

Growth: An Introduction

Background

Ultimately long-run growth is *the* most important aspect of how the economy performs. Material standards of living and levels of economic productivity in the United States today are about four times what they are today in, say, Mexico—and five or so times what they were at the end of the nineteenth century—because of rapid, sustained long-run economic growth. Good and bad policies can accelerate or cripple this growth. Argentines were richer than Swedes before World War I, but Swedes today have four times the standard of living and the productivity level of Argentines. Almost all of this difference is due to differences in growth policies working through two channels. The first is the impact of policies on the economy's *technology* that multiplies the efficiency of labor. The second is their impact on the economy's *capital intensity*—the stock of machines, equipment, and buildings.

In this growth section, Chapter 5 analyzes the facts of economic growth. Chapter 4 focuses on the theory. Its aim is to build up the growth model that economists use to analyze how much growth is generated by the advance of technology and how much by investment to boost capital intensity on the other.

Better Technology

The bulk of the reason that Americans today are more productive than their predecessors of a century ago is better technology. We now know

how to make electric motors, dope semiconductors, transmit signals over fiber optics, fly jet airplanes, machine internal combustion engines, build tall and durable structures out of concrete and steel, record entertainment programs on magnetic tape, make hybrid seeds, fertilize crops with nutrients, organize assembly lines, and a host of other things our predecessors did not know how to do. Better technology leads to a higher *efficiency of labor*--the skills and education of the labor force, the ability of the labor force to handle modern machine technologies, and the efficiency with which the economy's businesses and markets function.

Capital Intensity

However, a large part is also played by the second factor: *capital intensity*. The more capital the average worker has at his or her disposal to amplify productivity, the more prosperous the economy will be. In turn, there are two principal determinants of capital intensity. The first is the *investment effort* made by the economy: the share of total production--real GDP-- saved and invested to boost the capital stock. The second are the economy's *investment requirements*: how much new investment is needed to simply equip new workers with the standard level of capital, to keep up with new technology, and to replace worn- machines and buildings.

The ratio between the investment effort and the investment requirements of the economy determines the economy's capital intensity. Capital intensity is measured by the economy's capital-output ratio K/Y —the economy's capital stock K divided by its annual real GDP Y —which we will write using a lower-case Greek kappa, κ .

$$\kappa = \frac{K}{Y}$$

The Balanced-Growth Path

In economists' standard *growth model*¹ the type of equilibrium they study is a *balanced-growth equilibrium*. In the balanced-growth equilibrium the capital intensity of the economy—its capital stock divided by its total output—is constant. However, other variables like the capital stock, real GDP, and output per worker are growing.

Economists use the standard model to calculate the balanced-growth path. They then forecast that if the economy is on this path, it will grow along this path. And they forecast that if the economy is not on its balanced growth path, it will head toward that path.

The Steady-State Capital-Output Ratio

What is the economy's balanced-growth path? On the balanced-growth path, the economy's capital-output ratio—which we write κ —is equal to its particular steady-state value κ^* . We calculate this value by taking the share of production that is saved and invested for the future—the economy's saving-investment rate s —and then dividing it by the sum of the depreciation rate at which capital wears out (written δ), the proportional growth rate (written n) of the labor force, and the

¹ The standard model is called the Solow model, after Nobel Prize-winning M.I.T. economist Robert Solow.

proportional growth rate (written g) of the efficiency of labor.² In algebra:

$$\kappa^* = \frac{s}{n + g + \delta}$$

Along the balanced-growth path, the level of output per worker Y/L is found by raising the steady-state capital-output ratio κ^* to the power of the growth multiplier (written λ)³, and then multiplying the result by the current efficiency of labor (written E_t). In algebra:

$$\frac{Y_t}{L_t} = \kappa^{*\lambda} \times E_t$$

The steady-state capital-output ratio κ^* is constant (as long as the economy's savings-investment share s , its labor force growth rate n , and its efficiency of labor growth rate g do not change). However, the balanced-growth path level of output per worker is not constant. As time passes, the balanced-growth path level of output per worker rises. Why? Because output per worker Y/L is equal to the *current* efficiency of labor E_t times the steady-state capital-output ratio κ^*

² Recall that we call these last three *investment requirements*.

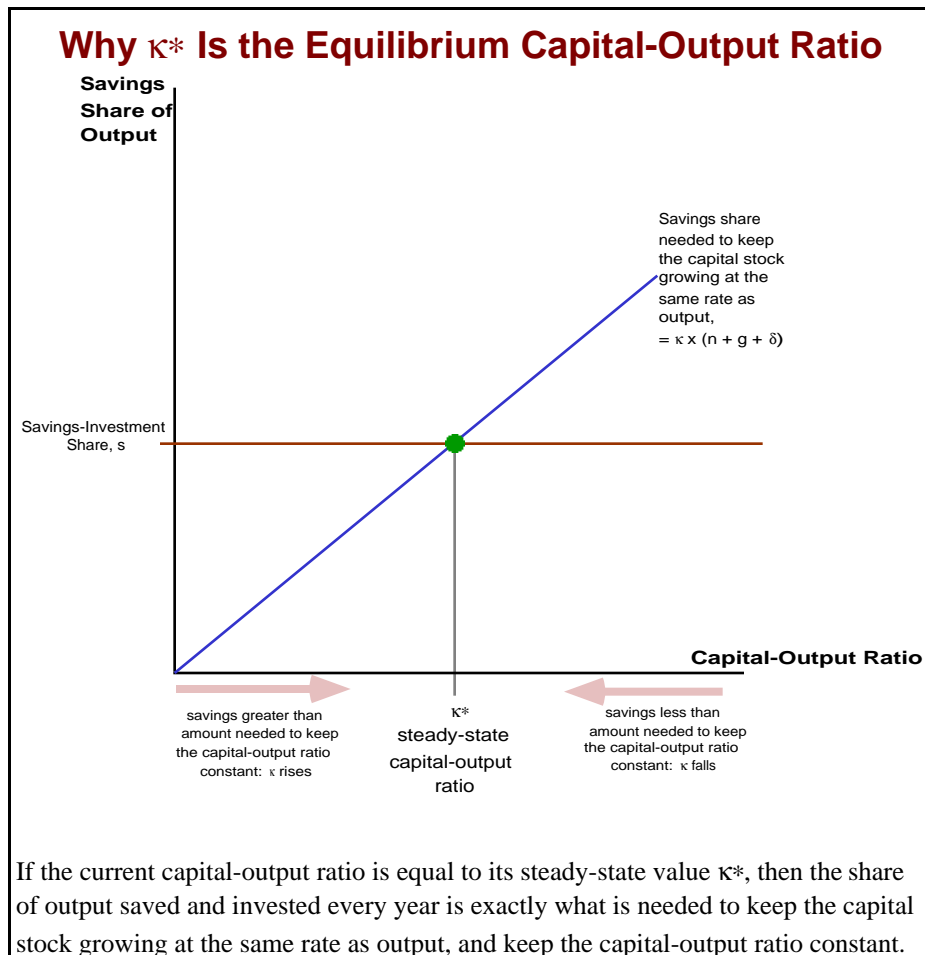
³ λ , the growth multiplier, is

$$\lambda = \frac{\alpha}{1 - \alpha}$$

where α is the diminishing-returns-to-scale parameter from last chapter's production function $Y/L = (K/L)^\alpha \times E^{1-\alpha}$. It tells by how much (in percentage terms) the economy's output would rise if its capital stock were to grow by one percent.

raised to the power λ ; and technological progress means that the efficiency of labor E_t grows at a proportional growth rate g .

Is the economy always on its balanced-growth path? No. But if the economy is not on it, it is heading towards it.



If the capital-output ratio κ is below κ^* , the share of output invested each year (equal to s) is greater than needed to keep the capital stock

growing as fast as output (equal to $\kappa(n + g + \delta)$). The capital-output ratio rises. If the capital-output ratio is above κ^* , the share invested each year (equal to s) is less than needed to keep the capital stock growing as fast as output (equal to $\kappa(n + g + \delta)$). The capital-output ratio falls. The economy closes some of the gap between its current position and its steady-state growth path.

The Determinants of the Balanced-Growth Path

Thus the steady-state balanced growth path depends on five factors:

1. the economy's savings-investment rate, the share of output used to buy investment goods to boost the capital stock (written s)
2. the growth rate of the efficiency of labor (written g)
3. the depreciation rate—the proportion of the existing capital stock K that wears out or becomes obsolete every year (written δ)
4. the economy's labor force growth rate (written n)
5. the economy's growth multiplier (written λ , equal to $\alpha/(1-\alpha)$, where α comes from the production function)
6. the current efficiency of labor—a measure of the economy's ability to use technology, where “technology” is defined in the broadest possible sense to include work organization, incentives, and all other factors that affect the ability of the economy to use resources to produce goods and services. (written E_t).

Factors (1) through (4) determine the steady-state capital-output ratio κ^* , which is then raised to the λ power (factor (5)), and the result is then multiplied by the current efficiency of labor E_t (factor (6)).

Forecasting the Economy's Destiny

The standard Solow growth model makes forecasting an economy's long-run growth destiny simple:

1. Calculate the steady-state capital-output ratio, $\kappa^* = s/(n+g+\delta)$, equal to the savings share divided by the investment requirements.
2. Amplify the steady-state capital-output ratio κ^* by raising it to the power of the growth multiplier $\lambda = (\alpha/(1-\alpha))$, where α is the production function's diminishing-returns-to-scale parameter.
3. Multiply the result by the current efficiency of labor E_t .

You have just calculated output per worker on the economy's *balanced-growth path*. If you just want to understand the present, you are done. If you want to also forecast the future, then:

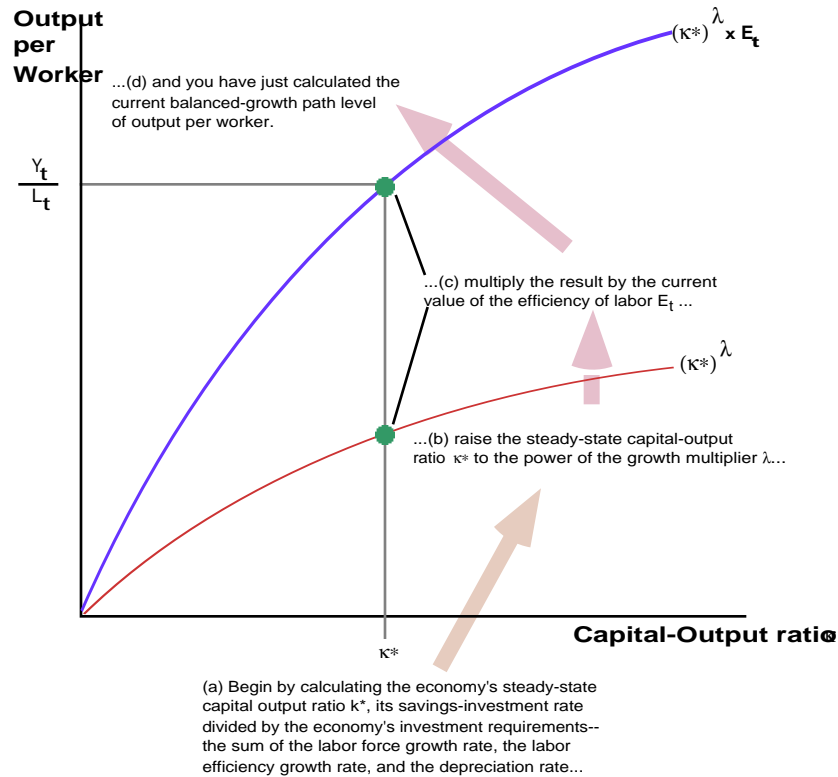
4. Forecast that balanced-growth output per worker will grow at the same proportional rate g as labor efficiency.

If the economy is on its balanced-growth path, you are done. But if the economy is not currently on its balanced-growth path, then:

5. Forecast that the economy is heading for its balanced-growth path.
6. Forecast that the economy will grow along its balanced-growth path after it has converged to it.

The growth model makes forecasts of the long-run destiny of the economy straightforward, and provides an easy way to analyze how the factors making for (a) higher capital intensity and (b) better technology and labor efficiency determine output per worker.

How to Calculate the Economy's Balanced-Growth Path



Calculating the balanced-growth level of output per worker is simple: (i) calculate the steady-state capital-output ratio κ^* , (ii) raise κ^* to the power of the growth multiplier λ , and (iii) multiply the result by the efficiency of labor E_t .

Why, and how, does this growth model work? Why is there a steady-state growth path? Why do these calculations above tell us what it is? To understand these issues, we need to back up and dig a little deeper. To explain them is the business of Chapter 4, to which we now turn.