Isoquants

An **isoquant** is a curve that shows the efficient combinations of labor and capital that can produce a single (*iso*)- level of output (*quantity*).

Isoquants reflect the flexibility that a firm has in producing a given level of output in the long-run.

Here is an example of "typical" isoquants reflecting the imperfect substitutability of capital and labor,

Figure 6.2 Family of Isoquants

These isoquants show the combinations of labor and capital that produce various levels of output. Isoquants farther from the origin correspond to higher levels of output. Points *a*, *b*, *c*, and *d* are various combinations of labor and capital the firm can use to produce $q = 24$ units of output. If the firm holds capital constant at 2 and increases labor from 1 (point *e*) to 3 (*c*) to 6 (*f*), it shifts from the $q = 14$ isoquant to the $q = 24$ isoquant and then to the $q = 35$ isoquant.

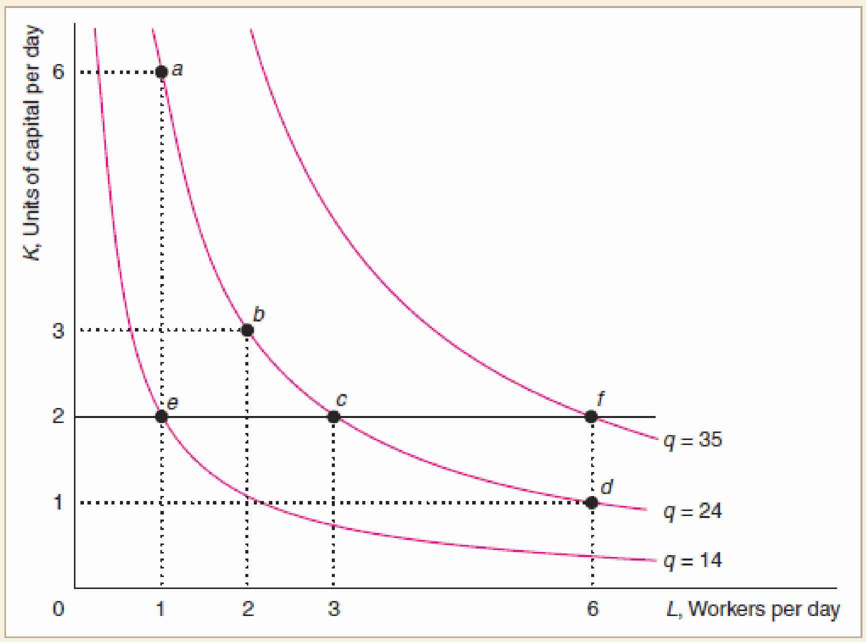

Figure 6.2., Perloff (2012)

<u>Characteristics of isoquants:</u>

1. Isoquants further from the origin produce more output.
2. Isoquants do not cross. If they crossed, then saying that could produce different levels of output with same combination of capital and labor. This violates the assumption of efficiency.
3. Holding one input constant (say K=6) and increasing the other input (Labor from 0 to 1) will move the firm from one isoquant to another.
4. Isoquants slope downward. If it sloped upward, then the firm could produce the same input with either lots of both inputs or few of both inputs. Producing with relatively many inputs would be inefficient.

Shapes of Isoquants

Typically, convex towards the origin. This reflects the fact that firms prefer "averages to extremes." In other words, capital and labor are complements to each other (i.e., the firm needs a little of both to operate).

Other shapes are possible:

Figure 6.3 Substitutability of Inputs

(a) If the inputs are perfect substitutes, each isoquant is a straight line. (b) If the inputs cannot be substituted at all, the isoquants are right angles (the dashed lines show that the isoquants would be right angles if we included inefficient production). (c) Typical isoquants lie between the extreme cases of straight lines and right angles. Along a curved isoquant, the ability to substitute one input for another varies.

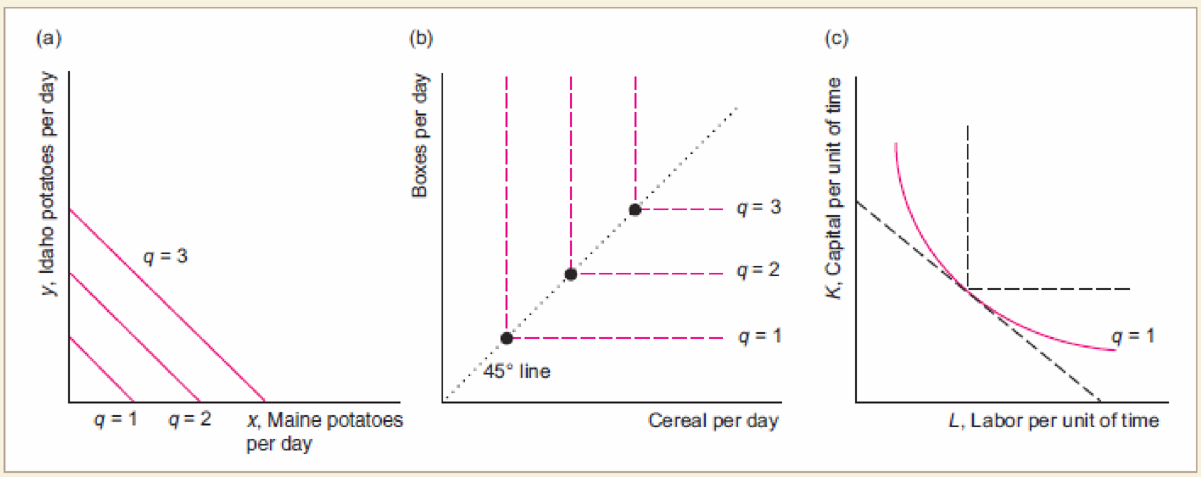

Figure 6.3., Perloff (2012)

Slope of the isoquant:

The slope of an isoquant shows the ability of a firm to replace one input with another while holding output constant. This last part "holding output constant" is important to remember.

We call the slope of the isoquant the **marginal rate of technical substitution** or (**MRTS**). Since slope is just "rise" divided by "run", we can write it as,

$$MRTS = \frac{change\ in\ capital}{change\ in\ labor} = \frac{\Delta K}{\Delta L}$$

The MRTS tells us how many units of capital the firm can replace with an extra unit of labor while holding output constant.

MRTS<0 always. The firm must substitute more capital for less labor (or vice versa) to keep output constant.

Here is an example of the MRTS at various points along a "typical" isoquant:

Figure 6.4 How the Marginal Rate of Technical Substitution Varies Along an Isoquant

Moving from point *a* to *b*, a U.S. printing firm (Hsieh, 1995) can produce the same amount of output, $q = 10$, using six fewer units of capital, $\Delta K = -6$, if it uses one more worker, $\Delta L = 1$. Thus, its $MRTS = \Delta K/\Delta L = -6$. Moving from point *b* to *c*, its *MRTS* is -3. If it adds yet another worker, moving from *c* to *d*, its *MRTS* is -2. Finally, if it moves from *d* to *e*, its *MRTS* is -1. Thus, because it curves away from the origin, this isoquant exhibits a diminishing marginal rate of technical substitution. That is, each extra worker allows the firm to reduce capital by a smaller amount as the ratio of capital to labor falls.

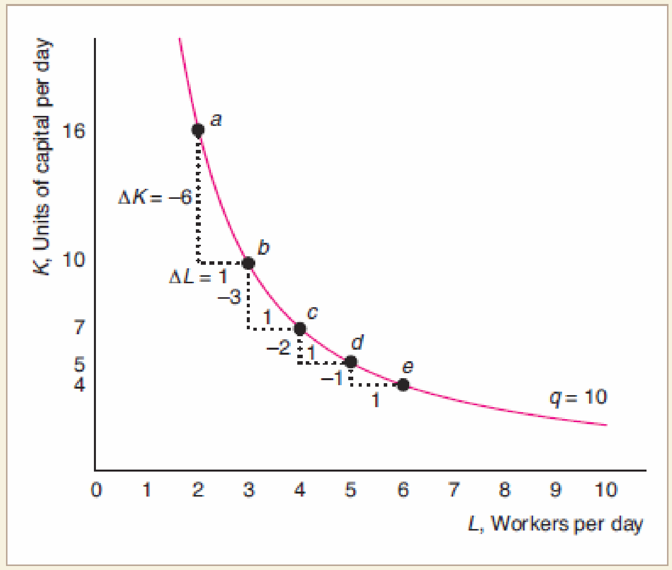

Figure 6.4., Perloff (2012)

In table form,

Point	ΔK	ΔL	**MRTS**$=\Delta K/\Delta L$
b	-6	1	-6
c	-3	1	-3
d	-2	1	-2
e	-1	1	-1

In the above figure and table, notice that MRTS is falling as the number of laborers increases (as we move down the isoquant). This is a common feature of isoquants. Economists call this **diminishing MRTS**. Basically, it means that the more labor the firm has, the harder it is to replace the remaining capital with labor, so the MRTS falls as the isoquant becomes flatter.