

Growth Data

We apply the compound annual growth rate (CAGR) and Rule of 70 to long-run output data. The goal is to understand basic facts about economic growth around the world and over time.

Amazingly, economic growth is brand new. It is a mystery and the focus of intense research. Perhaps the biggest open problem in economics is why some countries grow and others do not. One result of uneven growth is that economic inequality across countries keeps getting bigger and bigger.

Data Source and Description

The data come from an economic historian named Angus Maddison. He spent his working life compiling and estimating a variety of economic and demographic variables around the world over very long periods of time. Briefly, Maddison data are high-quality, but they are noisier the farther back you go (Barreto, 2016). Visit www.theworldeconomy.org if you want to know more.

Annual gross domestic product (GDP) is the value of all final goods and services produced in a year. GDP is where we begin when we measure economic performance. There are three key adjustments that must be made to GDP when it is used to compare countries over time.

1. Inflation: GDP uses current prices to compute the value of output. If prices double, but the number of units produced stays the same, nominal GDP doubles. That is not what we want. Our measure of economic performance needs to reflect only changes in output, not prices. Thus, we use Real GDP because it holds prices constant over time and gives us a better measure of economic performance.

2. Population: If two countries have the same GDP, but one has more people, we would say the smaller country is more productive in terms of output per person. We divide Real GDP by the number of people to get Real GDP per person (or per capita) to measure economic performance.
3. Purchasing Power Parity: To compare the GDP of countries with different monetary units, we need to convert currencies. For complicated reasons, the best way to do this involves a hypothetical “international Geary-Khamis dollar” (for more detail and explanation: www.google.com/search?q=geary-khamis). Adjusting Real GDP for purchasing power parity by using international Geary-Khamis dollars gives us a better comparison of GDP across countries.

Real GDP per person adjusted for purchasing power parity is the key variable used to measure economic performance across countries over time. There is a lot of preparation and statistical adjustment needed before we begin analyzing the data. Fortunately, Maddison has done this heavy lifting for us.

It is undoubtedly true that Real GDP per person is a cornerstone of economic analysis, but it is far from perfect. Its biggest failing is that it says nothing about the distribution of output. We can divide an economy’s GDP by the number of people, but it is not true that each person in that economy gets the same share of output. Measures of inequality in the distribution of output are an important aspect of economic performance that we will review later.

Accessing the Excel Workbook

STEP Go to tiny.cc/busanalyticsexcel and click the Excel Workbooks link (top right). Click *LongRunGrowth.xlsm* to download it. Move the file from your download folder to a folder on your computer or network.

Notice that the file has an *xlsm* extension. Regular Excel workbooks are *xls* or *xlsx*. The *m* stands for *macro*. *LongRunGrowth.xlsm* is a macro-enabled Excel workbook. When you open it, you must enable macros to get full functionality from the file.

STEP Open *LongRunGrowth.xlsm*, read the *Intro* sheet, and be sure to click the button. You may have to adjust your security settings as described in the *Intro* sheet.

Basic Geography

The workbook contains several sheets. The *IncomeGroups* sheet has World Bank classification of 217 countries and administrative regions by income. There are low, lower-middle, upper-middle, and high income groups.

STEP Go to the *IncomeGroups* sheet and scroll down to see the countries in each group. Look at a few rows and think about what you know about those four countries.

For example, row 25 has Niger, Ghana, Dominica, and Switzerland. You probably knew Switzerland is a rich country, but did you know Ghana is lower income, but not as poor as Niger?

The countries are sorted alphabetically so we cannot say anything about their order within a group. This sheet tells us nothing about Niger versus Somalia or Uganda other than they are all in the lowest income group.

The map in the sheet looks different the usual world map. This is because it is doing an equal area projection. Unlike the usual Mercator map, which shows Greenland as huge, this map accurately reflects geographic size. It really is true that Africa is three times bigger than the United States.

The colors correspond to the income categories, as shown in the legend. While the map in the Excel workbook is informative, the online version is even better.

STEP Click on the map or copy and paste the link below it in a browser to explore the interactive version online. It displays name and category information as you hover over the country.

Data Sheets

Maddison provides three sets of numbers, organized in three sheets. The first is *Population*, the second *GDP*, and *PerCapita GDP* is the third.

STEP Click in each of the three sheets to see how the data are presented. Scroll down to see all of the countries in column A (down to row 198).

The countries are organized by a combination of geography and cultural connection. Western Europe is followed by Western Offshoots: Australia, New Zealand, Canada, and the United States. Maddison also gives us groupings such as Latin America and East Asia.

As you scroll down, you will see labels that indicate how country borders have changed over time. Former Yugoslavia are the countries above it (as of 2010, when these data were compiled) and row 65 has the Former USSR.

Notice how the placement of the countries are the same in the three sheets. Maddison estimates population, then Real GDP in 1990 Geary-Khamis dollars for each country or group.

The values in the *PerCapita GDP* sheet are simply real GDP divided by the number of people. We focus on the data in the *PerCapita GDP* sheet because this is Real GDP per person adjusted for purchasing power parity—this is our measure of economic performance.

The *OnlyCountries* sheet removes all groups and headings from the *PerCapita GDP* sheet and displays an alphabetic listing of the countries. Sorting by Real GDP per person in 2008 compares the economies of these countries at that time.

EXCEL TIP Sorting is one of the most dangerous things you can do in a spreadsheet. It is remarkably easy to destroy a data set by sorting only part of it. When you sort, be very, very careful.

STEP Select cell range A3:GR165 in the *OnlyCountries* sheet. The easiest way to do this is to click on cell A3, hold down the shift key, and click on cell GR165. Click the *Data* tab in the Ribbon, and click *Filter* (in the *Sort and Filter* group).

Excel has added downward pointing arrows in the cells in row 3. Clicking one of these arrows pops a menu and enables easy sorting of the data. You can remove the arrows by clicking the *Filter* button again.

STEP Click the down arrow in column GR and select *Sort Largest to Smallest*.

Excel obliges and now shows Hong Kong in row 4. It is the richest country in the Maddison data set in 2008, the last available year. Today, Hong Kong is not a country, but a special administrative region of China. It is still rich, but lists of richest countries today, using Real GDP per person adjusted for purchasing power parity, usually show Luxembourg, Singapore, and Ireland as the richest countries.

STEP Scroll down slowly and look at the countries as they go by.

Switzerland is near the top, clearly in the high income group. Dominica (not the Dominican Republic) is not included in Maddison's data set (it is in the group of 21 small Caribbean countries). As you get near the bottom, you see Ghana (row 124), which is lower-middle income according to the World Bank. Niger, which is in the low income group, is third from the bottom.

The data show that Ghana's Real GDP per person of roughly GK\$1,500 is 3x (three times) bigger than Niger. That is a lot, but nothing compared to the 50x difference between Switzerland and Niger. This staggering difference is evidence of an important lesson that we will explore again:

Lesson 1: Country Real GDP per person is wildly uneven.

We can see the massive dispersion in economic performance by noting that the range in Real GDP per person goes from a few hundred GK dollars in the poorest countries to 30,000 GK dollars in the richest countries. We can display this in a histogram.

STEP Select cell range GR3:GR165, click the *Insert* menu item in the Ribbon, and click the *Histogram* chart type. Click the *x* axis and change the number of bins to 30.

Your histogram shows a tall rectangle at the left, indicating many poor countries, then a spread out distribution gradually getting smaller and smaller as you go right (these are the richest countries).

Another way to see the big disparity in economic outcomes is by computing the standard deviation of Real GDP per person for these countries.

STEP Enter the formula `=STDEV.P(GR4:GR165)` in cell GR2.

The SD displayed in cell GR2 says that the typical amount of dispersion around the average is about GK\$8,000. That is a lot of dispersion since the average is also around GK\$8,000.

It has not always been this way. We will see when we start looking at long-run growth that countries used to be much closer in terms of economic performance, but we can also find evidence for this lesson in the short run.

STEP Copy cell GR2 and paste it in cell GJ2. Paste again in cell FZ2.

1990 is the earliest we can compute the SD for this set of countries because the Soviet Union collapsed in 1989 and many countries in the set were part of the USSR. Even for this short period of time, the numbers are striking. The SD falls from GK\$8,000 in 2008 to under GK\$7,000 in 2000 and to GK\$5,400 in 1990. This is evidence for the second lesson:

Lesson 2: The disparity in country Real GDP per person is rising.

In fact, this part of the story is complicated. With free-flowing information and technology, we should see convergence in Real GDP per person. There is some evidence that a subset of countries do converge (so the SD of Real GDP per person would get smaller). Overall, however, as Maddison's set of countries shows, the spread in Real GDP per person has been growing.

Growth over the Long Run

Now that we know how Maddison created and organized the data, we are ready to use the data to examine the historical record to learn about economic growth. Begin with a screencast that introduces the *Compare* sheet and emphasizes this lesson:

Lesson 3: Economic growth is brand new.

STEP Watch vimeo.com/econexcel/longrungrowth

The screencast says that, for millennia, every country was poor. Yes, there were a few rich individuals, mostly monarchs and rulers, but everyone else was living at a subsistence level. It is only in the last few hundred years that some countries have broken out of the poverty trap.

Why did growth suddenly (on a time scale of millennia) explode on the scene? Why did only some countries grow? Believe it or not, we do not actually know the specific mechanisms involved. It was not simply money or trading since both have been around for a lot longer than the last few hundred years.

Economists point to the *market system* as the driver of growth. This loosely defined concept involves private property rights, rule of law, entrepreneurship, widespread individual striving for wealth, and celebration of financial success. This complicated, poorly understood cocktail of institutions and cultural norms has many names, such as capitalism and free enterprise.

We do not know exactly why, but growth emerged in Europe roughly a few hundred years ago and then it evolved unevenly. Some countries grew and others did not. Some grew fast and others slow. The *Compare* sheet can be used to display examples of this, as shown at the end of the screencast.

STEP Use the *Compare* sheet from 1950 to 2008 to see if Maddison data agree with the World Bank classification of Sudan as low income and Egypt as lower-middle income.

Your chart shows that these two countries, which share a border and were roughly equal in 1960, are no longer so. Egypt has done much better than Sudan and now has double the Real GDP per person.

STEP Choose an upper-middle income country from the *IncomeGroups* sheet and add it to the chart.

Adding an upper-middle income country changes the scale of the y axis and places another series above Egypt and Sudan.

STEP Add a rich country from Europe to your chart.

The y axis scale changes again and the spread of the four countries is quite large. Sudan is pushed close to the x axis with Egypt slightly above it. Notice that the gap between the rich European country you added and your upper-middle income country is big.

So far, we have been tracking the level of Real GDP per person, but we are also interested in the growth rate of Real GDP per person. The next screencast shows how we can use the Maddison data set and *Compare* sheet to find the growth rate and it makes this point:

Lesson 4: 2% per year in Real GDP per person is the magic growth number.

STEP Watch vimeo.com/econexcel/cagr.

Joseph Schumpeter is well known for his theory of the entrepreneur as innovator, perhaps best captured in the oxymoron *creative destruction*. Schumpeter, like many others who have studied economic growth, was awed by the productive powers of the market system.

In *Capitalism, Socialism, and Democracy*, published in 1942, Schumpeter used data to describe the historical success of capitalism before pronouncing that it could not survive. The heroic entrepreneur would become obsolete as rational, scientific thinking took hold. This has not happened (yet).

Using noisy, imperfect measures of Real GDP per person, Schumpeter found that the United States had enjoyed a spectacular run from after the Civil War to the Great Depression. He concluded that if this performance was repeated another 50 years, “this would do away with anything that according to present standards could be called poverty” (Schumpeter, 1942, p. 66).

Let’s see if Maddison data agree with Schumpeter as we explore the historical economic performance of the US economy.

STEP Use the Data Vertical button to get Real GDP per person in the United States in a vertical column (as shown in the screencast). Compute the CAGR in the United States from 1870 to 1929 and from 1950 to 2008 (as shown in the screencast). What would Schumpeter have said had he lived to see how the United States economy performed until 2008?

The United States actually did even better in the second half of the 20th century (2.06% per year) than during the Civil War to the Great Depression (1.77% per year). Schumpeter would have been shocked by this performance.

STEP Go to the *Compare* sheet and display US Real GDP per person from 1870 to 2008. Click the button.

Your chart is a snapshot of US economic history. There are three periods:

1. Before the Civil War, the United States was underdeveloped, rural, and quite poor.
2. After the Civil War, reconstruction and western development created a truly national economy that grew rapidly.
3. The Great Depression was traumatic, as was World War II, but the US economy has done extremely well since the 1950s.

CAGRs of 1.86% per year from 1870 to 2008 and 2.06% per year since 1950 are excellent analytics for the US economy. The Rule of 70 tells us we will get doubling in Real GDP per person every generation. But can we really count on this going forward? No, the fifth growth lesson says we cannot:

STEP Watch vimeo.com/econexcel/growthnotassured

There are many individual countries that could be used to support the lesson that growth is not assured, but perhaps Japan is the most surprising example.

STEP From the *Compare* sheet, display Japan's Real GDP per person from 1950 to 2008. Click the button.

The log scale linearizes exponential curves and clearly shows the remarkable reversal in the Japanese economy. From 1950 to 1973 the Japanese economy grew at an incredible 8% per year. That is doubling every 9 years!

But your chart shows that it suddenly leveled off in 1973. From 1973 to 1991, it grew at 3.3% per year. This is still excellent and everyone thought Japan would take over the world (much like China is feared today).

And, then suddenly, it all came to screeching halt. From 1991 to 2008, Japanese CAGR fell to 1% per year. Look carefully at your log-scale chart to see how flat the line is starting around 1990.

Why did this happen? We do not know. Standard macroeconomic policies to stimulate the economy have not worked. Japan is an aging society with a rapidly falling birth rate and it does not especially welcome immigrants so demographic explanations abound. But this is typical of how economists study growth—we come up with stories after the fact. No one predicted the sudden reversal in economic performance in Japan.

Remember, however, the difference between levels and growth. Japan remains a rich country. If you visit, you will see all the markers of wealth, such as shopping malls and fancy restaurants. Japanese enjoy long life expectancy and high education levels. The lack of growth, however, is a serious problem for the future.

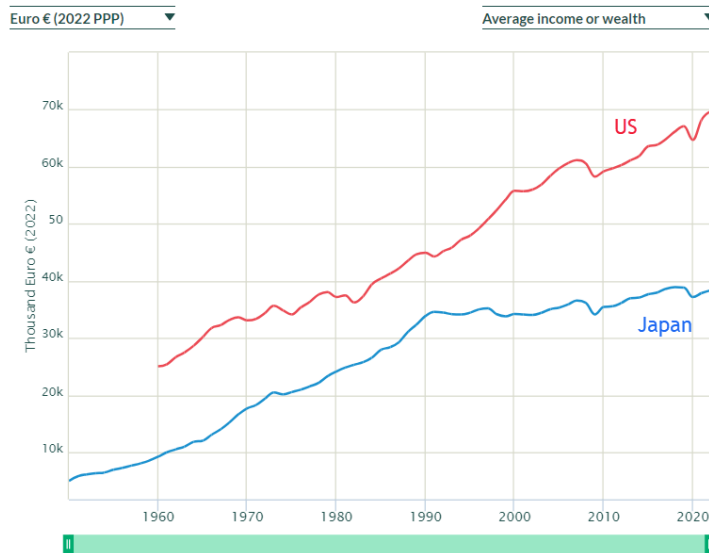


Figure 4.4: US and Japan Real GDP per person, 2022 Euro PPP.
Source: wid.world/world/#agdpro_p0p100_z/US;JP.

Maddison data only goes to 2008. What has happened to the United States and Japan since then? While there are many websites to choose from for country comparisons, an excellent one is wid.world. Figure 4.4 shows that Japan was growing incredibly fast until the early 1970s. It slowed down, but did well until 1990. Since then, it has gone sideways. An economic juggernaut from 1950 to 1990, but suddenly stagnant the last few decades: Japan is a good example of the lesson that growth is not assured.

We conclude our whirlwind tour of economic growth across time and around the world with a final lesson:

Lesson 6: Seemingly small differences in CAGR produce huge gaps in levels.

It is easy to think that there is little difference between percentage point changes in growth rates. After all, 0.01, 0.02, and 0.03 are all “small” numbers. So are they basically the same? No. Compounding is a powerful force and this is why we need to be careful when we compare CAGRs.

STEP Return to the *OnlyCountries* sheet and copy it. Add a filter if needed and sort by 1900, largest to smallest. Delete all countries (rows) without data for 1900.

You should have a sample of 39 countries with Real GDP per person values in 1900. The UK is richest and China is poorest when sorted by 1900 value.

STEP In cell GS3 enter the label, CAGR since 1900, and in cell GS4 enter the formula for the CAGR, $=(GR4/CN4)^{(1/108)}-1$. Fill it down. Delete the columns from 1901 to 2007 so that 1900 and 2008 are side-by-side to enable easy comparison.

Compare New Zealand and the United States, in second and third place in 1900 in Real GDP per person. From that time to 2008, the US growth rate is about half a percentage point (0.005) higher. This seemingly small difference produces a huge gap by 2008—31,178 to 18,653 in 1990 GK dollars. A picture is worth a thousand words.

STEP In the *Compare* sheet, display the US and New Zealand from 1900 to 2008.

That is astounding. Starting from essentially the same place, the “small” 0.5% point difference generates a huge gap by 2008.

Scroll down and look at Portugal and Sri Lanka. Again, they are essentially even in 1900 (and both poor), but in 2008 Portugal is 3x richer. Why? Because it grew 1% point faster than Sri Lanka.

STEP Return to the *Compare* sheet and display Portugal and Sri Lanka from 1900 to 2008.

Again, the picture is striking. That seemingly small percentage point difference causes a huge difference after 108 years of geometric progression.

A mathematician would not be surprised. They might point out that the difference between 1% and 2% CAGR is a “small” one percentage point, but it is a “big” 100% difference. We have doubled the CAGR when we go from 1 to 2 percent per year.

This lesson applies to personal finance. An expense ratio for an ETF or mutual fund that is a “small” 0.5% will end up seriously decreasing the value of the investment over time. This is worth remembering.

Summary

There are many business applications of CAGR and the Rule of 70, but applying these tools to Real GDP per person across countries is a great way to learn data analytics and the amazing story of economic growth.

Robert Lucas won a Nobel Prize in Economics and he drilled it when he said,

Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia’s or Egypt’s? If so, what exactly? If not, what is it about the “nature of India” that makes it so? The consequences for human welfare involved in questions like these are simply staggering: once one starts to think about them, it is hard to think about anything else (Lucas, 1988, p. 5).

The data show that economic growth exploded on the world stage just a few hundred years ago with the advent of the market system and simultaneous revolutions in science and industry. As a result, billions of people live healthier, richer lives. It is, of course, also true that billions remain poor and we need to figure out exactly what it is about the market system that enables growth and development.

Solving the puzzle of economic growth is the biggest open problem in economics. The puzzle is both incredibly challenging and critically important that we figure it out.

If you do not believe this, consider Haiti and the Dominican Republic. Go to the *Compare* sheet and display real GDP per person for these two countries from 1950 to 2008.

It will only take a few seconds to do this (that is what is so powerful about this workbook) and the resulting chart is guaranteed to absolutely blow you away.

In “The Underlying Tragedy,” an editorial in the October 15, 2010 edition of *The New York Times*, David Brooks communicates the frustration generated by our ignorance:

Why is Haiti so poor? Well, it has a history of oppression, slavery and colonialism. But so does Barbados, and Barbados is doing pretty well. Haiti has endured ruthless dictators, corruption and foreign invasions. But so has the Dominican Republic, and the D.R. is in much better shape. Haiti and the Dominican Republic share the same island and the same basic environment, yet the border between the two societies offers one of the starkest contrasts on earth—with trees and progress on one side, and deforestation and poverty and early death on the other.

Lucas was right, once you start thinking about economic growth and are aware of the tremendous variability in outcomes, it is hard to think about anything else.

Adam Smith’s *Inquiry into the Nature and Causes of the Wealth of Nations* was first published in 1776, at the dawn of the British Industrial Revolution. Smith had no data on Real GDP per person, but he knew something really weird was going on. He asked a fundamental and enduring question, “Why are some countries rich and others poor?”

We still do not know the answer.

Takeaways

Angus Maddison spent his life compiling estimates of output per person stretching all the way back to 1 AD. Maddison’s data enable us to see long-run economic growth.

A generation is roughly 30 years so growth of a little over 2% per year will produce doubling every generation. That is considered really good for rich countries.

Poor countries often grow faster than 2% when they first adopt the market system. This is called catch-up growth.

It is easy to fall into the trap of thinking that Real GDP per person is a perfect measure. It is not. It has several weaknesses, but perhaps its biggest problem is that it says nothing about the distribution of output.

Here are the six lessons in one place:

Lesson 1: Country Real GDP per person is wildly uneven.

Lesson 2: The disparity in country Real GDP per person is rising.

Lesson 3: Economic growth is brand new.

Lesson 4: 2% per year in Real GDP per person is the magic growth number.

Lesson 5: Growth is not assured.

Lesson 6: Seemingly small differences in CAGR produce huge gaps in levels.

References

Lucas, R. (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics*, 22, pp. 3-42.

Schumpeter, J. (1942) *Capitalism, Socialism, and Democracy* (George Allen & Unwin Ltd.)