02_Data_Code

Kevin Babb
October 31, 2018

The packages “tidyverse” and “broom” should be installed at this stage.

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

## ✔ ggplot2 3.1.0     ✔ purrr   0.2.5
## ✔ tibble  1.4.2     ✔ dplyr   0.7.7
## ✔ tidyr   0.8.1     ✔ 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()
```

And our data loaded as before.

```
raw_stats <-
read.csv("~/Documents/Class/CKME-136/Workshop/all_energy_statisti
cs.csv")
test_data <- as_tibble(raw_stats)
test_data <- test_data %>% select(-quantity_footnotes)
```

We check our data:

```
class(test_data)

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

head(test_data)

## # A tibble: 6 x 6
##   country_or_area commodity_transacti…  year unit     quantity
category
##   <fct>           <fct>                <int> <fct>       <dbl>
<fct>
## 1 Austria         Additives and Oxyge…  1996 Metric …        5
additives_…
## 2 Austria         Additives and Oxyge…  1995 Metric …       17
additives_…
## 3 Belgium         Additives and Oxyge…  2014 Metric …        0
additives_…
```

```
## 4 Belgium         Additives and Oxyge…  2013 Metric …         0
additives_…
## 5 Belgium         Additives and Oxyge…  2012 Metric …        35
additives_…
## 6 Belgium         Additives and Oxyge…  2011 Metric …        25
additives_…
```

Part I: 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")) )

head(hard_coal)
```

```
## # A tibble: 6 x 7
##   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 1 more variable: r_squared <dbl>
```

We can now begin our analysis on this data. We obtain the a list of the top 20 countries that began with the highest transformtion of coal into electricity.

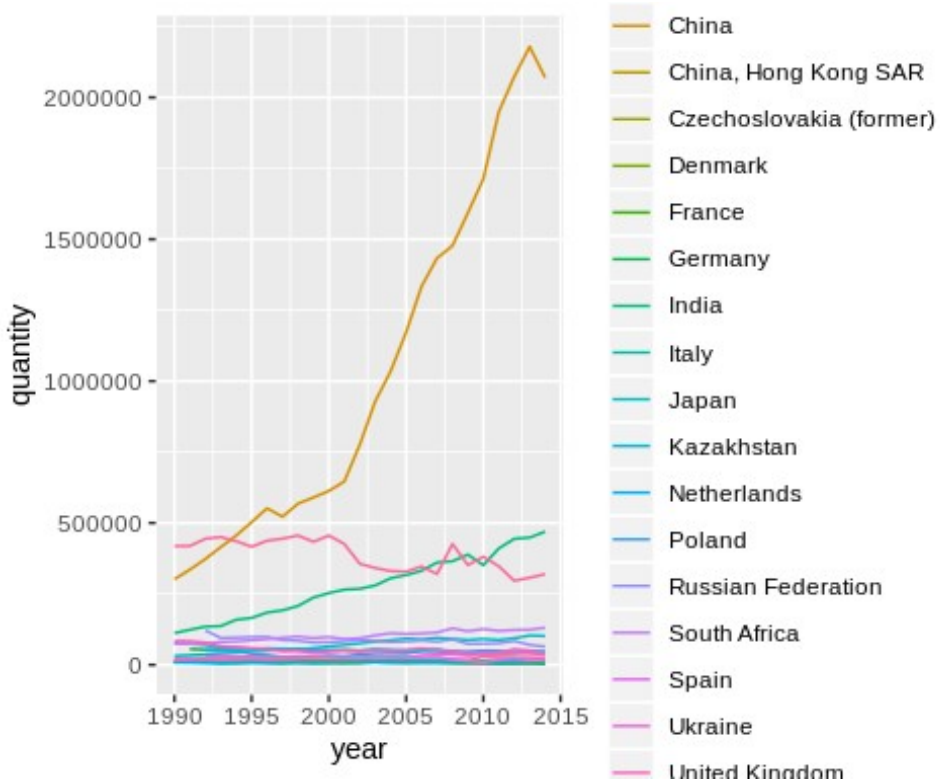
```
hard_coal %>% arrange(desc(initial_transformation)) %>% head(20)
```

```
## # A tibble: 20 x 7
##    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.
## 11 Ukraine         <tib…         1992            27000 <S3:…
557.
## 12 Australia       <tib…         1990            23913 <S3:…
-139.
## 13 Spain           <tib…         1990            18870 <S3:…
-131.
## 14 Canada          <tib…         1990            12208 <S3:…
-366.
## 15 France          <tib…         1990            11028 <S3:…
-165.
## 16 Italy           <tib…         1990            10782 <S3:…
480.
## 17 Denmark         <tib…         1990             9400 <S3:…
-307.
## 18 Czechoslovakia… <tib…         1990             9300 <S3:…
NA
## 19 China, Hong Ko… <tib…         1990             8929 <S3:…
164.
## 20 Netherlands     <tib…         1990             8721 <S3:…
12.4
## # ... with 1 more variable: 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(20)
%>% unnest(data) %>% ggplot(country_or_area, mapping = aes(x =
year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area))
```




```
# We may need to tease this out or do a logarithmic chart to
better represent this data.
```

Part II: 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")) )

head(brown_coal)
```

```
## # A tibble: 6 x 7
##   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 1 more variable: r_squared <dbl>
```

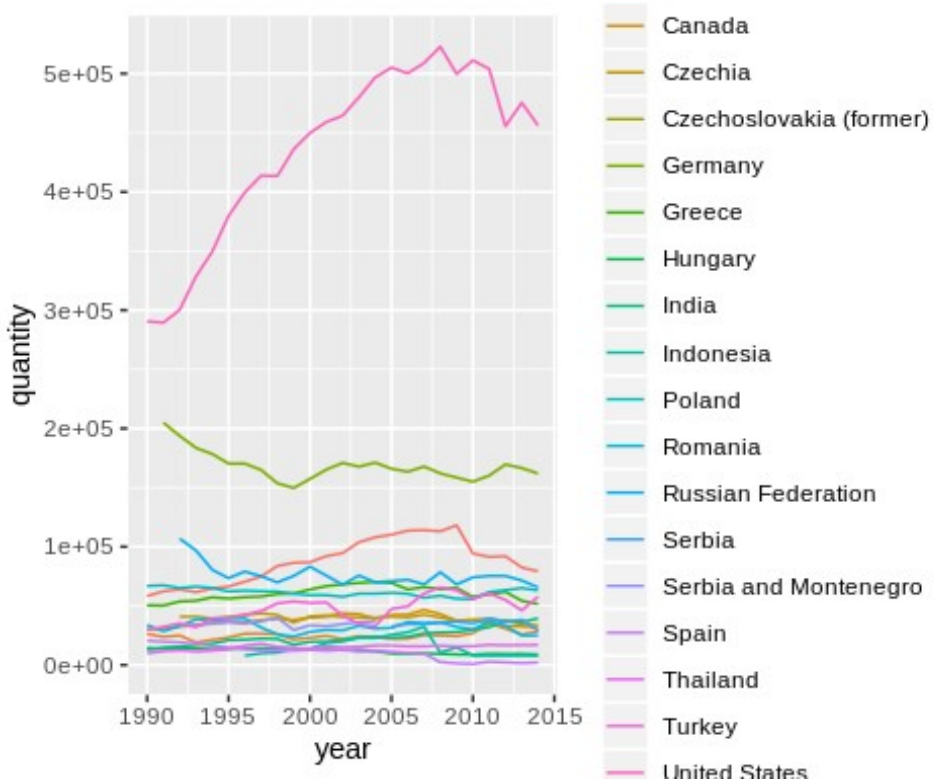
Analysis and charts

```
brown_coal %>% arrange(desc(initial_transformation)) %>% head(20)
```

```
## # A tibble: 20 x 7
##    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
## 11 Romania          <tib…          1990             33856 <S3:…
-151.
## 12 Serbia           <tib…          2005             32724 <S3:…
74.7
## 13 Canada           <tib…          1990             29946 <S3:…
158.
## 14 Turkey           <tib…          1990             29884 <S3:…
1050.
## 15 Bulgaria         <tib…          1990             26211 <S3:…
213.
## 16 Spain            <tib…          1990             20631 <S3:…
-801.
## 17 Hungary          <tib…          1990             14534 <S3:…
-274.
## 18 India            <tib…          1990             13001 <S3:…
880.
## 19 Thailand         <tib…          1990              9875 <S3:…
220.
## 20 Indonesia        <tib…          1996              7967 <S3:…
-201.
## # ... with 1 more variable: r_squared <dbl>
```

```
brown_coal %>% arrange(desc(initial_transformation)) %>% head(20)
%>% unnest(data) %>% ggplot(country_or_area, mapping = aes(x =
year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area))
```



Part III: 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]>

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
```

```
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")) )
```

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

```
head(fuel_oil)
```

```
## # A tibble: 6 x 7
##   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 1 more variable: r_squared <dbl>
```

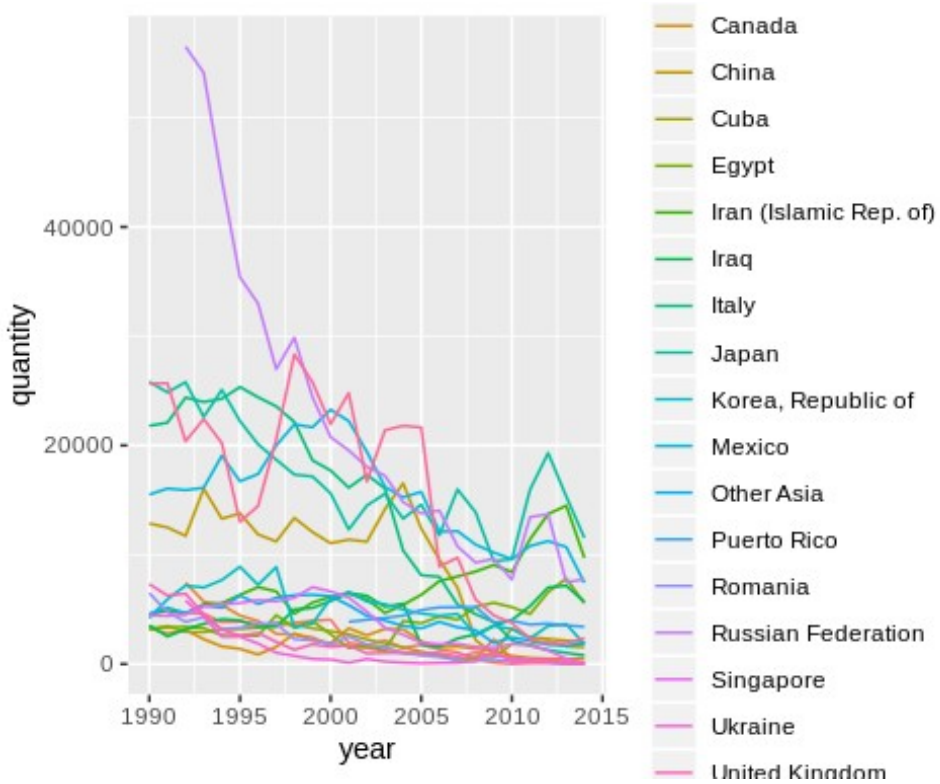
Analysis and charts

```
fuel_oil %>% arrange(desc(initial_transformation)) %>% head(20)
```

```
## # A tibble: 20 x 7
##    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.
## 11 Azerbaijan      <tib…         1992            4700  <S3:…
-241.
## 12 Other Asia      <tib…         1990            4585  <S3:…
-180.
## 13 Iran (Islamic … <tib…         1990            4542  <S3:…
293.
## 14 Singapore       <tib…         1990            4450  <S3:…
-236.
## 15 Korea, Republi… <tib…         1990            4198  <S3:…
-194.
## 16 Puerto Rico     <tib…         2001            3855. <S3:…
-67.7
## 17 Iraq            <tib…         1990            3544  <S3:…
69.7
## 18 Canada          <tib…         1990            3306  <S3:…
-82.8
## 19 Egypt           <tib…         1990            3260  <S3:…
139.
## 20 Cuba            <tib…         1990            3137  <S3:…
-102.
## # ... with 1 more variable: r_squared <dbl>
```

```
fuel_oil %>% arrange(desc(initial_transformation)) %>% head(20)
%>% unnest(data) %>% ggplot(country_or_area, mapping = aes(x =
year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area))
```



Part IV: 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")) )
```

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

```
head(gasdiesel_oil)
```

```
## # A tibble: 6 x 7
##   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 1 more variable: r_squared <dbl>
```

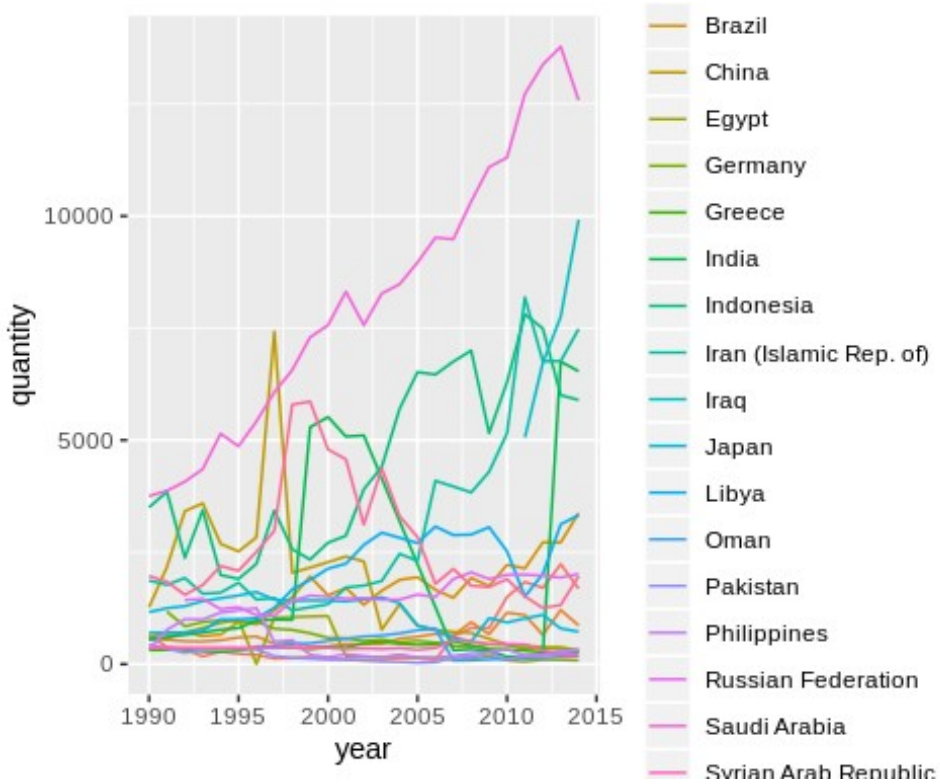
Analysis and charts

```
gasdiesel_oil %>% arrange(desc(initial_transformation)) %>%
head(20)
```

```
## # A tibble: 20 x 7
##    country_or_area data  initial_year initial_transfo… model
slope
##    <fct>           <lis>        <int>            <dbl> <lis>
<dbl>
##  1 Iraq            <tib…         2011             5061 <S3:…
1.56e+3
##  2 Saudi Arabia    <tib…         1990             3752 <S3:…
```

```
4.17e+2
##  3 Indonesia       <tib…          1990              3500 <S3:…
2.16e+2
##  4 United States   <tib…          1990              1969 <S3:… -
4.07e+1
##  5 Iran (Islamic … <tib…          1990              1868 <S3:…
2.46e+2
##  6 Russian Federa… <tib…          1992              1430 <S3:…
3.93e+1
##  7 China           <tib…          1990              1269 <S3:… -
1.39e+2
##  8 Germany         <tib…          1991              1172 <S3:… -
3.36e+1
##  9 Japan           <tib…          1990              1163 <S3:… -
2.97e+1
## 10 Libya           <tib…          1990               700 <S3:…
1.03e+2
## 11 Argentina       <tib…          1990               650 <S3:…
6.24e+1
## 12 Egypt           <tib…          1990               600 <S3:… -
3.87e+1
## 13 Brazil          <tib…          1990               567 <S3:…
9.07e+1
## 14 Australia       <tib…          1990               563 <S3:…
2.12e+1
## 15 India           <tib…          1990               550 <S3:…
7.82e+1
## 16 Pakistan        <tib…          1990               439 <S3:… -
6.39e+0
## 17 Oman            <tib…          1996               395 <S3:… -
2.53e+1
## 18 Syrian Arab Re… <tib…          1990               368 <S3:… -
5.68e-1
## 19 Philippines     <tib…          1990               329 <S3:… -
3.33e+1
## 20 Greece          <tib…          1990               315 <S3:…
3.22e-1
## # ... with 1 more variable: r_squared <dbl>

gasdiesel_oil %>% arrange(desc(initial_transformation)) %>%
head(20) %>% unnest(data) %>% ggplot(country_or_area, mapping =
aes(x = year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area))
```



Part V: 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")) )

head(natural_gas)
```

```
## # A tibble: 6 x 7
##   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 1 more variable: r_squared <dbl>
```

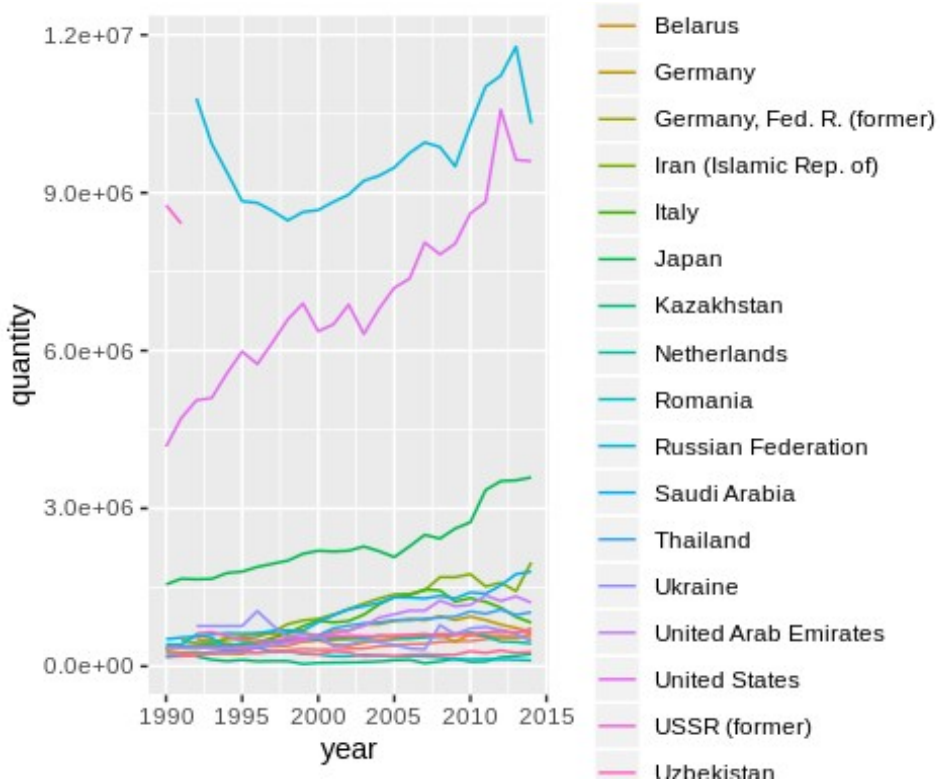
Analysis and charts

```
natural_gas %>% arrange(desc(initial_transformation)) %>%
head(20)
```

```
## # A tibble: 20 x 7
##    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
## 11 Italy            <tib…          1990            375640 <S3:…
4.32e4
## 12 United Arab Em… <tib…          1990            350000 <S3:…
4.95e4
## 13 Netherlands      <tib…          1990            330704 <S3:…
6.82e3
## 14 Iran (Islamic … <tib…          1990            311997 <S3:…
6.71e4
## 15 Germany, Fed. … <tib…          1990            277712 <S3:…
NA
## 16 Venezuela (Bol… <tib…          1990            259723 <S3:…
5.72e1
## 17 Argentina        <tib…          1990            243136 <S3:…
1.99e4
## 18 Kazakhstan       <tib…          1992            189263 <S3:…
2.10e3
## 19 Algeria          <tib…          1990            179712 <S3:…
1.64e4
## 20 Thailand         <tib…          1990            174916 <S3:…
4.06e4
## # ... with 1 more variable: r_squared <dbl>
```

```
natural_gas %>% arrange(desc(initial_transformation)) %>%
head(20) %>% unnest(data) %>% ggplot(country_or_area, mapping =
aes(x = year, y = quantity)) + geom_line(mapping = aes(color =
country_or_area))
```


1.2e+07
9.0e+06
6.0e+06
3.0e+06
0.0e+00
quantity
1990
1995
2000
2005
2010
2015
year
Belarus
Germany
Germany, Fed. R. (former)
Iran (Islamic Rep. of)
Italy
Japan
Kazakhstan
Netherlands
Romania
Russian Federation
Saudi Arabia
Thailand
Ukraine
United Arab Emirates
United States
USSR (former)
Uzbekistan