U.S. Department of Agriculture

CHAPTER

9

COST CONCEPTS IN ECONOMICS

CHAPTER OUTLINE

Opportunity Cost
Cash and Noncash Expenses
Fixed, Variable, and Total Costs
Application of Cost Concepts
Economies of Size
Long-Run Average Cost Curve
Summary
Questions for Review and Further Thought
Appendix. Cost Curves

CHAPTER OBJECTIVES

1. Explain the importance of opportunity cost and its use in managerial decision making
2. Clarify the difference between short run and long run
3. Discuss the difference between fixed and variable costs
4. Identify fixed costs and show how to compute them
5. Demonstrate the use of fixed and variable costs in making short-run and long-run production decisions
6. Explore economies and diseconomies of size and how they help explain changes in farm size and profitability

A good understanding of the costs of production is important in economics and very useful for making management decisions. Costs can be classified in different ways, depending on whether they are fixed or variable and cash or noncash. *Opportunity cost* is another type of cost not included in the accounting expenses for a business but an important economic cost nevertheless. It will be widely used in later chapters and will be the first cost discussed in this chapter.

Opportunity Cost

Opportunity cost is an economic concept, not a cost that can be found in an accountant's ledger or on an income tax return. However, it is an important and basic concept that needs to be considered when making managerial decisions. Opportunity cost is based on the fact that once an input has been acquired, it may have one or more alternative uses. Once an input is committed to a particular use, it is no longer available for any other alternative use, and the income from the alternative must be foregone.

Opportunity cost can be defined in one of two ways:

1. The income that could have been earned by selling or renting the input to someone else or
2. The additional income that would have been received if the input had been used in its most profitable alternative use

The latter definition is perhaps the more common, but both should be kept in mind as a manager makes decisions on input use. The real cost of an input may not be its purchase price. Its real cost, or its opportunity cost, in any specific use is the income it would have earned in its next best alternative use. If this is greater than the income expected from the planned use of the input, the manager should reconsider the decision. The alternative appears to be a more profitable use of the input.

Opportunity costs are used widely in economic analysis. For example, the opportunity costs of a farm operator's labor, management, and capital are used in several types of budgets used for analyzing farm profitability.

Labor

The opportunity cost of a farm operator's labor (and perhaps that of other unpaid family labor) would be what that labor would earn in its next best alternative use. That alternative use could be nonfarm employment, but depending on skills, training, and experience, it might also be employment in another farm or ranch enterprise. Some operators state that their own time is *free*, but it should be given a value at least as high as the value that they put on leisure time.

Management

Management is the process of making and executing decisions—it is different from physical labor used in agriculture. The opportunity cost of management is difficult to estimate. For example, what is the value of management per crop acre? Some percentage of all other costs or the gross income per acre is often used, but what is the proper percent? In other cases, an annual opportunity cost of management is needed. Here and elsewhere, the analyst must be careful to exclude labor from the estimate. For example, if the opportunity cost of labor is estimated at $30,000 per year, and the individual could get a job in *management* paying $40,000 per year, the opportunity cost of management is estimated as the difference, or $10,000 per year. The opportunity cost of labor plus that of management cannot be greater than the total salary in the best alternative job. It is difficult to estimate the opportunity cost of management, so the opportunity costs of labor and management are often combined into one value.

Capital

Capital presents a different set of problems for estimating opportunity costs. There are many uses of capital and generally a wide range of possible returns. However, alternative uses of capital with higher expected returns may carry a higher degree of risk as well. To avoid the problem of identifying a use with a comparable level of risk, the opportunity cost of farm capital is often set equal to the interest rate on savings accounts or the current cost of borrowed capital.

This assumes that the capital invested in a farm or ranch enterprise could have been deposited in savings or used to pay down debt. This represents a minimum opportunity cost and is a somewhat conservative approach. If the expected rate of return on an investment with a comparable level of risk can be determined, it would be appropriate to use that rate when analyzing farm investments.

A special problem is how to determine the opportunity cost on the annual service provided by long-lived inputs such as land, buildings, breeding stock, and machinery. It may be possible to use rental rates for land and for machinery services. However, this does not work well for all such items, and the opportunity cost of these inputs often should be determined by the most profitable alternative use of the capital invested in them outside the farm or ranch business. This is the real or true cost of using inputs to produce agricultural products.

Some farm assets such as machinery, buildings, fences, and livestock equipment decrease in value over time; they depreciate. Their opportunity cost should be adjusted each year, by multiplying the opportunity cost rate of return by the value for which the asset could be sold, also called its salvage value. Sometimes a long-term investment analysis uses the average salvage value of an asset over its lifetime to calculate the opportunity cost of investing capital in it. This will be illustrated later in the chapter.

CASH AND NONCASH EXPENSES

Fixed costs can be either *cash* or *noncash* expenses. They can be easily overlooked or underestimated, because a large part of total fixed cost can be noncash expenses, as shown in Table 9-1.

Depreciation and opportunity costs are always noncash expenses, because there is no annual cash outlay for them. Repairs and property taxes are always cash expenses, and interest and insurance may be either. If money is borrowed to purchase the asset, there will be some cash interest expense.

TABLE 9-1 Cash and Noncash Expense Items

Expense item	Cash expense	Noncash expense
Depreciation		X
Interest (own capital)		X
Interest (borrowed capital)	X	
Value of operator labor		X
Wages for hired labor	X	
Farm raised feed		X
Purchased feed	X	
Owned land		X
Cash rented land	X	
Seed, fertilizer, fuel, repairs	X	
Property taxes, insurance	X	

Box 9-1 Cash and Noncash Expenses

Any distinction between cash and noncash expenses does not imply that noncash expenses are any less important than cash expenses. In the short run, noncash expenses do mean that less cash is needed to meet current expenses. However, income must be sufficient to cover all expenses in the long run if the business is to survive, prosper, replace capital assets, and make an economic profit.

When the item is purchased entirely with the buyer's own capital, the interest charge would be the opportunity cost on this capital, and there is no cash payment to a lender. Insurance would be a cash expense if it is carried with an insurance company or noncash if the risk of loss is assumed by the owner. In the latter case, there would be no annual cash outlay, but the insurance charge should still be included in fixed costs to cover the possibility of damage to or loss of the item from fire, windstorm, theft, and so forth.

Some variable costs can be noncash costs as well. When crops are grown to feed livestock produced on the same farm, there is no cash outlay as there would be for purchased feed. However, there is an opportunity cost equal to the revenue that could have been received from selling the feed crop on the market.

Fixed, Variable, and Total Costs

Several important cost concepts were introduced in Chapter 7. Seven useful cost concepts and their abbreviations are

1. Total fixed cost (TFC)
2. Average fixed cost (AFC)
3. Total variable cost (TVC)
4. Average variable cost (AVC)
5. Total cost (TC)
6. Average total cost (ATC)
7. Marginal cost (MC)

These costs are *output* related. Marginal cost, also studied in Chapter 7, is the additional cost of producing an additional unit of output. The others are either the total cost or the cost per unit for producing a given amount of output.

Short Run and Long Run

Before these costs are discussed in some detail, it is necessary to distinguish between what economists call the short run and the long run. These are time concepts, but they are not defined as fixed periods of calendar time. The *short run* is that period during which the available quantity of one or more production inputs is fixed and cannot be changed. For example, at the beginning of the planting season, it may be too late to increase or decrease the amount of cropland owned or rented. The current crop production cycle would be a short-run period, as the amount of available land is fixed.

Over a longer period, land may be purchased, sold, or leased, or leases may expire causing the amount of land available to increase or decrease. The *long run* is defined as that period during which the quantity of all necessary productive inputs can be changed. In the long run, a business can expand by acquiring additional inputs or go out of existence by selling all its inputs. Farm managers and employees may come or go. The actual calendar length of the long run as well as the short run will vary with the situation and circumstances. Depending on which inputs are fixed, the short run may be anywhere from several days to several years. One year and one crop or livestock production cycle are common short-run periods in agriculture.

Fixed Costs

The costs associated with owning a fixed input are called *fixed costs*. These are the costs that are incurred even if the input is not used. Depreciation, insurance, taxes (property taxes, not income taxes), and interest are the usual costs considered to be fixed. Repairs and maintenance may also be included as a fixed cost (see Box 9-2). Fixed costs do not change as the level of production changes in the short run but can change in the long run as the quantity of the fixed input changes. By definition there need not be any fixed resources owned in the long run, so fixed costs exist only in the short run.

Another characteristic of fixed costs is that they are not under the control of the manager in the short run. They exist, and stay at the same level regardless of how much or how little the resource is used. The only way they can be avoided is to sell the item, which can be done in the long run.

Total fixed cost (TFC) is the summation of the several types of fixed costs. Computing the average annual TFC for a fixed input requires finding the average annual depreciation and interest costs, among others. The straight-line depreciation method discussed in Chapter 4 also provides the average annual depreciation from the equation

$$\text{Depreciation} = \frac{\text{purchase price} - \text{salvage value}}{\text{useful life}}$$

where purchase price is the initial cost of the asset, useful life is the number of years the item is expected to be owned, and salvage value is its expected value at the end of that useful life. Although other methods can be used to estimate depreciation for each year of the asset's useful life, as discussed in Chapter 5, this equation can always be used to find the *average* annual depreciation.

Capital invested in a fixed input has an opportunity cost, so interest on that investment also is included as part of the fixed cost. However, it is not correct to charge interest on the purchase price or original cost of a depreciable asset every year, because its value is decreasing over time. Therefore, the interest component of TFC is commonly computed from the formulas

$$\text{Average asset value} = \frac{\text{purchase price} + \text{salvage value}}{2}$$

$$\text{Interest} = \text{average asset value} \times \text{interest rate}$$

where the interest rate is the cost of capital to the ranch or farm.[1] This equation gives the interest charged for the average value of the item over its useful life and reflects that it is decreasing in value over time. Depreciation is being charged to account for this decline in value. To find the interest cost for the current year instead of the average cost over the entire useful life of an asset, use the following formula:

$$\text{Interest} = \text{current asset value} \times \text{interest rate}$$

Other ownership costs for fixed resources, such as property taxes and insurance, can be estimated as a percent of the average value of the asset over its useful life (long-term cost) or its current value (current year cost). The actual dollar amount of cost paid or to be paid for taxes and insurance can also be used.

As an example, assume the purchase of a harvesting machine for $120,000, with a salvage value of $50,000 and a useful life of five years. Annual property taxes are estimated to be $400, annual insurance is $500, and the cost of capital is 8 percent. Using these values and the two preceding equations results in the following annual TFC:

$$\text{Average value} = \frac{\$120{,}000 + 50{,}000}{2} = \$85{,}000$$

$$\text{Interest} = \$85{,}000 \times 8\% = \$\ 6{,}800$$

$$\text{Depreciation} = \frac{\$120{,}000 - 50{,}000}{5\ \text{Years}} = \$14{,}000$$

Taxes	400
Insurance	500
Annual total fixed cost	$ 21,700

The annual total fixed cost is nearly 20 percent of the purchase price. It is often 15 to 25 percent of the purchase price for a depreciable asset.

Fixed cost can be expressed as an average cost per unit of output. Average fixed cost (AFC) is calculated using the equation

$$\text{AFC} = \frac{\text{TFC}}{\text{output}}$$

where output is measured in physical units such as bushels, bales, or hundred-weights.

[1]This equation is widely used but is only a close approximation of the true opportunity cost. The capital recovery methods discussed in Chapter 17 can be used to find the true charge, which combines depreciation and interest into one value. This value recovers the investment in the asset plus compound interest over its useful life.

Box 9-2 Repairs as a Fixed Cost?

Repairs can be found in some lists of fixed costs. However, repairs typically increase as use of the asset increases, which does not fit the definition of a fixed cost. The argument for including repairs in fixed costs is that some minimum level of maintenance is needed to keep an asset in working order, even if it is not being used. Therefore, this maintenance expense is more like a fixed cost. The practical problem with this is calculating what part of an asset's total repair and maintenance expense should be a fixed cost.

In practice, all machinery repairs are generally considered variable costs, because most repairs are necessitated by use. Building repairs are more likely to be included as a fixed cost. These repairs are often more from routine maintenance caused by age and weather and less from use. This is particularly true for storage facilities and many general-purpose buildings. For convenience, all repair costs will be classified as variable costs when developing budgets in later chapters of this text.

Acres or hours are often used as the measure of output for machinery even though they are not units of production. By definition, TFC is a fixed or constant value, so AFC will decline continuously as output increases. One way to lower the per-unit cost of producing a given commodity is to get more output from the fixed resource. This will always lower the AFC per unit of output.

Variable Costs

Variable costs are those over which the manager has control at a given time. They can be increased or decreased at the manager's discretion and will increase as production is increased. Items such as feed, fertilizer, seed, pesticides, fuel, and livestock health expenses are examples of variable costs. A manager has control over these expenses in the short run, and they will not be incurred unless production takes place.

Total variable cost (TVC) can be found by summing the individual variable costs, each of which is equal to the quantity of the input used times its price. Average variable cost (AVC) is calculated from the equation

$$\text{AVC} = \frac{\text{TVC}}{\text{output}}$$

where output again is measured in physical units. AVC may be increasing, constant, or decreasing, depending on the underlying production function and the output level. For the production function illustrated in Figure 7-2, AVC will initially decrease as output is increased and then will increase beginning at the point where average physical product begins to decline.

Variable costs exist in both the short run and the long run. All costs can be considered to be variable costs in the long run, because there are no fixed inputs. The distinction between fixed and variable costs also depends on the exact time where the next decision is to be made. Fertilizer is generally a variable cost. Yet once it has been purchased and applied, the manager no longer has any control over the size of this expenditure. It must be considered a fixed cost for the remainder of the crop season, which can affect future decisions during that crop season. Labor cost and cash rent for land are similar examples. After a labor or lease contract is signed, the manager cannot change the amount of money obligated, and the salary or rent must be considered a fixed cost for the duration of the contract. Costs that are fixed because they have already been incurred or paid are sometimes called *sunk costs*.

Total Costs

Total cost (TC) is the sum of TFC and TVC (TC = TFC + TVC). In the short run, it will increase only as TVC increases, because TFC is a constant value. Average total cost (ATC) can be calculated by one of two methods. For a given output level, it is equal to AFC + AVC. It can also be calculated from the equation

$$\text{ATC} = \frac{\text{TC}}{\text{output}}$$

which will give the same result. ATC will typically be decreasing at low output levels, because AFC is decreasing rapidly and AVC may be decreasing also. At higher output levels, AFC will be decreasing less rapidly, and AVC will eventually increase and be increasing at a rate faster than the rate of decrease in AFC. This combination causes ATC to increase.

Marginal Costs

Marginal cost (MC) is defined as the change in total cost divided by the change in output:

$$\text{MC} = \frac{\Delta\ \text{TC}}{\Delta\ \text{output}} \text{ or } \text{MC} = \frac{\Delta\ \text{TVC}}{\Delta\ \text{output}}$$

It is also equal to the change in TVC divided by the change in output. TC = TFC + TVC, and TFC is constant, so the only way TC can change is from a change in TVC. Therefore, MC can be calculated either way with the same result.

APPLICATION OF COST CONCEPTS

Table 9-2 is an example of some cost figures for the common problem of determining the profit-maximizing stocking rate of steer caves for a fixed amount of pasture land. It illustrates many similar problems where an understanding of the different cost concepts and relations will help a manager in planning and decision making.

The size of the pasture and the amount of forage available are both limited, so adding more and more steers will eventually cause the average weight gain per steer to decline over a fixed period. This is reflected in diminishing returns and a declining marginal physical product (MPP) when more than 30 steers are placed in the pasture. Total hundred-weights of beef sold off the pasture still increases, but at a decreasing rate as more steers compete for the limited forage.

TFCs are assumed to be $10,000 per year in the example. This would cover the annual opportunity cost on the land and any improvements, depreciation on fences and water facilities, and insurance. Variable costs are assumed to be $990 per steer (steers are the only variable input in this example). This includes the cost of the steer, transportation, health expenses, feed, interest on the investment in the steer, and any other expenses that increase directly along with the number of steers purchased.

The total and average cost figures in Table 9-2 have the usual or expected pattern as production or output is increased. TFC remains constant by definition, while both TVC and TC are increasing. AFC declines rapidly at first and then continues to decline but at a slower rate. AVC and MC are constant as the number of steers increases from 0 to 30, and then begin to increase.

Profit-Maximizing Output

The profit-maximizing output level was defined in Chapter 7 as one where MR = MC, but this exact point does not exist in Table 9-2. However, MC is less than MR when moving from 50 to 60 steers, but more than MR when moving from 60 to 70 steers. This makes 60 steers and 420 hundred-weights of beef the profit-maximizing levels of input and output for this example. When MC is greater than MR, the additional cost per hundred-weight of beef produced from the additional 10 steers is greater than the additional income per hundred-weight. Therefore, placing 70 steers on the pasture would result in less profit than placing 60 steers.

Box 9-3 Is Labor a Variable or Fixed Cost?

The cost of labor used in ranching and farming is not always easy to classify as a variable or fixed cost. Labor is not used unless a certain enterprise is carried out, and the amount of labor used depends on the size of the enterprise. This fits the definition of a variable cost. On the other hand, labor resources may have to be paid regardless of how much work is performed, and some farm work such as record keeping and maintenance may have to be done regardless of what enterprises are carried out.

Several situations can occur:

1. Labor is hired only as needed and is paid by the hour, by the day, or by the amount of work accomplished. In this case it is a variable cost.
2. Labor is paid a fixed wage regardless of how much it is used, in which case it can be considered a fixed cost, at least for the period of the employment contract.
3. If labor is valued at its opportunity cost, as is often the case with unpaid operator labor, and using it in one enterprise reduces the labor available for another enterprise, then it can be considered a variable cost.
4. If permanent labor resources are in excess supply, that is, they have no significant opportunity cost, they can be treated as fixed resources and their cost can be ignored in short-run analysis.

Some producers use family living costs as an estimate of unpaid labor value. While withdrawals made for family living should be included in a cash flow budget (see Chapter 13), the amount withdrawn will depend on family size, consumption patterns, location, and other sources of income available. There is no reason to believe that living costs accurately reflect the economic cost of labor used in the farming operation, though.

The profit-maximizing point will depend on the selling price, or MR, and MC. Selling prices often change, and MC can change with changes in variable cost (primarily from a change in the cost of the steer in this example). The values in the MC column indicate that the most profitable number of steers would be 70 if the selling price is over \$180.00 but less than \$198.00. That number would drop to 50 steers if the selling price dropped to anywhere between \$152.31 and \$165.00. As shown in Chapter 7, the profit-maximizing input and output levels will always depend on prices of both the input and the output.

Total Profit

For the selling price of \$175.00 per hundred-weight and a stocking rate of 60 steers, the total revenue (TR) is \$73,500 (420 hundred-weight × \$175.00) and TC is \$69,400, leaving a profit of \$4,100.00. For a price of \$156.00, however, the MR = MC rule indicates a profit-maximizing point of 50 steers and 360 hundred-weights. The ATC per hundred-weight at this point is \$165.28, which would mean a loss of \$9.28 per hundred-weight (\$156.00 – \$165.28 = –9.28) or a total loss of \$3,340 (\$9.28 × 360 hundred-weights). What should a manager do in this situation? Should any steers be purchased if the expected selling price is less than ATC and a loss will result?

The answer is *yes* for some situations and *no* for others. Data in Table 9-2 indicate that there would be a loss equal to the TFC of \$10,000 if no steers were purchased. This loss would exist in the short run as long as the land is owned. It could be avoided in the long run by selling the land, which would eliminate the fixed costs. However, the fixed costs cannot be avoided in the short run, and the relevant question is, Can a profit be made or the loss reduced to less than \$10,000 in the

TABLE 9-2 Illustration of Cost Concepts Applied to a Stocking Rate Problem*

	Output		Total costs			Average costs			Marginal costs			
Number of steers	(hundred-weight of beef)	MPP	TFC ($)	TVC ($)	TC ($)	AFC ($)	AVC ($)	ATC ($)	MC ($)		MR ($)	Total profit ($)
0	0		10,000	0	10,000	—	—	—				(10,000)
		7.5							132.00	<	175.00	
10	75		10,000	9,900	19,900	133.33	132.00	265.33				(6,775)
		7.5							132.00	<	175.00	
20	150		10,000	19,800	29,800	66.67	132.00	198.67				(3,550)
		7.5							132.00	<	175.00	
30	225		10,000	29,700	39,700	44.44	132.00	176.44				(325)
		7							141.43	<	175.00	
40	295		10,000	39,600	49,600	33.90	134.24	168.14				2,025
		6.5							152.31	<	175.00	
50	360		10,000	49,500	59,500	27.78	137.50	165.28				3,500
		6							165.00	<	175.00	
60	**420**		**10,000**	**59,400**	**69,400**	**23.81**	**141.43**	**165.24**				**4,100**
		5.5							180.00	>	175.00	
70	475		10,000	69,300	79,300	21.05	145.89	166.95				3,825
		5							198.00	>	175.00	
80	525		10,000	79,200	89,200	19.05	150.86	169.90				2,675
		4.5							220.00	>	175.00	
90	570		10,000	89,100	99,100	17.54	156.32	173.86				650
		4							247.50	>	175.00	
100	610		10,000	99,000	109,000	16.39	162.30	178.69				(2,250)

*Total fixed cost is $10,000, and variable cost is $990 per steer. Selling price of the steers is assumed to be $175.00 per hundred-weight.

short run by purchasing some steers? Steers should not be purchased if it would result in a loss greater than $10,000, because the loss can be minimized at $10,000 by not purchasing any.

Variable costs are under the control of the manager and can be reduced to zero by not purchasing any steers. Therefore, no variable costs should be incurred unless the expected selling price is at least equal to or greater than the minimum AVC. This will provide enough total revenue to cover TVCs. If the selling price is greater than the minimum AVC but less than the minimum ATC, the income will cover all variable costs, with some left over to pay part of the fixed costs. There would be a loss, but it would be less than $10,000 in this example. To answer the previous question, yes, steers should be purchased when the expected selling price is less than the minimum ATC, but only if it is above the minimum AVC. This action will result in a loss, but it will be smaller than the loss that would result if no steers were purchased.

If the expected selling price is less than the minimum AVC, total revenue will be less than TVC: There will be a loss, and it will be greater than $10,000. Under these conditions, no steers should be purchased, which will minimize the loss at $10,000. In Table 9-2, the lowest AVC is $132.00 and the lowest ATC is $165.24. The loss would be minimized by not purchasing steers when the expected selling price is less than $132.00 and by purchasing steers when the expected selling price is between $132.00 and $165.24. In the last situation, the loss-minimizing output level is where MR = MC.

Production Rules for the Short Run

The preceding discussion leads to three rules for making production decisions in the short run. They are as follows:

1. Expected selling price is greater than minimum ATC (selling price of $165.24 in the following table). A profit can be made and is maximized by producing at the level where MR = MC.
2. Expected selling price is less than minimum ATC but greater than minimum AVC (selling price of $156.00 in the following table). A loss cannot be avoided but will be minimized by producing at the output level where MR = MC. The loss will be somewhere between zero and TFC.
3. Expected selling price is less than minimum AVC (selling price of $126.00 in the following table). A loss cannot be avoided but is minimized by not producing. The loss will be equal to TFC.

Selling price ($/cwt.)	Number of steers to buy	Total revenue ($)	Total costs ($)	Profit ($)
$175.00	60	$73,500	$69,400	$4,100
$156.00	50	$56,160	$59,500	($3,340)
$126.00	0	$ 0	$10,000	($10,000)

The application of these rules is graphically illustrated in Figure 9-1. With a selling price equal to MR_1, the intersection of MR and MC is well above ATC, and a profit is being made. When the selling price is equal to MR_2, the income will not be sufficient to cover total costs but will cover all variable costs, with some left over to pay part of fixed costs. In this situation, the loss is minimized by producing where MR = MC, because the loss will be less than TFC. Should the selling price be as low as MR_3, income would not even cover variable costs, and the loss would be minimized by stopping

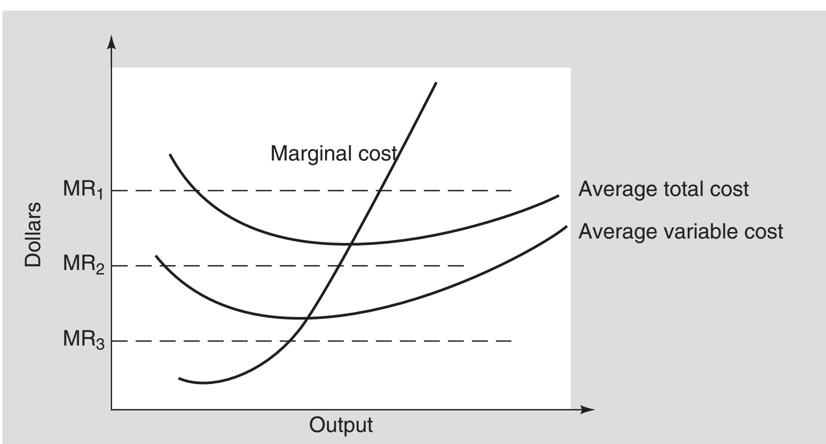

Figure 9-1 Illustration of short-run production decisions.

production altogether. This would minimize the loss at an amount equal to TFC.

Production Rules for the Long Run

The three production decision rules apply only to the short run where fixed costs exist. What about the long run where there are no fixed costs? Continual losses incurred by producing in the long run will eventually force the firm out of business.

There are only two rules for making production decisions in the long run:

1. Selling price is greater than ATC (or TR greater than TC). Continue to produce, because a profit is being made. This profit is maximized by producing at the point where MR = MC.
2. Selling price is less than ATC (or TR less than TC). There will be a continual loss. Stop production and sell the fixed asset(s), which eliminates the fixed costs. The money received should be invested in a more profitable alternative.

This does not mean that assets should be sold the first time a loss is incurred. Short-run losses will occur when there is a temporary drop in the selling price. Long-run rule number two should be invoked only when the drop in price is expected to be long lasting or permanent.

In some cases the selling price is known at the time the decision to produce or not is made, such as when a forward contract is available. Most of the time, though, the manager must decide based on a prediction or an estimate of the final selling price. Chapter 15 will discuss some techniques that a manager can use to deal with the effect of uncertain prices.

ECONOMIES OF SIZE

Economists and managers are interested in farm size and the relation between costs and size, for a number of reasons. The following are examples of questions being asked that relate to farm size and costs. What is the most profitable farm size? Can larger farms produce food and fiber more cheaply? Are large farms more efficient? Will family farms disappear and be replaced by large corporate farms? Will the number of farms and farmers continue to decline? The answers to these questions depend at least in part on what happens to costs and the cost per unit of output as farm size increases.

First, how is farm size measured? Number of livestock, number of acres, number of full-time workers, equity, total assets, profit, and other factors are used to measure size, and all have some advantages and disadvantages. For example, number of acres is a common and convenient measure of farm size but should be used only to compare farm sizes in a limited geographical area where farm type, soil type, and climate are similar. One hundred acres of irrigated vegetables in California is not the same size operation as 100 acres of arid range land in neighboring Arizona or Nevada.

Gross farm income, or total revenue, is a common measure of farm size. It has the advantage of converting everything into the common denominator of the dollar. This and other measures that are in dollar terms are better than any physical measure for determining and comparing farm size across different farming regions.

Size in the Short Run

In the short run, the quantity of one or more inputs is fixed, with land often being the fixed input. Given this fixed input, there will be a short-run average total cost curve, as shown in Figure 9-2. Short-run average cost curves typically will be U-shaped, with the average cost increasing at higher levels of production, because the limited fixed input makes additional production more and more difficult and therefore increases the average cost per unit of output.

For simplicity, size is measured as the output of a single product in Figure 9-2. The product can be produced at the lowest average cost per unit by producing the quantity $0a$. However,

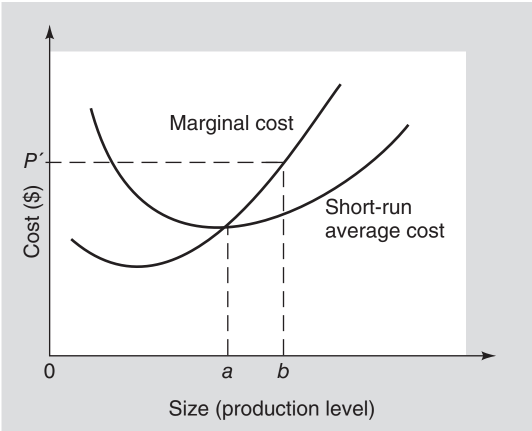

Figure 9-2 **Farm size in the short run.**

this may not be the profit-maximizing quantity, as profit is maximized at the output level where marginal revenue is equal to marginal cost. Marginal revenue is equal to output price, so a price of P' would cause profit to be maximized by producing the quantity $0b$. A higher or lower price would cause output to increase or decrease to correspond with the point where the new price is equal to marginal cost.

Because of a fixed input such as land, output can be increased in the short run only by intensifying production. This means more variable inputs such as fertilizer, chemicals, irrigation water, labor, and machinery time must be used. However, the limited fixed input tends to increase average and marginal costs as production is increased past some point and an absolute production limit is eventually reached. Additional production is possible only by acquiring more of the fixed input, a long-run problem.

Size in the Long Run

The economics of farm size is more interesting when analyzed in a long-run context. This gives the manager time to adjust all inputs to the level that will result in the desired farm size. One measure of the relation between output and costs as farm size increases is expressed in the following ratio:

$$\frac{\text{Percent change in costs}}{\text{Percent change in output value}}$$

Both changes are calculated in monetary terms to allow combining the cost of the many inputs and the value of several outputs into one figure. This ratio can have three possible results called decreasing costs, constant costs, or increasing costs.

Ratio value	Type of costs
<1	Decreasing
=1	Constant
>1	Increasing

These three possible results are also called, respectively, increasing returns to size, constant returns to size, and decreasing returns to size. Decreasing costs means increasing returns to size, and vice versa. These relations are shown in Figure 9-3 using the long-run average cost curve per unit of output. When decreasing costs exist, the average cost per unit of output is decreasing, so that the average profit per unit of output is increasing. Therefore, increasing returns to size are said to exist. The same line of reasoning explains the relation between constant

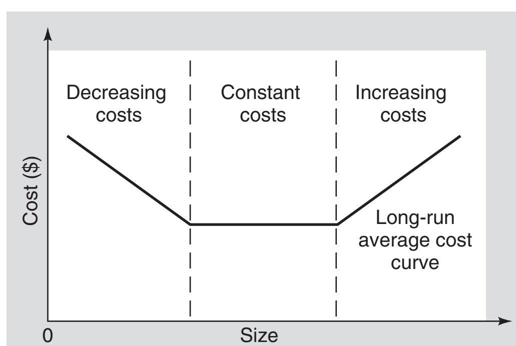

Figure 9-3 **Possible size–cost relations.**

costs and constant returns and between increasing costs and decreasing returns.

Economies of size exist whenever the long-run average cost curve is decreasing over some range of output (decreasing costs and increasing returns to size). *Diseconomies of size* exist when long-run average costs are increasing (increasing costs and decreasing returns to size). The existence or nonexistence of each and the range of farm sizes over which each occurs help explain and predict farm size. Farms of a size where long-run average costs are declining have an incentive to become larger. Any farms that may be so large that their long-run average costs are increasing will have less incentive to grow and will soon reach their long-run profit-maximizing size if they haven't already done so.

Causes of Economies of Size

Many studies of U.S. farms and ranches have documented the existence of economies of size over at least some initial size range. What is not always clear are the exact causes of these lower average costs as size increases. The following have been identified as possible reasons for economies of size.

Full Use of Existing Resources

One of the basic causes of economies of size is the more complete use of existing labor, machinery, capital, and management. These resources have fixed costs whether they are used or not. Their full use does not increase TFCs but does lower AFC per unit of output. Consider the farmer who rents some additional land and is able to farm it with existing labor and machinery. AFC per unit of output is now lower not only for the additional production but also for all of the original production.

Technology

New technology is often expensive but it can reduce the average cost per unit of output by the combination of replacing some current inputs and increasing production per acre or per head. However, because of the high initial investment, new technology must often be used over a larger number of acres or head to obtain these lower costs. This produces economies of size for larger farms and ranches but leaves smaller ones with older and less efficient technology.

Engineering Economies

As larger units of farm machinery are made available, the purchase price usually does not increase as fast as the capacity. This is because some components such as cabs, steering mechanisms, and electronic controls cost about the same regardless of the size of the machine. The same is true of many buildings. Only two end walls are needed regardless of the length of the building, and manure handling and feeding systems may not double even when floor space is doubled. This leads to lower fixed costs per unit of capacity.

Use of Specialized Resources

Labor and equipment on smaller farms must often be used for many different tasks and for several different enterprises, perhaps both crops and livestock. No single enterprise is large enough to justify specialized equipment that could do the job more efficiently and at less cost. Labor must perform so many different tasks that individuals do not have time to get sufficient experience to become skilled at any task. So little time may be spent on any single task during the year that it is difficult to justify the job training necessary to become more proficient. Larger farms can make full-time use of specialized equipment and individual workers can work full-time in one enterprise and perhaps at only one task. A large dairy where some workers can work full-time in the milking parlor and others in the feeding area is one example. Specialization often increases efficiency and reduces costs per unit of output.

Input Prices

Price discounts when purchasing large amounts of inputs and for buying in bulk are common in most industries including agriculture. Large farms and ranches can obtain substantial price discounts, for example, by buying feed by the truckload rather than a few bags at a time. Pesticides, fertilizer, seed, fuel, and supplies such as livestock vaccines and spare parts may also have price discounts for volume buying. These price discounts often are a result of lower transportation and handling costs per unit by the supplier or a vendor's desire to increase market share. Even if there is no price discount for bulk buying, the labor saved by the convenience, ease, and speed of handling the material can easily make up for additional storage and handling equipment needed.

Output Prices

Large-volume producers may also have a price advantage over smaller ones when selling their production. Grain producers may earn a premium price if they can deliver a large quantity at one time or guarantee the delivery of a fixed amount each month to a feedlot, feed mill, or ethanol plant. Ranchers who can deliver a full truckload of uniform weight cattle directly to a feedlot will usually receive a higher net price than those who sell a few at a time through a local auction barn.

In recent years many new, special-use grain varieties have been developed. Farmers receive a price premium for raising these specialized grains but they require special handling and separate storage away from all other varieties. Combines and trucks often need to be thoroughly cleaned before and after harvesting and hauling these varieties. This is another case where only larger-volume producers can justify the expense of separate and adequate storage and other related expenses to receive the premium for growing the crop.

Management

Many of the functions and tasks of management may contribute to economies of size. Purchasing inputs, marketing products, accounting, gathering information, planning, and supervising labor are examples. Doubling the size of the business may increase the time spent on each of these activities but not by 100 percent. Learning new management skills may take the same amount of time regardless of the number of units of production to which they are applied.

Causes of Diseconomies of Size

It is clear that economies of size exist over some initial range of farm sizes for nearly all types of farms and ranches. The existence of diseconomies of size is less clear as is the size at which diseconomies may begin. Diseconomies may result from any or all of the following.

Management

Limited management capacity has always been considered a prime cause of diseconomies of size. As a farm or ranch business becomes larger, it becomes more difficult for a manager to be knowledgeable about all aspects of all enterprises and to properly organize and supervise all activities. Multiple operators may have a harder time agreeing on management decisions or responding to problems quickly. Timeliness of operations and attention to detail begin to decline. The business becomes less efficient and average costs increase through some combination of increasing expenses and declining production.

Labor Supervision

Related to management is the increased difficulty of managing a larger labor force as size increases. In many types of agriculture, this is often further complicated by individuals working alone or in small groups spread over an entire field or many different fields on several different farms. This may require additional supervisors or considerable unproductive travel time by one supervisor.

Geographical Dispersion

Agricultural operations such as greenhouse production, cattle feedlots, confinement swine facilities, and poultry production can have a large operation concentrated in a relatively small area. However, increasing the size of a field crop operation requires additional land that may not always be available nearby. This increases the time and expense needed to move labor and equipment from farm to farm and the products from field to centralized storage or processing facilities.

Biohazards
Odor control, manure disposal, and increased risk of disease in large concentrations of livestock are potential sources of diseconomies in large livestock operations. State and federal regulations often require operations above a certain size to implement strict odor control and manure disposal procedures, which can increase costs compared to a smaller operation not subject to the regulations. Control of additional surrounding land may be required to keep odors from reaching neighbors and for manure disposal.

LONG-RUN AVERAGE COST CURVE

As farms and ranges increase in size, many of the economies and diseconomies of size occur simultaneously, and offset each other to some extent. The result is that efficiency as measured by long-run average cost (LRAC) per unit of output may stay fairly constant over a wide range of output levels.

Two possible LRAC curves are shown in Figure 9-4. Figure 9-4a assumes economies of size will dominate as a small business becomes larger. At some size all economies have been realized and LRAC is at a minimum. It is possible that this minimum cost may be constant or nearly so over a range of sizes (see Figure 9-3). However, diseconomies will eventually dominate as size grows beyond some point and LRAC will begin to increase. Management as the limiting input is often cited as the reason for the increasing costs.

The LRAC curve in Figure 9-4b is often referred to as an L-shaped curve. It describes the results found in a number of cost studies on crop farms of different sizes. Average costs usually fall rapidly and reach a minimum at a size often associated with a full-time family farmer who hires at least some additional labor, either full- or part-time, and fully uses a set of machinery. As size increases beyond this point, average cost remains constant or nearly so over a wide range of sizes as managers replicate efficient sets of machinery, buildings, and workers. These studies show little or no increase in average costs over the range of sizes studied.

The data in Figure 9-5 show three examples of how costs per unit of production are related to farm size, based on recent farm record data. In Figures 9-5a and 9-5c spring wheat and dairy show decreasing average costs per unit of output across all farm sizes. Soybeans, on the other hand, shows some slight increase in cost of production across the three mid-sized groups, but there is a substantial reduction in costs when the smallest category is compared to the largest.

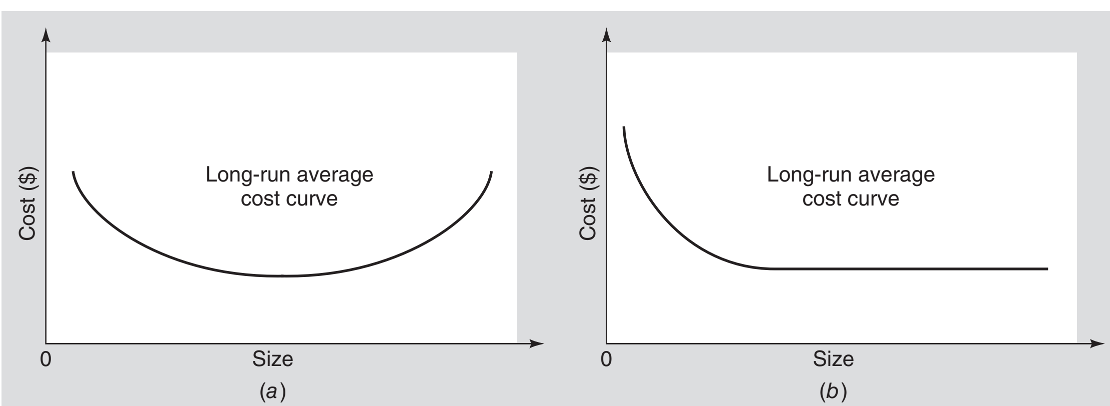

Figure 9-4 **Two possible LRAC curves.**

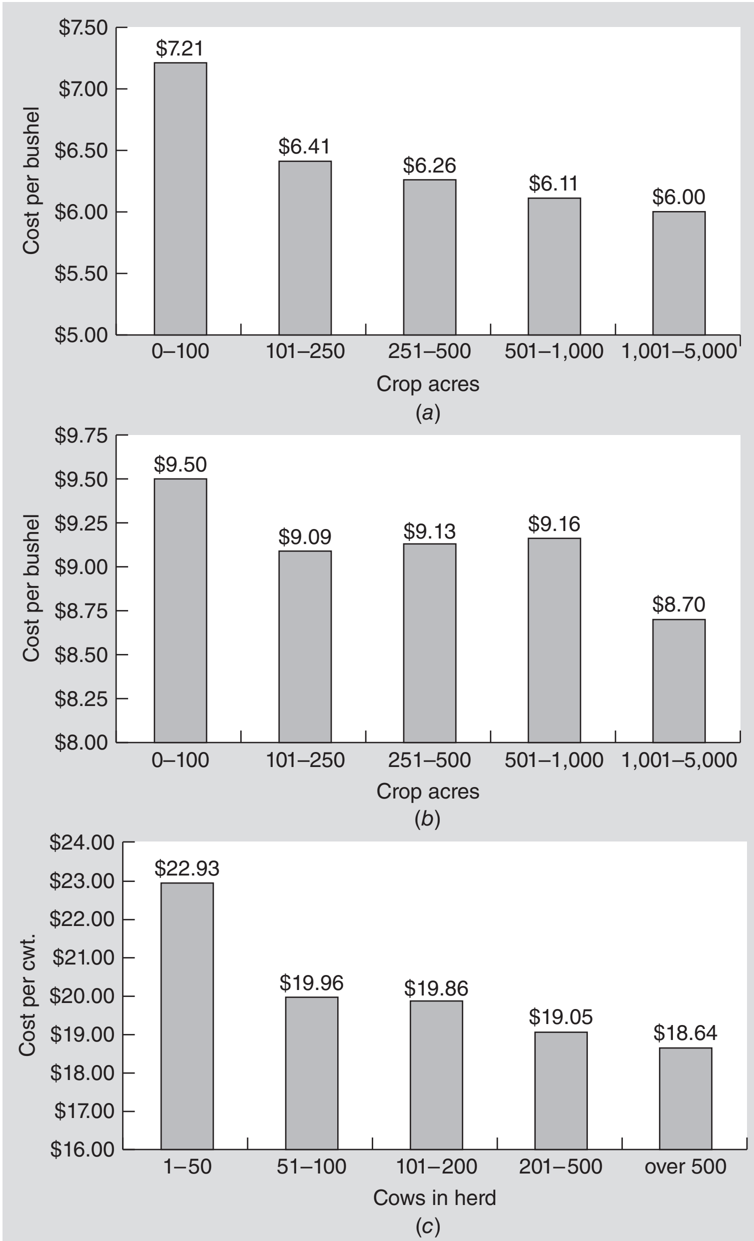

Figure 9-5 Costs per unit of production by farm size for (a) spring wheat; (b) soybeans; (c) milk.
Source: Center for Farm Financial Management, University of Minnesota, 2012.

SUMMARY

This chapter discussed the different economic costs and their use in managerial decision making. Opportunity costs are often used in budgeting and farm financial analysis. This noncash cost stems from inputs that have more than one use. Using an input one way means it cannot be put to any other alternative use, and the income from that alternative must be foregone. The income given up is the input's opportunity cost.

An analysis of costs is important for understanding and improving the profitability of a business. The distinction between fixed and variable costs is important and useful when making short-run production decisions. In the short run, production should take place only if the expected income will exceed the variable costs. Otherwise, losses will be minimized by not producing. Production should take place in the long run only if income is high enough to pay all costs. If all costs are not covered in the long run, the business will eventually fail or will be receiving less than the opportunity cost on one or more inputs.

An understanding of costs is also necessary for analyzing economies of size. The relation between cost per unit of output and size of the business determines whether there are increasing, decreasing, or constant returns to size. If unit costs decrease as size increases, there are increasing returns to size, and the business would have an incentive to grow, and vice versa. The type of returns that exist for an individual farm will determine in large part the success or failure of expanding farm size. Future trends in farm size, number of farms, and form of business ownership and control will be influenced by economies and diseconomies in farm and ranch businesses.

QUESTIONS FOR REVIEW AND FURTHER THOUGHT

1. How would you estimate the opportunity cost for each of the following items? What do you think the actual opportunity cost would be?
   - **a.** Capital invested in land
   - **b.** Your labor used in a farm business
   - **c.** Your management used in a farm business
   - **d.** One hour of tractor time
   - **e.** The hour you wasted instead of studying for your next exam
   - **f.** Your time earning a college degree
2. For each of the following, indicate whether it is a fixed or variable cost and a cash or noncash expense (assume short run).

	Fixed or variable?		**Cash or noncash?**	
a. Gas and oil	_____	_____	_____	_____
b. Depreciation	_____	_____	_____	_____
c. Property taxes	_____	_____	_____	_____
d. Salt and minerals	_____	_____	_____	_____
e. Labor hired on an hourly basis	_____	_____	_____	_____
f. Labor contracted for one year in advance	_____	_____	_____	_____
g. Insurance premiums	_____	_____	_____	_____
h. Electricity	_____	_____	_____	_____

3. Assume that Freda Farmer has just purchased a new combine. She has calculated total fixed cost to be $22,500 per year and estimates a total variable cost of $9.50 per acre.
   a. What will her average fixed cost per acre be if she combines 1,200 acres per year? 900 acres per year?
   b. What is the additional cost of combining an additional acre?
   c. Assume that Freda plans to use the combine only for custom work on 1,000 acres per year. How much should she charge per acre to be sure all costs are covered? If she would custom harvest 1,500 acres per year?
4. Assume the purchase price of a combine is $152,500. It is estimated to have a salvage value of $42,000 and a useful life of eight years. The opportunity cost of capital is 10 percent. Compute annual depreciation and interest.
5. Using the data in the table below, a price of $6 for the output, a cost of $10 per unit of variable input, and a TFC of $200, compute the three total costs (TVC, TFC, TC) and the three average costs (AVC, AFC, ATC).

Variable input (units)	Output (bushels)
0	0
10	35
20	75
30	105
40	130
50	140

   a. What is the maximum profit that can be made with the given prices?
   b. To continue production in the long run, the output price must remain equal to or above $_____.
   c. In the short run, production should stop whenever the output price falls below $_____.
6. Why is interest included as a fixed cost even when no money is borrowed to purchase the item?
7. What will profit be if production takes place at a level where MR = MC just at the point where ATC is minimum? At the point where MR = MC, and AVC is at its minimum?
8. Explain why and under what conditions it is rational for a farmer to produce a product at a loss.
9. Imagine a typical farm or ranch in your local area. Assume it doubles in size to where it is producing twice as much of each product as before.
   a. If total cost also doubles, is the result increasing, decreasing, or constant returns to size? What if total cost increases by only 90 percent?
   b. Which individual costs would you expect to exactly double? Which might increase by more than 100 percent? By less than 100 percent?
   c. Would you expect this farm or ranch to have increasing, decreasing, or constant returns to size? Economies or diseconomies of size? Why?

APPENDIX. COST CURVES

Relations among the seven output-related cost concepts can be graphically illustrated by a series of curves. The shape of these cost curves depends on the characteristics of the underlying production function. Figure 9-6 contains cost curves that represent the general production function shown in Figure 7-2. Other types of production functions would have cost curves with different shapes.

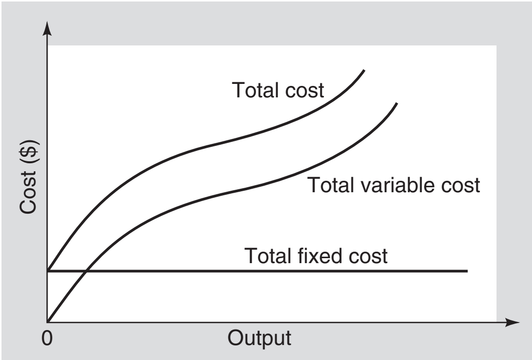

Figure 9-6 **Typical total cost curves.**

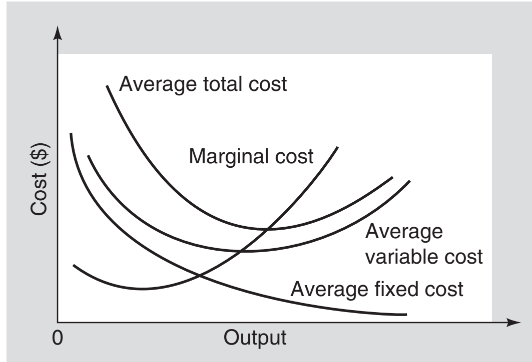

Figure 9-7 **Average and marginal cost curves.**

The relations among the three total costs are shown in Figure 9-6. Total fixed cost is constant and unaffected by output level. Total variable cost (TVC) is always increasing, first at a decreasing rate and then at an increasing rate. Total cost is the sum of total fixed cost and total variable cost, so its curve has the same shape as the total variable cost curve. However, it is always higher by a vertical distance exactly equal to total fixed cost.

The general shape and relation of the average and marginal cost curves are shown in Figure 9-7. Average fixed cost is always declining but at a decreasing rate. The average variable cost (AVC) curve is U-shaped, declining at first, reaching a minimum, and then increasing at higher levels of output. The average total cost (ATC) curve has a shape similar to that of the AVC curve. They are not an equal distance apart. The vertical distance between them is equal to average fixed cost (AFC), which changes with output level. This accounts for their slightly different shape and for the fact that their minimum points are at two different output levels.

The marginal cost curve will generally be increasing. However, for this particular production function, it decreases over a short range before starting to increase. The marginal cost curve crosses both average curves at their minimum points. As long as the marginal cost value is below the average cost value, the average cost will be decreasing, and vice versa. For this reason, the marginal cost curve will always cross the average variable and ATC curves at their minimum points.

Other Possible Cost Curves

As stated earlier, the shape of the cost curves is directly related to the nature of the underlying production function. The cost curves in Figures 9-6 and 9-7 are all derived from the shape of the generalized production function in Figure 7-2. Other types of production functions exist in agriculture, in particular, those which increase at a *decreasing* rate from the first unit of input. They do not have a Stage I and therefore begin with diminishing marginal returns. The data in Table 7-1 illustrate such a function.

Figure 9-8 shows the total, average, and marginal cost curves for this type of production function. The production function effectively begins in Stage II with diminishing marginal returns, so the TVC curve increases at an increasing rate from the beginning. This in turn causes the AVC curve to increase at an increasing rate throughout. However, because the ATC curve is the sum of AVC and AFC, it begins high due to the high AFC. Initially, AFC will be decreasing at a rapid rate and faster

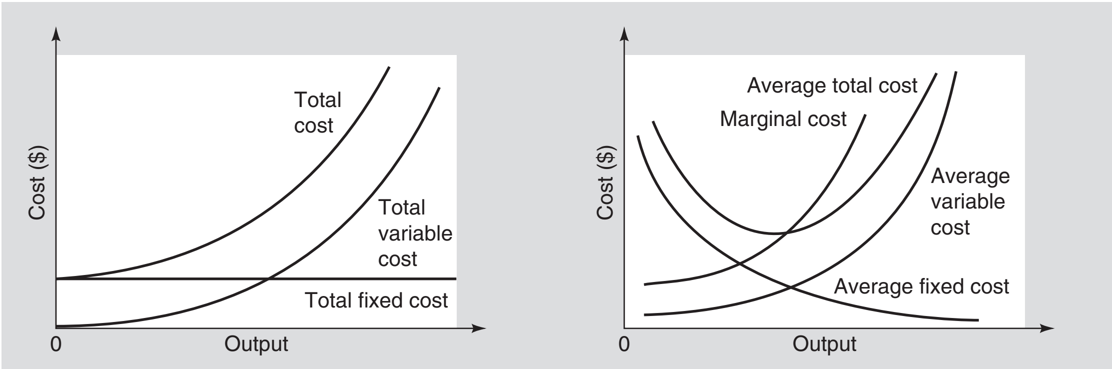

Figure 9-8 Cost curves for a diminishing marginal returns production function.

than AVC is increasing. This combination results in an ATC that decreases at first but eventually increases as the AVC curve begins increasing at a more rapid rate than the AFC curve is declining.

Cost curves with a different shape can result when output is measured in something other than the usual agricultural commodities. The output from machinery services is one example. It is difficult, if not impossible, to measure machinery output in bushels, pounds, or tons, particularly if the machine is used in the production of several outputs. Therefore, the output from tractors in particular, and often other machinery, is measured in hours of use or acres covered during a year. There is no declining marginal product in this case as another hour is another hour of the same length and the same amount of work can be performed in that hour. A constant marginal physical product results from each additional hour of use, that is, another hour of work performed.

Figure 9-9 illustrates the cost curves for this example. With a constant marginal physical product, TVC increases at a constant rate, which in turn causes AVC to be constant *per hour* of use. However, AFC is decreasing as hours of use increases. ATC is the sum of AVC and AFC, so it will also be continually decreasing as annual hours of use increases. (See Chapter 22 for more on machinery costs.)

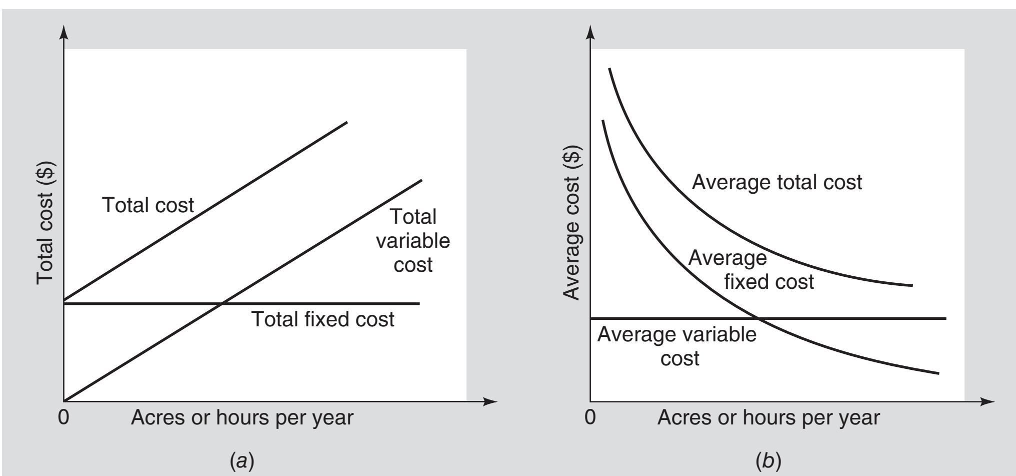

Figure 9-9 Cost curves for a production function with constant marginal returns.