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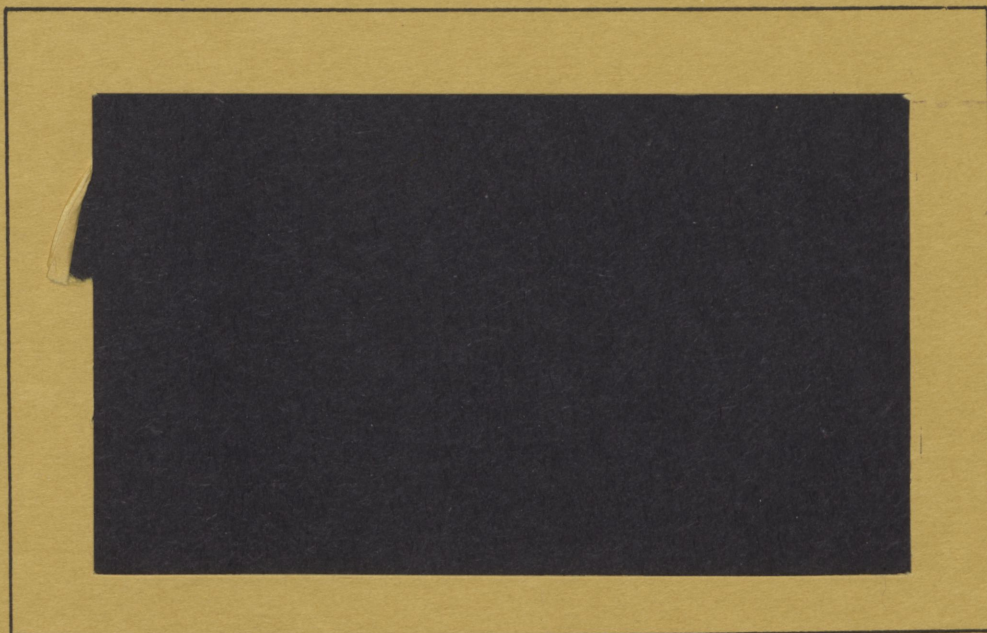
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ONTARIO AGRICULTURAL COLLEGE
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COST-VOLUME-PROFIT ANALYSIS
FOR FARM SUPPLY FIRMS

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Extension ~~AE/74/7~~

Bulletin AE/74/7 April 1974

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INTRODUCTION

Most planning in business is done on the basis of a fixed budget. This involves projecting a company's revenue, costs, and expenses on the basis of management's forecast of a fixed volume of sales for a given period. While this is an important step in the planning process, in many situations it may not be adequate.

As an illustration, assume the ABC Fertilizer Company estimates that its sales for the coming year will be \$1,000,000. On the basis of a fixed budget it estimates that costs at this level of sales will be \$900,000 resulting in a profit for the year of \$100,000. The sales estimate, of course, is only an approximation. Actual sales may vary considerably from the estimate. For instance, actual sales may fall short of the estimate and end up at a level of \$700,000 instead of \$1,000,000. If this occurs, what will happen to costs and profits? Will costs likewise decrease by 30 percent leaving a smaller, yet acceptable profit, or is it possible that costs may decrease by only 10 percent leaving the company in the position of experiencing a substantial loss? The answer to this question depends upon the cost structure of the firm which is the focal point of cost-volume-profit (C-V-P) analysis.

Experienced business managers know that the various costs of a firm do not respond uniformly to changes in volume. Some costs will vary almost in direct proportion with changes in volume; others will remain fixed over a fairly wide range of volume levels; while still others will respond only in part to these changes. Depending upon the cost structure of the firm, very small volume changes can lead to substantial profit changes in the short run.

In most firms it is extremely difficult to forecast accurately future levels of volume. Estimates of the probable range in which sales may fall is often the best forecast available. In this situation it is imperative for management to know the profit implications of various volume levels within the estimated range. Based upon this information management may be able to reformulate operating plans in an effort to better achieve profit objectives. C-V-P analysis can provide this information for management.

C-V-P analysis also provides a framework for analyzing a variety of "what if" type questions. What if the sales forecast is not achieved? How will this affect profits? The cash flow? What if selling price is reduced 2 percent? How much additional volume must be achieved to offset this price cut? What if a special promotional campaign is undertaken? How much additional volume is required to pay for it? These are just a few of the many major questions facing managers of farm supply firms. C-V-P analysis can deepen a manager's understanding of the interrelationships among sales, costs, and profit, and thus provide guidance in these important areas.

The objective of this paper is to describe the C-V-P analysis technique and show how it can be applied to a variety of decision problems. This will be accomplished first by discussing some basic concepts, then by illustrating the use of the technique in the case of bulk blending fertilizer plants, and finally by showing how certain changes can be analyzed in the framework of C-V-P analysis.

BASIC CONCEPTS

Unit Costs and Total Costs

A 1972 cost study of bulk blending fertilizer plants in Ontario^{1/} showed that the total cost, including return on investment, for the average plant was approximately \$335,000. To the manager of a plant, however, this figure becomes more meaningful when it is stated as an amount per unit. In this study, tons blended per year were chosen as the unit of measurement since they seemed to be the most useful to plant managers. The unit cost per ton was \$76.74. Stated in these terms, the manager can make a direct comparison with current selling prices to determine the profitability of his firm.

Variable Costs

Even unit costs have to be used with care. The unit cost per ton of \$76.74 found in the Ontario study was based on annual sales volume of 4368 tons. Would the unit cost have been the same at 5000 tons or 3700 tons? The answer is no in both cases. The reason for this can be found in the behaviour of various cost components which make up the total cost. Materials are a good example. The total materials cost for 4368 tons was \$246,595. If the sales volume increased to 5000 tons then we would expect total materials cost to be $\$246,595 \times \frac{5000}{4368} = \$282,274$, assuming each ton of fertilizer contains the same amount of materials. Therefore total materials cost would change in direct proportion to changes in sales volume (i.e., assuming constant inventory levels, ingredient prices, and product mix.) Any cost where the total changes in direct proportion

^{1/} Funk, T.F. and H. Tran, Cost Structure of Ontario Bulk Blending Fertilizer Plants, Working Paper AE/73/15, School of Agricultural Economics and Extension Education, University of Guelph, October, 1972.

to changes in related activity or volume is called a variable cost. Materials are a good example; others would include bags, utilities, and interest on working capital. This relationship is shown graphically in Exhibit 1.

Fixed Costs

Not all costs behave in a manner similar to material costs. Property taxes are an example of one that doesn't; they remain unchanged during the year regardless of the sales volume. Costs which show this kind of behaviour are called fixed costs. Other examples of fixed costs are depreciation on buildings and equipment, property insurance, and interest on investment. These costs are not affected by changes in sales volume that may take place during the year. An example of fixed costs is shown graphically in Exhibit 2.

Comparison of Variable and Fixed Costs

Note carefully the difference between the two types of costs. Variable costs per unit remain constant but total variable costs change proportionately to changes in volume. Fixed costs on the other hand remain constant in total but vary inversely with volume on a per unit basis.

Relevant Range

A fixed cost is fixed only in relationship to a given period of time called the budget period, and over a given range of activity or volume, called the relevant range. Fixed costs may vary from budget period to budget period because of increases in property taxes, insurance rates, etc. They are not likely to change within a given budget period. Total budgeted fixed costs are developed on the basis of an expected level of activity or volume within some relevant planning range. Operations outside that range would

probably result in the layoff or hiring of full-time personnel, and the disposal or acquisition of equipment.

These assumptions - of a given budget period and a given relevant range - are shown graphically in Exhibit 3. Here the relevant range is assumed to be 2000 tons. As volume increases beyond this range, additional capital investment must be made which increases depreciation expense.

Step Variable Costs

We have seen that costs which vary in direct proportion to volume are called variable costs. Cost which remain unchanged during the years regardless of volume are called fixed costs. Unfortunately not all costs are so easily classified. The behaviour of many costs do not fit the pattern shown in either Exhibit 1 or Exhibit 2. Labour is a good example. Total labour costs may not increase in direct proportion to increases in volume, instead they may increase in steps as depicted graphically in Exhibit 4.

This happens when volume goes beyond what the existing staff can handle. In this situation the firm may hire temporary help to handle the overload; this makes it a true variable cost. In other situations the firm may decide to hire permanent staff, even though present volume doesn't justify it, in the expectation of future volume increases. This makes labour a step-variable cost. For practical budgeting purposes, costs do not have to vary in a strictly linear fashion in order to be classified as a variable cost.

Mixed Costs

Finally some costs are called mixed costs because they consist of both a fixed and variable component. Repairs and supplies are an example. For costs of this type it becomes necessary to divide them into their fixed and variable

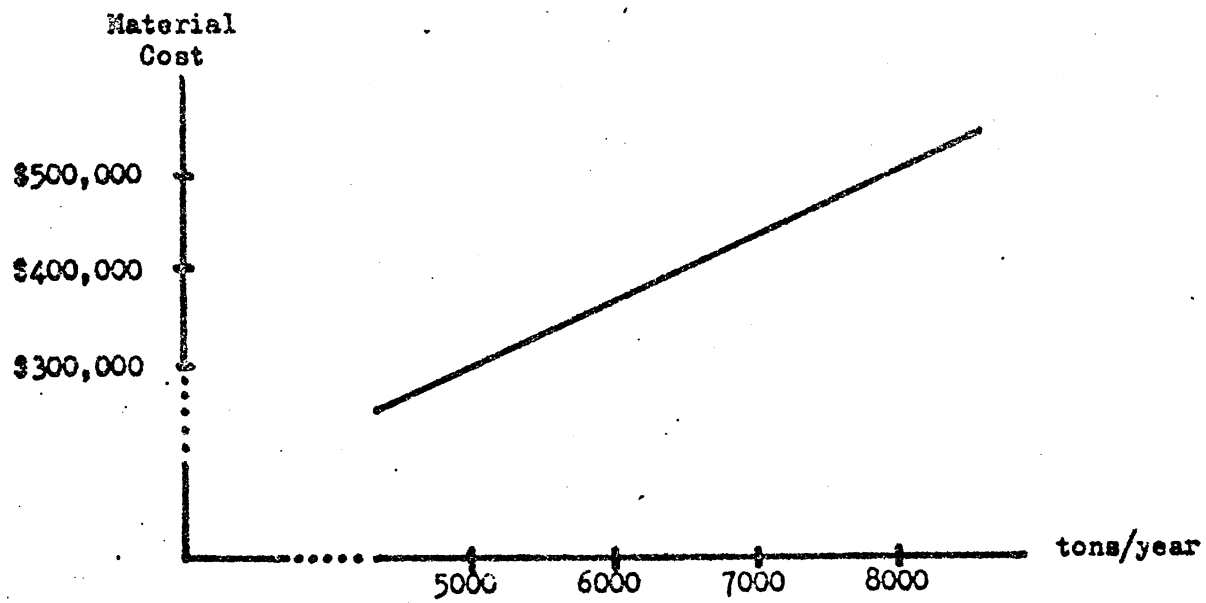
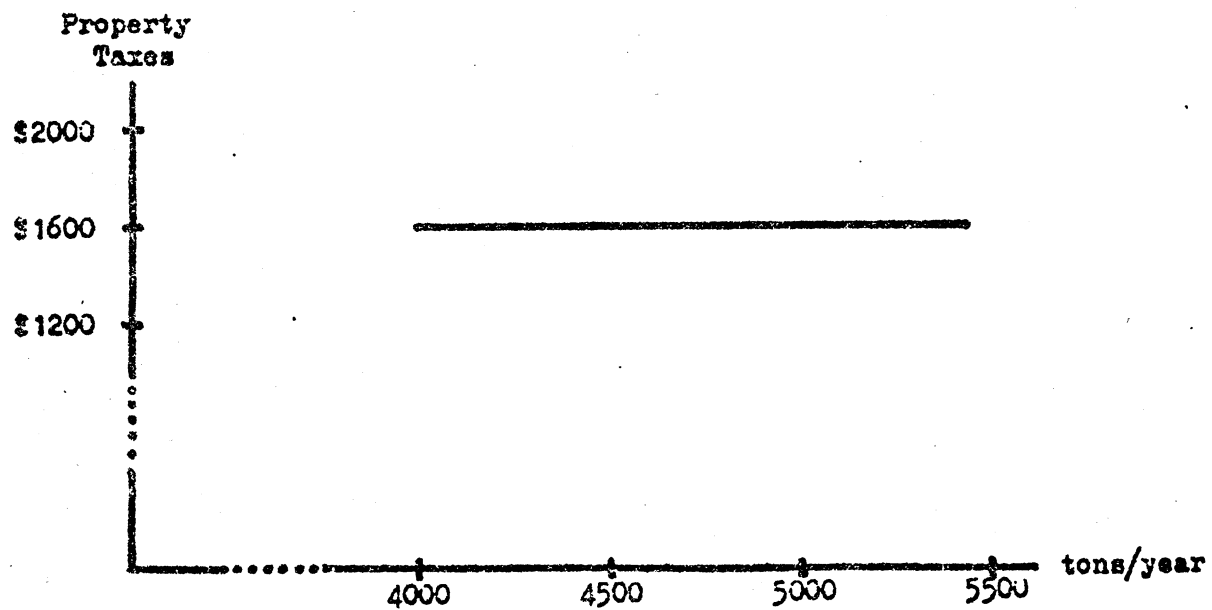
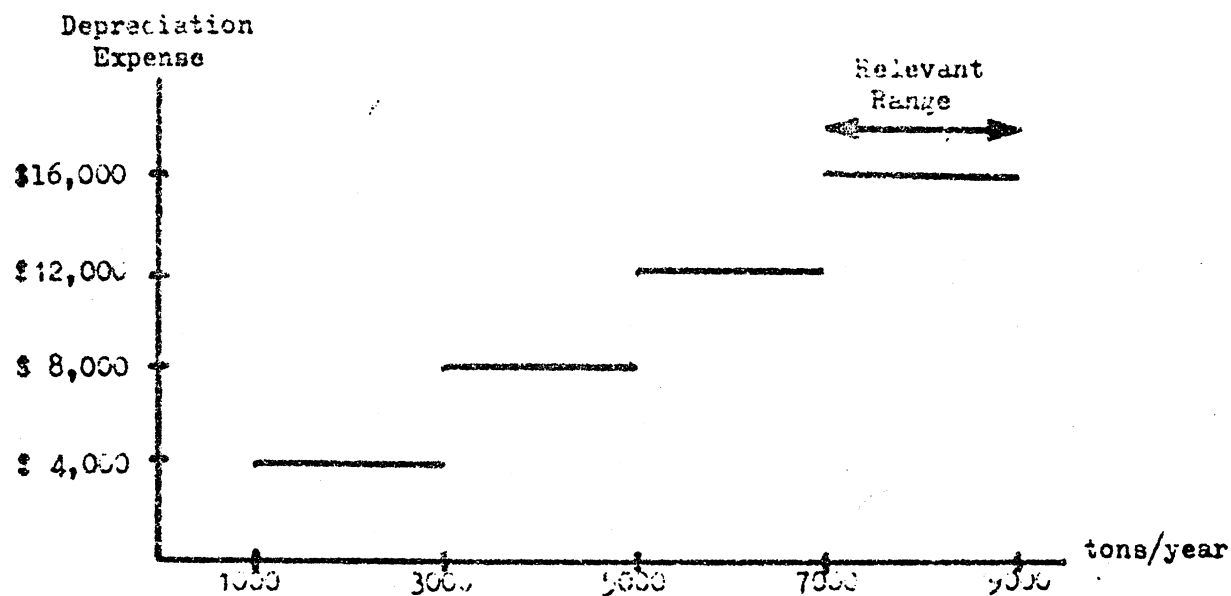
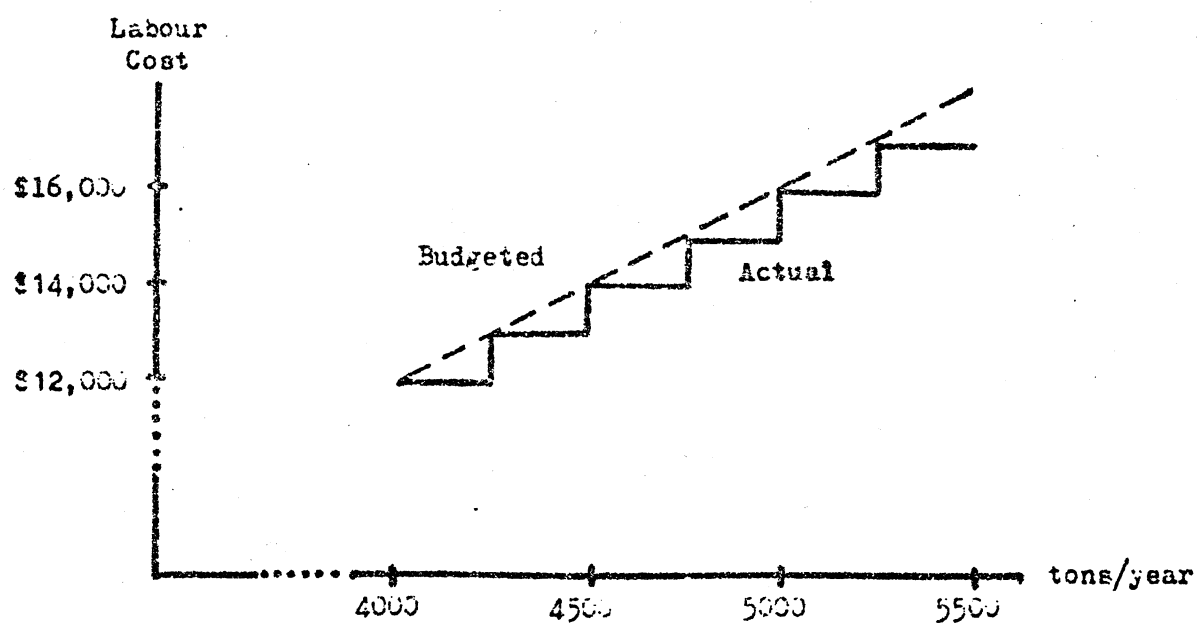
EXHIBIT 1EXHIBIT 2

EXHIBIT 3EXHIBIT 4

components.

AN ILLUSTRATION

In this section C-V-P analysis will be applied to a bulk blending fertilizer plant to illustrate how this tool can be used in management decision-making.

In Exhibit 5, all of the costs associated with a bulk blending operation having an annual volume of 4368 tons have been classified as variable and fixed costs. The classification has resulted in \$285,409 or \$65.33/ton being attributed to variable costs and \$49,865 to fixed costs.

Most of the variable cost categories shown in Exhibit 5 are pure variable costs in the sense discussed earlier. Utilities, bags, discounts on sales, materials, and interest on working capital are all closely related to the volume sold. Operating labour is an example of step-variable cost. In this application it has been classified as a variable cost because we have assumed a fairly wide relevant range. Repairs and supplies are a mixed cost and as a result have been divided into fixed and variable components on an arbitrary basis.

Insurance, property taxes, depreciation, and interest on fixed investment are all relatively constant over a wide range of output. As a result, they are examples of true fixed costs. Administrative salaries, clerical labour, and selling expenses are step-variable costs, however, they tend to be fixed within the relevant range, hence are classified as fixed costs.

Given this information, together with revenue data, it is possible to determine the breakeven volume for the firm. In this example, the average price per ton of product and associated services was \$73.41. Thus at an

EXHIBIT 5

Fixed and Variable Costs Incurred by Bulk Blenders
With a Sales Volume of 4,368 Tons (1)

Variable Costs	Total	\$/Ton
Operating Labour	\$12,970	\$2.96
Utilities, gas, oil	1,330	0.30
Repairs & Supplies (2)	2,676	0.61
Bags	1,904	0.43
Leased Equipment	1,652	0.38
Fringe Benefits (2)	1,837	0.42
Discount on Sales	2,075	0.48
Other Operating (3)	5,665	1.30
Materials	246,595	56.45
Interest on Working Capital	<u>8,705</u>	<u>1.99</u>
	\$285,409	\$65.33
<hr/>		
<u>Fixed Costs</u>		
Repairs and Supplies (2)	\$ 2,676	\$ 0.61
Insurance	1,661	0.38
Administrative Salaries	7,302	1.67
Clerical Labour	1,745	0.40
Fringe Benefits (2)	1,837	0.42
Property Taxes	1,615	0.37
Other Administrative (4)	5,457	1.25
Selling Expenses (5)	7,565	1.73
Depreciation	10,640	2.43
Interest on Fixed Investment	<u>9,266</u>	<u>2.12</u>
	\$49,865	\$11.41

(1) The average price per ton of product and associated services was \$73.41.

(2) Apportioned equally between fixed and variable costs.

(3) Also includes freight and bad debts.

(4) Also includes license, telephone, postage, soil and tissue testing, and legal and accounting.

(5) Includes salesmen's salaries, salesmen's expenses, advertising, automobile expense, and other selling expenses.

annual volume of 4,368 tons, the total revenue is \$320,655. Since total costs at this annual volume are \$335,274, it is clear that the firm is losing \$14,619. How much will volume have to be increased for this firm to break-even? To answer this question we need to determine the breakeven point.

In the earlier discussion of costs it was pointed out that total costs can be broken down into the two categories of fixed and variable. Fixed costs are those which remain constant over the relevant range while variable costs are related to volume and tend to increase in some proportion with volume. We can develop some simple equations which show these relationships.

Letting:

TR = Total revenue in dollars

p = Selling price per unit in dollars

x = Volume sold in units

Then total revenue is given by:

$$TR = xp$$

Letting:

TC = Total cost (fixed plus variable)

TVC = Total variable costs

TFC = Total fixed costs

v = Variable cost per unit in dollars

Then total variable costs and total costs are given by:

$$TVC = xv$$

$$TC = TVC + TFC = xv + TFC$$

Substituting the data from bulk blenders (see Exhibit 5) our equations become:

$$TR = 73.41 x$$

$$TC = 49,865 + 65.33 x$$

Using the above two equations it is possible to determine the revenue and costs at any level of sales within the relevant range. For instance, at 5000 tons total revenue and total costs are:

$$TR = 73.41 (5000) = \$367,050$$

$$TC = 49,865 + 65.33 (5000) = \$376,515$$

Thus if sales were projected to be 5000 tons, the firm would expect to lose over \$9,000. ($TR - TC$)

By definition the breakeven point occurs where profits are zero. Since profits are simply the difference between total revenue and total costs, the breakeven point is where this difference is zero, or where total revenue is equal to total costs. We can easily determine this point in the following manner.

At the breakeven point

$$TR = TC$$

and

$$xp = xv + TFC$$

Therefore, the breakeven volume is given by:

$$x = \frac{TFC}{p-v}$$

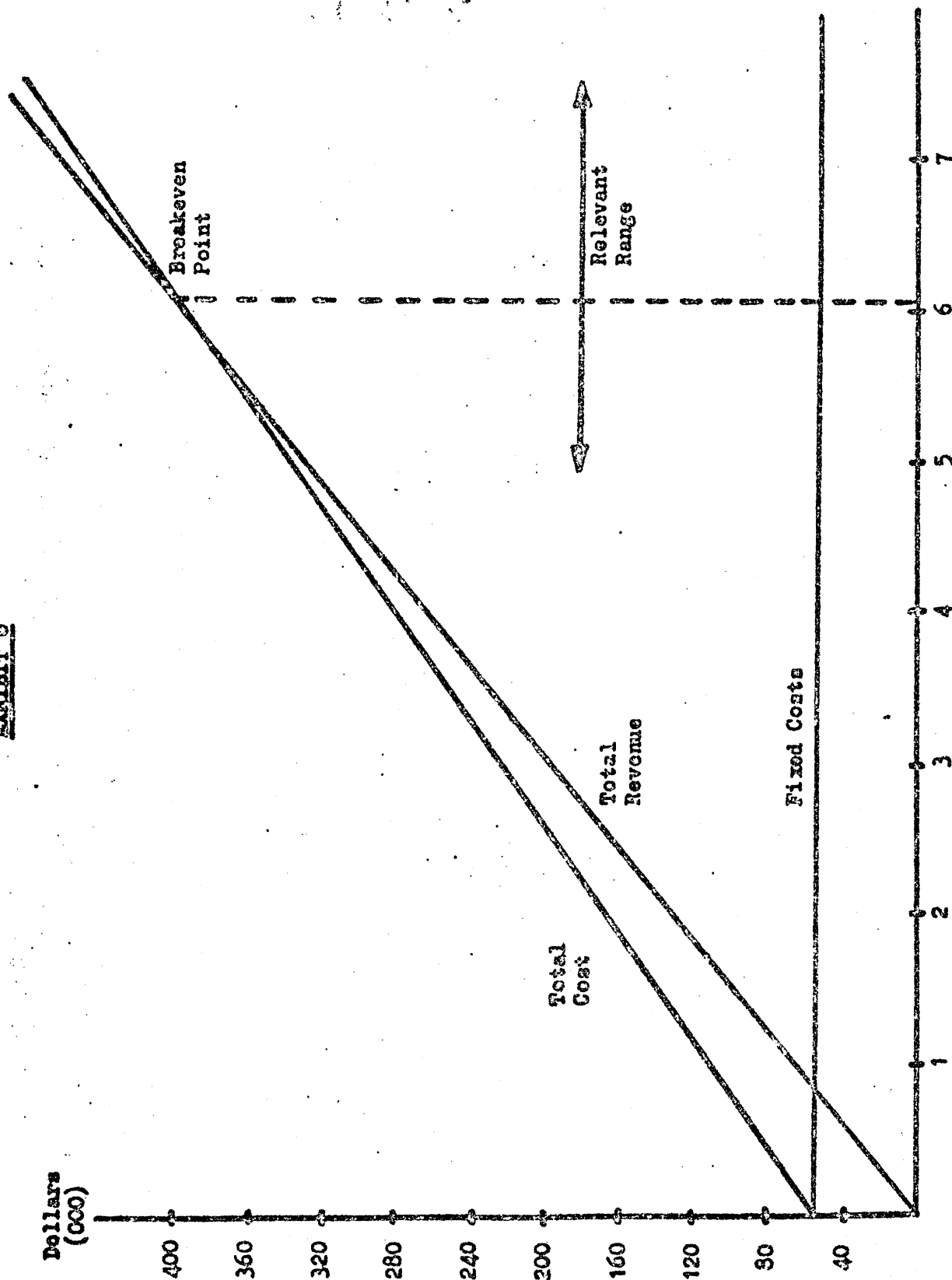
In the case of bulk blenders this becomes:

$$x = \frac{49,865}{73.41 - 65.33} = 6171 \text{ tons}$$

Thus given the cost structure for the average bulk blending firm, it can be seen that the breakeven volume is 6171 tons per year. Below this level losses are incurred, while above this level, profits are earned.

These relationships are plotted on the graph in Exhibit 6. In this graph the vertical axis is measured in terms of dollars, while the horizontal

EXHIBIT 6



1,000 Tons of Product

axis is measured in terms of tons of fertilizer sold per year. The break-even point occurs where the total revenue line crosses the total cost line or where total revenue is equal to total costs. As volume expands, to say 8000 tons, it can be seen that total revenue is greater than total costs and a profit is earned. On the other hand, at the average volume of 4,368 tons, a loss is incurred.

ANALYZING CHANGES WITH C-V-P ANALYSIS

Once the cost structure of the firm has been determined, and the break-even chart prepared, this information can be used to analyze the impact of various changes on the profitability of the firm. To illustrate how this is done, four examples will be discussed. Data used in these examples illustrates the situation of the average bulk blending fertilizer plan in Ontario.

Case I

In Case I, assume that the firm lowers its selling price by \$1 per ton. What effect will this have on the profitability and breakeven point? If the price is lowered by \$1 per ton, the new price is \$72.41 per ton. Substituting this into the breakeven formulation developed earlier, we can calculate a new breakeven point.

$$x = \frac{TFC}{p-v} = \frac{49,865}{72.41 - 65.33} = 7043 \text{ tons}$$

Thus by reducing the price \$1 per ton, the breakeven point increases by 872 tons (from 6171 tons to 7043 tons) or approximately 14 percent. Management assumes that a reduction in price will lead to a greater volume. In this example, management would have to decide whether a \$1 per ton price reduction would increase volume by 14 percent. Breakeven analysis does not answer this question, but it does show the volume change which would be necessary to justify this price change.

This situation is illustrated in Exhibit 7. Note that the effect of the price change is shown by a lowering of the total revenue line. This causes the new total revenue line to intersect the total cost line at a higher volume, hence the breakeven point increases.

Case II

Case II, illustrates the situation where material costs increase by \$2 per ton and everything else remains constant. This cost is classified as a variable cost, therefore the effect of this change will be to increase variable costs from \$65.33 to \$67.33 per ton. We can easily determine the effect of this change on the breakeven volume.

$$x = \frac{TFC}{p-v} = \frac{49,865}{73.41 - 67.33} = 8201 \text{ tons}$$

Thus a \$2 per ton increase in materials cost has a significant effect on the breakeven volume. In this example, the breakeven volume increases by 2030 tons (from 6171 tons to 8201 tons) or approximately 33 percent as a result of this cost change. To respond to this change management can attempt to increase volume through additional sales efforts, and/or lower the breakeven point by increasing their product prices.

The effect of a variable cost increase is shown in Exhibit 8. When variable costs increase, this tends to raise the total cost line so that it intersects the total revenue line at a higher volume.

Case III

The change shown in Case III is the addition of one new salesman. We will assume that the salary and expenses of this salesman comes to \$12,000 per year. Since this cost is not dependent upon volume it must be classified as a fixed cost. Incorporating this cost into the breakeven formulation,

EXHIBIT 7

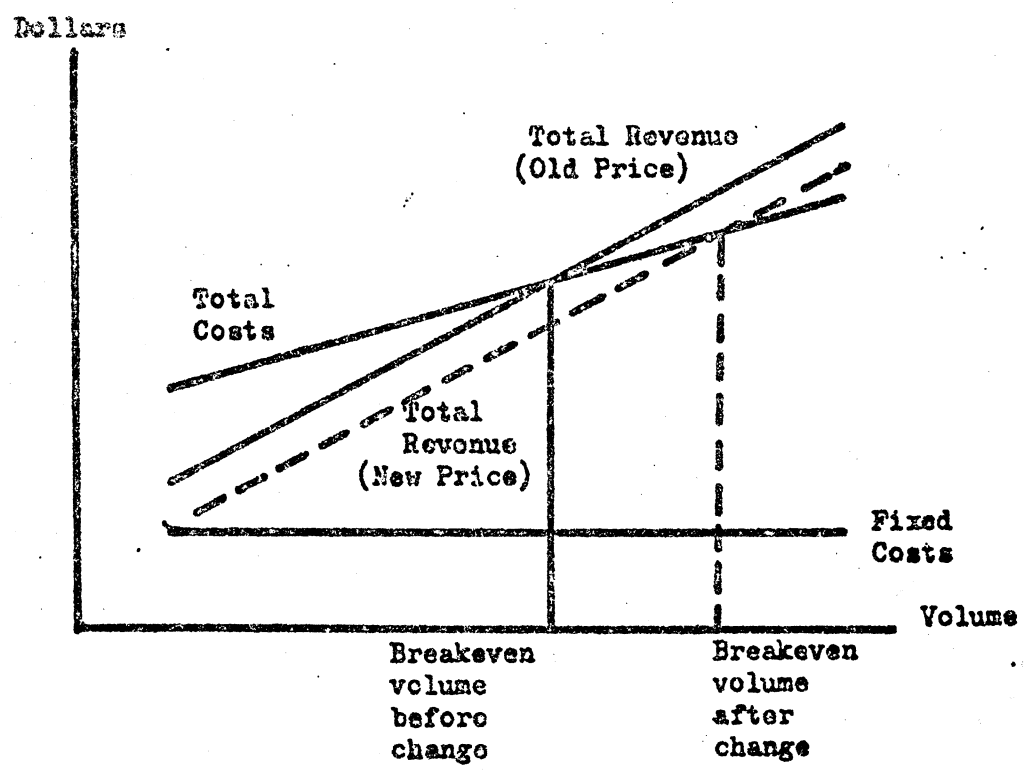
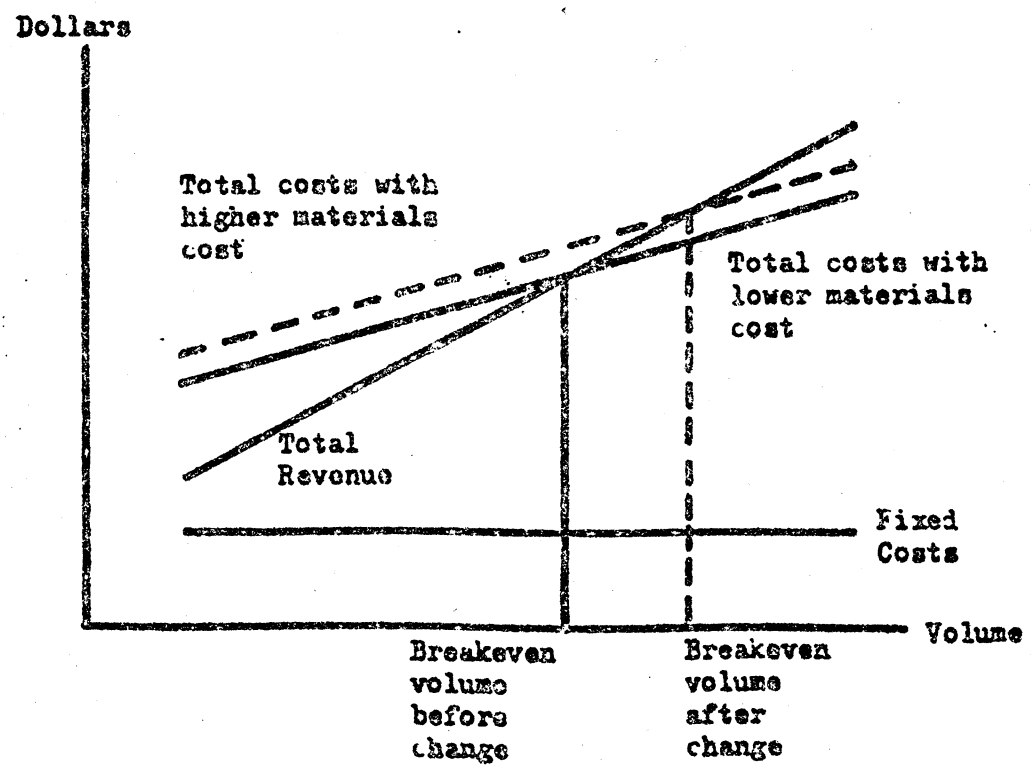


EXHIBIT 8



we can see the effect of this change on the breakeven point.

$$x = \frac{TFC}{p-v} = \frac{61,865}{73.41 - 65.33} = 7656 \text{ tons}$$

Thus the addition of one new salesman increases the breakeven volume by 1485 tons, or roughly 24 percent. According to this analysis, the salesman would be worthwhile if he could generate at least 1485 additional tons of sales per year.

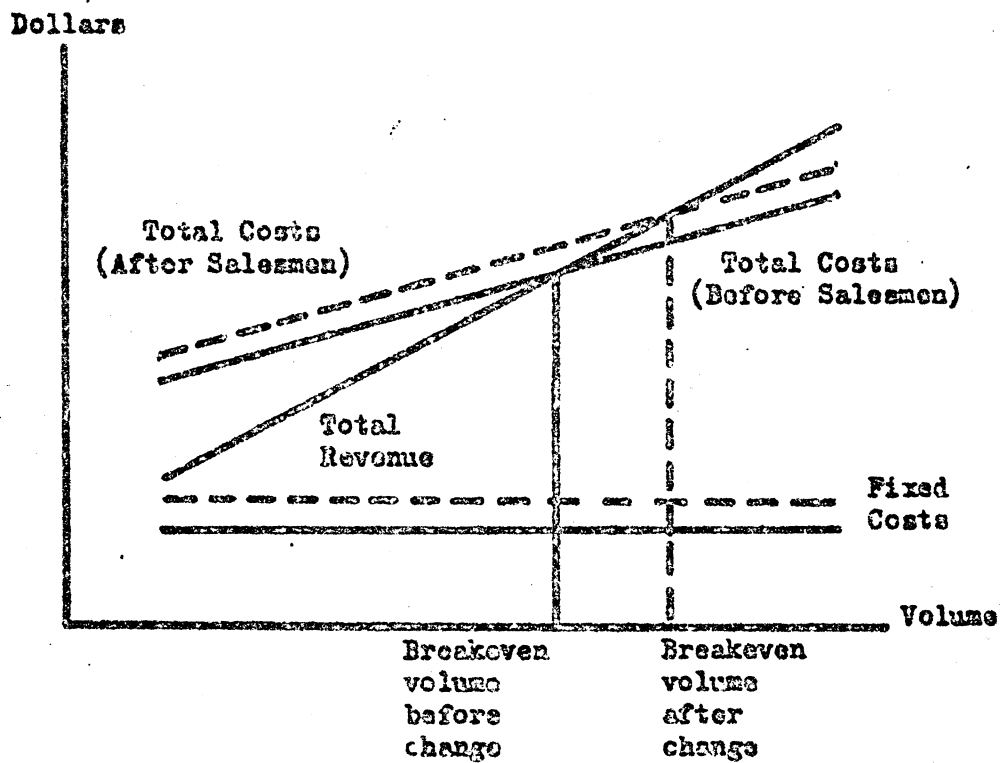
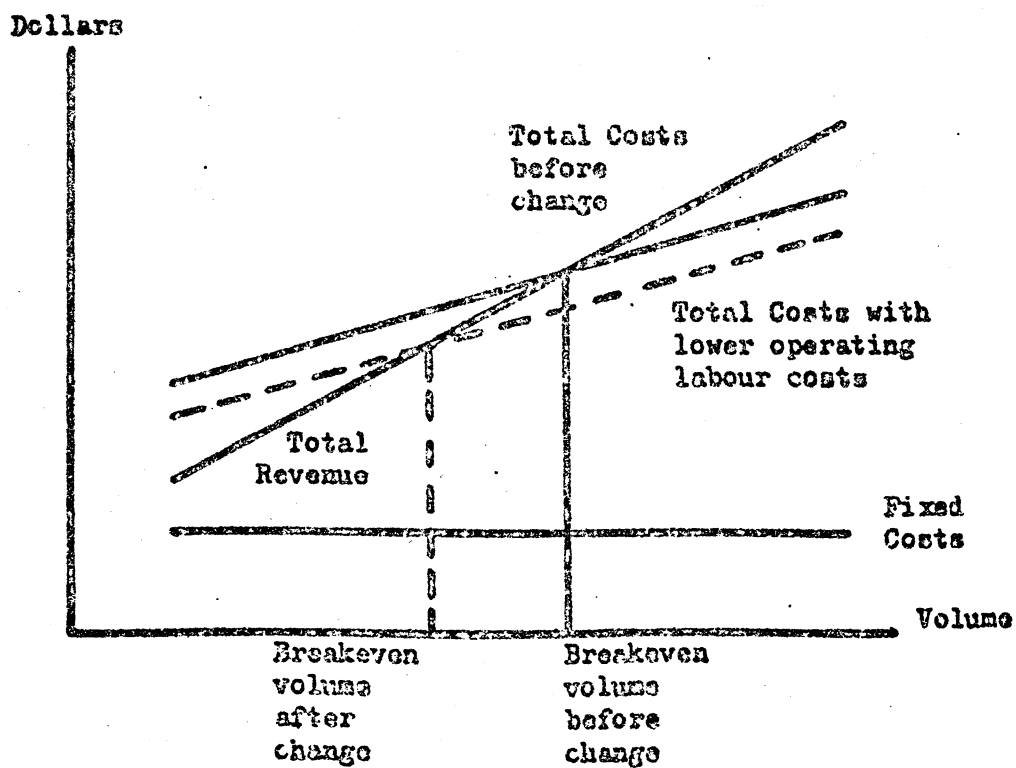
This situation is shown graphically in Exhibit 9. Note that in this case the fixed cost component of total costs increases causing the total cost line to intersect the total revenue line at a higher volume.

Case IV

Finally, Case IV examines the situation where operating labour is reduced. For the sake of this example, assume that the firm reduces operating labour by letting a full-time man go, and increases the use of part-time labour during the peak season. Assume that the net effect of this change is a reduction in operating labour cost of \$6000 per year or \$1.37 per ton. The consequences of this change in terms of the breakeven volume can be determined in the following manner.

$$x = \frac{TFC}{p-v} = \frac{49,865}{73.41 - 63.96} = 5267 \text{ tons}$$

In this case, the reduction of variable costs has caused the breakeven point to move to a lower level. This is shown in Exhibit 10 by lowering the total cost line.

EXHIBIT 9EXHIBIT 10

MANAGEMENT IMPLICATIONS OF C-V-P

The objective of this paper has been to describe the C-V-P analysis technique and show how it can be applied to a variety of decision problems. We have seen that the primary purpose of C-V-P analysis is to investigate the behaviour of costs and profits as volume changes. As a result, the technique can be used by management in formulating operating plans within some estimated volume range. The technique also provides a framework for analyzing a variety of "what if" type questions. Four such questions were investigated in this paper, but these by no means exhaust the possible applications of C-V-P analysis. Any proposed change in operations can be studied in a similar manner, provided the change affects the costs or revenues of the firm.

Although C-V-P is a useful tool, it does not solve problems. The best it can do is to help management diagnose a problem. All the information required is usually available in the firm's regular accounting reports. C-V-P analysis merely presents this information in a more meaningful manner. It does have several weaknesses that the manager should be aware of:

- 1) Unless the firm has only one product, C-V-P analysis assumes a constant product mix. Actual profits may vary from that projected by C-V-P analysis because proportionately more of one was sold than was assumed in the analysis.
- 2) The total cost and total revenue lines shown on Exhibit 6 are linear approximations of curvilinear functions. The further away actual volume is from the volumes used to develop these lines (i.e., those within the relevant range) the less accurate are these approximations of the true cost and revenue lines.

- 3) There is a chance that the break-even point may be overstated.

This is because as sales volume drops to the breakeven point there is a possibility that fixed costs could be reduced. Many fixed costs are discretionary in nature and can in reality be reduced when times get tough.

It is important to emphasize that an increase in the breakeven point (in terms of tons sold) is not necessarily a bad thing. In most cases production capacity cannot be increased without increasing the breakeven point.

The important comparison is the breakeven as a percentage of capacity. If this is increasing it could be a sign of some unfavourable conditions. For example, if the contribution per dollar of sales is reduced because of lower selling prices or increased variable costs then the breakeven increases both absolutely and as a percentage of capacity. This is not a good situation. On the other hand a plant expansion will increase the breakeven point absolutely but will lower it as a percentage of capacity. This is what you would expect to happen.

