The Optimal Combination of Resources

In Activity 4-1, we assumed the Acme Yo-Yo Company was operating in the short run with a fixed amount of capital (equipment) and with labor as its variable resource. Let's now consider a long-run example where the firm can change its capital as well as its labor. What combination of labor (L) and capital (K) should the firm employ?

Part A: The Least-Cost Combination of Resources

What should a firm do if it wants to produce the most output possible from a given resource budget? What should it do if it wants to produce a given level of output at the lowest total cost? The approach to both of these problems is similar. The firm should allocate its resource budget between units of labor and units of capital in such a way that the following condition is satisfied, where marginal physical product is MPP and marginal resource cost is MRC:

$$\frac{MPP_L}{MRC_L} = \frac{MPP_K}{MRC_K}.$$

If the resource markets are perfectly competitive, the price the firm pays for an extra unit of a resource is equal to its MRC. In that case the condition can be written as

$$\frac{MPP_L}{P_L} = \frac{MPP_K}{P_K}.$$

where P_L is the price of a unit of labor and P_K is the price of a unit of capital.

Another way of stating this condition for *economic efficiency* is that the firm should get the same extra output from the last dollar spent on each type of resource.

Assume a firm has allocated its given resource budget between labor and capital and finds the marginal physical product for the resources to be 200 units from labor and 400 units from capital. That means the last unit of labor increased total output by 200 units while the last unit of capital increased output by 400 units. At first glance, you might think the firm should move some money away from labor and over to capital. But that would totally ignore the prices of the two resources. Assume the prices of labor and capital in competitive resource markets are \$10 and \$40, respectively.

1. Calculate the "MPP per \$1" for each resource.

   Labor: $\frac{\textit{200 units}}{\textit{\$10}}$ ***= 20 units per \$1.*** ***Capital:*** $\frac{\textit{400 units}}{\textit{\$40}}$ ***= 10 units per \$1.***

2. Based on your work in Question 1, is the firm getting the most output possible from its given resource budget? If so, explain why. If not, how should it reallocate its budget between labor and capital?
   No, the firm can do better. It should spend more of its budget on labor and less on capital. Labor is giving more output per \$1 on the margin than is capital.

3. Suppose the MPP values are as given in Question 1, but that the prices of labor and capital are \$10 and \$20, respectively. Is the firm now getting the most output possible from its resource budget? Explain.

$$\textit{Labor: } \frac{200 \text{ units}}{\$10} = 20 \text{ units per } \$1. \qquad \textit{Capital: } \frac{400 \text{ units}}{\$20} = 20 \text{ units per } \$1.$$

The firm is getting the most output possible from its resource budget. If it moved a dollar from one resource to the other, there would be no net change in output.

4. A different firm has allocated its resource budget between labor and capital and is producing a given output level at the lowest possible total cost. The MPP of labor is 25 units, and the MPP of capital is 20 units. If the price of a unit of labor is \$100, what is the price of a unit of capital?
Since we know the firm is using the least-cost combination of resources, we can solve for the price of capital:

$$\frac{25 \text{ units}}{\$100} = \frac{20 \text{ units}}{P_K} \qquad (25 \text{ units})(P_K) = \$2{,}000 \qquad P_K = \$80.$$

Part B: The Profit-Maximizing Combination of Resources

The economic efficiency condition in Part A is what economists call a "necessary but not sufficient" condition for profit maximization. In other words, if a firm is not using an economically efficient (least-cost) combination of resources, then it cannot possibly be maximizing its total profit. If it is using an economically efficient combination, then it might be profit maximizing, but an additional condition must be satisfied to guarantee that is the case.

Here is the profit-maximizing condition for a combination of two resources:

$$\frac{MRP_L}{MRC_L} = \frac{MRP_K}{MRC_K} = 1.$$

If the resource markets are perfectly competitive, the condition can be written as

$$\frac{MRP_L}{P_L} = \frac{MRP_K}{P_K} = 1.$$

While this condition looks similar to the one in Part A, there are two significant differences.

1. The firm is comparing MRP, not MPP, to MRC.
2. The two ratios must both be equal to 1.

The second difference means the MRP from the last unit of each resource must be equal to its MRC. If the MRP of a unit of labor is greater than its MRC, the firm should hire more labor. If the MRP of a unit of capital is less than its MRC, the firm should get rid of some capital. (This is the rule we used in Activity 4-1 to find the profit-maximizing amount of labor in the short run when capital was fixed: Hire the amount of labor where MRP = MCL.)

5. Suppose the Ebbets Company produces 1,000 units of output with a combination of labor and capital such that the MRP of labor is \$30 and the MRP of capital is \$40. If this firm is maximizing its total profit at this output, what are the prices of units of labor and capital? (Assume the firm buys resources in perfectly competitive markets.)

$$\frac{\$30}{P_L} = \frac{\$40}{P_K} = 1.$$

The price of labor is \$30 and the price of capital is \$40.

6. The Shibe Company produces 800 units of output per period. The MRP of labor is \$60, and the MRP of capital is \$40. The market prices of units of labor and capital are \$12 and \$8, respectively. Is this firm maximizing its total profit? Explain.

$$\textit{Labor: } \frac{\$60}{\$12} = \frac{\$5}{\$1}. \qquad \textit{Capital: } \frac{\$40}{\$8} = \frac{\$5}{\$1}.$$

No, it is not maximizing its total profits. Since the MRP from each resource exceeds the price (MRC) of that resource, the firm should hire more of each resource and expand its output. Don't be fooled by the fact that in this example the two ratios are equal. The point is that both ratios are greater than 1, which means the firm should employ more labor and more capital.

7. The Honus Company currently produces Q_1 units of output each period. It sells its good in a perfectly competitive product market and buys its resources in perfectly competitive factor markets. The MPP of labor is 50 units, and the MPP of capital is 80 units. The prices it pays for units of labor and capital are \$100 and \$160, respectively.

(A) Is the company operating in an economically efficient manner? Explain.

$$\textit{Labor: } \frac{50 \text{ units}}{\$100} = 0.5 \text{ units per } \$1. \qquad \textit{Capital: } \frac{80 \text{ units}}{\$160} = 0.5 \text{ units per } \$1.$$

Yes, the firm is economically efficient. It is producing its output Q_1 at the lowest possible total cost.

(B) What would the market price of its good have to be for the firm to be maximizing its total profit?

Since it is using an economically efficient combination of resources, the firm might be maximizing its total profit. For profit-maximization to occur, the firm must use a combination of resources such that $MRP_L = P_L$ and $MRP_K = P_K$.

$MPR_L = P_L$	$MPR_K = P_K$
$(MPP_L)(P_{good}) = P_L$	$(MPP_K)(P_{good}) = P_K$
$(50 \text{ units})(P_{good}) = \$100$	$(80 \text{ units})(P_{good}) = \$160$
$P_{good} = \$2.00$	$P_{good} = \$2.00$

For profit-maximization, the price of its good would have to be \$2.00.

The least-cost and profit-maximization conditions also apply to a firm with more than two resources (W, X, and Y).

Least-cost combination: $$\frac{MPP_W}{MRC_W} = \frac{MPP_X}{MRC_X} = \frac{MPP_Y}{MRC_Y}.$$

Profit-maximization combination: $$\frac{MRP_W}{MRC_W} = \frac{MRP_X}{MRC_X} = \frac{MRP_Y}{MRC_Y} = 1.$$