What causes real GDP per capita to rise by 2% per year in the long run? Why does real GDP growth not converge to zero? Why do some countries grow faster than others? Why do some countries not grow at all? These are the most important questions in macro and perhaps the most important questions period. Small differences in the long run growth rate is the difference between being rich and poor in a matter of a generation.

Consider Canada, which grew at 2.15% per year over 1870-1990 and Argentina, which grew at 1.09% per year from 1900-1987.

- Argentina and Canada were similar countries with similar GDP’s in the late 1800’s.
- Canada grew 1.06% faster and is now developed. The average Canadian is more than 12 times as wealthy as his great grandfather.
- The average Argentinian is only 2.5 times as wealthy as his great grandfather.
- The average Canadian enjoys many things Argentinians do not: high quality health care, more leisure time, a cleaner environment, and all the latest gadgets.

Consider now China, which grew at 1.71% from 1900-87 and Bangladesh, which grew at 0.08% during the same period.

- Both were essentially farming economies in 1900.
- Both were vulnerable to floods and natural disasters.
- The average Chinese person makes more than 4 times his great grandfather.
- The average Bangladesh person is in about the same position as his great grandfather and the country is still vulnerable to natural disasters.

I Determinants of Long Run Growth (chapter 8)

Definition 49 Aggregate Demand is the relationship between total demand for real goods and services (real GDP) by consumers, firms, government, and foreigners and a price index.

Definition 50 Aggregate Supply is the relationship between the total value of all real goods and services (real GDP) produced in the economy and a price index.
Aggregate Supply:

- Looks at real GDP from the production (value added) side.
- Inputs capital, labor, and technology grow steadily.
- Growth in inputs is therefore a good place to look for causes of long run growth.

Aggregate Demand:

- Looks at real GDP from the spending (spending approach) side.
- Volatility in investment spending creates volatility in total spending which is aggregate demand.
- Aggregate demand is a good place to look for causes of business cycles.

Aggregate supply is determined from a production function. Let $y$ be production or real GDP, $N$ be hours worked (note total population $L$ is used in the book), $K$ be capital, and $T$ be technology. Then:

$$y = f(N, K, T) \tag{55}$$

So a long run increase in real GDP must come from increases in $N$, $K$, or $T$ or some combination. Let’s check them out one by one.

A Can Long Run Growth Result From Increased Hours Alone?

Hours worked on an individual basis does not change much. But populations grow and so total hours also grows. Additionally, the percent of the population working has grown as retirees work more and women work more. Hold $K$ and $T$ constant then:
As we increase $N$ through population growth, we increase hours and so we increase real GDP. But:

**Definition 51 Diminishing Returns to Labor**: successive increases in the use of labor input results in a decline in additional production per unit of labor.

Eventually, with a fixed number of machines and a growing number of workers, the workers will begin to crowd around each machine and get in each other’s way. Eventually, additional workers do not add much to the total amount produced.

Examples:

- Johnny Rockets ice cream machine.
- Switzerland: growth but no population growth.

Therefore, population increases alone cannot account for the long run growth of output, especially output per person.

**B Can Long Run Growth Result From Increases in Capital Alone?**

Capital has also increased over the years, but also faces diminishing returns. Hold $N$ and $T$ constant, then we have:
But eventually, more machines without workers to operate them will sit idle and not be able to produce much more output.

Definition 52 Diminishing Returns to Capital: successive increases in the use of capital input results in a decline in additional production per unit of capital.

The Johnny Rockets ice cream machine example works here as well.

C Can Long Run Growth Result From Balanced Growth?

1 Balanced Growth

Definition 53 Balanced Growth: Capital and Labor Inputs grow together

It is easy to see that in the long run, we must see balanced growth. Suppose capital grew at a faster rate than labor. Then after some time, many more machines would exist than workers. Adding an extra machine would not be smart, no one would be around to operate it. Starting a new business would be a mistake. Existing workers would be in such demand that wages would be really high, making it difficult to make money. So capital growth would slow until labor growth catches up.

Suppose that labor grew faster than capital. Then many more workers would exist than machines. Such workers would be willing to work for very low wages, since most would be unemployed. This would be an attractive time to add a new machine or start a new business. Labor costs are low so it would be easy to make money. In this way, capital would grow faster than labor until the capital growth caught up.

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2 Catch up Hypothesis

Note the following implication of balanced growth.

- Less developed countries should have relatively large populations and have a smaller capital stock.
- Less developed countries should have low wages.
- Less developed countries should see higher capital inflows.
- More developed countries should see immigration.
- Less developed countries should grow faster than developed countries.

The evidence for most of the above implications are good. Less developed countries do have low wages and small capital stocks. More developed countries see immigration. The last implication is very important, but less clear.

**Definition 54** Catch up Hypothesis: Less developed countries should grow faster than developed countries

3 Evidence for and against Catch up

As seen in the graphs presented, there is evidence both ways.

- Japan, Germany post WWII. Yes.
- US States after Civil War. Yes.
- Developed countries since 1960. Yes.
- No global evidence.

So the evidence seems to favor catch-up only for countries that are similar except for the initial size of their capital stock.

4 Total GDP versus GDP/person

Notice that balanced growth will grow total GDP, as both capital and labor increase together. However, balanced growth alone will not increase output per person. With balanced growth, each time we add a person we add some capital and therefore some production. So each person adds a fixed amount to the total GDP and per capita GDP is unchanged.
D Technology

Definition 55 Technology is anything that raises the amount of output that is produced from a given amount of capital and labor.

1 Types of Technical Change

Technological change includes many things. Some types of technological change:

- INNOVATION: Applications of new knowledge in a way that increases production. May exhibit diminishing returns. Faster chip.
- LEARNING BY DOING: By repeating a task, workers become more proficient. May exhibit diminishing returns. Learning to use a computer.

Technology can also decrease. Examples:

- Bad weather decreases crop output despite same capital and labor.
- Government problems: Government may subsidize inefficient technologies (e.g., airlines). Example of two airline technologies: point-to-point (Southwest) and hub-and-spoke (US Air, hub in Pittsburgh). Suppose point to point is at a higher technology ($T_p > T_h$). Total output is:

\[
Y = F(N_p, K_p, T_p) + F(N_h, K_h, T_h)
\]  

(56)

Now suppose the government subsidizes US Air. Then capital and labor flow to US Air (US Air is able to use the subsidies to expand operations). Some $K_p$ and $N_p$ are able to produce less than previously. Economy wide technology falls.

2 Possible sources of growth in GDP per capita

So in general we have two possibilities: balanced growth in which capital and hours grow together, and technology growth through new inventions.
E Growth Accounting

Is there a way to determine scientifically which of the three inputs accounts for long run growth?

**GROWTH ACCOUNTING FORMULA** Tells how much of long run growth is due to increases in capital, total hours, and technology.

There are two versions:

1. **Total Real GDP Growth**

   \[
   \text{growth rate, GDP} = \frac{1}{3} \text{(growth rate, capital)} + \frac{2}{3} \text{(growth rate, total hours)} + \text{growth rate, technology} \quad (57)
   \]

   Where does the number \( \frac{1}{3} \) come from? Well, one way to get the number is to look at average change in capital versus average change in output. On average, for each extra dollar of capital, output goes up by 33 cents. Alternatively, one can rely on economic theory, which says that inputs are paid according to their contribution to production. It turns out that capital income (profits, dividends, etc.) are about one third of total income.


   \[
   2.92\% = \frac{1}{3}1.7\% + \frac{2}{3}2.01\% + g_T \quad (59)
   \]

   \[
   2.92\% = 1.9\% + g_T \quad (60)
   \]

   \[
   g_T = 1.02\% \quad (61)
   \]

   Thus about two thirds of all long run growth in total GDP comes from balanced growth, and one third from technological change.

2. **Growth in Real GDP per capita**

   Of more importance is real GDP per capita.
growth rate, GDP per person = \frac{1}{3} \text{(growth rate, capital per person)} + \text{growth rate, technology} \tag{62}

Example 2: long run US growth in productivity:

\[ 1.9\% = \frac{1}{3} 1.8\% + g_T \tag{64} \]

\[ 1.9\% = 0.6\% + g_T \tag{65} \]

\[ g_T = 1.3\% \tag{66} \]

Thus two thirds of real GDP growth per person (productivity growth) comes from technological change, the rest from balanced growth.

Contribution: \( x = \frac{g_x}{g_y} \tag{67} \)

Contribution: \( T = \frac{1.3\%}{1.9\%} = \frac{2}{3} \tag{68} \)

Contribution: \( K/N = \frac{0.6\%}{1.9\%} = \frac{1}{3} \tag{69} \)

Example 3: 1970s productivity slowdown in the US. See graph. We see that most of the productivity slowdown can be accounted for by the lack of increase in technology.

\textbf{II Government Policies to Encourage Growth}

Technology growth accounts for most of long run productivity growth. Inventions and technology are a special market. Not only is technology important for long run growth, but it is undersupplied in a market economy. This is because others may copy your invention or produce innovations on your invention without compensating the inventor. Thus there is a disincentive to invent because you cannot fully protect your invention.

Two types of technical change:
Definition 56  *Embodied technical change is technical change that occurs through improvements in labor or capital*

Definition 57  *Disembodied technical change requires no labor or capital*

A  **Encourage growth by subsidizing human capital**

This is embodied technical change. Includes:

1. College loans and other school subsidies. An increase of 2.5 years of school equals a 1% increase in the economic growth rate.

2. Government sponsored training programs.

3. Improve school quality.

4. Improve life expectancy, through better health care. An increase of 12.5 years of life expectancy equals a 1% increase in growth rate.

B  **Encourage growth by subsidizing new capital**

Some technologies require new capital spending. New capital spending usually has the latest technology.

1. Lower or eliminate taxes on capital: profits taxes, capital gains taxes, dividend taxes. These are by far the worst taxes. Not only do they slow down technology growth by inhibiting adoption of new technologies, but they force the economy to use too much labor and too little capital, leading to lower technology due to inefficient mix of labor and capital. Changes in capital taxes have large effects on, for example, stock market performance. Recently, many increases in capital taxes have passed are more are in the works.

2. Investment incentives for firms such as depreciation allowances and other tax credits.

3. Protect private property (property rights). To encourage investment, need protection so that investment is not stolen by government or private entities.

   (a) Looting. Destruction or theft of business property. LA riots, riots in Haiti.

   (b) Clear Titling. Clearly owned property can be used as collateral for loans to start a new business.
(c) Eliminating restrictive zoning rules. Can UM expand operations by building grad housing?


(e) Reduce Crime.

4. Eliminate regulation for starting a new business. In Peru it takes many years and several times the average wage to start a new business. The median firm size is one employee. Firms are inefficient because firms with few workers cannot efficiently add capital and workers to grow their business. Example of taxis versus vans.

5. Eliminate subsidies for inefficient technologies (reduce bailouts). Suppose firms vary in productivity levels. Then the worst firms will tend to go bankrupt, increasing technology. But if the government subsidizes, then inefficient firms may remain. Examples include steel subsidies and farm subsidies.

6. Improve functioning of credit markets. Shut down the banking sector and you inhibit borrowing to start new businesses. Argentina’s banks example.


C Encourage growth by subsidizing new Disembodied Technical Change

These include:

1. Government sponsored R&D. NIH, NSF.

2. Tax credits for private R&D.

3. Improve patent protection. Problem: monopoly may discourage innovation by the monopolist.