Leseaufträge «Mikroökonomik I»

Modul 3: Produktion und Kosten

Unit 2:

- Kurzfristige Produktion

Quellen:

- **Chapter 10 – Production**
  Frank, Robert H, & Cartwright, Edward. (2016). *Microeconomics and Behaviour (2nd European ed.)*. London: McGraw-Hill Education.

salaried job, but would also cost money. And the salary she earns may not be enough to compensate. Indeed, many families find that the costs of childcare exceed the wage they can earn on the job market.

Seen in this light Alice 'earns' money for her family even though she does not get a pay cheque at the end of the month. In particular, there is a significant opportunity cost of her not doing the housework. It is important to recognize this opportunity cost.

Note, however, that national accounts do not take account of household production. If Alice pays someone to, say, look after her child then it counts in the GDP statistics. If she looks after the child at home then it does not count. This creates a non-negligible bias in the statistics. Household production, for example, has decreased considerably over the last 100 years. We use childcare more, eat out at restaurants more, hire domestic cleaners, and so forth. This means that estimates of GDP growth over the last 100 years are biased upwards. ■

Intermediate Products

Capital (as embodied, for example, in the form of stoves and frying pans) and labour (as embodied in the services of a chef) are clearly by themselves insufficient to produce meals. Raw foodstuffs are also necessary. The production process described by Equation 10.1 is one that transforms raw foodstuffs into the finished product we call meals. In this process, foodstuffs are *intermediate products,* which many economists treat as inputs like any others. For the sake of simplicity, we will ignore intermediate products in the examples we discuss in this chapter. But this feature could be built into all these examples without changing any of our essential conclusions.

SHORT RUN AND LONG RUN

The production function tells us how output will vary if some or all of the inputs are varied. In practice, there are many production processes in which the quantities of at least some inputs cannot be altered quickly. The FM radio broadcast of classical music is one such process. To carry it out, complex electronic equipment is needed, and also a music library and a large transmission tower. Music files can be purchased in a matter of minutes. But it may take weeks to acquire the needed equipment to launch a new station, and months or even years to purchase a suitable location and construct a new transmission tower.

long run the shortest period of time required to alter the amounts of all inputs used in a production process.

short run the longest period of time during which at least one of the inputs used in a production process cannot be varied.

variable input an input that can be varied in the short run.

fixed input an input that cannot vary in the short run.

The **long run** for a particular production process is defined as the shortest period of time required to alter the amounts of *every* input. The **short run**, by contrast, is defined as that period during which one or more inputs cannot be varied. Clearly this distinction is somewhat arbitrary. There may be some inputs that can be varied in a matter of minutes, some a matter of weeks, and others a matter of years or decades. Where we draw the line between the long and short run is, therefore, often a matter of judgement. We shall see, though, in this and subsequent chapters that the distinction is a very useful one.

An input whose quantity can be altered in the short run is called a **variable input**. One whose quantity cannot be altered—except perhaps at prohibitive cost—within a given time period is called a **fixed input**. In the long run, all inputs are variable inputs, by definition. In the classical music broadcast example, music files are variable inputs in the short run, but the broadcast tower is a fixed input. If sufficient time elapses, however, even it becomes a variable input.

Note that the long run is determined by the ease with which inputs can be varied and so should not be equated to a period of calendar time. In some production activities, like those of a window cleaner, the long run could be a matter of weeks. In other production activities, like that of a ship builder, the long run could be years or decades. The period of time it takes to vary inputs can also change with technological progress, as the following Economic Naturalist illustrates.

Why does it take so long to produce a blockbuster movie?

ECONOMIC NATURALIST 10.2

In the 1950s making a movie was a very involved process indeed. Any kind of filming required huge cameras. Editing involved cutting and splicing together film reels. And the only way the film could be viewed would be at a cinema.

In the 2010s anyone with a smartphone can produce high quality imagery. Editing can be done almost effortlessly with the latest software. And the movie can be on YouTube for all to see in the time it takes to connect to the internet.

Yet, the time it takes to produce a blockbuster movie has, if anything, increased since the 1950s. The *Lego* movie, for example, took an impressive four years to make. So, why have massive advances in technology not translated into shorter production times?

Changes in technology have undoubtedly changed the production function. Inputs that may have been fixed in the 1950s, such as cameras, editing equipment and film location, are now much more easily changed in the short run.

A good film, though, is about more than filming. It is also about actors, directors and the script. And these are as hard to change now as in the 1950s. They are fixed inputs. And no amount of technology is going to change that. The *Lego* movie, for example, took so long to produce because of extensive rewrites to the script.

What's more, the ease with which films can now be produced means cinema goers will inevitably be more discerning. They want to watch movies that are better than they can download for free on YouTube. That means the actors and script need to be better now than in the 1950s. ■

We begin the next section by considering short-run production and then we move on to long-run production in the following section.

PRODUCTION IN THE SHORT RUN

Consider again the production process described by $Q = F(K, L) = 2KL$, the simple two-input production function described in Table 10.1. And suppose we are concerned with production in the short run—here, a period of time in which the labour input is variable but the capital input is fixed, say, at the value $K = K_0 = 1$. With capital held constant, output becomes, in effect, a function of only the variable input, labour: $F(K, L) = 2K_0L = 2L$. This means we can plot the production function in a two-dimensional diagram, as in Figure 10.2(a). For this particular $F(K, L)$, the short-run production function is a straight line through the origin whose slope is 2 times the fixed

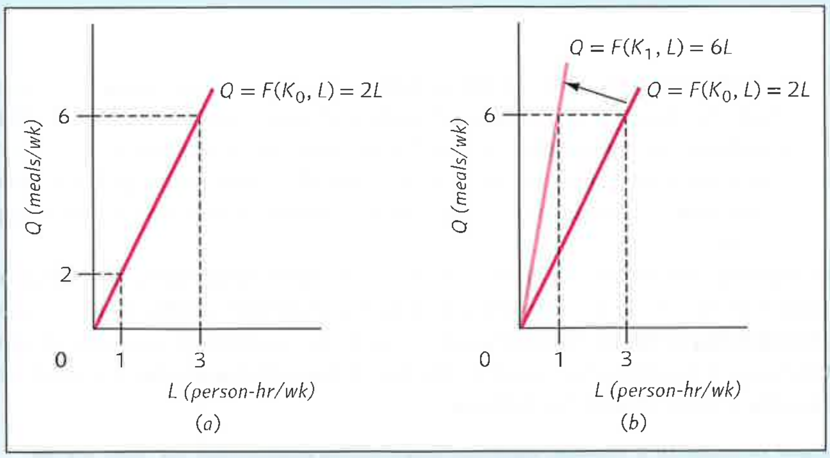


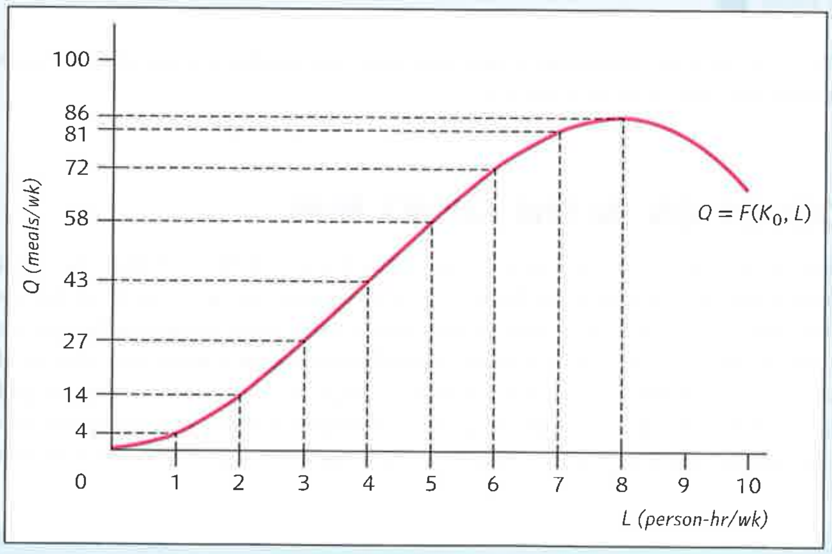
FIGURE 10.2
A Specific Short-Run Production Function
Panel (a) shows the production function, $Q = 2KL$, with K fixed at $K_0 = 1$. Panel (b) shows how the short-run production function shifts when K is increased to $K_1 = 3$.

value of K: thus, $\Delta Q/\Delta L = 2K_0$. In Figure 10.2(b), note that the short-run production rotates upward to $F(K_1, L) = 6L$ when K rises to $K_1 = 3$.

EXERCISE 10.1 Graph the short-run production function for $F(K, L) = \sqrt{K}\sqrt{L}$ when K is fixed at $K_0 = 4$.

As you saw in Exercise 10.1, the graphs of short-run production functions will not always be straight lines. The short-run production function shown in Figure 10.3 has several properties that are commonly found in production functions observed in practice. First, it passes through the origin, which is to say that we get no output if we use no variable input. Second, initially the addition of variable inputs augments output at an increasing rate: moving from 1 to 2 units of labour yields 10 extra units of output, while moving from 2 to 3 units of labour gives 13 additional units. Finally, the function shown in Figure 10.3 has the property that beyond some point ($L = 4$ in the diagram), additional units of the variable input give rise to smaller and smaller increments in output. Thus, the move from 5 to 6 units of labour yields 14 extra units of output, while the move from 6 to 7 units of labour yields only 9. For some production functions, the level of output may actually decline with additional units of the variable input beyond some point, as happens here for $L > 8$. With a limited amount of capital to work with, additional workers may eventually begin to get in one another's way.

FIGURE 10.3
Another Short-Run Production Function
The curvilinear shape shown here is common to many short-run production functions. Output initially grows at an increasing rate as labour increases. Beyond $L = 4$, output grows at a diminishing rate with increases in labour.



law of diminishing returns if other inputs are fixed, the increase in output from an increase in the variable input must eventually decline.

The property that output initially grows at an increasing rate may stem from the benefits of division of tasks and specialization of labour. With one employee, all tasks must be done by the same person, while with two or more employees, tasks may be divided and employees may better perform their dedicated tasks. (Similar logic applies to specializing in one task within any period of time.)

The final property noted about the short-run production function in Figure 10.3—that beyond some point, output grows at a diminishing rate with increases in the variable input—is known as the **law of diminishing returns**. And although it too is not a universal property of short-run production functions, it is extremely common. The law of diminishing returns is a short-run phenomenon. Formally, it may be stated as follows:

> As equal amounts of a variable input are sequentially added while all other inputs are held fixed, the resulting increments to output will eventually diminish.

Why can't all the world's people be fed from the amount of grain grown in a single flowerpot?

ECONOMIC NATURALIST 10.3

The law of diminishing returns suggests that no matter how much labour, fertilizer, water, seed, capital equipment and other inputs are used, only a limited amount of grain could be grown in a single flowerpot. With the land input fixed at such a low level, increases in other inputs would quickly cease to have any effect on total output. ■

Employing the logic of Economic Naturalist 10.3, the British economist Thomas Malthus argued in 1798 that the law of diminishing returns implied eventual misery for the human race. The difficulty is that agricultural land is fixed and, beyond some point, the application of additional labour will yield ever smaller increases in food production. The inevitable result, as Malthus saw it, is that population growth will drive average food consumption down to the starvation level.

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Thomas Malthus failed to anticipate the capacity of productivity growth to keep pace with population growth. But his basic insight—that a planet with fixed resources can support only so many people—remains valid.

Whether Malthus prediction will be borne out in the future remains to be seen. But he would never have imagined that food production per capita would grow more than twenty-fold during the ensuing two centuries. Note carefully, however, that the experience of the last 200 years does not contradict the law of diminishing returns. What Malthus did not foresee was the explosive growth in agricultural technology that has far outstripped the effect of a fixed supply of land. Still, the ruthless logic of Malthus observation remains. No matter how advanced our technology, if population continues to grow, it is just a matter of time before limits on arable land spell persistent food shortages.

The world's population has grown rapidly during the years since Malthus wrote, more than doubling during the last 50 years alone. Are we in fact doomed to eventual starvation? Perhaps not. As the late economist Herbert Stein once famously remarked, 'If something can't go on forever, it won't.' And indeed, population specialists now predict that the earth's population will peak by the year 2070 and then begin to decline.[2] If we don't blow ourselves up in the meantime, there is thus a good chance that we will escape the dire fate that Malthus predicted.

Technological improvements in production are represented graphically by an upward shift in the production function. In Figure 10.4, for example, the curves labelled F_1 and F_2 are used to denote the agricultural production functions in 1808 and 2008, respectively. The law of diminishing returns applies to each of these curves, and yet the growth in food production has kept pace with the increase in labour input during the period shown.

Total, Marginal and Average Products

Short-run production functions like the ones shown in Figures 10.3 and 10.4 are often referred to as **total product curves**. They relate the total amount of output to the quantity of the variable input. Also of interest in many applications is the *marginal product* of a variable input. It is defined as *the change in the total product that occurs in response to a unit change in the variable input (all other inputs held fixed)*. A business manager trying to decide whether to hire or fire another worker has an obvious interest in knowing what the **marginal product** of labour is.

total product curve a curve showing the amount of output as a function of the amount of variable input.

marginal product change in total product due to a unit change in the variable input.

[2]See Wolfgang Lutz, Warren Sanderson and Sergei Sherbov, 'The End of World Population Growth', *Nature*, 412, 2 August 2001: 543–545.

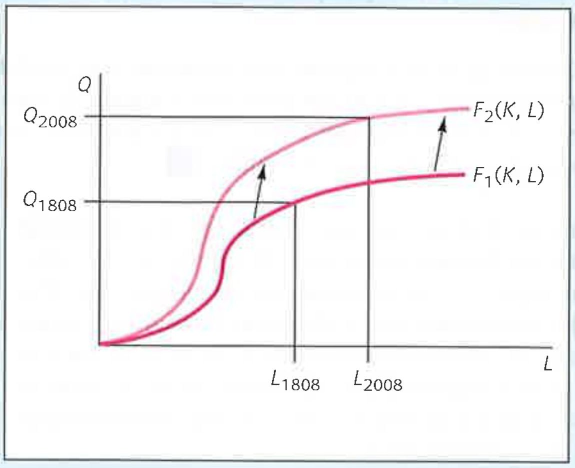

FIGURE 10.4
The Effect of Technological Progress in Food Production
F_1 represents the production function for food in the year 1808. F_2 represents the corresponding function for 2008. The effect of technological progress in food production is to cause F_2 to lie above F_1. Even though the law of diminishing returns applies to both F_1 and F_2, the growth in food production between 1808 and 2008 has more than kept pace with the growth in labour inputs over the same period.

More formally, if ΔL denotes a small change in the variable input, and ΔQ denotes the resulting change in output, then the marginal product of L, denoted MP_L, is defined as

$$MP_L = \frac{\Delta Q}{\Delta L} \tag{10.2}$$

Geometrically, the marginal product at any point is simply the slope of the total product curve at that point, as shown in the top panel of Figure 10.5.[3] For example, the marginal product of labour when $L = 2$ is $MP_{L=2} = 12$. Likewise, $MP_{L=4} = 16$ and $MP_{L=7} = 6$ for the total product curve shown in Figure 10.5. Note, finally, that MP_L is negative for values of L greater than 8.

The marginal product curve itself is plotted in the bottom panel in Figure 10.5. Note that it rises at first, reaches a maximum at $L = 4$, and then declines, finally becoming negative for values of L greater than 8. Note also that the maximum point on the marginal product curve corresponds to the inflection point on the total product curve, the point where its curvature switches from convex (increasing at an increasing rate) to concave (increasing at a decreasing rate). Note also that the marginal product curve reaches zero at the value of L at which the total product curve reaches a maximum.

As we will see in greater detail in later chapters, the importance of the marginal product concept lies in the fact that decisions about running an enterprise most naturally arise in the form of decisions about *changes*. Should we hire another engineer or accountant? Should we reduce the size of the maintenance staff? Should we install another copier? Should we lease another delivery truck?

To answer such questions intelligently, we must compare the benefit of the change in question with its cost. And as we will see, the marginal product concept plays a pivotal role in the calculation of the benefits when we alter the level of a productive input. Looking at Figure 10.5, we may identify a range of values of the variable input that a rational manager would never employ. In particular, as long as labour commands a positive wage, such a manager would never want to employ the variable input in the region where its marginal product is negative ($L > 8$ in Figure 10.5). Equivalently, he would never employ a variable input past the point where the total product curve reaches its maximum value (where $MP_L = 0$).

EXERCISE 10.2 **What is the marginal product of labour when $L = 3$ in the short-run production function shown in Figure 10.2(*a*)? When $L = 1$? Does this short-run production function exhibit diminishing returns to labour?**

[3]The formal definition of the marginal product of a variable input is given by $MP(L) = \partial F(K, L)/\partial L$.

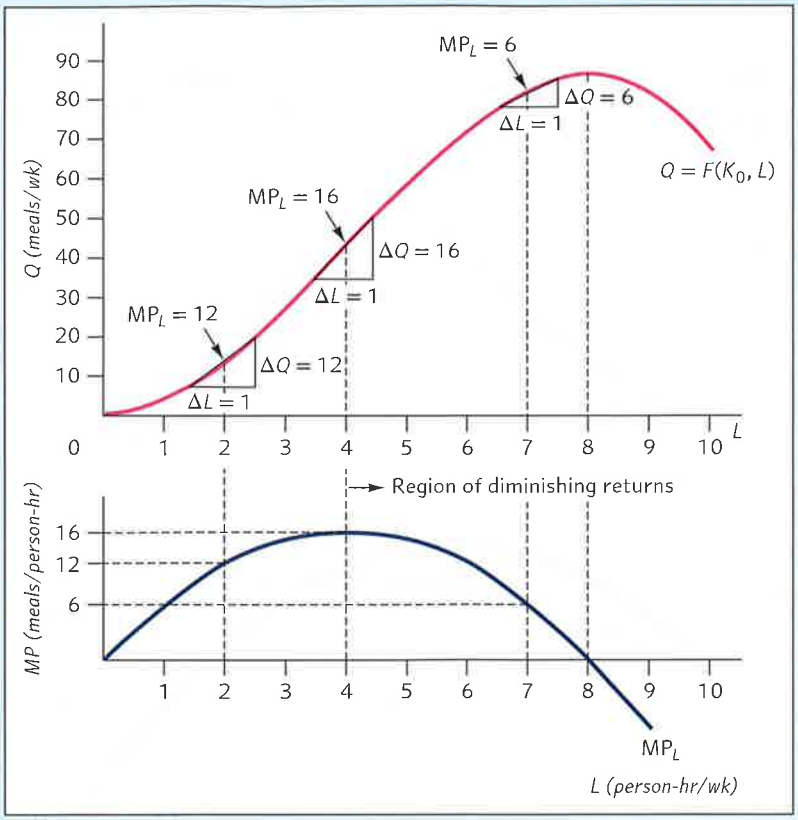

FIGURE 10.5
The Marginal Product of a Variable Input
At any point, the marginal product of labour, MP_L, is the slope of the total product curve at that point (top panel). For the production function shown in the top panel, the marginal product curve (bottom panel) initially increases as labour increases. Beyond $L = 4$, however, the marginal product of labour decreases as labour increases. For $L > 8$ the total product curve declines with L, which means that the marginal product of labour is negative in that region.

The **average product** of a variable input is defined as the total product divided by the quantity of that input. Denoted AP_L, it is thus given by

$$AP_L = \frac{Q}{L} \tag{10.3}$$

average product total output divided by the quantity of the variable input.

When the variable input is labour, the average product is also called labour productivity.

Geometrically, the average product is the slope of the line joining the origin to the corresponding point on the total product curve. Three such lines, R_1, R_2 and R_3, are drawn to the total product curve shown in the top panel in Figure 10.6. The average product at $L = 2$ is the slope of R_1, which is $14/2 = 7$. Note that R_2 intersects the total product curve in two places—first, directly above $L = 4$, and then directly above $L = 8$. Accordingly, the average products for these two values of L will be the same—namely, the slope of R_2, which is $43/4 = 86/8 = 10.75$. R_3 intersects the total product curve at only one point, directly above $L = 6$. The average product for $L = 6$ is thus the slope of R_3, $72/6 = 12$.

EXERCISE 10.3 For the short-run production function shown in Figure 10.2(*a*), what is the average product of labour at *L* = 3? At *L* = 1? How does average product compare with marginal product at these points?