

Mini Project 1: Convergence

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Executive Summary:

In this project, we aim to study two different sets of countries. The countries are separated into two groups, namely richer countries and poorer countries based on GDP per capita. We study the trend of change in GDP over 60 years from 1960 till 2020. The idea of convergence in economics (catch-up effect) is the hypothesis that poorer economies' per capita incomes will tend to grow at faster rates than the richer economies. The main question here is, has there been a convergence in GDP capita since 1960? If so, when, and where did this convergence happen. This question is tricky and needs to be answered in simple boiled down parts, which can be assessed independently to get various conclusions.

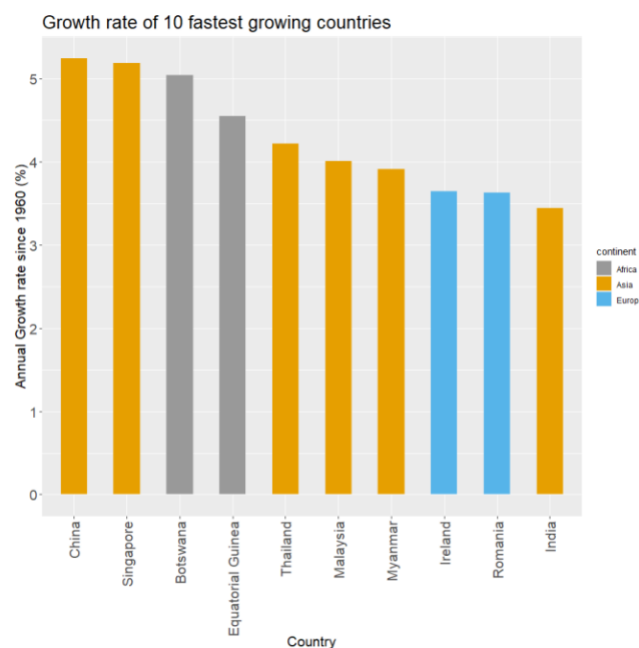
We found that most of the fastest-growing countries belonged to the Asian continent. Despite that, Asia remained one of the most impoverished continents, coming next to Africa. After the year 2000, we found that the overall GDP growth rate of Asia overall was the highest, and it managed to reduce the GDP gap between itself and the richer continents notably. Africa remained the poorest continent, with most of the least fast-growing countries also belonging to Africa. Also, there were no signs of convergence, and the GDP per capita gap kept on increasing as we traversed further through the years. European countries managed to display convergence for each period from 1960 to 1980, 1980 to 2000, and 2000 to 2020. There are subtle signs of convergence for the countries in the Americas. Although the poorer countries did not manage to catch up with the richer countries fully, they managed to reduce the disparity.

Data:

To test the above hypothesis, we worked on the data for Income per person (GDP/capita, PPP\$ inflation-adjusted) in the 'gapminder' dataset. This data coupled with the population of each country, gave us the total GDP for each country for each year. Additionally, we have studied these trends for each continent by leveraging the weighted sum of GDP for each country.

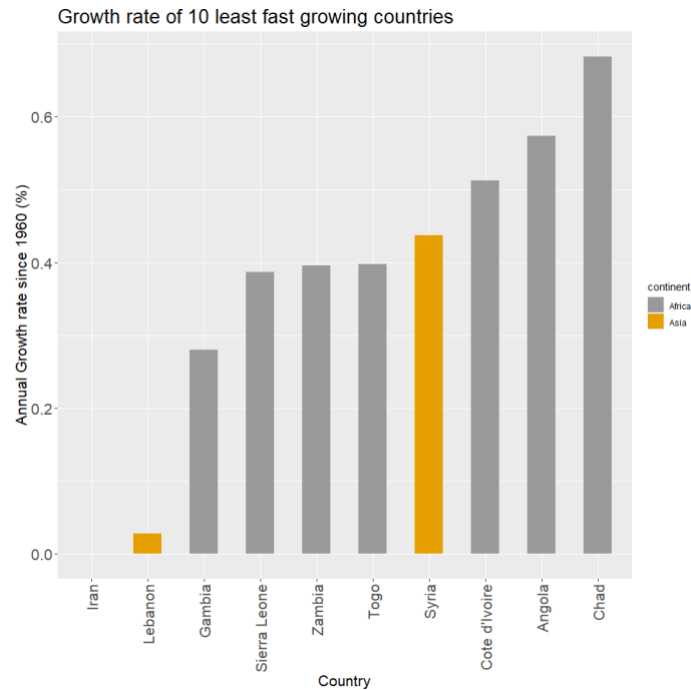
Q.1) What countries have grown the most and least since 1960?

Fastest growing countries vs Growth rate since 1960:



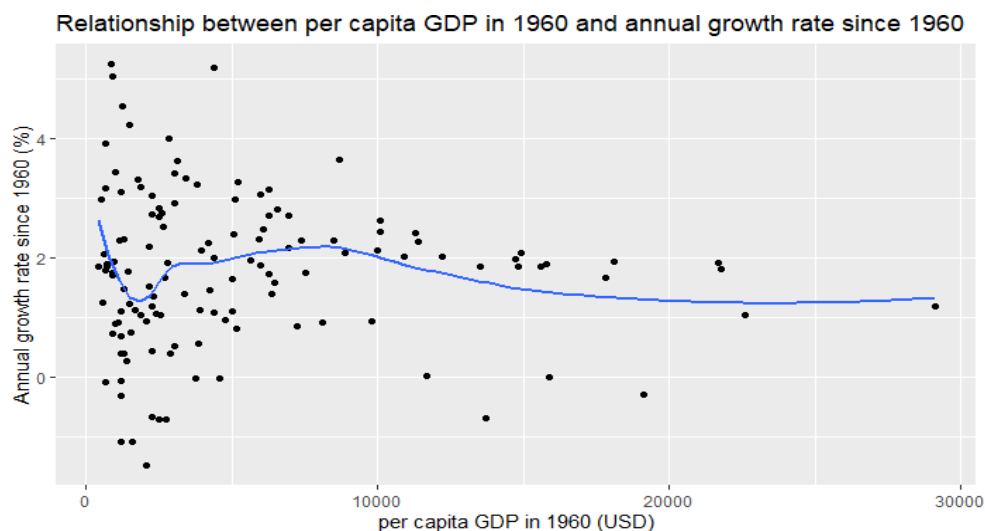
From the graph, we can observe that among the ten fastest-growing countries, China has the highest growth rate, while India has the least growth rate. The most important thing to note is that, out of the ten fastest-growing countries, most of them, i.e., six countries, belong to continent Asia.

Least fast-growing countries vs. Growth Rate since 1960:



The term least fast-growing countries pertains to those countries which have grown over the years from 1960 to 2020 with the lowest growth rate amongst all the countries. The growth rate should be non-negative to be considered growing, as a negative growth rate would indicate a shrinking economy. The above bar graph clearly shows that the growth rate of Iran is approximately zero suggesting that the GDP per capita for Iran in 2020 is the same as it was in 1960. However, out of the ten fastest-growing countries, almost all of them, i.e., around seven countries, belongs to the African continent.

Q. 2) In general, has there been convergence since 1960?

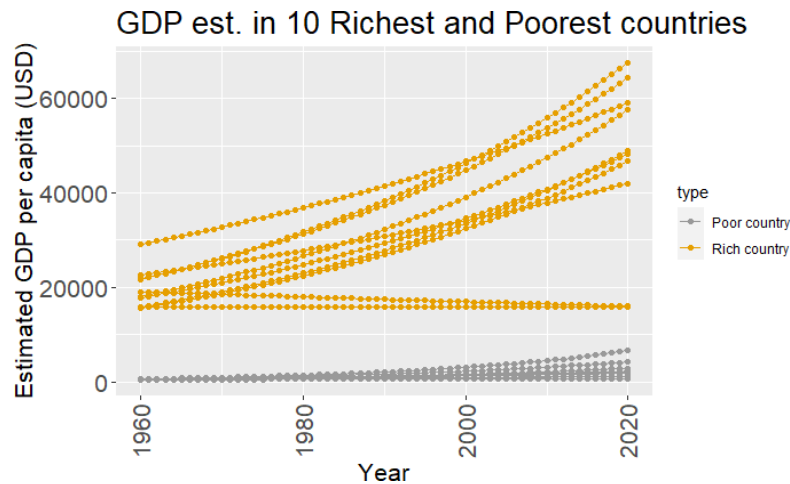


In this case, we have used a Loess model to fit the data. This is a non-parametric regression method that combines multiple regression models. Loess combines linear least squares regression with the nonlinear regression by fitting simple linear models to the local subset of the data, which eventually describes the deterministic section of the variations in the data for each data point. We have used Loess to fit our data as it is useful in situations in which the classical models such as 'lm' do not perform well or cannot be effectively applied.

The distribution is somewhat similar to a Normal distribution if we view it with Y-axis as the base. Most countries are concentrated on the left side of the graph. This means that the majority of them are poor countries. As we move towards the right in the X-axis, we can see that the loess line tends to shift slightly downwards. This shows that rich countries have lower growth rates than poor countries.

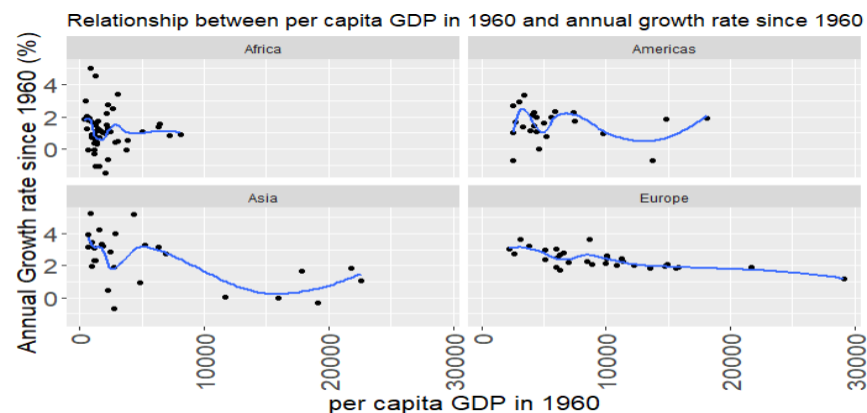
Rich and Poor countries' GDP per capita of the world:

To determine whether a country is rich or poor, we compare a country's GDP per capita with other countries' GDP per capita as considering only the GDP of a country would negatively affect countries with small population size. We selected the top 10 countries as the rich countries and the bottom 10 countries as the poor countries when ordered by GDP per capita.



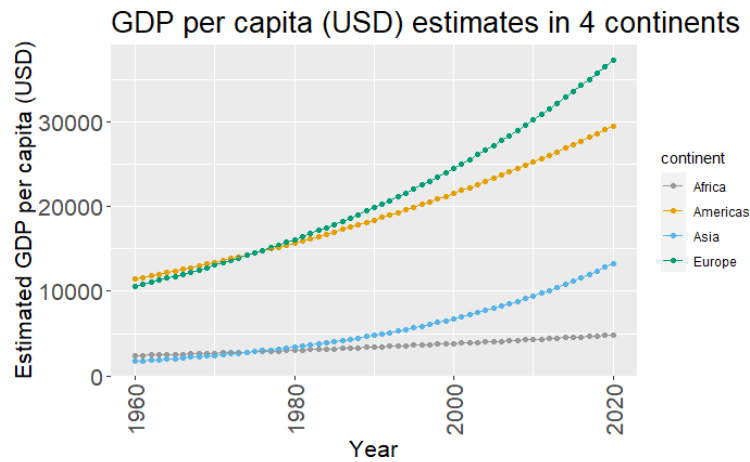
The above graph shows the change in GDP per capita of the 10 richest and the 10 poorest countries over 60 years. Although 2 rich countries have an eccentric trend, where the GDP has shrunk over time and made the gap narrower, poorer countries' GDP per capita fails to converge with richer countries' GDP as we can see that the gap between them grows over time.

Relationship between per capita GDP 1960-2020 and annual growth rate 1960-2020:



The faceted plot shows the relationship between per capita GDP in 1960 and the annual growth rate from 1960 to 2020 for the four continents, respectively.

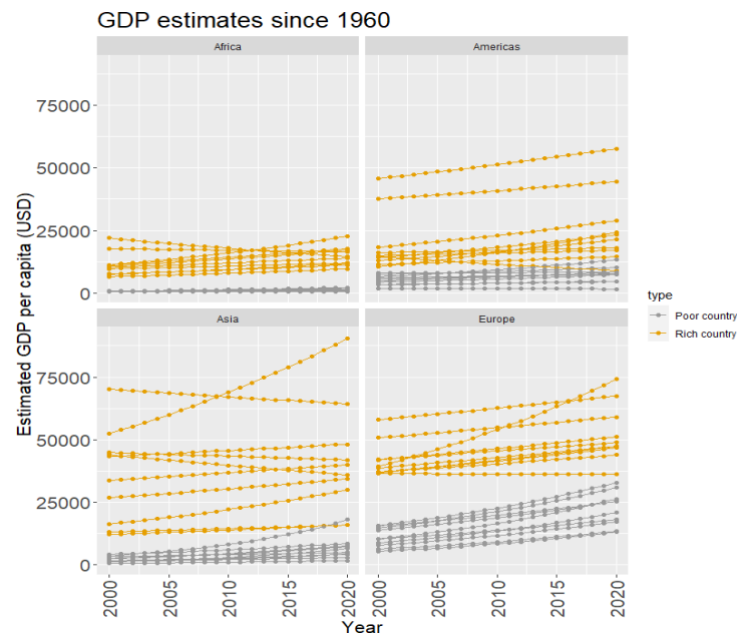
GDP per capita for continents:



To calculate the GDP per capita of a continent, we first calculated the GDP of each country in that continent by multiplying the population data and the GDP per capita of that country. The sum of the individual GDP of each country was then divided by the entire population of that continent. So, the GDP per capita of a continent is the weighted GDP of countries. We cannot observe convergence in this scenario also.

GDP estimates for rich & poor countries in each continent:

By splitting the dataset into continents, we micro-analyzed the data for 40 countries. Each continent's visualization of the change in GDP per capita of the top 10 richest and the top 10 poorest countries over 60 years is shown below.



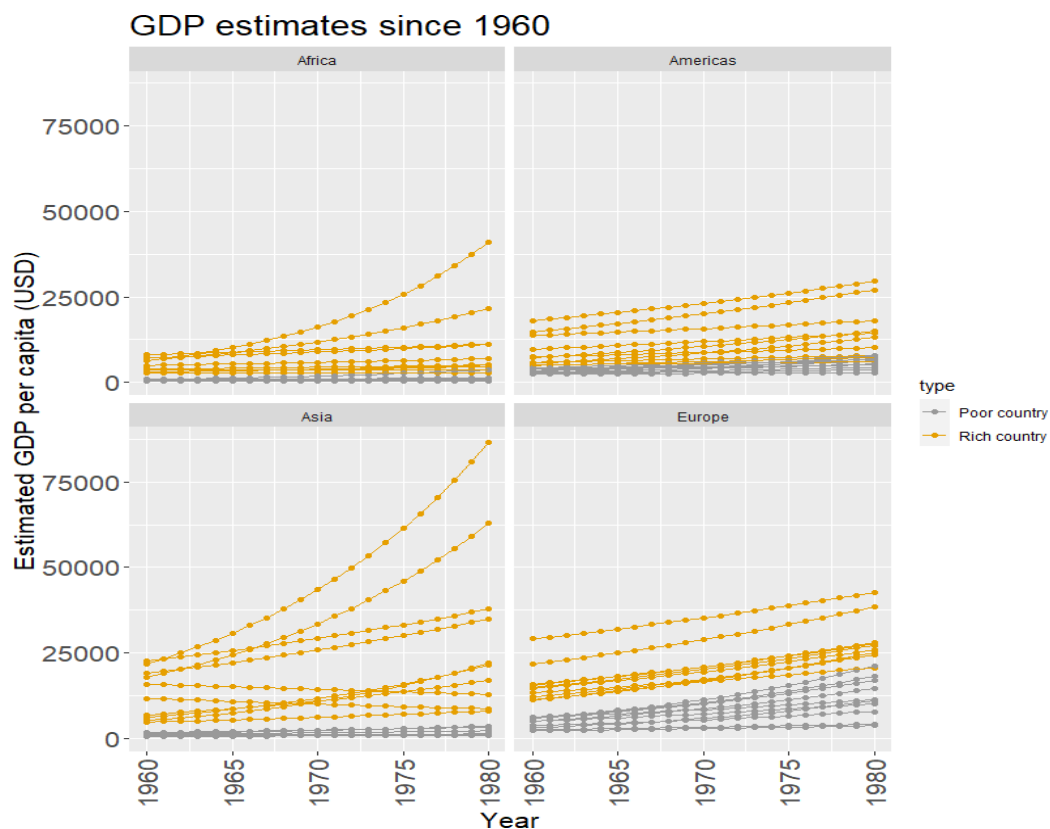
We can observe that there are signs of convergence in the European and the American continent. In the Asian continent, richer countries have either minimal growth rates or negative growth rates, and poorer countries have slightly positive growth rates. This means that the gap has reduced, but owing to a minimal change over 60

years, nothing can be said with certainty. The African continent shows no signs of convergence because the gap has indeed increased.

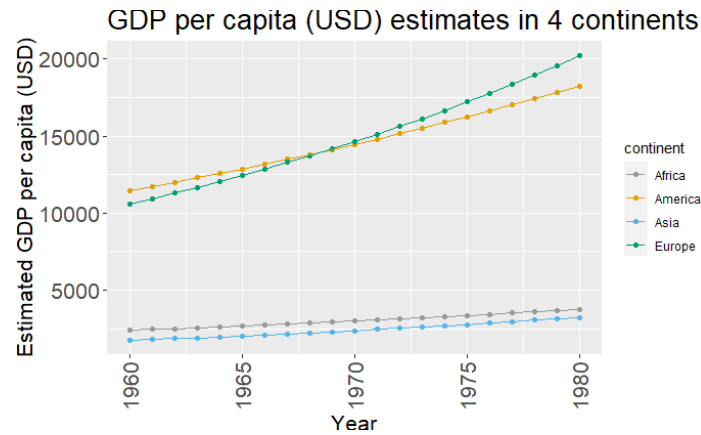
3. Has the pattern been different in different periods?

The overall trend for the years 1960 to 2020 did not give a clear picture of convergence. So, we decided to divide the time variable into three periods: 1960 to 1980, 1980 to 2000, and 2000 to 2020 (present). We repeated the same process that we did in the second part for the three periods.

1960-1980

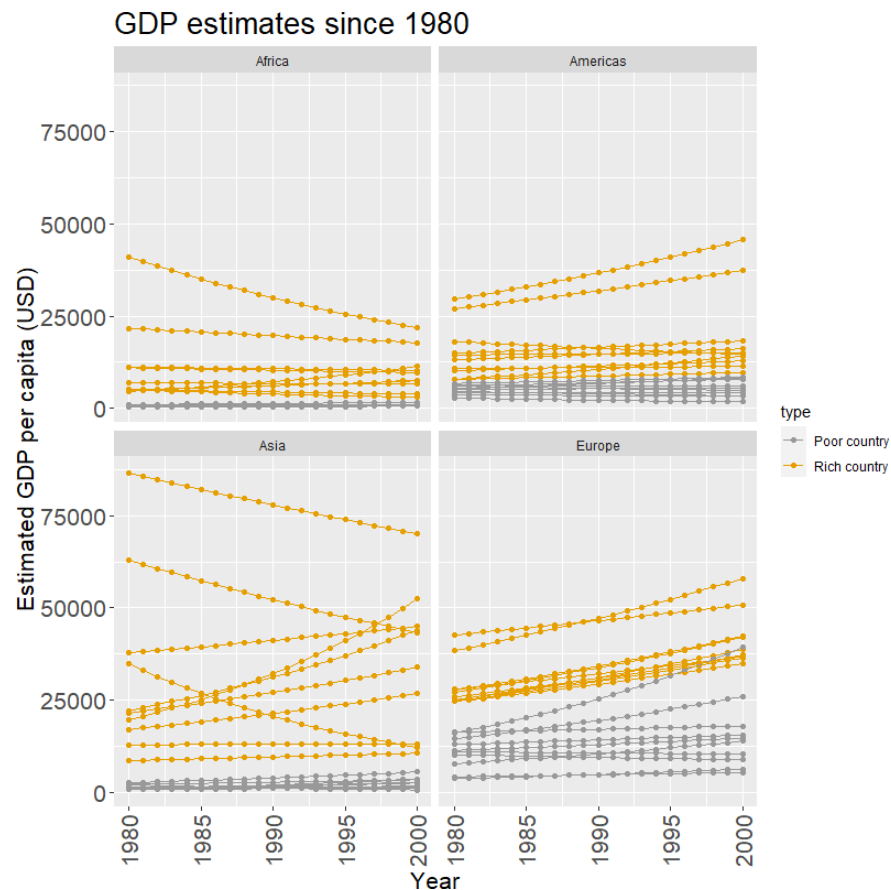


Some of the countries in Africa show convergence. A few of the poor countries (in 1960) manage to outgrow some of the rich countries and merge with them as they reach 1980. A similar trend can be seen in the Americas, where the lowest of the rich countries join the upper of the poor countries as we transition from 1960 to 1980. For the Asian continent, we can see that the economies of some rich countries have shrunk as the growth rate went negative, but still it was not enough for the poor countries to make up and reach their GDP level by 1980, but is still a sign of convergence. In Europe, there has been a drastic growth in the GDP of poor countries. For all the poor countries in the four continents, we can say that they have the highest growth rate (as evident by the curve in the plots). Although they couldn't manage to reach the level of GDP of the richer countries in 2020, we can surely say that they have managed to reduce the gap.



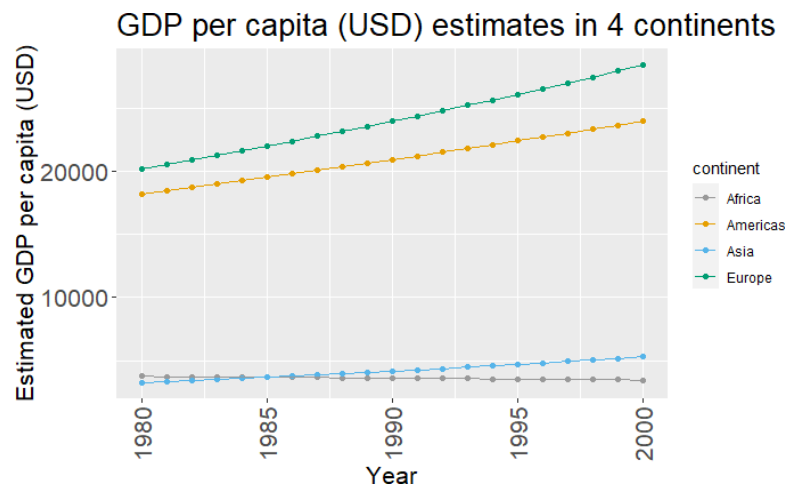
Europe and the Americas are richer continents as they have three times more GDP than Africa and Asia in 1960. This separation is further increased as we reach the year 1980, where the ratio becomes 5:1. Hence, there are no signs of convergence between the continents itself.

1980 – 2000:



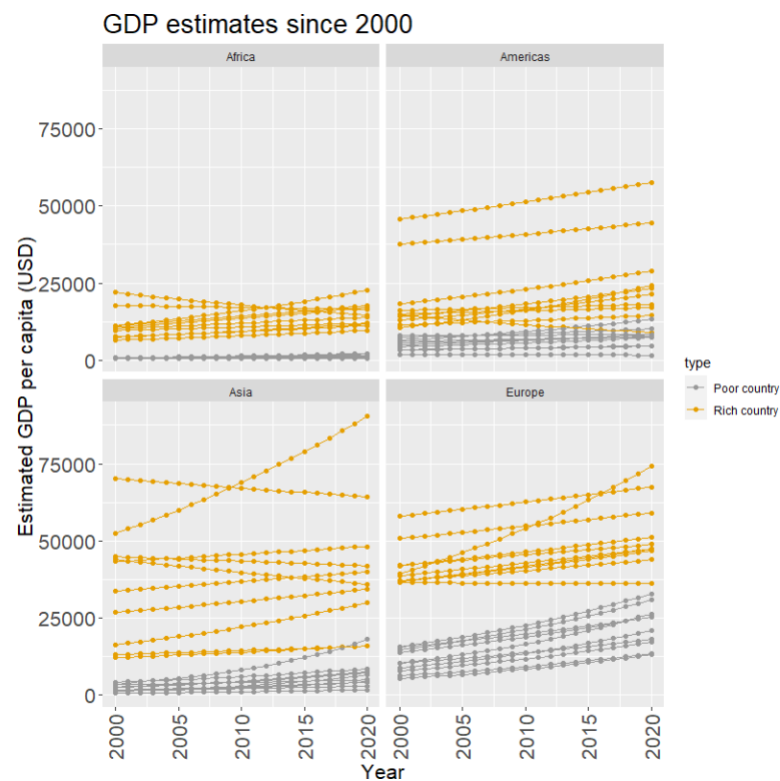
For the years 1980 to 2000, Africa has shown little signs of convergence, as the rich countries suffered constant and negative growth rates, while the poor countries have a constant growth rate. The economies of the poor countries did not grow, but some of the rich countries' economies shrunk over the years to reduce the gap. This trend can be seen better for Asian countries, where many rich countries have a negative or constant growth rate, and all the poor countries have a slight positive growth rate. In the Americas, for this period, almost all the countries (except a

couple of countries) have a slight positive growth rate. A couple of the rich countries have a tremendous growth rate and expanded by almost 50%. So, there is no sign of convergence. In Europe, there are visible signs of convergence, as a couple of poor countries have growth rate so large that they manage to overtake four rich countries.

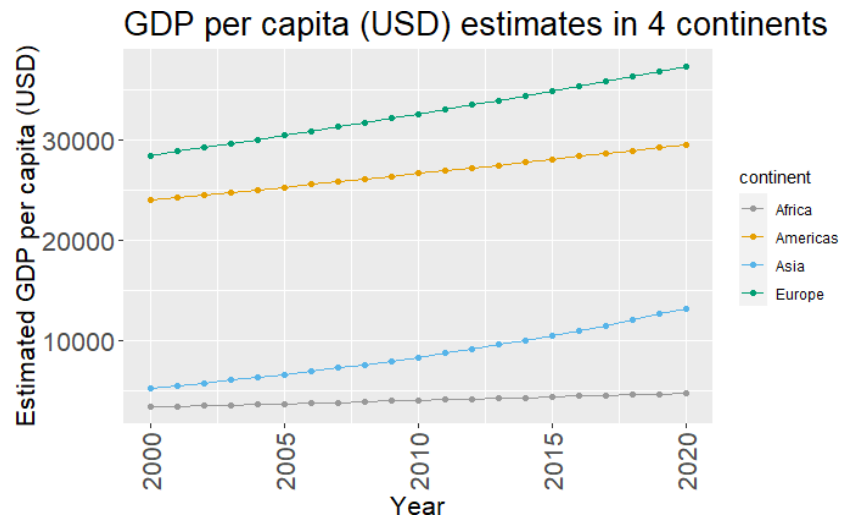


Similar to the years 1960 to 1980, the disparity continued to grow from 1980 to 2000. This separation is further increased as we reach the year 2000, where the ratio becomes more than 5:1. Hence, there are no signs of convergence between the continents itself.

2000 – 2020:



For the time period 2000-2020, we can say that the trend was similar to the time period 1980-2000. Africa and Asia show little to no signs of convergence. Americas remain somewhere in the middle where a few countries show convergence. Whereas European countries manage to display convergence perfectly as all the poorer countries have significant growth rates compared to the richer countries. This made the disparity in GDP per capita between richer and poorer countries lesser.



From 2000 to 2020, the growth rate of Asia is the highest, and we can see the gap closing between Asia and the other two rich continents (namely, Europe and the Americas). Therefore, it is a sign of convergence. Africa, on the other hand, does not display any such behavior as the GDP per capita ratio remains somewhat constant. Therefore, it does not show any signs of convergence.