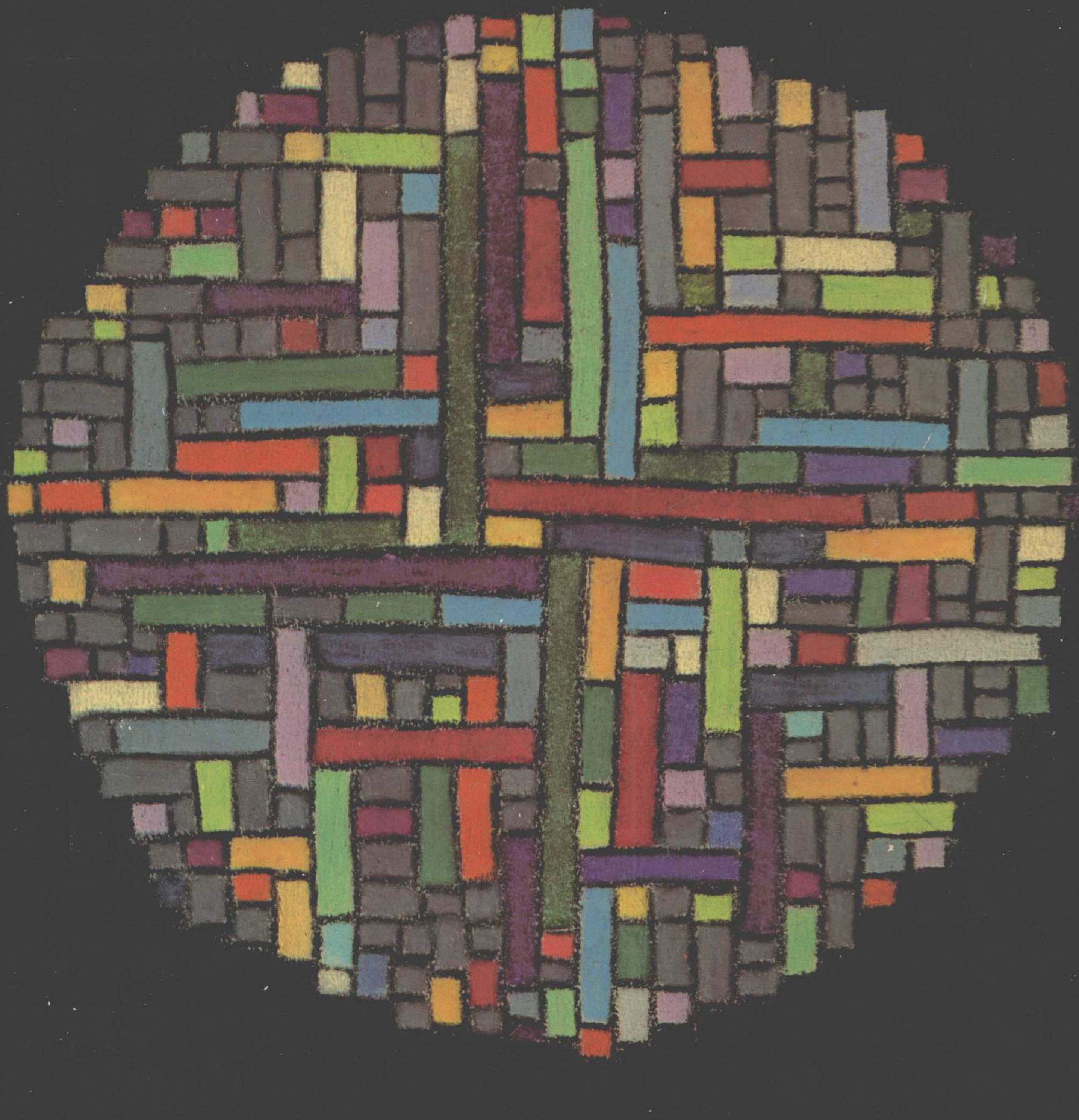
Alchian and Allen
Exchange and Production: Competition, Coordination, and Control
Second Edition



Exchange and Production: Competition, Coordination, and Control

Second Edition

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Preface

The test of any science is its ability to explain the events of the real world in a coherent, consistent fashion. Economics passes that test. This book presents, at the introductory level, an exposition of economic analysis with persistent emphasis on its empirical meaningfulness and validity.

Economics is relevant to the everyday activities and situations of our personal lives. We find, from some thirty years of experience in teaching, that students show keen interest and even excitement in discovery of economic theory—mainly because, we believe, the theory is made pertinent and convincing by repeated, realistic applications within their own range of experiences. At the same time, major questions of national policy are considered again and again without a loss of continuity of interest.

Of course, in any such book much must be left out; to cover everything is to learn little about anything. But the fundamental principles and theorems of analysis are included and stressed and repeatedly applied. The propriety in stressing the few fundamentals is, we think, illustrated by the statement of an economist, Alain A. Enthoven, who has worked very successfully at the highest levels of national policy in the Department of Defense:

> *. . . the tools of analysis that we [in Defense] use are the simplest, most fundamental concepts of economic theory, combined with the simplest quantitative methods. The requirements for success in this line of work are a thorough understanding of and, if you like, belief in the relevance of such concepts as marginal products and marginal costs, and an ability to discover the marginal products and costs in complex situations, combined with a good quantitative sense. The economic theory we are using is the theory most of us learned as sophomores. The reason Ph.D's are required is that many economists do not believe what they have learned until they have gone through graduate school and acquired a vested interest in marginal analysis.* ("Economic Analysis in the Department of Defense," *American Economic Review*, 53 [May 1963], p. 422).

The instructor will find that the scope of the theory covering choice, demand, exchange, and supply has been extended to behavior beyond the old, narrow, wealth-maximizing behavior in simple private-property markets. The scope of costs, and their relation to various dimensions of outputs, includes modern industrial techniques of mass-production economies. Furthermore, recognition of the role of information and the costs of acquiring it and the costs of transactions and agency relationships have enabled economists to discern a unified theory of economics valid for both individual behavior and for fluctuations in national aggregates of employment and income.

But the test of a text is the text itself—not promises and self-advertising in the preface. So we add only that questions appear at the end of each chapter, and answers to most questions are at the end of the book. Question numbers in boldface type in the margin at the end of major sections throughout the chapters indicate the best places to study the answer.

We must record appreciation to an unnamed host of economists, mostly of the past two centuries, who developed the analysis presented here. The temptation for living economists to think all modern analysis was discovered by them is something that gets easier to resist as one gets older. To all, living or dead, we express our ad-

miration and appreciation for being able to put their ideas in this text and for having benefitted from them. We also wish to thank Robert McCloskey (University of Chicago), Tim Ozenne (University of Washington), and David Gay (University of Arkansas, Fayetteville), who read the manuscript for the publisher and provided many helpful comments.

Armen Alchian
William R. Allen

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How Much Mathematics and Graphs?

"How much mathematics must I know to understand economics?" Only arithmetic, but one must also be able to read charts and graphs. Arithmetic or graph reading are less a cause of confusion than is *interpretation* of quantitative relationships between economic magnitudes. Therefore, this Note presents interpretations along with the arithmetic and chart reading. If you can follow it, you are adequately prepared. The arithmetic, chart reading, and interpretation are presented by simple examples in imaginary economic contexts. Numbers are chosen primarily to make computations and relationships easy to see, rather than to reflect reality.

Imagine we are producing "tees" for golf balls—little wooden devices on which the ball is placed prior to striking it 250 yards down the middle of the fairway. To make one tee costs, we assume, $1.00, counting all material, labor, etc. Costs of producing two, three, four, etc., tees per day are in Table 0–1. The more tees produced in a day, the greater the total cost of that day's output. Two tees cost $1.90, and three cost $2.70. "Total costs" and "tees produced" both change in the same direction. The change of two magnitudes in the same direction is called a *positive* relationship. Another example would be daily caloric intake and one's weight—usually assumed to be positive, for more of one means more of the other. (Nothing is assumed about *causal* connection in saying a relationship exists. Whether or not any causality runs either way from one magnitude to the other is not our concern here.)

Table 0–1. Output of Tees and Costs

Tees Produced Daily	Total Costs
1	$1.00
2	1.90
3	2.70
4	3.40
5	4.00
6	4.70
7	5.50
8	6.40
9	7.40
10	8.60

An example of a *negative* relationship is age and strength for people over about 30 years: As age increases, strength decreases. For younger people, the relationship is positive: A youth gets stronger as he grows. But after some age, strength ceases to grow and then decreases with age. Thus over the *entire* range of age, the relationship with strength is at first positive, then possibly zero (indicating no change in strength as age increases), and then negative.

We can picture relationships with graphs. Figure 0–1 portrays the relationship that is assumed between costs and number of tees. The height of each bar indicates *total costs* of the number of tees to which it corresponds. Each bar has an upper shaded section showing how much higher it is than the neighboring bar of one less unit of output. The shaded part of the bar portrays the *increment* to total costs consequent to producing one more. We could draw a smooth line along the tops of the bars to indicate total costs without showing a lot of bars; this is done in Figure 0–2 to make a cleaner looking chart. You will see that the line passes through several dots. You may interpret the *line* between the dots as guiding the eye from point to point, or the line

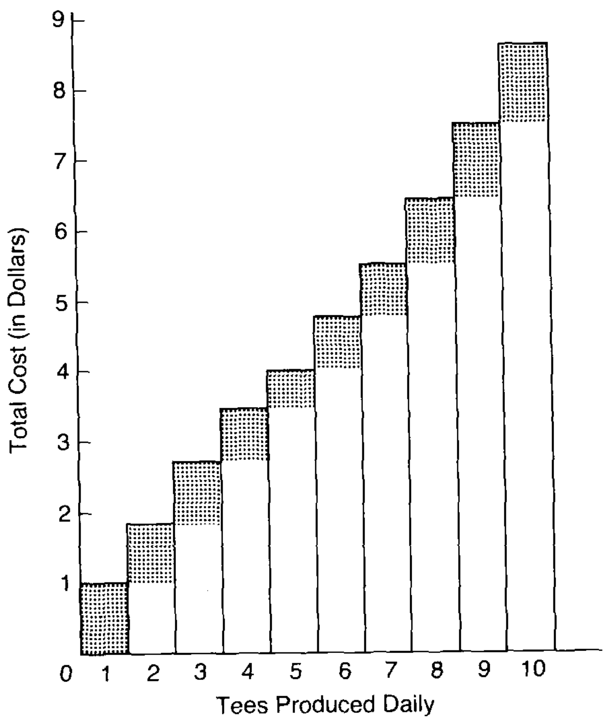

Figure 0–1. Bar Chart of Total-Cost–Output-of-Tees Relationship

Shaded sections denote how much cost increases with each unit increase in daily output. Relationship between total cost and tees produced is positive, *for both increase (or decrease) together.*

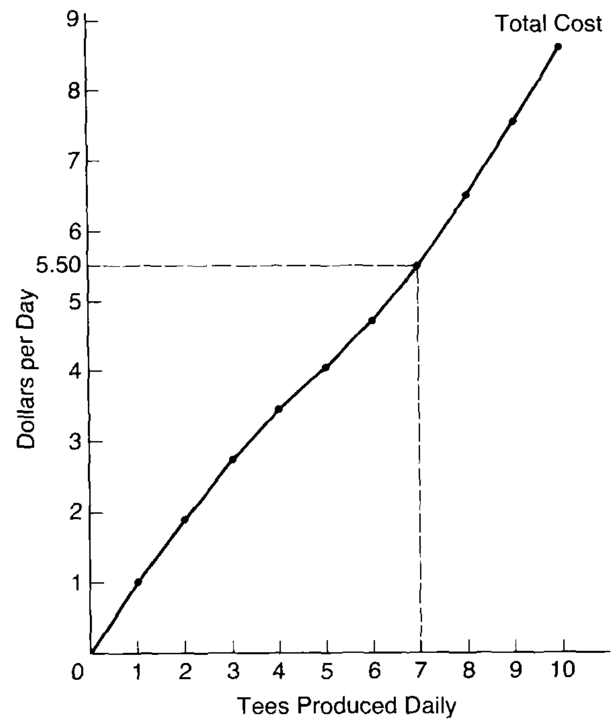

Figure 0–2. Line Chart of Total-Cost–Output Relationship

Line chart shows more clearly how total cost varies with daily output of tees. Height of line at each output measures daily total cost. Upward slope, called positive slope, indicates positive relationship.

may represent the costs of producing fractional amounts. For example, if three tees are produced in two days, this is 1.5 tees per day. So fractional amounts of even nondivisible things do make sense, if interpreted as a *rate* of production per day. Even though only discrete or "integral" amounts of some good can be produced, we can still speak of fractional amounts per some unit of time.

So far in interpreting a chart, we have taken a point on the horizontal axis and then read up to the line to find the value of the corresponding variable in which we were interested. We first found five units of tees on the horizontal axis, and then by reading up directly above that point we saw the cost was $4. Usually the graph can also be read the other way. Suppose you were told that $4 could be spent on producing tees.

How many could be produced? To answer, find $4 on the vertical scale, then go horizontally across the chart to the curve and drop straight down to the horizontal axis to an output of five tees.

We now direct attention to three different aspects of costs as different outputs of tees are considered. Three different, important concepts, *total, average,* and *marginal,* must be understood. The *total* costs of Table 0–1 are again shown in Table 0–2, along with *average cost* per tee and *marginal cost* of tees. The *average* cost is the total cost per day divided by the number of tees per day. For two tees, the total cost per day, $1.90, divided by 2, is 95 cents per tee. And for five tees the average cost is 80 cents. Compute the average cost of five and of six tees. If you agree with the numbers shown, proceed; if not, give up.

The continuing scholars should next look at the *marginal* costs column of Table 0–2. These are the *differences* in the *total* costs of producing two different quantities of tees—differing by one tee. For five tees a day the total cost is $4.00, and for six tees is $4.70; the difference, called the *marginal cost,* is 70 cents. This is shown in Figure 0–1 as the shaded section of the bar for six units.

This simple concept of change, difference, or increment in cost associated with *one* unit larger output is *"marginal* cost." It is the *change* in one variable (here, total cost) associated with a *one* unit change in the other (in this case, output of tees). This could have been called the "incremental cost when six are produced rather than five," or the "marginal cost of producing six rather than five," but it is in fact called the *"marginal* cost at, *or of,* six." Note carefully that it is not the total cost of producing six, for that is $4.70, and it is not the average cost of producing six,

Table 0–2. Costs and Output of Tees

Tees Produced Daily	Costs		
	Total	Average	Marginal
1	$1.00	$1.000	$1.00
2	1.90	.950	.90
3	2.70	.900	.80
4	3.40	.850	.70
5	4.00	.800	.60
6	4.70	.783	.70
7	5.50	.785	.80
8	6.40	.800	.90
9	7.40	.822	1.00
10	8.60	.860	1.20

Total costs increase with number of tees produced daily. Average costs are total costs divided by number of tees produced daily. Marginal cost is increase in total costs for *one* unit increased output.

for that is 78 cents per unit. It is the *increase* in total cost of six over the cost of five.

We shall use these concepts extensively. Unless you *always* keep these three *concepts*—(1) total, (2) average, and (3) marginal—clearly separated, you will almost certainly not acquire a good grasp of economic principles. Hint: Never use the term "cost" by itself; always identify it with "total," "average," or "marginal," so that you won't confuse one with the others. Let's test your ability to *interpret* and apply these concepts. Someone asks the question, "What is the cost of six tees?" If you try to answer that question as it stands, you have just missed the point. What cost? Total, average, or marginal? Each is different. But there lurks still another potential ambiguity. What is meant by the "marginal cost of six tees?" It means, as we have said, how much more total costs are than if only five are to be produced. In the present example that seems clear enough. But to see how things can get muddied up in other contexts, we give you the following example.

Imagine a retail store with four clerks. Total sales are $2000 per day for the total of all four clerks—with some selling more than the $500 average and some less. Add a fifth clerk to the sales force, and sales increase by $200 to $2200. Now it is *erroneous,* but tempting, to infer that the new person is not as productive as the first four. If you were to look at the details you would discover that he had $800 of sales, which is more than for any other clerk. His presence enabled the store to sell $200 more by getting customers who otherwise would have decided not to buy, but he also managed to attract customers away from the other clerks, because of his superior looks and personality. *His* sales were $800, but that is not called his marginal sales or the marginal sales of the fifth person. The marginal sales with a fifth person were $200. Average sales were $440 with five people ($2200/5). And what about his $800? Is that *necessarily* comprised of $600 of sales taken from other clerks plus $200 of new customers? Not necessarily. All of the $800 may have been from old customers attracted from other clerks, while the other clerks scrounged around to get the extra $200 in sales. As we use the term, "marginal sales with a fifth person" is *not* to be interpreted as what *a* particular person or any other one did, but only as the *change* in the *total* results of having a *team* of five clerks rather than a team of four. "Marginal sales" or "marginal costs" or "marginal whatever" will always be interpreted that way—as the *change in total* of one variable consequent to having *one* more of the other variable.

We do not give any name to the $800 of sales of the fifth person. In fact, often it cannot even be detected or conceived. For example, you have a team of four men rowing a boat with a trailing net to catch fish. You add a fifth man to row or help tend the net. How can you make any meaning of what the fifth man himself caught? You can't. The only possibility is the meaning we have given—the change in the *total* consequent to having five rather than four.

Turn your attention to the possible quantitative *behavior* of these magnitudes. Looking in Table 0–2 at larger outputs of tees, you will notice marginal costs *increase* after their earlier initial decreases at small outputs of tees. Taking the total costs as correct data, check the average cost and marginal costs calculations.

To exercise your arithmetic talents a bit more, consider how "averages" *must* behave relative to "marginals." Suppose that as you increase output by one unit, from eight to nine, the total cost *increase* (the marginal cost) is greater than the average cost at eight. What will be the average cost of nine? To see what is meant by the question, look at the output of eight tees. For that output, average cost is 80 cents. Now the question is, "What will happen to the average cost of output, if you know that when you expand output from eight to nine, the *increase* in total cost, 90 cents (i.e., the *marginal* cost), is greater than the average cost (80 cents) at eight?" Isn't this exactly like asking what will happen to your average test score if the points earned on your next test are higher than your present average? Won't it raise your average? And if one more test adds *fewer* points than your existing average, the average will be pulled down. We repeat, if the marginal exceeds the average, the average will rise; and if it is less than the current average, the average will go down. Hence the answer to the question is, "The average will be rising if the marginal is greater than the average." To verify this, look at the marginal costs for tees ranging from 7 to 10. For all those, the marginal cost is greater than the average, and the average cost rises in that output range.

If you examine all the marginal costs for tees 0 through 6 you will see that the marginal cost is less than the average, so the average falls with increases in outputs. Where the marginal value exceeds the average value, the average must always increase. And if the marginal value of the variable is less than its average, the average must decrease. Only if the marginal value equals the average will the average remain unchanged.

To familiarize yourself with graphic presentation and analysis, examine Figure 0–3, which shows bars for total costs; superimposed are the marginal costs, this time at the bottom of each bar. The marginal cost bars are exactly the same as the shaded sections at the top of the total cost bars in Figure 0–2. We quickly see that the marginal costs at first decrease and then increase. Note also that the *sum* of all the marginal costs up through seven tees is the total cost of seven units. This equality between the sum of marginal costs and the total cost is true for every output, by definition. Also shown are average costs per unit of each output, as dots connected by a line. You can see that average costs decrease so long as marginal costs are less than average costs, and that average costs rise when marginal costs have risen above average cost.

The same figure is repeated as Figure 0–4 but with lines rather than bars. The total cost of seven units of output is shown in three ways: (1) by the *height* of the total cost line at 7; (2) by the *area* under the marginal cost line from the first through the seventh—the sum of the marginal costs; and (3) by the shaded area of a rectangle whose base is the horizontal axis from 0 through 7 and whose height is the average cost of seven. The average cost of seven ($.785), shown by the height at 7, multiplied by 7 will be the total cost ($5.50, rounded to 3 figures). If you

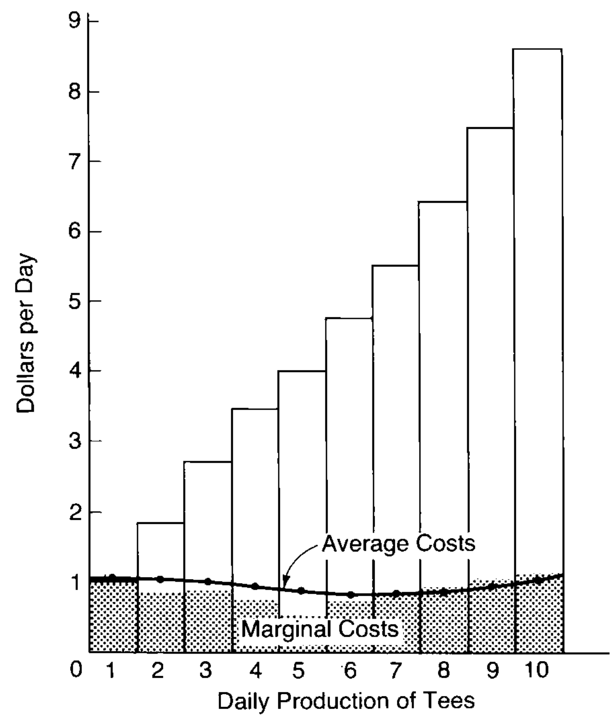

Figure 0–3. Bar Chart of Total and Marginal Cost–Output Relationship

Shaded sections show marginal costs. Average costs are shown by line through dots, to avoid cluttering graph. Average costs fall when marginal costs are less than average cost; and rise when marginal cost exceeds average cost.

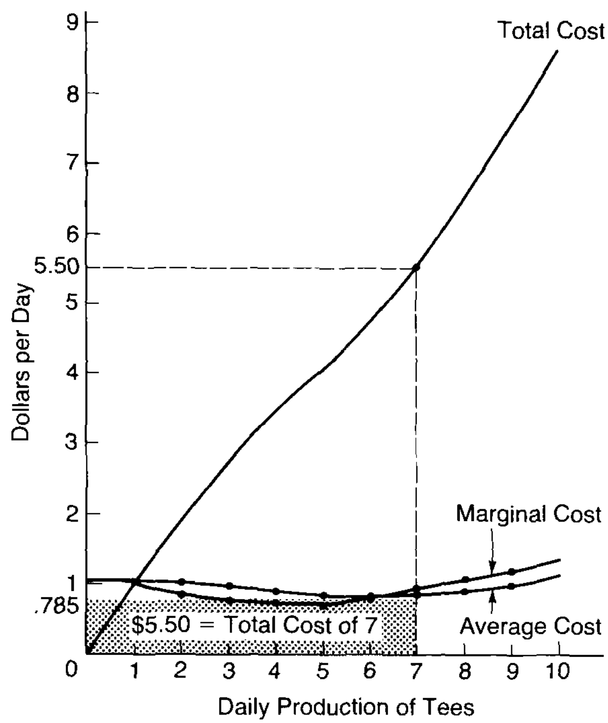

Figure 0–4. Line Chart of Total, Average, and Marginal Cost Relationship with Output Rate

Rectangular area with height at average cost and base at output rate is measure of total cost. Area under marginal cost curve is also measure of total cost.

see that both the area *under the marginal cost curve* and the *rectangular area* formed by the average cost curve height at 7 units represent the total cost, then you have passed the hardest arithmetic and graphic interpretation test.

As evidence of your talents, examine the new data in Table 0–3. The first two columns show prices and the number of tees that can be sold. The lower the price, the more that can be sold at any price. Complete the empty spaces in

Table 0–3. Sales Price and Number of Tees Sold Daily

Tees Sold	Price of Tee	Sales Receipts or Revenue (Dollars) Total	Marginal	Average
1	$10	$10	—	10
2	9	18	+8	9
3	8	24	+6	—
4	7	28	—	—
5	6	30	—	—
6	5	30	—	—
7	4	28	−2	—
8	3	24	—	—
9	2	18	—	—
10	1	10	—	—

Complete the table and plot the results in Figure 0–5. Negative marginal sales receipts indicate that total sales proceeds diminish at lower price despite increased number sold. Sales proceeds are typically called "revenue."

the columns labeled "marginal receipts" and "average receipts"—which you will see is the same as price, because each unit is sold at the same price. Do not be surprised to get some *negative* marginal receipts. And in any event do the arithmetic without worrying much about why the relationship is shown as it is.

On the partially completed graph in Figure 0–5, some of the points have already been placed. Put in the rest of the dots for the average receipts and for the marginal receipts and connect the points in each set with a smooth line. Then draw in the *two* alternative areas representing total receipts for four tees at a price of $7. Do the same for eight tees at a price of $3. Which has the larger area?

Finally, some algebra. If you put $100 in a bank that pays interest at the rate of 5 percent per year, at the end of one year you will have $105.

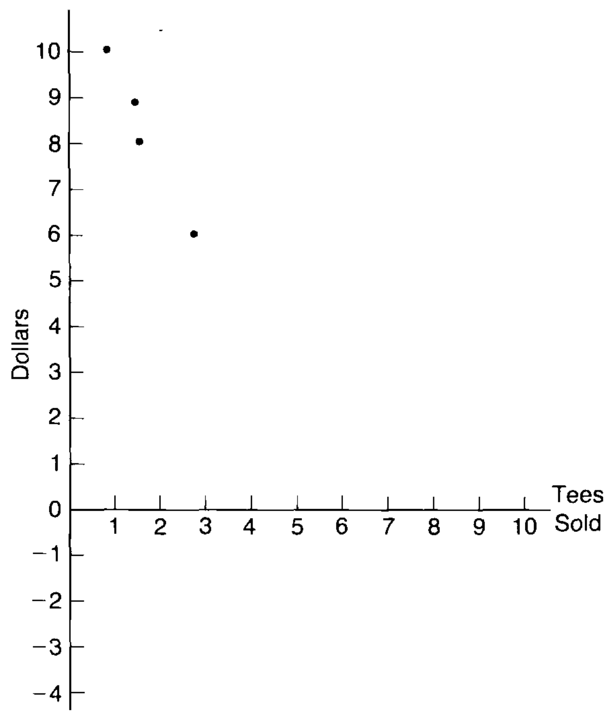

Figure 0–5. Exercise Graph for Receipts–Units-Sold Relationship

You are to complete set of dots and draw lines of average costs and marginal costs. Relationship of price and units sold is negative. Is relationship between total sales receipts positive, negative, or both?

At the end of two years you will have earned another 5 percent of the $105 with which you ended the first year, so you will have 5 percent of $105 added to the $105, a total of $110.25. How can this be written in algebraic form? At the end of the first year you will have $\$100 + (\$100 \times .05) = \$105$ which can be written as $\$100(1.05) = \$105$. At the end of the second year, the amount is multiplied again by 1.05. Therefore the initial amount of $100 will in two years be $\$100(1.05)(1.05) = \$110.25$ which can be written as $\$100(1.05)^2$. This is what is meant by compounded interest, compounded once a year for two years. The initial investment is increased by 5 percent by the end of the first year and then that entire amount (initial principal plus accumulated interest) earns interest the next year and grows by another 5 percent, or by the multiple 1.05. Succinctly, it grows to $\$100(1.05)^2 = \$110.25$. In three years it will grow to $100(1.05)(1.05)(1.05) or $\$100(1.05)^3$ which is $115.76. In ten years it will be $\$100(1.05)^{10}$ which is $162.89. If you understand this, with only some minor hesitancy, by writing it down and checking it, all will be well. For the concluding twist, suppose you want to have $150 in six years at 5 percent interest compounded annually. How much must you invest *now* so that the value will grow to $150 in six years? The answer is obtained by noting that a present amount, P, will grow in six years at 5 percent interest compounded annually to $P(1.05)^6 = F$, where F denotes some future amount. In the example we have $P(1.05)^6 = \$150$. So dividing through by $(1.05)^6$ we have $P = \$150/(1.05)^6 = \$150/1.34 = \$111.93$. Of course, computing the value of $(1.05)^6$ is tedious, but don't worry. You won't have to, because we have tables in which to look up the answer.

You have now demonstrated adequate knowledge of arithmetic graphics and algebra. If some of the concepts are a little unfamiliar, don't worry. So long as you understand them, later exercises will make them familiar and easy. It really is easy—or will be. Your instructor will probably help make it easy and will cleverly take you on to more mathematics with no trouble at all.

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Scarcity, Competition, and Social Control