Figure 10A.7 Income and Substitution Effects of a Price Change (1 of 2)

When the price of pizza falls, Dave changes his consumption from *A* to *C*.

We can think of this as two separate effects:

1. A change in relative price keeping utility constant, causing a movement along indifference curve I_1; this is the **substitution effect.**

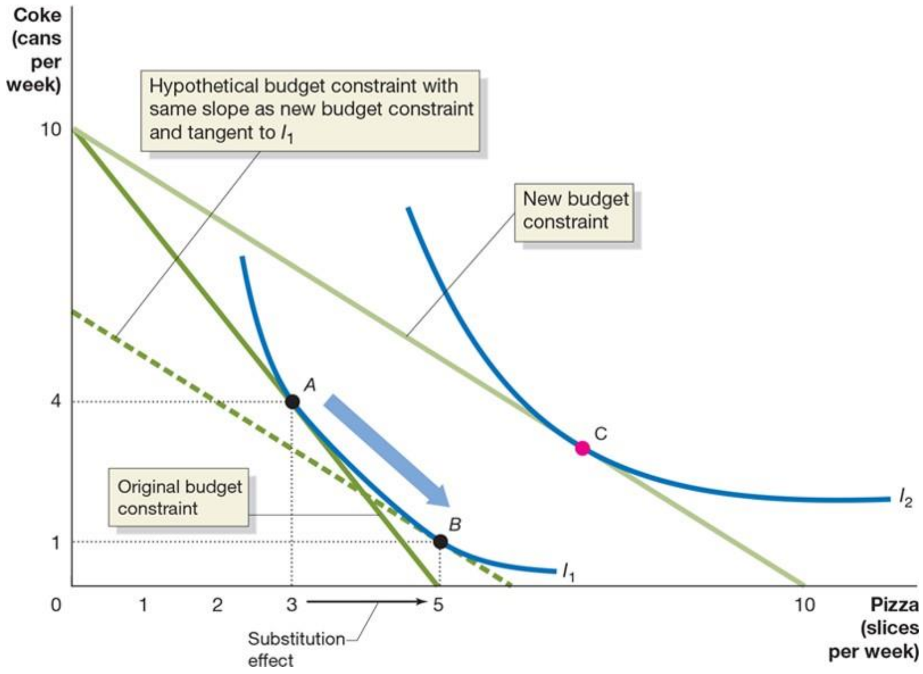


Figure 10A.7 Income and Substitution Effects of a Price Change (2 of 2)

When the price of pizza falls, Dave changes his consumption from *A* to *C*.

We can think of this as two separate effects:

2. An increase in purchasing power, causing a movement from *B* to *C*; this is the **income effect**.

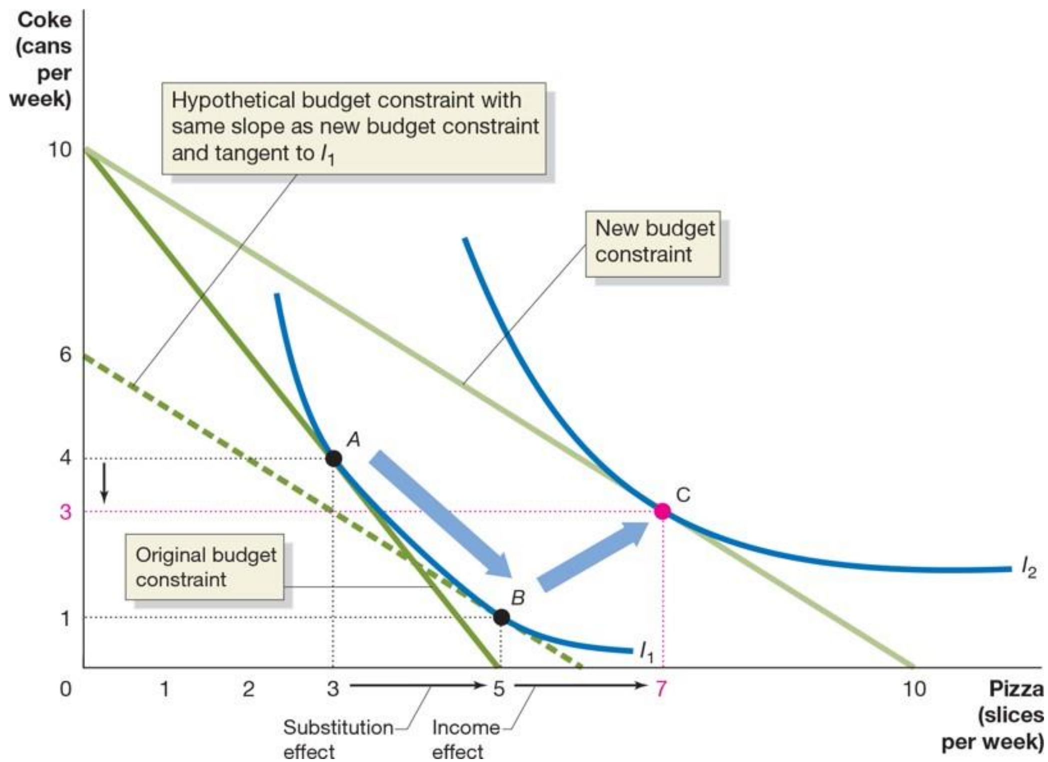


Figure 10A.8 How a Change in Income Affects the Budget Constraint

When the income Dave can spend on pizza and Coke Increases from $10 to $20 his budget constraint shifts Outward.

With $10, Dave could buy a maximum of 5 slices of pizza or 10 cans of Coke.

With $20, he can buy a maximum of 10 slices of pizza or 20 cans of Coke.

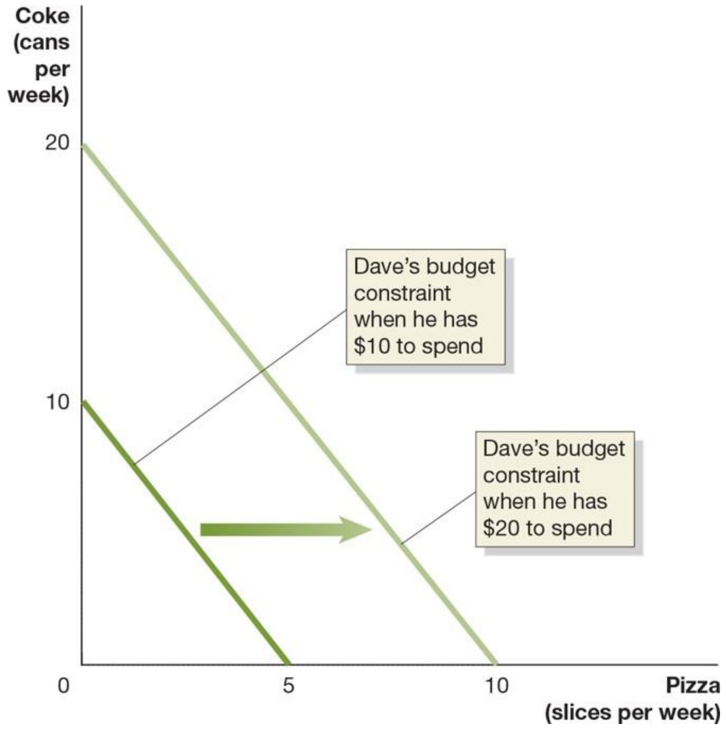


Figure 10A.9 How a Change in Income Affects Optimal Consumption

An increase in income leads Dave to consume more Coke…

… and more pizza.

For Dave, both Coke and pizza are **normal goods**.

A different consumer might have different preferences, and an increase in income might **decrease** the demand for Coke, for example; now, Coke would be an **inferior good**.

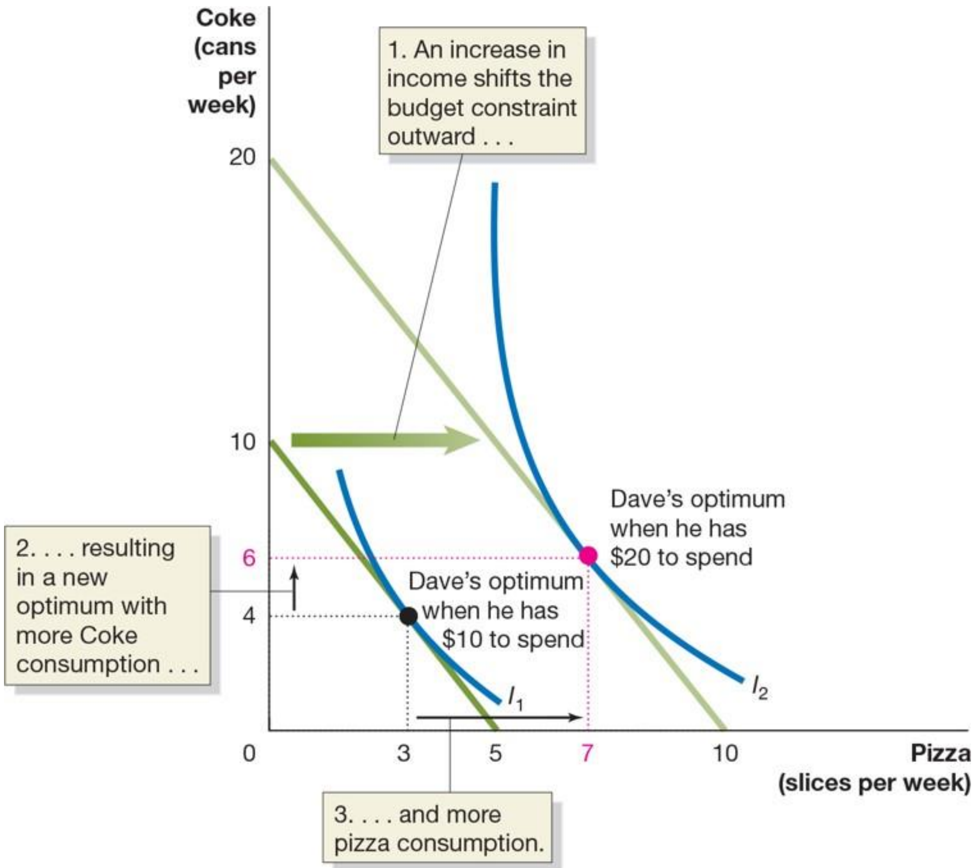


Figure 10A.10 At the Optimum Point, the Slopes of the Indifference Curve and the Budget Constraint Are the Same (1 of 2)

At the optimal point of consumption, the indifference curve is just tangent to the budget line; their slopes are equal.

- The slope of the indifference curve is the (negative of the) marginal rate of substitution.

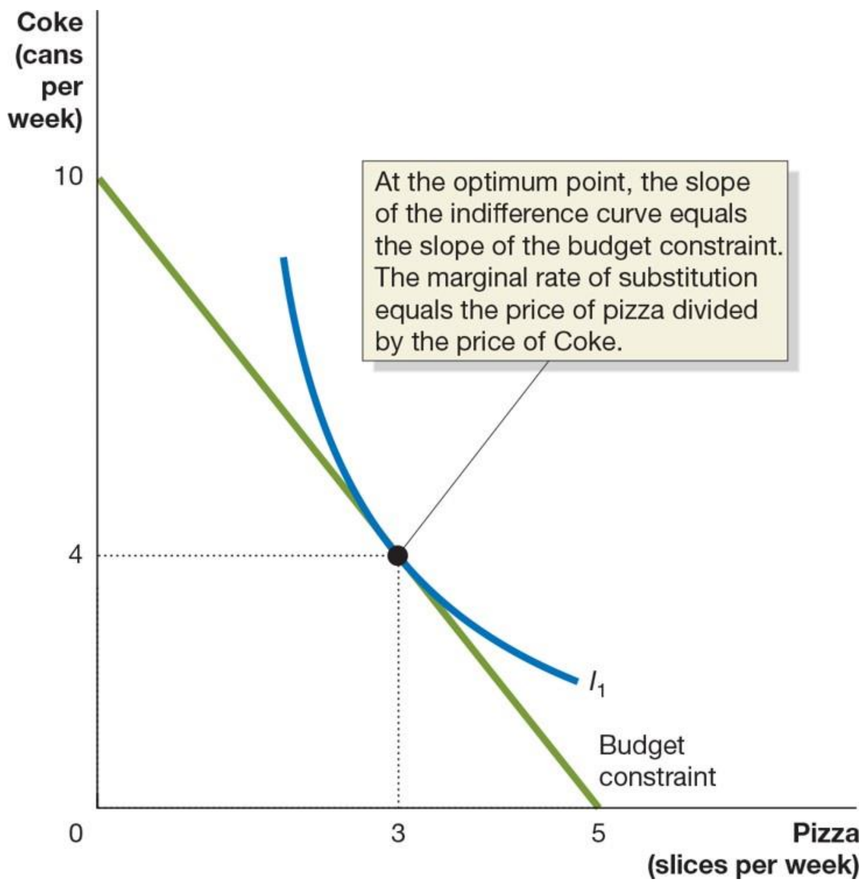
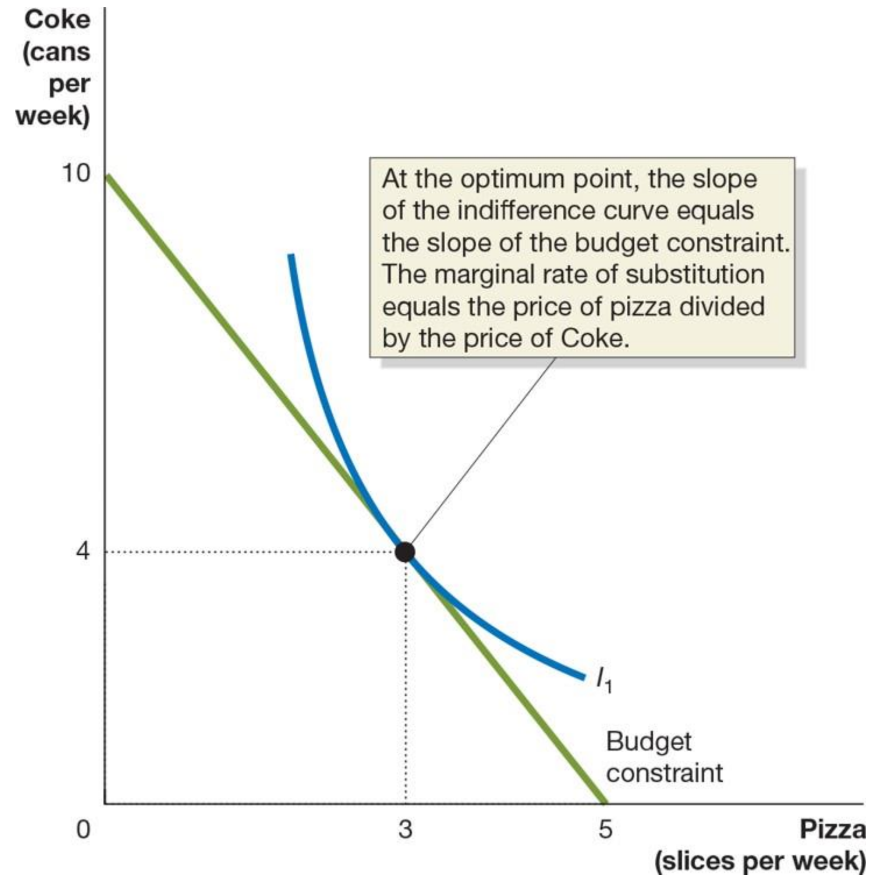


Figure 10A.10 At the Optimum Point, the Slopes of the Indifference Curve and the Budget Constraint Are the Same (2 of 2)

- The slope of the budget line is the (negative of the) ratio of the price of the horizontal axis good to the price of the vertical axis good.

So at the optimum,

$$MRS = \frac{P_{Pizza}}{P_{Cook}}$$



Relating MRS and Marginal Utility

Suppose Dave is indifferent between two bundles, *A* and *B*. *A* has more Coke than *B*, so *B* must have more pizza than *A*.

As Dave moves from *A* to *B*, the loss (in utility) from consuming less Coke must be just offset by the gain (in utility) from consuming more pizza. We can write:

$$-\left(\text{Change in the quantity of Coke} \times MU_{Coke}\right) = \left(\text{Change in the quantity of pizza} \times MU_{Pizza}\right)$$

Rearranging terms gives:

$$\frac{-\text{Change in the quantity of Coke}}{\text{Change in the quantity of pizza}} = \frac{MU_{Pizza}}{MU_{Coke}}$$

And this first term is the slope of the indifference curve: the *MRS*.

$$\frac{-\text{Change in the quantity of Coke}}{\text{Change in the quantity of pizza}} = MRS = \frac{MU_{Pizza}}{MU_{Coke}}$$

The Rule of Equal Marginal Utility per Dollar Spent

The last two slides have given us:

$$MRS = \frac{P_{Pizza}}{P_{Coke}}$$

and

$$MRS = \frac{MU_{Pizza}}{MU_{Coke}}$$

So now we know:

$$\frac{P_{Pizza}}{P_{Coke}} = \frac{MU_{Pizza}}{MU_{Coke}}$$

Rearrange to obtain our desired rule:

$$\frac{MU_{Coke}}{P_{Coke}} = \frac{MU_{Pizza}}{P_{Pizza}}$$

11.3 The Marginal Product of Labor and the Average Product of Labor

Explain and illustrate the relationship between the marginal product of labor and the average product of labor.

Suppose Jill Johnson hires just one worker; what does that worker have to do?

- Take orders
- Make and cook the pizzas
- Take pizzas to the tables
- Run the cash register, etc.

By hiring another worker, these tasks could be divided up, allowing for some **specialization** to take place, resulting from the **division of labor**.

Two workers can probably produce more output per worker than one worker can alone.

Apply the Concept: Adam Smith and the Division of Labor in a Pin Factory

One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds… the important business of making a pin is, in this manner, divided into eighteen distinct operations.

Adam Smith in The Wealth of Nations

Smith estimated a single worker could make 20 pins per day by himself; but by division of labor and specialization, workers produced on average 4,800 pins per day.

Table 11.3 The Marginal Product of Labor at Jill Johnson's Restaurant (1 of 2)

Quantity of Workers	Quantity of Pizza Ovens	Quantity of Pizzas	Marginal Product of Labor
0	2	0	—
1	2	200	200
2	2	450	250
3	2	550	100
4	2	600	50
5	2	625	25
6	2	640	15

Let's examine what happens as Jill Johnson hires more workers.

To think about this, consider the **marginal product of labor**: the additional output a firm produces as a result of hiring one more worker.

- The first worker increases output by 200 pizzas; the second increases output by 250.

Table 11.3 The Marginal Product of Labor at Jill Johnson's Restaurant (2 of 2)

Quantity of Workers	Quantity of Pizza Ovens	Quantity of Pizzas	Marginal Product of Labor
0	2	0	—
1	2	200	200
2	2	450	250
3	2	550	100
4	2	600	50
5	2	625	25
6	2	640	15

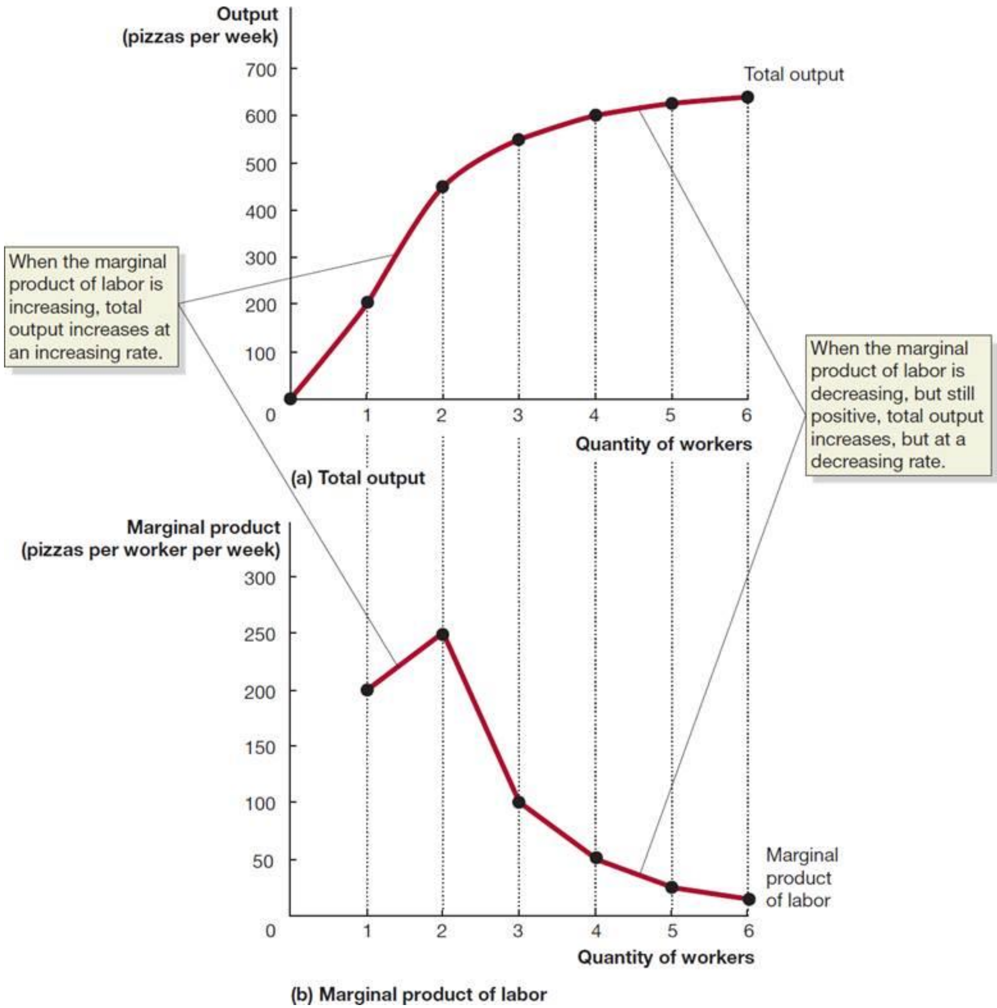
Additional workers add to the potential output but not by as much. Eventually they start getting in each other's way, etc., because there is only a fixed number of pizza ovens, cash registers, etc.

Law of diminishing returns: The principle that, at some point, adding more of a variable input, such as labor, to the same amount of a fixed input, such as capital, will cause the marginal product of the variable input to decline.

Figure 11.2 Total Output and the Marginal Product of Labor

Graphing the output and marginal product against the number of workers allows us to see the law of diminishing returns more clearly.

The output curve flattening out, and the decreasing marginal product curve, both illustrate the law of diminishing returns.



Average Product of Labor

Another useful indication of output is the **average product of labor**, the total output produced by a firm divided by the quantity of workers.

- With 3 workers, the restaurant can produce 550 pizzas, giving an average product of labor of:

$$\frac{550}{3} = 183.3$$

A useful way to think about this is that **the average product of labor is the average of the marginal products of labor.**

- The first three workers give 200, 250, and 100 additional pizzas respectively:

$$\frac{200 + 250 + 100}{3} = 183.3$$

Average and Marginal Product of Labor

With only two workers, the average product of labor was:

$$\frac{200+250}{2}=\frac{450}{2}=225$$

So the third worker made the average product of labor go down.

- This happened because the third worker produced **less (marginal) output than the average of the previous workers.**

If the next worker produces more (marginal) output than the average, then the average product will rise instead.

- The next slide illustrates this idea using college grade point averages (GPAs).

Figure 11.3 Marginal and Average GPAs

Paul's semester GPA starts off poorly, rises, then eventually falls in his senior year.

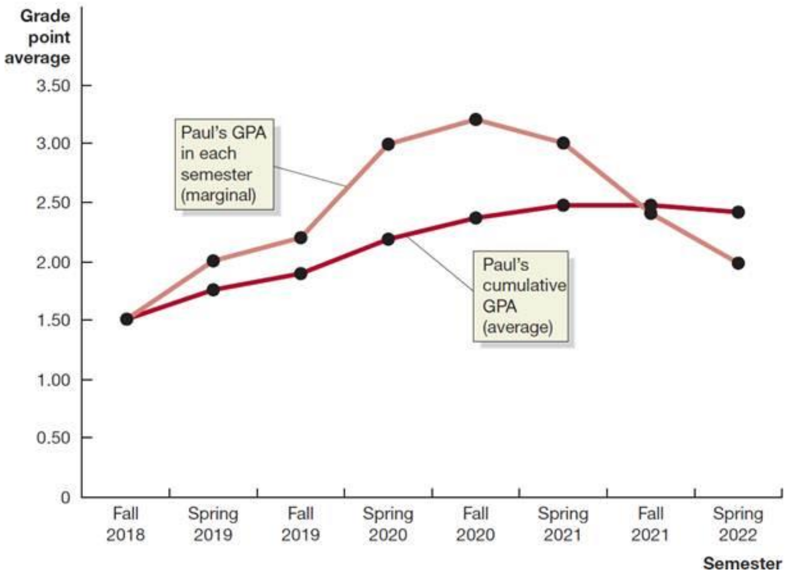
His cumulative GPA follows his semester GPA upward, as long as the semester GPA is higher than the cumulative GPA.

When his semester GPA dips down below the cumulative GPA, the cumulative GPA starts to head down also.

	Semester GPA (marginal GPA)	Cumulative GPA (average GPA)
First year		
Fall	1.50	1.50
Spring	2.00	1.75
Sophomore year		
Fall	2.20	1.90
Spring	3.00	2.18
Junior year		
Fall	3.20	2.38
Spring	3.00	2.48
Senior year		
Fall	2.40	2.47
Spring	2.00	2.41

Average GPA continues to rise, although marginal GPA falls.

With the marginal GPA below the average, the average GPA falls.



11.4 The Relationship Between Short-Run Production and Short-Run Cost

Explain and illustrate the relationship between marginal cost and average total cost.

We have already seen the **average total cost**: total cost divided by output.

We can also define the **marginal cost** as the change in a firm's total cost from producing one more unit of a good or service:

$$MC = \frac{\Delta TC}{\Delta Q}$$

Sometimes $\Delta Q = 1$, so we can ignore the bottom line, but don't get in the habit of doing that, or you'll make mistakes when quantity changes by more than 1 unit.

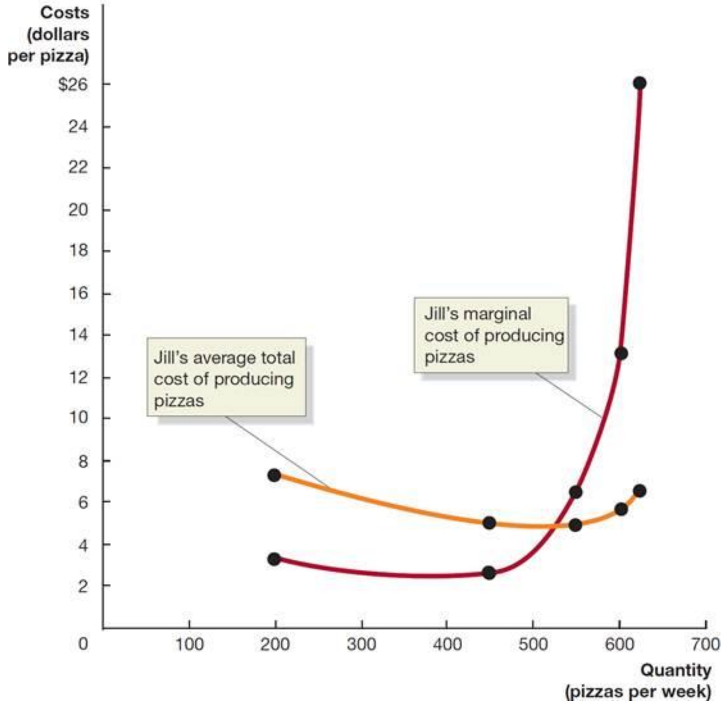
Figure 11.4 Jill Johnson's Marginal Cost and Average Cost of Producing Pizzas

We can visualize the average and marginal costs of production with a graph.

The first two workers increase average production, and cause cost per unit to fall; the next four workers are less productive, resulting in high marginal costs of production.

Since the average cost of production "follows" the marginal cost down and then up, this generates a U-shaped average cost curve.

Quantity of Workers	Quantity of Pizzas	Marginal Product of Labor	Total Cost of Pizzas	Marginal Cost of Pizzas	Average Total Cost of Pizzas
0	0	–	$800	–	–
1	200	200	1,450	$3.25	$7.25
2	450	250	2,100	2.60	4.67
3	550	100	2,750	6.50	5.00
4	600	50	3,400	13.00	5.67
5	625	25	4,050	26.00	6.48
6	640	15	4,700	43.33	7.34



11.5 Graphing Cost Curves

Graph average total cost, average variable cost, average fixed cost, and marginal cost.

We know that total costs can be divided into fixed and variable costs:

$$TC = FC + VC$$

Dividing both sides by output (*Q*) gives a useful relationship:

$$TC / Q = FC / Q + VC / Q$$

- The first quantity is **average total cost**.
- The second is **average fixed cost**: fixed cost divided by the quantity of output produced.
- The third is **average variable cost**: variable cost divided by the quantity of output produced.

So,

$$ATC = AFC + AVC$$

Figure 11.5 Costs at Jill Johnson's Restaurant (1 of 2)

Quantity of Workers	Quantity of Ovens	Quantity of Pizzas	Cost of Ovens (fixed cost)	Cost of workers (variable cost)	Total Cost of Pizzas	*ATC*	*AFC*	*AVC*	*MC*
0	2	0	$800	$0	$800	-	-	-	-
1	2	200	800	650	1450	$7.25	$4.00	$3.25	$3.25
2	2	450	800	1,300	2,100	4.67	1.78	2.89	2.60
3	2	550	800	1,950	2,750	5.00	1.45	3.54	6.50
4	2	600	800	2,600	3,400	5.67	1.33	4.33	13.00
5	2	625	800	3,250	4,050	6.48	1.28	5.20	26.00
6	2	640	800	3,900	4,700	7.34	1.25	6.09	43.33

Observe that:

- In each row, *ATC* = *AFC* + *AVC.*
- When *MC* is above *ATC*, *ATC* is falling.
- When *MC* is above *ATC*, *ATC* is rising.
- The same is true for *MC* and *AVC*.

Figure 11.5 Costs at Jill Johnson's Restaurant (2 of 2)

This results in both *ATC* and *A VC* having their U-shaped curves.

The *MC* curve cuts through each at its minimum point, since both *ATC* and *AVC* "follow" the *MC* curve.

Also notice that the vertical sum of the *AVC* and *AFC* curves is the *ATC* curve.

And because *AFC* gets smaller, the *ATC and AVC* curves converge.