Development and Growth Facts

This chapter documents some of the key development and growth facts that need to be explained. In doing so, it first describes the methods that have been used to compare international incomes, and the data sets that have been constructed using these methods. It then documents the long-run properties of these data- the so called Development and Growth Facts.

I. The Data on International Outputs

A single nation's Gross Domestic Product (GDP) or Gross National Product (GNP) is reported in its own national accounts in units of its own currency. Obviously, it makes no sense to compare the GDP of different economies measured in their own currencies. For instance, you cannot tell whether Japan is more productive than the United States if you are only told that Japan's 2003 GDP is 590 trillion yen and the U.S.'s 2003 GDP is 4.5 trillion dollars. Obviously, comparisons can only be made if the two measures are expressed in the same units.

Historically, there are two methods that have been used to convert individual country's GDP measures into a common currency: the *exchange rate method* and the *purchasing power parity (PPP) method*. The important point that we will establish is that the PPP method is superior to the exchange rate method because the former ensures that the same prices are used to weigh the quantities of goods produced in each country whereas the

latter does not. Using the same prices is the key to generating accurate measures of income differences across countries.

1.1.a The Exchange Rate Method

We begin with the Exchange Rate Method, which has a longer history relative to the PPP method. To begin, let us write the GDP of a country **i** in year t in its own currency as

(GDP OC) $$GDP_t^i = \sum_{j=1}^{J} p_{jt}^i x_{jt}^i ,$$

where J is the number of final goods and services produced in the economy, p_{jt}^i is the price of good j in country i, and x_{jt}^i is the quantity of good j produced in country i. Remember that GDP only considers final goods and services, so that it is the meaning of x_{jt}^i.

The exchange rate method is straightforward. It take each country's output in domestic prices given by equation (GDP OC) and multiplies it by the exchange rate of its currency with the US dollar so as to convert the measure into US dollars. More specifically, let e_t^i denote the exchange rate of a country i's currency with the US dollar in year t, i.e., e_t^i = \$'s per unit of domestic currency. Then the dollar equivalent output of country i is

(GDP Ex) $$e_t GDP_t^i = \sum_{j=1}^{J} e_t p_{jt}^i x_{jt}^i$$

The exchange rate method is simple to implement, but does it generate accurate estimates of output differences across countries? In order to make accurate comparisons of output across countries, a method must ensure that the same price is used to value the quantity of each particular good in each country. With respect to the exchange rate method, the

procedure will produce reliable comparisons only if the dollar equivalent price of the good is the same for all countries, namely if, $e_t^i p_{jt}^i = p_{jt}^{US}$ for each good j=1, 2,3,,,,J.

This relation is known as the *Law of One Price*. It is based on the idea that in a frictionless world with no trade costs and perfectly competitive markets, arbitrage opportunities would equate the dollar price and the dollar equivalent price of the good in the foreign country. In a frictionless world, the arbitrager could make infinite profits by buying the good in the low-price location and selling it in the high price location.

Of course, the world is not frictionless. There are real costs to moving goods. Some goods and services are too costly to move, and hence are traded infrequently. Haircuts are an extreme example of this. Moreover, most markets are not characterized by perfect competition and free entry. Entry in many markets is artificially restricted and in others it requires huge costs associated with setting up distribution centers and retail outlets.

Not surprisingly, the data does not support the law of one price. This failure is dramatically displayed in the "Big Mac Index" that has been compiled by the *Economist* since 1986. In 2012, for example, the dollar price of a Big Mac in Switzerland was $6.81, in the U.S. $4.20 and in Thailand $2.46.

As a result, the exchange rate method implies that different prices are used to value the same good in different countries. Consequently, comparisons of international income levels that are based on the exchange rate method are not very reliable. Additionally,

there is a bias associated with the exchange rate method that actually makes poor countries appear even poorer than they actually are. The reason for this bias is that the law of one prices tends to be violated in a systematic way in the case of non-tradeable goods and services with, $e_t^i p_{Nt}^{Poor} < p_{Nt}^{US}$. Consequently, non-tradeables in poor countries are given a smaller weight compared to non-tradeables in rich countries. The problem is exacerbated by the fact that most of a poor country's output consists of non-tradeables. This makes poor countries look poorer than they actually are.

1.1.b Purchasing Power Parity

In contrast to the exchange rate method, the Purchasing Power Parity (PPP) method guarantees that the same price is used to value the quantities of a good in different countries. This explains the current dominance of this approach among data collecting institutions. For example, The *Organisation of Economic Co-operation and Development* (OECD), the *International Monetary Fund* in their World Economic Outlook database and the *World Bank* in their World Development Indicators all provide PPP adjusted estimates of GDP.

If we go back to the Big Mac example from above, the purchasing power parity essentially gives us the exchange rate between two countries that guarantees that the dollar equivalent price of a Big Mac is the same in both countries, or that guarantees you can buy the same quantity of the same good or service in each country. Thus, if a Big Mac sold for 1€ in Germany and $5 in the Unites States, the purchasing power parity rate is 1 Euro to $5. The Big Mac Index table reports purchasing power parity rates. As you

can see, these PPP rates in the Big Mac Index table are expressed in terms of local currency to US dollars, so in the above example, the PPP rate would be .20€/$.

Although the idea of purchasing power parity rate is straightforward, there are several deep issues related to price index theory that make applying this concept to output measures challenging. Returning to our Big Mac example, whereas it is straightforward to figure out the purchasing power parities for Big Macs between any two countries, it is less so when we need to consider all the goods in the economy, as we need to do here. In truth, there is no universally accepted PPP index out there; there are many PPP indexes, each with its virtues and deficiencies. In what follows, we describe the Purchasing Power Parities that are based on the Geary-Khamis method as these are the indexes that underlie the construction of the two main databases on international incomes.

The Gheary-Khamis method calculates both a PPP index for each country as well as a set of world prices. The PPP of a country is essentially the ratio of its GDP evaluated at domestic prices to its GDP valued at world prices, and the world price of a good is the essentially a weighted average of the dollar equivalent price of the good in each country, where the weights are each country's share of total world production of that particular good. The price and quantity data that are the key inputs in these calculations are collected by the *International Comparisons Project* (ICP).

The world prices of each good are fundamental to computing the PPP adjusted GDP measures for each country. For our purposes, it is not important that we know the method

for computing world prices. Once they have been computed, the procedure to construct PPP adjusted GDP involves three steps. For describing these steps, it is useful to introduce some additional notation. Let E^i_{jt} denote the nominal expenditures on a good j (say apples) in country i (say Japan) at date t. The steps that are used in the PPP approach is

1. Take total expenditures of good *j* in country *i*, E^i_{jt}, and divide this by the price of good *j* in country *i*, p^i_{jt} to arrive at the quantity of good j, x^i_{jt}.
2. Multiply the quantity of good *j* in country *i* by the world price of good *j*, p^W_{jt} to obtain the value of the good in the world price, $p^W_{jt} x^i_{jt}$.
3. Repeat this procedure for all goods and services in country i and sum these values to get P.P.P. adjusted output for country *i*, namely, $\sum_{j=1}^{J} p^W_{jt} x^i_{jt}$.

In this way, the method guarantees that the same price is used to value the quantity of a given good in each country. Consequently, the income comparisons made with the PPP method are far more accurate compared to the exchange rate method.

1.2 Databases

Two data sources of PPP adjusted international incomes dominate the empirical growth and development literature. The first was started by Robert Summers and Alan Heston at

the University of Pennsylvania and is referred to the *Penn World Tables* (PWT).[1] The second was started by Angus Maddison of the Groningen Growth and Development Centre and is referred to as the Maddison Project (MP). The main difference between the two data sets is that the PWT data cover the post 1950 period for almost every country in the world whereas the MP provides estimates for GDP going back far earlier in time (basically 1820) for a large number of countries. Through the years, the MP dataset has been modified to include estimates for more and more countries going further back in time. As such, it has come to be more frequently used.

Like the PWT, the MP covers most every country over the post World War II period. For most countries, there is little difference between the GDP estimates in the PWT and MP. The one exception is China. In 1952, the MP estimate for China's per capita GDP is 5.3 percent of the US level whereas the PWT estimate puts China to be at 2.7 percent of the US level.

As you can imagine, the PPP method is an extremely labor intensive procedure, as it must be applied to each good in each country at each point in time. Obviously, there is a limit to the amount of disaggregation of goods, so all goods must be lumped into some broadly-defined category. Still, the number of categories is large. For instance, in the *PWT* there are 1,600 categories of goods, with 1,200 of these being consumption goods and another 400 being investment goods.

1.3 . Per Worker vs. Per Capita measure

[1] In the latest version of the Penn World Tables, PWT 6.2, Bettina Aten has been added as a contributor.

Most comparisons of output between countries (and across time within a given country) are made on a per capita basis or a per worker basis. The per capita measure, which is obtained by dividing a country's GDP by its population, is a proxy for the average living standard and the overall well-being of the country. The per worker measure, in contrast, which is calculated by dividing a country's GDP by its workforce, is a measure of labor's productivity. Additionally, for rich countries, comparisons are often made on a per work hour basis. This is calculated by taking a country's GDP and dividing it by the total hours individuals. This is an even more informative measure of labor's productivity.

Rankings of countries can differ between measures. For instance, a country can have a low per capita GDP but a very high per worker GDP if unemployment is high or if the population consists of a large fraction of children. Similarly, it can have a high output per worker but a low output per work hour if labor works long hours. The United States, in fact, has the highest GDP per worker in the world, but not the highest output per work hour. Norway, France, and Belgium each have higher labor productivities measured by output per work hour. Workers in these countries do not produce as much in a day, however, because they work fewer hours than their US counterparts. Why individuals in Europe work fewer hours than Americans is an interesting question that we will address later in this book.

II. Some Key Development and Growth Facts

Now that we understand the data, we can proceed to document the pattern of development over the last two thousand years. A list of the key development and growth facts is:

- Prior to 1700, living standards were constant over time and did not vary much across countries. The factor difference in per capita income across countries was more on the order of 2.
- Around 1700, England began to experience sustained increases in per capita output. Initially, these increases were irregular and modest in size, but after 1900 these increases became regular with a doubling of per capita income every 35 years.
- Other countries started to experience increases in per capita income shortly after England. These countries include many Western European nations and the ethnic offshoots of England.
- Countries have differed dramatically in the date they have started to experience sustained increases in their living standards. Some countries, particularly located in sub-Sahara Africa have only now begun to experience increases in their living standards, although these increases are rather modest in size and fairly irregular.
- On account of these different starting dates, the disparity in international incomes increased dramatically since 1700, especially until 1950.
- Since 1950, the disparity in international incomes has not increased by as much. By 1950, most countries in the world had started the process of

economic growth. Some of these late starters have eliminated a large fraction of their income gap with the industrial leader over this period.

- Growth miracles are a relatively recent phenomenon and are limited to countries that were poor at the time their miracles began.
- There seems to be an advantage associated with being a later starter. Late starters typically have been able to double their incomes in far less time compared to earlier starters at comparable starting income levels.

Let us look at these facts more closely.

2.1 Pre-1700 Stagnation

Prior to 1700, living standards were constant over time and did not vary much across countries. Figure 1 plots per capita income of the leader country dating back to 2000 B.C. Up until 1700, the living standard of the leader country, or any other country for that matter, displayed no secular increase. Between 1580 and 1920, the richest country in the world was the Netherlands; form 1820 to 1890, it was England; and thereafter it has been the United States. During this time, the living standard was significantly above the subsistence level. In 1688, for example, the poorest quarter of the population in England- the paupers and the cottagers- survived on a consumption level that was roughly one-fourth the national average. A few societies, such as the Roman Empire in the first century, the Arab Caliphates in the tenth century, China in the eleventh century, and India in the seventeenth century realized some increase in their per capita incomes. However, these increases were not sustained. Why these countries were unable to sustain these

increases is an interesting question that has received a good deal of attention among economic historians. We do not take this question up in this book however.

Technology was not stagnant over any part of this period. Economic historians, particularly, Joel Mokyr (1990), have documented a steady flow of technological innovations in this 2000 BC to 1700 AD period. Yet, these innovations did not translate into increased living standards. Instead, they translated into increased populations; as total output increased, the population adjusted so as to maintain a constant level of per capita output. This is shown in Figure 2, which is taken from Robert E. Lucas's 2002 book, *Lectures in Economics*. Figure 2 plots world population and world output from 1000 AD to 2000 AD taken from Madison. Up until 1700, the two curves are increasing but parallel, reflecting the constant living standard.

Figure 1: The Leader's Per Capita GDP Relative to Pre-1800 Level

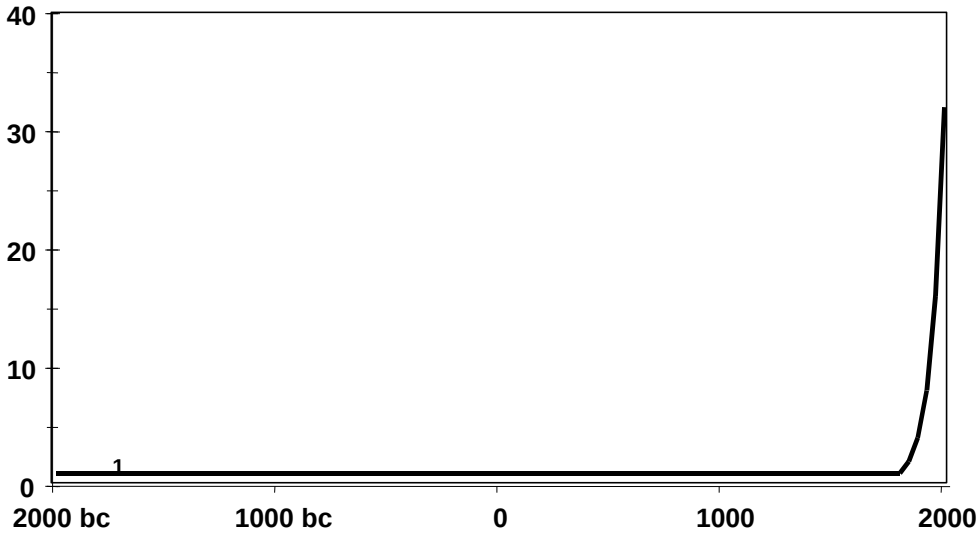
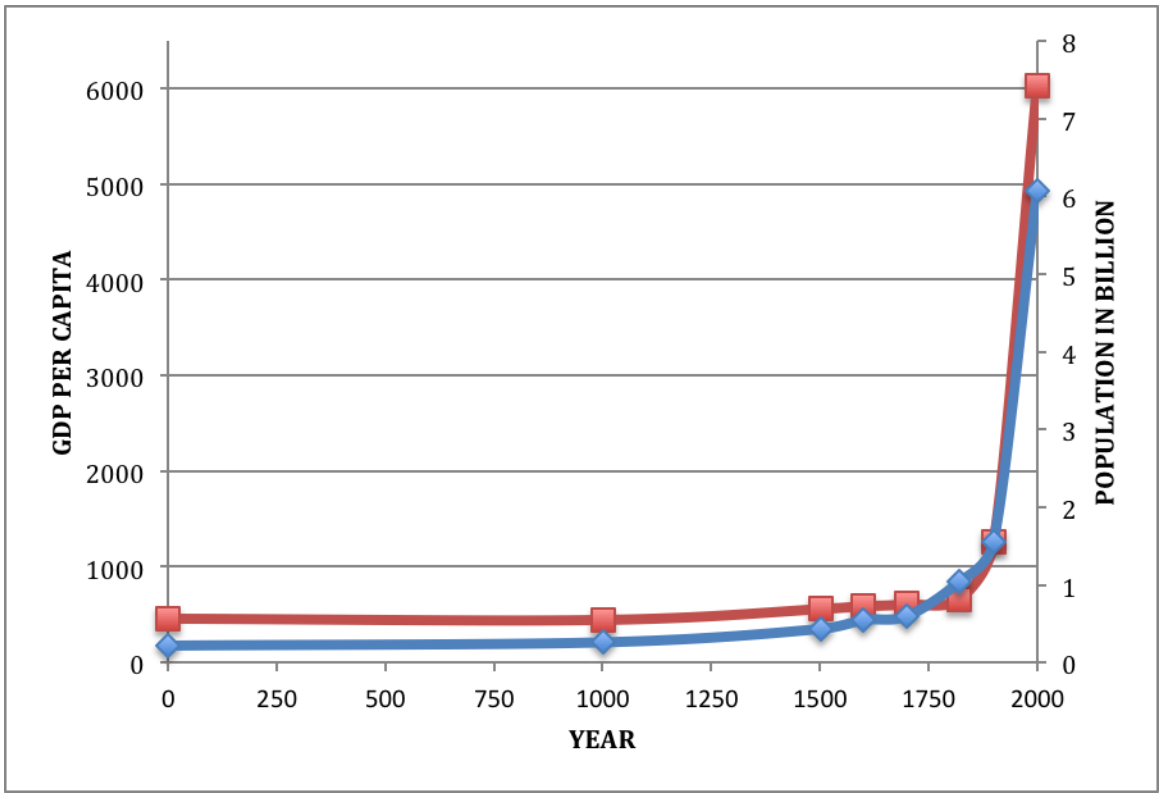


Figure 2: World Population and Output



2.2 Post-1700 Development and Growth

Only after 1700 do we see an increase in per capita output in the world. This is shown in both Figures 1 and 2. Figure 2 makes apparent that total output started to increase faster than the rate of population growth around then, implying an increase in the world's living standards. Economic growth, that is sustained increases in per capita output, is a very recent historical phenomenon!

Dynamic Presentation of the Evolution of international incomes. *Modern technology can be a most useful tool in teaching. Check out this youtube video by Hans Rosling called 200 Countries, 200 years, and 4 Minutes- The Joy of Stats.*

Who is Hans Rosling by the way? Dr. Rosling is a professor of International Health at Karolinska Institute in Stockholm. In addition to being a licensed physician, Dr. Rosling holds a Ph.D. and has been active in researching malnutrition and disease outbreak in sub-Sahara Africa. He is also co-founder of the Gapminder Foundation that developed the Trendalyzer software used in the video.

The first country to experience sustained increases in per capita output was England- a so called industrial revolution. Historians date the start of this growth in per capita output around 1700. Over the next 150 years, these increases in the leader country were modest in size and irregular. However, since 1900, these increases have been larger and fairly irregular with per capita income doubling roughly every 35 years. This is what Simon Kuznets called *modern economic growth*.

Western Europe and the ethnic offshoots of England (i.e., the United States, Canada, Australia, and New Zealand) were next to experience sustained increases in per capita output. Other countries were much later in their starting dates. For example, Figure 3 shows the date at which economic growth started in Japan, Brazil, and India. As can be seen, India did not start to experience increases in its per capita output until well after 1950. Japan is the earliest starter of these three countries shown in Figure 3, with a starting date of 1870, nearly 150 years after England.

Even within a region there is a great deal of disparity in starting dates. Figure 4 shows how very diverse these dates are among Asian countries. Bangladesh is even later than India in its start. China starts somewhat earlier, around 1950.

As a result of these different starting dates, differences in living standards widened between countries, especially between 1750 and 1950. In 1950, for example, the average country in Africa was $1/12^{th}$ as rich as the United States in terms of per capita output. Sub-Sahara Africa countries tend to be even poorer. In 1950, the poorest countries in sub-Sahara Africa had a per capita output around 3 to 4 percent of the US level. In 2000, these differences were even larger, with the poorest of these countries having a living standard which is below 2 percent of the US level.

Figure 3: Different Starting Dates

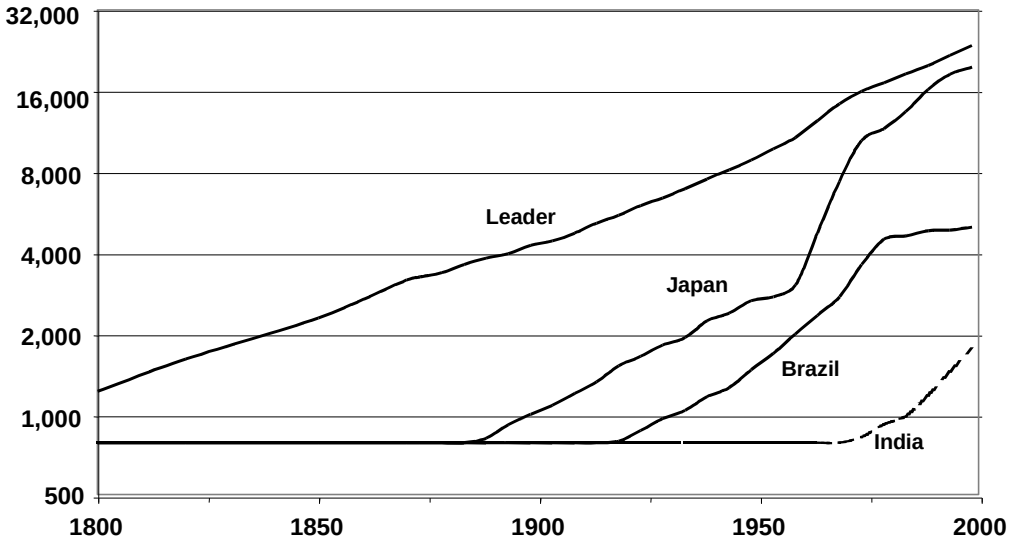


Figure 5 presents the time path of per capita output relative to the leader grouped by regions of the world, and thus provides a more comprehensive picture of the evolution of international incomes since 1700. In general, Latin America started modern economic

growth in the first part of the twentieth century. For Asia, the approximate start of modern economic growth is the middle of the twentieth century. For Africa, modern economic growth has yet to start; although per capita income has increased in many African nations, since 1960, the increases have been irregular, and clearly less than the increases in the leader, the United States. Interestingly enough, it is only after 1950 that the path of Asia and Africa diverge.

Figure 4: Different Starting Dates for Selected Asian Countries

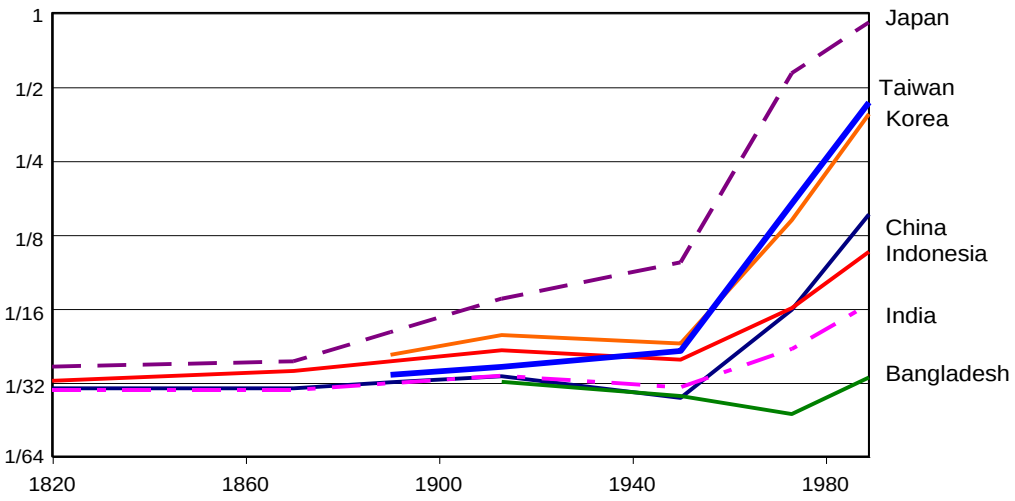


Figure 6 gives a more complete picture of today's disparity in per capita income levels. Figure 6 shows a bar graph depicting the number of countries with 1995 per capita GDP within a given range of the leader. These ranges or bins are [1, 1/2], [1/2, 1/4], [1/4, 1/8], [1/8, 1/16], and [1/16, 1/32], and [1/32, 0]. The data is taken from the Penn World Tables. In 1995, there were more extremely poor countries, countries in the [1/32,0] bin than in rich countries, countries in the [1,1/2] bin.

Figure 5: Evolution of International Income Levels (Fraction of Leader)

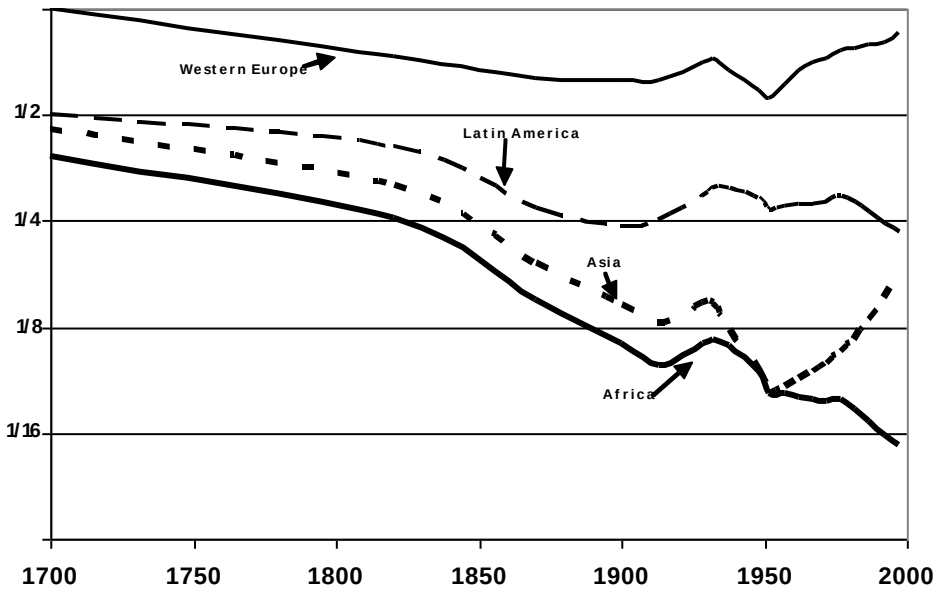
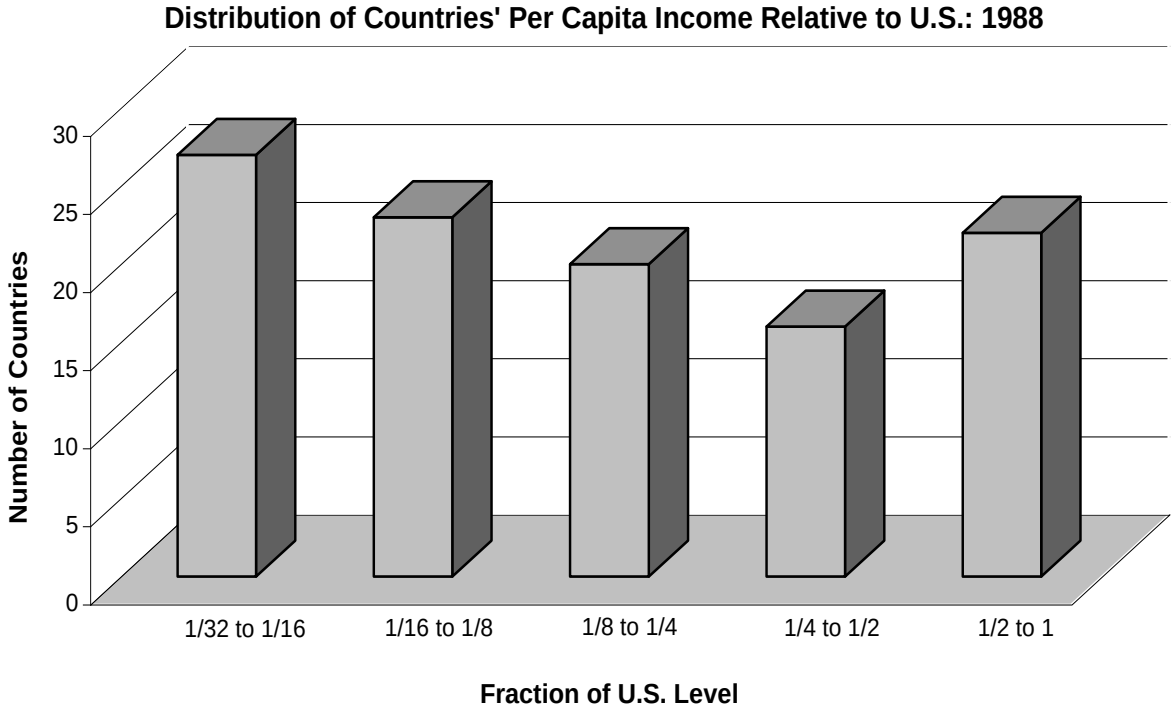


Figure 6:



Some countries and regions have dramatically reduced their income gap with the leader subsequent to starting modern economic growth. This is apparent in Figure 5. For example, in the postwar period, Western Europe managed to eliminate much of its income gap with the United States, the leader since 1890.

Asia is another region that has been catching up to the leader in the postwar period. China and India, which did not begin to experience increases in per capita GDP until well after 1950, have eliminated some part of their gap with the United States since 1980. China in 1980 was at 5 percent of the US level. In 2000, it was at 10 percent. India in

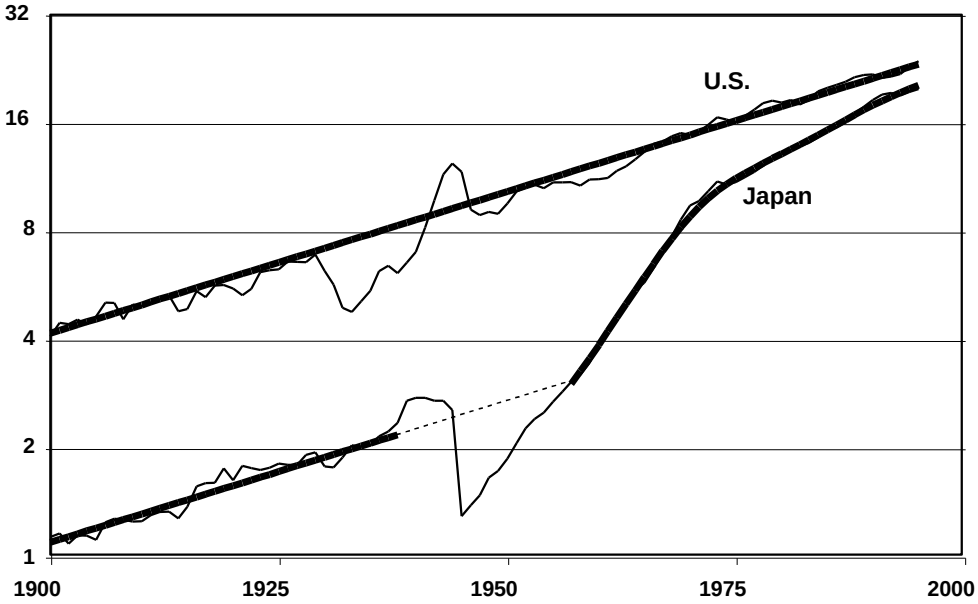
1980 was at 6 percent of the US level and subsequently increased to 8 percent of the US level in 2000. With growth there, the living standard of the average person living in this world has increased both in absolute terms and relative terms.

The catch-up Asia is also due to the growth miracles experienced by Japan, South Korea, Taiwan, Hong Kong, and Singapore. The catch-up between the United States and Japan is shown in Figure 7. It is clear from Figure 7 that Japan did not return to its pre-World War II path.

Not all countries have eliminated their gap with the leader after starting modern economic growth. Latin America is one region that has maintained the same relative income level of 25 percent of the US level over the last century. Sub-Sahara Africa has not eliminated any of its gap either. It has fallen further behind the leader over the post-1950 period. Most of the countries there have realized some increase in their living standard over this period, but lost ground relative to the United States as these increases have been smaller than the ones realized by the United States in this period.

The growth miracles experienced by Japan, South Korea, Taiwan, Hong Kong, Singapore, and most recently China in the post 1950 period are unprecedented. These countries were able to double their incomes in a decade or less. In terms of growth rates, these countries' per capita GDPs grew on average at more than 6 percent per year.

Figure 7: Trends in Output per Capita 1900-1995 (1990 $US)

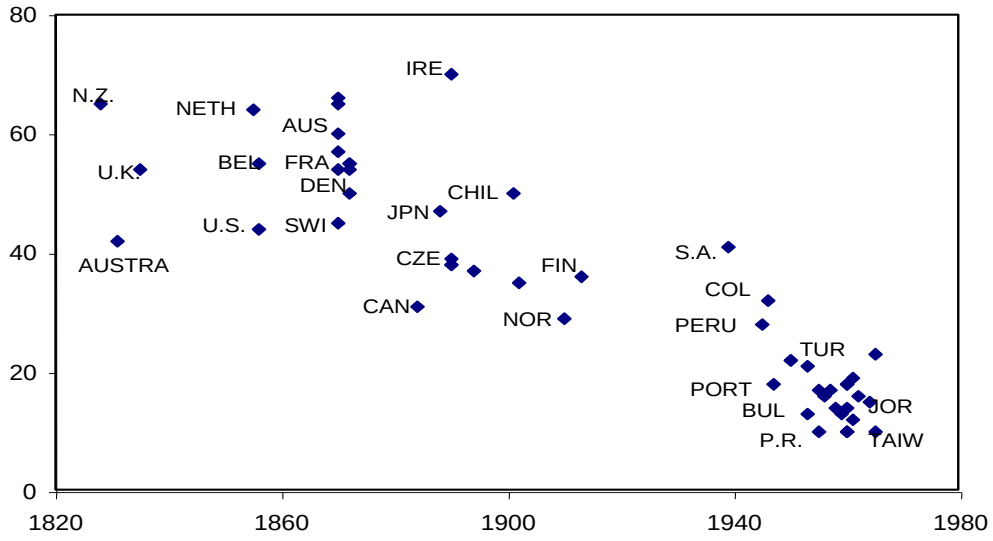


These growth miracles are a recent phenomenon; no country was able to double its income in a decade or less before 1950. Additionally, these miracles are limited to countries that were poor relative to the industrial leader at the time their miracles started. We have never observed the leader or a country with an income gap less than one half the leader's, double its per capita income in less than a decade. This suggests that there is an advantage associated with being a late starter, something noted by Alexander Gerschenkron in 1951.

Late starters do seem to have an advantage over earlier starters. Figure 8 documents this general pattern. It plots the number of years it took a country to go form 10 percent to 20 percent of the 1985 US per capita GDP level versus the first year that the country achieved the 10 percent level. 1985 per capita GDP was 20,000 in 1990 dollars. The difference in the length of doubling period between the set of late starters and the set of

earlier starters is dramatic. For early starters, which are those achieving 10 percent of the US level before 1950, the median length of the doubling period is 45 years. For late starters, defined as those achieving 10 percent of the 1985 US level after 1950, the median length of the doubling period is 15 years. The choice of the starting level in unimportant. A similar pattern emerges when the starting level is fixed at 5 percent or 20 percent of the 1985 US level.

Figure 8: Years for Per Capita Income to Grow from 2000 to 4000 (1990 $US)



III. Conclusion

Today, huge disparity characterizes the distribution of international income levels. Three-hundred years ago, this disparity was small. We know that the rise in this disparity is the result of different countries starting to grow at different dates. Why some

countries started to grow earlier than others is a critical question we shall want to address in the next chapters.

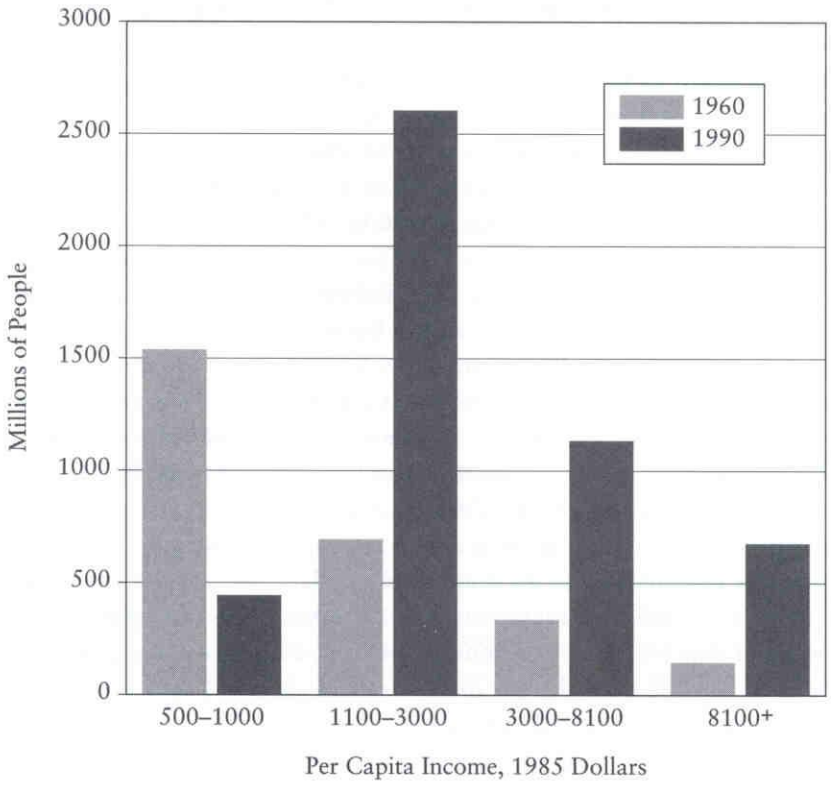
Subsequent to starting to grow, the experience of late starters has varied dramatically. Some countries, especially those located in Asia, have eliminated much of their gaps with the early starters. Some countries, particularly, those located in Central and South America have not eliminated any part of their gap with the leaders over the last century. Some of the countries that have eliminated much of their gap with the leader were able to double their incomes in a decade or less. These growth miracles are a very recent phenomenon and are reserved to poor countries. This suggests there is an advantage to being a late starter. Indeed, analyzing the data over the last three centuries, we see that late starters have been able to double their incomes in far shorter periods of time. Of course, not all late starters have bettered early starters in this regard, but it does suggest a possibility that never exited earlier.

For sure, there are still a large number of countries that remain extremely poor today. However, a consequence of the catch-up that has occurred in the post World War II period, particularly in China and India where most of the world's population lives, is that the welfare of the average person in the world has increased dramatically over the last 50 years. This is shown in Figure 9, which is taken from Lucas (2002). Figure 9 plots the distribution of income across people in the world. In contrast to the other figures in this chapter, this figure does not use the country as the basis for the GDP measurement. The estimates in this figure take each country's per capita GDP and multiply that number by

the country's population. This then allows us to determine the number of people in the world with a certain living standard. Thus, Figure 9 shows the distribution of income across people in the world, rather than the distribution across countries.

Since 1960, there has been a large decrease in the number of people with per capita GDP between $500 and $1000 1985 US dollars. Yes, there is still a large number of people living in poverty, but the good news is that this number is falling.

Figure 9: Distribution of World Income 1960 and 1990



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Lucas, Robert E. 2002. Lectures on Economic Growth. Cambridge and London: Harvard University Press.

Mokyr, Joel (1990). The Lever of Riches: Technological Creativity and Economic Progress. Oxford: Oxford University Press.

Problems:

For these problems you will need to download data from the PWT7.1 data set. The address is https://pwt.sas.upenn.edu/php_site/pwt71/pwt71_form.php

1. Determine the relationship between savings rates and per capita incomes in 1960 and 2000. To do this, you will need to download for all countries the variable ci and y in both 1960 and 2000 in the PWT7.1. The variable labeled *ci* is the investment share of GDP (i.e. savings rate) and the variable labeled *y* is per capita GDP of a country expressed relative to the US level in percentage terms. Thus if y=50 in the data, it means that country i has a per capita GDP in 1960 that is ½ the US level in that year.
Hand in a scatter plot for 1960 and 2000. Also calculate and hand in the correlation coefficient for saving rates and income levels in 1960 and 2000.
Note: I suggest you download the data in two steps. The first is for 1960 and the second is for 2000. To import into an excel file, you should Select "CSV" and click on the "Send" button. Once the data is produced for you, copy it with your browser. Open up excel and paste. Now click on the data heading and then click on the "Text to Columns" option. On the first page, make sure delimited option is checked, then click the "next" button. On the next page, check the tab and comma options. Click Next and then Click Finished. Repeat this for the 2000 download.

2: Calibrated Solow Model. Next calculate the average annual population growth rate for each country between 1960 and 2000. If either the 1960 or 2000 data is missing, use the first the years closest to these years for which data is available. For this you will need to download the variable labeled POP in the PWT7.1. Now use the savings rate for 2000 for each country you imported in Question 1. Assume all countries have the same depreciation rate $\delta = .05$, the same rate of exogenous technological change, $\gamma = .02$, and the same TFP parameter A=1. Use the formula for the ratio of the balanced growth path per capita output for the Solow model that we used in the 2/10/2014 class $y_{i,t}^{BGP} / y_{US,t}^{BGP}$, where the comparison is being made to the US. More specifically, take the average savings rate and average annual population growth rate for each country and compute its output per capita relative to the US level.

Hand in a scatter plot which relates Solow relative GDPs per capita $100y_{i,t}^{BGP} / y_{US,t}^{BGP}$ and actual relative 2000 GDPs per capita (i.e. y in the data). We multiply Solow relative GDP per capita by 100 so as to put it in percentage terms as is the case with the variable y.

3. Download the variable y for each country in 1960, 1970, 1980, 1990 and 2000. Next, remove from the spreadsheet any country for which data is missing in one of these five years. In doing so, you will end up with a balanced panel.

a. For each year, calculate the standard deviation of relative per capita GDP. Hand in a plot of the standard deviation against time.

b. For each year, compute the average relative income of the top 5% of the richest countries in each year. Do this for the poorest 5% of countries as well. Hand in a plot that shows the ratio of the top 5% to bottom 5% against time.

c. For each year, calculate the average relative income. Hand in a plot that shows the average in each year.

d. For each of the 5 years, calculate the median relative income. Hand in a plot that shows the median relative income.

Note: You can put the plots for (b), (c) and (d) on one figure.

4. Now download the variable rgdpch, real per capita GDP (Chain Series) for all countries in 1960 and 2000. For those countries for which data is available in both years, compute the average annual growth rates.

a. Hand in a scatter plot of average annual growth rate against a country's 1960 the logarithm of per capita GDP.

b. Hand in the names of the 10 fastest growing economies over this time period, and the names of the 10 slowest growing economies over this time period.