OPTIMUM ECONOMIC YIELD WITH
COST INPUTS

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by

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Achieving the optimum level of production (or the maximum economic yield) has always been an important, if unrecognized, goal for farmers. Emphasis for many years focused on the production component (Q) of the profit equation: where Profit = Total Revenue - Total Cost, and Total Revenue = Quantity x Price. Given the economic situation that exists in the farm sector today, however, this important question is now a critical question.

The farmer of today is a business manager. As a manager he makes a myriad of decisions. These decisions should be calculated toward maximizing profits within the constraints imposed by his particular situation. In order to achieve this, the farmer should be trying to maximize returns to "all" production inputs: labor, land, water, chemicals, fertilizer, etc. This becomes a very complicated equation when defined in the calculus of production economics.

Can economics provide a simple method of analysis? Yes. Will economics provide "the" answer? No. Economics does not provide "the" answer, but serves as a tool or a guideline for the manager to get an answer.

Economics uses principles and laws which are nothing more than a generalization that simplifies the understanding of a body of knowledge:

- no law is valid without conditions
- in economics the conditions are called assumptions
- the laws don't change, the conditions change

In the discussion that follows a number of conditions are initially assumed to exist:

- variable level of input
- variable level of output
- fixed factors of production
- unlimited resources

This last condition, unlimited resources, doesn't fit well in the "real world". Later, this condition will be relaxed in discussing resource allocation among competing uses.

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Production Functions

One tool used by economists is the production function. A production function merely describes the relationship between the inputs used in the production process and the resulting output or yield. (See Figure 1.) The simple two dimensional production function shown in Figure 1 focuses on the relationship between only one particular input and yield. With computers this limit of two dimensional analysis is eliminated, but it still provides a useful reference for discussing the basic principles of production economics.

The shape of the production function is determined by the physical or biological relationship of the input to the particular crop. The production function is merely a model, and like all models, abstracts from the "real world" and serves to represent rather than replicate. Figure 1, a quadratic function, is just one of many functional relationships that economists use. It is a most useful model when looking at many agricultural production problems. The quadratic function can be split into three distinct factor-product relationships. Economists refer to these as the Three Stages of Production.

Figure 1 also shows where these three stages occur. Stage I defines an area where the level of production increases at an increasing rate. Each successive input added in this area results in a larger increase in production than the previous input. In Stage II production is still increasing, but at a decreasing rate so that each successive input increases total production by less than the previous input. The third Stage of production starts where adding additional units of input has a detrimental effect and actually decreases production. This occurs, for example, when excessive nitrogen is applied and burns the crop. Just precisely where these three stages of production start and stop for any crop depends on a variety of conditions as does the recommendations made by chemical and fertilizer dealers; soil type, moisture level, etc. What is important to understand is the concepts. One obvious conclusion from this type of production function, if it is economical to add the first unit of input, continue to add inputs at least to the beginning of Stage II and stop before reaching Stage III.

Two other useful production curves are found in Figure 1, Average Product -- total production divided by the quantity of inputs used -- and Marginal Product -- the incremental change in output resulting from the use of an additional unit of input. The marginality concept is a very important one in economics.

Cost Functions

So far only physical units have been used to describe these functional relationships. If the economics of the situation is to be analyzed, however, the physical units of inputs used in the production function need to be converted to dollar values. This is shown in Figure 2. A second change is also made. The level of production (physical units, i.e. cwt, bu., etc.) is moved from the Y-axis to the X-axis. Mathematicians argue that by doing so economists have the axis backwards. Regardless of whether it meets the approval of mathematicians, it provides a useful analytical tool for economists and others.

The two major types of costs are shown, fixed costs and variable costs. As implied by their name, fixed costs do not change with the level of production. Variable costs, on the other hand, do change with the level of production and represent the production inputs you are most familiar with, i.e. seed, fertilizer, chemicals, etc. When these two costs are combined they become the total cost curve.

(Table 1 provides the physical data for the curves.)

Four additional cost curves are shown in Figure 3: Average Fixed Cost, Average Variable Cost, Average Total Cost, and the most important, Marginal Cost. The average cost -- whether fixed, variable or total -- is simply the cost -- fixed, variable, or total -- divided by the level of production as shown in Table 1. The marginal cost is the incremental change in cost from one level of production to the next. This very important concept will be used later. Table 1 shows the marginal cost as well.

Revenue Function

Costs have been discussed at some length. Attention will now switch to the other side of the profit equation, revenue. Again, the physical units are converted into a common denominator, dollars (see Table 2.). If the level of production does not affect the market price of the product, then the total revenue curve shown in Figure 4 will be linear. This is a reasonable assumption for most agricultural products at the producer level. Two additional revenue curves are shown in Figure 4, Average Revenue and Marginal Revenue. Average revenue is simply the total revenue divided by total production and is a horizontal line at the price of the output. Marginal revenue is the same as average revenue in this situation, and like marginal cost, a very useful concept.

Solving For Maximum Profit

All the relevant information for finding the point of maximum profit has been described. Profit, as previously mentioned, is merely the positive difference between total cost and total revenue. Rather than using the precise but complex methods of calculus to determine the point of profit maximization, the graphical method will be used along with the aid of the accompanying tables. This will illustrate the principle just as effectively.

Figure 5 shows the total cost curve from Figure 3 and the total revenue from Figure 4. The point of maximum profit occurs where these two curves are widest apart, somewhere between output level 5 and 6. This is intuitive. The same solution could have been achieved by using the cost data from Table 1 and the revenue data from Table 2.

Figure 6 shows an alternative and preferred method of calculating the point of maximum profit using marginal analysis when resources are unlimited. This point occurs where marginal cost and marginal revenue are equal, and coincides with the point where the distance between total cost and total revenue is the greatest. Again, the tables could have provided a solution to this problem.

Real World Unknowns and Complexities

Defining the point of maximum profit is easy in the preceeding example. More complex and comprehensive examples can be solved as quickly with the aid of a computer. There is still a major difference between the "real world" and that of a well defined problem, regardless of its complexity. The real world is beset by unknowns: price of commodities, level of production, the exact response of production to a variety of inputs, etc., etc. The above example also contained the normally unrealistic assumption of unlimited resources. Do these complexities invalidate the use of economics in solving this dilema? No. They do prevent, however, determining a single specific point on a production function that will achieve an optimum economic yield given the uncertainties that exist.

Uncertainty

The solution to uncertainty can be partly resolved by placing probabilities or confidence bounds around reasonable estimates. Some of the uncertainty can be removed by keeping and using good production records. What type of yield response was achieved on a particular field with which variety and what combination of cultural practices. The more specific the information, the better the resulting estimates. Establish confidence bounds by combining sound historic data with current information and situation reports. The "correct" answer, however, will only be known in retrospect.

Limited Resources

Dealing with the issue of limited resources (money available to the farmer to purchase inputs) is a bit more difficult. The farmer and those who supply his inputs look at the world through different eyes. There is no way around this. What is "good" for the farmer, however, is also good for his suppliers. Only farmers who stay in business pay their bills.

How should the farmer allocate his limited resources between competing uses? By following the principle of substitution with the concept of opportunity cost. Opportunity cost is the foregone benefit of using a resource in one way and not another. Where should the farmer put his scarce resource (money)? Where it will achieve the highest return, or the use with the highest relative opportunity cost. Allocate to the most cost effective use.

Continuous vs. Discrete Problems

Problems concerning continuous production relationships, such as fertilizer useage, vs. discrete treatment problems, such as whether or not to treat for late blight, present another difficulty to solving the production riddle.

An example of this type occurs when a farmer contemplates the application of Bravo for controlling late blight. The level needed to achieve control is easily determined. What is not so easy to determine is the decision of whether or not to apply. Or, will the expected damage prevented justify the treatment cost. This is a benefit cost decision. If the expected value of the saved production, or a higher price achieved with improved quality, exceeds the cost, then the treatment should be made. Assumptions must be made.

Conclusion

Did I answer the question of what level of inputs to use in achieving the optimum economic yield? No. But I hope I provided some useful guidelines for you to use as you search for solutions.

Table 1. COSTS

Output	Fixed Cost	Variable Cost	Total Cost	Marginal Cost	Average Cost	Average Fixed Cost	Average Variable Cost
0	55	0	55				
1	55	30	85	30	85.00	55.00	30.00
2	55	55	110	25	55.00	27.50	27.50
3	55	75	130	20	43.33	18.30	25.00
4	55	105	160	30	40.00	13.75	26.25
5	55	155	210	50	42.00	11.00	31.00
6	55	225	280	70	46.66	9.17	37.50
7	55	315	370	90	52.86	7.86	45.00
8	55	425	480	110	60.00	6.88	53.15
9	55	555	610	130	67.78	6.11	61.66
10	55	705	760	150	76.00	5.50	70.50

Table 2. Revenue

Output	Total Revenue	Marginal Revenue	Average Revenue
0	0		0
1	70	70	70
2	140	70	70
3	210	70	70
4	280	70	70
5	350	70	70
6	420	70	70
7	490	70	70
8	560	70	70
9	630	70	70
10	700	70	70

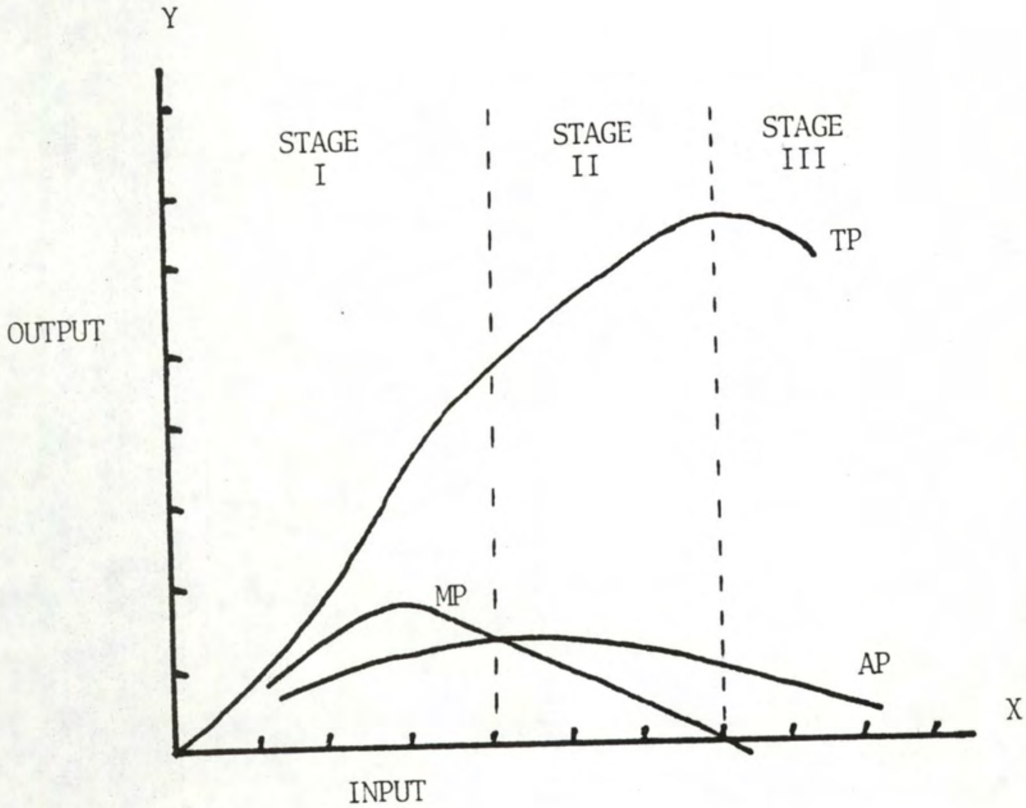

FIGURE 1. PRODUCTION FUNCTION.

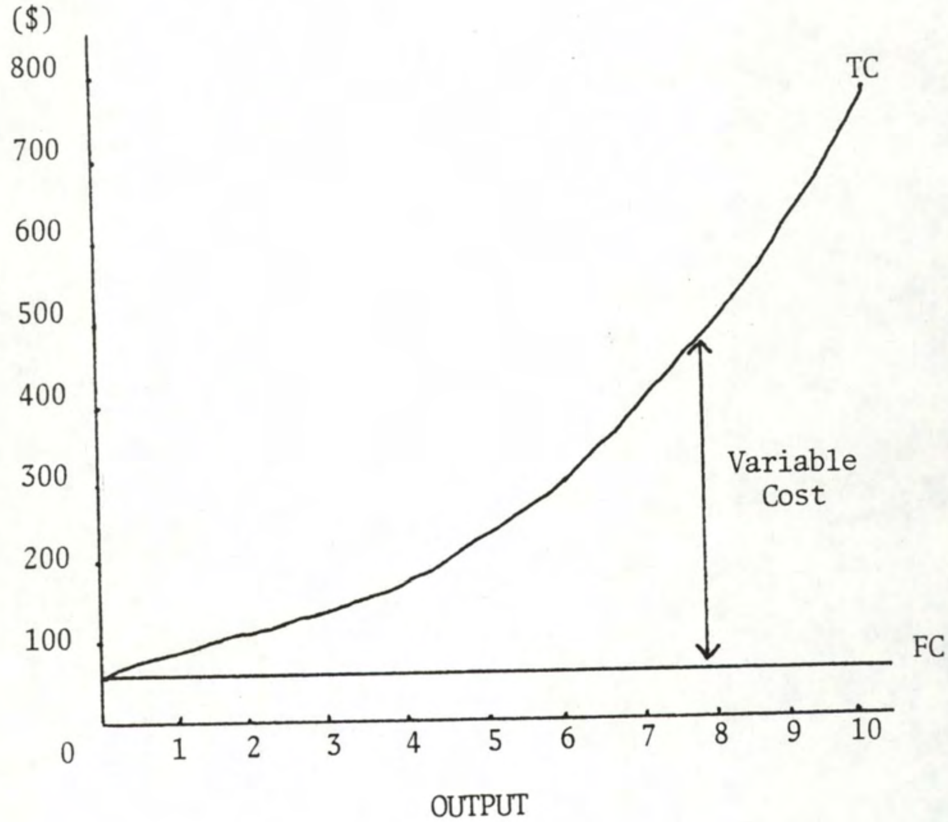

FIGURE 2. TOTAL, FIXED AND VARIABLE COST.

TC = TOTAL COST

FC = FIXED COST

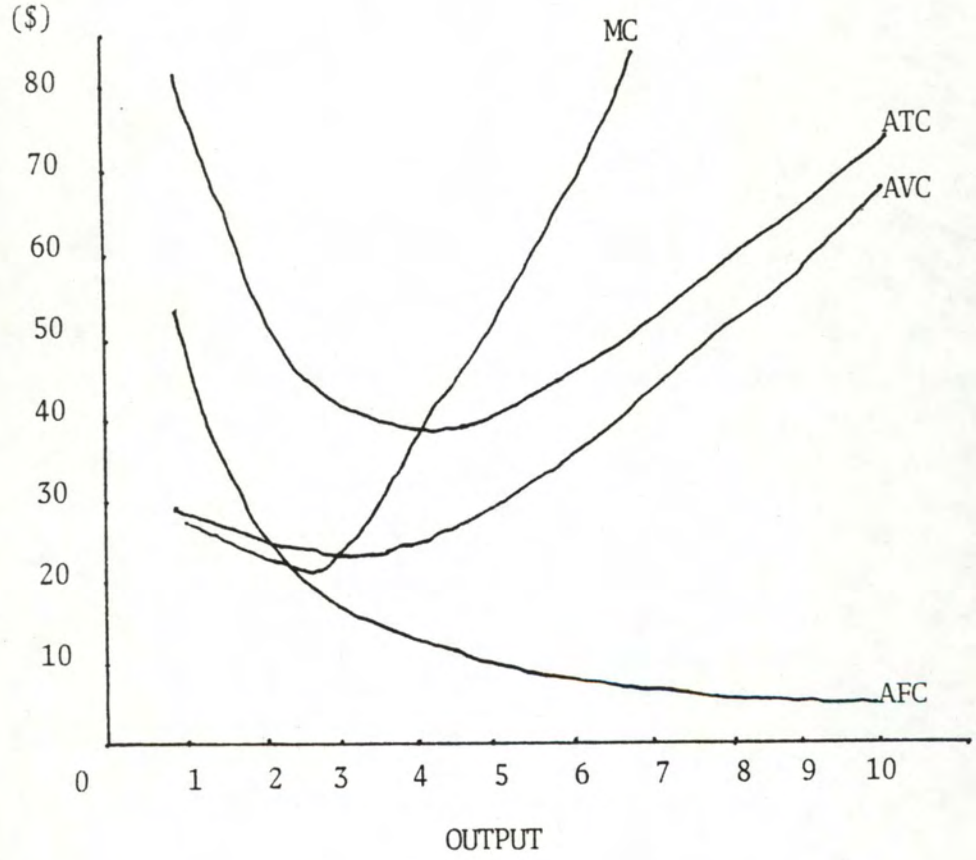

FIGURE 3. AVERAGE AND MARGINAL COSTS.

MC = MARGINAL COST

ATC = AVERAGE TOTAL COST

AVC = AVERAGE VARIABLE COST

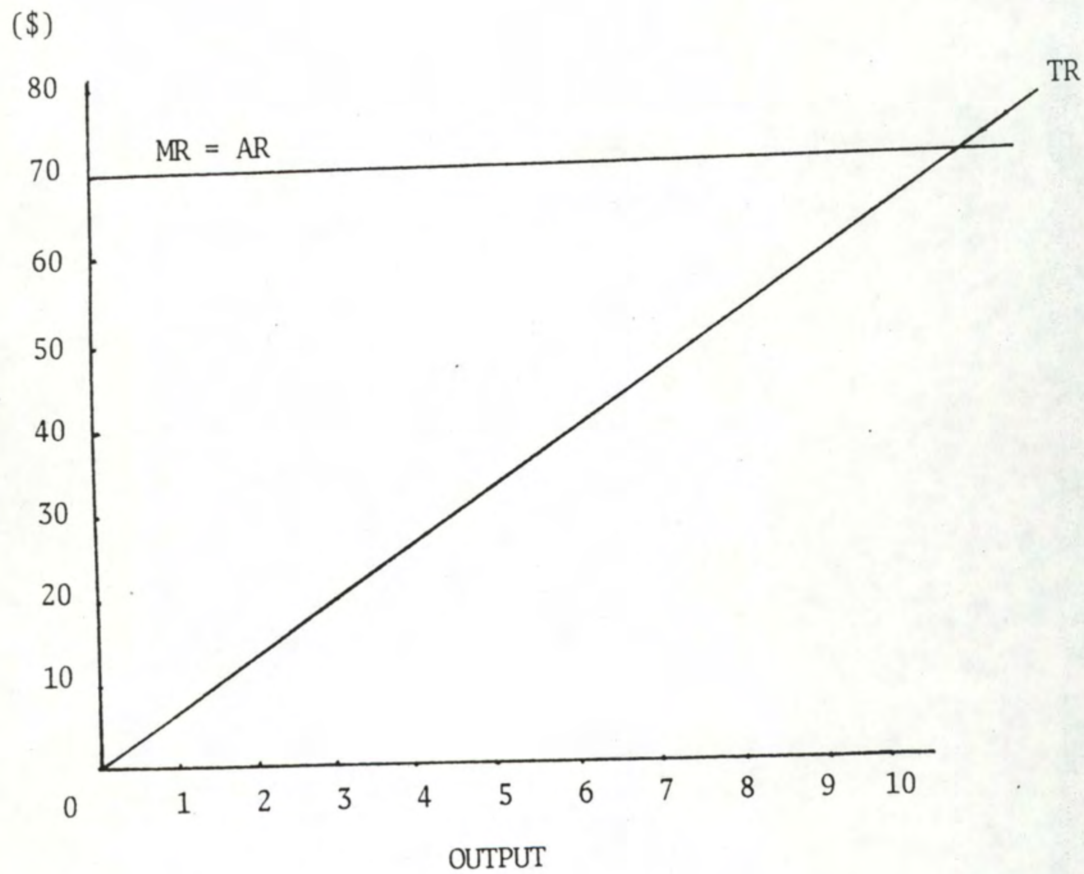

FIGURE 4. REVENUE CURVES.

MR = MARGINAL REVENUE

AR = AVERAGE REVENUE

TR = TOTAL REVENUE

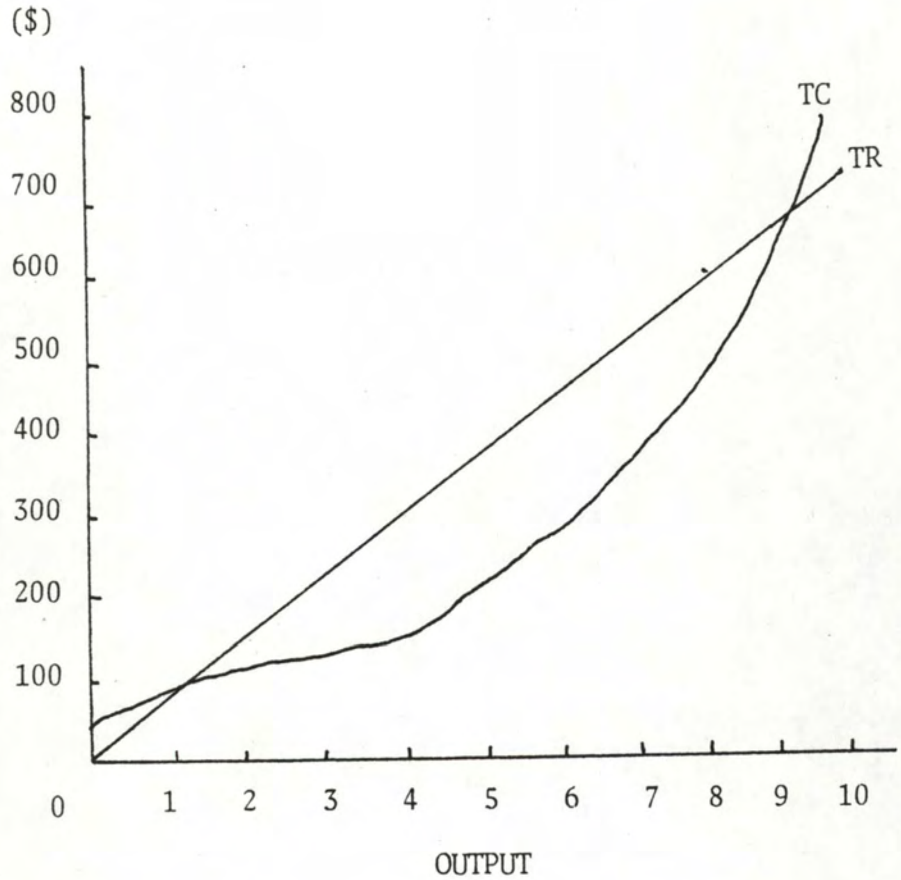

FIGURE 5. PROFIT USING TOTAL REVENUE AND TOTAL COST.

TC = TOTAL COST

TR = TOTAL REVENUE

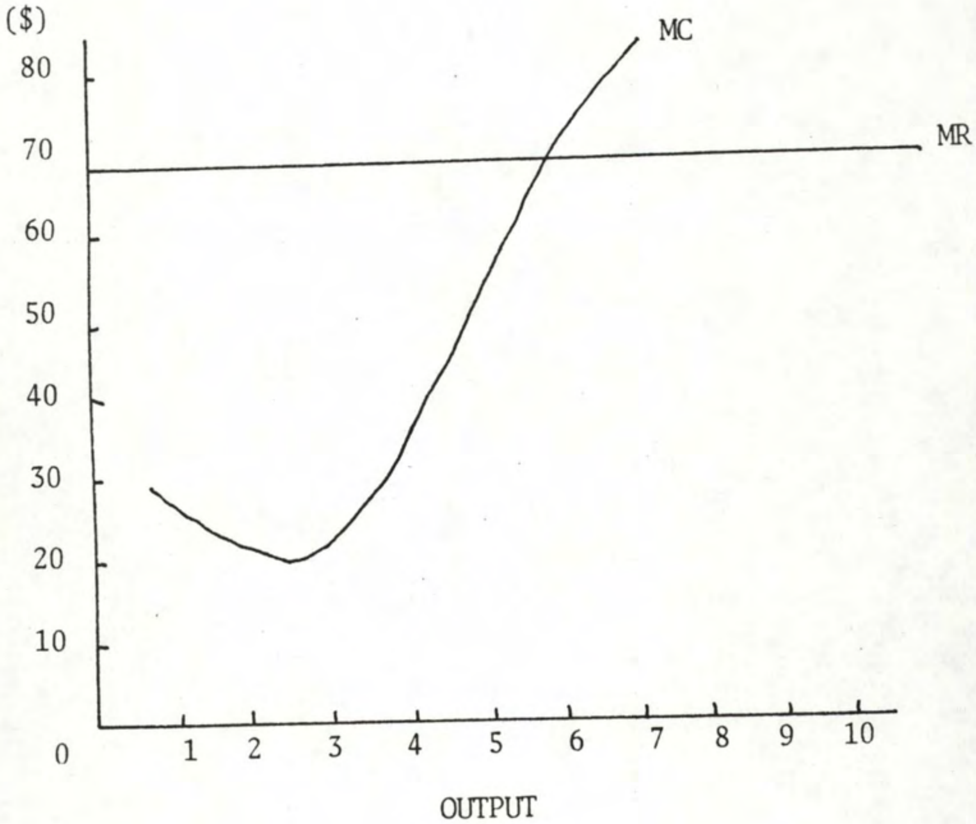

FIGURE 6. PROFIT USING MARGINAL REVENUE AND MARGINAL COST.

MC = MARGINAL COST

MR = MARGINAL REVENUE