GLOBAL EDITION

MICROECONOMICS

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Third Edition

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Exhibit 6.1 Production Data for The Wisconsin Cheeseman

The Wisconsin Cheeseman is tasked with choosing how much output to generate per day, and the table summarizes the number of workers the firm will need for any given level of output. The first column is the number of cheese boxes produced per day, the second column is the number of workers employed, and the third column is marginal product: the additional output produced by each additional input (in this case, workers).

Details of Production		
(1) Output per Day	(2) Number of Workers	(3) Marginal Product
0	0	
100	1	100
207	2	107
321	3	114
444	4	123
558	5	114
664	6	106
762	7	98
854	8	92
939	9	85
1,019	10	80
1,092	11	73
1,161	12	69
1,225	13	64
1,284	14	59
1,339	15	55
1,390	16	51
1,438	17	48
...	...	...
1,934	38	10
1,834	39	–100

sandwich. Finally, the third worker packages the sandwich and tallies the bill. This is a true assembly line of beauty, something that specialization has created naturally.

2. The marginal product eventually decreases with successive additions of workers. That is, as more and more workers are added, they begin to add less and less to total production. For example, the marginal product of the fourth worker is 123 boxes, whereas it is only 114 boxes for the fifth worker. Economists call this decreasing production pattern the **Law of Diminishing Returns**. This law states that at a certain point of successive increases in inputs, marginal product begins to decrease. This law might apply for a number of reasons. For example, with a set amount of physical capital, successive increases in labor eventually lead to lower output per worker because there is idle time—workers cannot use the machines as often as they would like.

The Law of Diminishing Returns states that successive increases in inputs eventually lead to less additional output.

3. Adding too many workers can actually decrease overall production. This point refers to the fact that adding too many workers can be counterproductive. Indeed, this is exactly the situation with the last worker that The Cheeseman hires: Exhibit 6.1 shows that adding the 39th worker has a negative marginal product of 100 boxes! You can see this situation vividly in Exhibit 6.2, where the production curve begins to slope downward at that point. Management should send this worker home, dispatch him to a different task, or even have him wash the owner's dog because he is lowering total production of cheese boxes. This might happen because congestion causes workers to get in the way of one another.

The Cost of Doing Business: Introducing Cost Curves

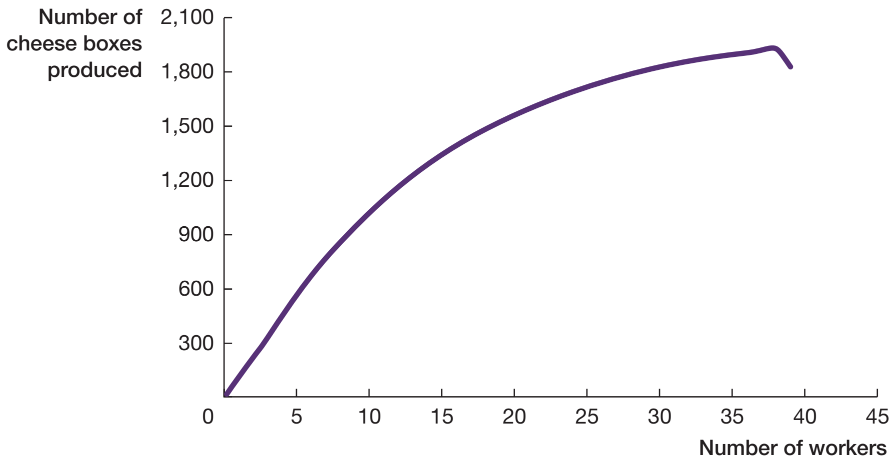
The cost of production is what a firm must pay for its inputs.

We now look at the second component of the seller's problem: what the firm must pay for its inputs, or the **cost of production**. Similar to the two factors of production discussed previously, there is a natural division in the total cost of production:

$$\text{Total cost} = \text{Variable cost} + \text{Fixed cost}.$$

Exhibit 6.2 The Short-Run Production Function for The Cheeseman

Plotted here is the number of workers on the *x*-axis and the number of cheese boxes produced on the *y*-axis. As the number of workers increases, the number of cheese boxes that can be produced tends to increase, but notice that the first 10–15 workers lead to much steeper increases in production than the 25th–35th additional worker. Also notice that the last worker actually reduces productivity.



Total cost is the sum of variable and fixed costs.

A variable cost (VC) is the cost of variable factors of production, which change along with a firm's output.

A fixed cost (FC) is the cost of fixed factors of production, which a firm must pay even if it produces zero output.

This equation has three parts. **Total cost** is the sum of variable and fixed costs. **Variable costs (VCs)** are those costs associated with variable factors of production. In The Cheeseman's case, these are costs associated with workers and therefore change with the level of production in the short run. In contrast to VCs, a **fixed cost (FC)** is a cost associated with a fixed factor of production, such as structures or equipment, and therefore does not change with production in the short run. Indeed, in the short run, The Wisconsin Cheeseman has to pay for these factors even if it produces nothing because the firm cannot sell its plant and equipment in the short run.

These costs are summarized in Exhibit 6.3. Column 4 shows VCs—because workers at The Cheeseman are paid a daily wage of $72 ($9 per hour, 8 hours per day), the daily VCs increase by $72 for each worker hired. We assume that The Cheeseman can hire as many workers as it wants at this wage. The cost of structures and machinery represents the cost of physical capital, and in this example is $200 per day. These are the FCs given in column 5 of Exhibit 6.3. These costs are the same no matter how many workers are hired. Thus, FCs do not vary in the short run, but VCs do. Column 6 shows total cost (TC), which is the sum of VCs and FCs for a particular quantity of output.

We are provided with three more interesting cost concepts if we divide both sides of our total cost equation by total output Q (quantity that The Cheeseman produces):

$$\frac{\text{Total cost}}{Q} = \frac{\text{Variable cost}}{Q} + \frac{\text{Fixed cost}}{Q}.$$

Average total cost (ATC) is the total cost divided by the total output.

Average variable cost (AVC) is the total variable cost divided by the total output.

Average fixed cost (AFC) is the total fixed cost divided by the total output.

The term on the left-hand side of this equation is called **average total cost (ATC)**, which is total cost divided by total output. Column 7 in Exhibit 6.3 shows the ATC for The Cheeseman. For example, the ATC for The Wisconsin Cheeseman with an output of 321 units is computed by taking the total cost of $416 and dividing it by the total output of 321, which yields $1.29, as shown in Exhibit 6.3. This means that when The Cheeseman produces 321 units, the average total cost per cheese box packed is $1.29.

The first term on the right-hand side of this equation is called the **average variable cost (AVC)**, which is the total variable cost divided by total output. For The Cheeseman, when it produces 321 units, its AVC is $0.67, which means that it pays its variable factor of production (labor) an average of $0.67 per cheese box packed.

Finally, **average fixed cost (AFC)** is the total fixed cost divided by the total output. For The Cheeseman, when it produces 321 units, its AFC is $0.62, which means that it pays its fixed factor of production (physical capital) an average of $0.62 per cheese box packed. What this all means is that of the $1.29 ATC when The Cheeseman produces 321 units, $0.67 goes to VCs (labor) and $0.62 goes to FCs (physical capital).

Exhibit 6.3 Costs of Production with Additional Cost Concepts for The Wisconsin Cheeseman

The Wisconsin Cheeseman produces cheese boxes; this exhibit summarizes the cost of various levels of production. The total cost is the sum of fixed and variable costs. The average total cost is the sum of average fixed and average variable costs. The marginal cost is the change in total cost associated with producing one more unit of output. For convenience, the numbers are rounded.

Cost of Production									
(1) Output per Day (*Q*)	(2) Number of Workers	(3) Marginal Product = Change in (1)	(4) Variable Cost (VC) = $72 × (2)	(5) Fixed Cost (FC)	(6) Total Cost (TC) = (4) + (5)	(7) Average Total Cost (ATC) = (6)/(1)	(8) Average Variable Cost (AVC) = (4)/(1)	(9) Average Fixed Cost (AFC) = (5)/(1)	(10) Marginal Cost (MC) = Change in (6)/Change in (1)
0	0		$0	$200	$200				
100	1	100	$72	$200	$272	$2.72	$0.72	$2.00	$0.72
207	2	107	$144	$200	$344	$1.66	$0.70	$0.97	$0.67
321	3	114	$216	$200	$416	$1.29	$0.67	$0.62	$0.63
444	4	123	$288	$200	$488	$1.10	$0.65	$0.45	$0.59
558	5	114	$360	$200	$560	$1.00	$0.65	$0.36	$0.63
664	6	106	$432	$200	$632	$0.95	$0.65	$0.30	$0.68
762	7	99	$504	$200	$704	$0.92	$0.66	$0.26	$0.73
854	8	92	$576	$200	$776	$0.91	$0.67	$0.23	$0.78
939	9	85	$648	$200	$848	$0.90	$0.69	$0.21	$0.85
1,019	10	80	$720	$200	$920	$0.90	$0.71	$0.20	$0.90
1,092	11	73	$792	$200	$992	$0.91	$0.73	$0.18	$0.99
1,161	12	69	$864	$200	$1,064	$0.92	$0.74	$0.17	$1.04
1,225	13	64	$936	$200	$1,136	$0.93	$0.76	$0.16	$1.13
1,284	14	59	$1,008	$200	$1,208	$0.94	$0.79	$0.16	$1.22
1,339	15	55	$1,080	$200	$1,280	$0.96	$0.81	$0.15	$1.31
1,390	16	51	$1,152	$200	$1,352	$0.97	$0.83	$0.14	$1.41
1,438	17	48	$1,224	$200	$1,424	$0.99	$0.85	$0.14	$1.50

Marginal cost (MC) is the change in total cost associated with producing one more unit of output.

Our last cost concept is *marginal cost*, which is presented in column 10 of Exhibit 6.3. **Marginal cost (MC)** is the change in total cost associated with producing one more unit of output. Marginal cost can be written as:

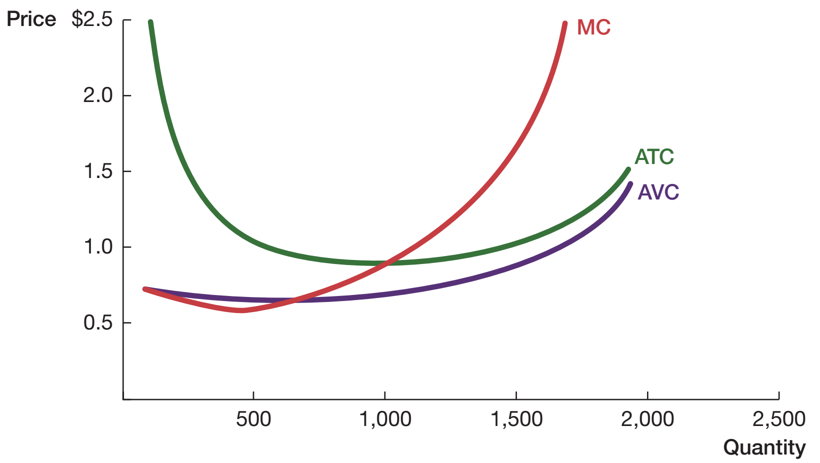
$$\text{Marginal cost} = \frac{\text{Change in total cost}}{\text{Change in output}}.$$

When The Wisconsin Cheeseman produces 321 units, a MC of $0.63 means that it costs The Cheeseman $0.63 to produce the 321st cheese box. Exhibit 6.3 also reveals another interesting relationship: MC and marginal product are inversely related to one another. As one increases, the other automatically decreases. To see why, consider The Cheeseman's production and cost relationships. When The Cheeseman adds its first few workers (up to four), the marginal product increases, decreasing MC. Yet, as more workers are hired, marginal product decreases, which increases MC. For example, hiring the fifth worker decreases marginal product to 114 units and increases the MC to $0.63.

Using the data from Exhibit 6.3, Exhibit 6.4 shows a graphical representation of the important relationships between costs and quantity produced: the MC curve, ATC curve, and AVC curve for The Cheeseman. Output quantity is plotted on the *x*-axis and costs (in dollars) on the *y*-axis. One interesting feature about these cost curves is that when the MC curve is below the average cost curves (both ATC and AVC), they must be falling or sloping downward, and when the MC curve is above the average cost curves, they must be rising or upward-sloping.

Exhibit 6.4 MC, ATC, and AVC Curves for The Wisconsin Cheeseman

This figure plots several cost measures with the output (or quantity) on the *x*-axis and the cost (or price) on the *y*-axis. Each cost measure is plotted across various output levels. Notice that the MC curve intersects the ATC and AVC curves at their respective minimums.



Why? This is by itself the very nature of the definition of MC. To capture this intuition, think of your last trip to the campus store. Say that in your basket, you have one can of Pringles that is $3 and one candy bar that has a price of $1. Your average price per item is $2. Now let's say that you add a bag of oranges, which has a price of $5. What will happen to your average price per item? It will rise; in fact, it will increase from $2 to $3. Now what happens to your basket average if you add a bag of popcorn that has a price of $1? It decreases. This is because the bag of popcorn is priced below the average price of goods that you had in your basket already.

This provides the intuition for why MC intersects AVC and ATC at their minimums: when MC is below ATC and AVC, they must be falling; and when MC is above ATC and AVC, they must be rising, as in Exhibit 6.4. An understanding of these curves leads to powerful implications, as we discuss next.

The Rewards of Doing Business: Introducing Revenue Curves

Revenue is the amount of money the firm brings in from the sale of its outputs.

We are now ready to look at the third component of the seller's problem: the price at which a firm can sell its goods. A firm makes money from selling goods, and The Wisconsin Cheeseman is no different. The **revenue** of a firm is the amount of money it brings in from the sale of its outputs. Revenue is determined by the price of goods sold times the number of units sold:

$$\text{Total revenue} = \text{Price} \times \text{Quantity sold}.$$

Recall that in perfectly competitive markets, sellers can sell all they want at the market price. Thus, they are price-takers.

But what determines the price of cheese boxes? Chapter 4 can lend insights into this question: the price comes from the intersection of the market demand curve and the market supply curve. This is just like any other market equilibrium you learned about in Chapter 4: the intersection of market supply and market demand gives the equilibrium price.

Exhibit 6.5 reveals this intuition. Panel (a) of Exhibit 6.5 shows the market supply and market demand curves. Recall that we can construct the market demand curve as described in Chapters 4 and 5. We can construct the market supply curve in exactly the same manner as the market demand curve—through horizontally summing the individual supply curves. To see how this works, let's assume that in equilibrium, the cheese box packing industry has 10,000 identical firms, which each produce 1,225 cheese boxes per day. Thus, a total of 12,250,000 cheese boxes are packed daily in this market. As shown in panel (b) of Exhibit 6.5, this equilibrium quantity occurs at an equilibrium price of $1.13 per cheese box packed.

At this point, it is important to recognize the difference between the demand curve facing The Cheeseman and the demand curve in a perfectly competitive market. As panel (b) of Exhibit 6.5 reveals, a perfectly competitive firm, such as The Wisconsin Cheeseman,

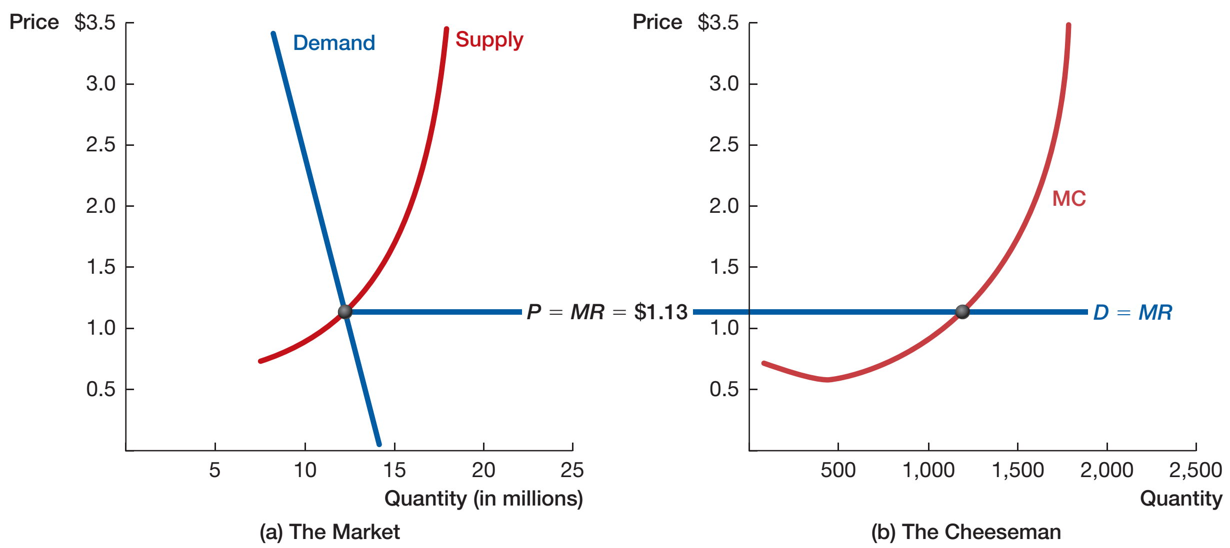


Exhibit 6.5 Supply and Demand: The Market Versus The Wisconsin Cheeseman

Panel (a) summarizes the market supply and market demand curves for cheese boxes. The price determined by the market equilibrium is the price The Cheeseman faces, which is shown in panel (b). We think of that price as representing the demand curve The Cheeseman faces, which is the flat blue line. This demand curve is equal to MR because it represents the change in revenues from selling one more cheese box.

faces a horizontal demand curve, or a demand curve that is perfectly elastic. What this means is that The Cheeseman can pack as many cheese boxes as it desires and be paid the market equilibrium price ($1.13) for every cheese box packed. If The Cheeseman attempts to charge a little bit more than $1.13 per box, it will have no customers because buyers can go to a different packer and pay $1.13 per box. In addition, there is no reason for The Cheeseman to lower its price below $1.13 to attract buyers because it can sell all it wants at $1.13 per box.

Marginal revenue (MR) is the change in total revenue associated with producing one more unit of output.

Besides showing the demand curve facing The Cheeseman, panel (b) of Exhibit 6.5 shows the *marginal revenue* curve. **Marginal revenue (MR)** is the change in total revenue associated with producing one more unit of output. In a perfectly competitive market, MR is equal to the market price. Therefore, the MR curve is equivalent to the demand curve facing sellers. Because the price that The Cheeseman faces is $1.13, the MR is $1.13 for every cheese box packed. We are now in a position to learn about the good stuff—making money!

Putting It All Together: Using the Three Components to Do the Best You Can

The profits of a firm are equal to its revenues minus its costs.

Now that we have the three components of the seller's problem in place, we can use them to show how a firm maximizes its profits, since the goal of the seller is to maximize net benefits, or profits. The **profits** of a firm are the difference between total revenues and total costs:

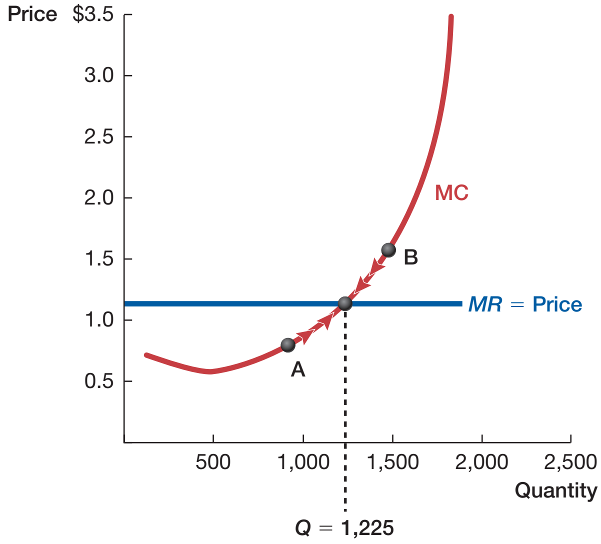
$$\text{Profits} = \text{Total revenues} - \text{Total costs}.$$

The goal of the seller is to maximize net benefits, or profits.

For The Wisconsin Cheeseman to determine its profits, there is only one more question to answer: how much to produce? To figure out what quantity maximizes profits, we need to think about a production level and conduct a thought experiment as to how producing a bit more or a bit less affects both revenues and costs. That is, the key behind maximizing profits is to think about the firm's MRs and MCs. This is an application of optimizing from Chapter 3.

Exhibit 6.6 Movement of Production Toward Equilibrium

The red curve is The Cheeseman's MC curve, and the blue line is The Cheeseman's MR curve. At point A, The Cheeseman should produce more to increase profits. At point B, The Cheeseman should produce less. To maximize profits, The Cheeseman produces where MC equals MR.



To see how this works, consider Exhibit 6.6, which recreates panel (b) of Exhibit 6.5. Let's first think about point A in the exhibit. At this point, The Cheeseman hires 9 workers and it produces 939 cheese boxes (see Exhibit 6.1). At this production level, it costs $0.85 to pack the last cheese box, as given by the MC in Exhibit 6.3. We know that The Cheeseman is paid $1.13 for each packed box.

Can The Cheeseman earn higher profits? Yes. If it produces one more cheese box, it increases revenues by $1.13, which is greater than the $0.85 it costs to produce. Profit could be increased by $0.28 just by selling one more cheese box! This provides a general rule: if a firm can produce another unit of output at a MC that is less than the market price (that is, MC < Price), it should do so because it can make a profit on producing that unit.

Consider the other side of the coin: if The Cheeseman chose to produce at point B—hiring 17 workers and producing 1,438 units—its MC of producing the last unit is greater than the market price ($1.50 versus $1.13). Thus, it loses money by producing that last unit. The company therefore shouldn't produce it and should hire fewer workers.

In fact, with this marginal decision making in mind, it's straightforward to see how a firm maximizes its profits. It should expand production until:

$$\text{Marginal revenue} = \text{Marginal cost}.$$

This is the same as producing where price equals MC because MR equals price in a perfectly competitive market.

How can we compute the level of profits at this point? One aid is to overlay the ATC curve on Exhibit 6.6, which we do in Exhibit 6.7. Because total revenues $=$ Price $\times\ Q$ and total costs $= ATC \times Q$, we can write total profits as:

$$\text{Price} \times Q - ATC \times Q = (\text{Price} - ATC) \times Q.$$

In other words, we can compute total profits by taking the difference between price and ATC at the point of production and multiplying that difference by the total quantity produced. In the case of producing at $MR = MC$, this provides the shaded area in Exhibit 6.7.

We can compute this area as follows:

$$(P - ATC) \times Q = (\$1.13 - \$0.93) \times 1{,}225 = \$245.$$

This follows because The Cheeseman is paid $1.13 per box at a production level of 1,225 boxes. At this level of production, the ATC cost is $0.93 (see Exhibit 6.3). So, taking the price of $1.13 and subtracting the ATC of $0.93, we get $0.20, which is per-unit profit. We then multiply this per-unit profit by quantity sold, or 1,225, to find the daily profit figure of $245. This profit level is equal to the base times the height of the shaded rectangle in