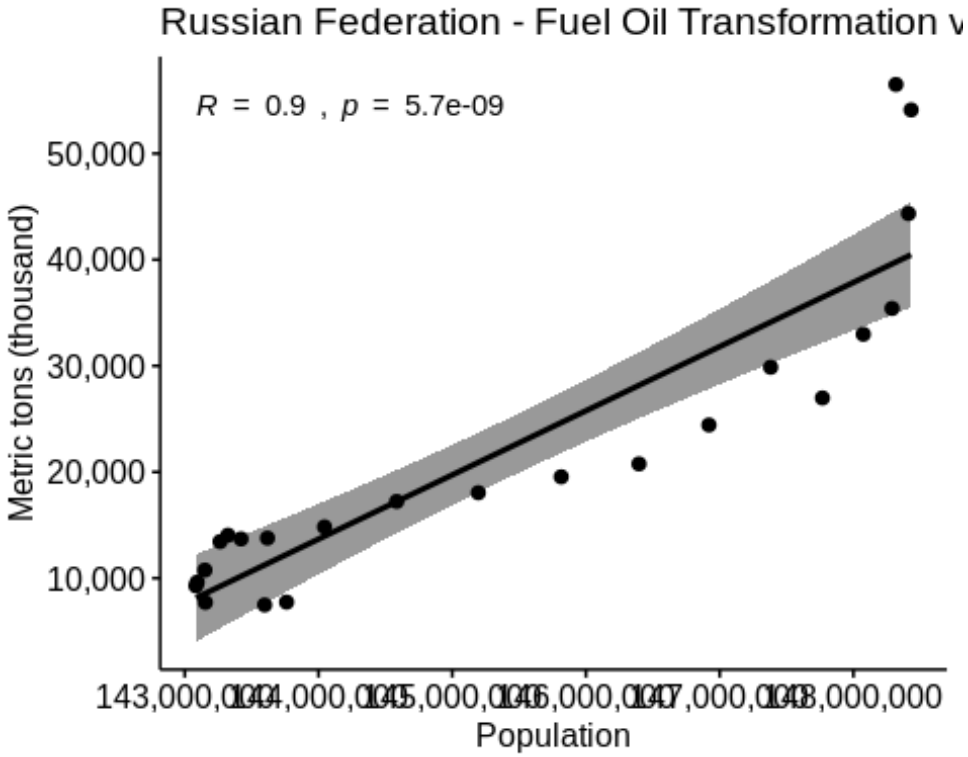

```
bc_06 <- brown_coal_10_pop %>% filter(country_or_area ==
"Greece") %>% unnest(data)

cor.test(bc_06$population, bc_06$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bc_06$population and bc_06$quantity
## t = 4.236, df = 23, p-value = 0.0003127
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.3614095 0.8379462
## sample estimates:
##       cor
## 0.6620036
```

(iii) Fuel Oil:

```
# Now we look at fuel oil:

fuel_oil_10_pop

## # A tibble: 10 x 2
##    country_or_area    data
##    <chr>              <list>
##  1 Russian Federation <tibble [23 × 6]>
```

```
##  2 Japan              <tibble [25 × 6]>
##  3 United States      <tibble [25 × 6]>
##  4 Italy              <tibble [25 × 6]>
##  5 Mexico             <tibble [25 × 6]>
##  6 China              <tibble [25 × 6]>
##  7 Belarus            <tibble [23 × 6]>
##  8 United Kingdom     <tibble [25 × 6]>
##  9 Romania            <tibble [25 × 6]>
## 10 Ukraine            <tibble [23 × 6]>
```

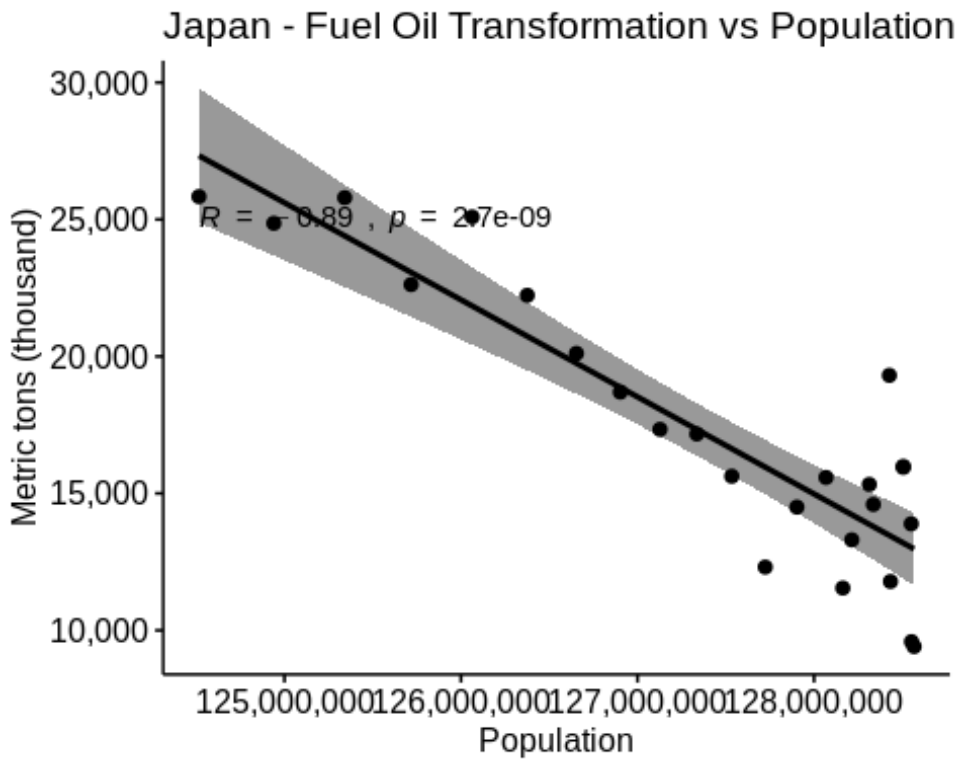
```
# These are the 10 countries that we need to investigate.

# 1: Russian Federation
fuel_oil_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "population", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +
scale_x_continuous(name="Population", labels = comma)+
ggtitle("Russian Federation - Fuel Oil Transformation vs
Population (1990 - 2015)")
```




```
fo_01 <- fuel_oil_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(fo_01$population, fo_01$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_01$population and fo_01$quantity
## t = 9.4006, df = 21, p-value = 5.654e-09
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7731525 0.9566330
## sample estimates:
##       cor
## 0.8988845
```

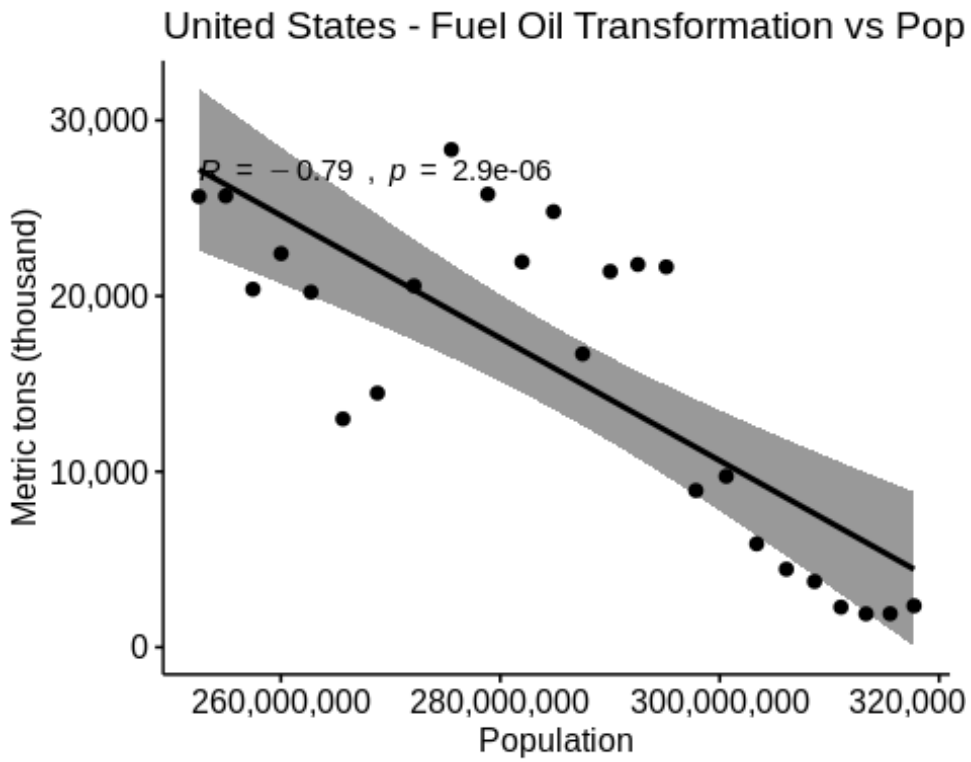
```
# 2: Japan
fuel_oil_10_pop %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Japan - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_02 <- fuel_oil_10_pop %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(fo_02$population, fo_02$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_02$population and fo_02$quantity
## t = -9.3526, df = 23, p-value = 2.661e-09
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9506975 -0.7629565
## sample estimates:
##       cor
## -0.8898319
```

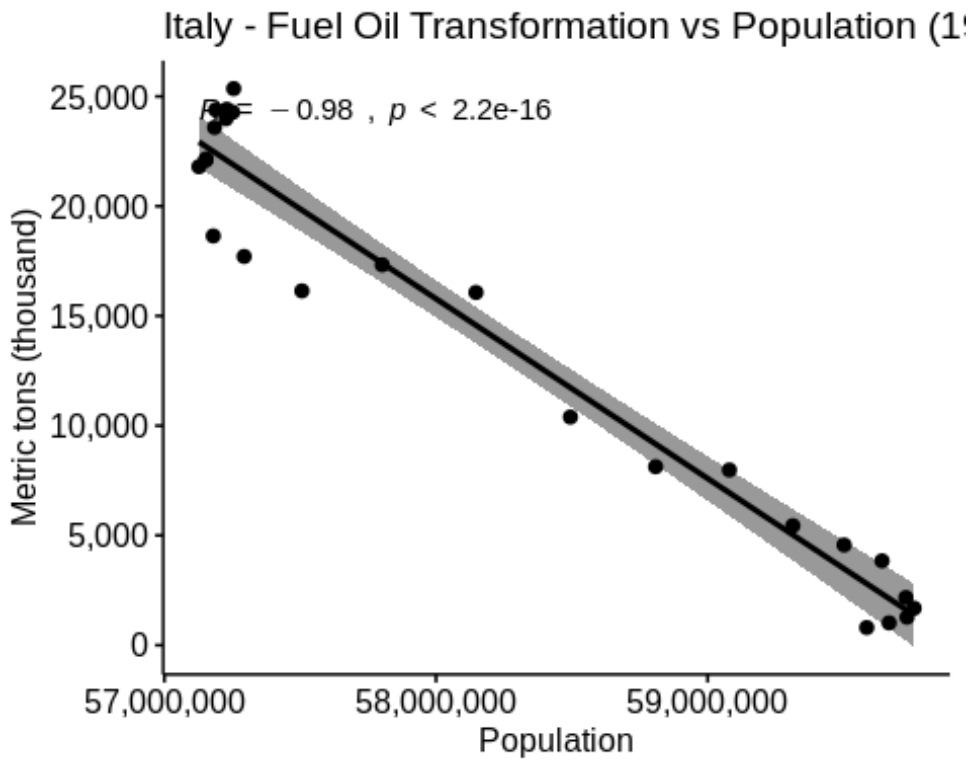
```
# 3: United States
fuel_oil_10_pop %>% filter(country_or_area == "United States") %>
% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("United States - Fuel Oil Transformation vs
Population (1990 - 2015)")
```




```
fo_03 <- fuel_oil_10_pop %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(fo_03$population, fo_03$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_03$population and fo_03$quantity
## t = -6.1397, df = 23, p-value = 2.906e-06
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9022500 -0.5706313
## sample estimates:
##       cor
## -0.7880724
```

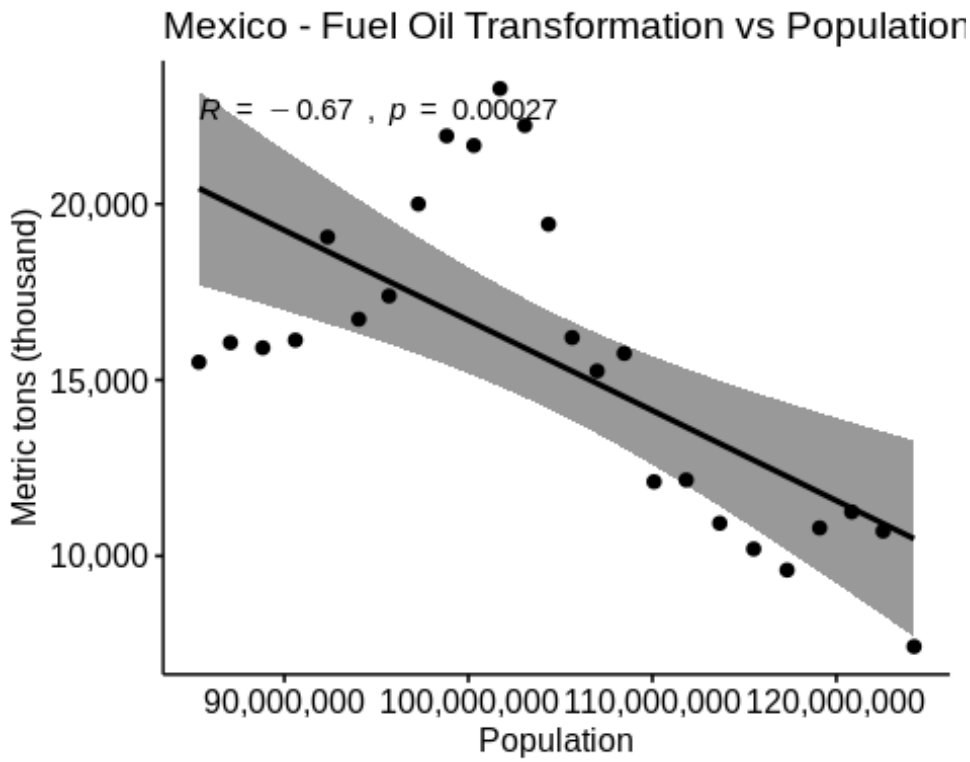
```
# 4: Italy
fuel_oil_10_pop %>% filter(country_or_area == "Italy") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Italy - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_04 <- fuel_oil_10_pop %>% filter(country_or_area == "Italy")
%>% unnest(data)

cor.test(fo_04$population, fo_04$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_04$population and fo_04$quantity
## t = -21.981, df = 23, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9899696 -0.9477705
## sample estimates:
##       cor
## -0.9770155
```

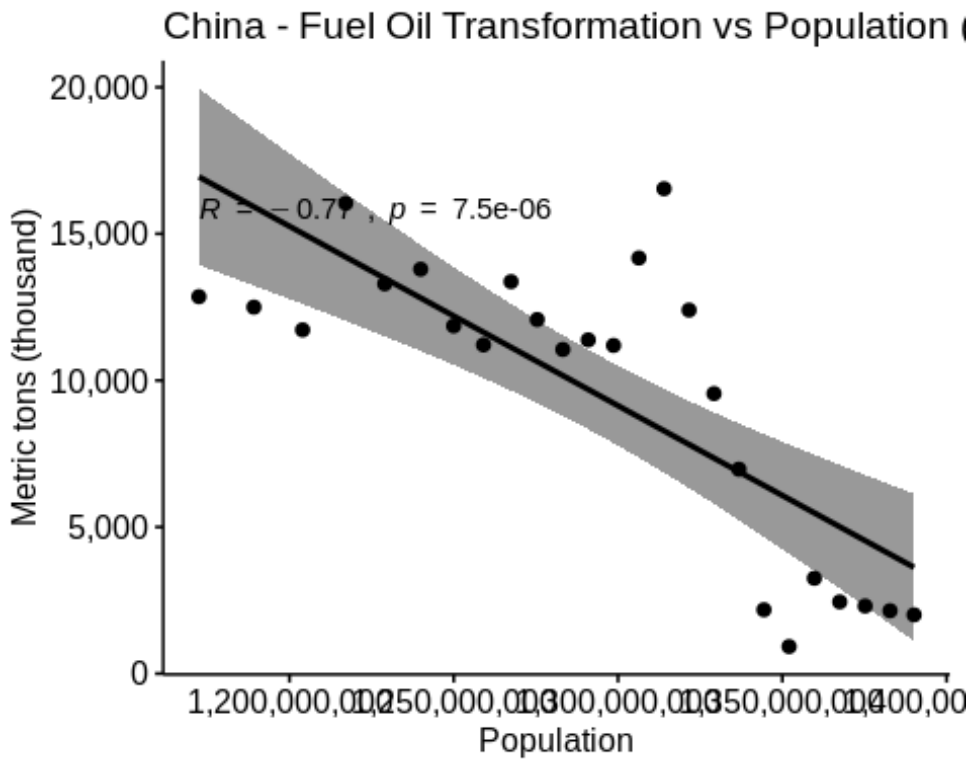
```
# 5: Mexico
fuel_oil_10_pop %>% filter(country_or_area == "Mexico") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Mexico - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_05 <- fuel_oil_10_pop %>% filter(country_or_area == "Mexico")
%>% unnest(data)

cor.test(fo_05$population, fo_05$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_05$population and fo_05$quantity
## t = -4.301, df = 23, p-value = 0.0002659
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8409379 -0.3701842
## sample estimates:
##       cor
## -0.6676562
```

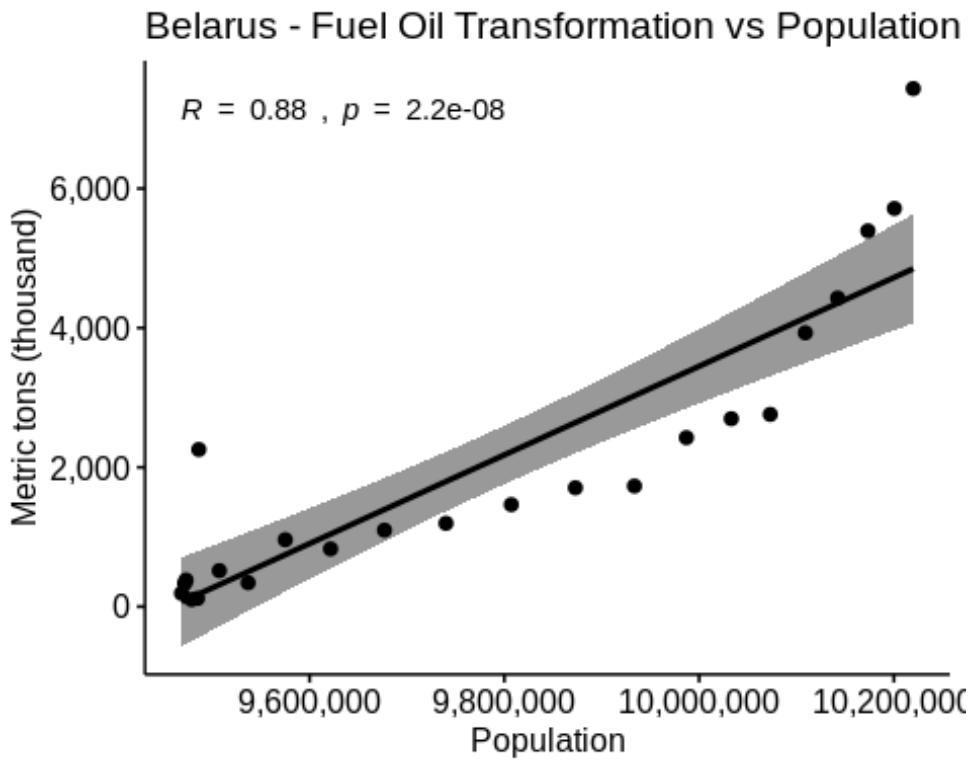
```
# 6: China
fuel_oil_10_pop %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("China - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_06 <- fuel_oil_10_pop %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(fo_06$population, fo_06$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_06$population and fo_06$quantity
## t = -5.7439, df = 23, p-value = 7.519e-06
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8921496 -0.5346475
## sample estimates:
##       cor
## -0.7676152
```

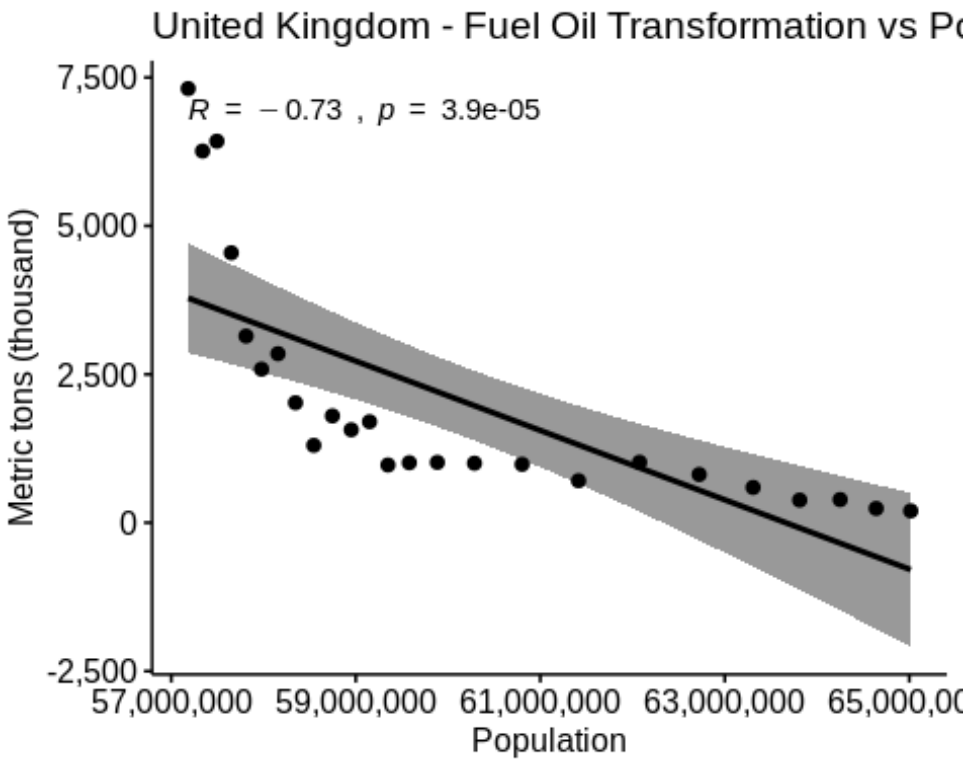
```
# 7: Belarus
fuel_oil_10_pop %>% filter(country_or_area == "Belarus") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Belarus - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_07 <- fuel_oil_10_pop %>% filter(country_or_area == "Belarus")
%>% unnest(data)

cor.test(fo_07$population, fo_07$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_07$population and fo_07$quantity
## t = 8.6828, df = 21, p-value = 2.162e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7430617 0.9501969
## sample estimates:
##       cor
## 0.8843844
```

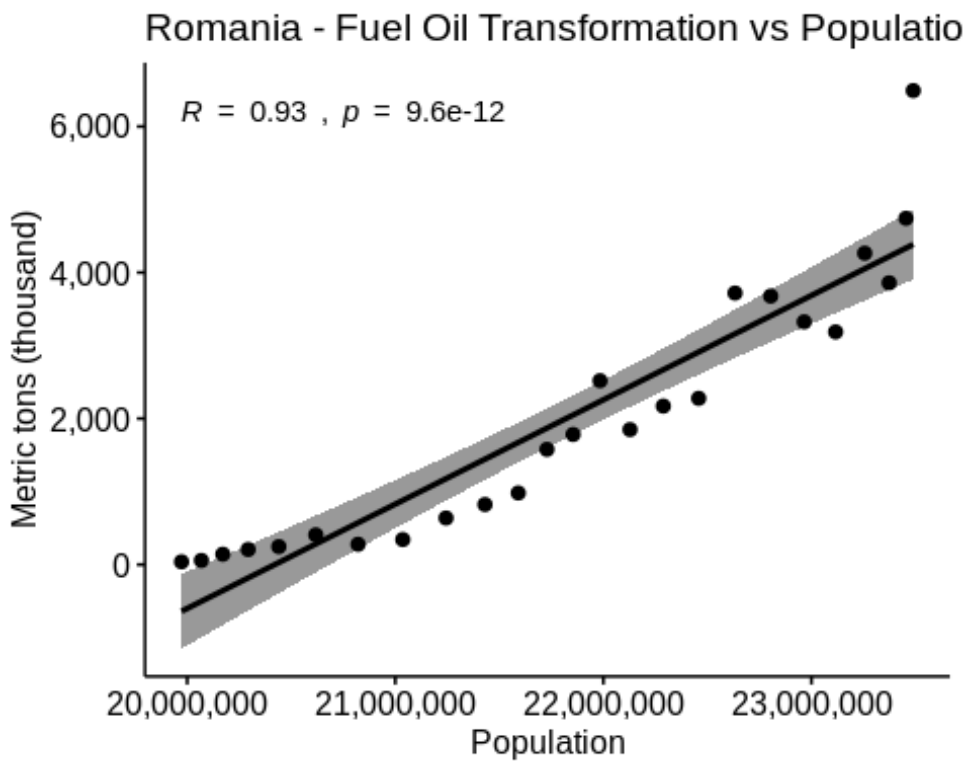
```
# 8: United Kingdom
fuel_oil_10_pop %>% filter(country_or_area == "United Kingdom")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("United Kingdom - Fuel Oil Transformation vs
Population (1990 - 2015)")
```




```
fo_08 <- fuel_oil_10_pop %>% filter(country_or_area == "United
Kingdom") %>% unnest(data)

cor.test(fo_08$population, fo_08$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_08$population and fo_08$quantity
## t = -5.0693, df = 23, p-value = 3.929e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8714282 -0.4646720
## sample estimates:
##       cor
## -0.7264264
```

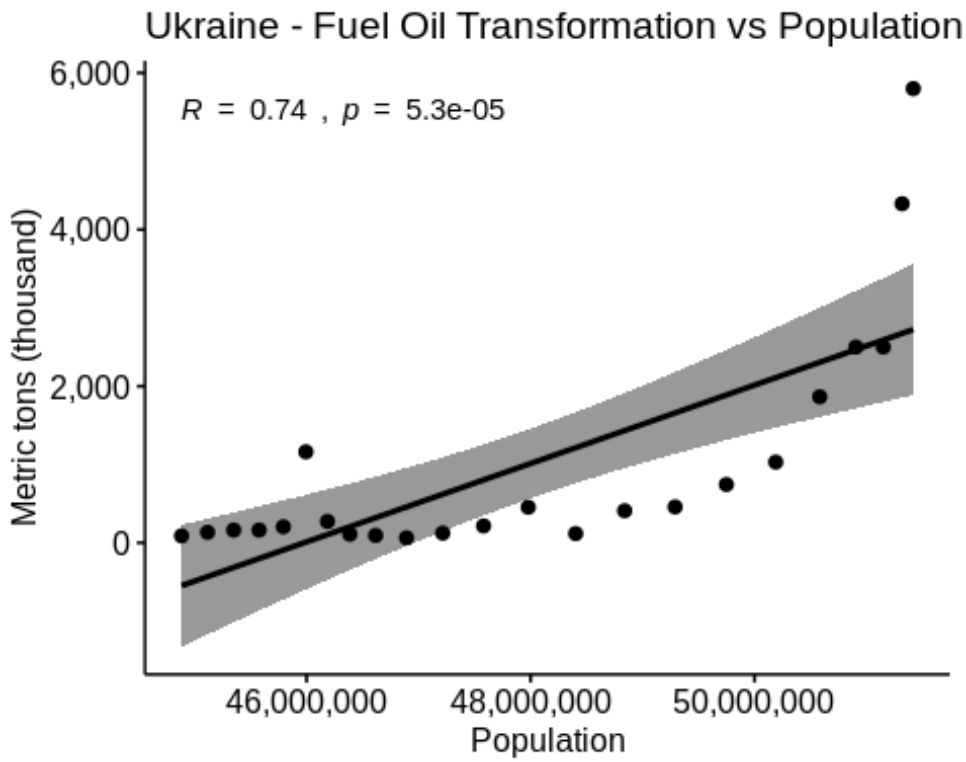
```
# 9: Romania
fuel_oil_10_pop %>% filter(country_or_area == "Romania") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Romania - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_09 <- fuel_oil_10_pop %>% filter(country_or_area == "Romania")
%>% unnest(data)

cor.test(fo_09$population, fo_09$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fo_09$population and fo_09$quantity
## t = 12.508, df = 23, p-value = 9.614e-12
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8534742 0.9707151
## sample estimates:
##       cor
## 0.9337222
```

```
# 10: Ukraine
fuel_oil_10_pop %>% filter(country_or_area == "Ukraine") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Ukraine - Fuel Oil Transformation vs Population
(1990 - 2015)")
```




```
fo_10 <- fuel_oil_10_pop %>% filter(country_or_area == "Ukraine")
%>% unnest(data)

cor.test(fo_10$population, fo_10$quantity, method = "pearson")
```

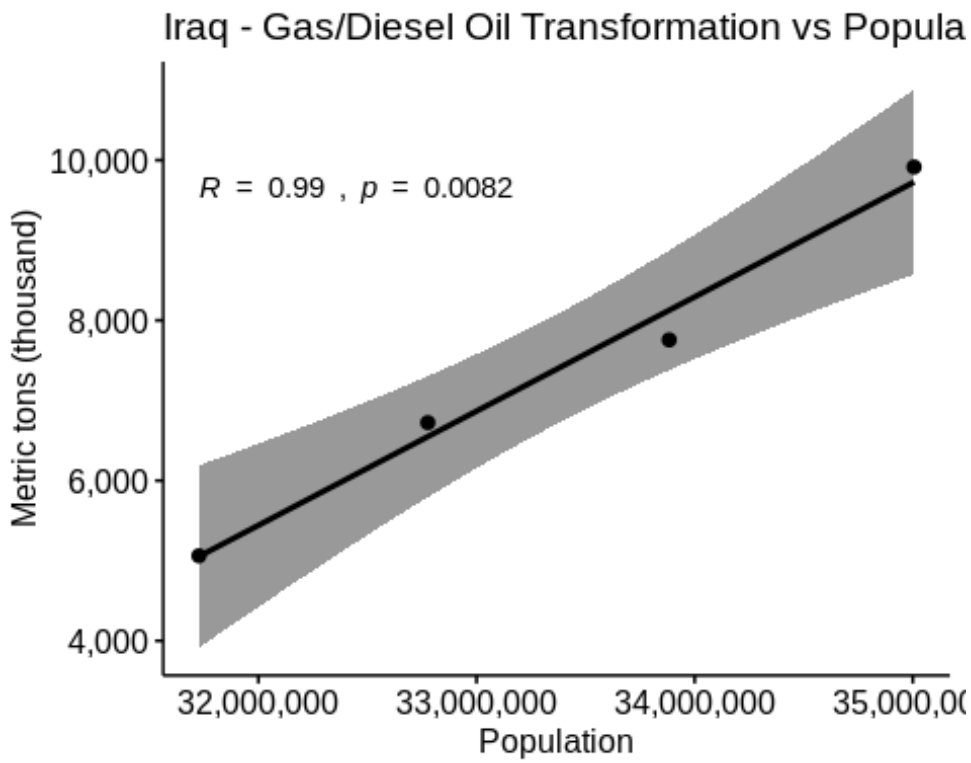
```
##
##  Pearson's product-moment correlation
##
## data:  fo_10$population and fo_10$quantity
## t = 5.052, df = 21, p-value = 5.302e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4728420 0.8832252
## sample estimates:
##       cor
## 0.7406807
```

(iv) Gas/Diesel Oil:

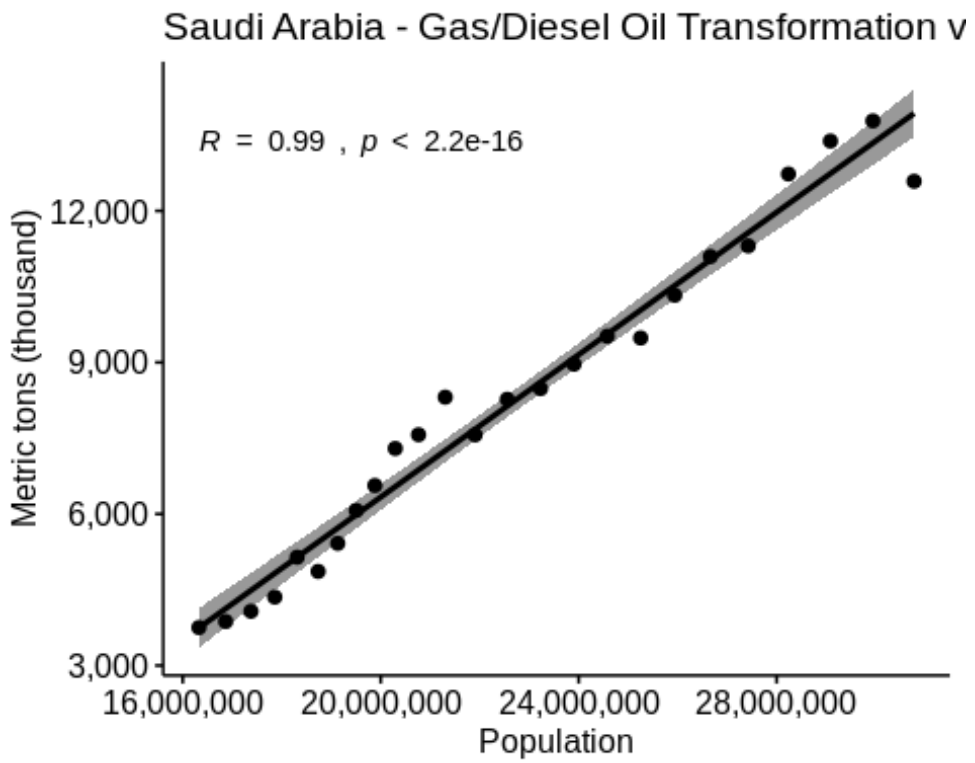
```
# Now we look at gas/diesel oil:

gasdiesel_10_pop
```

```
## # A tibble: 10 x 2
##    country_or_area        data
##    <chr>                  <list>
##  1 Iraq                   <tibble [4 × 6]>
##  2 Saudi Arabia           <tibble [25 × 6]>
##  3 Indonesia              <tibble [25 × 6]>
##  4 United States          <tibble [25 × 6]>
##  5 Iran (Islamic Rep. of) <tibble [25 × 6]>
##  6 Russian Federation     <tibble [23 × 6]>
##  7 China                  <tibble [25 × 6]>
##  8 Germany                <tibble [24 × 6]>
##  9 Japan                  <tibble [25 × 6]>
## 10 Libya                  <tibble [25 × 6]>
```

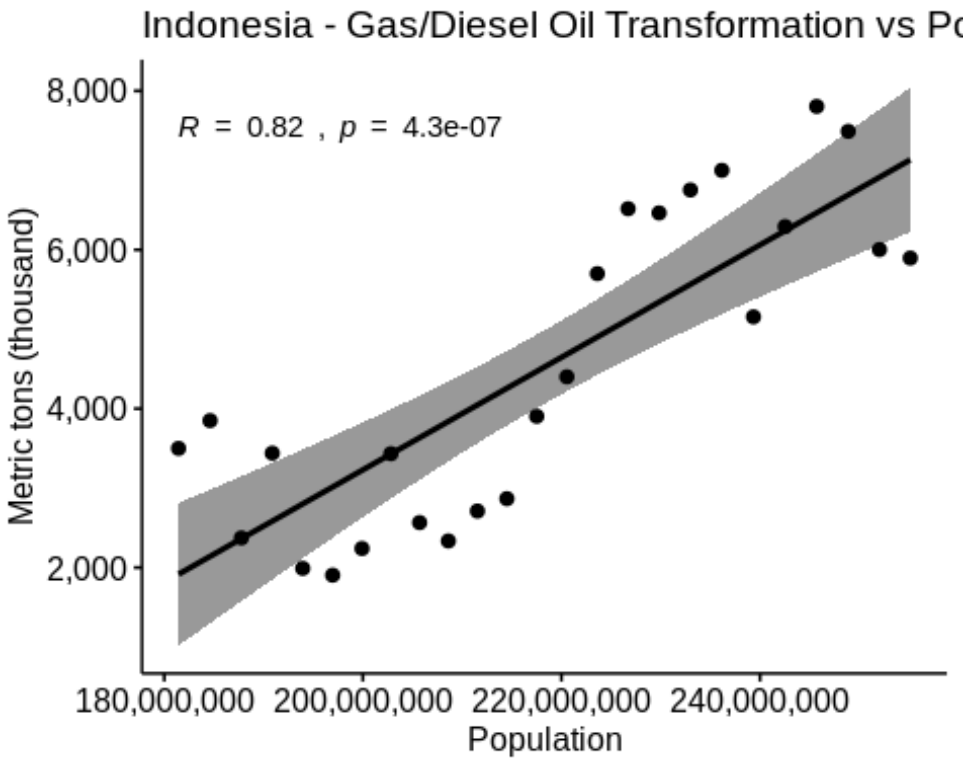
```
# Once again 10 countries:

# 1: Iraq
gasdiesel_10_pop %>% filter(country_or_area == "Iraq") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Iraq - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```



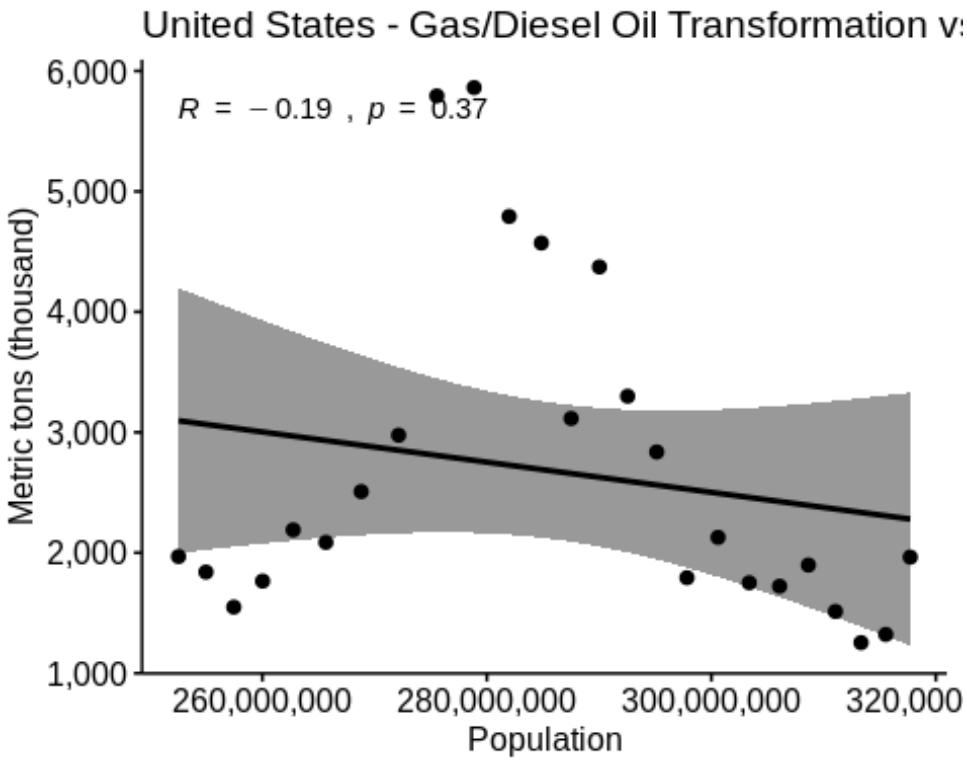

```
gd_01 <- gasdiesel_10_pop %>% filter(country_or_area == "Iraq")
%>% unnest(data)

cor.test(gd_01$population, gd_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_01$population and gd_01$quantity
## t = 10.956, df = 2, p-value = 0.008229
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6553507 0.9998361
## sample estimates:
##       cor
## 0.9917714

# 2: Saudi Arabia
gasdiesel_10_pop %>% filter(country_or_area == "Saudi Arabia") %>
% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Saudi Arabia - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```



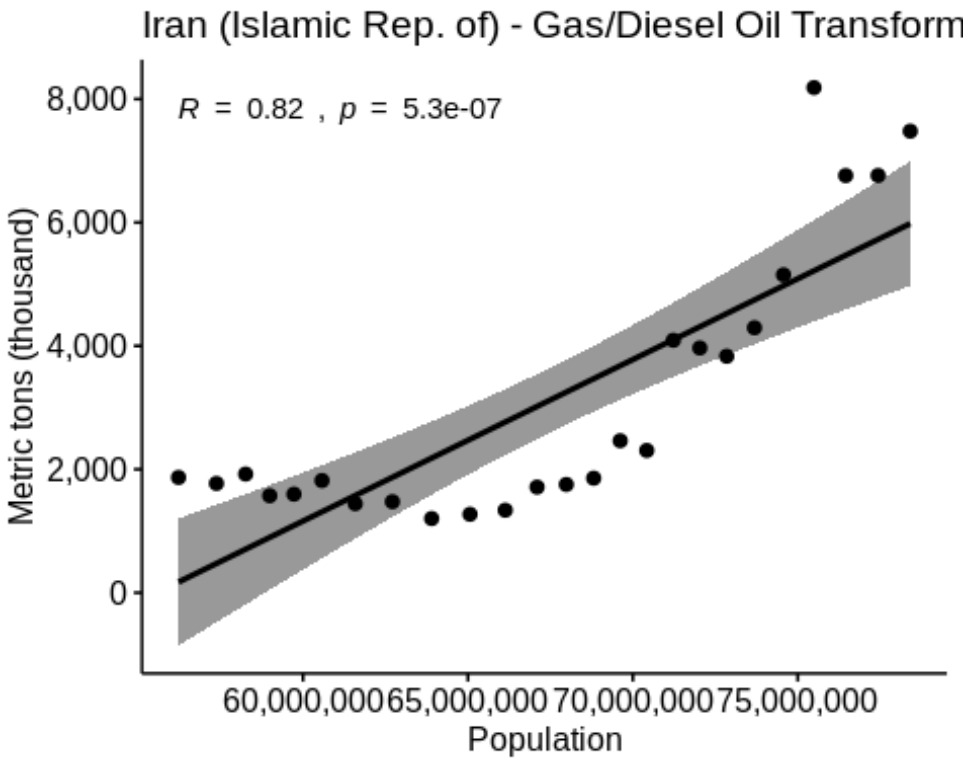

```
gd_02 <- gasdiesel_10_pop %>% filter(country_or_area == "Saudi
Arabia") %>% unnest(data)

cor.test(gd_02$population, gd_02$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_02$population and gd_02$quantity
## t = 28.451, df = 23, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9682017 0.9939446
## sample estimates:
##       cor
## 0.9860883

# 3: Indonesia
gasdiesel_10_pop %>% filter(country_or_area == "Indonesia") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Indonesia - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```



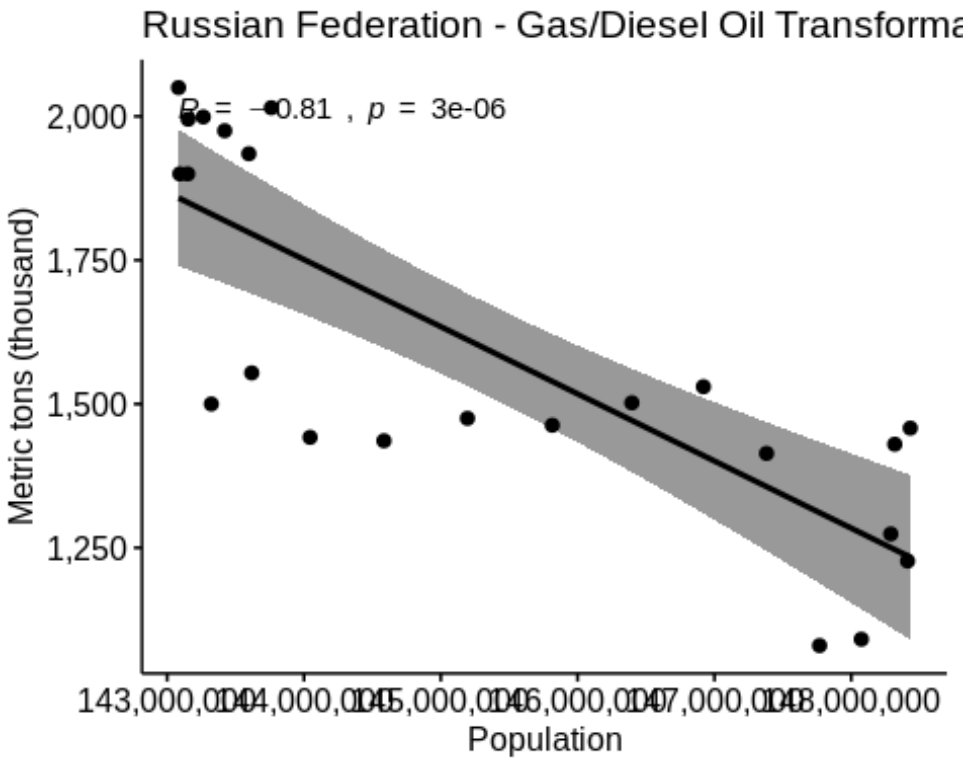

```
gd_03 <- gasdiesel_10_pop %>% filter(country_or_area == "Iraq")
%>% unnest(data)

cor.test(gd_03$population, gd_03$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_03$population and gd_03$quantity
## t = 10.956, df = 2, p-value = 0.008229
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6553507 0.9998361
## sample estimates:
##       cor
## 0.9917714

# 4: United States
gasdiesel_10_pop %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("United States - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```



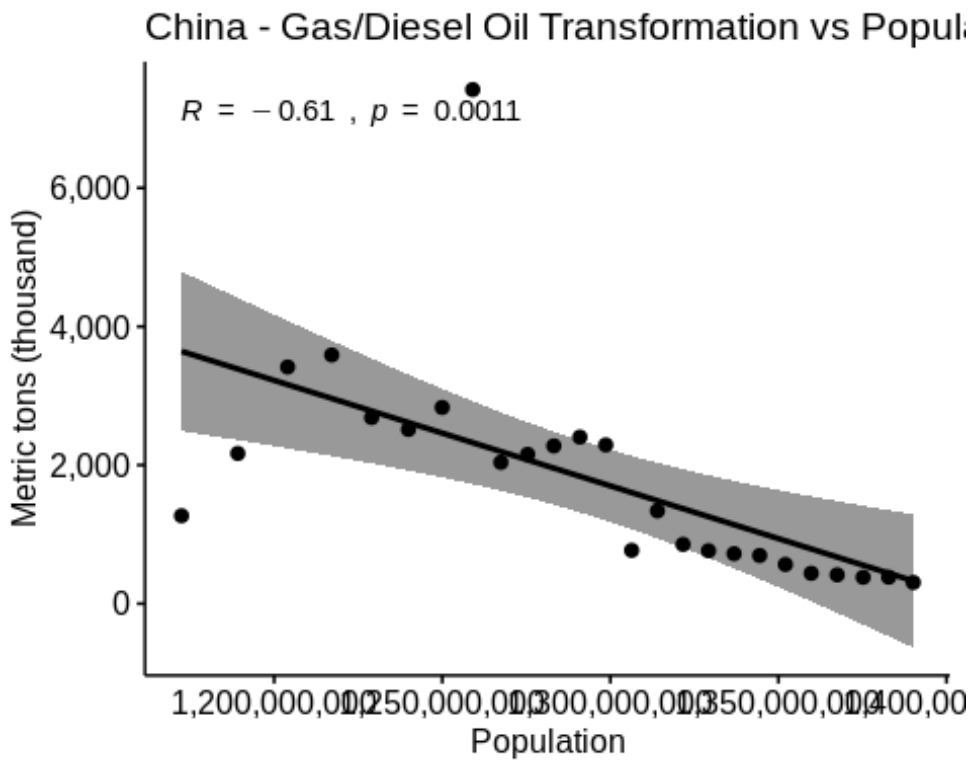

```
gd_04 <- gasdiesel_10_pop %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(gd_04$population, gd_04$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_04$population and gd_04$quantity
## t = -0.92403, df = 23, p-value = 0.3651
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5436806  0.2225768
## sample estimates:
##       cor
## -0.189193

# 5: Iran (Islamic Rep. of)
gasdiesel_10_pop %>% filter(country_or_area == "Iran (Islamic
Rep. of)") %>% unnest(data) %>% ggscatter(x = "population", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +
scale_x_continuous(name="Population", labels = comma)+
ggtitle("Iran (Islamic Rep. of) - Gas/Diesel Oil Transformation
vs Population (1990 - 2015)")
```



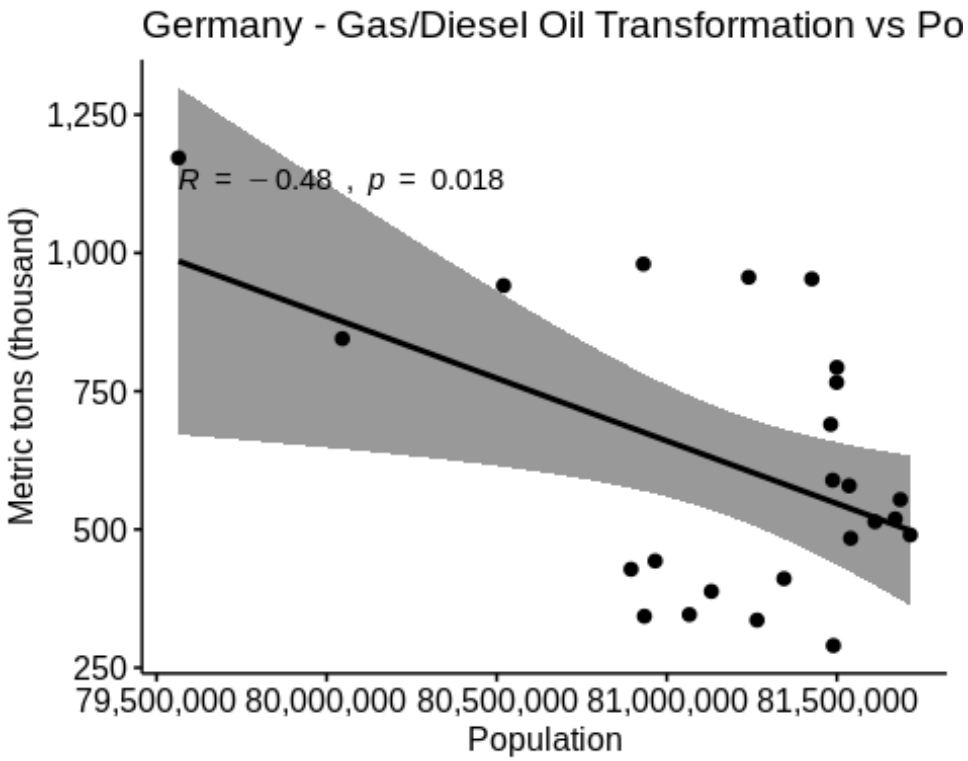

```
gd_05 <- gasdiesel_10_pop %>% filter(country_or_area == "Iran
(Islamic Rep. of)") %>% unnest(data)

cor.test(gd_05$population, gd_05$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_05$population and gd_05$quantity
## t = 6.8702, df = 23, p-value = 5.266e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6284667 0.9177559
## sample estimates:
##       cor
## 0.8199758

# 6: Russian Federation
gasdiesel_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "population", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +
scale_x_continuous(name="Population", labels = comma)+
ggtitle("Russian Federation - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```



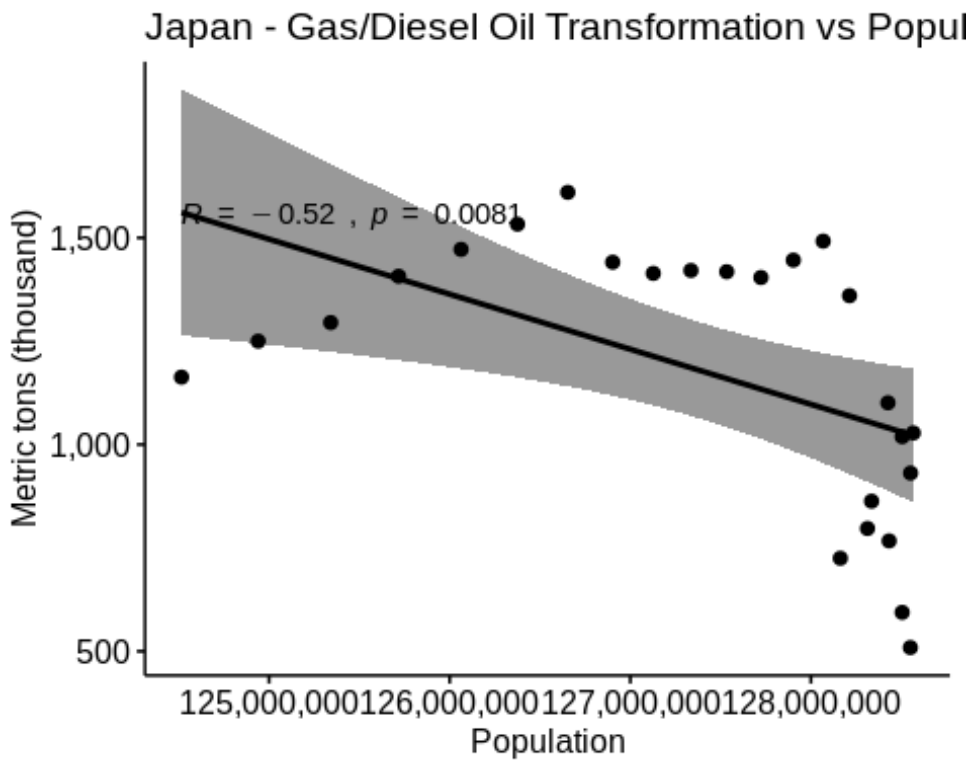

```
gd_06 <- gasdiesel_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(gd_06$population, gd_06$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_06$population and gd_06$quantity
## t = -6.309, df = 21, p-value = 2.953e-06
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9158477 -0.5954841
## sample estimates:
##        cor
## -0.8090877

# 7: China
gasdiesel_10_pop %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("China - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```



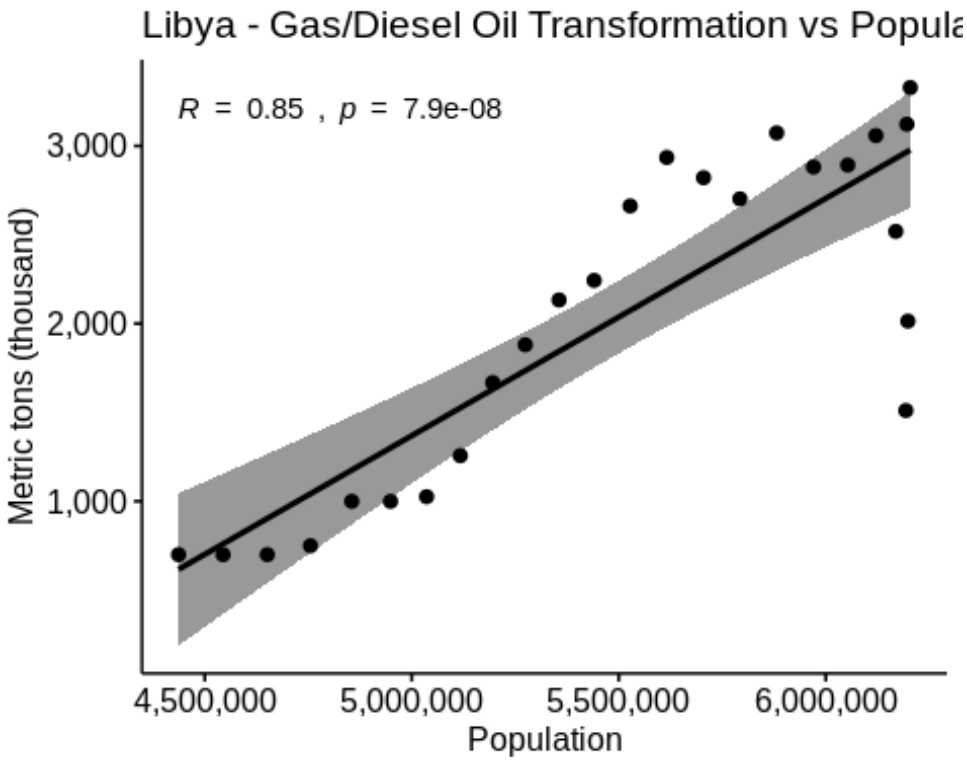

```
gd_07 <- gasdiesel_10_pop %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(gd_07$population, gd_07$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_07$population and gd_07$quantity
## t = -3.7342, df = 23, p-value = 0.001086
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8123024 -0.2895080
## sample estimates:
##        cor
## -0.6143601

# 8: Germany
gasdiesel_10_pop %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Germany - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```




```
gd_08 <- gasdiesel_10_pop %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(gd_08$population, gd_08$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_08$population and gd_08$quantity
## t = -2.5526, df = 22, p-value = 0.01815
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.73892657 -0.09244765
## sample estimates:
##       cor
## -0.4780176

# 9: Japan
gasdiesel_10_pop %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Japan - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```




```
gd_09 <- gasdiesel_10_pop %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(gd_09$population, gd_09$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_09$population and gd_09$quantity
## t = -2.896, df = 23, p-value = 0.008147
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7573616 -0.1530547
## sample estimates:
##       cor
## -0.5169237

# 10: Libya
gasdiesel_10_pop %>% filter(country_or_area == "Libya") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Libya - Gas/Diesel Oil Transformation vs
Population (1990 - 2015)")
```

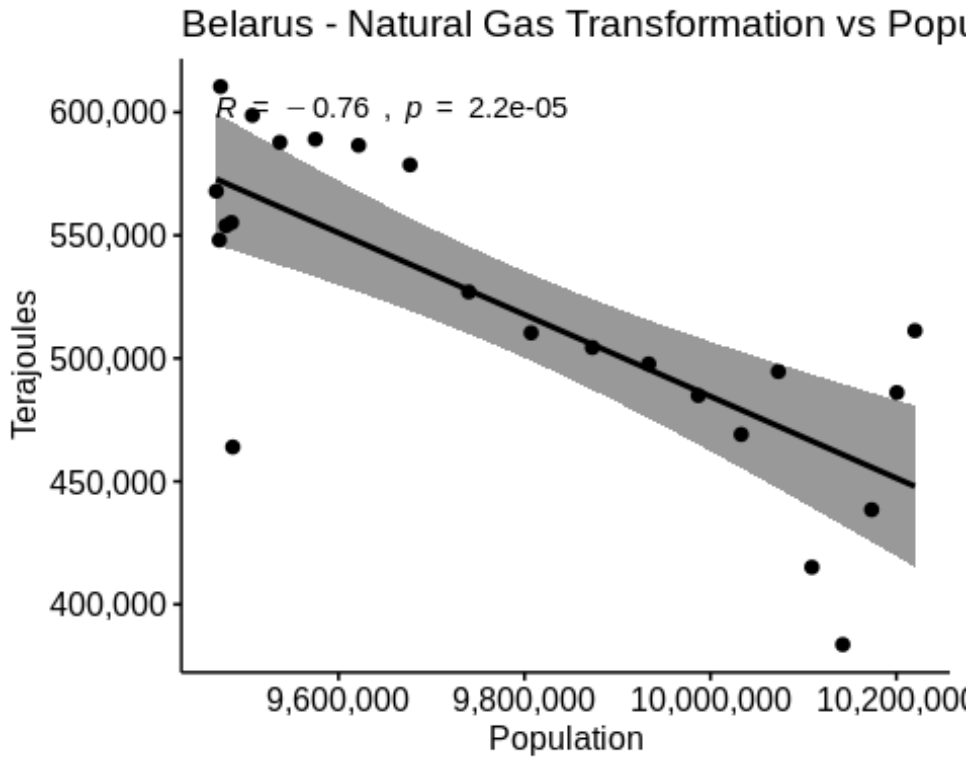



```
gd_10 <- gasdiesel_10_pop %>% filter(country_or_area == "Libya")
%>% unnest(data)

cor.test(gd_10$population, gd_10$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gd_10$population and gd_10$quantity
## t = 7.7195, df = 23, p-value = 7.868e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6837977 0.9318082
## sample estimates:
##       cor
## 0.8494233
```

(v) Natural Gas:

```
# Lastly there is Natural Gas:

natural_gas_10_pop

## # A tibble: 9 x 2
##   country_or_area    data
##   <chr>              <list>
## 1 Belarus            <tibble [23 × 6]>
## 2 Germany            <tibble [24 × 6]>
```

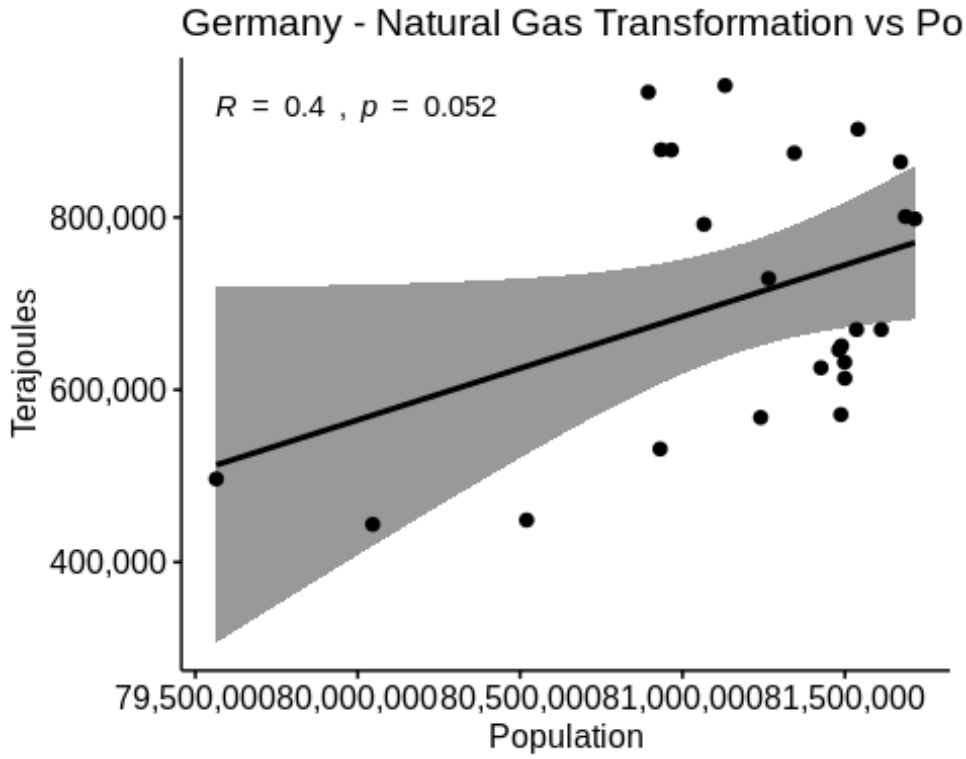
```
## 3 Japan               <tibble [25 × 6]>
## 4 Romania             <tibble [25 × 6]>
## 5 Russian Federation <tibble [23 × 6]>
## 6 Saudi Arabia        <tibble [25 × 6]>
## 7 Ukraine             <tibble [23 × 6]>
## 8 United States       <tibble [25 × 6]>
## 9 Uzbekistan          <tibble [23 × 6]>

# There are 9 countries:

# 1: Belarus
natural_gas_10_pop %>% filter(country_or_area == "Belarus") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Belarus - Natural Gas Transformation vs Population (1990
- 2015)")
```




```
ng_01 <- natural_gas_10_pop %>% filter(country_or_area ==
"Belarus") %>% unnest(data)

cor.test(ng_01$population, ng_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
```

```
## data:  ng_01$population and ng_01$quantity
## t = -5.4182, df = 21, p-value = 2.248e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8942774 -0.5126842
## sample estimates:
##       cor
## -0.7635299
```

```
# 2: Germany
natural_gas_10_pop %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Germany - Natural Gas Transformation vs Population (1990
- 2015)")
```

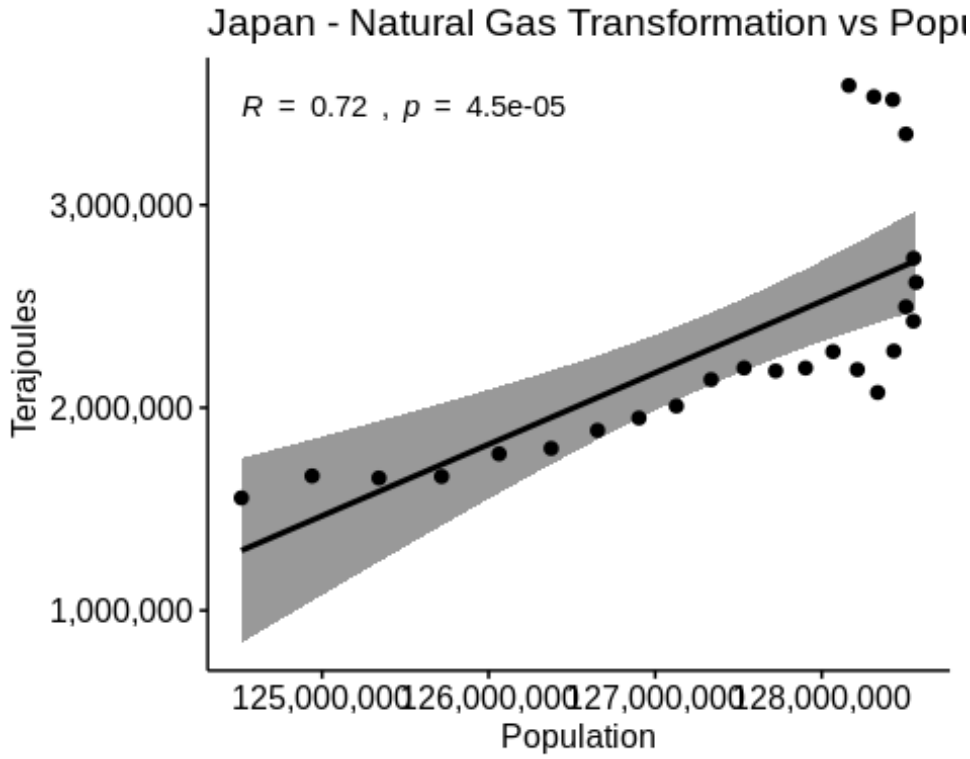



```
ng_02 <- natural_gas_10_pop %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(ng_02$population, ng_02$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ng_02$population and ng_02$quantity
```

```
## t = 2.0563, df = 22, p-value = 0.05181
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.002245396  0.692713089
## sample estimates:
##      cor
## 0.401515
```

```
# 3: Japan
natural_gas_10_pop %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Japan - Natural Gas Transformation vs Population (1990 -
2015)")
```

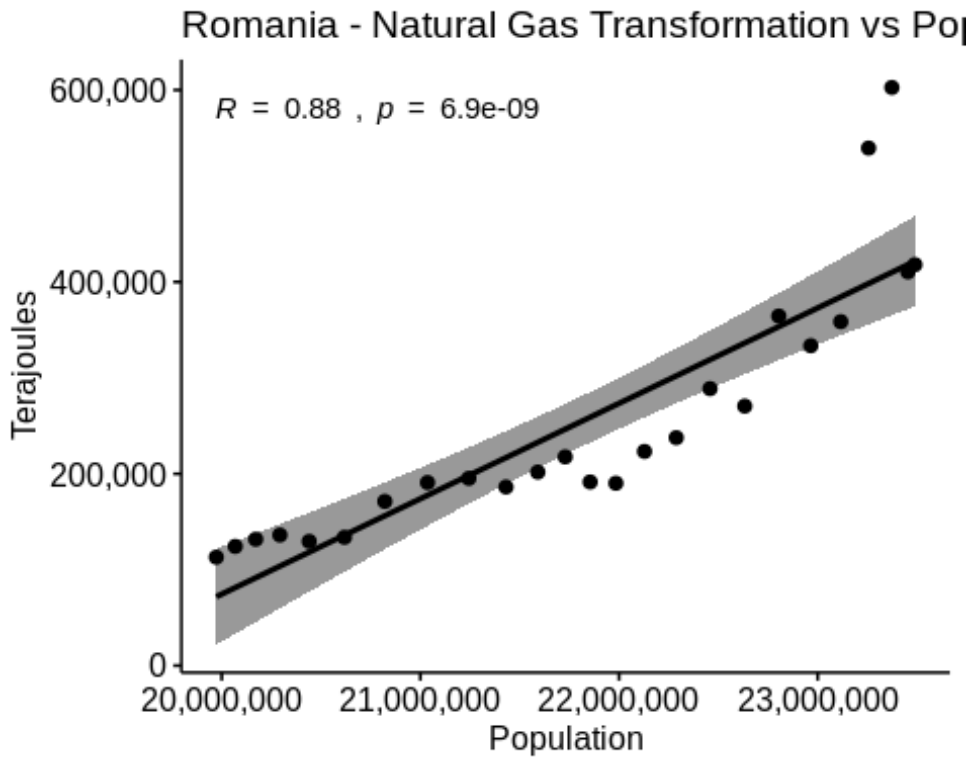



```
ng_03 <- natural_gas_10_pop %>% filter(country_or_area ==
"Japan") %>% unnest(data)

cor.test(ng_03$population, ng_03$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ng_03$population and ng_03$quantity
## t = 5.0138, df = 23, p-value = 4.507e-05
```

```
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4584002 0.8694973
## sample estimates:
##       cor
## 0.7226406
```

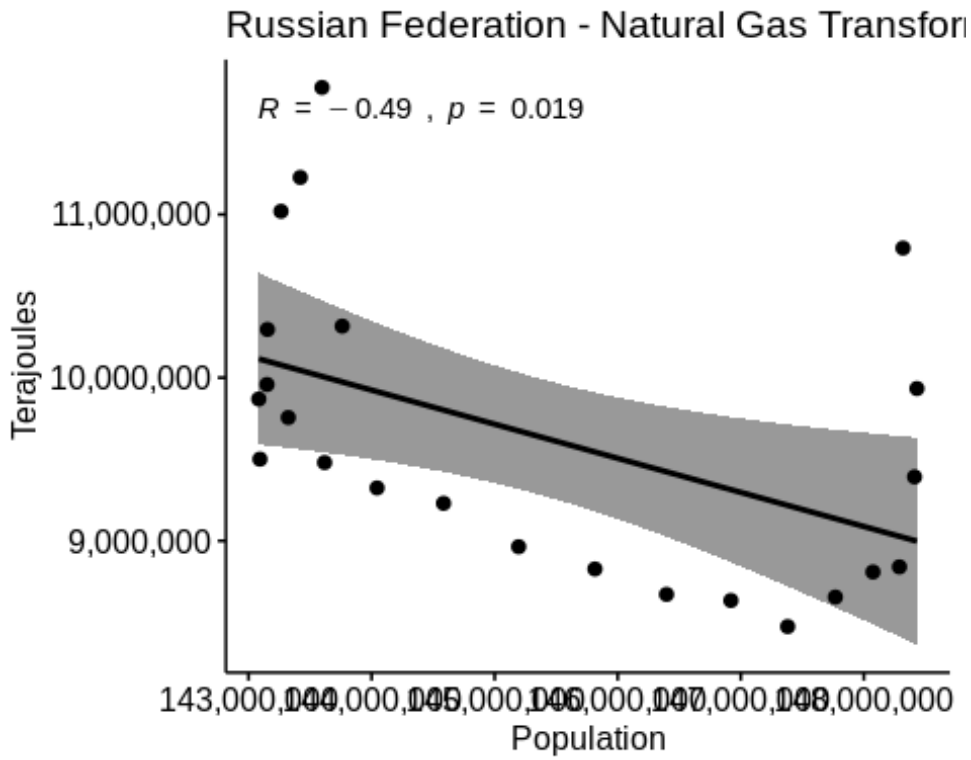
```
# 4: Romania
natural_gas_10_pop %>% filter(country_or_area == "Romania") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Romania - Natural Gas Transformation vs Population (1990
- 2015)")
```




```
ng_04 <- natural_gas_10_pop %>% filter(country_or_area ==
"Romania") %>% unnest(data)

cor.test(ng_04$population, ng_04$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ng_04$population and ng_04$quantity
## t = 8.8784, df = 23, p-value = 6.863e-09
## alternative hypothesis: true correlation is not equal to 0
```

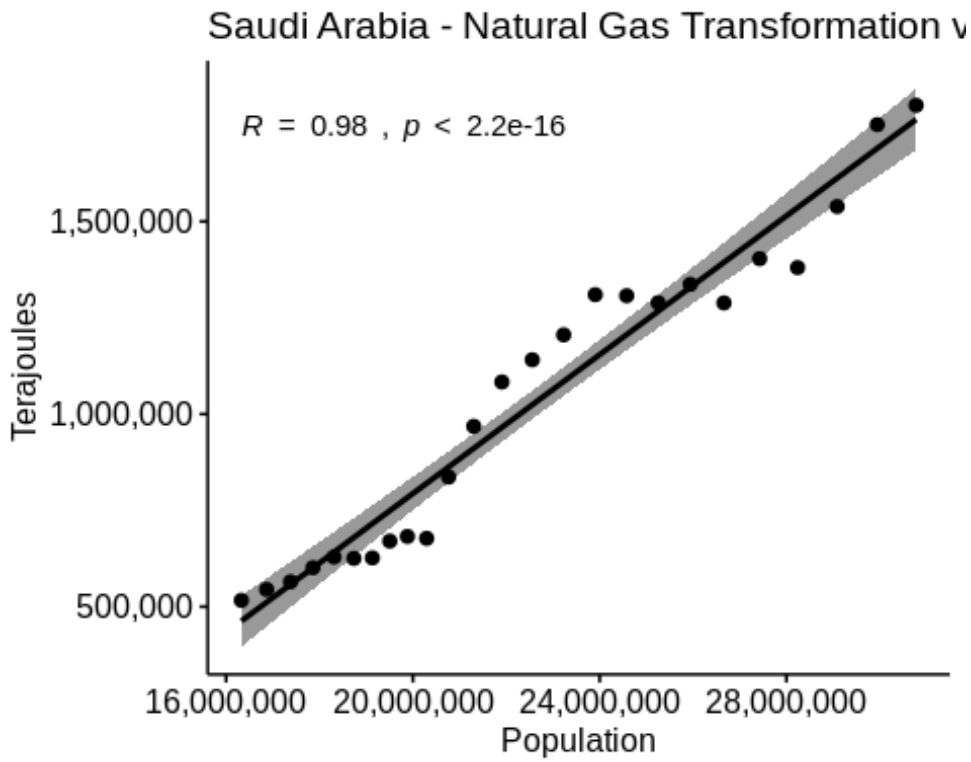
```
## 95 percent confidence interval:
##  0.7430288 0.9460699
## sample estimates:
##       cor
## 0.8798433

# 5: Russian Federation
natural_gas_10_pop %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "population", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Terajoules",
labels = comma) +  scale_x_continuous(name="Population", labels =
comma)+ ggtitle("Russian Federation - Natural Gas Transformation
vs Population (1990 - 2015)")
```




```
ng_05 <- natural_gas_10_pop %>% filter(country_or_area ==
"Russian Federation") %>% unnest(data)

cor.test(ng_05$population, ng_05$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ng_05$population and ng_05$quantity
## t = -2.549, df = 21, p-value = 0.01868
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
```

```
##  -0.74835454 -0.09241758
## sample estimates:
##        cor
## -0.4861018
```

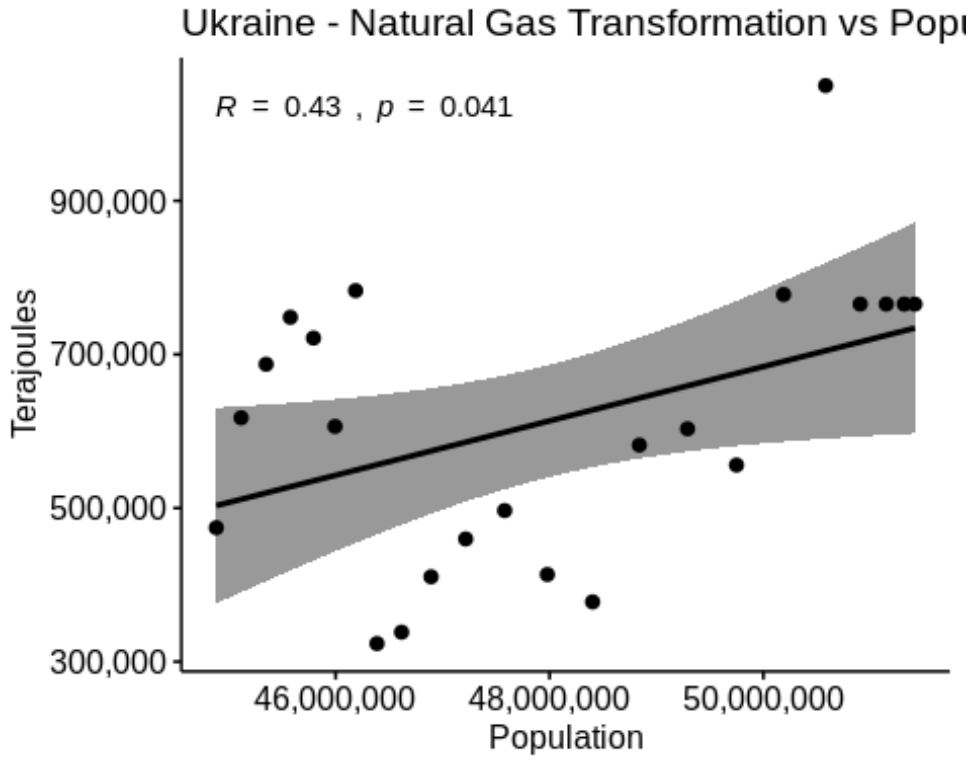
```
# 6: Saudi Arabia
natural_gas_10_pop %>% filter(country_or_area == "Saudi Arabia")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Saudi Arabia - Natural Gas Transformation vs Population
(1990 - 2015)")
```




```
ng_06 <- natural_gas_10_pop %>% filter(country_or_area == "Saudi
Arabia") %>% unnest(data)

cor.test(ng_06$population, ng_06$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ng_06$population and ng_06$quantity
## t = 21.392, df = 23, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9450023 0.9894259
```

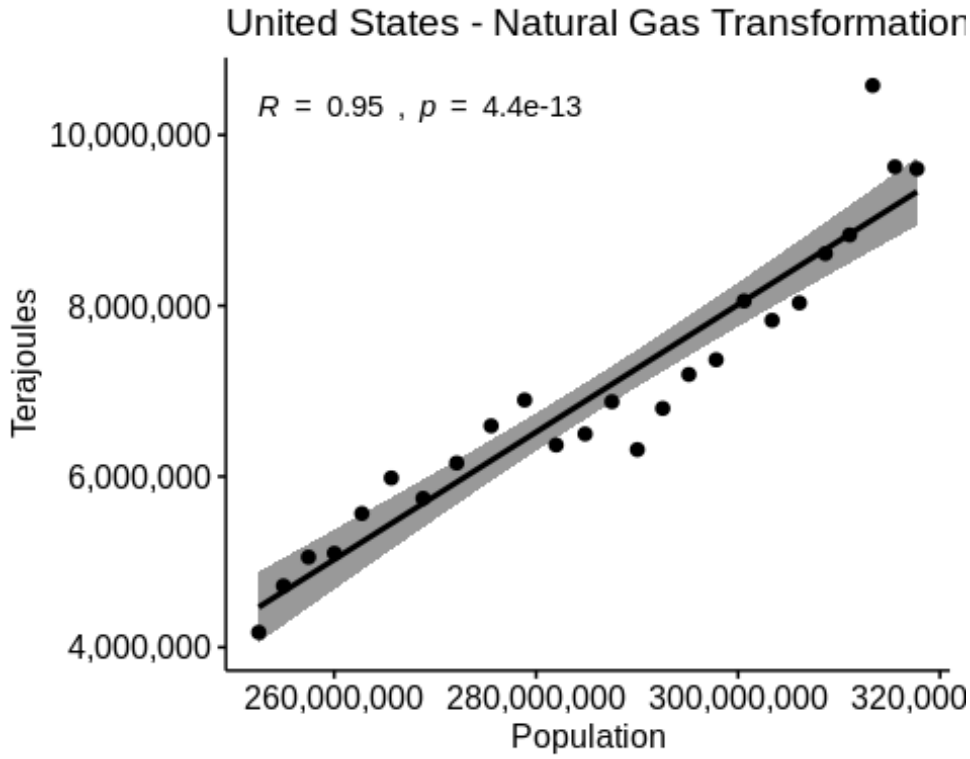
```
## sample estimates:
##       cor
## 0.9757781

# 7: Ukraine
natural_gas_10_pop %>% filter(country_or_area == "Ukraine") %>%
unnest(data) %>% ggscatter(x = "population", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Ukraine - Natural Gas Transformation vs Population (1990
- 2015)")
```




```
ng_07 <- natural_gas_10_pop %>% filter(country_or_area ==
"Ukraine") %>% unnest(data)

cor.test(ng_07$population, ng_07$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ng_07$population and ng_07$quantity
## t = 2.1783, df = 21, p-value = 0.04093
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.02077862 0.71498268
## sample estimates:
```

```
##       cor
## 0.4293038
```

```
# 8: United States
natural_gas_10_pop %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("United States - Natural Gas Transformation vs Population
(1990 - 2015)")
```

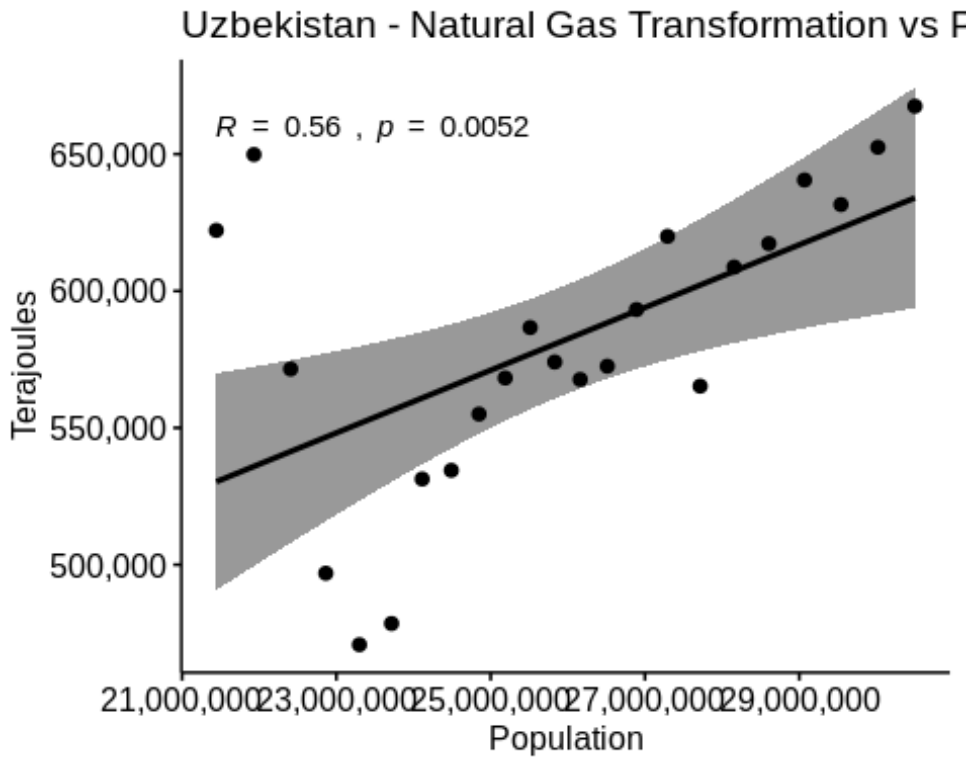



```
ng_08 <- natural_gas_10_pop %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(ng_08$population, ng_08$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ng_08$population and ng_08$quantity
## t = 14.538, df = 23, p-value = 4.397e-13
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8875937 0.9778604
## sample estimates:
```

```
##       cor
## 0.9496629
```

```
# 9: Uzbekistan
natural_gas_10_pop %>% filter(country_or_area == "Uzbekistan") %>
% unnest(data) %>% ggscatter(x = "population", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Population", labels = comma)+
ggtitle("Uzbekistan - Natural Gas Transformation vs Population
(1990 - 2015)")
```




```
ng_09 <- natural_gas_10_pop %>% filter(country_or_area ==
"Uzbekistan") %>% unnest(data)

cor.test(ng_09$population, ng_09$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ng_09$population and ng_09$quantity
## t = 3.1151, df = 21, p-value = 0.005238
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1952083 0.7910641
## sample estimates:
```

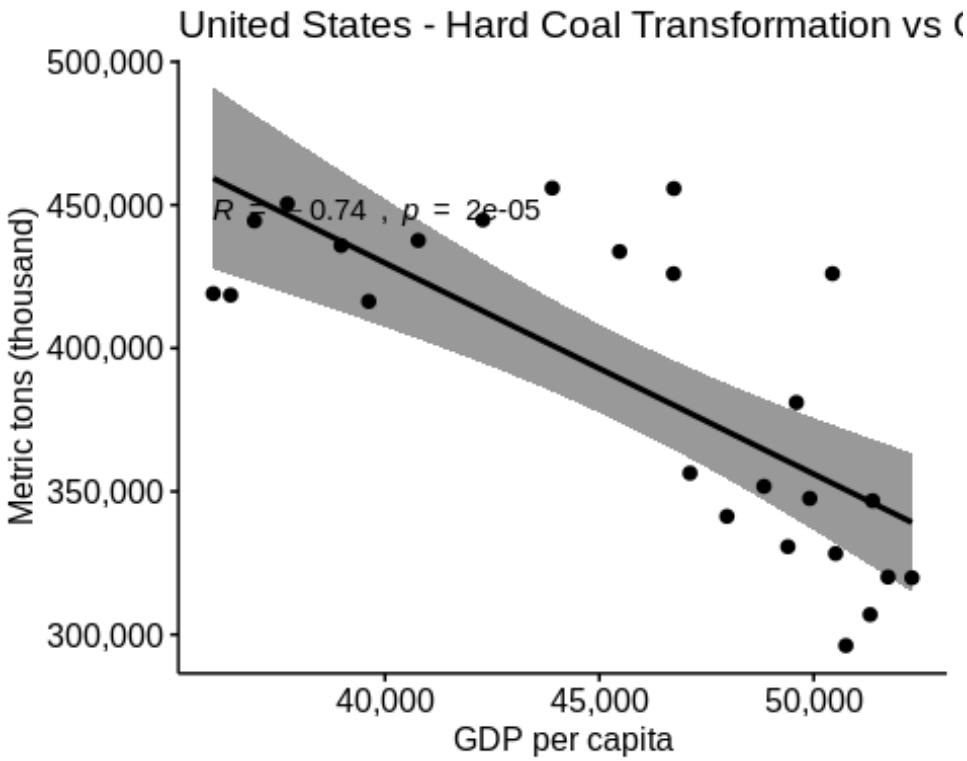
```
##       cor
## 0.5621749
```

Part 2: Energy Transformations against GDP # (i) Hard Coal

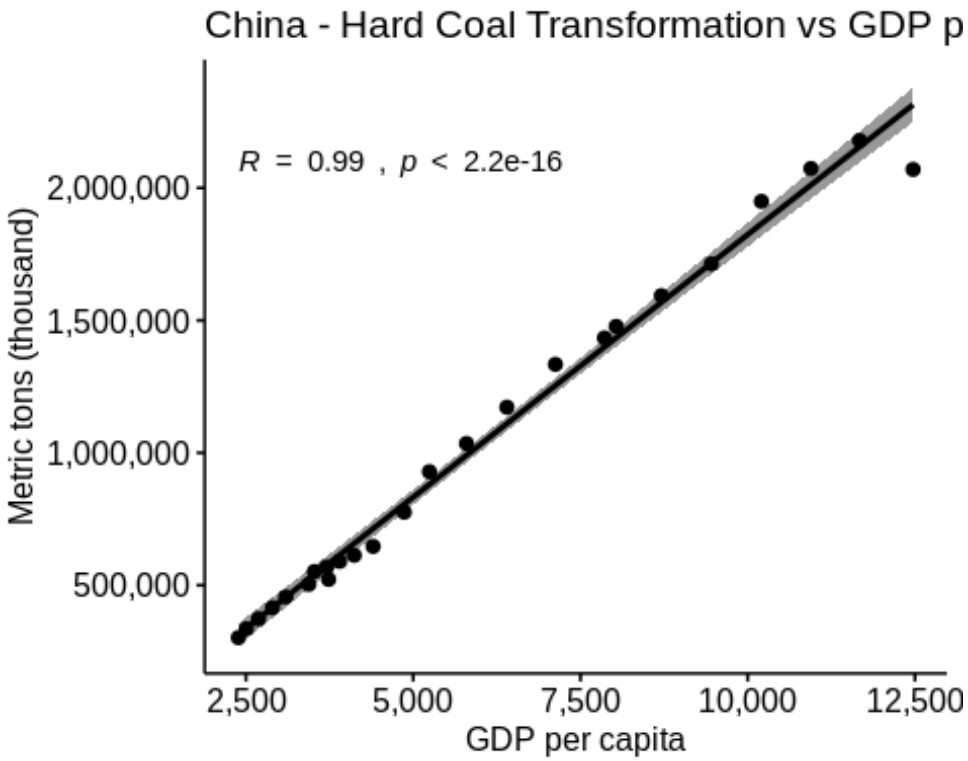
```
# Now we look at our hard coal data more closely

hard_coal_10_gdp
```

```
## # A tibble: 10 x 2
##    country_or_area    data
##    <chr>              <list>
##  1 United States      <tibble [25 × 6]>
##  2 China              <tibble [25 × 6]>
##  3 Russian Federation <tibble [23 × 6]>
##  4 India              <tibble [25 × 6]>
##  5 United Kingdom     <tibble [25 × 6]>
##  6 Poland             <tibble [25 × 6]>
##  7 South Africa       <tibble [25 × 6]>
##  8 Germany            <tibble [24 × 6]>
##  9 Kazakhstan         <tibble [23 × 6]>
## 10 Japan              <tibble [25 × 6]>
```

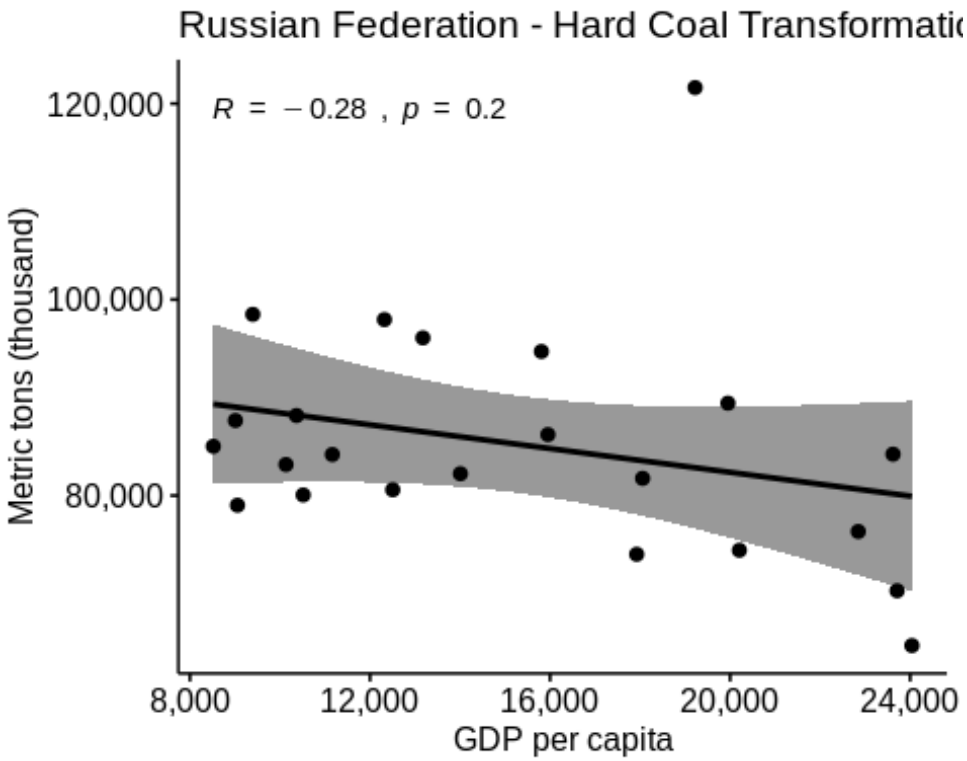
```
# These are the 10 countries that we need to investigate.

# 1: United States
hard_coal_10_gdp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("United States - Hard Coal
Transformation vs GDP per capita (1990 - 2015)")
```



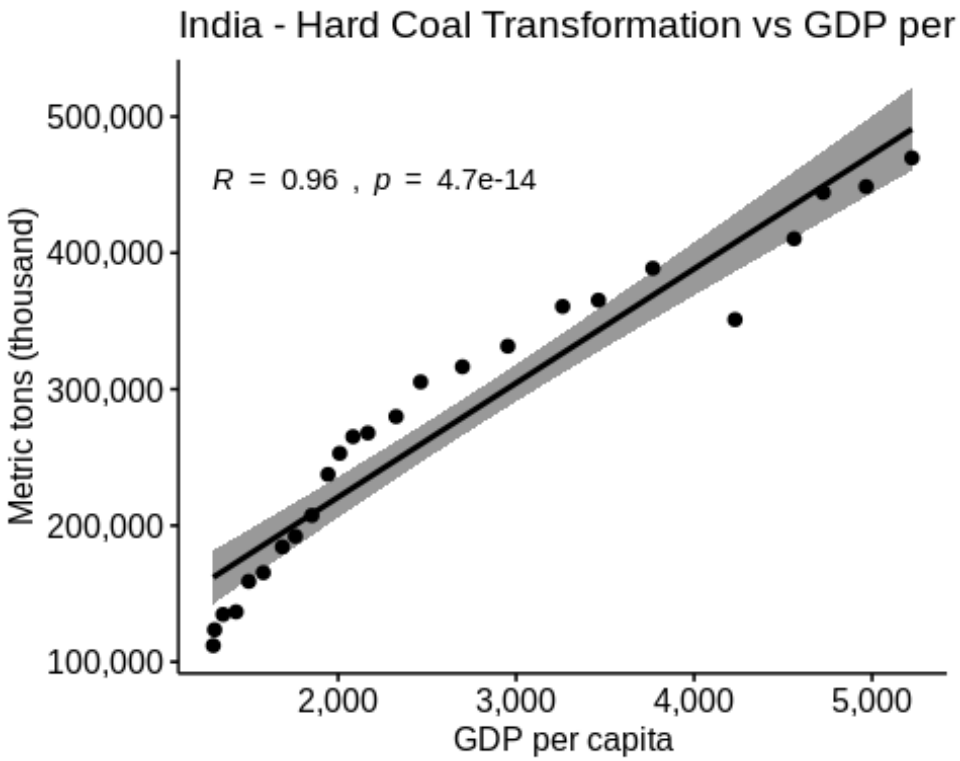

```
ghc_01 <- hard_coal_10_gdp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(ghc_01$gdp_per_capita, ghc_01$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_01$gdp_per_capita and ghc_01$quantity
## t = -5.3378, df = 23, p-value = 2.026e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8802626 -0.4938969
## sample estimates:
##        cor
## -0.7438605

# 2: China
hard_coal_10_gdp %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("China - Hard Coal Transformation vs GDP
per capita (1990 - 2015)")
```



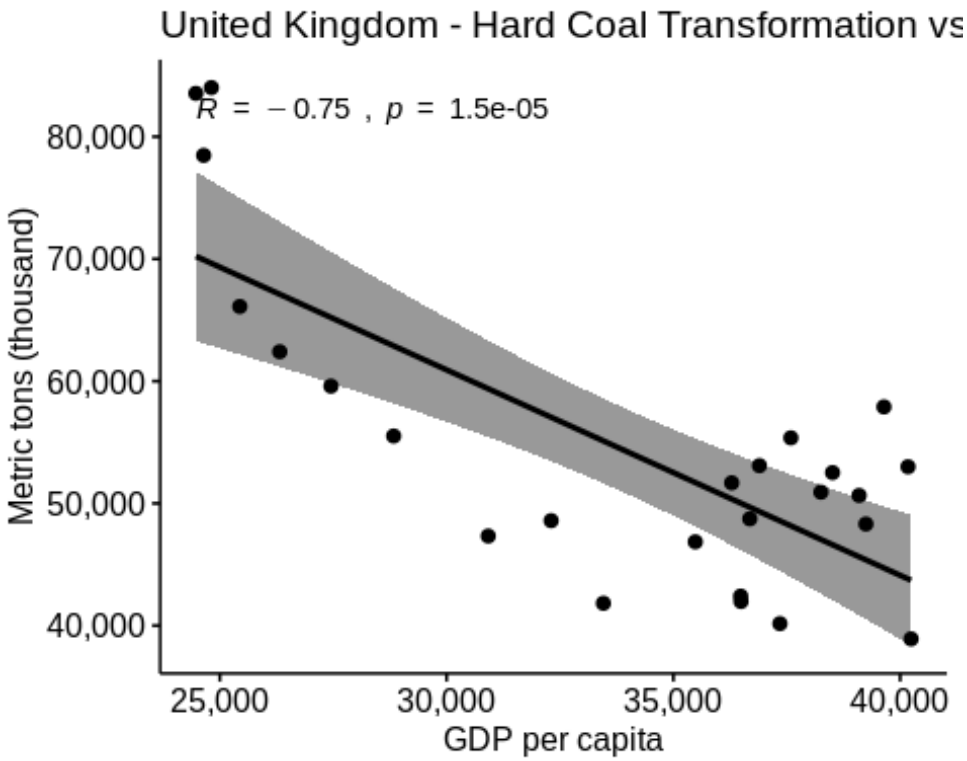

```r
ghc_02 <- hard_coal_10_gdp %>% filter(country_or_area == "China") %>% unnest(data)

cor.test(ghc_02$gdp_per_capita, ghc_02$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_02$gdp_per_capita and ghc_02$quantity
## t = 45.621, df = 23, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9874050 0.9976203
## sample estimates:
##       cor
## 0.9945198

# 3: Russian Federation
hard_coal_10_gdp %>% filter(country_or_area == "Russian Federation") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method = "pearson") + scale_y_continuous(name="Metric tons (thousand)", labels = comma) +  scale_x_continuous(name="GDP per capita", labels = comma)+ ggtitle("Russian Federation - Hard Coal Transformation vs GDP per capita (1990 - 2015)")
```




```
ghc_03 <- hard_coal_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(ghc_03$gdp_per_capita, ghc_03$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_03$gdp_per_capita and ghc_03$quantity
## t = -1.3197, df = 21, p-value = 0.2011
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.6183938  0.1529136
## sample estimates:
##        cor
## -0.2767313

# 4: India
hard_coal_10_gdp %>% filter(country_or_area == "India") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("India - Hard Coal Transformation vs GDP
per capita (1990 - 2015)")
```



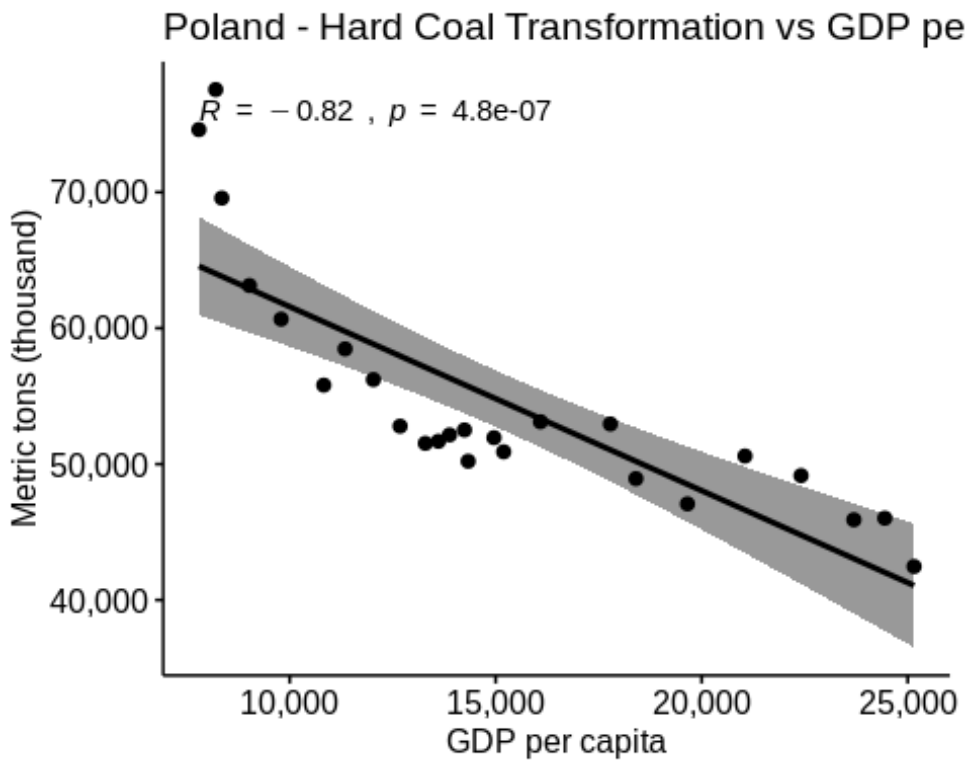

```
ghc_04 <- hard_coal_10_gdp %>% filter(country_or_area == "India")
%>% unnest(data)

cor.test(ghc_04$gdp_per_capita, ghc_04$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_04$gdp_per_capita and ghc_04$quantity
## t = 16.173, df = 23, p-value = 4.674e-14
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9073275 0.9818991
## sample estimates:
##       cor
## 0.9587382

# 5: United Kingdom
hard_coal_10_gdp %>% filter(country_or_area == "United Kingdom")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("United Kingdom - Hard Coal
Transformation vs GDP per capita (1990 - 2015)")
```



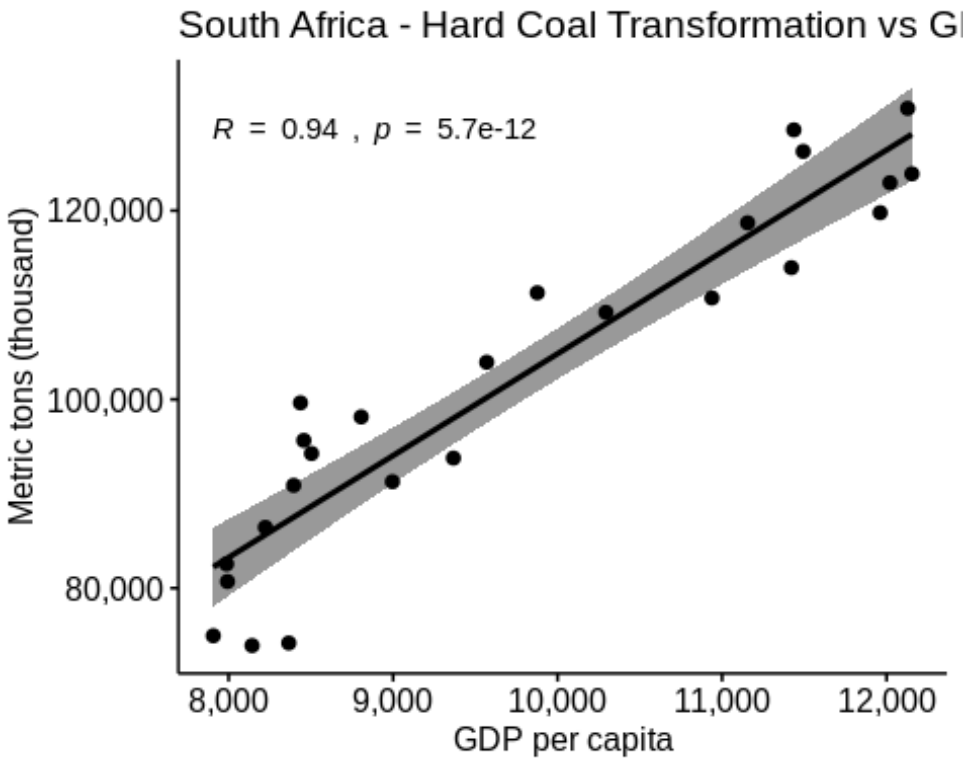

```r
ghc_05 <- hard_coal_10_gdp %>% filter(country_or_area == "United Kingdom") %>% unnest(data)

cor.test(ghc_05$gdp_per_capita, ghc_05$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ghc_05$gdp_per_capita and ghc_05$quantity
## t = -5.4476, df = 23, p-value = 1.548e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8836427 -0.5053143
## sample estimates:
##       cor
## -0.7505803
```

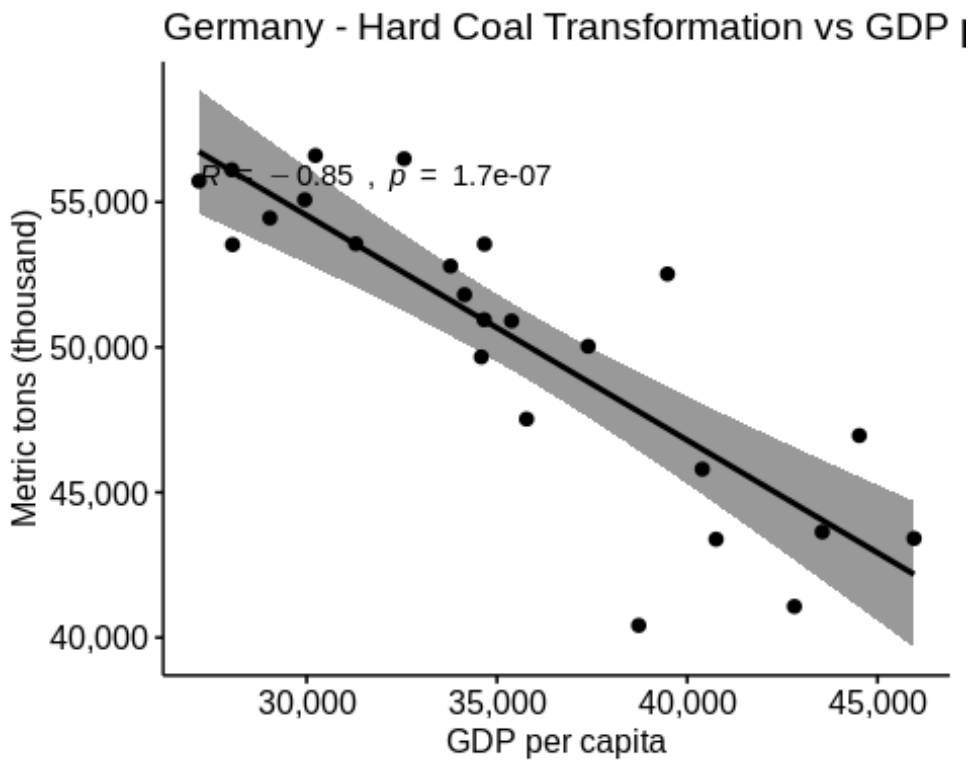
```r
# 6: Poland
hard_coal_10_gdp %>% filter(country_or_area == "Poland") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method = "pearson") + scale_y_continuous(name="Metric tons (thousand)", labels = comma) +  scale_x_continuous(name="GDP per capita", labels = comma)+ ggtitle("Poland - Hard Coal Transformation vs GDP per capita (1990 - 2015)")
```



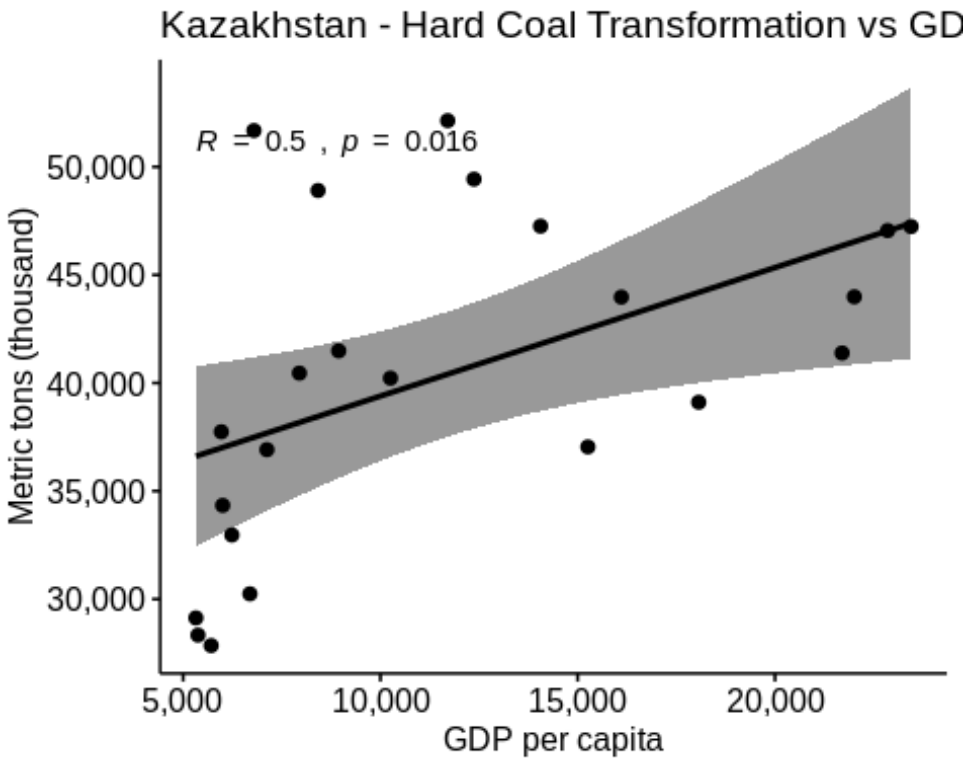

```
ghc_06 <- hard_coal_10_gdp %>% filter(country_or_area ==
"Poland") %>% unnest(data)

cor.test(ghc_06$gdp_per_capita, ghc_06$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_06$gdp_per_capita and ghc_06$quantity
## t = -6.9085, df = 23, p-value = 4.824e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9184729 -0.6312208
## sample estimates:
##        cor
## -0.8214659

# 7: South Africa
hard_coal_10_gdp %>% filter(country_or_area == "South Africa") %>
% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("South Africa - Hard Coal
Transformation vs GDP per capita (1990 - 2015)")
```



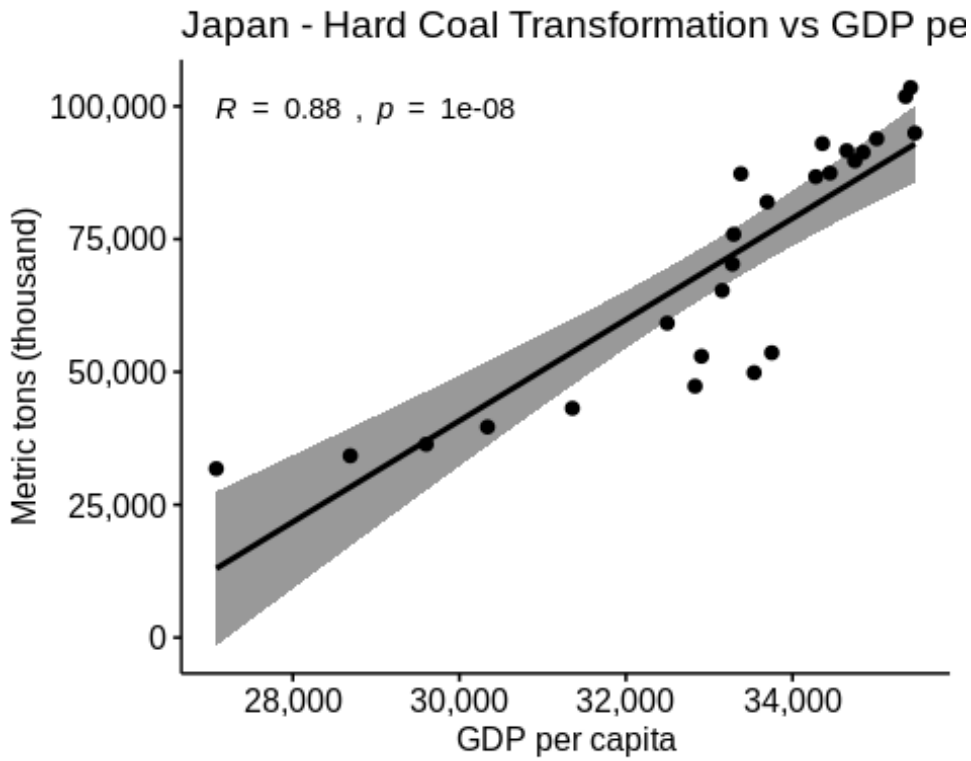

```
ghc_07 <- hard_coal_10_gdp %>% filter(country_or_area == "South
Africa") %>% unnest(data)

cor.test(ghc_07$gdp_per_capita, ghc_07$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_07$gdp_per_capita and ghc_07$quantity
## t = 12.831, df = 23, p-value = 5.739e-12
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8598197 0.9720598
## sample estimates:
##       cor
## 0.9367111

# 8: Germany
hard_coal_10_gdp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Germany - Hard Coal Transformation vs
GDP per capita (1990 - 2015)")
```




```
ghc_08 <- hard_coal_10_gdp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(ghc_08$gdp_per_capita, ghc_08$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_08$gdp_per_capita and ghc_08$quantity
## t = -7.4877, df = 22, p-value = 1.74e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9321785 -0.6747236
## sample estimates:
##       cor
## -0.8474581

# 9: Kazakhstan
hard_coal_10_gdp %>% filter(country_or_area == "Kazakhstan") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Kazakhstan - Hard Coal Transformation
vs GDP per capita (1990 - 2015)")
```




```
ghc_09 <- hard_coal_10_gdp %>% filter(country_or_area ==
"Kazakhstan") %>% unnest(data)

cor.test(ghc_09$gdp_per_capita, ghc_09$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_09$gdp_per_capita and ghc_09$quantity
## t = 2.6165, df = 21, p-value = 0.01612
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1051262 0.7539470
## sample estimates:
##       cor
## 0.4958419

# 10: Japan
hard_coal_10_gdp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Japan - Hard Coal Transformation vs GDP
per capita (1990 - 2015)")
```

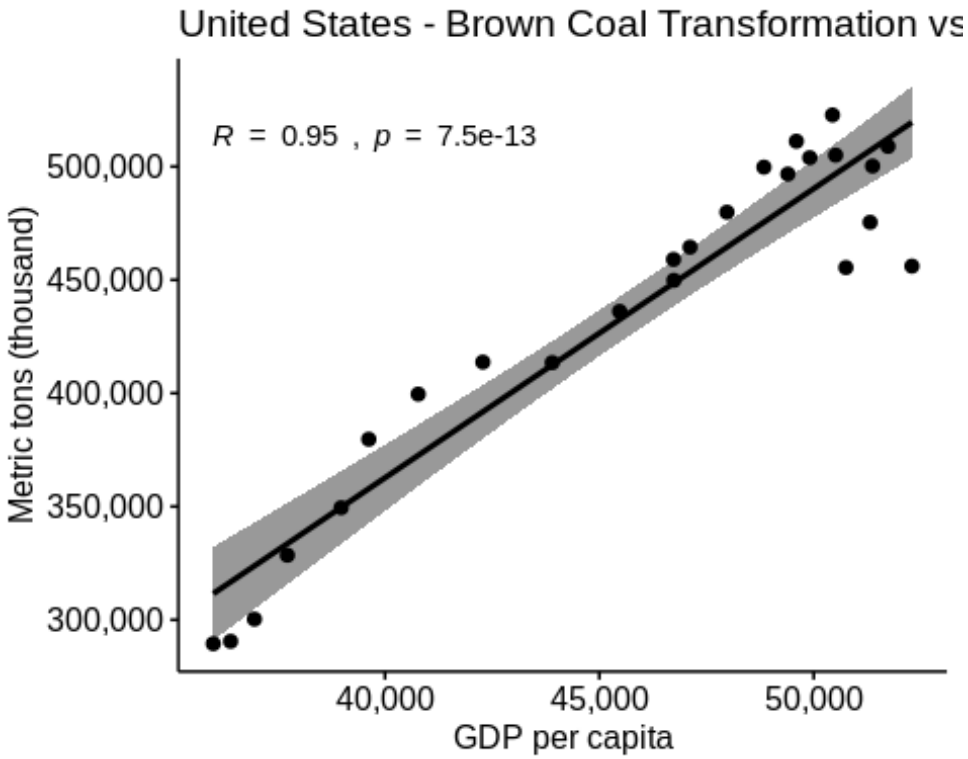



```
ghc_10 <- hard_coal_10_gdp %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(ghc_10$gdp_per_capita, ghc_10$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  ghc_10$gdp_per_capita and ghc_10$quantity
## t = 8.6904, df = 23, p-value = 1.007e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7344960 0.9440628
## sample estimates:
##       cor
## 0.8755291
```

(ii) Brown Coal

```
# Now we look at brown coal:

brown_coal_10_gdp

## # A tibble: 6 x 2
##   country_or_area    data
##   <chr>              <list>
```

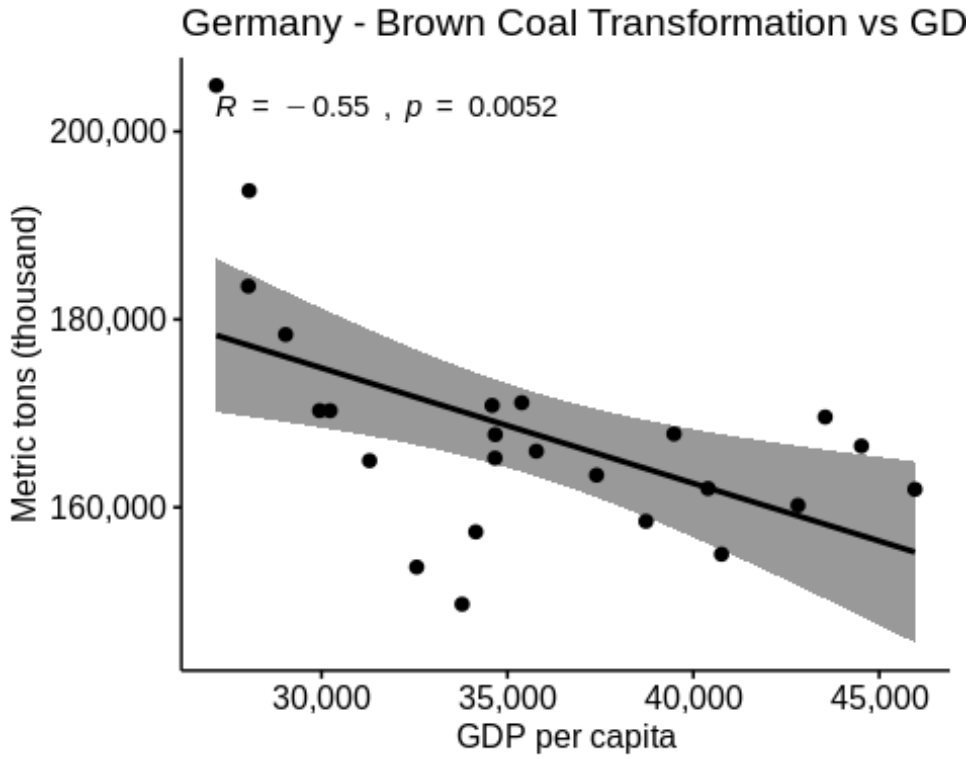
```
## 1 United States      <tibble [25 × 6]>
## 2 Germany            <tibble [24 × 6]>
## 3 Russian Federation <tibble [23 × 6]>
## 4 Poland             <tibble [25 × 6]>
## 5 Australia          <tibble [25 × 6]>
## 6 Greece             <tibble [25 × 6]>

# These are the 6 countries that we need to investigate.

# 1: United States
brown_coal_10_gdp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("United States - Brown Coal
Transformation vs GDP per capita (1990 - 2015)")
```




```
gbc_01 <- brown_coal_10_gdp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(gbc_01$gdp_per_capita, gbc_01$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
```

```
## data:  gbc_01$gdp_per_capita and gbc_01$quantity
## t = 14.171, df = 23, p-value = 7.477e-13
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8823404 0.9767738
## sample estimates:
##       cor
## 0.9472293
```

```
# 2: Germany
brown_coal_10_gdp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Germany - Brown Coal Transformation vs
GDP per capita (1990 - 2015)")
```

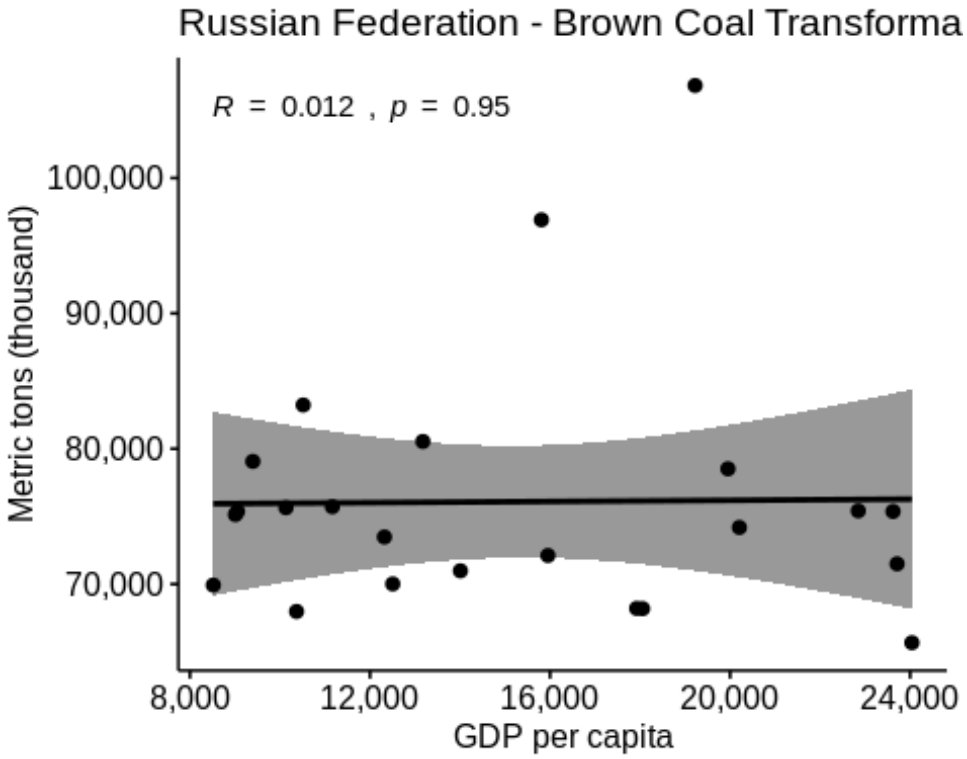



```
gbc_02 <- brown_coal_10_gdp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(gbc_02$gdp_per_capita, gbc_02$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
```

```
## data:  gbc_02$gdp_per_capita and gbc_02$quantity
## t = -3.102, df = 22, p-value = 0.0052
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7811921 -0.1906615
## sample estimates:
##       cor
## -0.551631
```

```
# 3: Russian Federation
brown_coal_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita",
y = "quantity", add = "reg.line", conf.int = TRUE, cor.coef =
TRUE, cor.method = "pearson") + scale_y_continuous(name="Metric
tons (thousand)", labels = comma) +  scale_x_continuous(name="GDP
per capita", labels = comma)+ ggtitle("Russian Federation - Brown
Coal Transformation vs GDP per capita (1990 - 2015)")
```

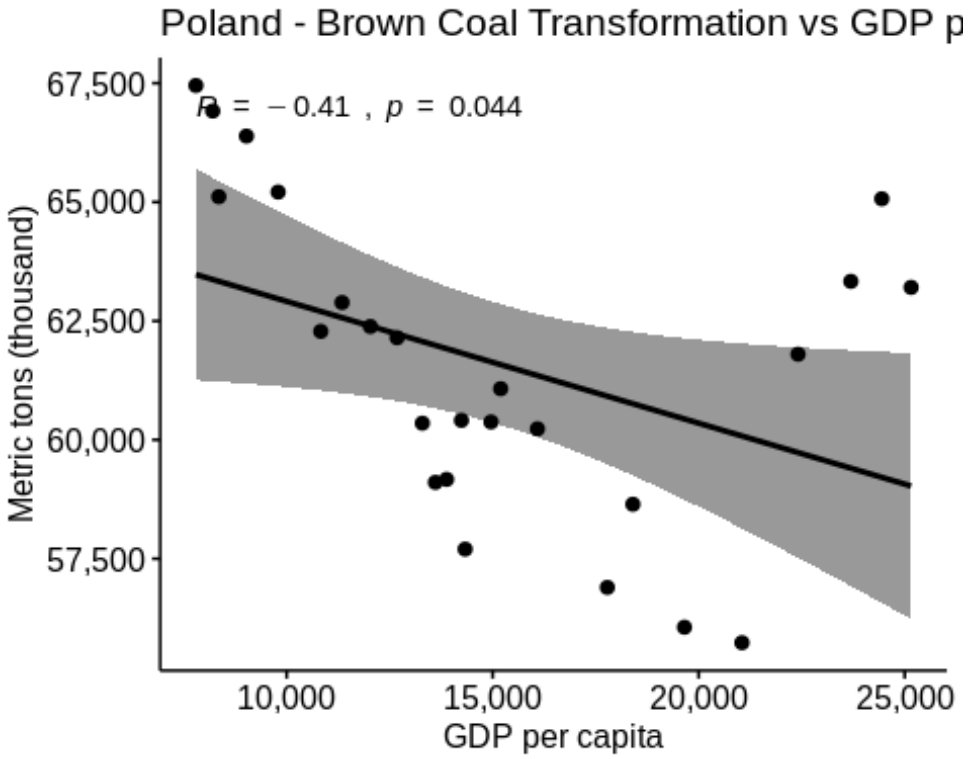



```
gbc_03 <- brown_coal_10_gdp %>% filter(country_or_area ==
"Russian Federation") %>% unnest(data)

cor.test(gbc_03$gdp_per_capita, gbc_03$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
```

```
## data:  gbc_03$gdp_per_capita and gbc_03$quantity
## t = 0.057113, df = 21, p-value = 0.955
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.401804  0.422494
## sample estimates:
##        cor
## 0.01246219
```

```
# 4: Poland
brown_coal_10_gdp %>% filter(country_or_area == "Poland") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Poland - Brown Coal Transformation vs
GDP per capita (1990 - 2015)")
```

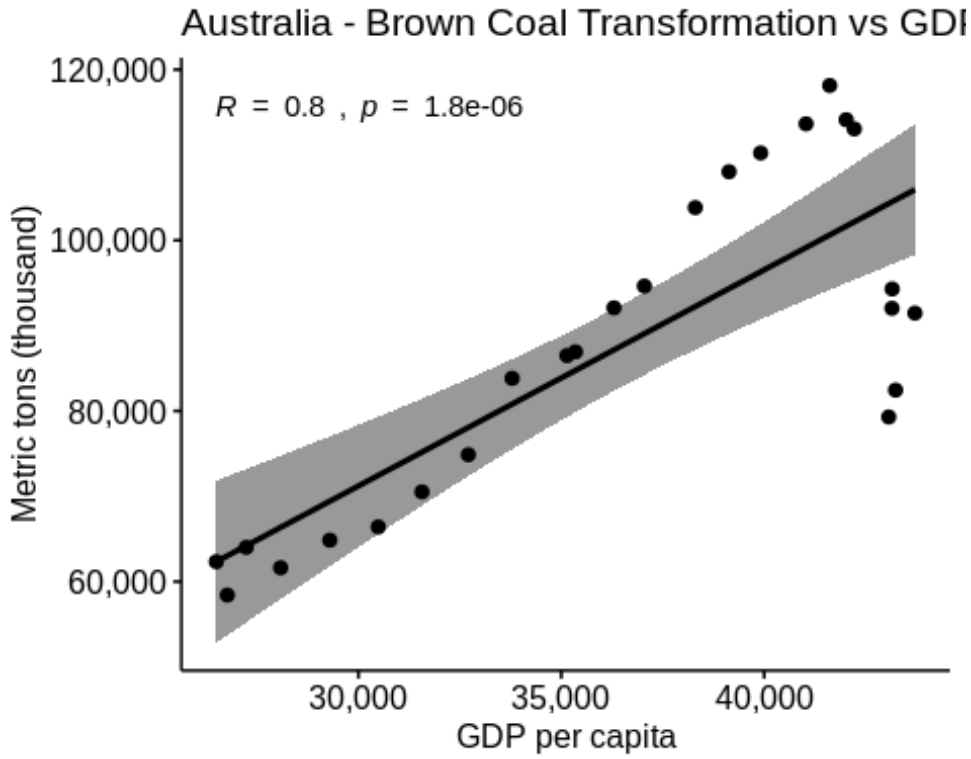



```
gbc_04 <- brown_coal_10_gdp %>% filter(country_or_area ==
"Poland") %>% unnest(data)

cor.test(gbc_04$gdp_per_capita, gbc_04$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
```

```
## data:  gbc_04$gdp_per_capita and gbc_04$quantity
## t = -2.1344, df = 23, p-value = 0.04369
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.69075348 -0.01366309
## sample estimates:
##       cor
## -0.4065989
```

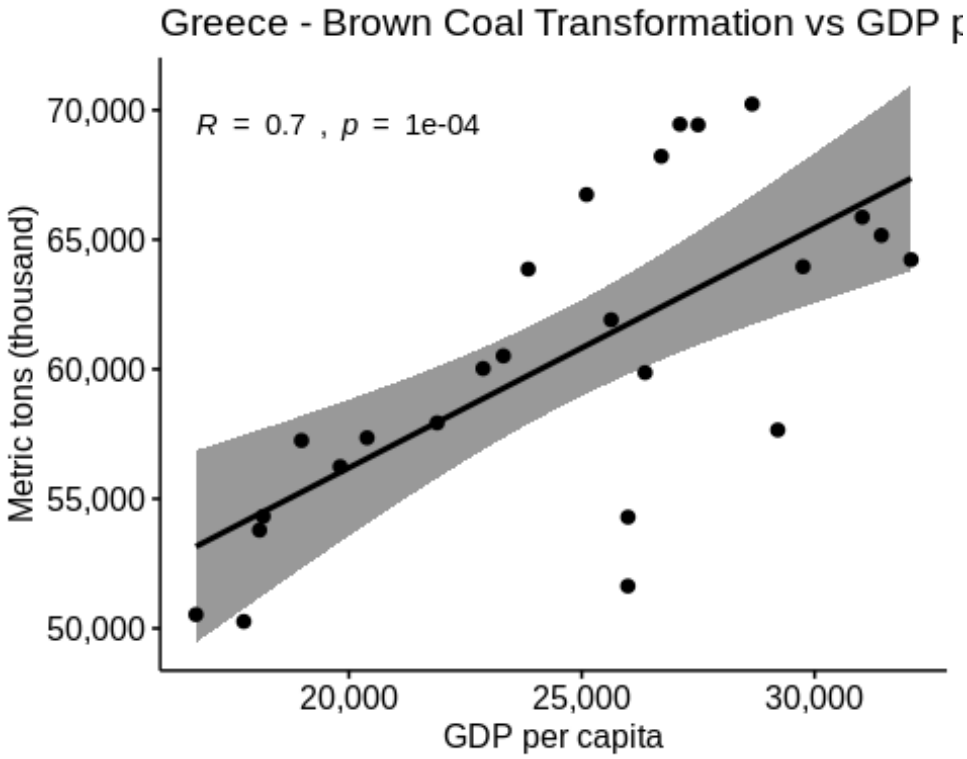
```
# 5: Australia
brown_coal_10_gdp %>% filter(country_or_area == "Australia") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Australia - Brown Coal Transformation
vs GDP per capita (1990 - 2015)")
```




```
gbc_05 <- brown_coal_10_gdp %>% filter(country_or_area ==
"Australia") %>% unnest(data)

cor.test(gbc_05$gdp_per_capita, gbc_05$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
```

```
## data:  gbc_05$gdp_per_capita and gbc_05$quantity
## t = 6.3522, df = 23, p-value = 1.756e-06
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.5885544 0.9071487
## sample estimates:
##       cor
## 0.7980857
```

```
# 6: Greece
brown_coal_10_gdp %>% filter(country_or_area == "Greece") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Greece - Brown Coal Transformation vs
GDP per capita (1990 - 2015)")
```




```
gbc_06 <- brown_coal_10_gdp %>% filter(country_or_area ==
"Greece") %>% unnest(data)

cor.test(gbc_06$gdp_per_capita, gbc_06$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
```

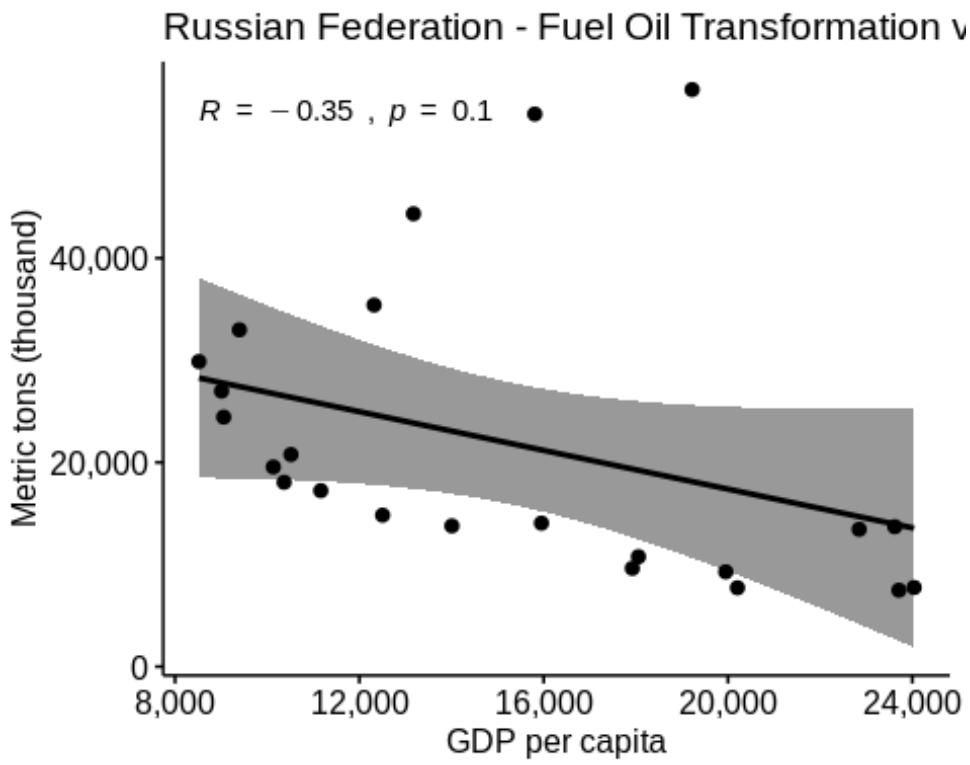
```
## data:  gbc_06$gdp_per_capita and gbc_06$quantity
## t = 4.678, df = 23, p-value = 0.0001039
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4186305 0.8569536
## sample estimates:
##       cor
## 0.6982596
```

(iii) Fuel Oil:

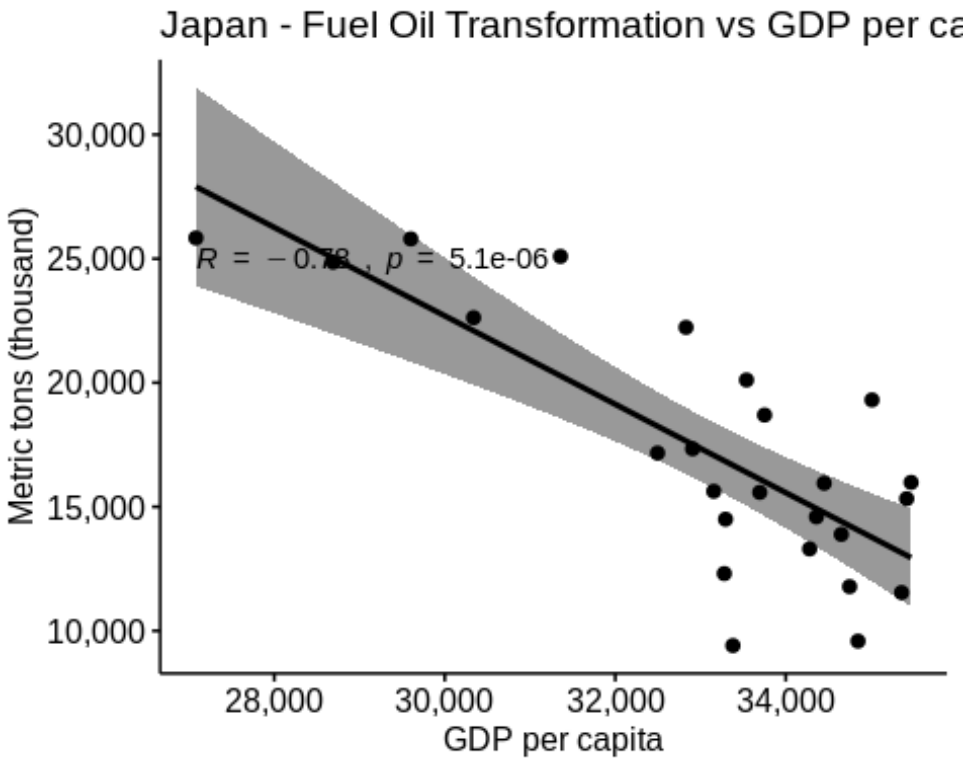
```
# Now we look at fuel oil:

fuel_oil_10_gdp
```

```
## # A tibble: 10 x 2
##    country_or_area    data
##    <chr>              <list>
##  1 Russian Federation <tibble [23 × 6]>
##  2 Japan              <tibble [25 × 6]>
##  3 United States      <tibble [25 × 6]>
##  4 Italy              <tibble [25 × 6]>
##  5 Mexico             <tibble [25 × 6]>
##  6 China              <tibble [25 × 6]>
##  7 Belarus            <tibble [23 × 6]>
##  8 United Kingdom     <tibble [25 × 6]>
##  9 Romania            <tibble [25 × 6]>
## 10 Ukraine            <tibble [23 × 6]>
```

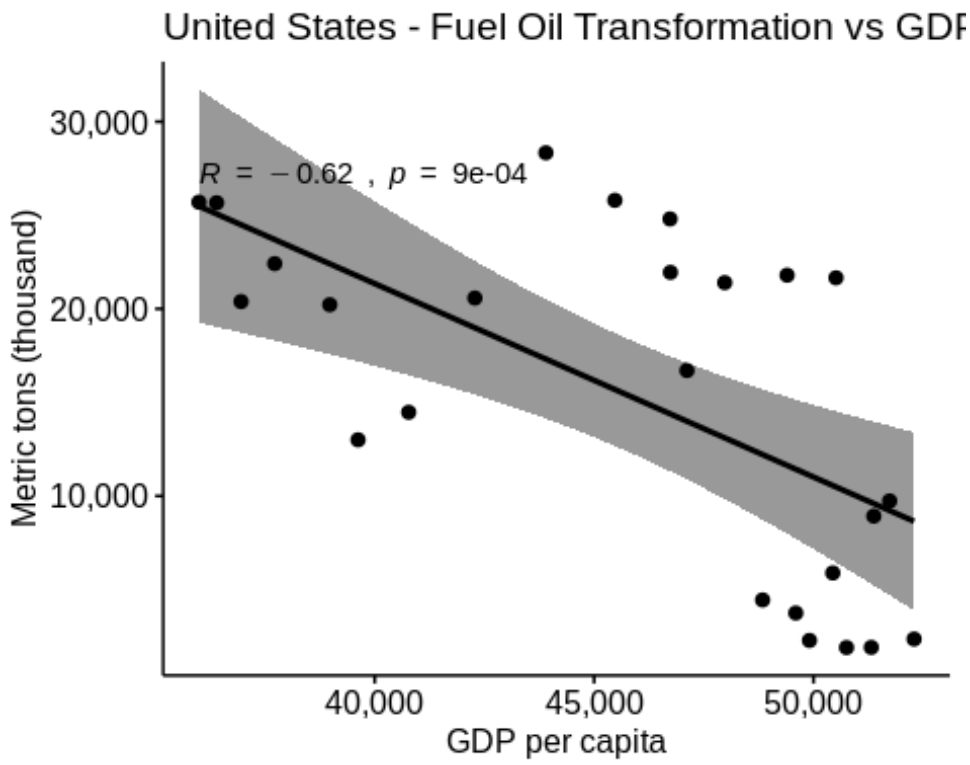
```
# These are the 10 countries that we need to investigate.

# 1: Russian Federation
fuel_oil_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita",
y = "quantity", add = "reg.line", conf.int = TRUE, cor.coef =
TRUE, cor.method = "pearson") + scale_y_continuous(name="Metric
tons (thousand)", labels = comma) +  scale_x_continuous(name="GDP
per capita", labels = comma)+ ggtitle("Russian Federation - Fuel
Oil Transformation vs GDP per capita (1990 - 2015)")
```



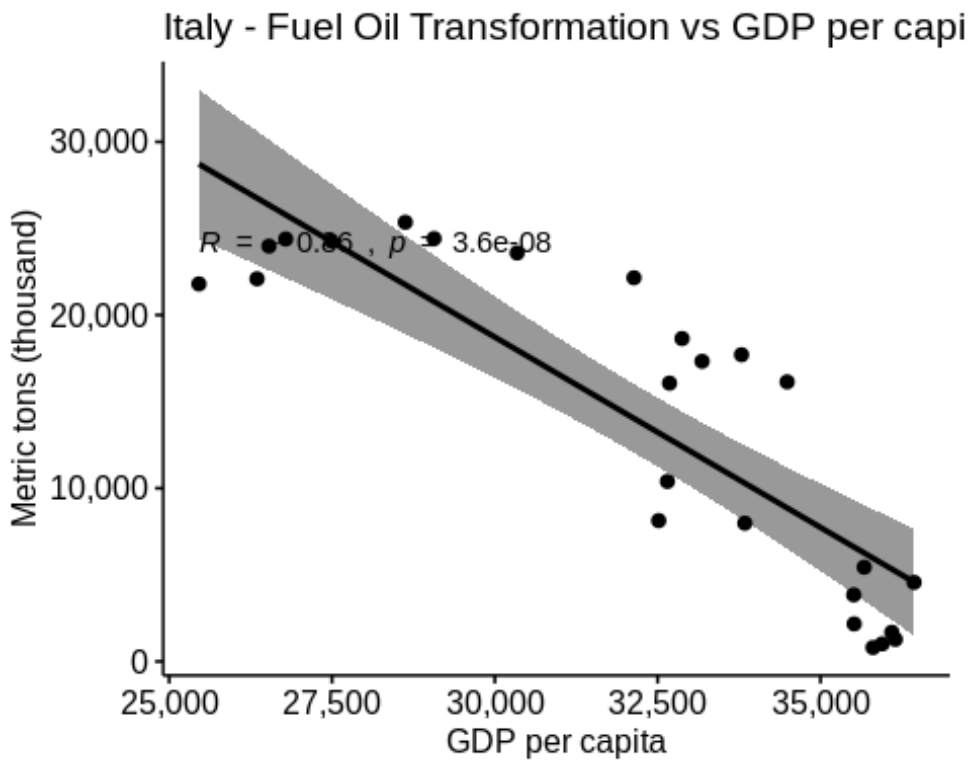

```
gfo_01 <- fuel_oil_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(gfo_01$gdp_per_capita, gfo_01$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_01$gdp_per_capita and gfo_01$quantity
## t = -1.7173, df = 21, p-value = 0.1006
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.66668593  0.07164594
## sample estimates:
##        cor
## -0.3509198

# 2: Japan
fuel_oil_10_gdp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Japan - Fuel Oil Transformation vs GDP
per capita (1990 - 2015)")
```



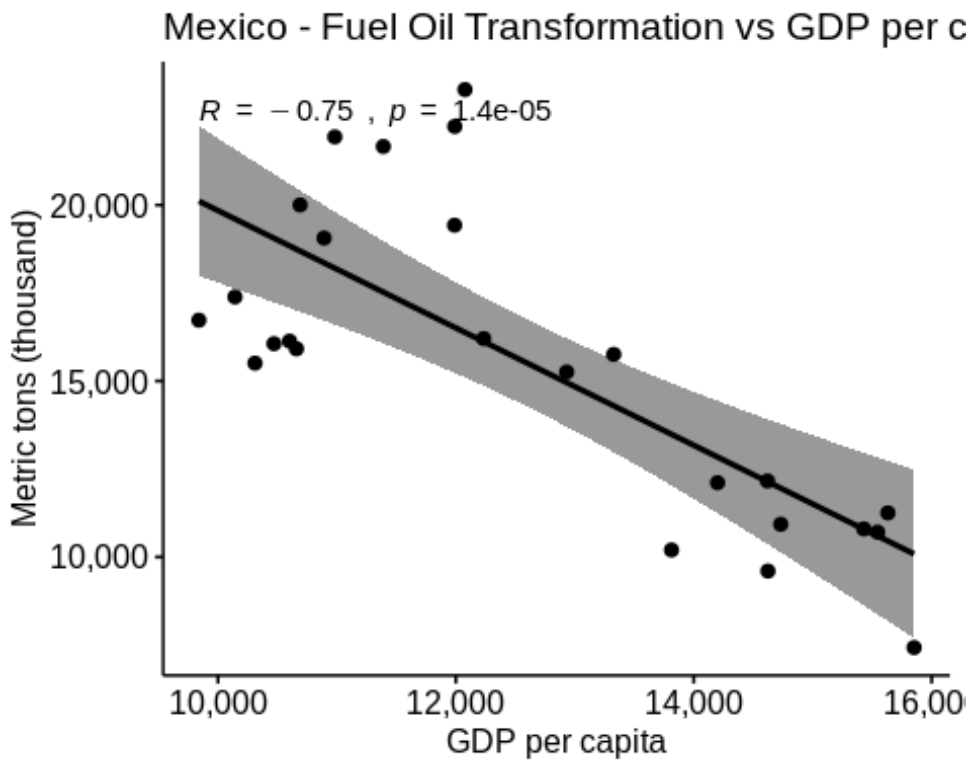

```
gfo_02 <- fuel_oil_10_gdp %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(gfo_02$gdp_per_capita, gfo_02$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_02$gdp_per_capita and gfo_02$quantity
## t = -5.9038, df = 23, p-value = 5.111e-06
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8963933 -0.5496097
## sample estimates:
##       cor
## -0.7761794

# 3: United States
fuel_oil_10_gdp %>% filter(country_or_area == "United States") %>
% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("United States - Fuel Oil
Transformation vs GDP per capita (1990 - 2015)")
```



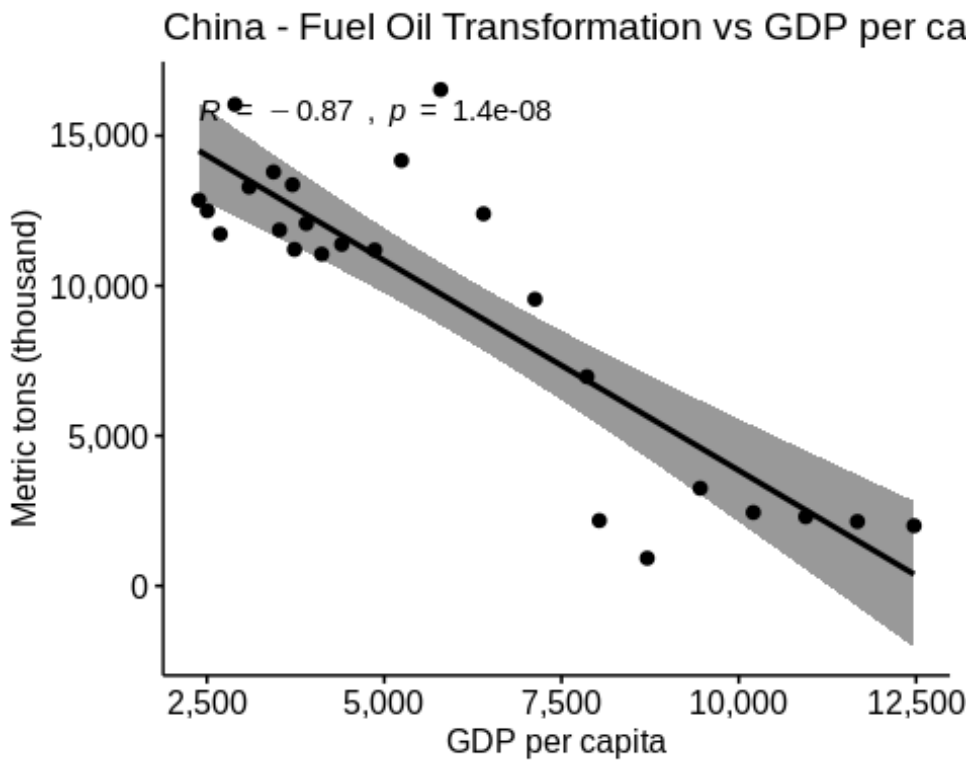

```
gfo_03 <- fuel_oil_10_gdp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(gfo_03$gdp_per_capita, gfo_03$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_03$gdp_per_capita and gfo_03$quantity
## t = -3.8114, df = 23, p-value = 0.0008976
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8165614 -0.3010544
## sample estimates:
##       cor
## -0.6221741

# 4: Italy
fuel_oil_10_gdp %>% filter(country_or_area == "Italy") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Italy - Fuel Oil Transformation vs GDP
per capita (1990 - 2015)")
```



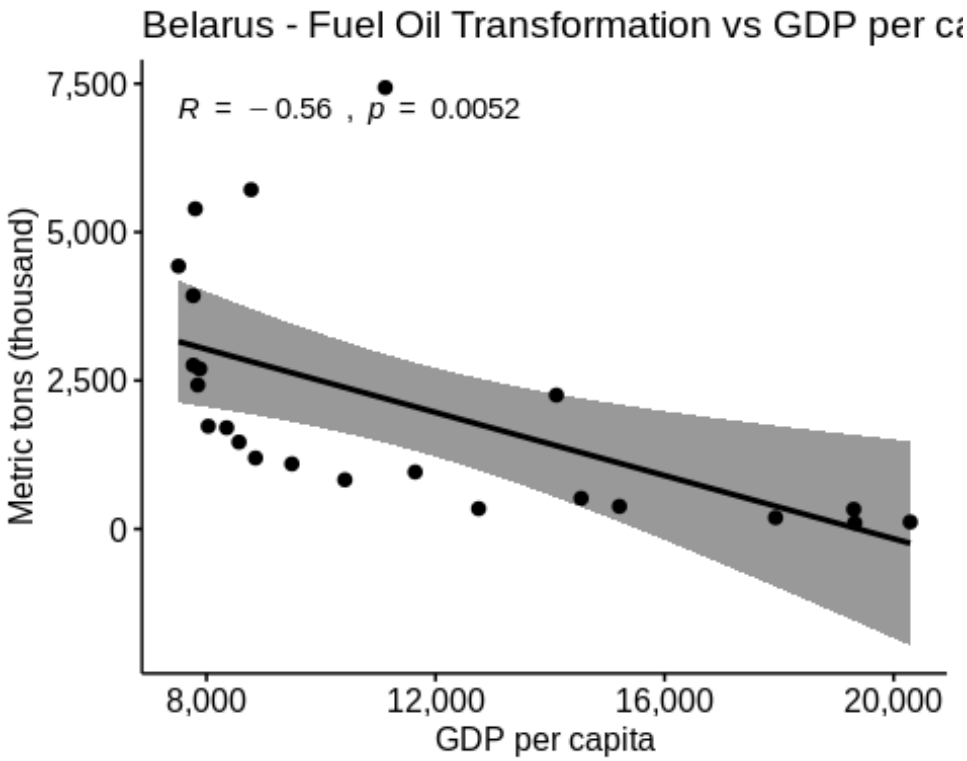

```
gfo_04 <- fuel_oil_10_gdp %>% filter(country_or_area == "Italy")
%>% unnest(data)

cor.test(gfo_04$gdp_per_capita, gfo_04$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_04$gdp_per_capita and gfo_04$quantity
## t = -8.0817, df = 23, p-value = 3.601e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9367866 -0.7041090
## sample estimates:
##        cor
## -0.8599803

# 5: Mexico
fuel_oil_10_gdp %>% filter(country_or_area == "Mexico") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Mexico - Fuel Oil Transformation vs GDP
per capita (1990 - 2015)")
```



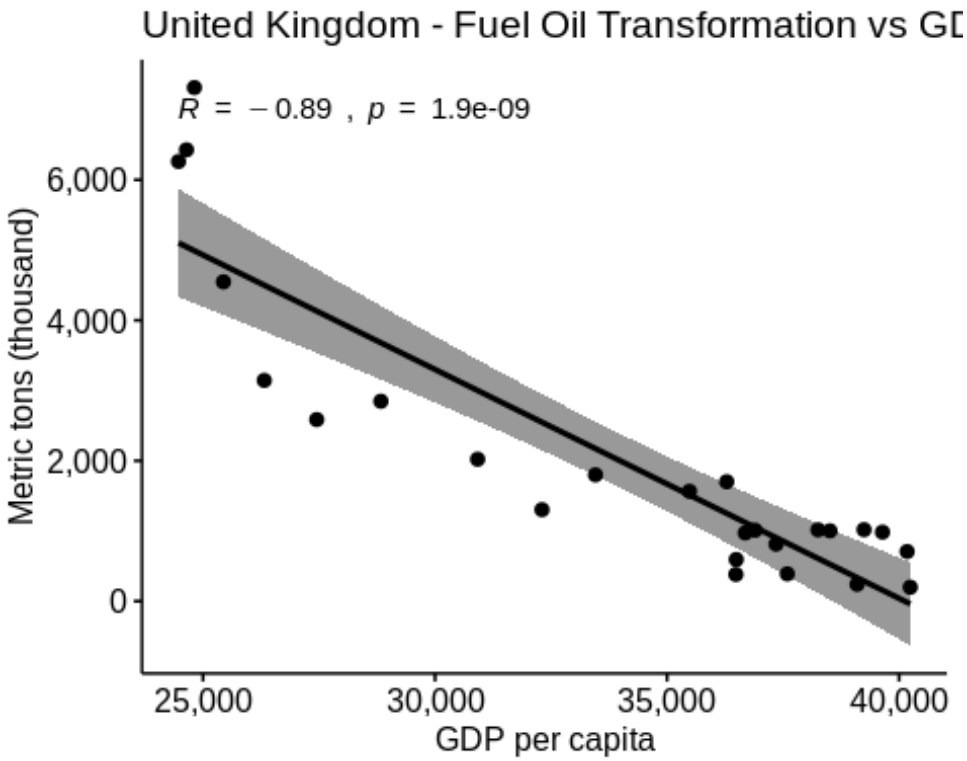

```
gfo_05 <- fuel_oil_10_gdp %>% filter(country_or_area == "Mexico")
%>% unnest(data)

cor.test(gfo_05$gdp_per_capita, gfo_05$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_05$gdp_per_capita and gfo_05$quantity
## t = -5.484, df = 23, p-value = 1.416e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8847342 -0.5090297
## sample estimates:
##       cor
## -0.7527562

# 6: China
fuel_oil_10_gdp %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("China - Fuel Oil Transformation vs GDP
per capita (1990 - 2015)")
```



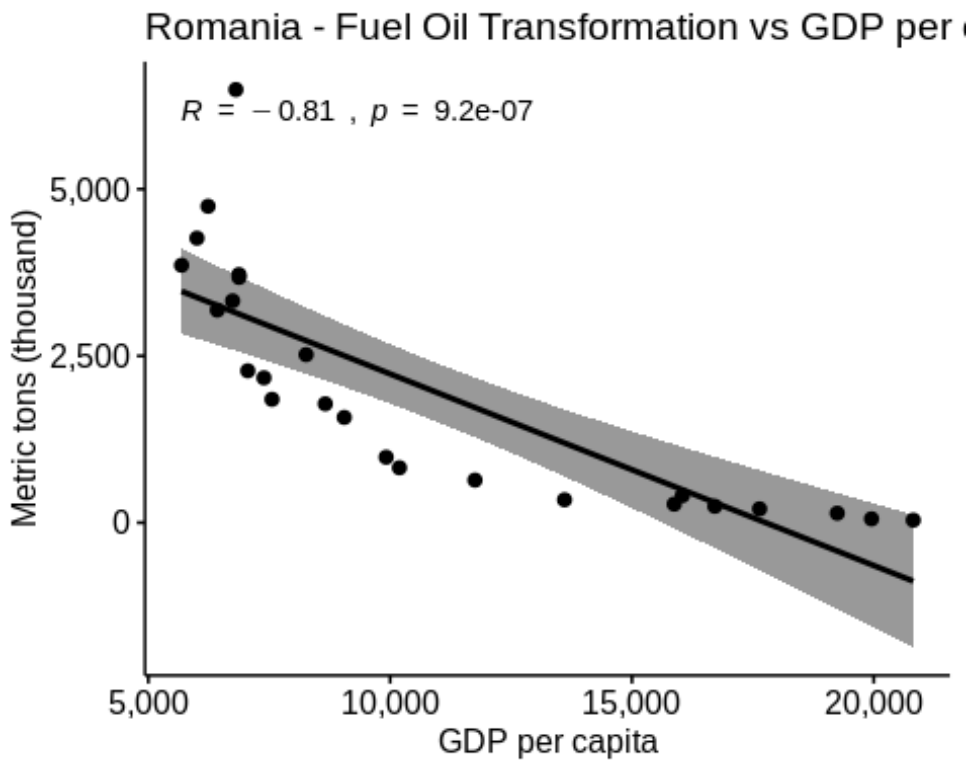

```
gfo_06 <- fuel_oil_10_gdp %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(gfo_06$gdp_per_capita, gfo_06$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_06$gdp_per_capita and gfo_06$quantity
## t = -8.5217, df = 23, p-value = 1.427e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9421709 -0.7265132
## sample estimates:
##       cor
## -0.8714724

# 7: Belarus
fuel_oil_10_gdp %>% filter(country_or_area == "Belarus") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Belarus - Fuel Oil Transformation vs
GDP per capita (1990 - 2015)")
```



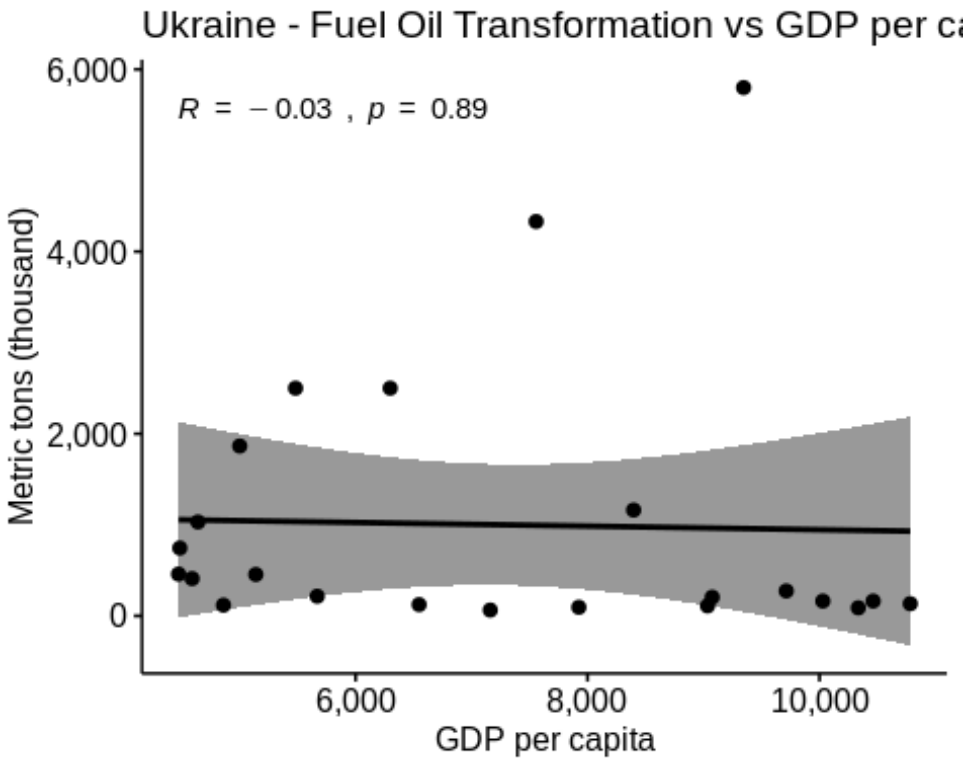

```
gfo_07 <- fuel_oil_10_gdp %>% filter(country_or_area ==
"Belarus") %>% unnest(data)

cor.test(gfo_07$gdp_per_capita, gfo_07$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_07$gdp_per_capita and gfo_07$quantity
## t = -3.1203, df = 21, p-value = 0.005175
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7914179 -0.1961185
## sample estimates:
##       cor
## -0.5628219

# 8: United Kingdom
fuel_oil_10_gdp %>% filter(country_or_area == "United Kingdom")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("United Kingdom - Fuel Oil
Transformation vs GDP per capita (1990 - 2015)")
```




```
gfo_08 <- fuel_oil_10_gdp %>% filter(country_or_area == "United
Kingdom") %>% unnest(data)

cor.test(gfo_08$gdp_per_capita, gfo_08$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_08$gdp_per_capita and gfo_08$quantity
## t = -9.5165, df = 23, p-value = 1.931e-09
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9521653 -0.7693527
## sample estimates:
##       cor
## -0.8930123

# 9: Romania
fuel_oil_10_gdp %>% filter(country_or_area == "Romania") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Romania - Fuel Oil Transformation vs
GDP per capita (1990 - 2015)")
```




```
gfo_09 <- fuel_oil_10_gdp %>% filter(country_or_area ==
"Romania") %>% unnest(data)

cor.test(gfo_09$gdp_per_capita, gfo_09$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gfo_09$gdp_per_capita and gfo_09$quantity
## t = -6.6294, df = 23, p-value = 9.182e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9130444 -0.6105486
## sample estimates:
##       cor
## -0.8102173

# 10: Ukraine
fuel_oil_10_gdp %>% filter(country_or_area == "Ukraine") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Ukraine - Fuel Oil Transformation vs
GDP per capita (1990 - 2015)")
```




```
gfo_10 <- fuel_oil_10_gdp %>% filter(country_or_area ==
"Ukraine") %>% unnest(data)

cor.test(gfo_10$gdp_per_capita, gfo_10$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  gfo_10$gdp_per_capita and gfo_10$quantity
## t = -0.13622, df = 21, p-value = 0.8929
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.4365677  0.3872324
## sample estimates:
##         cor
## -0.02971236
```

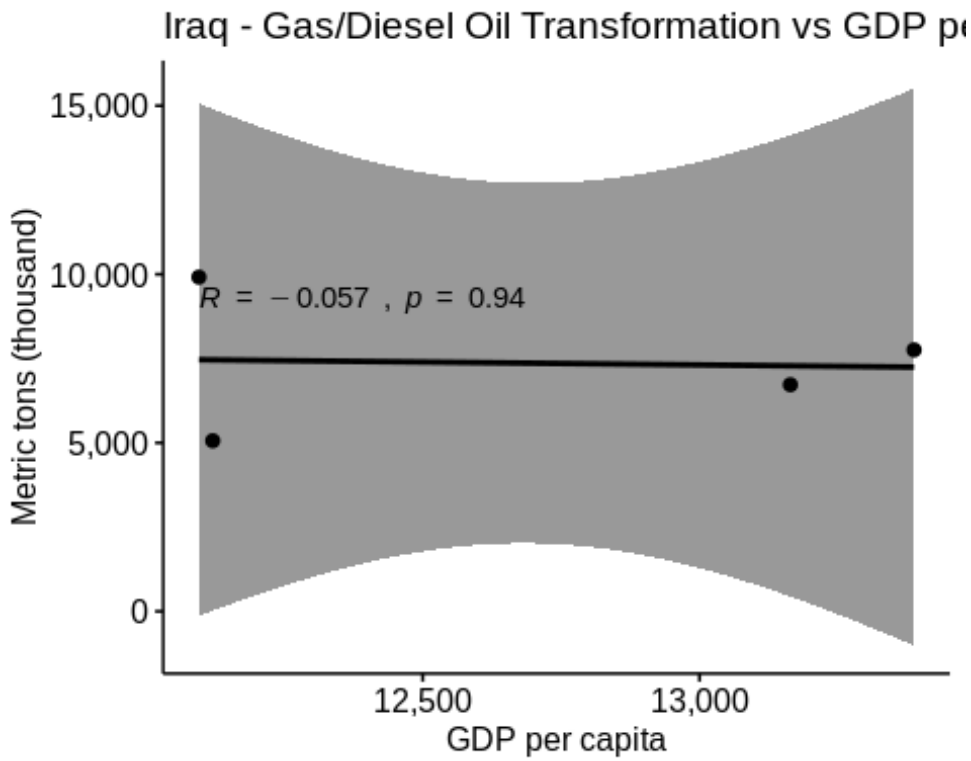
(iv) Gas/Diesel Oil:

```
# Now we look at gas/diesel oil:

gasdiesel_10_gdp
```

```
## # A tibble: 9 x 2
##   country_or_area        data
##   <chr>                  <list>
```

```
## 1 Iraq                    <tibble [4 × 6]>
## 2 Saudi Arabia            <tibble [25 × 6]>
## 3 Indonesia               <tibble [25 × 6]>
## 4 United States           <tibble [25 × 6]>
## 5 Iran (Islamic Rep. of) <tibble [25 × 6]>
## 6 Russian Federation      <tibble [23 × 6]>
## 7 China                   <tibble [25 × 6]>
## 8 Germany                 <tibble [24 × 6]>
## 9 Japan                   <tibble [25 × 6]>
```

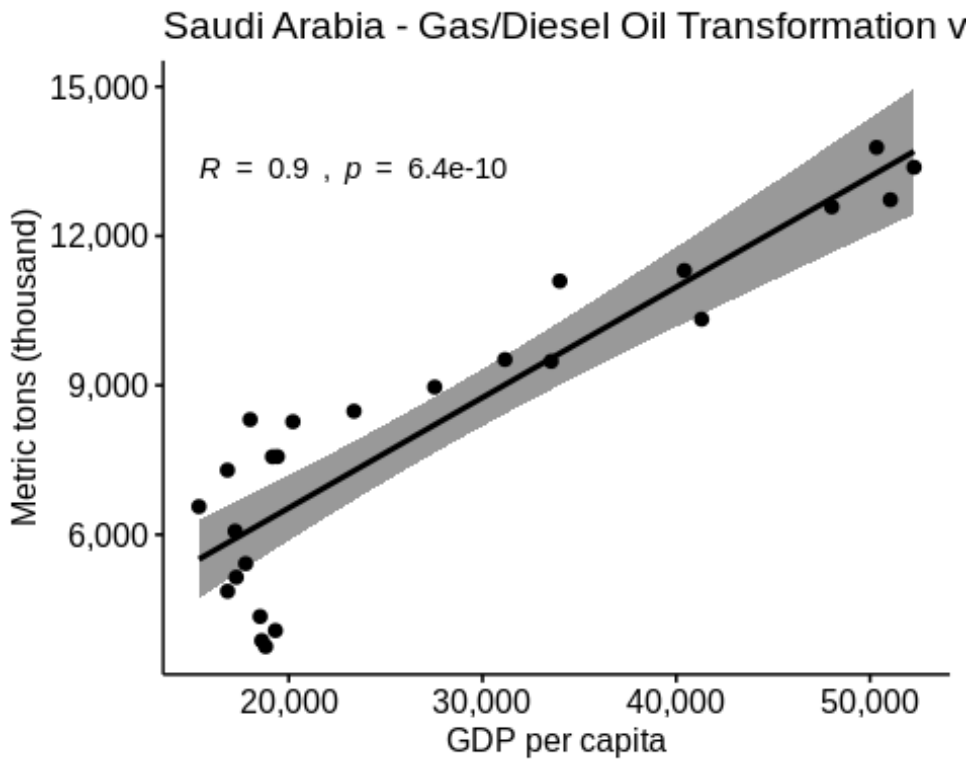
```
# Nine countries:

# 1: Iraq
gasdiesel_10_gdp %>% filter(country_or_area == "Iraq") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Iraq - Gas/Diesel Oil Transformation vs
GDP per capita (1990 - 2015)")
```




```
ggd_01 <- gasdiesel_10_gdp %>% filter(country_or_area == "Iraq")
%>% unnest(data)

cor.test(ggd_01$gdp_per_capita, ggd_01$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_01$gdp_per_capita and ggd_01$quantity
## t = -0.080425, df = 2, p-value = 0.9432
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9651956  0.9565042
## sample estimates:
##         cor
## -0.05677723
```

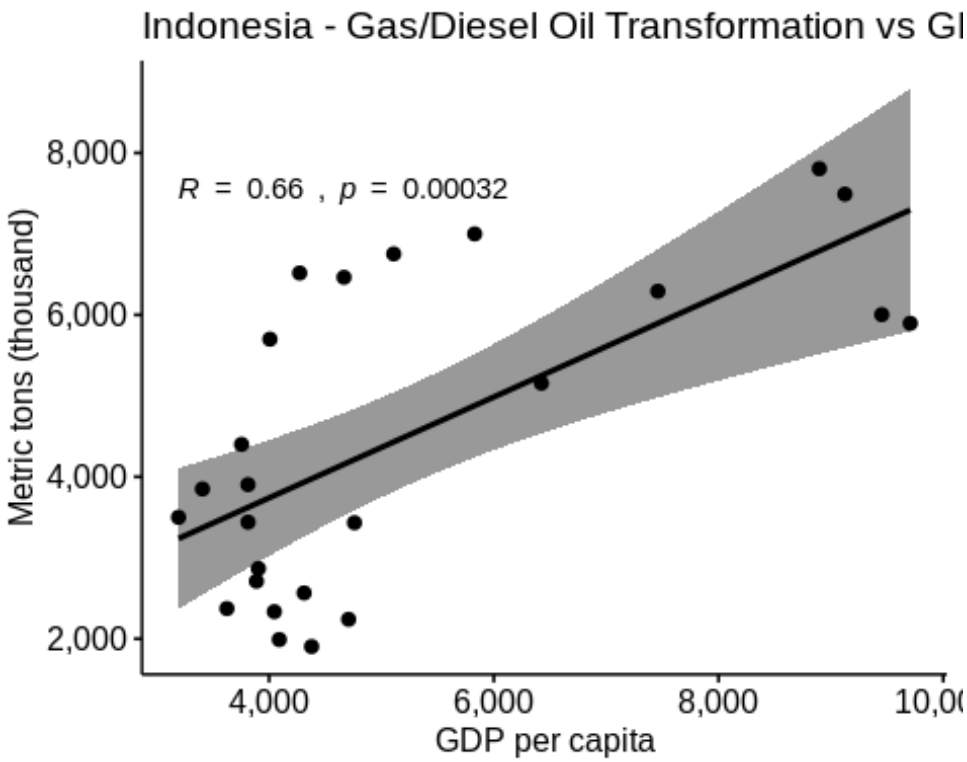
```
# 2: Saudi Arabia
gasdiesel_10_gdp %>% filter(country_or_area == "Saudi Arabia") %>
% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("Saudi Arabia - Gas/Diesel Oil
Transformation vs GDP per capita (1990 - 2015)")
```




```
ggd_02 <- gasdiesel_10_gdp %>% filter(country_or_area == "Saudi
Arabia") %>% unnest(data)

cor.test(ggd_02$gdp_per_capita, ggd_02$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_02$gdp_per_capita and ggd_02$quantity
## t = 10.091, df = 23, p-value = 6.438e-10
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7899947 0.9568453
## sample estimates:
##       cor
## 0.9031928
```

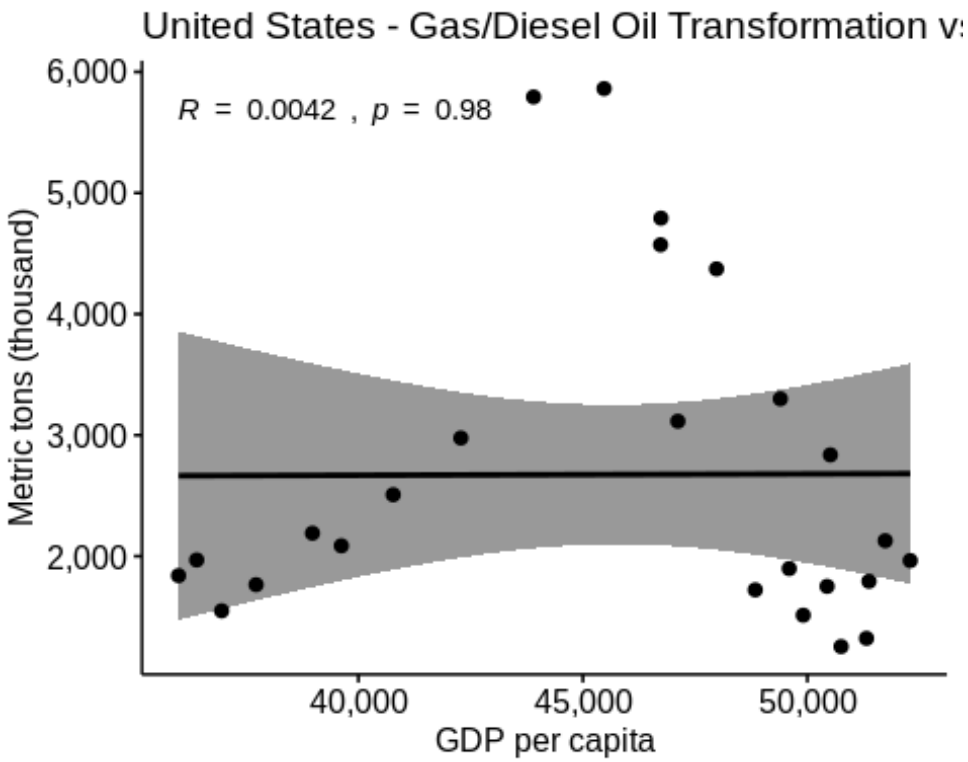
```
# 3: Indonesia
gasdiesel_10_gdp %>% filter(country_or_area == "Indonesia") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Indonesia - Gas/Diesel Oil
Transformation vs GDP per capita (1990 - 2015)")
```




```
ggd_03 <- gasdiesel_10_gdp %>% filter(country_or_area == "Iraq")
%>% unnest(data)

cor.test(ggd_03$gdp_per_capita, ggd_03$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_03$gdp_per_capita and ggd_03$quantity
## t = -0.080425, df = 2, p-value = 0.9432
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9651956  0.9565042
## sample estimates:
##         cor
## -0.05677723
```

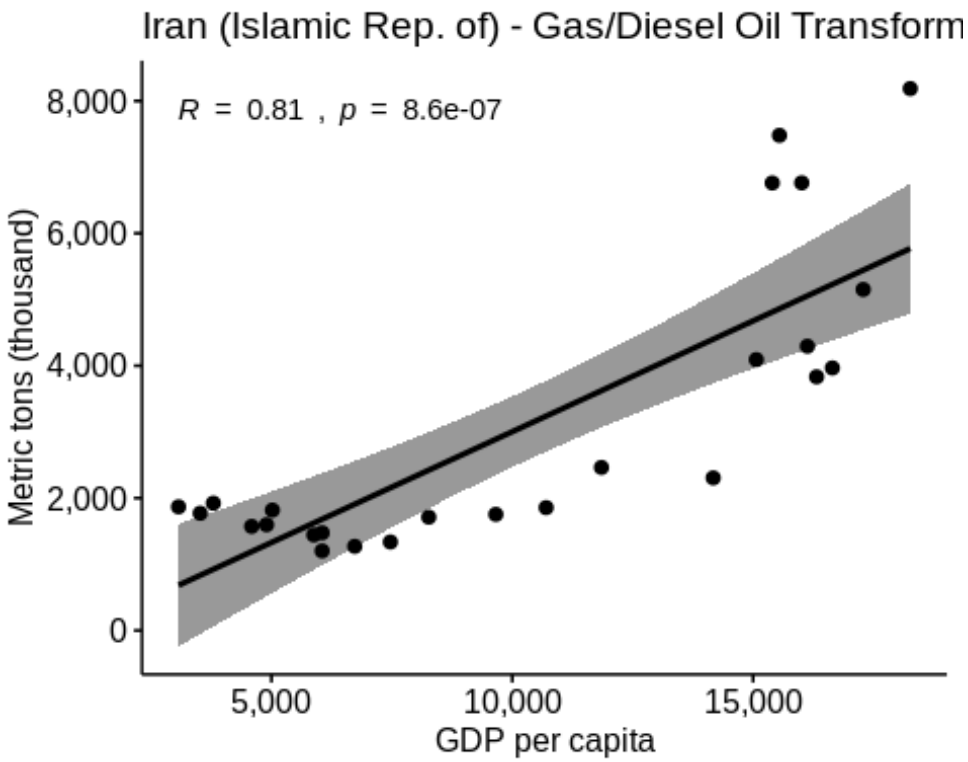
```
# 4: United States
gasdiesel_10_gdp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("United States - Gas/Diesel Oil
Transformation vs GDP per capita (1990 - 2015)")
```




```
ggd_04 <- gasdiesel_10_gdp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(ggd_04$gdp_per_capita, ggd_04$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_04$gdp_per_capita and ggd_04$quantity
## t = 0.020284, df = 23, p-value = 0.984
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.3915557  0.3986941
## sample estimates:
##         cor
## 0.004229554
```

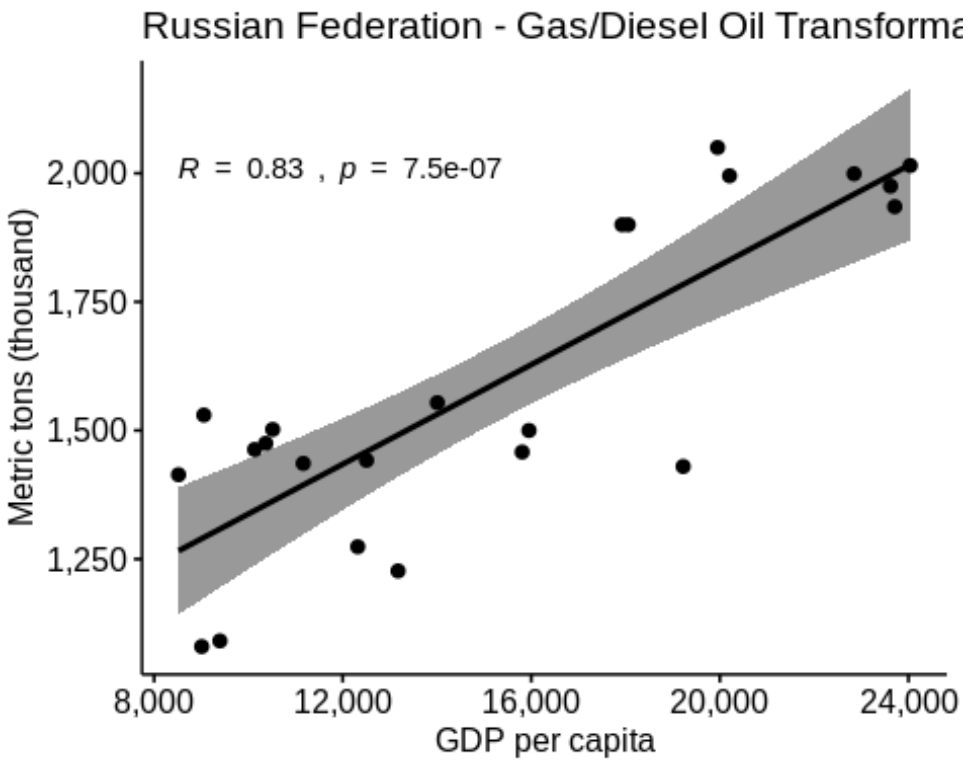
```
# 5: Iran (Islamic Rep. of)
gasdiesel_10_gdp %>% filter(country_or_area == "Iran (Islamic
Rep. of)") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y
= "quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="GDP per
capita", labels = comma)+ ggtitle("Iran (Islamic Rep. of) -
Gas/Diesel Oil Transformation vs GDP per capita (1990 - 2015)")
```




```
ggd_05 <- gasdiesel_10_gdp %>% filter(country_or_area == "Iran
(Islamic Rep. of)") %>% unnest(data)

cor.test(ggd_05$gdp_per_capita, ggd_05$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_05$gdp_per_capita and ggd_05$quantity
## t = 6.6587, df = 23, p-value = 8.577e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6127883 0.9136378
## sample estimates:
##       cor
## 0.8114432
```

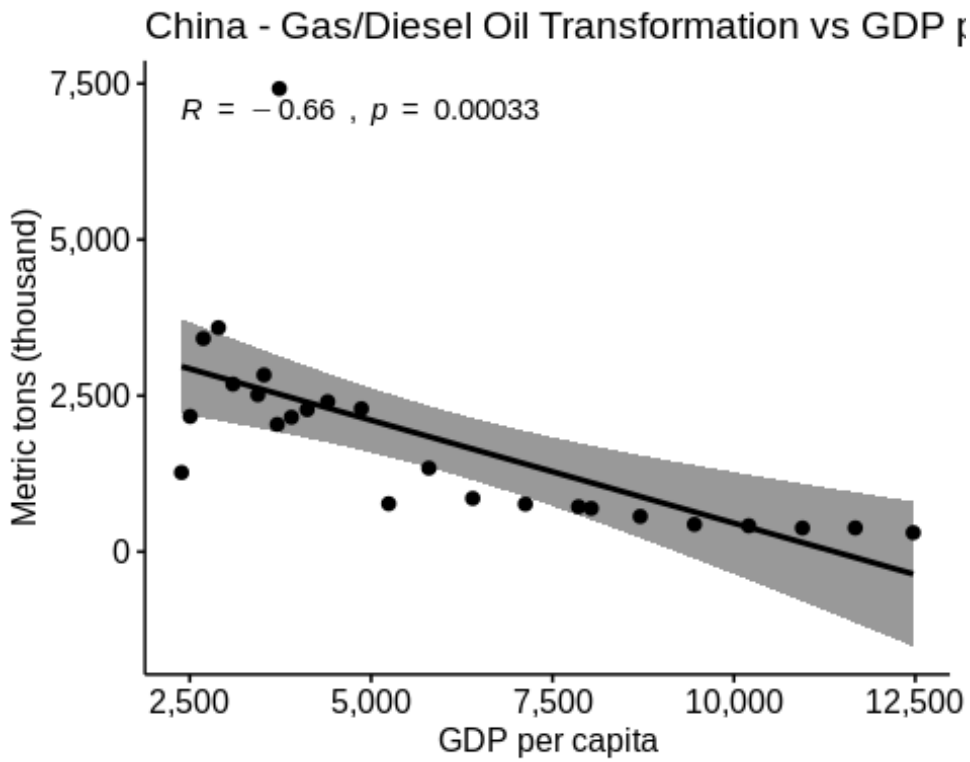
```
# 6: Russian Federation
gasdiesel_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita",
y = "quantity", add = "reg.line", conf.int = TRUE, cor.coef =
TRUE, cor.method = "pearson") + scale_y_continuous(name="Metric
tons (thousand)", labels = comma) +  scale_x_continuous(name="GDP
per capita", labels = comma)+ ggtitle("Russian Federation -
Gas/Diesel Oil Transformation vs GDP per capita (1990 - 2015)")
```




```
ggd_06 <- gasdiesel_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(ggd_06$gdp_per_capita, ggd_06$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_06$gdp_per_capita and ggd_06$quantity
## t = 6.9359, df = 21, p-value = 7.494e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6434207 0.9275441
## sample estimates:
##       cor
## 0.8343398
```

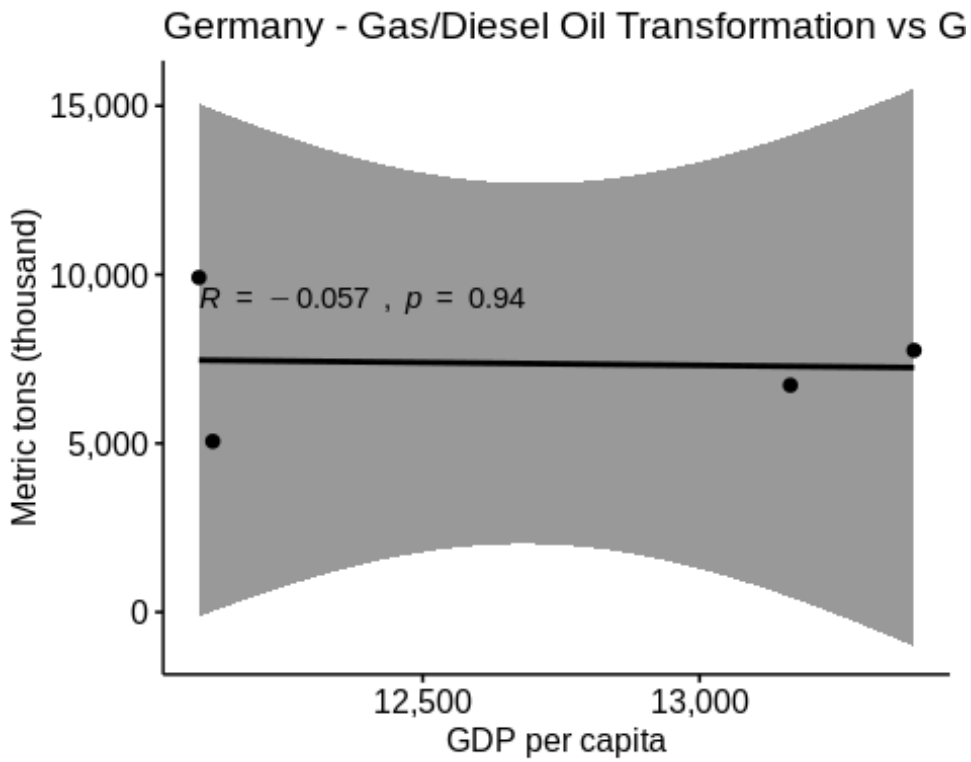
```
# 7: China
gasdiesel_10_gdp %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("China - Gas/Diesel Oil Transformation
vs GDP per capita (1990 - 2015)")
```




```
ggd_07 <- gasdiesel_10_gdp %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(ggd_07$gdp_per_capita, ggd_07$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_07$gdp_per_capita and ggd_07$quantity
## t = -4.2173, df = 23, p-value = 0.0003276
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8370733 -0.3588652
## sample estimates:
##       cor
## -0.6603581
```

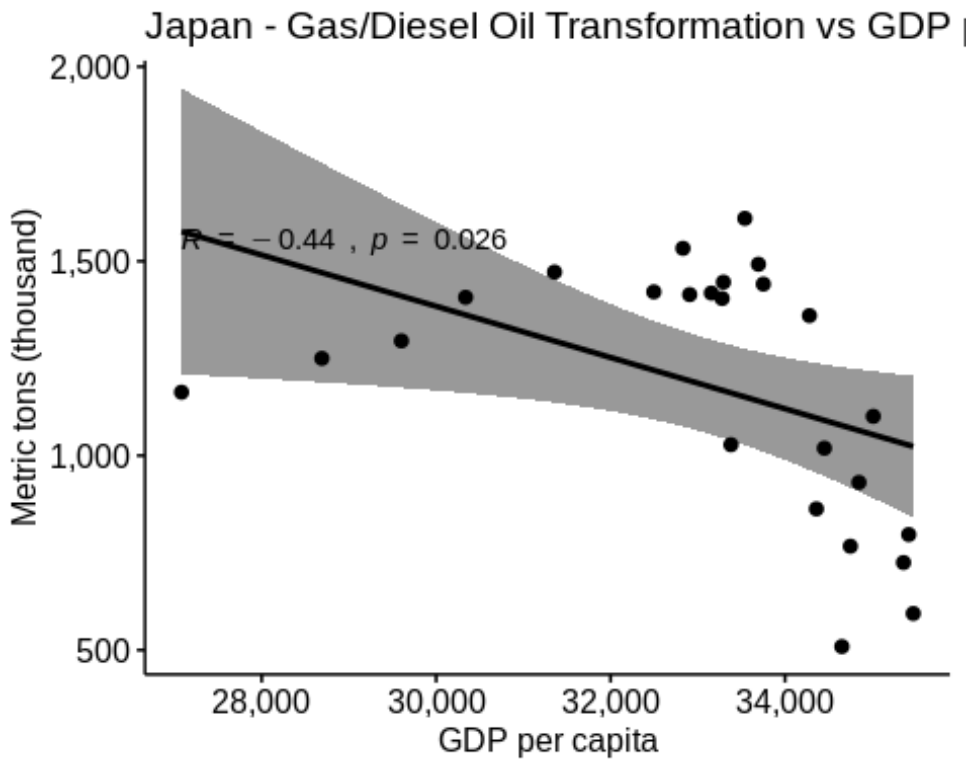
```
# 8: Germany
gasdiesel_10_gdp %>% filter(country_or_area == "Iraq") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Germany - Gas/Diesel Oil Transformation
vs GDP per capita (1990 - 2015)")
```




```
ggd_08 <- gasdiesel_10_gdp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(ggd_08$gdp_per_capita, ggd_08$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  ggd_08$gdp_per_capita and ggd_08$quantity
## t = -12.221, df = 22, p-value = 2.799e-11
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9712227 -0.8505153
## sample estimates:
##       cor
## -0.9335988
```

```
# 9: Japan
gasdiesel_10_gdp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Japan - Gas/Diesel Oil Transformation
vs GDP per capita (1990 - 2015)")
```




```
ggd_09 <- gasdiesel_10_gdp %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(ggd_09$gdp_per_capita, ggd_09$quantity, method =
"pearson")
```

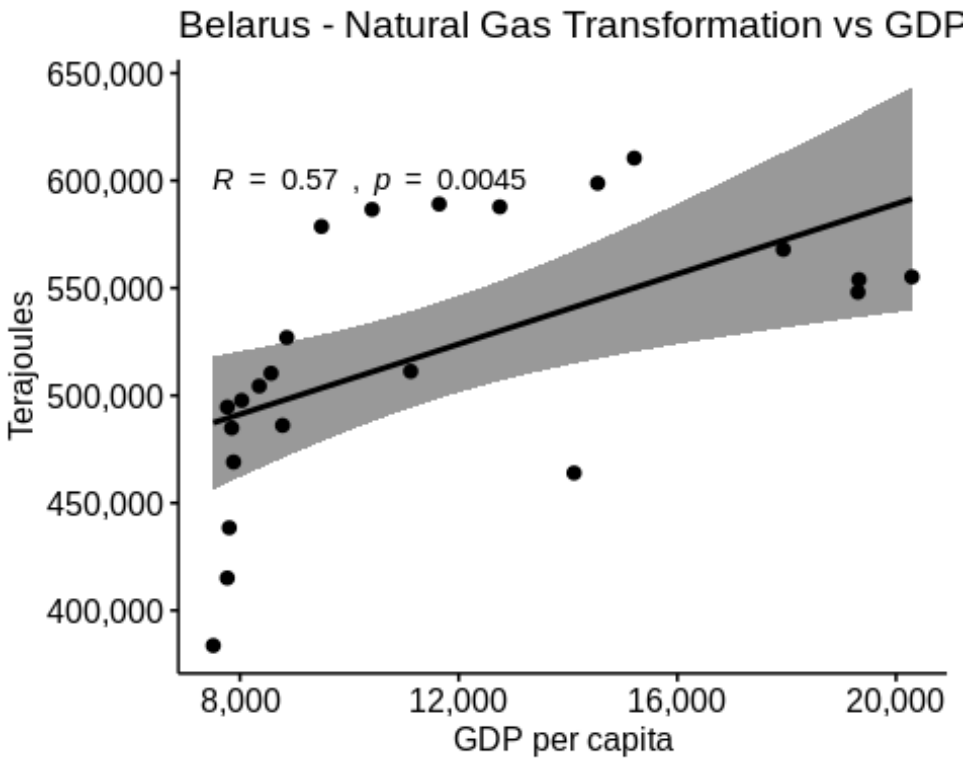
```
##
##  Pearson's product-moment correlation
##
## data:  ggd_09$gdp_per_capita and ggd_09$quantity
## t = -2.3755, df = 23, p-value = 0.02624
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.71380468 -0.05909791
## sample estimates:
##       cor
## -0.443864
```

(v) Natural Gas:

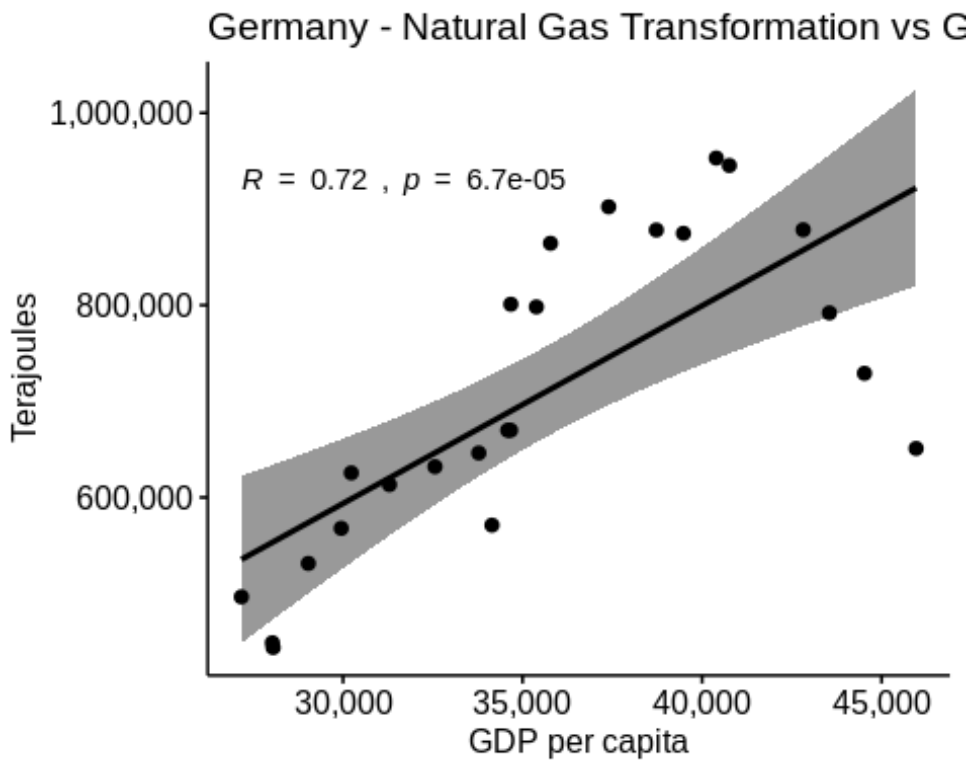
```
# Lastly there is Natural Gas:

natural_gas_10_gdp
```

```
## # A tibble: 9 x 2
##   country_or_area    data
##   <chr>              <list>
## 1 Russian Federation <tibble [23 × 6]>
## 2 United States      <tibble [25 × 6]>
## 3 Japan              <tibble [25 × 6]>
## 4 Ukraine            <tibble [23 × 6]>
## 5 Uzbekistan         <tibble [23 × 6]>
## 6 Saudi Arabia       <tibble [25 × 6]>
## 7 Belarus            <tibble [23 × 6]>
## 8 Germany            <tibble [24 × 6]>
## 9 Romania            <tibble [25 × 6]>
```

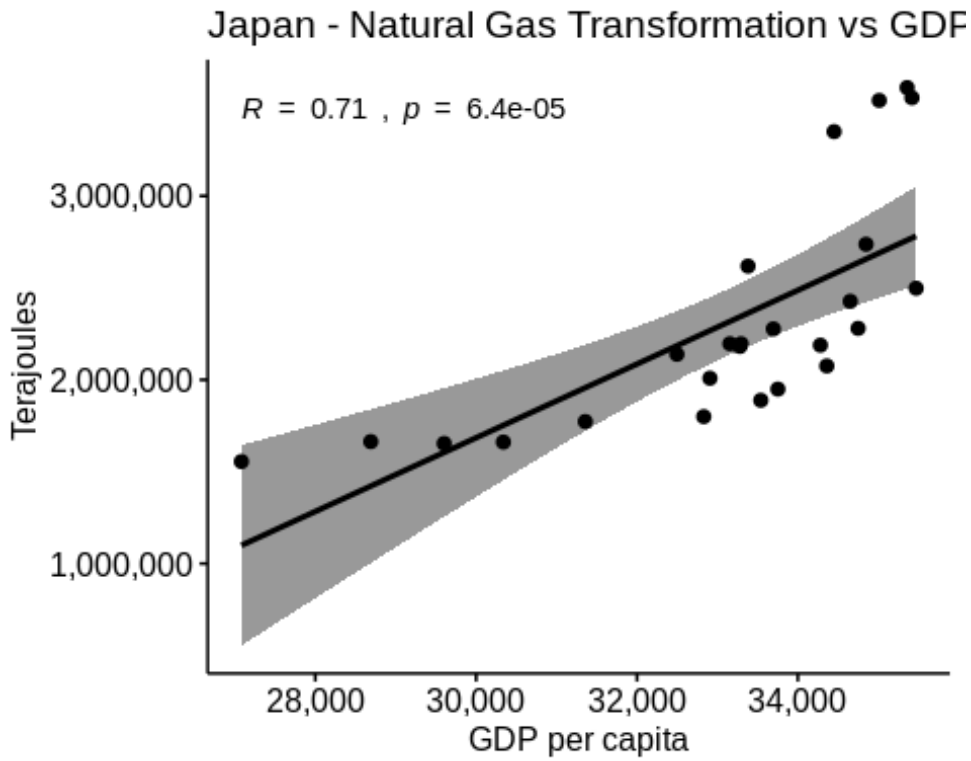
```
# There are 9 countries:

# 1: Belarus
natural_gas_10_gdp %>% filter(country_or_area == "Belarus") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="GDP per capita", labels =
comma)+ ggtitle("Belarus - Natural Gas Transformation vs GDP per
capita (1990 - 2015)")
```



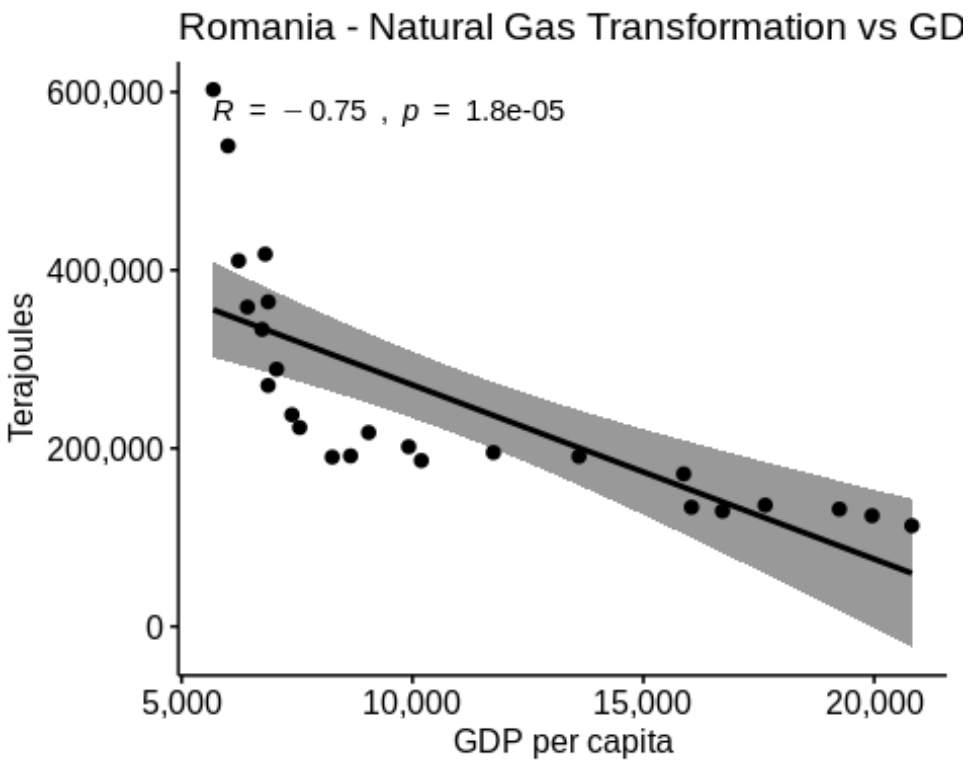

```
gng_01 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Belarus") %>% unnest(data)

cor.test(gng_01$gdp_per_capita, gng_01$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_01$gdp_per_capita and gng_01$quantity
## t = 3.18, df = 21, p-value = 0.004507
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2064251 0.7953978
## sample estimates:
##       cor
## 0.5701167

# 2: Germany
natural_gas_10_gdp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="GDP per capita", labels =
comma)+ ggtitle("Germany - Natural Gas Transformation vs GDP per
capita (1990 - 2015)")
```



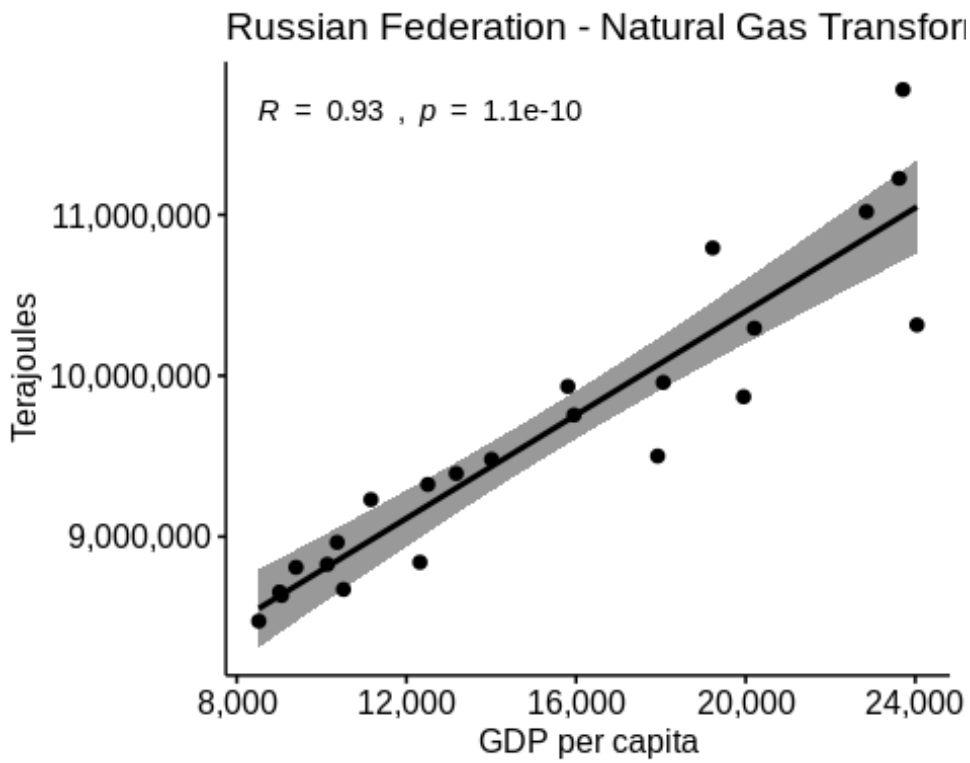

```
gng_02 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(gng_02$gdp_per_capita, gng_02$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_02$gdp_per_capita and gng_02$quantity
## t = 4.9007, df = 22, p-value = 6.702e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4502570 0.8717733
## sample estimates:
##       cor
## 0.7224361

# 3: Japan
natural_gas_10_gdp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="GDP per capita", labels =
comma)+ ggtitle("Japan - Natural Gas Transformation vs GDP per
capita (1990 - 2015)")
```



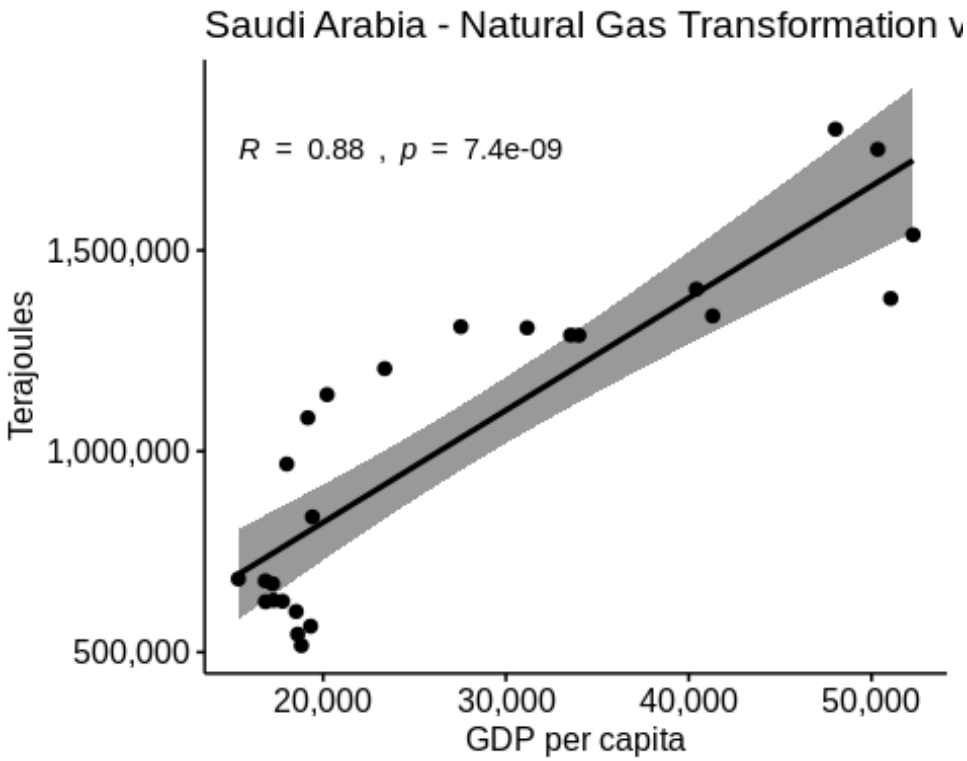

```
gng_03 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Japan") %>% unnest(data)

cor.test(gng_03$gdp_per_capita, gng_03$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_03$gdp_per_capita and gng_03$quantity
## t = 4.8734, df = 23, p-value = 6.387e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4421432 0.8644330
## sample estimates:
##      cor
## 0.712753

# 4: Romania
natural_gas_10_gdp %>% filter(country_or_area == "Romania") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="GDP per capita", labels =
comma)+ ggtitle("Romania - Natural Gas Transformation vs GDP per
capita (1990 - 2015)")
```



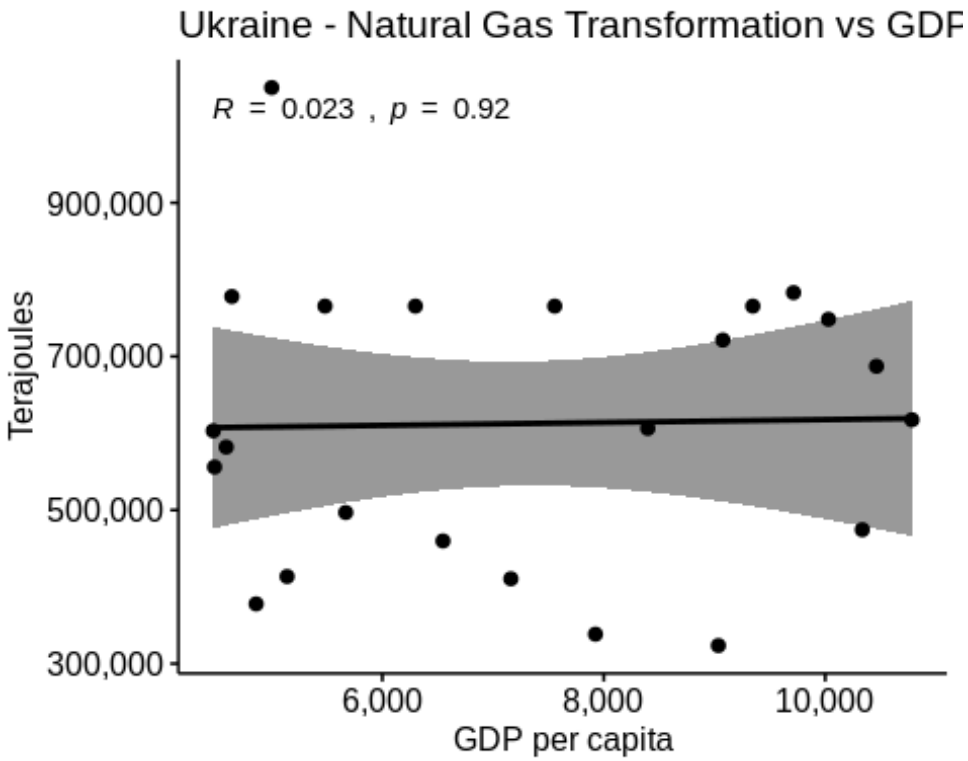

```
gng_04 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Romania") %>% unnest(data)

cor.test(gng_04$gdp_per_capita, gng_04$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_04$gdp_per_capita and gng_04$quantity
## t = -5.3862, df = 23, p-value = 1.799e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8817693 -0.4989699
## sample estimates:
##       cor
## -0.7468525

# 5: Russian Federation
natural_gas_10_gdp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "gdp_per_capita",
y = "quantity", add = "reg.line", conf.int = TRUE, cor.coef =
TRUE, cor.method = "pearson") +
scale_y_continuous(name="Terajoules", labels = comma) +
scale_x_continuous(name="GDP per capita", labels = comma)+
ggtitle("Russian Federation - Natural Gas Transformation vs GDP
per capita (1990 - 2015)")
```



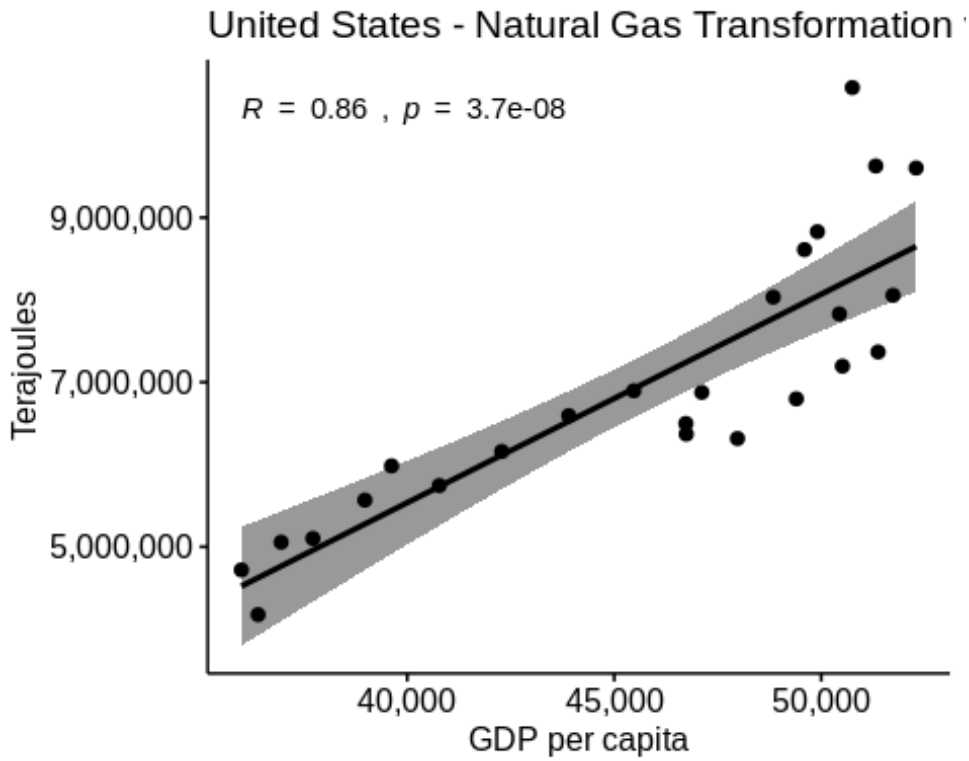

```
gng_05 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Russian Federation") %>% unnest(data)

cor.test(gng_05$gdp_per_capita, gng_05$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_05$gdp_per_capita and gng_05$quantity
## t = 11.761, df = 21, p-value = 1.055e-10
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8435522 0.9710221
## sample estimates:
##       cor
## 0.9317662

# 6: Saudi Arabia
natural_gas_10_gdp %>% filter(country_or_area == "Saudi Arabia")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Terajoules",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Saudi Arabia - Natural Gas
Transformation vs GDP per capita (1990 - 2015)")
```



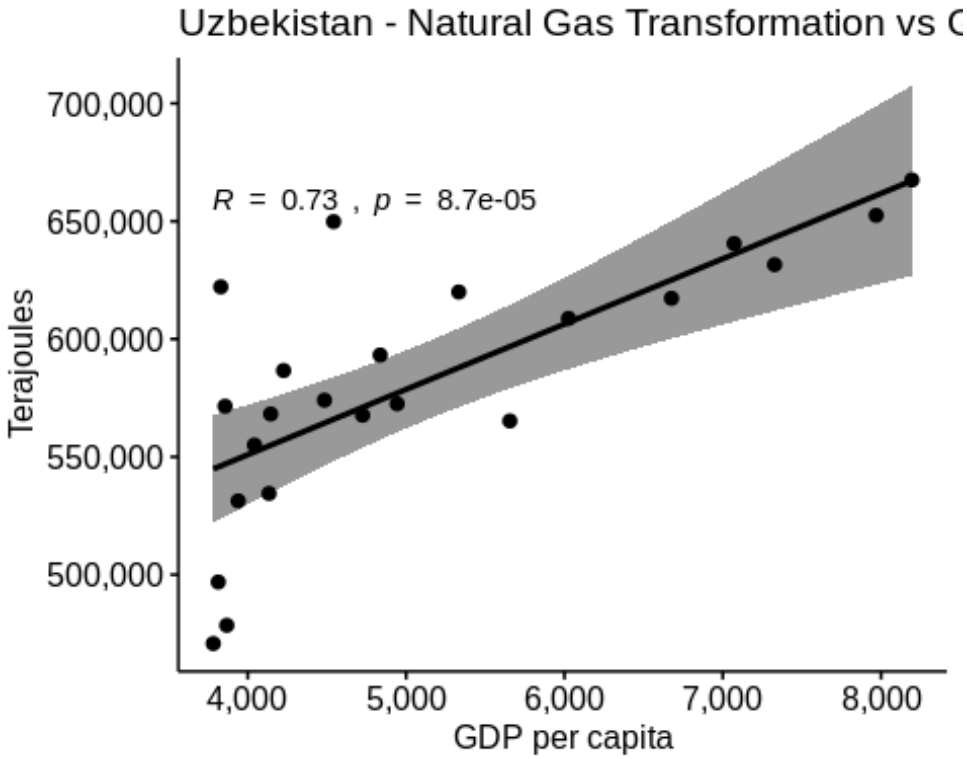

```
gng_06 <- natural_gas_10_gdp %>% filter(country_or_area == "Saudi
Arabia") %>% unnest(data)

cor.test(gng_06$gdp_per_capita, gng_06$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_06$gdp_per_capita and gng_06$quantity
## t = 8.8442, df = 23, p-value = 7.357e-09
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7415043 0.9457125
## sample estimates:
##       cor
## 0.8790742

# 7: Ukraine
natural_gas_10_gdp %>% filter(country_or_area == "Ukraine") %>%
unnest(data) %>% ggscatter(x = "gdp_per_capita", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="GDP per capita", labels =
comma)+ ggtitle("Ukraine - Natural Gas Transformation vs GDP per
capita (1990 - 2015)")
```




```
gng_07 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Ukraine") %>% unnest(data)

cor.test(gng_07$gdp_per_capita, gng_07$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_07$gdp_per_capita and gng_07$quantity
## t = 0.1062, df = 21, p-value = 0.9164
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.3927840  0.4312529
## sample estimates:
##        cor
## 0.02316944

# 8: United States
natural_gas_10_gdp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Terajoules",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("United States - Natural Gas
Transformation vs GDP per capita (1990 - 2015)")
```




```
gng_08 <- natural_gas_10_gdp %>% filter(country_or_area ==
"United States") %>% unnest(data)

cor.test(gng_08$gdp_per_capita, gng_08$quantity, method =
"pearson")

##
##  Pearson's product-moment correlation
##
## data:  gng_08$gdp_per_capita and gng_08$quantity
## t = 8.0714, df = 23, p-value = 3.681e-08
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.7035553 0.9366521
## sample estimates:
##       cor
## 0.8596943

# 9: Uzbekistan
natural_gas_10_gdp %>% filter(country_or_area == "Uzbekistan") %>
% unnest(data) %>% ggscatter(x = "gdp_per_capita", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Terajoules",
labels = comma) +  scale_x_continuous(name="GDP per capita",
labels = comma)+ ggtitle("Uzbekistan - Natural Gas Transformation
vs GDP per capita (1990 - 2015)")
```




```
gng_09 <- natural_gas_10_gdp %>% filter(country_or_area ==
"Uzbekistan") %>% unnest(data)

cor.test(gng_09$gdp_per_capita, gng_09$quantity, method =
"pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  gng_09$gdp_per_capita and gng_09$quantity
## t = 4.8406, df = 21, p-value = 8.74e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4481446 0.8761374
## sample estimates:
##       cor
## 0.7261988
```

Part 3: Energy Transformations against Mean Temperatures.

For this analysis, we downloaded the dataset at World Bank Group: Climate Change Knowledge Portal http://sdwebx.worldbank.org/climateportal/index.cfm?page=downscaled_data_download&menu=historical

The countries downloaded into an xls file (1901 to 2015) were: Australia Belarus Czech Republic China Germany Greece India

Indonesia Iran Iraq Italy Japan Kazkhstan Libya Mexico Poland Romania Russia Saudia Arabia Serbia and Montenegro South Africa Ukraine United Kingdom United States Uzbekistan

```
library(readxl)
temps <-
read_xls("~/Documents/Class/CKME-136/Workshop/CKME136_Capstone/Da
ta/temp_1901_2015.xls")

# We examine this data
head(temps)

## # A tibble: 6 x 6
##     tas Year  Month Country ISO3  ISO2
##   <dbl> <chr> <dbl> <chr>   <lgl> <lgl>
## 1  27.8 1901      1 AUS     NA    NA
## 2  27.3 1901      2 AUS     NA    NA
## 3  24.7 1901      3 AUS     NA    NA
## 4  21.4 1901      4 AUS     NA    NA
## 5  17.9 1901      5 AUS     NA    NA
## 6  13.9 1901      6 AUS     NA    NA

summary(temps)

##       tas              Year               Month
Country
##  Min.   :-31.196   Length:34500       Min.   : 1.00
Length:34500
##  1st Qu.:  5.498   Class :character   1st Qu.: 3.75
Class :character
##  Median : 14.530   Mode  :character   Median : 6.50
Mode  :character
##  Mean   : 12.928                      Mean   : 6.50

##  3rd Qu.: 21.017                      3rd Qu.: 9.25

##  Max.   : 36.090                      Max.   :12.00

##    ISO3           ISO2
##  Mode:logical   Mode:logical
##  NA's:34500     NA's:34500
##
##
##
##

str(temps)

## Classes 'tbl_df', 'tbl' and 'data.frame':    34500 obs. of  6
variables:
##  $ tas    : num  27.8 27.3 24.7 21.4 17.9 ...
```

```
##  $ Year   : chr  "1901" "1901" "1901" "1901" ...
##  $ Month  : num  1 2 3 4 5 6 7 8 9 10 ...
##  $ Country: chr  "AUS" "AUS" "AUS" "AUS" ...
##  $ ISO3   : logi  NA NA NA NA NA NA ...
##  $ ISO2   : logi  NA NA NA NA NA NA ...

anyNA(temps$tas)

## [1] FALSE

anyNA(temps$Year)

## [1] FALSE

anyNA(temps$Month)

## [1] FALSE

# No missing temperatures, years, or months

ncol(temps)

## [1] 6

nrow(temps)

## [1] 34500

# We need to drop the redundant columns
temps <- temps %>% select(-c(ISO3, ISO2))


# Next, we downloaded the code table to correlate the country
code to the nation name. This xlsx dataset was obtained from:
# http://kejser.org/resources/free-data/free-data-countries-
world/

nations <-
read_xlsx("~/Documents/Class/CKME-136/Workshop/CKME136_Capstone/D
ata/country.xlsx")

# Quick examination of this data
head(nations)

## # A tibble: 6 x 6
##   SK_Country Number Alpha2Code Alpha3Code CountryName
TopLevelDomain
##        <dbl>  <dbl> <chr>      <chr>      <chr>
<chr>
## 1          1     20 ad         and
Andorra           .ad
## 2          2      4 af         afg
```

```
Afghanistan       .af
## 3          3     28 ag         atg        Antigua and
Barb… .ag
## 4          4    660 ai         aia
Anguilla          .ai
## 5          5      8 al         alb
Albania           .al
## 6          6     51 am         arm
Armenia           .am

summary(nations)

##    SK_Country         Number       Alpha2Code
Alpha3Code
##  Min.   :  1.00   Min.   :  4.0   Length:248
Length:248
##  1st Qu.: 62.75   1st Qu.:217.0   Class :character
Class :character
##  Median :124.50   Median :432.0   Mode  :character
Mode  :character
##  Mean   :124.50   Mean   :432.6

##  3rd Qu.:186.25   3rd Qu.:647.5

##  Max.   :248.00   Max.   :894.0

##  CountryName        TopLevelDomain
##  Length:248         Length:248
##  Class :character   Class :character
##  Mode  :character   Mode  :character
##
##
##

str(nations)

## Classes 'tbl_df', 'tbl' and 'data.frame':    248 obs. of  6
variables:
##  $ SK_Country    : num  1 2 3 4 5 6 7 8 9 10 ...
##  $ Number        : num  20 4 28 660 8 51 24 10 32 16 ...
##  $ Alpha2Code    : chr  "ad" "af" "ag" "ai" ...
##  $ Alpha3Code    : chr  "and" "afg" "atg" "aia" ...
##  $ CountryName   : chr  "Andorra" "Afghanistan" "Antigua and
Barbuda" "Anguilla" ...
##  $ TopLevelDomain: chr  ".ad" ".af" ".ag" ".ai" ...

anyNA(nations$Alpha3Code)

## [1] FALSE

anyNA(nations$CountryName)
```

```
## [1] FALSE

# Nothing is missing

# Problem is that the Alpha 3 code is in lower case
nations$Alpha3Code <- toupper(nations$Alpha3Code)

# We select the columns of interest
nations <- nations %>% select(Alpha3Code, CountryName)

# We need to join these two tables together by 3 letter code.
First to rename the column headings
colnames(temps) <- c("tas", "Year", "Month", "Alpha3Code")

# The year column of table is character, we should to change to
number
temps$Year <- as.numeric(as.character(temps$Year))
summary(temps$Year)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1901    1929    1958    1958    1987    2015

# Also, the dataset ranges from 1901 to 2015. We need to narrow
this down
temps <- temps %>% filter(between(Year, 1990, 2014))

# Now we join our tables together and group by CountryName and
Year
new_temps <- inner_join(nations, temps, by = "Alpha3Code")  %>%
select(-Alpha3Code) %>% group_by(CountryName, Year) %>% nest()

head(new_temps)

## # A tibble: 6 x 3
##   CountryName  Year data
##   <chr>       <dbl> <list>
## 1 Australia    1990 <tibble [12 × 2]>
## 2 Australia    1991 <tibble [12 × 2]>
## 3 Australia    1992 <tibble [12 × 2]>
## 4 Australia    1993 <tibble [12 × 2]>
## 5 Australia    1994 <tibble [12 × 2]>
## 6 Australia    1995 <tibble [12 × 2]>

# The temperature data we have is by month, we need to generate
mean temperature data
new_temps <- new_temps %>% mutate(mean_temp = sapply(map(data,
"tas"), mean, na.rm = TRUE))

# Then we can drop the monthly data, and filter out only the
distinct entries
new_temps <- new_temps %>% unnest() %>% select(-c(tas, Month)) %>
```

```
% distinct(CountryName, Year, mean_temp)

# Lastly need to list the names and rename Russia" to "Russian
Federation" for consistency. Also with "Iran" to "Iran (Islamic
Rep. of)"

unique(new_temps$CountryName)
```

```
##  [1] "Australia"          "Belarus"            "China"

##  [4] "Czech Republic"     "Germany"            "Greece"

##  [7] "India"              "Indonesia"          "Iran"

## [10] "Iraq"               "Italy"              "Japan"

## [13] "Kazakhstan"         "Libya"              "Mexico"

## [16] "Poland"             "Russian Federation" "Saudi Arabia"

## [19] "Serbia"             "South Africa"       "Ukraine"

## [22] "United Kingdom"     "United States"      "Uzbekistan"
```

```
# We need to rename "Iran" to "Iran (Islamic Rep. of)" for
consistency. Also with
length(grep("\\<Iran\\>", new_temps$CountryName))
```

```
## [1] 25
```

```
# 25 Occurrences of "Iran" in this data - we need to rename these
new_temps$CountryName <- as.character(new_temps$CountryName)
new_temps$CountryName[new_temps$CountryName == "Iran"] <- "Iran
(Islamic Rep. of)"
new_temps$CountryName <- as.factor(new_temps$CountryName)

# Sanity check
unique(new_temps$CountryName)
```

```
##  [1] Australia              Belarus                China

##  [4] Czech Republic         Germany                Greece

##  [7] India                  Indonesia              Iran
(Islamic Rep. of)
## [10] Iraq                   Italy                  Japan

## [13] Kazakhstan             Libya                  Mexico

## [16] Poland                 Russian Federation     Saudi
```

```
Arabia
## [19] Serbia                  South Africa           Ukraine

## [22] United Kingdom          United States          Uzbekistan

## 24 Levels: Australia Belarus China Czech Republic Germany
Greece ... Uzbekistan
```

```
# We also need to rename the column headings to that of our
prepared data for merging.
names(new_temps) <- c("country_or_area", "year", "mean_temp")
```

Now we can join on our temperature tables.

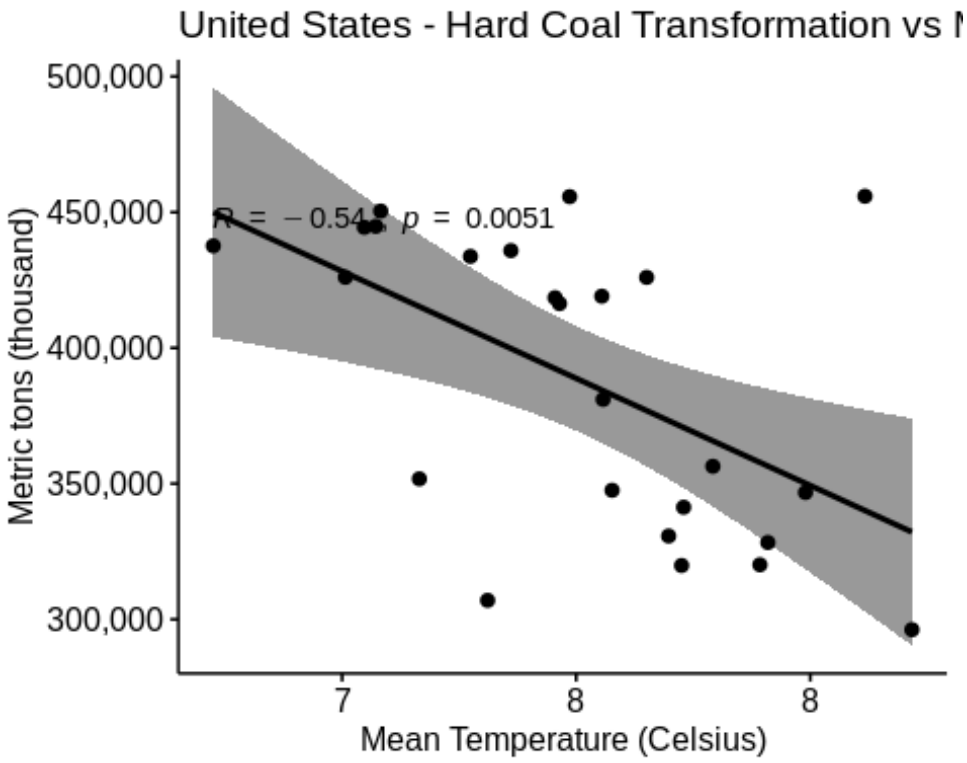
```
hard_coal_10_tmp <- inner_join(hard_coal_10, new_temps, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

brown_coal_10_tmp <- inner_join(brown_coal_10, new_temps, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

fuel_oil_10_tmp <- inner_join(fuel_oil_10, new_temps, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

gasdiesel_10_tmp <- inner_join(gasdiesel_10, new_temps, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector

natural_gas_10_tmp <- inner_join(natural_gas_10, new_temps, by =
c("country_or_area", "year")) %>% group_by(country_or_area) %>%
nest()

## Warning: Column `country_or_area` joining factors with
different levels,
## coercing to character vector
```

(i) Hard Coal

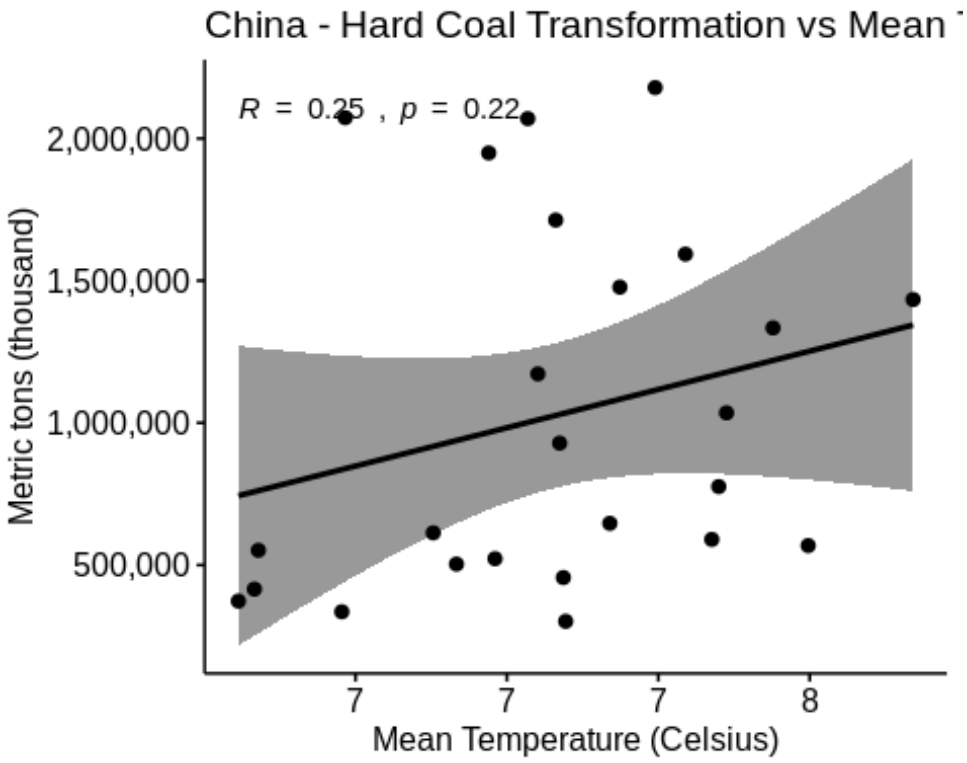
```
# Now we look at our hard coal data against temperature

hard_coal_10_tmp
```

```
## # A tibble: 10 x 2
##    country_or_area    data
##    <chr>              <list>
##  1 United States      <tibble [25 × 5]>
##  2 China              <tibble [25 × 5]>
##  3 Russian Federation <tibble [23 × 5]>
##  4 India              <tibble [25 × 5]>
##  5 United Kingdom     <tibble [25 × 5]>
##  6 Poland             <tibble [25 × 5]>
##  7 South Africa       <tibble [25 × 5]>
##  8 Germany            <tibble [24 × 5]>
##  9 Kazakhstan         <tibble [23 × 5]>
## 10 Japan              <tibble [25 × 5]>
```

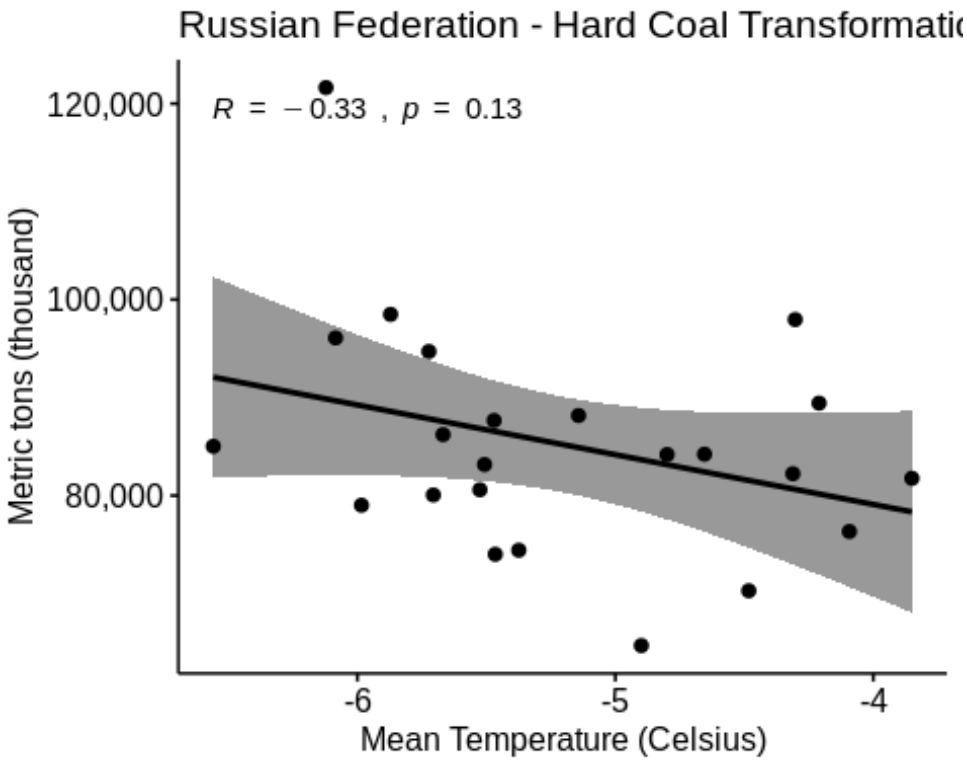
```
# These are the 10 countries that we need to investigate.

# 1: United States
hard_coal_10_tmp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("United States - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



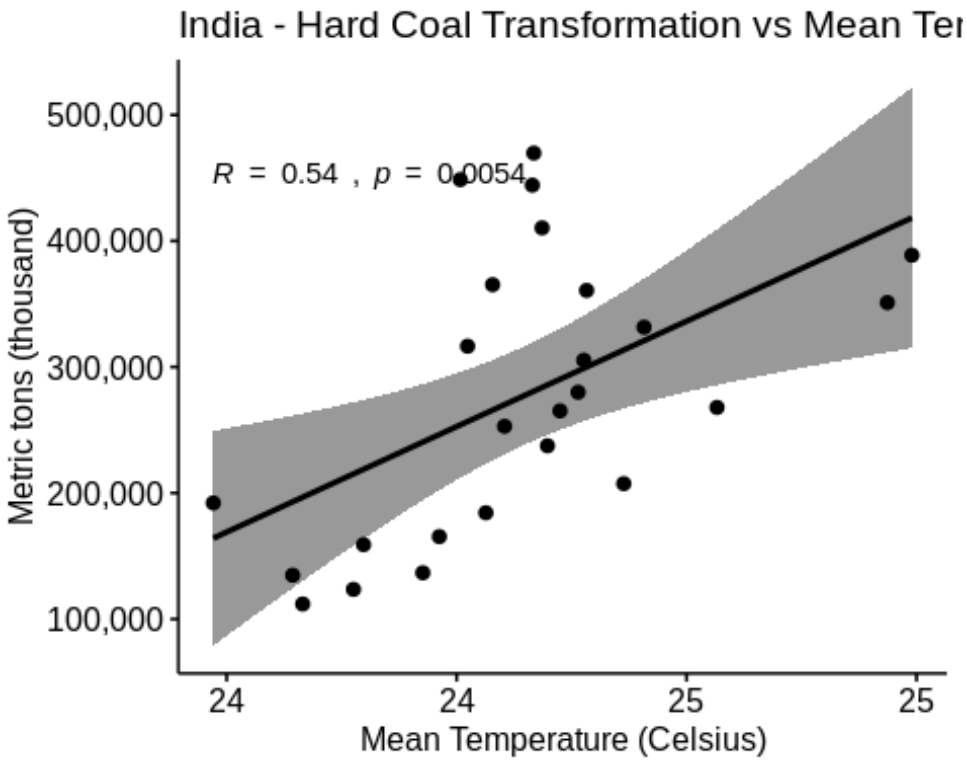

```
hct_01 <- hard_coal_10_tmp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(hct_01$mean_temp, hct_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_01$mean_temp and hct_01$quantity
## t = -3.093, df = 23, p-value = 0.005133
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7718268 -0.1868771
## sample estimates:
##       cor
## -0.5419872

# 2: China
hard_coal_10_tmp %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("China - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



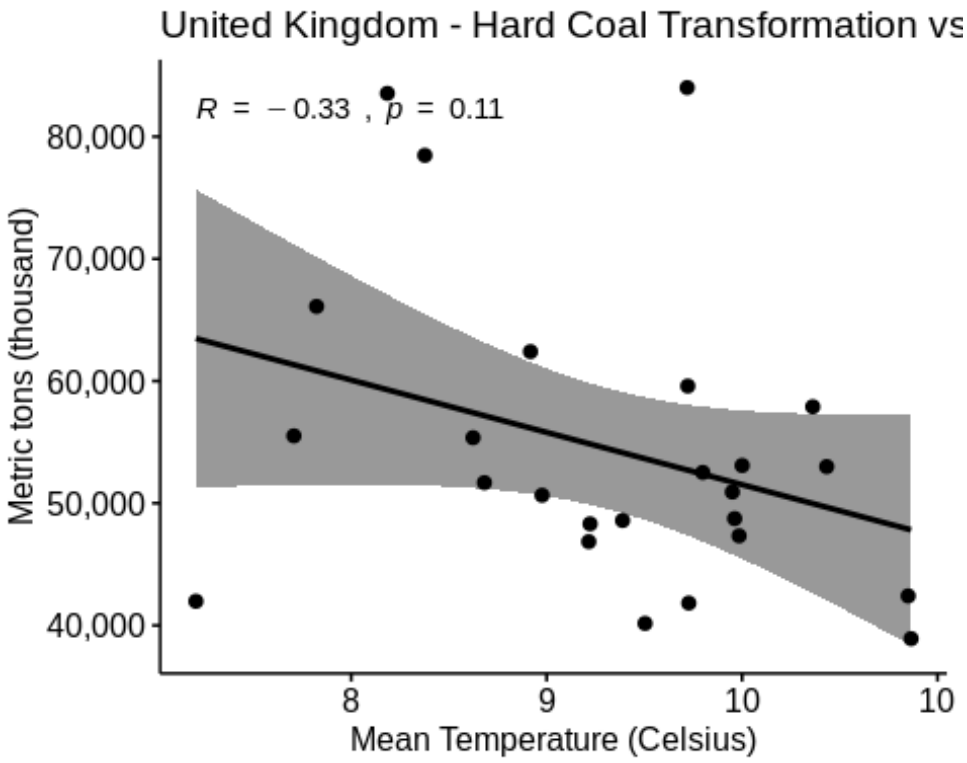

```
hct_02 <- hard_coal_10_tmp %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(hct_02$mean_temp, hct_02$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_02$mean_temp and hct_02$quantity
## t = 1.2575, df = 23, p-value = 0.2212
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.1572499  0.5896738
## sample estimates:
##       cor
## 0.2536408

# 3: Russian Federation
hard_coal_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "mean_temp", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Mean
Temperature (Celsius)", labels = comma)+ ggtitle("Russian
Federation - Hard Coal Transformation vs Mean Temperature (1990 -
2015)")
```



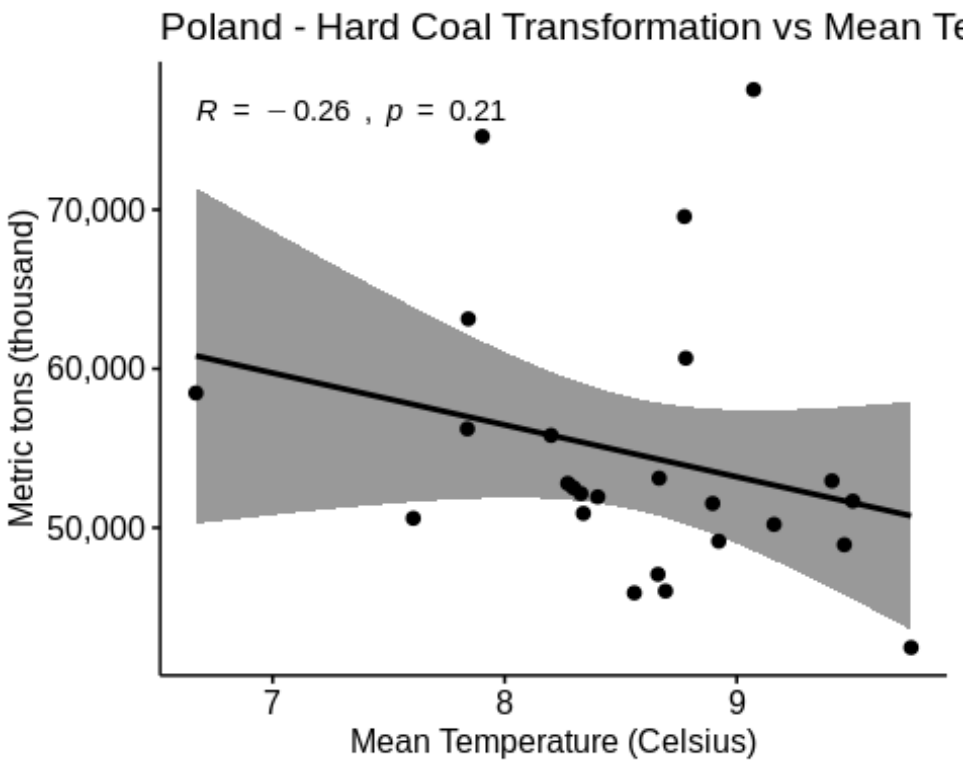

```
hct_03 <- hard_coal_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(hct_03$mean_temp, hct_03$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_03$mean_temp and hct_03$quantity
## t = -1.5828, df = 21, p-value = 0.1284
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.65106110  0.09905831
## sample estimates:
##       cor
## -0.3264745

# 4: India
hard_coal_10_tmp %>% filter(country_or_area == "India") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("India - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



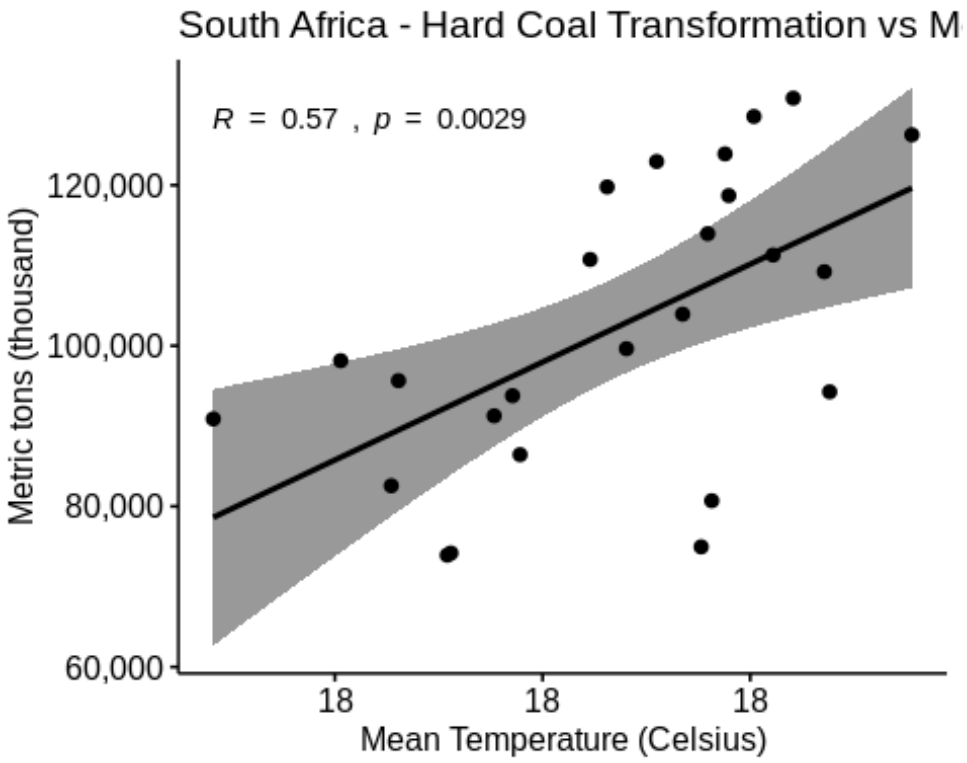

```
hct_04 <- hard_coal_10_tmp %>% filter(country_or_area == "India")
%>% unnest(data)

cor.test(hct_04$mean_temp, hct_04$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_04$mean_temp and hct_04$quantity
## t = 3.0697, df = 23, p-value = 0.005423
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1829387 0.7701730
## sample estimates:
##       cor
## 0.5391008

# 5: United Kingdom
hard_coal_10_tmp %>% filter(country_or_area == "United Kingdom")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("United Kingdom - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



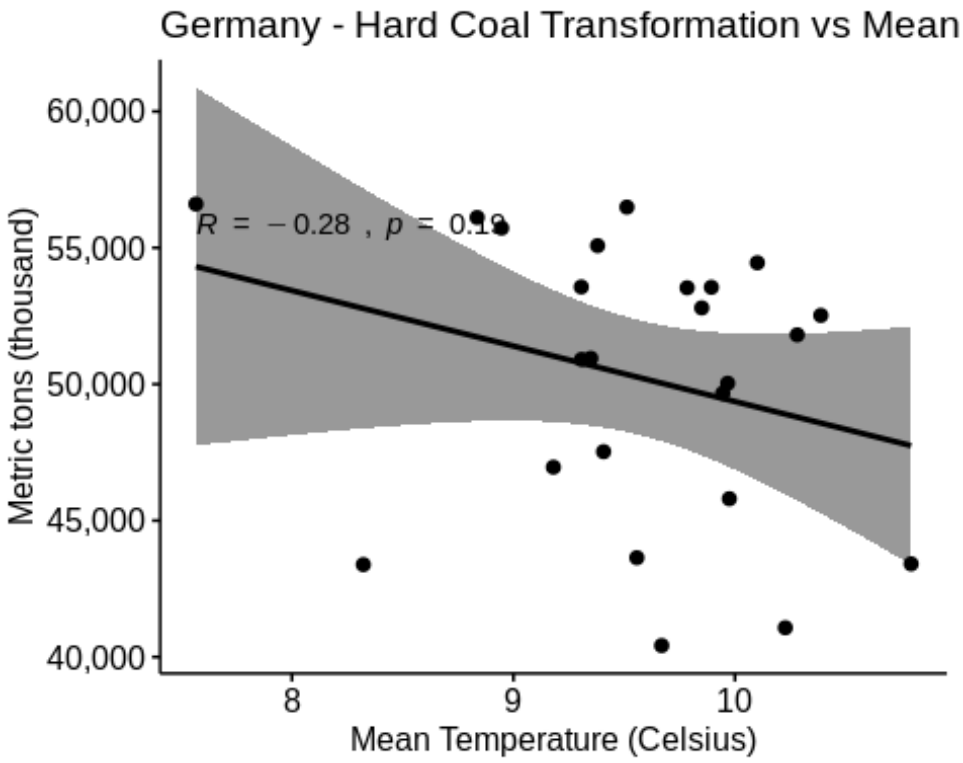

```
hct_05 <- hard_coal_10_tmp %>% filter(country_or_area == "United
Kingdom") %>% unnest(data)

cor.test(hct_05$mean_temp, hct_05$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_05$mean_temp and hct_05$quantity
## t = -1.6862, df = 23, p-value = 0.1053
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.6425973  0.0730159
## sample estimates:
##       cor
## -0.3316844

# 6: Poland
hard_coal_10_tmp %>% filter(country_or_area == "Poland") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Poland - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



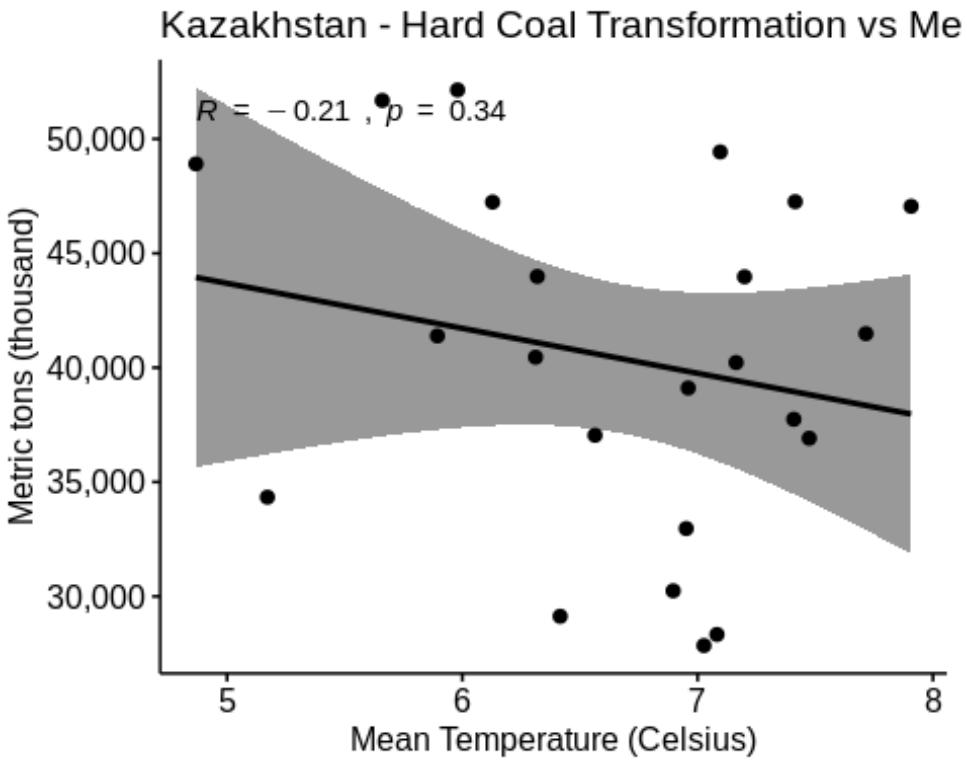

```
hct_06 <- hard_coal_10_tmp %>% filter(country_or_area ==
"Poland") %>% unnest(data)

cor.test(hct_06$mean_temp, hct_06$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_06$mean_temp and hct_06$quantity
## t = -1.2832, df = 23, p-value = 0.2122
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5930346  0.1522056
## sample estimates:
##      cor
## -0.25847

# 7: South Africa
hard_coal_10_tmp %>% filter(country_or_area == "South Africa") %>
% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("South Africa - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



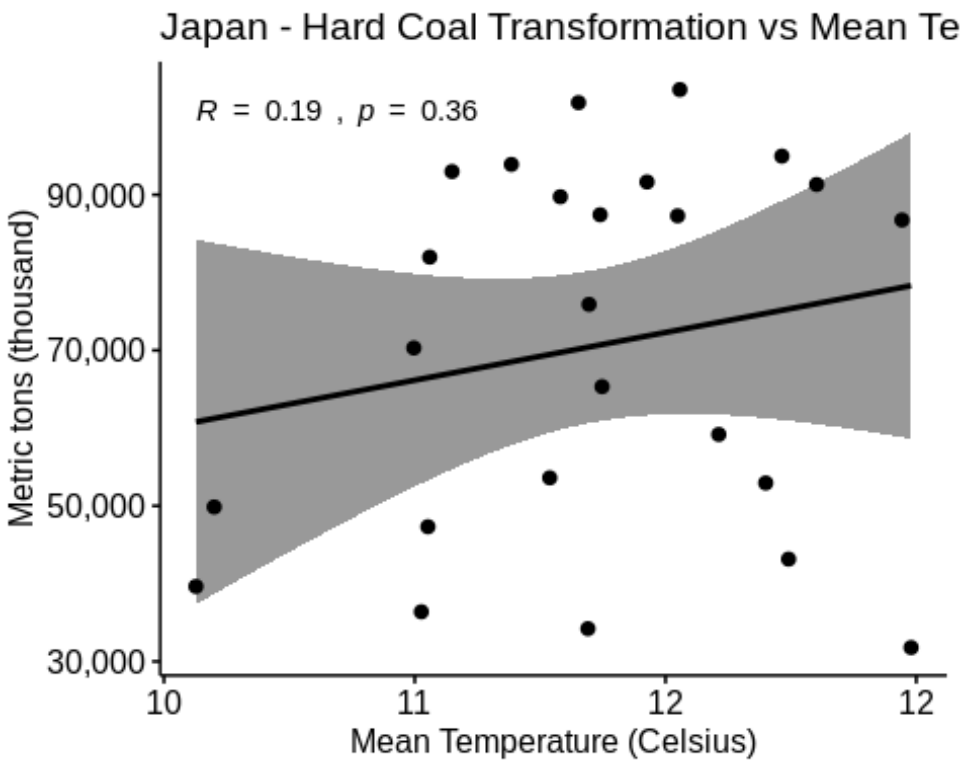

```
hct_07 <- hard_coal_10_tmp %>% filter(country_or_area == "South
Africa") %>% unnest(data)

cor.test(hct_07$mean_temp, hct_07$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_07$mean_temp and hct_07$quantity
## t = 3.3279, df = 23, p-value = 0.002927
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2258451 0.7877744
## sample estimates:
##       cor
## 0.5701011

# 8: Germany
hard_coal_10_tmp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Germany - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```




```
hct_08 <- hard_coal_10_tmp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(hct_08$mean_temp, hct_08$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_08$mean_temp and hct_08$quantity
## t = -1.3562, df = 22, p-value = 0.1888
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.6125312  0.1414803
## sample estimates:
##        cor
## -0.2777694

# 9: Kazakhstan
hard_coal_10_tmp %>% filter(country_or_area == "Kazakhstan") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Kazakhstan - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```




```
hct_09 <- hard_coal_10_tmp %>% filter(country_or_area ==
"Kazakhstan") %>% unnest(data)

cor.test(hct_09$mean_temp, hct_09$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_09$mean_temp and hct_09$quantity
## t = -0.97061, df = 21, p-value = 0.3428
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5706681  0.2241386
## sample estimates:
##        cor
## -0.2072075

# 10: Japan
hard_coal_10_tmp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Japan - Hard Coal
Transformation vs Mean Temperature (1990 - 2015)")
```




```
hct_10 <- hard_coal_10_tmp %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(hct_10$mean_temp, hct_10$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  hct_10$mean_temp and hct_10$quantity
## t = 0.94351, df = 23, p-value = 0.3552
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.2187825  0.5464840
## sample estimates:
##       cor
## 0.1930359
```

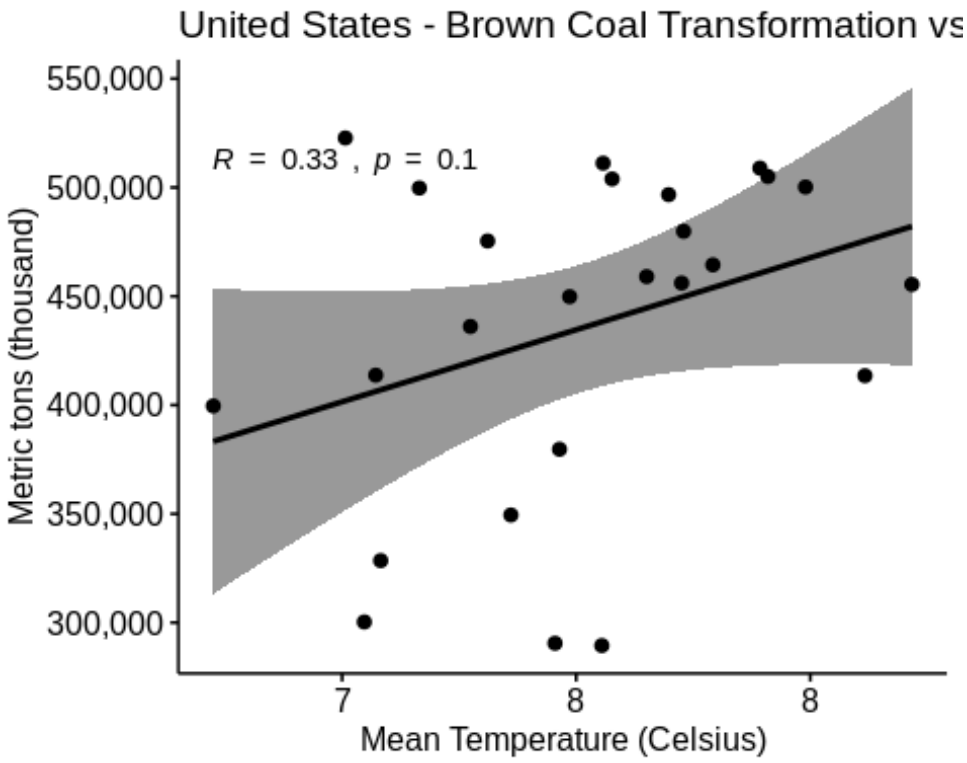
From all of this data we can conclude that the correlation bewteen coal transformation and temperature is not significant.

(ii) Brown Coal

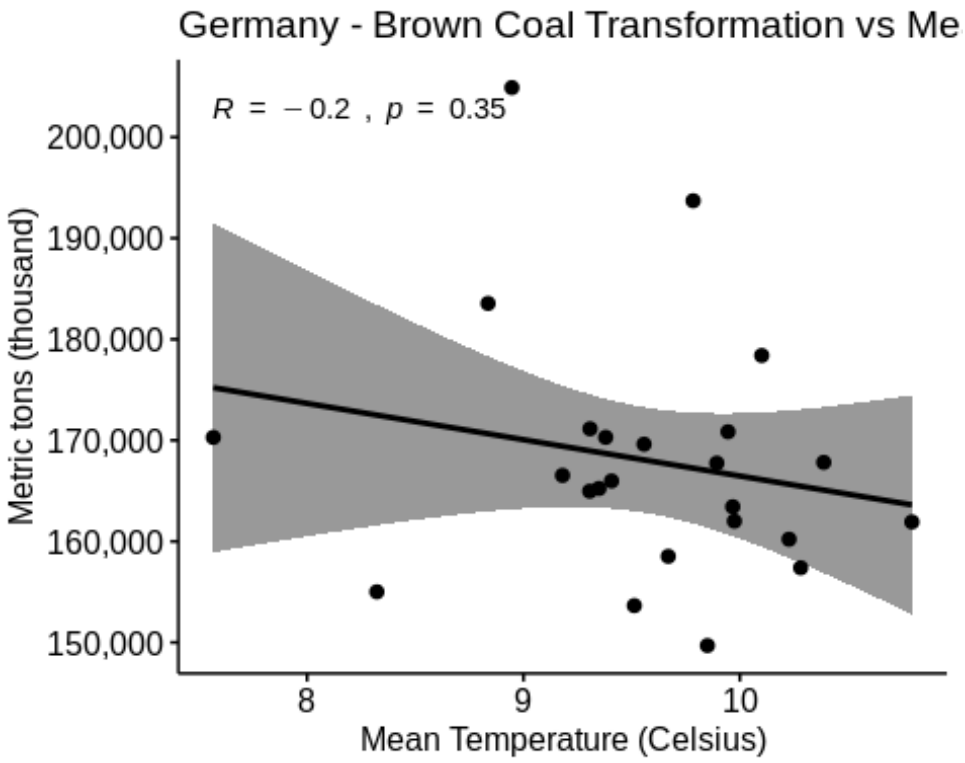
```
# Now we look at brown coal:

brown_coal_10_tmp
```

```
## # A tibble: 6 x 2
##   country_or_area    data
##   <chr>              <list>
## 1 United States      <tibble [25 × 5]>
## 2 Germany            <tibble [24 × 5]>
## 3 Russian Federation <tibble [23 × 5]>
## 4 Poland             <tibble [25 × 5]>
## 5 Australia          <tibble [25 × 5]>
## 6 Greece             <tibble [25 × 5]>
```

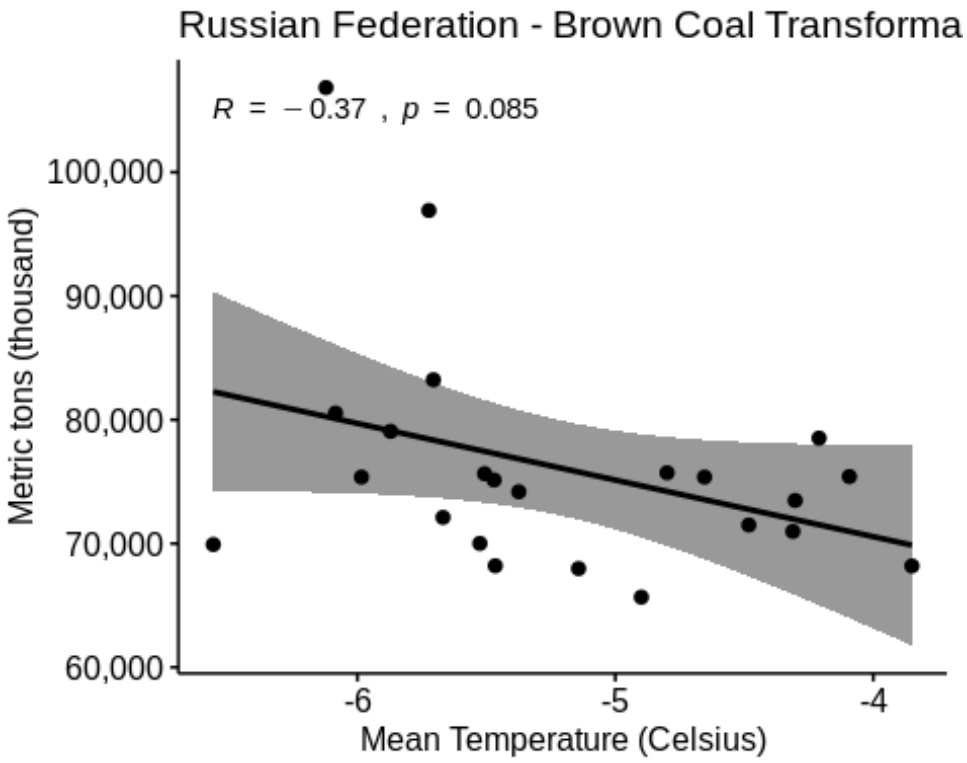
```
# These are the 6 countries that we need to investigate.

# 1: United States
brown_coal_10_tmp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("United States - Brown Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



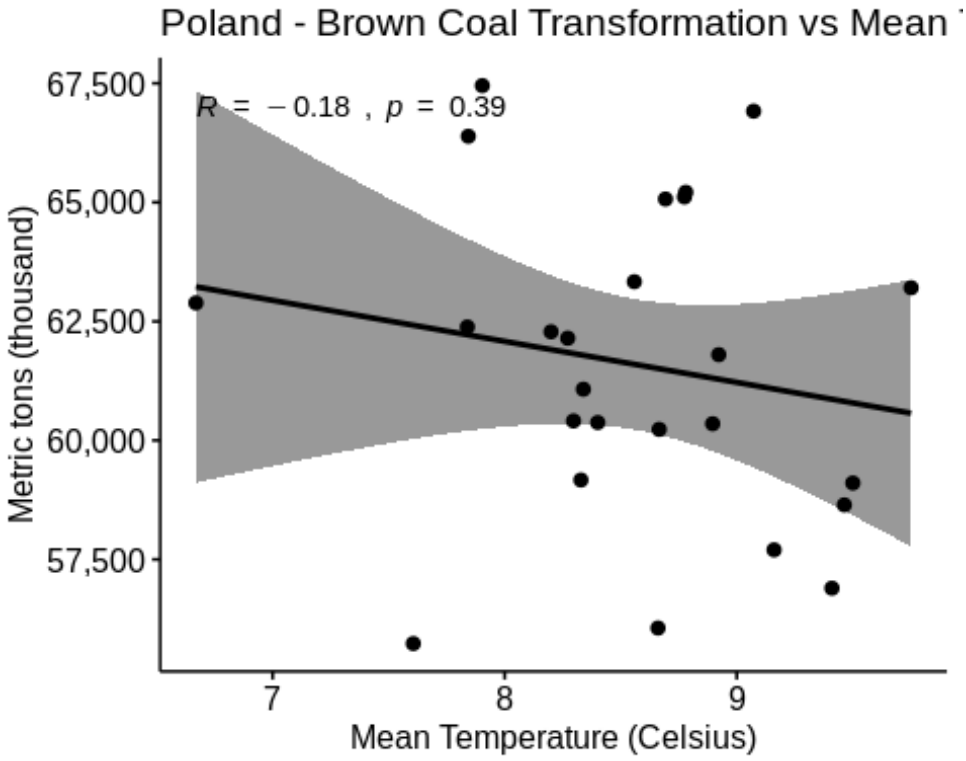

```
bct_01 <- brown_coal_10_tmp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(bct_01$mean_temp, bct_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bct_01$mean_temp and bct_01$quantity
## t = 1.7012, df = 23, p-value = 0.1024
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.0700671  0.6443340
## sample estimates:
##       cor
## 0.3343197

# 2: Germany
brown_coal_10_tmp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Germany - Brown Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



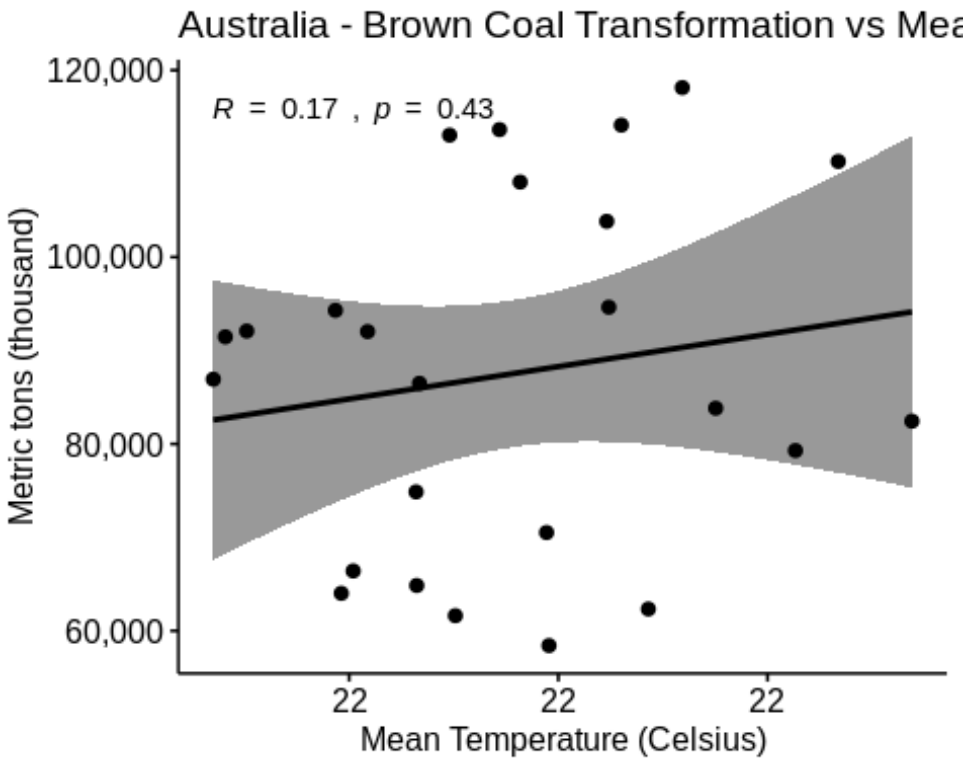

```
bct_02 <- brown_coal_10_tmp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(bct_02$mean_temp, bct_02$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bct_02$mean_temp and bct_02$quantity
## t = -0.96495, df = 22, p-value = 0.3451
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5594300  0.2197518
## sample estimates:
##       cor
## -0.201508

# 3: Russian Federation
brown_coal_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "mean_temp", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Mean
Temperature (Celsius)", labels = comma)+ ggtitle("Russian
Federation - Brown Coal Transformation vs Mean Temperature (1990
- 2015)")
```



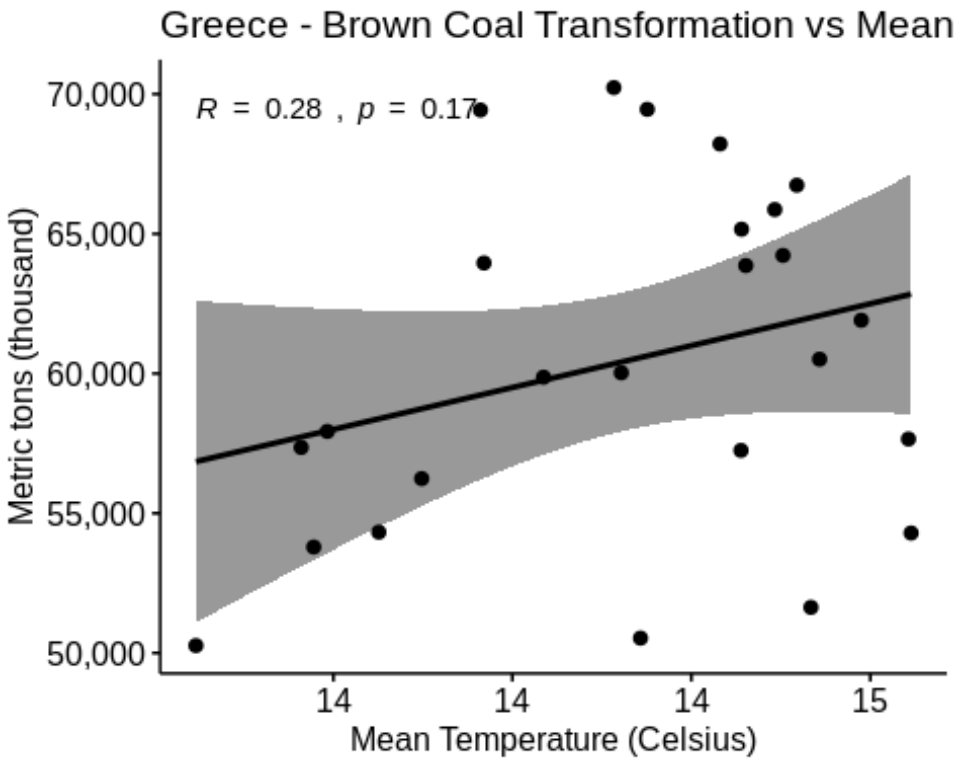

```
bct_03 <- brown_coal_10_tmp %>% filter(country_or_area ==
"Russian Federation") %>% unnest(data)

cor.test(bct_03$mean_temp, bct_03$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bct_03$mean_temp and bct_03$quantity
## t = -1.8102, df = 21, p-value = 0.08461
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.67705567  0.05281585
## sample estimates:
##       cor
## -0.3673846

# 4: Poland
brown_coal_10_tmp %>% filter(country_or_area == "Poland") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Poland - Brown Coal
Transformation vs Mean Temperature (1990 - 2015)")
```




```
bct_04 <- brown_coal_10_tmp %>% filter(country_or_area ==
"Poland") %>% unnest(data)

cor.test(bct_04$mean_temp, bct_04$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bct_04$mean_temp and bct_04$quantity
## t = -0.86922, df = 23, p-value = 0.3937
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5357194  0.2332266
## sample estimates:
##        cor
## -0.1783392

# 5: Australia
brown_coal_10_tmp %>% filter(country_or_area == "Australia") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Australia - Brown Coal
Transformation vs Mean Temperature (1990 - 2015)")
```




```
bct_05 <- brown_coal_10_tmp %>% filter(country_or_area ==
"Australia") %>% unnest(data)

cor.test(bct_05$mean_temp, bct_05$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bct_05$mean_temp and bct_05$quantity
## t = 0.80294, df = 23, p-value = 0.4302
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.2460596  0.5259410
## sample estimates:
##       cor
## 0.1651258

# 6: Greece
brown_coal_10_tmp %>% filter(country_or_area == "Greece") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Greece - Brown Coal
Transformation vs Mean Temperature (1990 - 2015)")
```



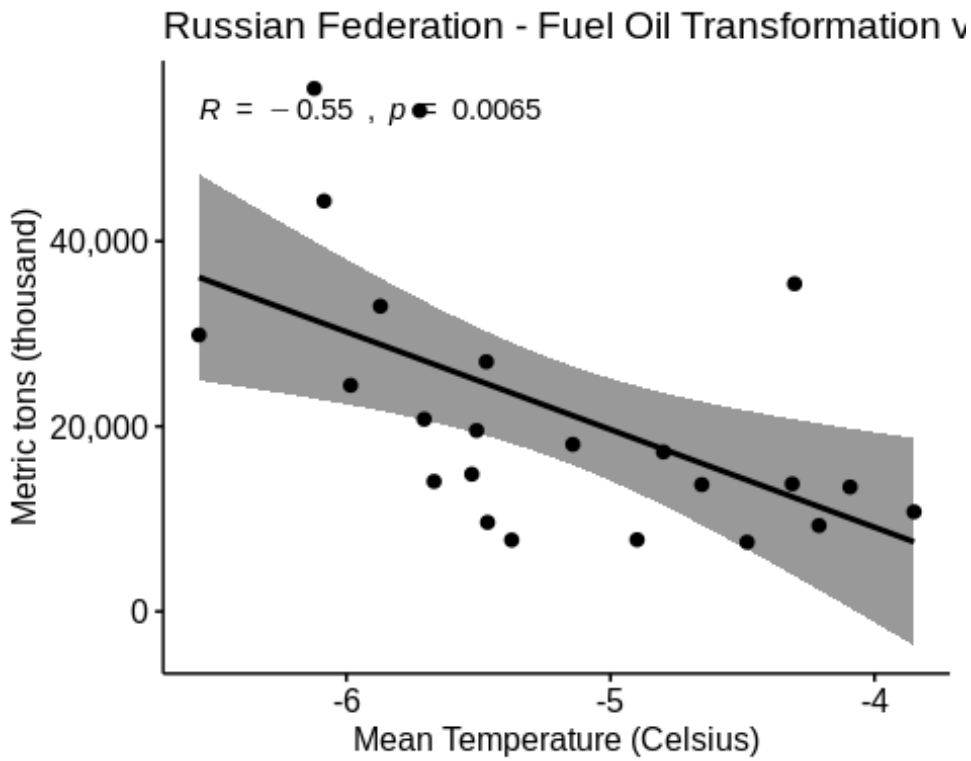

```
bct_06 <- brown_coal_10_tmp %>% filter(country_or_area ==
"Greece") %>% unnest(data)

cor.test(bct_06$mean_temp, bct_06$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  bct_06$mean_temp and bct_06$quantity
## t = 1.4256, df = 23, p-value = 0.1674
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.1241781  0.6112466
## sample estimates:
##       cor
## 0.2849335
```

(iii) Fuel Oil:

```
# Now we look at fuel oil:

fuel_oil_10_tmp

## # A tibble: 9 x 2
##   country_or_area    data
##   <chr>              <list>
## 1 Russian Federation <tibble [23 × 5]>
```

```
## 2 Japan              <tibble [25 × 5]>
## 3 United States      <tibble [25 × 5]>
## 4 Italy              <tibble [25 × 5]>
## 5 Mexico             <tibble [25 × 5]>
## 6 China              <tibble [25 × 5]>
## 7 Belarus            <tibble [23 × 5]>
## 8 United Kingdom     <tibble [25 × 5]>
## 9 Ukraine            <tibble [23 × 5]>
```

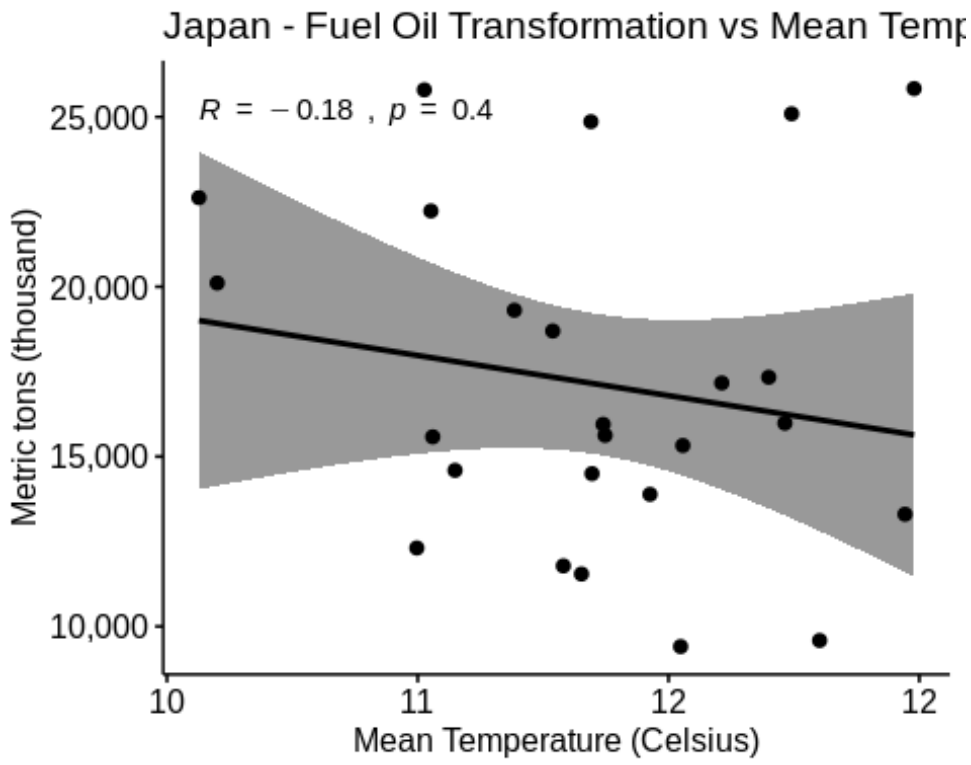
```
# These are the 9 countries that we need to investigate.

# 1: Russian Federation
fuel_oil_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "mean_temp", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Mean
Temperature (Celsius)", labels = comma)+ ggtitle("Russian
Federation - Fuel Oil Transformation vs Mean Temperature (1990 -
2015)")
```




```
fot_01 <- fuel_oil_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(fot_01$mean_temp, fot_01$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_01$mean_temp and fot_01$quantity
## t = -3.0209, df = 21, p-value = 0.006504
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7845869 -0.1787293
## sample estimates:
##       cor
## -0.5503833
```

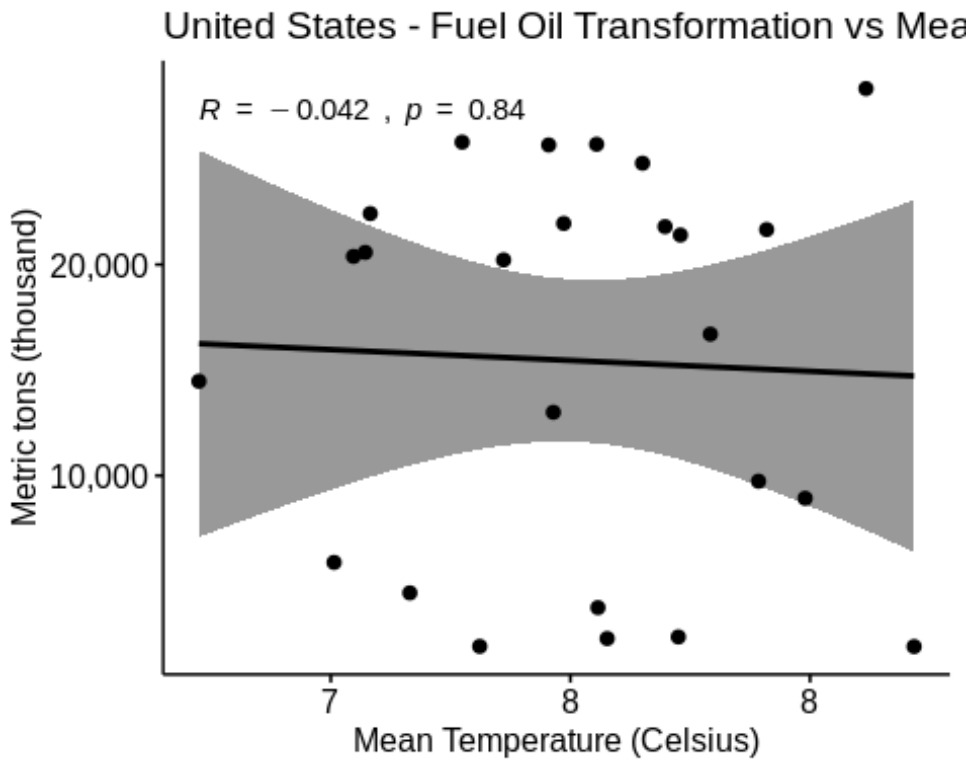
```
# 2: Japan
fuel_oil_10_tmp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Japan - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_02 <- fuel_oil_10_tmp %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(fot_02$mean_temp, fot_02$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_02$mean_temp and fot_02$quantity
## t = -0.85728, df = 23, p-value = 0.4001
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5339708  0.2355412
## sample estimates:
##        cor
## -0.1759669
```

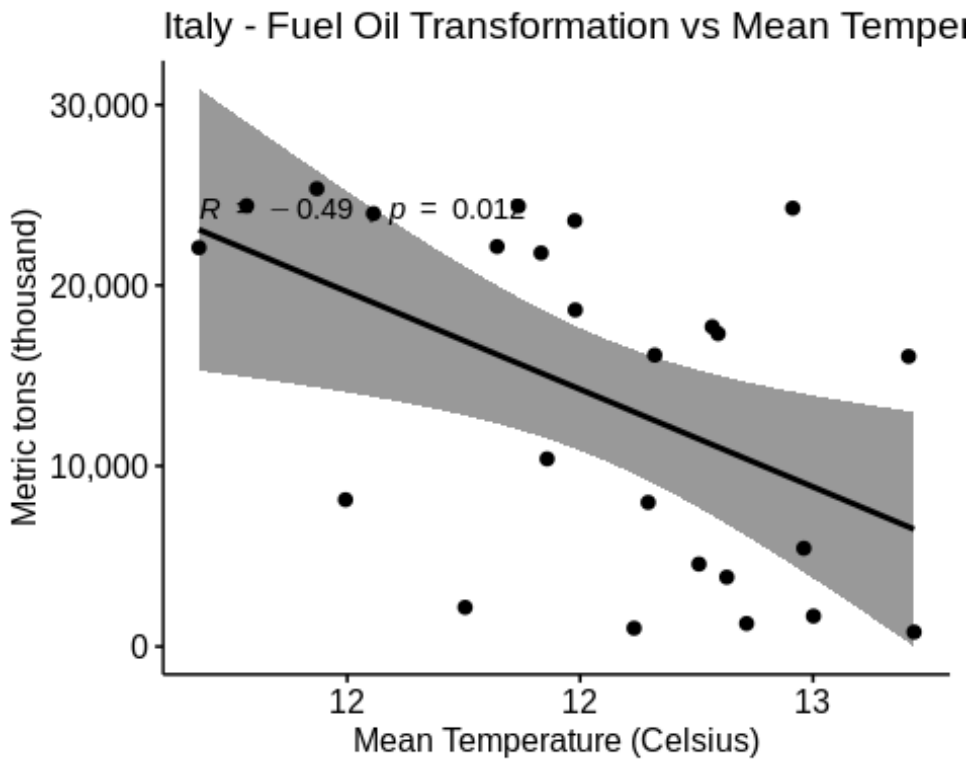
```
# 3: United States
fuel_oil_10_tmp %>% filter(country_or_area == "United States") %>
% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("United States - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_03 <- fuel_oil_10_tmp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(fot_03$mean_temp, fot_03$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_03$mean_temp and fot_03$quantity
## t = -0.20143, df = 23, p-value = 0.8421
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.4299664  0.3591207
## sample estimates:
##         cor
## -0.04196502
```

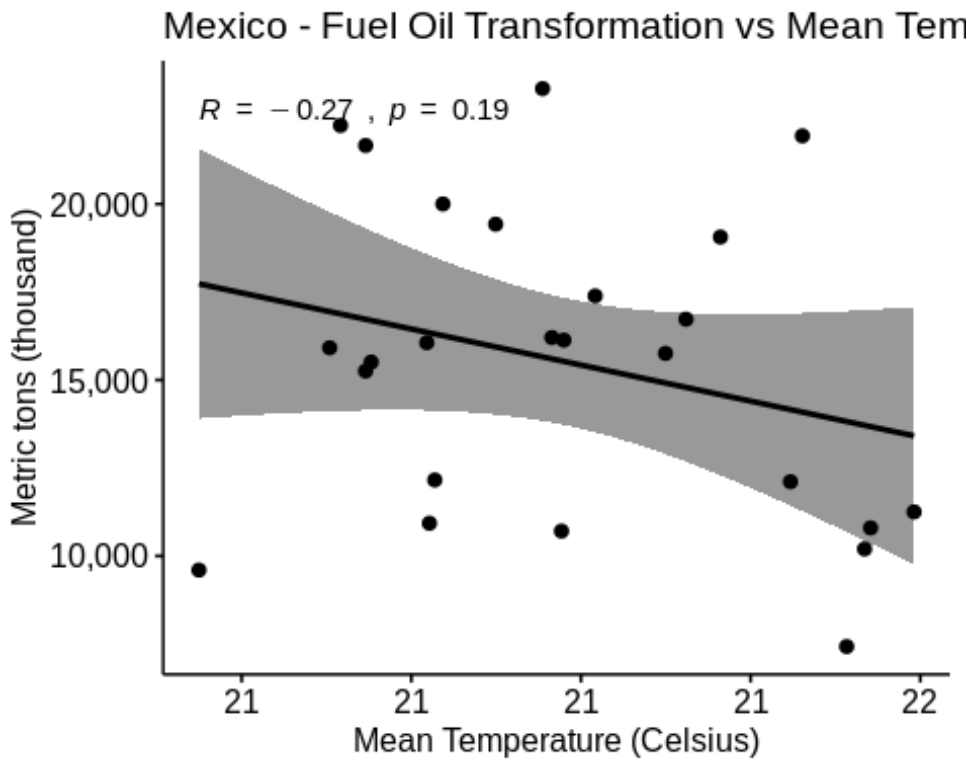
```
# 4: Italy
fuel_oil_10_tmp %>% filter(country_or_area == "Italy") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Italy - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_04 <- fuel_oil_10_tmp %>% filter(country_or_area == "Italy")
%>% unnest(data)

cor.test(fot_04$mean_temp, fot_04$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_04$mean_temp and fot_04$quantity
## t = -2.7261, df = 23, p-value = 0.01204
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7440257 -0.1230786
## sample estimates:
##       cor
## -0.4941766
```

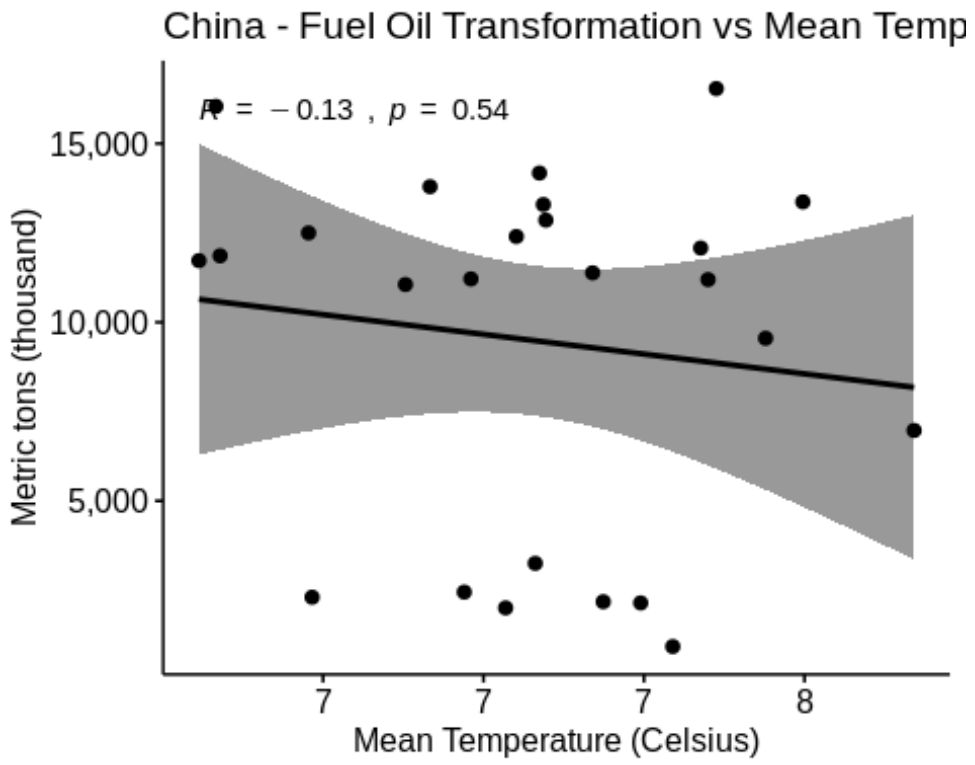
```
# 5: Mexico
fuel_oil_10_tmp %>% filter(country_or_area == "Mexico") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Mexico - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_05 <- fuel_oil_10_tmp %>% filter(country_or_area == "Mexico")
%>% unnest(data)

cor.test(fot_05$mean_temp, fot_05$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_05$mean_temp and fot_05$quantity
## t = -1.3629, df = 23, p-value = 0.1861
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.6033207  0.1365217
## sample estimates:
##        cor
## -0.2733551
```

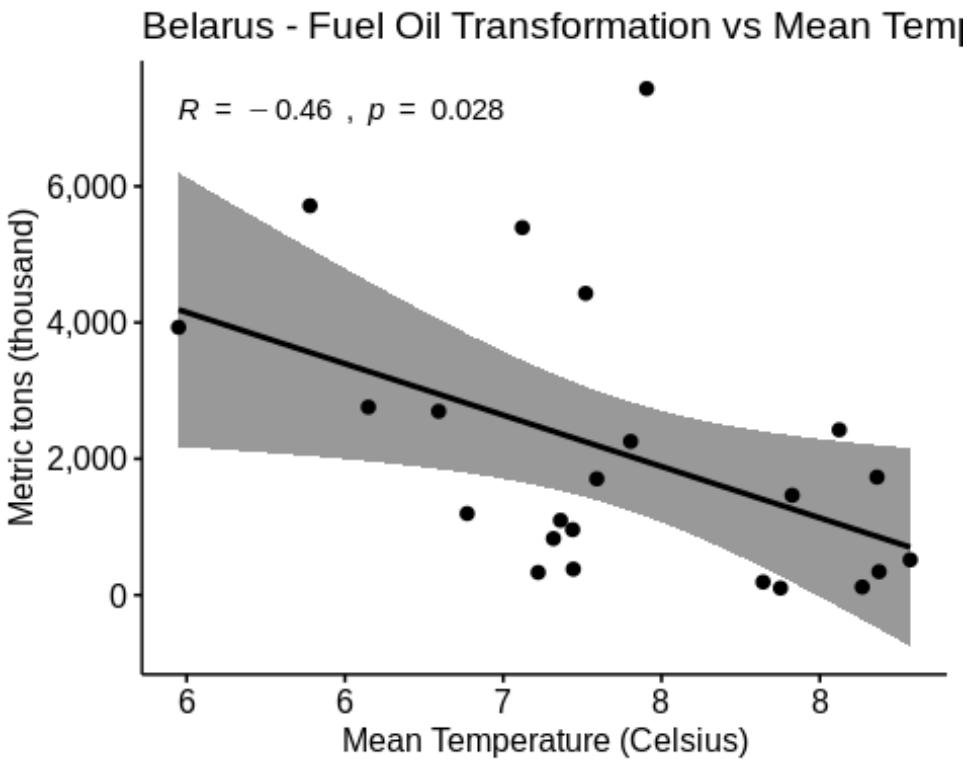
```
# 6: China
fuel_oil_10_tmp %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("China - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_06 <- fuel_oil_10_tmp %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(fot_06$mean_temp, fot_06$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_06$mean_temp and fot_06$quantity
## t = -0.62512, df = 23, p-value = 0.538
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.4989035  0.2801882
## sample estimates:
##        cor
## -0.1292524
```

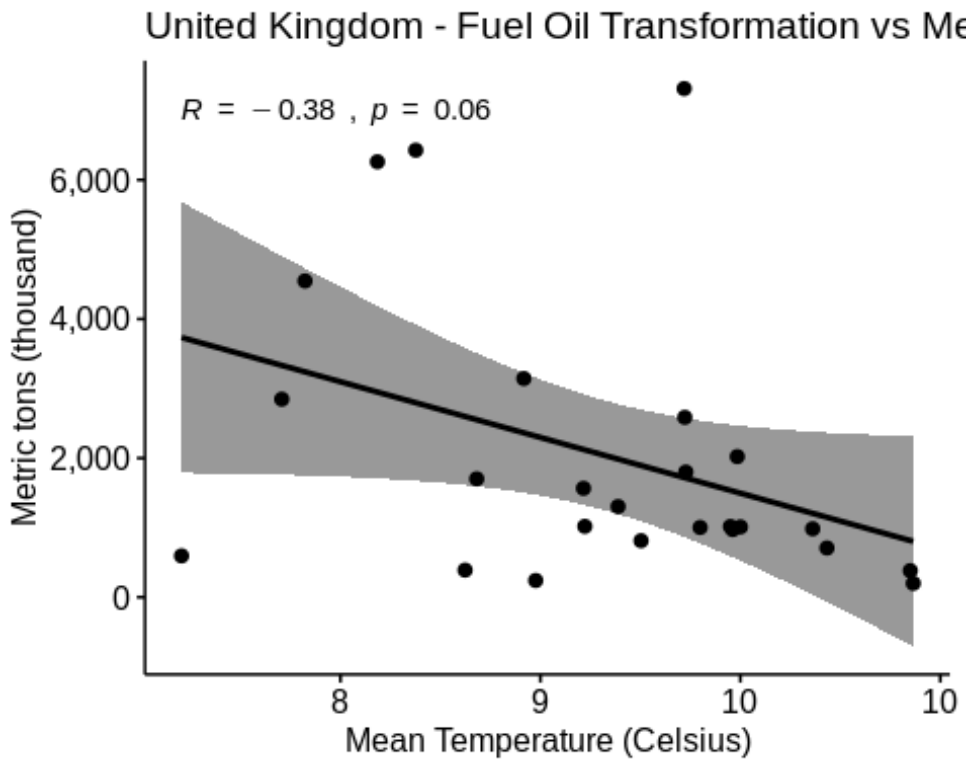
```
# 7: Belarus
fuel_oil_10_tmp %>% filter(country_or_area == "Belarus") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Belarus - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_07 <- fuel_oil_10_tmp %>% filter(country_or_area ==
"Belarus") %>% unnest(data)

cor.test(fot_07$mean_temp, fot_07$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_07$mean_temp and fot_07$quantity
## t = -2.3679, df = 21, p-value = 0.02756
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.73262723 -0.05778817
## sample estimates:
##       cor
## -0.4590555
```

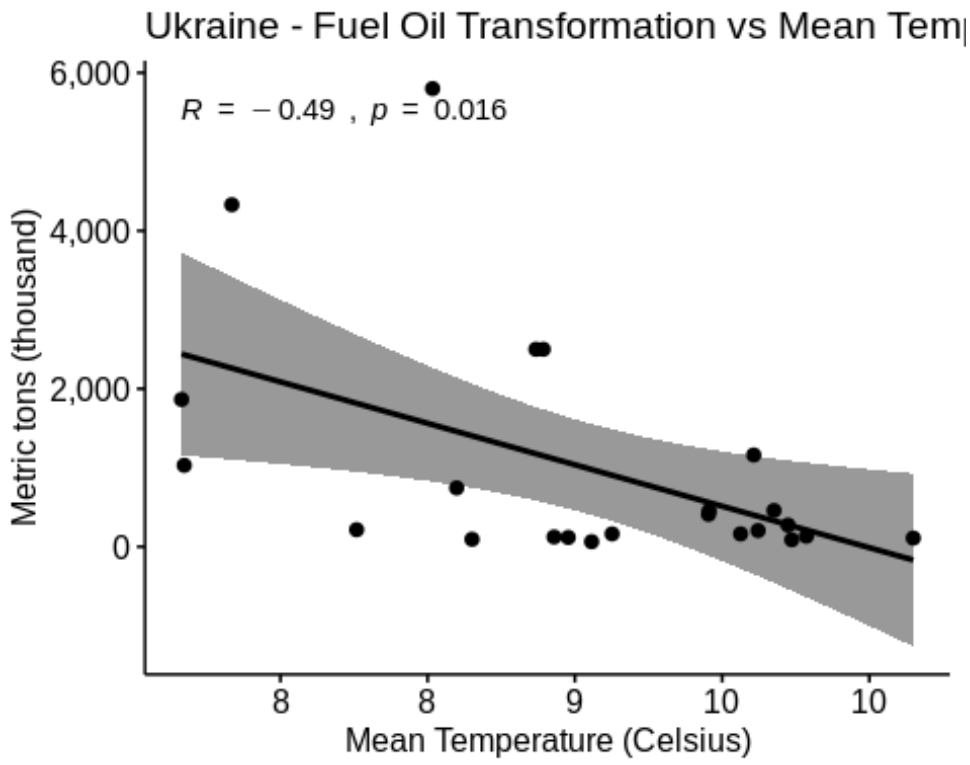
```
# 8: United Kingdom
fuel_oil_10_tmp %>% filter(country_or_area == "United Kingdom")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("United Kingdom - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_08 <- fuel_oil_10_tmp %>% filter(country_or_area == "United
Kingdom") %>% unnest(data)

cor.test(fot_08$mean_temp, fot_08$quantity, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  fot_08$mean_temp and fot_08$quantity
## t = -1.976, df = 23, p-value = 0.06027
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.67454756  0.01668893
## sample estimates:
##       cor
## -0.3809541
```

```
# 09: Ukraine
fuel_oil_10_tmp %>% filter(country_or_area == "Ukraine") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Ukraine - Fuel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
fot_09 <- fuel_oil_10_tmp %>% filter(country_or_area ==
"Ukraine") %>% unnest(data)

cor.test(fot_09$mean_temp, fot_09$quantity, method = "pearson")
```

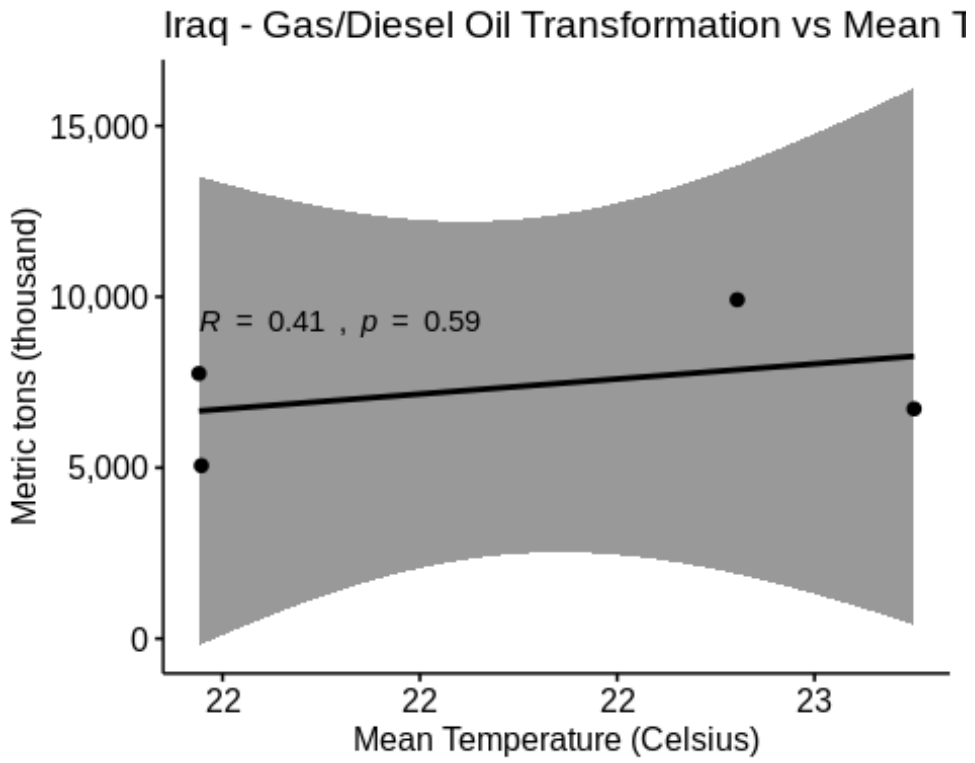
```
##
##  Pearson's product-moment correlation
##
## data:  fot_09$mean_temp and fot_09$quantity
## t = -2.6102, df = 21, p-value = 0.01635
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.7534296 -0.1039413
## sample estimates:
##       cor
## -0.4949379
```

(iv) Gas/Diesel Oil:

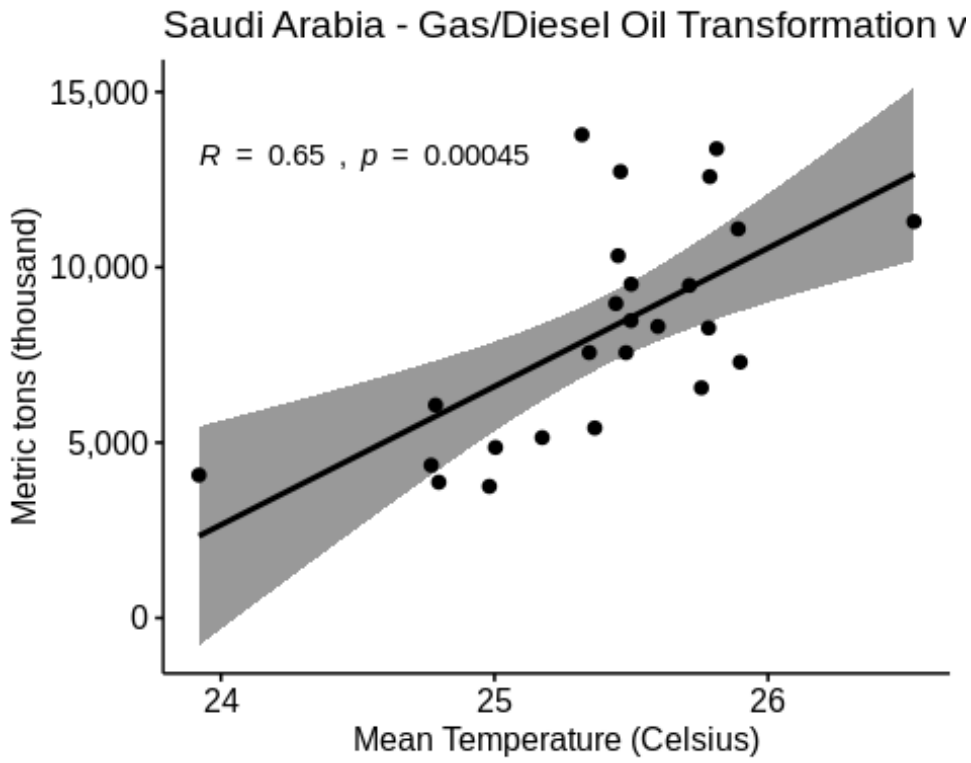
```
# Now we look at gas/diesel oil:

gasdiesel_10_tmp
```

```
## # A tibble: 10 x 2
##    country_or_area        data
##    <chr>                  <list>
##  1 Iraq                   <tibble [4 × 5]>
##  2 Saudi Arabia           <tibble [25 × 5]>
##  3 Indonesia              <tibble [25 × 5]>
##  4 United States          <tibble [25 × 5]>
##  5 Iran (Islamic Rep. of) <tibble [25 × 5]>
##  6 Russian Federation     <tibble [23 × 5]>
##  7 China                  <tibble [25 × 5]>
##  8 Germany                <tibble [24 × 5]>
##  9 Japan                  <tibble [25 × 5]>
## 10 Libya                  <tibble [25 × 5]>
```

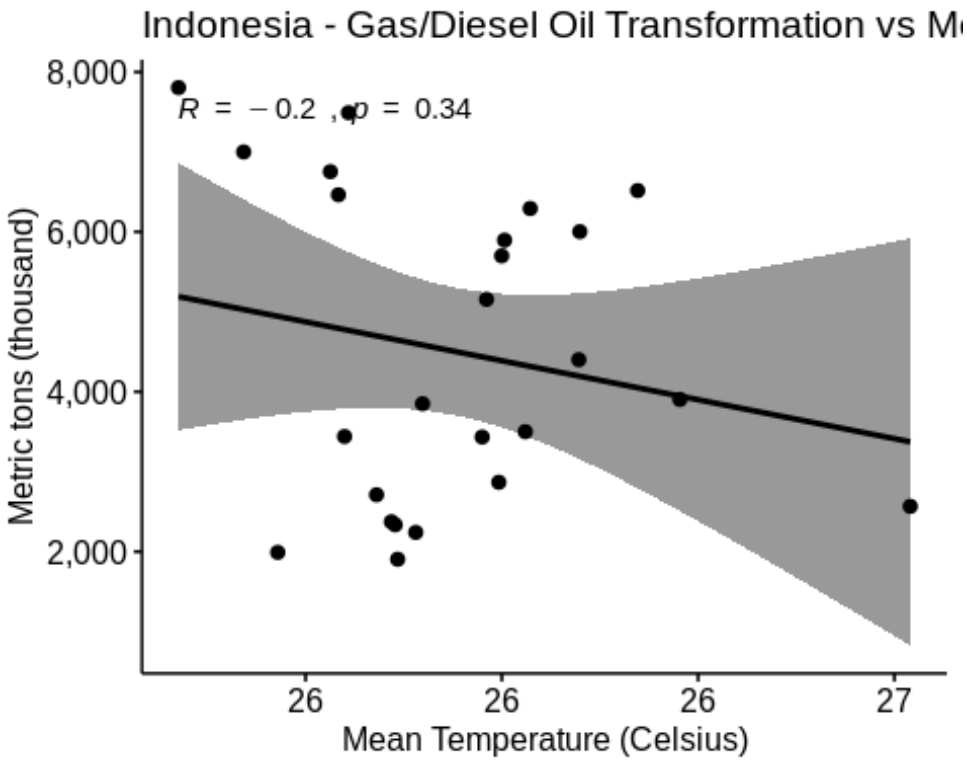
```
# Once again 10 countries:

# 1: Iraq
gasdiesel_10_tmp %>% filter(country_or_area == "Iraq") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Iraq - Gas/Diesel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```



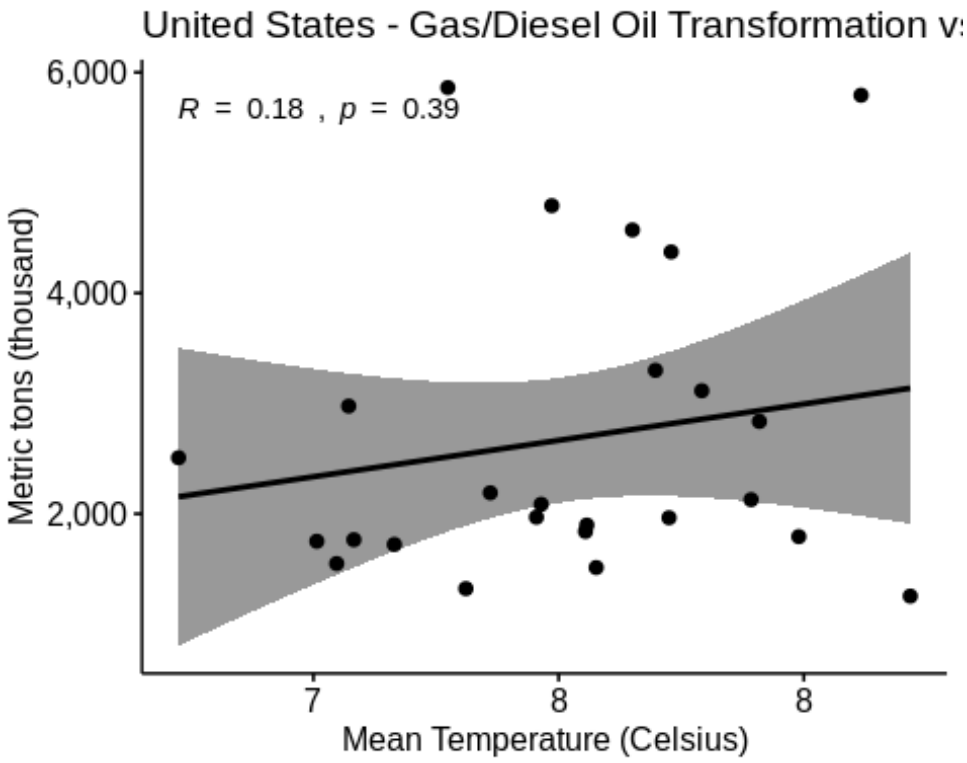

```
gdt_01 <- gasdiesel_10_tmp %>% filter(country_or_area == "Iraq")
%>% unnest(data)

cor.test(gdt_01$mean_temp, gdt_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_01$mean_temp and gdt_01$quantity
## t = 0.62698, df = 2, p-value = 0.5947
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9104231  0.9833457
## sample estimates:
##       cor
## 0.4052984

# 2: Saudi Arabia
gasdiesel_10_tmp %>% filter(country_or_area == "Saudi Arabia") %>
% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Saudi Arabia - Gas/Diesel
Oil Transformation vs Mean Temperature (1990 - 2015)")
```



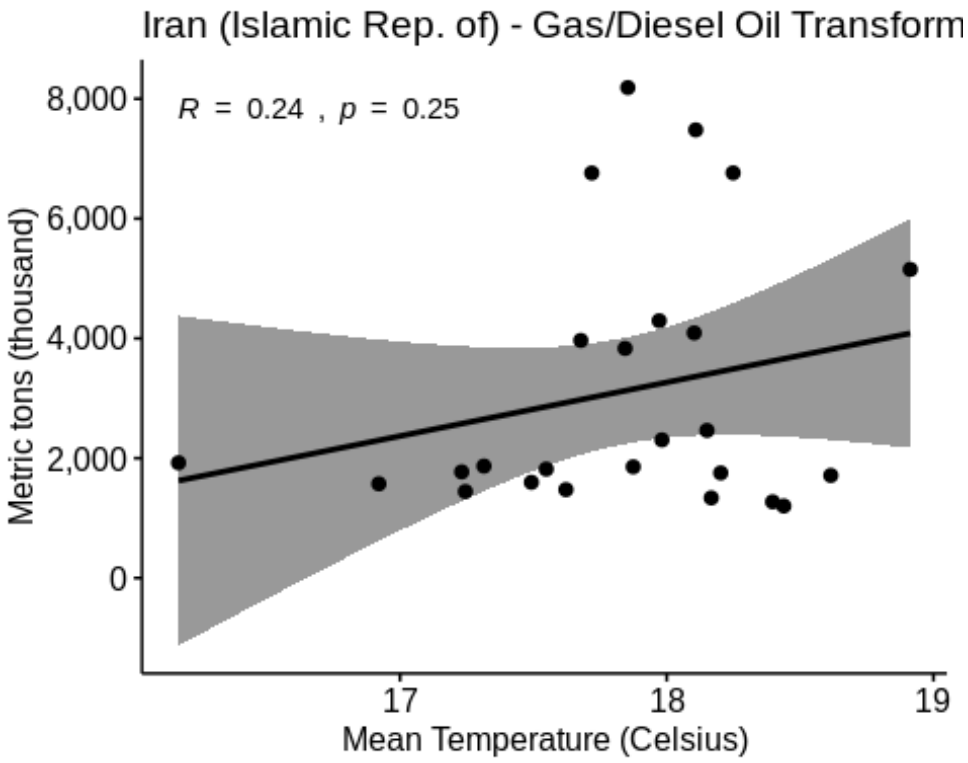

```
gdt_02 <- gasdiesel_10_tmp %>% filter(country_or_area == "Saudi
Arabia") %>% unnest(data)

cor.test(gdt_02$mean_temp, gdt_02$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_02$mean_temp and gdt_02$quantity
## t = 4.0913, df = 23, p-value = 0.0004484
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.3414427 0.8310299
## sample estimates:
##       cor
## 0.6490123

# 3: Indonesia
gasdiesel_10_tmp %>% filter(country_or_area == "Indonesia") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Indonesia - Gas/Diesel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```



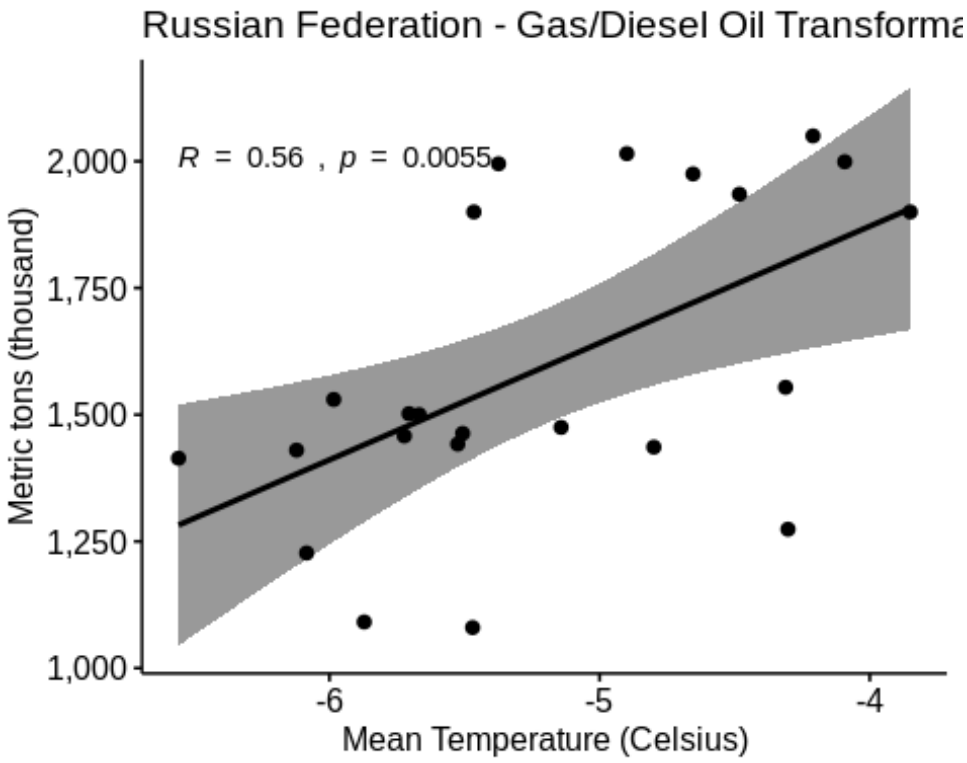

```
gdt_03 <- gasdiesel_10_tmp %>% filter(country_or_area == "Iraq")
%>% unnest(data)

cor.test(gdt_03$mean_temp, gdt_03$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_03$mean_temp and gdt_03$quantity
## t = 0.62698, df = 2, p-value = 0.5947
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9104231  0.9833457
## sample estimates:
##       cor
## 0.4052984

# 4: United States
gasdiesel_10_tmp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("United States - Gas/Diesel
Oil Transformation vs Mean Temperature (1990 - 2015)")
```



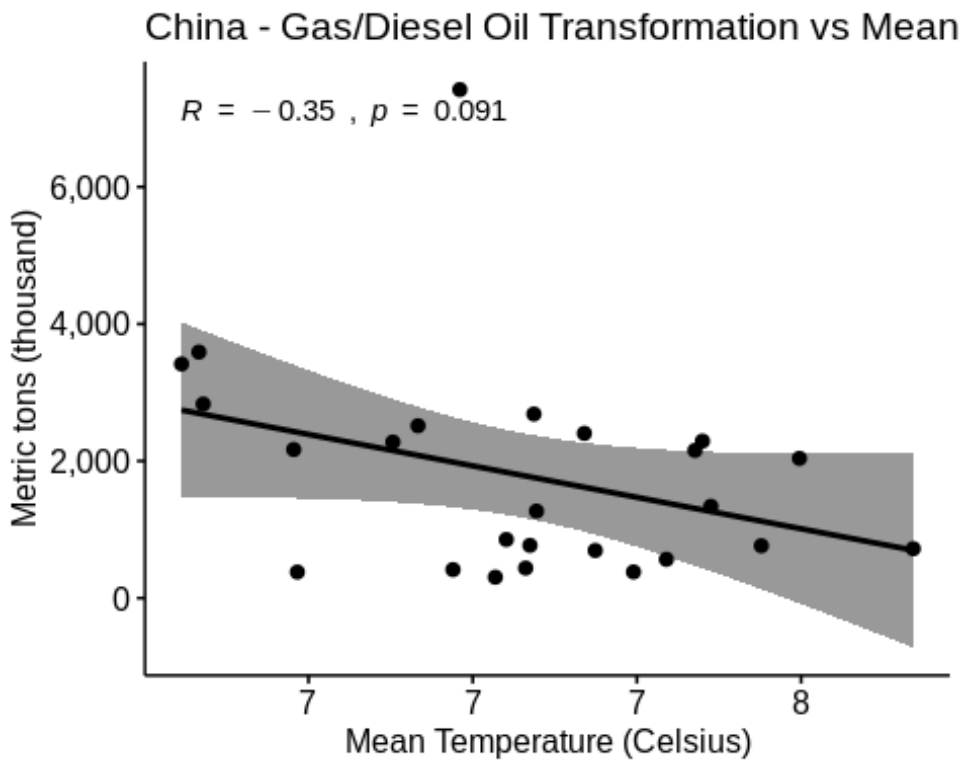

```
gdt_04 <- gasdiesel_10_tmp %>% filter(country_or_area == "United
States") %>% unnest(data)

cor.test(gdt_04$mean_temp, gdt_04$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_04$mean_temp and gdt_04$quantity
## t = 0.88, df = 23, p-value = 0.388
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.2311352  0.5372936
## sample estimates:
##       cor
## 0.1804785

# 5: Iran (Islamic Rep. of)
gasdiesel_10_tmp %>% filter(country_or_area == "Iran (Islamic
Rep. of)") %>% unnest(data) %>% ggscatter(x = "mean_temp", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Mean
Temperature (Celsius)", labels = comma)+ ggtitle("Iran (Islamic
Rep. of) - Gas/Diesel Oil Transformation vs Mean Temperature
(1990 - 2015)")
```



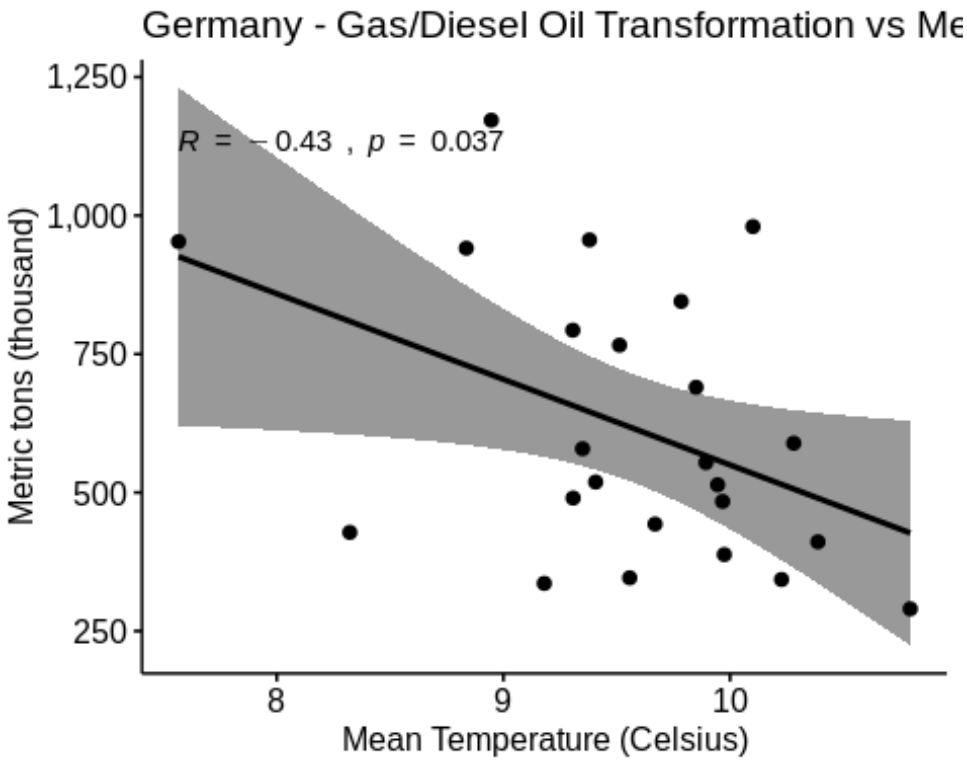

```
gdt_05 <- gasdiesel_10_tmp %>% filter(country_or_area == "Iran
(Islamic Rep. of)") %>% unnest(data)

cor.test(gdt_05$mean_temp, gdt_05$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_05$mean_temp and gdt_05$quantity
## t = 1.1837, df = 23, p-value = 0.2486
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.1717577  0.5798617
## sample estimates:
##       cor
## 0.2396366

# 6: Russian Federation
gasdiesel_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "mean_temp", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Metric tons
(thousand)", labels = comma) +  scale_x_continuous(name="Mean
Temperature (Celsius)", labels = comma)+ ggtitle("Russian
Federation - Gas/Diesel Oil Transformation vs Mean Temperature
(1990 - 2015)")
```



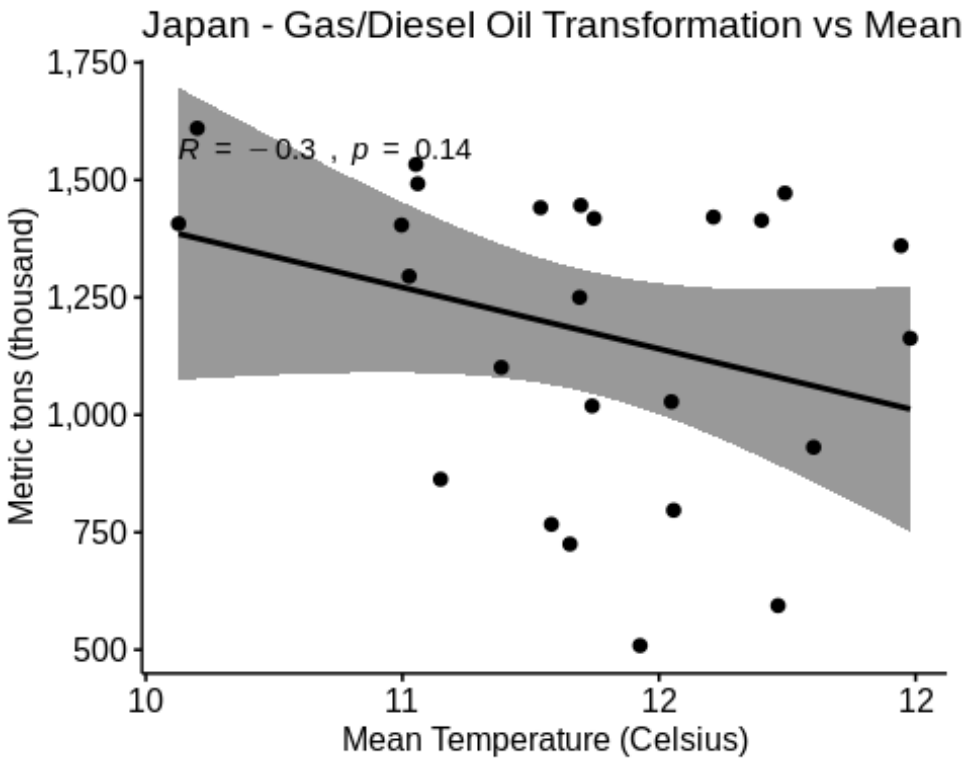

```
gdt_06 <- gasdiesel_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data)

cor.test(gdt_06$mean_temp, gdt_06$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_06$mean_temp and gdt_06$quantity
## t = 3.0956, df = 21, p-value = 0.005478
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1918334 0.7897483
## sample estimates:
##       cor
## 0.5597721

# 7: China
gasdiesel_10_tmp %>% filter(country_or_area == "China") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("China - Gas/Diesel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```



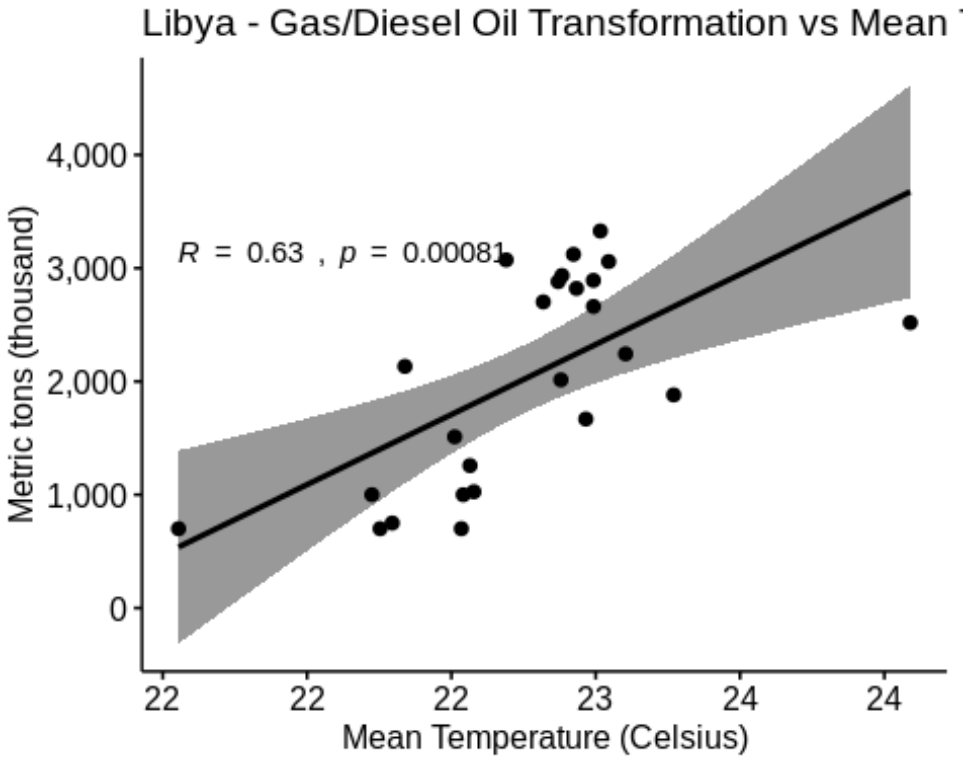

```
gdt_07 <- gasdiesel_10_tmp %>% filter(country_or_area == "China")
%>% unnest(data)

cor.test(gdt_07$mean_temp, gdt_07$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_07$mean_temp and gdt_07$quantity
## t = -1.7638, df = 23, p-value = 0.09105
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.65145426  0.05784576
## sample estimates:
##       cor
## -0.3451747

# 8: Germany
gasdiesel_10_tmp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Germany - Gas/Diesel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
gdt_08 <- gasdiesel_10_tmp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(gdt_08$mean_temp, gdt_08$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_08$mean_temp and gdt_08$quantity
## t = -2.216, df = 22, p-value = 0.03734
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.70848679 -0.02873269
## sample estimates:
##        cor
## -0.4271781

# 9: Japan
gasdiesel_10_tmp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Japan - Gas/Diesel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```




```
gdt_09 <- gasdiesel_10_tmp %>% filter(country_or_area == "Japan")
%>% unnest(data)

cor.test(gdt_09$mean_temp, gdt_09$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_09$mean_temp and gdt_09$quantity
## t = -1.5159, df = 23, p-value = 0.1432
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.6223992  0.1064152
## sample estimates:
##        cor
## -0.3013885

# 10: Libya
gasdiesel_10_tmp %>% filter(country_or_area == "Libya") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Metric tons (thousand)",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Libya - Gas/Diesel Oil
Transformation vs Mean Temperature (1990 - 2015)")
```

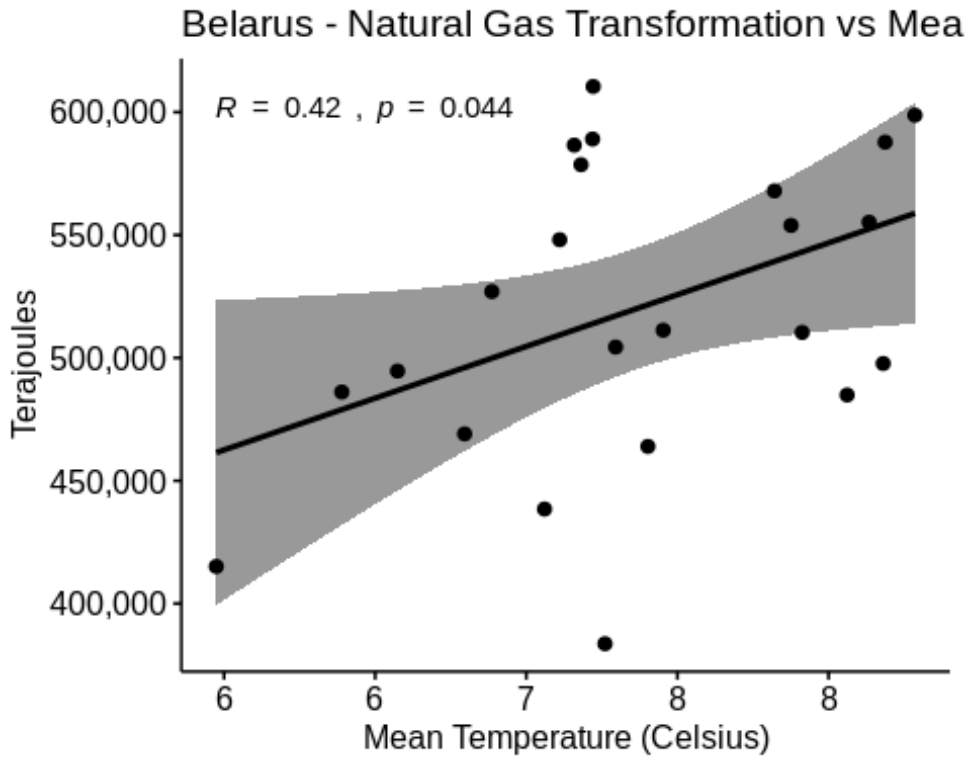



```
gdt_10 <- gasdiesel_10_tmp %>% filter(country_or_area == "Libya")
%>% unnest(data)

cor.test(gdt_10$mean_temp, gdt_10$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  gdt_10$mean_temp and gdt_10$quantity
## t = 3.8532, df = 23, p-value = 0.0008095
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.3072372 0.8188191
## sample estimates:
##       cor
## 0.6263321
```

(v) Natural Gas:

```
# Lastly there is Natural Gas:

natural_gas_10_tmp

## # A tibble: 8 x 2
##   country_or_area    data
##   <chr>              <list>
## 1 Russian Federation <tibble [23 × 5]>
## 2 United States      <tibble [25 × 5]>
```

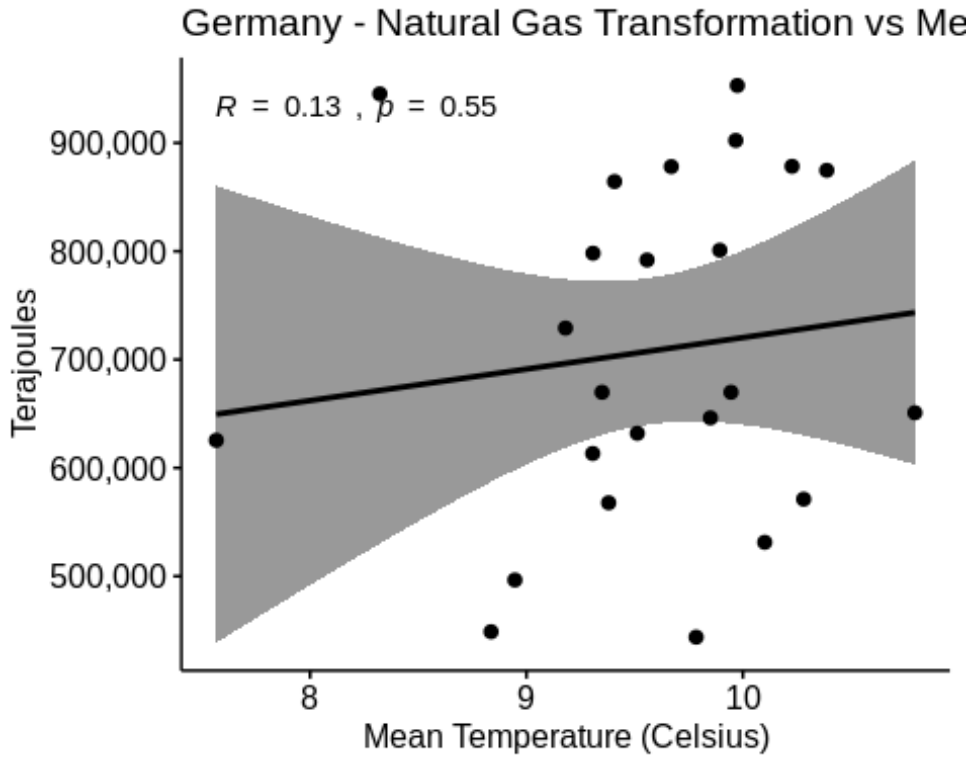
```
## 3 Japan              <tibble [25 × 5]>
## 4 Ukraine            <tibble [23 × 5]>
## 5 Uzbekistan         <tibble [23 × 5]>
## 6 Saudi Arabia       <tibble [25 × 5]>
## 7 Belarus            <tibble [23 × 5]>
## 8 Germany            <tibble [24 × 5]>

# There are 8 countries:

# 1: Belarus
natural_gas_10_tmp %>% filter(country_or_area == "Belarus") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("Belarus - Natural Gas Transformation vs
Mean Temperature (1990 - 2015)")
```




```
ngt_01 <- natural_gas_10_tmp %>% filter(country_or_area ==
"Belarus") %>% unnest(data)

cor.test(ngt_01$mean_temp, ngt_01$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ngt_01$mean_temp and ngt_01$quantity
```

```
## t = 2.1431, df = 21, p-value = 0.04397
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.01384965 0.71157795
## sample estimates:
##       cor
## 0.4236334
```

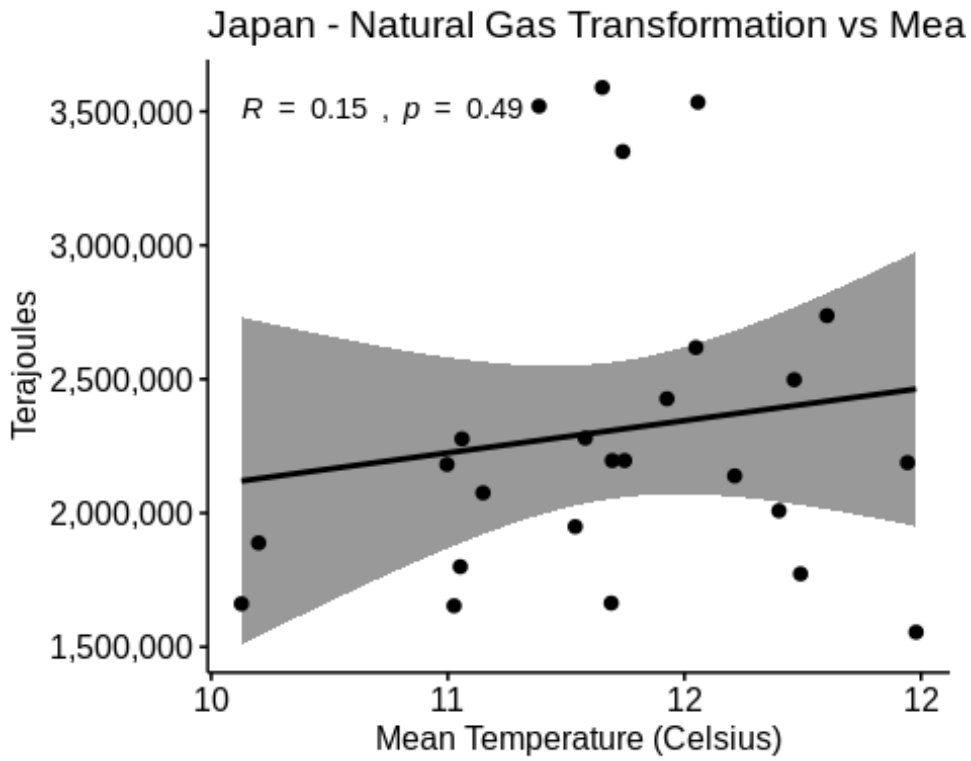
```
# 2: Germany
natural_gas_10_tmp %>% filter(country_or_area == "Germany") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("Germany - Natural Gas Transformation vs
Mean Temperature (1990 - 2015)")
```




```
ngt_02 <- natural_gas_10_tmp %>% filter(country_or_area ==
"Germany") %>% unnest(data)

cor.test(ngt_02$mean_temp, ngt_02$quantity, method = "pearson")
```

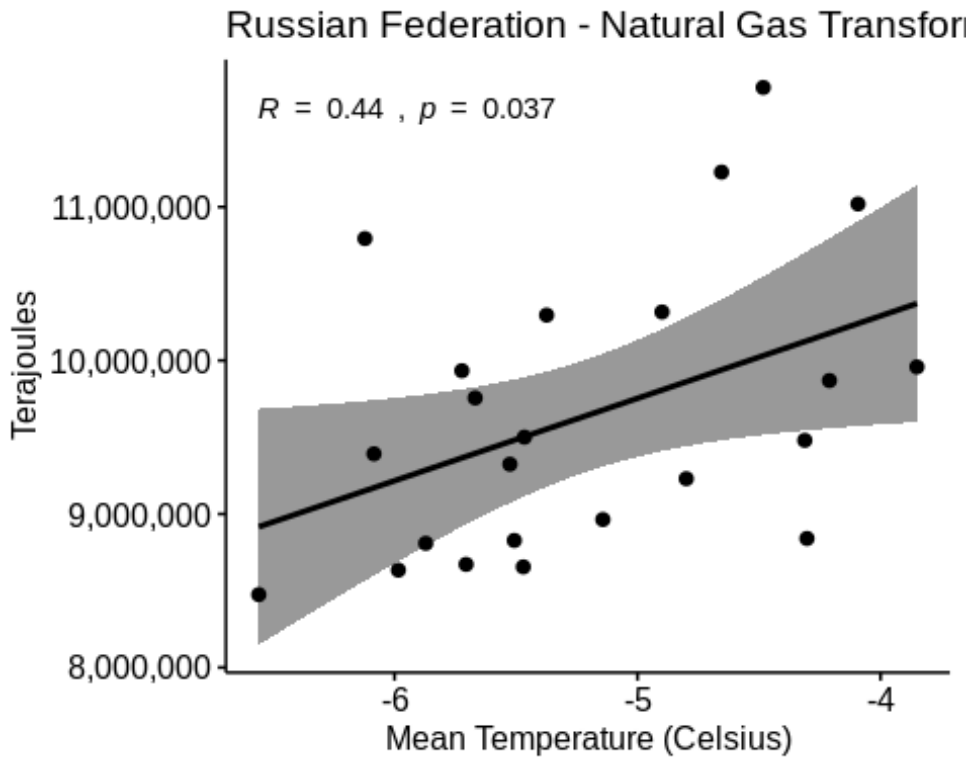
```
##
##  Pearson's product-moment correlation
##
## data:  ngt_02$mean_temp and ngt_02$quantity
## t = 0.6029, df = 22, p-value = 0.5527
```

```
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.2908660  0.5049189
## sample estimates:
##       cor
## 0.1274896

# 3: Japan
natural_gas_10_tmp %>% filter(country_or_area == "Japan") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("Japan - Natural Gas Transformation vs
Mean Temperature (1990 - 2015)")
```




```
ngt_03 <- natural_gas_10_tmp %>% filter(country_or_area ==
"Japan") %>% unnest(data)

cor.test(ngt_03$mean_temp, ngt_03$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ngt_03$mean_temp and ngt_03$quantity
## t = 0.70919, df = 23, p-value = 0.4853
## alternative hypothesis: true correlation is not equal to 0
```

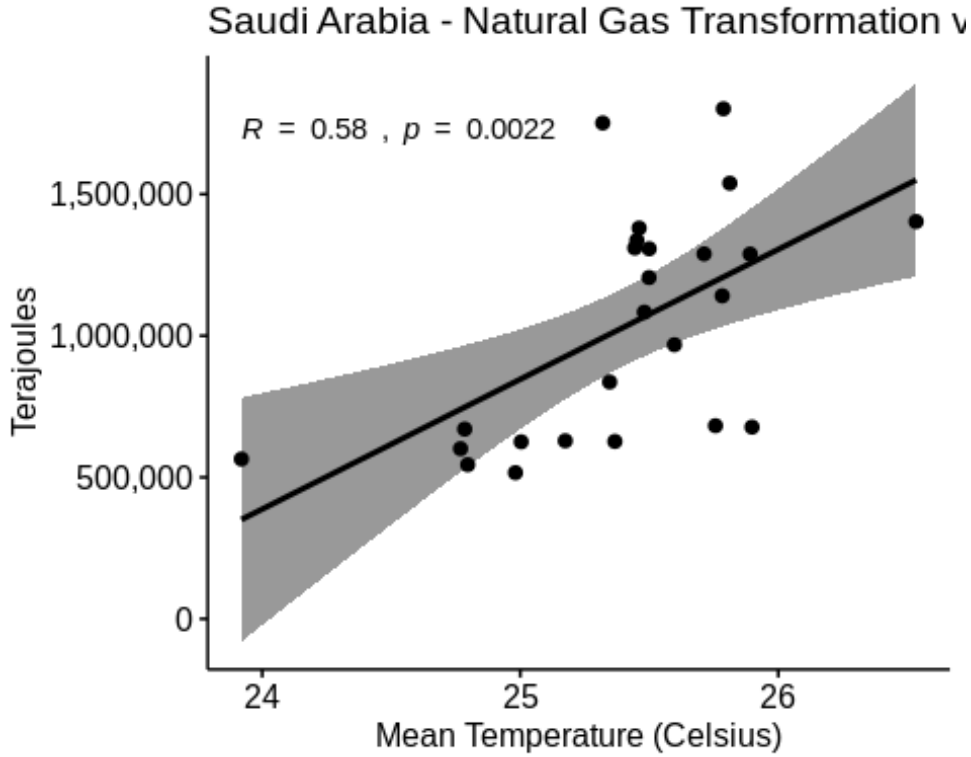
```
## 95 percent confidence interval:
##  -0.2641122  0.5118310
## sample estimates:
##       cor
## 0.1462848

# 4: Russian Federation
natural_gas_10_tmp %>% filter(country_or_area == "Russian
Federation") %>% unnest(data) %>% ggscatter(x = "mean_temp", y =
"quantity", add = "reg.line", conf.int = TRUE, cor.coef = TRUE,
cor.method = "pearson") + scale_y_continuous(name="Terajoules",
labels = comma) +  scale_x_continuous(name="Mean Temperature
(Celsius)", labels = comma)+ ggtitle("Russian Federation -
Natural Gas Transformation vs Mean Temperature (1990 - 2015)")
```




```
ngt_04 <- natural_gas_10_tmp %>% filter(country_or_area ==
"Russian Federation") %>% unnest(data)

cor.test(ngt_04$mean_temp, ngt_04$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ngt_04$mean_temp and ngt_04$quantity
## t = 2.2329, df = 21, p-value = 0.03657
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
```

```
##  0.03151908 0.72019599
## sample estimates:
##       cor
## 0.4380303
```

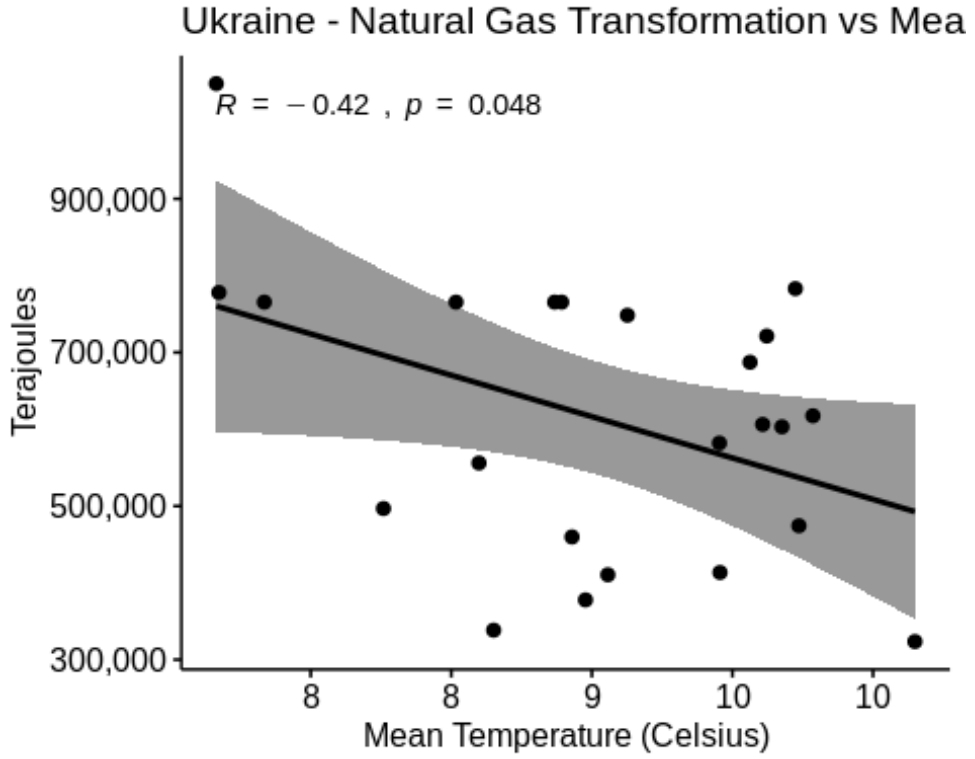
```
# 5: Saudi Arabia
natural_gas_10_tmp %>% filter(country_or_area == "Saudi Arabia")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("Saudi Arabia - Natural Gas
Transformation vs Mean Temperature (1990 - 2015)")
```




```
ngt_05 <- natural_gas_10_tmp %>% filter(country_or_area == "Saudi
Arabia") %>% unnest(data)

cor.test(ngt_05$mean_temp, ngt_05$quantity, method = "pearson")
```

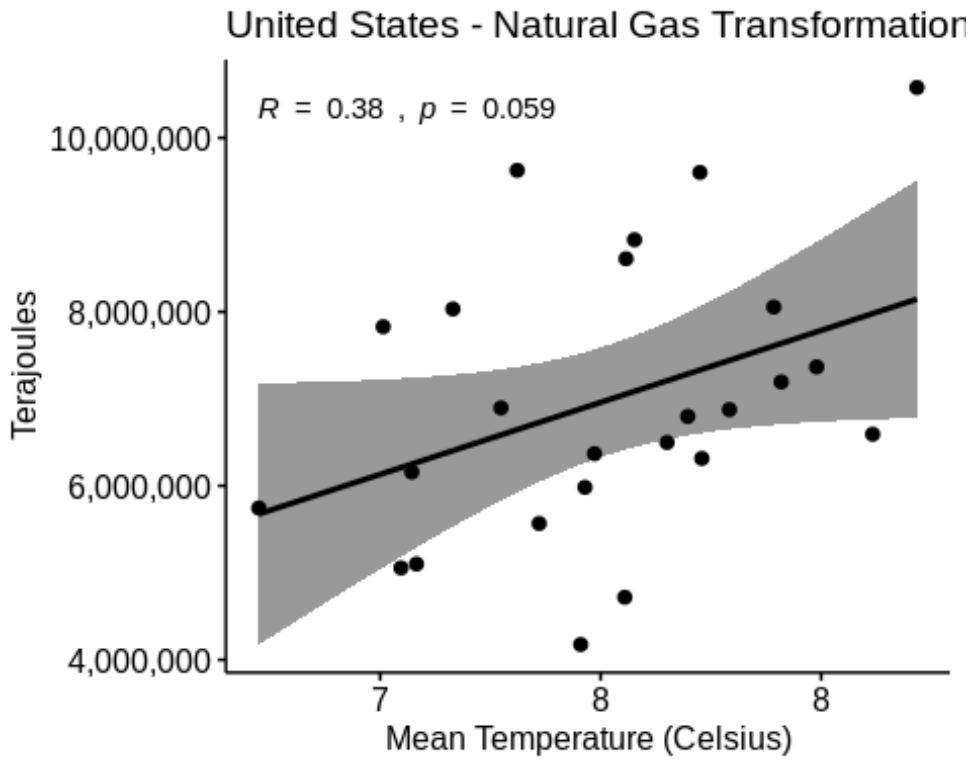
```
##
##  Pearson's product-moment correlation
##
## data:  ngt_05$mean_temp and ngt_05$quantity
## t = 3.4488, df = 23, p-value = 0.002184
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2452891 0.7954597
```

```
## sample estimates:
##      cor
## 0.583834

# 6: Ukraine
natural_gas_10_tmp %>% filter(country_or_area == "Ukraine") %>%
unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add =
"reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("Ukraine - Natural Gas Transformation vs
Mean Temperature (1990 - 2015)")
```



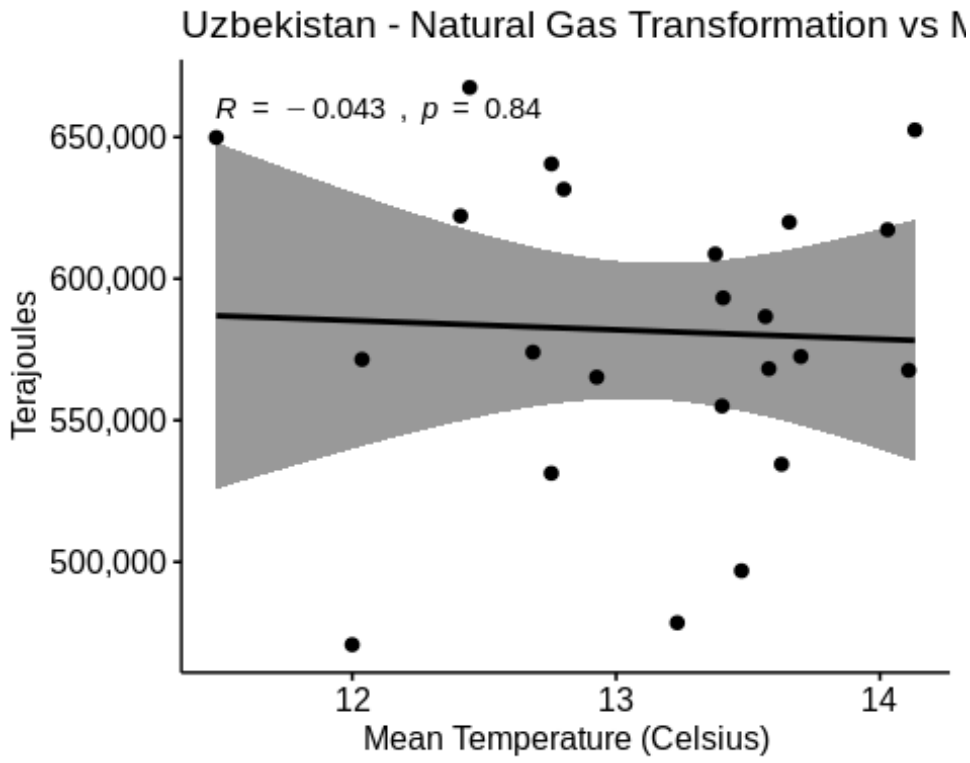

```
ngt_06 <- natural_gas_10_tmp %>% filter(country_or_area ==
"Ukraine") %>% unnest(data)

cor.test(ngt_06$mean_temp, ngt_06$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ngt_06$mean_temp and ngt_06$quantity
## t = -2.0992, df = 21, p-value = 0.04807
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.707252988 -0.005143476
## sample estimates:
```

```
##        cor
## -0.4164627

# 7: United States
natural_gas_10_tmp %>% filter(country_or_area == "United States")
%>% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity",
add = "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("United States - Natural Gas
Transformation vs Mean Temperature (1990 - 2015)")
```




```
ngt_07 <- natural_gas_10_tmp %>% filter(country_or_area ==
"United States") %>% unnest(data)

cor.test(ngt_07$mean_temp, ngt_07$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ngt_07$mean_temp and ngt_07$quantity
## t = 1.9826, df = 23, p-value = 0.05948
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.01541918  0.67523914
## sample estimates:
```

```
##       cor
## 0.3820393

# 8: Uzbekistan
natural_gas_10_tmp %>% filter(country_or_area == "Uzbekistan") %>
% unnest(data) %>% ggscatter(x = "mean_temp", y = "quantity", add
= "reg.line", conf.int = TRUE, cor.coef = TRUE, cor.method =
"pearson") + scale_y_continuous(name="Terajoules", labels =
comma) +  scale_x_continuous(name="Mean Temperature (Celsius)",
labels = comma)+ ggtitle("Uzbekistan - Natural Gas Transformation
vs Mean Temperature (1990 - 2015)")
```




```
ngt_08 <- natural_gas_10_tmp %>% filter(country_or_area ==
"Uzbekistan") %>% unnest(data)

cor.test(ngt_08$mean_temp, ngt_08$quantity, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  ngt_08$mean_temp and ngt_08$quantity
## t = -0.19809, df = 21, p-value = 0.8449
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.4474234  0.3757043
## sample estimates:
```

```
##         cor
## -0.04318596
```