OUTPUT AND COSTS
The **firm makes many decisions** to achieve its main objective: *profit maximization*.

Some decisions are critical to the survival of the firm.

Some decisions are irreversible (or very costly to reverse).

Other decisions are easily reversed and are less critical to the survival of the firm, but still influence profit.

All decisions can be placed in two time frames:

- **The short run**
- **The long run**
Decision Time Frames

The Short Run

The short run is a time frame in which the quantity of one or more resources used in production is fixed.

For most firms, the capital, called the firm’s plant, is fixed in the short run.

Other resources used by the firm (such as labor, raw materials, and energy) can be changed in the short run.

Short-run decisions are easily reversed.
The Long Run

The long run is a time frame in which the quantities of all resources—including the plant size—can be varied. Long-run decisions are not easily reversed.

A sunk cost is a cost incurred by the firm and cannot be changed.

- If a firm’s plant has no resale value, the amount paid for it is a sunk cost.
- Sunk costs are irrelevant to a firm’s current decisions.
Short-Run Technology Constraint

To increase output in the short run,

- a firm must increase the amount of labor employed.

Three concepts describe the relationship between output and the quantity of labor employed:

1. Total product (TP)
2. Marginal product (MP)
3. Average product (AP)
Short-Run Technology Constraint

Product Schedules

**Total product** is the total output produced in a given period.

The **marginal product** of labor:

- the **change in total product** that results from a one-unit increase in the quantity of labor employed, with all other inputs remaining the same.

The **average product** of labor is equal to total product divided by the quantity of labor employed.
Table 11.1 shows a firm’s product schedules.

As the quantity of labor employed increases:

- Total product increases.
- Marginal product increases initially …
- but eventually decreases.
- Average product decreases.
Product Curves

Product curves show how the firm’s total product, marginal product, and average product change as the firm varies the quantity of labor employed.

Total Product Curve

The total product curve shows how total product changes with the quantity of labor employed.
Short-Run Technology Constraint

Marginal Product Curve

- Figure 11.2 shows the MP of labor curve and how the MP curve relates to the total product curve.
- The first worker hired produces 4 units of output.
- When labor increases from 2 to 3, total product increases from 10 to 13,
  - so the marginal product of the 3rd worker is 3 units of output.

The height of each bar measures the marginal product of labor.

<table>
<thead>
<tr>
<th>Labor (workers per day)</th>
<th>Total product (sweaters per day)</th>
<th>Marginal product (sweaters per additional worker)</th>
<th>Average product (sweaters per worker)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: 0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B: 1</td>
<td>4</td>
<td>.6</td>
<td>4.00</td>
</tr>
<tr>
<td>C: 2</td>
<td>10</td>
<td>.3</td>
<td>5.00</td>
</tr>
<tr>
<td>D: 3</td>
<td>13</td>
<td>.2</td>
<td>4.33</td>
</tr>
<tr>
<td>E: 4</td>
<td>15</td>
<td>.1</td>
<td>3.75</td>
</tr>
<tr>
<td>F: 5</td>
<td>16</td>
<td>.1</td>
<td>3.20</td>
</tr>
</tbody>
</table>

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Almost all production processes are like the one shown here and have:

- Increasing marginal returns initially
- Diminishing marginal returns eventually
Short-Run Technology Constraint

Diminishing Marginal Returns

Eventually, the marginal product of a worker is less than the marginal product of the previous worker.

- Diminishing marginal returns arises because each additional worker has less access to capital and less space in which to work.

- As a firm uses more of a variable input with a given quantity of fixed inputs, the marginal product of the variable input eventually diminishes.
Increasing Marginal Returns

Initially, the marginal product of a worker **exceeds** the marginal product of the previous worker.

> Increasing marginal returns arise from increased specialization and division of labor.
Average Product Curve

- its relationship with the marginal product curve.

When MP > AP
- average product increases.

When MP < AP
- average product decreases.

When MP = AP
- average product is at its maximum
Short-Run Cost

To produce more output in the short run, the firm must employ more labor, which means that it must increase its costs.

Three cost concepts and three types of cost curves are

- Total cost (TC)
- Marginal cost (MC)
- Average cost (AC)
Short-Run Cost

**Total Cost (TC)**

A firm’s total cost \((TC)\) is the cost of *all* resources used.

**Total fixed cost** \((TFC)\) is the cost of the firm’s fixed inputs. Fixed costs do **not change with output**.

**Total variable cost** \((TVC)\) is the cost of the firm’s variable inputs. Variable costs **do change with output**.

Total cost equals total fixed cost plus total variable cost. That is:

\[
TC = TFC + TVC
\]
Figure 11.4 shows a firm’s total cost curves.

Total fixed cost is the same at each output level.

Total variable cost increases as output increases.

Total cost, which is the sum of \( TFC \) and \( TVC \) also increases as output increases.
Short-Run Cost

Notice that the $TP$ curve becomes steeper at low output levels and then less steep at high output levels.

In contrast, the $TVC$ curve becomes less steep at low output levels and steeper at high output levels.
Short-Run Cost

To see the relationship between the TVC curve and the TP curve, let's look again at the TP curve. But let us add a second x-axis to measure total variable cost.

1 worker costs $25; 2 workers cost $50; and so on, so the two x-axes line up.
Short-Run Cost

We can replace the quantity of labor on the $x$-axis with total variable cost.

But it is graphed with cost on the $x$-axis and output on the $y$-axis.
Marginal Cost

Marginal cost \((MC)\) is the increase in total cost that results from a one-unit increase in total product.

Over the output range with increasing marginal returns, marginal cost falls as output increases.

Over the output range with diminishing marginal returns, marginal cost rises as output increases.
Short-Run Cost

Average Cost

Average cost measures can be derived from each of the total cost measures:

**Average fixed cost** \((AFC)\) is total fixed cost per unit of output.

**Average variable cost** \((AVC)\) is total variable cost per unit of output.

**Average total cost** \((ATC)\) is total cost per unit of output.

\[
ATC = AFC + AVC.
\]
Figure 11.5 shows the $MC$, $AFC$, $AVC$, and $ATC$ curves.

The $AFC$ curve shows that average fixed cost falls as output increases.

The $AVC$ curve is U-shaped. As output increases, average variable cost falls to a minimum and then increases.
Short-Run Cost

The $ATC$ curve is also U-shaped.

The $MC$ curve is very special.

For outputs over which $AVC$ is falling, $MC$ is below $AVC$.

For outputs over which $AVC$ is rising, $MC$ is above $AVC$.

For the output at minimum $AVC$, $MC$ equals $AVC$. 
Similarly, for the outputs over which \( ATC \) is falling, \( MC \) is \textit{below} \( ATC \).

For the outputs over which \( ATC \) is rising, \( MC \) is \textit{above} \( ATC \).

For the output at minimum \( ATC \), \( MC \) \textit{equals} \( ATC \).
Why the Average Total Cost Curve Is U-Shaped

The $ATC$ curve is the vertical sum of the $AFC$ curve and the $AVC$ curve.

The U-shape of the $ATC$ curve arises from the influence of two opposing forces:

1. Spreading total fixed cost over a larger output—$AFC$ curve slopes downward as output increases.

2. Eventually diminishing returns—the $AVC$ curve slopes upward and $AVC$ increases more quickly than $AFC$ is decreasing.
Short-Run Cost

The $AVC$ curve is U-shaped because:

Initially, $MP$ exceeds $AP$, which brings rising $AP$ and falling $AVC$.

Eventually, $MP$ falls below $AP$, which brings falling $AP$ and rising $AVC$.

The $ATC$ curve is U-shaped for the same reasons.

In addition, $ATC$ falls at low output levels because $AFC$ is falling quickly.
Short-Run Cost

Average and Marginal Product and Cost

Initially, \( MP \) exceeds \( AP \):
- rising \( AP \)
- falling \( AVC \).

 Eventually, \( MP \) falls below \( AP \),
- falling \( AP \)
- rising \( AVC \).

\( ATC \) falls at low output levels:
\[ => AFC \text{ is falling quickly.} \]
Short-Run Cost

Shifts in the Cost Curves

The position of a firm’s cost curves depends on two factors:

- Technology
- Prices of factors of production
Technology

Technological change influences both the product curves and the cost curves.

An increase in productivity shifts the product curves upward and the cost curves downward.

If a technological advance results in the firm using more capital and less labor, fixed costs increase and variable costs decrease.

In this case ATC increases at low output levels and decreases at high output levels.
Prices of Factors of Production

An increase in the price of a factor of production increases costs and shifts the cost curves.

An increase in a **fixed cost** shifts the total cost ($TC$) and average total cost ($ATC$) curves upward but does **not** shift the marginal cost ($MC$) curve.

An increase in a **variable cost** shifts the total cost ($TC$), average total cost ($ATC$), and marginal cost ($MC$) curves upward.
Long-Run Cost

In the long run, all inputs are variable and all costs are variable.

The Production Function

The behavior of long-run cost depends upon the firm’s production function.

The firm’s production function is the relationship between the maximum output attainable and the quantities of both capital and labor.
Table 11.3 shows a firm’s production function.

As the size of the plant increases, the output that a given quantity of labor can produce increases.

But for each plant, as the quantity of labor increases, diminishing returns occur.
Long-Run Cost

Short-Run Cost and Long-Run Cost

The **average cost** of producing a given output varies and depends on the firm’s plant.

The **larger the plant**, the **greater is the output** at which \( ATC \) is at a minimum.

The firm has 4 different plants: 1, 2, 3, or 4 knitting machines.

Each plant has a short-run \( ATC \) curve.

The firm can compare the \( ATC \) for each output at different plants.
$\text{ATC}_4$ is the $\text{ATC}$ curve for a plant with 4 knitting machines.
Long-Run Cost

The long-run average cost curve is made up from the lowest point of ATC for each output level.

So, we want to decide which plant has the lowest cost for producing each output level.

Let’s find the least-cost way of producing a given output level.

Suppose that the firm wants to produce 13 sweaters a day.
Long-Run Cost

13 sweaters a day cost $7.69 each on $ATC_1$.
13 sweaters a day cost $6.80 each on $ATC_2$.
13 sweaters a day cost $7.69 each on $ATC_3$.
13 sweaters a day cost $9.50 each on $ATC_4$.

The least-cost way of producing 13 sweaters a day is to use 2 knitting machines.
Long-Run Cost

Long-Run Average Cost Curve

The long-run average cost curve is the relationship between the lowest attainable average total cost and output when both the plant and labor are varied.

The long-run average cost curve is a planning curve that tells the firm the plant that minimizes the cost of producing a given output range.

Once the firm has chosen its plant, the firm incurs the costs that correspond to the $ATC$ curve for that plant.
Long-Run Cost

Economies and Diseconomies of Scale

**Economies of scale** are features of a firm’s technology that lead to **falling long-run average cost** as output increases.

**Diseconomies of scale** are features of a firm’s technology that lead to **rising long-run average cost** as output increases.

**Constant returns to scale** are features of a firm’s technology that lead to **constant long-run average cost** as output increases.
Figure 11.9 illustrates economies and diseconomies of scale.
Long-Run Cost

Minimum Efficient Scale

A firm experiences **economies of scale** up to some output level.

- Beyond that output level, it moves into constant returns to scale or diseconomies of scale.

**Minimum efficient scale:**

is the smallest quantity of output at which the long-run average cost reaches its lowest level.

If the long-run average cost curve is U-shaped, the minimum point identifies the minimum efficient scale output level.
After studying this chapter, you will be able to:

- Distinguish between the short run and the long run
- Explain and illustrate a firm’s short-run product curves
- Explain and derive a firm’s short-run cost curves
- Explain and derive a firm’s long-run average cost curve
What do McDonald’s and Campus Sweaters, a small (fictional) producer of knitwear that we’ll study in this chapter, have in common?

Like every firm,

- They must decide how much to produce.
- How many people to employ.
- How much and what type of capital equipment to use.

How do firms make these decisions?