cdf5579_dev_econ_HW3

2023-02-22

R Markdown

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CARLOS FIGUEROA - CDF5579 - PROBLEM SET 3 - DEVELOPMENT ECONOMICS

```
#remove.packages("vctrs")
#install.packages("vctrs")

#'vctrs'
```

```
#install.packages("pwt10")

library("pwt10")
library(reshape2)
library(effectsize)
library(estimatr)
library(dplyr)
```

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

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

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

```
library("ggpubr")
```

```
## Loading required package: ggplot2

## Warning: package 'ggplot2' was built under R version 4.2.2
```

```
library(modelsummary)
library(magrittr)
library(readxl)
library(tinytex)
library(tibble)
library(tidyverse)  # ggplot(), %>%, mutate(), and friends
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --

## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1
## v purrr   0.3.4
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x tidyr::extract()   masks magrittr::extract()
## x dplyr::filter()    masks stats::filter()
## x dplyr::lag()       masks stats::lag()
## x purrr::set_names() masks magrittr::set_names()
```

```
library(broom)  # Convert models to data frames
library(rdrobust)  # For robust nonparametric regression discontinuity
library(rddensity)  # For nonparametric regression discontinuity density tests
```

```
#install.packages("gridExtra")
library("gridExtra")
```

```
## Warning: package 'gridExtra' was built under R version 4.2.2

##
## Attaching package: 'gridExtra'

## The following object is masked from 'package:dplyr':
##
##     combine
```

```
#install.packages("cowplot")
#install.packages("rlang")
library("cowplot")
```

```
## Warning: package 'cowplot' was built under R version 4.2.2

##
## Attaching package: 'cowplot'

## The following object is masked from 'package:ggpubr':
##
##     get_legend
```

1. How quickly will a country, growing at 2% a year, double its income? What about a country growing at 4% per year? How would that compare with a country growing at alternating rates of 0% and 8% per year? (in other words, which country grew faster, a steady 4% per year, or the "unstable" growth country, after 20 years). Please include your R code in addition to your answers.1

Starting from the compound interest formula, we have

A = p(1 + r/n) to the power of nt

Then, taking logs and solving for t, as well as defining A = 1

t = ln(WA)/ln(n x ln(1+r/n))

Where W is the increase we will want to calculate, and n is the amount of compounds per year. Then, n = A = 1, and W = 2 since we want t see when its income doubles.

t = ln(2)/ln(1.02) which is roughtly 35 years.

Additionally, a good linear approximation is to use the 69, 70 or 72 rule. The one we will use for this example will be 70 since it is the best approximation we can obtain out of the three. What we do is the t = 70/percentage of growth

t = 70/2 percent = 35 years

Then, for the case of 4 percent annual growth, we will have

t = ln(2)/ln(1.04) = 17.67 years

or

t = 70/4 percent = 17.5 years

```
print("for the country with 2 percent:")
```

```
## [1] "for the country with 2 percent:"
```

```
log(2)/log(1.02)
```

```
## [1] 35.00279
```

```
print("for the country with 2 percent:")
```

```
## [1] "for the country with 2 percent:"
```

```
log(2)/log(1.04)
```

```
## [1] 17.67299
```

Now, for the case of a country growing at 8 percent and 0 percent interchangeably, such calculation would not be that simple. Both of our equations break drown with the 0 percent change.

Which country grew faster, a steady 4% per year, or the "unstable" growth country, after 20 years. To solve this question, we will establish that in the spam of 20 years, the unstable country spend 10 years growing at 8 percent, and 10 years not growing at all. While the steady country grew 4 percent in those 20 years. Then, using the equations and assumptions we added before, we will have:

(1 + 0.08/n) to the power of n x 10 and (1 + 0.04/n) to the power of n x 20

```
print("for the unsteady country:")
```

```
## [1] "for the unsteady country:"
```

```
(1 + 0.08)^10
```

```
## [1] 2.158925
```

```r
print("for the steady country:")
```

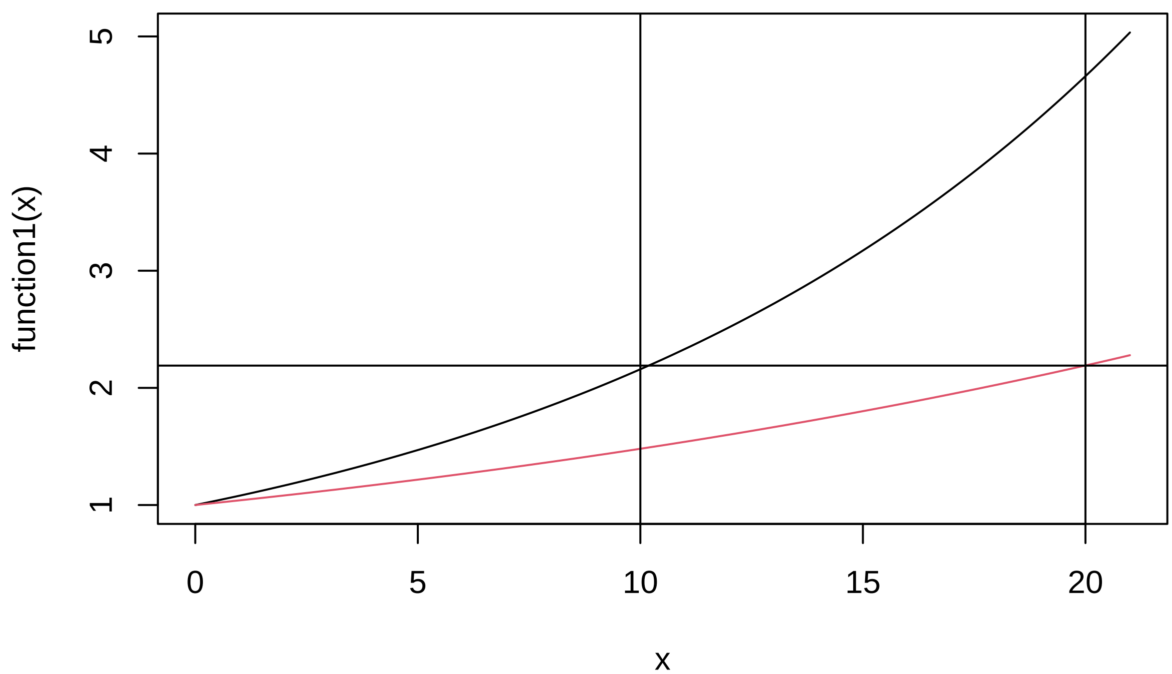
```
## [1] "for the steady country:"
```

```r
(1 + 0.04)^20
```

```
## [1] 2.191123
```

Therefore, the country with the steady growth rate will be better off than the country with the unstable growth rates in 20 years, but only by a small fraction.

```r
library("ggplot2")
function1<- function(x){1.08 ^ x}
function2<-function(x){1.04 ^ x}

curve(function1,to = 21, from = 0, col = 1)
curve(function2, to = 21, from = 0, col = 2, add = TRUE)
abline(v = 10)
abline(v = 20)

abline(h = 2.19)
```



But as we can see in this graph, then again, the steady country is doing better off just by a little.

2. Suppose a country's per capita income is currently growing at 4% per year. Then it adds an additional percentage point to its population growth rate for the next twenty years, but overall income continues to grow at the same rate. How much poorer/richer would the country be at the end of twenty years (per capita)?

You don't need to solve it out - just show us the equation. But the equation should not include the number "4" - you can simplify this problem.

By deriving the equations from class, we have that since growth rate of k is assumed to be zero, we will have that:

g(y) = g(A) + n

If a country's per capita income is growing at 4%: g(y), = 0.04 This means g(y) is also 0.04

If there is an additional percentage point added to its population growth rate but overall income grows at the same rate, we can use g(y) = g(A) + n and see that gA would decrease one percentage point to make this relationship hold.

In other words, from the g(y) = g(A) relationship we can then see g(y) would be a percentage point lower, making the country poorer per capita. Then, if we calculate how much poorer per capita after 20 years, we will use the following equation:

y x (1 + g(y)(1)) to the power of 20 - y x (1 + g(y)(0)) to the power of 20

As an example, we could have:

growth = y x (1 + 0.02) to the power of 20 - y x (1 +0 .04) to the power of 20

In conclusion, the country will be poorer with an additional percentage point to its population growth rate.

Another iconic development article that we didn't have time to discuss in class is Lucas, R. E. (1990). Why doesn't capital flow from rich to poor countries?. The American Economic Review, 80(2), 92-96.2 The question that is raised in the paper is often called the "Lucas puzzle". Briefly answer the following questions:

3. What does the simple economic theory predict? Shortly explain this prediction in your own words.

What we know by theory and analysis, is that if production per worker differs between two countries, it must be because they have different levels of capital per worker, meaning they are more effective in one country than the other in terms of production.

Notwithstanding, given the Law of Diminishing Returns, this will also imply that the marginal product of capital is higher in the less productive (i.e., in the poorer) economy. In other words, there is more space to grow in less productive nations since an additional untio of capital will have a greater impact in production than in already very productive nations.

This will drive us to the theory prediction that Lucas mentions: if trade in capital good is free and competitive, new investment will occur only in the poorer economy, since there are no incentives to invest in a country where the marginal product of capital is potentially close to zero. And this prediction will continue to be true until capital-labor ratios, wages and capital returns, are equalized among nations.

4. What counter example to the theory is given in the text? Can you think of a historical example for a time and place when the theory didn't get it wrong?

The first thing that he raises as a question is: is that prediction really the case? lets look at the case of US and India. Why are investments in the US still increasing in comparison to the investments made in India. This theory prediction will tell us that there is no point of investing in a high-productive country like the US, and that all investments should be going to developing nations, and India is a good case study because of its size and potential in terms of population. And there is a giantic gap in terms of investment between these countries.

The same is true for many other countries: for instance, United States with Mexico, were trading barriers are practically zero since they are neighbor countries, but Mexico has not seen any substantial growth in investment, or at least not in the scales of magnitute predicted by theory.

5. Explain the first candidate answer Lucas raises for the question. (Hint: ". . . each American or Canadian worker was estimated to be productive equivalent to about five Indians or Ghanians"). How does he refute this answer?

The context that he is discussing about is that he mentions: "28 countries examined could attain, expressed as a fraction of U.S. income, if each country had the same physical capital per worker endowment as did the United States. In that comparison each American or Canadian worker was estimated to be productive equivalent to about five Indians or Ghanians"

What Lucas takes into consideration in that scenario is Krueger's estimated human capital differentials, and re-interprets the initial equations. Basically, what this entails is that there is a difference between per worker and per effective worker (marked by Krueger), which lowers the ratios mentioned before substantially, but not close to the ones we see in the data, which is close to zero.

So even though this first candidate encompasses a important differentiation, it is still not able to fit the data properly, so he argues that the paradox still pretty much alive: "a factor of 5 difference in rates of return is still large enough to lead one to expect capital flows much larger than any- thing we observe"

6. Choose another candidate answer from the next two in the text and briefly explain it, in your own words.

One of the next and final proposals is adding human capital to production and making some handy assumption about what that rate might be worldwide.The assumption is that the total stock of human capital grows at the same rate, .009, as that part of the stock that is accumulated through formal schooling. Which, in order words is that we are not accounting for human capital, such as education and other things that are more advanced in big economies than in small ones.

With this additional variable, and taking the Krueger estimates as well, will drive us to a rate of return ratio between India and the United States of about (3)1.55 -l = 1.04, way lower than before.

However, as Lucas argues, these results are based on the cross-country comparison assumption that the external benefits of a country's stock of human capital accrue entirely to producers within that country. Therefore, we should not take them by face value, and provides the example of knowledge spillovers being troublesome for these relationship with stock of human capital to be true to our assumptions.

7. After reading this paper and hopefully thinking about this puzzle a bit, give your opinion - why doesn't capital flow from rich to poor countries?

Even before reading this paper, my opinion was pretty similar to one of the conclusions that Lucas reaches in this paper: political issues that are not being accounted, and many many existing trading barriers for trade out there.

Without having to rely in that many other assumptions about the economy to get a reasonable differential of capital PC in each country,for such a pattern to be a competitive equilibrium, it is evident that there must be an effective mechanism for enforcing international borrowing agreements.

Political risk is a common way to describe this kind of flaw in the capital markets. For instance, the fact that the US does not shift all its investments into India might be accompanied with political interests from the US. A good example of this is the tariffs imposed by the US in China, or many other countries that were prohibited to negotiate with the international community due to political ideologist and war threats, such as Venezuela or Afghanistan. Which is something really important to account for: these less developed countries that should be receiving investments, they are often the countries with most political instability and prone to rejection of US dogmas in terms of trade.

8. In the first problem set, you looked at the growth rates for one country. Now I want you to use the data to make slightly more complicated graphs. Specifically, I want you to make a graph that looks like the one on slide 30 of the problem set, reproduced below.

That is to say: a scatterplot for each time period and a best fit line, with labeled X and Y axis. Make one graph for GDP per Capita, just like the one above, and also make one for TFP (don't use the PWT TFP measures, use the ones you calculated on the first problem set, but now calculate it for all countries.

Since you didn't start in 1960 for your problem set, your graphs don't need to start in 1960 either. You don't need to make exactly the same formatting choices for the graph - in fact you shouldn't, since the one on the slides is hard to read in black and white.

This question is left intentionally vague. You may find yourself with lots of options at various steps, where the options seem pretty similar. You should do whatever you think is reasonable, but please write out what the various choices you made along the way were. You do not need to include your code, just a words-based description (and then of course you should include the graphs). I am also intentionally not giving you instructions or hints for how to do this. There are lots of good resources online for ggplot2 help.

Lets make them first GDP per capital, and then TFP

```
pwt = select(pwt10.0, 'year','country','rgdpna', 'rnna', 'emp','pop', 'hc')

pwt_short = drop_na(filter(pwt,year>1958))

df <- drop_na(pwt_short %>% mutate(y = rgdpna/emp, k = rnna/emp,
y_growth = y/lag(y) -1, log_y = log(y)/100 ,k_growth = ((k/ lag(k))^(1/1))-1, h_growth = ((hc/ lag(hc))

#---------------------------------------------------------------------------

pwt_60 = filter(df,year>=1960 & year < 1970)

pwt_60_plt <- merge(aggregate(pwt_60$log_y, list(pwt_60$country), FUN=first),aggregate(pwt_60$y_growth,

colnames(pwt_60_plt) <- c("Country","initial_value_GDP","avg_GDP_growth")

pwt_60_plt$initial_value_GDP <- pwt_60_plt$initial_value_GDP*100
pwt_60_plt$avg_GDP_growth <- pwt_60_plt$avg_GDP_growth*100

#---------------------------------------------------------------------------

pwt_70 = filter(df,year>=1970 & year < 1980)

pwt_70_plt <- merge(aggregate(pwt_70$log_y, list(pwt_70$country), FUN=first),aggregate(pwt_70$y_growth,

colnames(pwt_70_plt) <- c("Country","initial_value_GDP","avg_GDP_growth")

pwt_70_plt$initial_value_GDP <- pwt_70_plt$initial_value_GDP*100
pwt_70_plt$avg_GDP_growth <- pwt_70_plt$avg_GDP_growth*100

#---------------------------------------------------------------------------
```

```r
pwt_80 = filter(df,year>=1980 & year < 1990)

pwt_80_plt <- merge(aggregate(pwt_80$log_y, list(pwt_80$country), FUN=first),aggregate(pwt_80$y_growth,

colnames(pwt_80_plt) <- c("Country","initial_value_GDP","avg_GDP_growth")

pwt_80_plt$initial_value_GDP <- pwt_80_plt$initial_value_GDP*100
pwt_80_plt$avg_GDP_growth <- pwt_80_plt$avg_GDP_growth*100

#-----------------------------------------------------------------------------

pwt_90= filter(df,year>=1990 & year < 2000)

pwt_90_plt <- merge(aggregate(pwt_90$log_y, list(pwt_90$country), FUN=first),aggregate(pwt_90$y_growth,

colnames(pwt_90_plt) <- c("Country","initial_value_GDP","avg_GDP_growth")

pwt_90_plt$initial_value_GDP <- pwt_90_plt$initial_value_GDP*100
pwt_90_plt$avg_GDP_growth <- pwt_90_plt$avg_GDP_growth*100

#-----------------------------------------------------------------------------

pwt_2000 = filter(df,year>=2000 & year < 2010)

pwt_2000_plt <- merge(aggregate(pwt_2000$log_y, list(pwt_2000$country), FUN=first),aggregate(pwt_2000$y_

colnames(pwt_2000_plt) <- c("Country","initial_value_GDP","avg_GDP_growth")

pwt_2000_plt$initial_value_GDP <- pwt_2000_plt$initial_value_GDP*100
pwt_2000_plt$avg_GDP_growth <- pwt_2000_plt$avg_GDP_growth*100

#-----------------------------------------------------------------------------

#no need for an upper bound of this
pwt_2010 = filter(df,year>=2010)

pwt_2010_plt <- merge(aggregate(pwt_2010$log_y, list(pwt_2010$country), FUN=first),aggregate(pwt_2010$y_

colnames(pwt_2010_plt) <- c("Country","initial_value_GDP","avg_GDP_growth")

pwt_2010_plt$initial_value_GDP <- pwt_2010_plt$initial_value_GDP*100
pwt_2010_plt$avg_GDP_growth <- pwt_2010_plt$avg_GDP_growth*100

#-----------------------------------------------------------------------------

head(pwt_60,10)
```

```
##          year   country   rgdpna      rnna      emp      pop       hc        y
## ARG-1960 1960 Argentina 270190.9  664212.9 7.642992 20.54567 1.953866 35351.46
## ARG-1961 1961 Argentina 278983.0  714515.6 7.739992 20.87911 1.964928 36044.35
## ARG-1962 1962 Argentina 280767.9  752595.4 7.838223 21.21117 1.976053 35820.35
## ARG-1963 1963 Argentina 270458.1  774720.6 7.937701 21.54266 1.987240 34072.60
## ARG-1964 1964 Argentina 291478.7  812756.6 8.038442 21.87436 1.998491 36260.60
```

```
## ARG-1965 1965 Argentina 318291.7  851048.2 8.140460 22.20708 2.009806 39099.96
## ARG-1966 1966 Argentina 319042.9  883975.8 8.240280 22.53446 2.022713 38717.48
## ARG-1967 1967 Argentina 327935.4  918022.8 8.341325 22.85598 2.035703 39314.55
## ARG-1968 1968 Argentina 344874.7  957268.6 8.443606 23.18116 2.048777 40844.47
## ARG-1969 1969 Argentina 376485.5 1013607.0 8.547144 23.51951 2.061934 44048.10
##                  k     y_growth     log_y   k_growth    h_growth   TFP_growth
## ARG-1960  86904.82  0.093897463 0.1047310 0.06376475 0.006779240  0.068123052
## ARG-1961  92314.77  0.019599936 0.1049251 0.06225134 0.005661610 -0.004924918
## ARG-1962  96016.07 -0.006214511 0.1048627 0.04009434 0.005661648 -0.023353722
## ARG-1963  97600.12 -0.048792071 0.1043625 0.01649785 0.005661687 -0.058065813
## ARG-1964 101108.72  0.064215801 0.1049849 0.03594870 0.005661667  0.048458456
## ARG-1965 104545.47  0.078304255 0.1057388 0.03399058 0.005661645  0.063199631
## ARG-1966 107274.96 -0.009782017 0.1056405 0.02610823 0.006422145 -0.022766190
## ARG-1967 110057.20  0.015421045 0.1057935 0.02593552 0.006422065  0.002494495
## ARG-1968 113372.01  0.038915021 0.1061753 0.03011902 0.006422077  0.024593963
## ARG-1969 118590.14  0.078434814 0.1069304 0.04602662 0.006422060  0.058811233
```

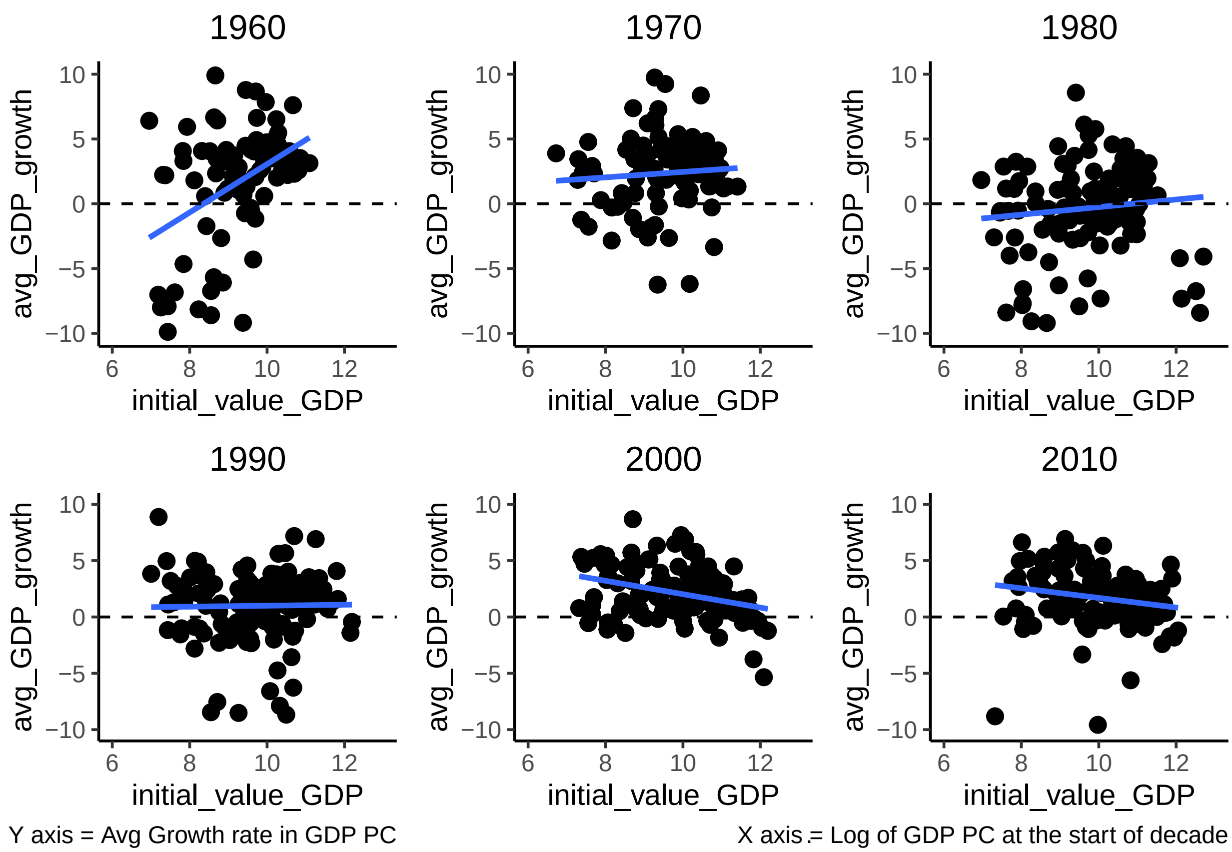
```r
library(ggplot2)

# Scatter plot
sp <- ggplot(pwt_60_plt, aes(x = initial_value_GDP, y = avg_GDP_growth))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp2 <- ggplot(pwt_70_plt, aes(x = initial_value_GDP, y = avg_GDP_growth))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp3 <- ggplot(pwt_80_plt, aes(x = initial_value_GDP, y = avg_GDP_growth))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp4 <- ggplot(pwt_90_plt, aes(x = initial_value_GDP, y = avg_GDP_growth))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp5 <- ggplot(pwt_2000_plt, aes(x = initial_value_GDP, y = avg_GDP_growth))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp6 <- ggplot(pwt_2010_plt, aes(x = initial_value_GDP, y = avg_GDP_growth))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

print("Absolute convergence by decade?")
```

```
## [1] "Absolute convergence by decade?"
```

```r
plot_grid(sp, sp2,sp3,sp4,sp5,sp6, labels=c("","","","","",""), ncol = 3, nrow = 2)
```

```
## Warning: Removed 6 rows containing non-finite values (‘stat_smooth()‘).

## Warning: Removed 6 rows containing missing values (‘geom_point()‘).

## Warning: Removed 11 rows containing non-finite values (‘stat_smooth()‘).

## Warning: Removed 11 rows containing missing values (‘geom_point()‘).
```

```
## Warning: Removed 5 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 5 rows containing missing values (`geom_point()`).

## Warning: Removed 4 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 4 rows containing missing values (`geom_point()`).

## Warning: Removed 2 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 2 rows containing missing values (`geom_point()`).
```



Now TFP ————————————————————————————————

first, calculate TFP. We already have TFP growth but not TFP in order to take logs

We will say that in per capital levels, TFP =

y = A time K to the power of alpha times h to the power of 1 - alpha

A = Y / (K to the power of alpha times h to the power of 1 - alpha)

```
pwt = select(pwt10.0, 'year','country','rgdpna', 'rnna', 'emp','pop', 'hc')

pwt_short = drop_na(filter(pwt,year>1958))
```

```r
df <- drop_na(pwt_short %>% mutate(y = rgdpna/emp, k = rnna/emp,
y_growth = ((y/ lag(y))^(1/1))-1, k_growth = ((k/ lag(k))^(1/1))-1, TFP = y/(k^(1/3)*hc^(2/3)),log_TFP =

head(df,10)
```

```
##           year country   rgdpna     rnna      emp      pop       hc        y
## AGO-1971 1971  Angola 57454.12 314195.1 3.742484 6.040777 1.018196 15351.87
## AGO-1972 1972  Angola 57569.04 332435.8 3.853271 6.248552 1.020712 14940.30
## AGO-1973 1973  Angola 62232.13 352647.9 3.987807 6.496962 1.023234 15605.60
## AGO-1974 1974  Angola 64161.32 373267.7 4.130696 6.761380 1.025762 15532.81
## AGO-1975 1975  Angola 60953.26 391161.9 4.270974 7.024000 1.028297 14271.51
## AGO-1976 1976  Angola 57783.69 406898.4 4.405441 7.279509 1.030838 13116.44
## AGO-1977 1977  Angola 58245.95 423176.3 4.537667 7.533735 1.033385 12836.10
## AGO-1978 1978  Angola 55158.92 437047.6 4.670081 7.790707 1.035939 11811.13
## AGO-1979 1979  Angola 55324.40 450429.5 4.807217 8.058067 1.038498 11508.61
## AGO-1980 1980  Angola 56652.18 462300.9 4.952234 8.341289 1.041064 11439.72
##                 k     y_growth     k_growth      TFP    log_TFP testing_growth
## AGO-1971 83953.62  0.038395738  0.041533299 346.4128 0.05847631    0.022721245
## AGO-1972 86273.66 -0.026808859  0.027634759 333.5272 0.05809725   -0.037197180
## AGO-1973 88431.55  0.044530496  0.025012098 344.9543 0.05843412    0.034261203
## AGO-1974 90364.35 -0.004664416  0.021856514 340.3193 0.05829884   -0.013436583
## AGO-1975 91586.10 -0.081202245  0.013520283 310.7762 0.05739073   -0.086809804
## AGO-1976 92362.69 -0.080935685  0.008479350 284.3523 0.05650214   -0.085025448
## AGO-1977 93258.57 -0.021372928  0.009699518 276.9249 0.05623747   -0.026120376
## AGO-1978 93584.58 -0.079850904  0.003495833 254.0976 0.05537718   -0.082431542
## AGO-1979 93698.60 -0.025612523  0.001218334 247.0822 0.05509721   -0.027609091
## AGO-1980 93351.98 -0.005986078 -0.003699305 245.5025 0.05503307   -0.006393435
##             h_growth  TFP_growth
## AGO-1971 0.002471072  0.02290392
## AGO-1972 0.002470952 -0.03766775
## AGO-1973 0.002471051  0.03454576
## AGO-1974 0.002471018 -0.01359727
## AGO-1975 0.002470970 -0.08735632
## AGO-1976 0.002471024 -0.08540948
## AGO-1977 0.002471062 -0.02625348
## AGO-1978 0.002470970 -0.08266349
## AGO-1979 0.002470978 -0.02766595
## AGO-1980 0.002470971 -0.00640029
```

Ok so testing_growth is very similar to TFP_growth, so our TFP measurement is accurate, and we can take logs of it to plot it as we did with GDP.

```r
pwt = select(pwt10.0, 'year','country','rgdpna', 'rnna', 'emp','pop', 'hc')

pwt_short = drop_na(filter(pwt,year>1958))

df <- drop_na(pwt_short %>% mutate(y = rgdpna/emp, k = rnna/emp,
y_growth = ((y/ lag(y))^(1/1))-1, k_growth = ((k/ lag(k))^(1/1))-1, TFP = y/(k^(1/3)*hc^(2/3)),log_TFP =

#---------------------------------------------------------------------------

pwt_60 = filter(df,year>=1960 & year < 1970)
```

```
pwt_60_plt <- merge(aggregate(pwt_60$log_TFP, list(pwt_60$country), FUN=first),aggregate(pwt_60$TFP_grow

colnames(pwt_60_plt) <- c("Country","initial_value_TFP","average_value_TFP")

pwt_60_plt$initial_value_TFP <- pwt_60_plt$initial_value_TFP*100
pwt_60_plt$average_value_TFP <- pwt_60_plt$average_value_TFP*100

#---------------------------------------------------------------------------

pwt_70 = filter(df,year>=1970 & year < 1980)

pwt_70_plt <- merge(aggregate(pwt_70$log_TFP, list(pwt_70$country), FUN=first),aggregate(pwt_70$TFP_grow

colnames(pwt_70_plt) <- c("Country","initial_value_TFP","average_value_TFP")

pwt_70_plt$initial_value_TFP <- pwt_70_plt$initial_value_TFP*100
pwt_70_plt$average_value_TFP <- pwt_70_plt$average_value_TFP*100

#---------------------------------------------------------------------------

pwt_80 = filter(df,year>=1980 & year < 1990)

pwt_80_plt <- merge(aggregate(pwt_80$log_TFP, list(pwt_80$country), FUN=first),aggregate(pwt_80$TFP_grow

colnames(pwt_80_plt) <- c("Country","initial_value_TFP","average_value_TFP")

pwt_80_plt$initial_value_TFP <- pwt_80_plt$initial_value_TFP*100
pwt_80_plt$average_value_TFP <- pwt_80_plt$average_value_TFP*100

#---------------------------------------------------------------------------

pwt_90= filter(df,year>=1990 & year < 2000)

pwt_90_plt <- merge(aggregate(pwt_90$log_TFP, list(pwt_90$country), FUN=first),aggregate(pwt_90$TFP_grow

colnames(pwt_90_plt) <- c("Country","initial_value_TFP","average_value_TFP")

pwt_90_plt$initial_value_TFP <- pwt_90_plt$initial_value_TFP*100
pwt_90_plt$average_value_TFP <- pwt_90_plt$average_value_TFP*100

#---------------------------------------------------------------------------

pwt_2000 = filter(df,year>=2000 & year < 2010)

pwt_2000_plt <- merge(aggregate(pwt_2000$log_TFP, list(pwt_2000$country), FUN=first),aggregate(pwt_2000$

colnames(pwt_2000_plt) <- c("Country","initial_value_TFP","average_value_TFP")

pwt_2000_plt$initial_value_TFP <- pwt_2000_plt$initial_value_TFP*100
pwt_2000_plt$average_value_TFP <- pwt_2000_plt$average_value_TFP*100

#---------------------------------------------------------------------------
```

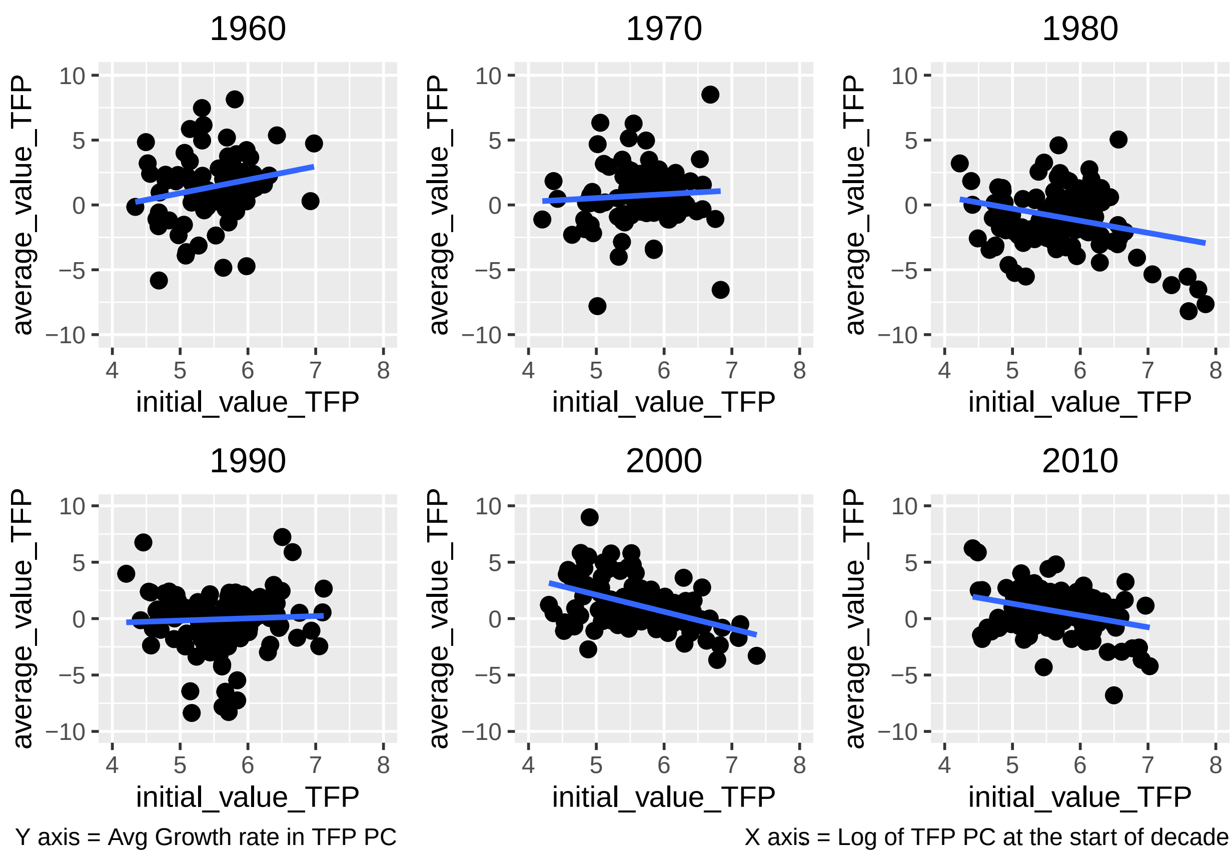
```r
#no need for an upper bound of this
pwt_2010 = filter(df,year>=2010)

pwt_2010_plt <- merge(aggregate(pwt_2010$log_TFP, list(pwt_2010$country), FUN=first),aggregate(pwt_2010$

colnames(pwt_2010_plt) <- c("Country","initial_value_TFP","average_value_TFP")

pwt_2010_plt$initial_value_TFP <- pwt_2010_plt$initial_value_TFP*100
pwt_2010_plt$average_value_TFP <- pwt_2010_plt$average_value_TFP*100

#---------------------------------------------------------------------------

head(pwt_60,10)
```

```
##          year   country   rgdpna      rnna      emp      pop       hc        y
## ARG-1960 1960 Argentina 270190.9  664212.9 7.642992 20.54567 1.953866 35351.46
## ARG-1961 1961 Argentina 278983.0  714515.6 7.739992 20.87911 1.964928 36044.35
## ARG-1962 1962 Argentina 280767.9  752595.4 7.838223 21.21117 1.976053 35820.35
## ARG-1963 1963 Argentina 270458.1  774720.6 7.937701 21.54266 1.987240 34072.60
## ARG-1964 1964 Argentina 291478.7  812756.6 8.038442 21.87436 1.998491 36260.60
## ARG-1965 1965 Argentina 318291.7  851048.2 8.140460 22.20708 2.009806 39099.96
## ARG-1966 1966 Argentina 319042.9  883975.8 8.240280 22.53446 2.022713 38717.48
## ARG-1967 1967 Argentina 327935.4  918022.8 8.341325 22.85598 2.035703 39314.55
## ARG-1968 1968 Argentina 344874.7  957268.6 8.443606 23.18116 2.048777 40844.47
## ARG-1969 1969 Argentina 376485.5 1013607.0 8.547144 23.51951 2.061934 44048.10
##                  k     y_growth   k_growth      TFP    log_TFP testing_growth
## ARG-1960  86904.82  0.093897463 0.06376475 510.6574 0.06235699    0.066772755
## ARG-1961  92314.77  0.019599936 0.06225134 508.3729 0.06231215   -0.004473583
## ARG-1962  96016.07 -0.006214511 0.04009434 496.7633 0.06208114   -0.022836698
## ARG-1963  97600.12 -0.048792071 0.01649785 468.1894 0.06148873   -0.057520231
## ARG-1964 101108.72  0.064215801 0.03594870 490.5733 0.06195575    0.047809557
## ARG-1965 104545.47  0.078304255 0.03399058 521.1609 0.06256059    0.062350598
## ARG-1966 107274.96 -0.009782017 0.02610823 509.4694 0.06233370   -0.022433532
## ARG-1967 110057.20  0.015421045 0.02593552 510.7450 0.06235870    0.002503825
## ARG-1968 113372.01  0.038915021 0.03011902 523.1605 0.06259888    0.024308525
## ARG-1969 118590.14  0.078434814 0.04602662 553.4280 0.06316132    0.057855191
##             h_growth   TFP_growth
## ARG-1960 0.006779240  0.068123052
## ARG-1961 0.005661610 -0.004924918
## ARG-1962 0.005661648 -0.023353722
## ARG-1963 0.005661687 -0.058065813
## ARG-1964 0.005661667  0.048458456
## ARG-1965 0.005661645  0.063199631
## ARG-1966 0.006422145 -0.022766190
## ARG-1967 0.006422065  0.002494495
## ARG-1968 0.006422077  0.024593963
## ARG-1969 0.006422060  0.058811233
```

```r
library(ggplot2)

# Scatter plot
sp <- ggplot(pwt_60_plt, aes(x = initial_value_TFP, y = average_value_TFP))+
  geom_point(size=2.5) + xlim(4,8) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE) +
```

```
sp2 <- ggplot(pwt_70_plt, aes(x = initial_value_TFP, y = average_value_TFP))+
  geom_point(size=2.5) + xlim(4,8) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE) +

sp3 <- ggplot(pwt_80_plt, aes(x = initial_value_TFP, y = average_value_TFP))+
  geom_point(size=2.5) + xlim(4,8) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE) +

sp4 <- ggplot(pwt_90_plt, aes(x = initial_value_TFP, y = average_value_TFP))+
  geom_point(size=2.5) + xlim(4,8) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE) +

sp5 <- ggplot(pwt_2000_plt, aes(x = initial_value_TFP, y = average_value_TFP))+
  geom_point(size=2.5) + xlim(4,8) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE) +

sp6 <- ggplot(pwt_2010_plt, aes(x = initial_value_TFP, y = average_value_TFP))+
  geom_point(size=2.5) + xlim(4,8) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE) +


plot_grid(sp, sp2,sp3,sp4,sp5,sp6, labels=c("","","","","",""), ncol = 3, nrow = 2)
```

```
## Warning: Removed 3 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 3 rows containing missing values (`geom_point()`).

## Warning: Removed 9 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 9 rows containing missing values (`geom_point()`).

## Warning: Removed 3 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 3 rows containing missing values (`geom_point()`).

## Warning: Removed 5 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 5 rows containing missing values (`geom_point()`).

## Warning: Removed 2 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 2 rows containing missing values (`geom_point()`).

## Warning: Removed 2 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 2 rows containing missing values (`geom_point()`).
```



Same movement occurring!

9. As we discussed in class, there are many different sources for per capita gdp. Another source of data is the World Development Indicators, also called the WDI. Plot the an equivalent of the decade-by-decade convergence pictures from the question above, but now for real gdp per capita from the WDI. Hopefully this is pretty easy, since your code should be straightforward to adapt to a new dataset. You should read question 11 before doing this question, since it will be more efficient to download more than out outcome at once.

Lets first look at what we want

```r
#WDIsearch('gdp.*capita.*constant')


#install.packages('WDI')
library(WDI)
```

```
## Warning: package 'WDI' was built under R version 4.2.2
```

```r
#WDIsearch('gdp.*capita')

data = WDI(
  country = "all",
  indicator = "NY.GDP.PCAP.KD",
  extra = FALSE,
```

```r
  cache = NULL,
  latest = NULL,
  language = "en")
head(data,10)
```

```
##                        country iso2c iso3c year NY.GDP.PCAP.KD
## 1  Africa Eastern and Southern    ZH   AFE 2021       1460.918
## 2  Africa Eastern and Southern    ZH   AFE 2020       1437.302
## 3  Africa Eastern and Southern    ZH   AFE 2019       1519.880
## 4  Africa Eastern and Southern    ZH   AFE 2018       1529.002
## 5  Africa Eastern and Southern    ZH   AFE 2017       1531.651
## 6  Africa Eastern and Southern    ZH   AFE 2016       1533.289
## 7  Africa Eastern and Southern    ZH   AFE 2015       1540.850
## 8  Africa Eastern and Southern    ZH   AFE 2014       1538.249
## 9  Africa Eastern and Southern    ZH   AFE 2013       1520.267
## 10 Africa Eastern and Southern    ZH   AFE 2012       1499.245
```

```r
#install.packages('WDI')
library(WDI)

#WDIsearch('gdp')

data = WDI(
  country = "all",
  indicator = "NY.GDP.PCAP.KD",
  start = 1960,
  end = 2020,
  extra = FALSE,
  language = "en")

#NY.GDP.PCAP.PP.KD
#NY.GDP.PCAP.KD

df <- drop_na(data %>% mutate(y_growth = ((NY.GDP.PCAP.KD/ lag(NY.GDP.PCAP.KD))^(1/1))-1, log_y = log(N

# calculating reverse
rev_data_frame <- apply(df, 2, rev)

# converting the result to dataframe
df <- as.data.frame(rev_data_frame)

#setting variables as numeric
df <- transform(df,NY.GDP.PCAP.KD= as.numeric(NY.GDP.PCAP.KD))
df <- transform(df,y_growth = as.numeric(y_growth))
df <- transform(df,log_y = as.numeric(log_y))
df <- transform(df,year = as.numeric(year))

df <- subset(df, y_growth<2)


#---------------------------------------------------------------------------

pwt_60 = filter(df,year>=1960 & year < 1970)
```

```
pwt_60_plt <- merge(aggregate(pwt_60$log_y, list(pwt_60$country), FUN=first),aggregate(pwt_60$y_growth,

colnames(pwt_60_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_60_plt$initial_value_GDP <- pwt_60_plt$initial_value_GDP*100
pwt_60_plt$average_value_GDP <- -pwt_60_plt$average_value_GDP*100

#---------------------------------------------------------------------------

pwt_70 = filter(df,year>=1970 & year < 1980)

pwt_70_plt <- merge(aggregate(pwt_70$log_y, list(pwt_70$country), FUN=first),aggregate(pwt_70$y_growth,

colnames(pwt_70_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_70_plt$initial_value_GDP <- pwt_70_plt$initial_value_GDP*100
pwt_70_plt$average_value_GDP <- -pwt_70_plt$average_value_GDP*100

#---------------------------------------------------------------------------

pwt_80 = filter(df,year>=1980 & year < 1990)

pwt_80_plt <- merge(aggregate(pwt_80$log_y, list(pwt_80$country), FUN=first),aggregate(pwt_80$y_growth,

colnames(pwt_80_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_80_plt$initial_value_GDP <- pwt_80_plt$initial_value_GDP*100
pwt_80_plt$average_value_GDP <- -pwt_80_plt$average_value_GDP*100

#---------------------------------------------------------------------------

pwt_90= filter(df,year>=1990 & year < 2000)

pwt_90_plt <- merge(aggregate(pwt_90$log_y, list(pwt_90$country), FUN=first),aggregate(pwt_90$y_growth,

colnames(pwt_90_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_90_plt$initial_value_GDP <- pwt_90_plt$initial_value_GDP*100
pwt_90_plt$average_value_GDP <- -pwt_90_plt$average_value_GDP*100

#---------------------------------------------------------------------------

pwt_2000 = filter(df,year>=2000 & year < 2010)

pwt_2000_plt <- merge(aggregate(pwt_2000$log_y, list(pwt_2000$country), FUN=first),aggregate(pwt_2000$y

colnames(pwt_2000_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_2000_plt$initial_value_GDP <- pwt_2000_plt$initial_value_GDP*100
pwt_2000_plt$average_value_GDP <- -pwt_2000_plt$average_value_GDP*100

#---------------------------------------------------------------------------
```

```r
#no need for an upper bound of this
pwt_2010 = filter(df,year>=2010)

pwt_2010_plt <- merge(aggregate(pwt_2010$log_y, list(pwt_2010$country), FUN=first),aggregate(pwt_2010$y

colnames(pwt_2010_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_2010_plt$initial_value_GDP <- pwt_2010_plt$initial_value_GDP*100
pwt_2010_plt$average_value_GDP <- -pwt_2010_plt$average_value_GDP*100

#-----------------------------------------------------------------------------

head(pwt_60,10)
```

```
##     country iso2c iso3c year NY.GDP.PCAP.KD    y_growth      log_y
## 1  Zimbabwe    ZW   ZWE 1960       1137.391 -0.02984403 0.07036492
## 2  Zimbabwe    ZW   ZWE 1961       1172.379  0.01695249 0.07066790
## 3  Zimbabwe    ZW   ZWE 1962       1152.836 -0.02898883 0.07049980
## 4  Zimbabwe    ZW   ZWE 1963       1187.253  0.04323049 0.07079397
## 5  Zimbabwe    ZW   ZWE 1964       1138.054 -0.01655130 0.07037075
## 6  Zimbabwe    ZW   ZWE 1965       1157.207  0.01631141 0.07053765
## 7  Zimbabwe    ZW   ZWE 1966       1138.635 -0.04781497 0.07037585
## 8  Zimbabwe    ZW   ZWE 1967       1195.812  0.01209061 0.07086581
## 9  Zimbabwe    ZW   ZWE 1968       1181.527 -0.08181665 0.07074563
## 10 Zimbabwe    ZW   ZWE 1969       1286.810 -0.15842880 0.07159921
```

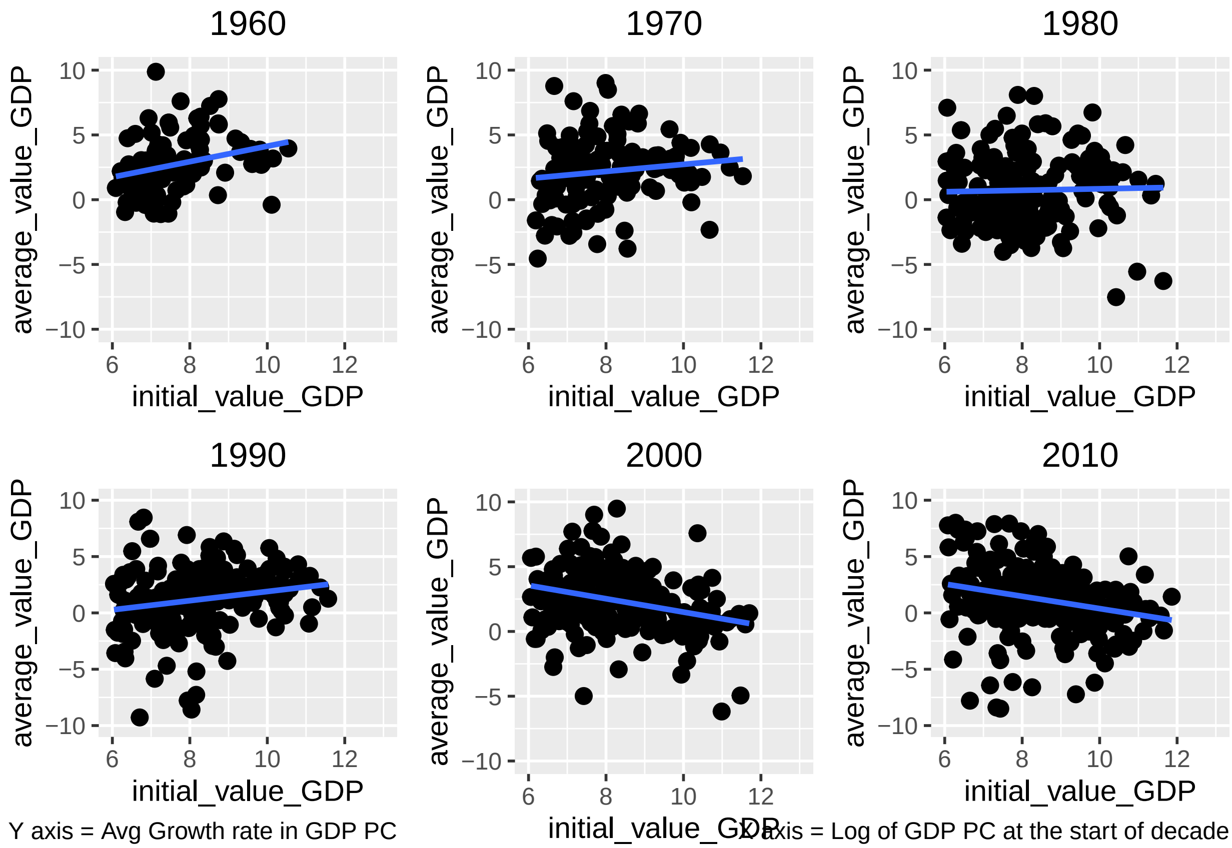
```r
head(pwt_60_plt,10)
```

```
##                         Country initial_value_GDP average_value_GDP
## 1  Africa Eastern and Southern          7.070456         1.7224736
## 2   Africa Western and Central          6.990779         1.7345107
## 3                       Algeria          7.652655         0.7217762
## 4                     Argentina          8.910627         2.0856306
## 5                     Australia          9.900912         2.9180170
## 6                       Austria          9.396915         3.9782302
## 7                  Bahamas, The          9.864463         3.2446582
## 8                    Bangladesh          6.090061         0.9058313
## 9                       Belgium          9.370272         4.1005371
## 10                       Belize          7.351408         2.2081957
```

```r
library(ggplot2)

# Scatter plot
sp <- ggplot(pwt_60_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp2 <- ggplot(pwt_70_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp3 <- ggplot(pwt_80_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)
```

```
sp4 <- ggplot(pwt_90_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp5 <- ggplot(pwt_2000_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp6 <- ggplot(pwt_2010_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)


plot_grid(sp, sp2,sp3,sp4,sp5,sp6, labels=c("","","","","",""), ncol = 3, nrow = 2)
```

```
## Warning: Removed 19 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 19 rows containing missing values (`geom_point()`).

## Warning: Removed 16 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 16 rows containing missing values (`geom_point()`).

## Warning: Removed 13 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 13 rows containing missing values (`geom_point()`).

## Warning: Removed 11 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 11 rows containing missing values (`geom_point()`).

## Warning: Removed 12 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 12 rows containing missing values (`geom_point()`).

## Warning: Removed 14 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 14 rows containing missing values (`geom_point()`).
```



10. There is a very famous view that there is a "middle income trap." Does either dataset suggest that middle income countries are trapped?

Looking for the definition of middle income trap, we have that this concept "captures a situation where a middle-income country can no longer compete internationally in standardized, labor-intensive goods because wages are relatively too high, but it also cannot compete in higher value-added activities on a broad enough scale because productivity is relatively too low"

This is a famous concept in macroeconomics, since we have seen many examples of this: US switching to a service economy, and shipping labor intensive labor to places with lower wages. It is also a big concern, and we are still leaving through such changes. For instance, China 30 years ago had the biggest potential to manufacture goods with low wages, but ever since, we have been seeing wages going up, and China shifting away from being the producer of labor-intensive goods for the world.

In terms of the graphs we are seeing, the middle income trap will fairly connect to a country with a log GDP PC at the beginning of each century around 8 to 9, together with a time-series that shows these middle income cloud of countries going from positive average GDP PC growth rate per decade, to negative ranges. As we can see from both datasets, it looks like the perimeter on negative average GDP PC growth rate per decade above the countries with a log GDP PC at the beginning of each century around 8 to 9 is growing as decades go by. So our graphs slightly show this effect being true.

However, every nation is undergoing different processes, and it could be that the points we are looking as new in that perimeter aren't the same middle income countries from the last decade, but new countries that were poor in the past decade, and are going through an either temporal or perpetual contraction (Venezuela could be a good example of this). So in order to look at this effect better, we will have to isolate data points, and think of what we want to see a little bit more throughout.

11. The WDI has all sorts of interesting indicators about development beyond GDP. Pick one that you think is interesting, the main website is good for exploring which ones exist. Try to pick one that exists for lots of countries and for several decades. Make the convergence plot for this outcome too. What does the pattern look like?

Now using a different real GDP per capital PPP metric: Same x and Y axis from previous analysis

```
#install.packages('WDI')
library(WDI)

#WDIsearch('gdp.*capita')


data = WDI(
  country = "all",
  indicator = "NY.GDP.PCAP.PP.KD",
  extra = FALSE,
  cache = NULL,
  latest = NULL,
  language = "en")
head(data,10)
```

```
##                       country iso2c iso3c year NY.GDP.PCAP.PP.KD
## 1  Africa Eastern and Southern    ZH   AFE 2021          3517.767
## 2  Africa Eastern and Southern    ZH   AFE 2020          3455.516
## 3  Africa Eastern and Southern    ZH   AFE 2019          3648.709
## 4  Africa Eastern and Southern    ZH   AFE 2018          3661.769
## 5  Africa Eastern and Southern    ZH   AFE 2017          3659.361
## 6  Africa Eastern and Southern    ZH   AFE 2016          3654.774
## 7  Africa Eastern and Southern    ZH   AFE 2015          3658.719
## 8  Africa Eastern and Southern    ZH   AFE 2014          3643.014
## 9  Africa Eastern and Southern    ZH   AFE 2013          3593.397
## 10 Africa Eastern and Southern    ZH   AFE 2012          3543.829
```

```
df <- drop_na(data %>% mutate(y_growth = ((NY.GDP.PCAP.PP.KD
/ lag(NY.GDP.PCAP.PP.KD))^(1/1))-1, log_y = log(NY.GDP.PCAP.PP.KD)/100))

# calculating reverse
rev_data_frame <- apply(df, 2, rev)

# converting the result to dataframe
df <- as.data.frame(rev_data_frame)

#setting variables as numeric
df <- transform(df,NY.GDP.PCAP.PP.KD= as.numeric(NY.GDP.PCAP.PP.KD))
df <- transform(df,y_growth = as.numeric(y_growth))
df <- transform(df,log_y = as.numeric(log_y))
df <- transform(df,year = as.numeric(year))

#---------------------------------------------------------------------------

pwt_90= filter(df,year>=1990 & year < 2000)
```

```r
pwt_90_plt <- merge(aggregate(pwt_90$log_y, list(pwt_90$country), FUN=first),aggregate(pwt_90$y_growth,

colnames(pwt_90_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_90_plt$initial_value_GDP <- pwt_90_plt$initial_value_GDP*100
pwt_90_plt$average_value_GDP <- -pwt_90_plt$average_value_GDP*100

#---------------------------------------------------------------------------

pwt_2000 = filter(df,year>=2000 & year < 2010)

pwt_2000_plt <- merge(aggregate(pwt_2000$log_y, list(pwt_2000$country), FUN=first),aggregate(pwt_2000$y

colnames(pwt_2000_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_2000_plt$initial_value_GDP <- pwt_2000_plt$initial_value_GDP*100
pwt_2000_plt$average_value_GDP <- -pwt_2000_plt$average_value_GDP*100

#---------------------------------------------------------------------------

#no need for an upper bound of this
pwt_2010 = filter(df,year>=2010)

pwt_2010_plt <- merge(aggregate(pwt_2010$log_y, list(pwt_2010$country), FUN=first),aggregate(pwt_2010$y

colnames(pwt_2010_plt) <- c("Country","initial_value_GDP","average_value_GDP")

pwt_2010_plt$initial_value_GDP <- pwt_2010_plt$initial_value_GDP*100
pwt_2010_plt$average_value_GDP <- -pwt_2010_plt$average_value_GDP*100

#---------------------------------------------------------------------------

head(pwt_2000,10)
```

```
##     country iso2c iso3c year NY.GDP.PCAP.PP.KD     y_growth      log_y
## 1  Zimbabwe    ZW   ZWE 2000          2750.601 -0.007836021 0.07919575
## 2  Zimbabwe    ZW   ZWE 2001          2772.325  0.104411300 0.07927442
## 3  Zimbabwe    ZW   ZWE 2002          2510.229  0.213914000 0.07828129
## 4  Zimbabwe    ZW   ZWE 2003          2067.880  0.069133580 0.07634279
## 5  Zimbabwe    ZW   ZWE 2004          1934.165  0.066140420 0.07567431
## 6  Zimbabwe    ZW   ZWE 2005          1814.174  0.044815660 0.07503386
## 7  Zimbabwe    ZW   ZWE 2006          1736.358  0.048026120 0.07459545
## 8  Zimbabwe    ZW   ZWE 2007          1656.789  0.224342400 0.07412637
## 9  Zimbabwe    ZW   ZWE 2008          1353.207 -0.098090110 0.07210233
## 10 Zimbabwe    ZW   ZWE 2009          1500.380 -0.166242700 0.07313474
```

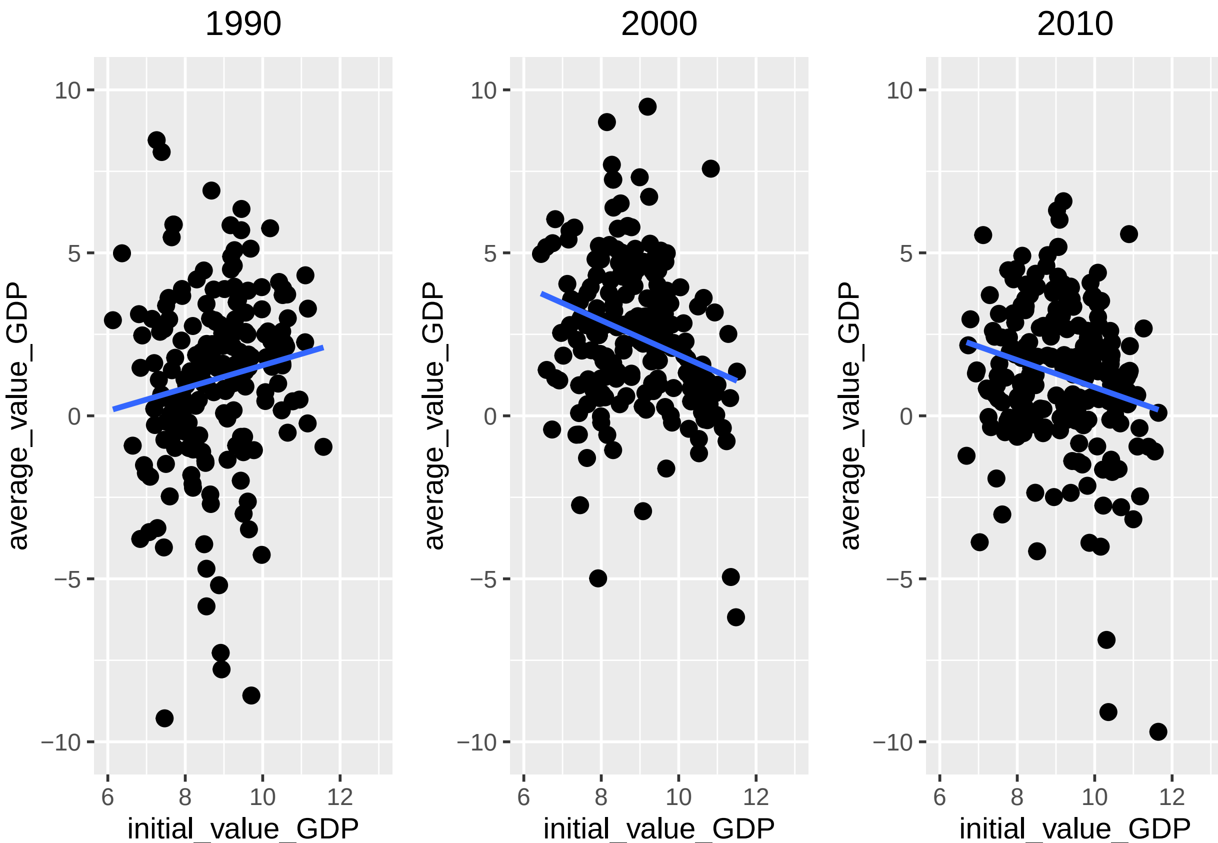
```r
head(pwt_2000_plt,10)
```

```
##                        Country initial_value_GDP average_value_GDP
## 1                  Afghanistan          7.154977         5.4082359
## 2  Africa Eastern and Southern          7.971145         1.8990203
## 3   Africa Western and Central          7.888571         3.3003822
```

```
## 4                      Albania          8.681631         5.8240630
## 5                      Algeria          9.080936         2.2128358
## 6                       Angola          8.457095         4.6897564
## 7          Antigua and Barbuda          9.828005        -0.2073465
## 8                   Arab World          9.296706         1.6682639
## 9                    Argentina          9.826866         2.0832217
## 10                     Armenia          8.274321         7.7017911
```

```
library(ggplot2)


sp4 <- ggplot(pwt_90_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp5 <- ggplot(pwt_2000_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)

sp6 <- ggplot(pwt_2010_plt, aes(x = initial_value_GDP, y = average_value_GDP))+
  geom_point(size=2.5) + xlim(6,13) + ylim(-10,10) + geom_smooth(method='lm', formula= y~x, se = FALSE)


plot_grid(sp4,sp5,sp6, labels=c("","",""), ncol = 3, nrow = 1)
```

```
## Warning: Removed 4 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 4 rows containing missing values (`geom_point()`).

## Warning: Removed 2 rows containing non-finite values (`stat_smooth()`).

## Warning: Removed 2 rows containing missing values (`geom_point()`).
```



Convergence looks roughly the same