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OVERHEAD ALLOCATION AND
MARGINAL COST IN U.S. AND BRAZILIAN
DEFENSE CONTRACTING

by

Paulo M. Falcão

December, 1993

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DEFENSE CONTRACTING

by

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Captain, Brazilian Air Force

Submitted in partial fulfillment
of the requirements for the degree of

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I. INTRODUCTION

Cost analysis has become a very important theme in the Brazilian Air Force over the past few years.

When the Brazilian Air Force (BAF) contracted the Brazilian aircraft manufacturer (Embraer) to manufacture a new aircraft in a joint venture with an Italian company, there was an increased demand for more specialized personnel and procedural changes. The whole program has been contracted without competitive procurement, because Embraer is the only company in Brazil that manufactures aircraft. Also, the Brazilian Ministry of Aeronautics is interested in developing the Brazilian Aerospace industry.

The costs involved in the program represent a large amount of resources. These expenditures necessitate a constant evaluation of technical, economic, and accounting performance.

Cost analysis has been demonstrated to be an effective tool in evaluating and understanding how the company deals with cost when charging the Government during different phases of the program. However, several disagreements and controversies have arisen from questions surrounding the amount of resources involved in such issues as cost allocation, overhead costs, regulations and standard procedures.

To rectify the problems, the Brazilian Government and Embraer have been examining better ways to accomplish their objectives during the acquisition process by involving highly capable personnel, applying modern techniques, and creating standard and clear procedures.

These issues are not only a sensitive area in the BAF, but in the American military as well. The U.S. Government, through its DoD, is, and has been, engaged in activities designed to increase efficiency in cost analysis, and to improve those instruments that serve to accomplish this task properly. In doing so, the DoD has found several approaches to dealing with cost analysis, and has created regulations and procedures that have been demonstrated to be useful. The objective of this work is to analyze some of these alternatives and to present marginal analysis as a possibly useful tool in decisions when cost analysis is applied, particularly as it relates to overhead cost.

A. BACKGROUND

Governments deal more and more with cost analysis because of the nature and specification of the acquisitions that are required to accomplish their mission. The DoD has implemented several programs to expedite the procurement process. These programs extensively involve cost analysis, which plays a particularly important role when competitive procurement is

inappropriate. In addition, the reduction of the defense budget has driven the DoD to improve its tools, in order to reduce cost and optimize resources in contracting services and buying goods.

The DoD is concerned about the indirect costs of its contractors because it represents at least one-third of the price that the DoD pays for its weapon systems. In 1984, the Deputy Secretary of Defense emphasized the need for DoD to reduce cost by using evaluation tools. [Ref. 1]

Several tools have been developed to improve the understanding of overhead cost and find better approaches for allocating these costs. Regulations that establish principles and procedures to deal with overhead cost have also been the subject of discussions and debates, in an attempt to make them more suitable to the needs of contractors and governments.

1. The Role of Overhead Cost

It is important to emphasize that over time, the proportion of overhead cost to direct cost has grown. Figure 1 shows notionally how the ratio of indirect to direct cost has changed over time.

In the past, direct costs made up the majority of total costs, and cost management was relatively straightforward. Pricing decisions were not as likely to be affected by overhead cost. This is not true in today's cost environment. Also, the importance of overhead costs to a particular company

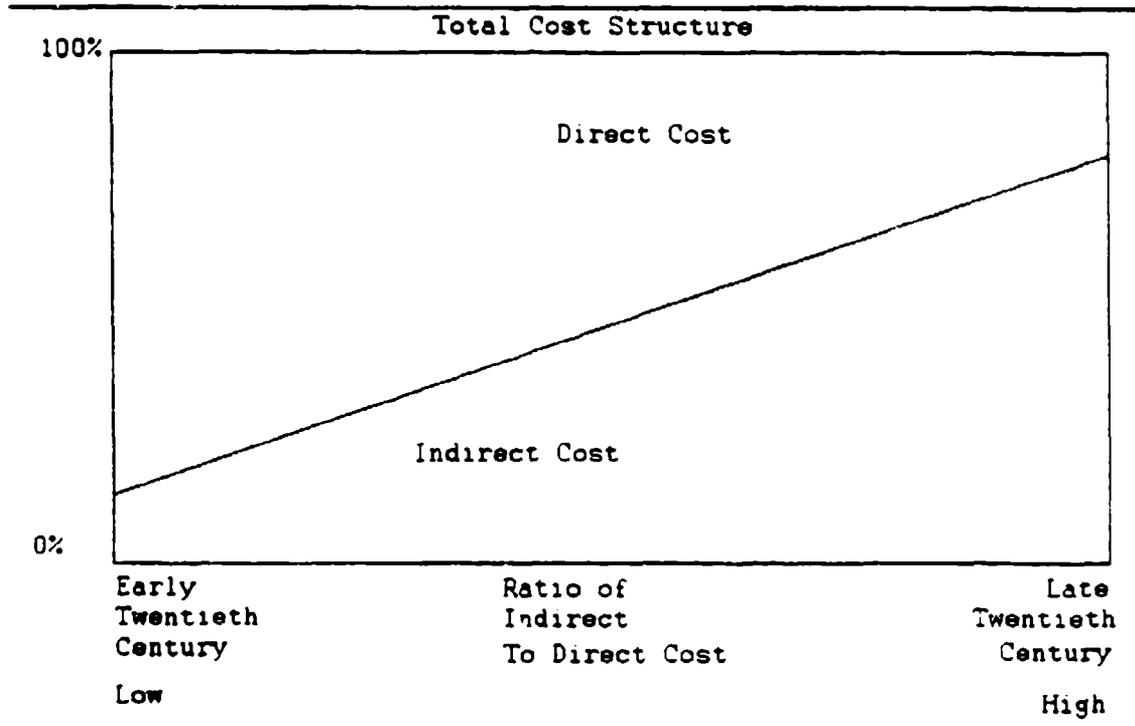


Figure 1. The Changing Composition of Total Cost
Source: "Activity-Based Costing: New Insights for Cost Management" Armed Forces Comptroller, Spring 1991, p. 24

will depend on the size of that company and the nature of its product range (hence its technology) and the characteristics of the market it serves. Companies involved with high technology and complex manufacturing processes, and with long channels of distribution, will tend to have high levels of overhead in the factory, the laboratory, the administrative system, and in the marketing operation.

The importance of overhead costs is increasing as the proportion of the total costs that are indirect in nature continues to increase. This trend is shown, for example, in the steady rise in the proportion of employees engaged in

administrative, clerical, and technical work in the manufacturing industry in Great Britain. The current figure is in excess of 25% of those employed, and a similar pattern exists in the U.S. [Ref. 2].

Evidence of the increasing importance of overhead costs include: large-scale operations, specialization, product diversification, competitive pressures, technological development, and automation.

Advanced technology demands a large amount of capital investment. This must inevitably take place in an atmosphere of complexity, and this is associated with a high proportion of overhead cost. [Ref. 2]

Also, the level of automation is another determinant in high overhead costs. Higher levels of automation bring higher levels of capital investment. Automation often entails a reduction in direct labor costs and an increase in overhead costs. An increased number of complex machines requires an increased amount of maintenance. This too leads to further overhead costs.

Another important insight from Figure 1 is in regard to the nature of indirect cost behavior. Over time, overhead costs are clearly variable and increasing, rather than fixed. In the short run, these costs only appear to be fixed, due to the choice of production unit volume as the basis for determining variability of costs. On a unit volume basis, only

direct materials and labor and a limited amount of overhead costs appear to be variable. [Ref. 3]

In general, overhead costs do not relate to volume as one might expect. In theory, overhead should decline as a percentage of sales as volume increases. For most companies, however, the long-run trend is not toward a smaller percentage in spite of general growth. This is to say that it is hard to predict the behavior of overhead costs with an increase in size. Comparisons of large and small companies in the same fields support this conclusion. The smaller companies will have relatively lower overhead costs, although they may also have relatively higher manufacturing costs. From these considerations, we can say that controlling and measuring overhead requires special attention. [Ref. 4]

B. RESEARCH QUESTIONS

This study will investigate marginal analysis as a useful tool in cost analysis, particularly in overhead cost analysis. The differences between the BAF and the DoD regarding regulation and accounting procedures in analyzing overhead cost will also be addressed.

So the question is, given different methods of allocating overhead cost, what are the effects of overhead allocation on the ability to estimate marginal cost? Subsidiary research questions are:

- How is overhead cost identified?
- What different methods are used to calculate overhead cost?
- What effect will full absorption overhead calculation have on the estimation of marginal cost?
- How do economists and accountants differ in their consideration of cost?

C. SCOPE, LIMITATION, AND ASSUMPTIONS

While the BAF and Embraer are the subjects of this research effort, current data from cost analysis conducted in Brazil are unavailable; therefore, the bulk of our discussion deals with U.S. and DoD procedures.

The objective of this thesis is to develop marginal analysis as a possibly effective tool for improving cost analysis, and to gather information regarding regulation, accounting procedures, and cost concepts that could be applied in the BAF.

This thesis deals only with the principles and concepts of applying marginal analysis. The main finding is that the use of marginal analysis can identify alternatives which improve the quality of cost analysis, especially the analysis involving overhead cost.

D. ORGANIZATION

This study is organized into six chapters. Following the introduction in Chapter I, Chapter II presents a cost frame-

work that is based on marginal analysis. Chapter III reviews some cost accounting concepts and also provides a description of how overhead cost is evaluated by American industries and Embraer. Chapter IV presents some DoD regulations that deal with cost analysis, especially overhead cost. Chapter V contains an analysis of how marginal analysis can be an effective tool in cost analysis in the BAF. Finally, Chapter VI provides conclusions and recommendations.

II. COST FRAMEWORK

Cost is a very important theme in economic decision making, because firms must decide both the types and quantities of goods to produce and sell as a function of the price and the cost of those goods. This means that to better understand supply, one must be aware of issues like allocation of cost, maximization of profit, and minimization of cost.

This chapter is divided into five major parts. In the first part, cost concepts will be considered and the views of accountants and economists will be discussed, in order to illustrate the contrast between them. In the second part, the link between cost and production is presented for both the long run and the short run. The third part will address marginalism. The source of marginal concepts will be described, since incremental or marginal costs play an important role in optimally productive decision making. In the fourth part, the use of marginal analysis in cost analysis will be discussed. Finally, in the fifth part, marginal analysis will be considered in the context of a multi-product firm.

A. COST CONCEPTS

From the view of economics, cost equals the benefit foregone by not using resources for the next best alternative use. This idea constitutes one of the great insights in economics. Cost, for the economist, is defined as opportunity cost. [Ref. 5]

It is very important to understand this concept of cost, because most of the cost analysis in economics depends on the idea of measuring cost in terms of the value of things given up. As much as possible, the benefit foregone will be translated into a monetary value, in order to make the cost of alternatives commensurable.

Opportunity cost reminds us that we should always think about costs, but it also tells us that the costs relevant to decisions are those associated with opportunities foregone. [Ref. 6]

1. Opportunity Cost

Opportunity cost plays a fundamental role in addressing problems of scarcity. The following is a useful example of opportunity cost:

A student attends school for a year, and incurs an expense of \$5,000. One can say that the cost of the study is \$5,000, but several other implications of the decision to attend school can be identified as opportunity costs. Suppose, for example, that the time spent studying, doing research,

attending class and other school activities could be replaced by time spent working in his/her own business. In this business, the student could make \$10,000 a year. Thus, the opportunity cost of college is \$15,000 rather than \$5,000.

2. Economists' and Accountants' Views of Cost

The concept of cost varies between economists and accountants, since each one approaches the task of cost measurement differently. The accountant is mainly concerned with seeing that the firm meets its financial obligations. The economist is more concerned with the way the firm uses its resources. [Ref. 7]

Because accountants and economists measure costs in different ways, they also reach different conclusions about the firm's situation. The important point here is to understand those basic dimensions that have a different meaning for economists and accountants when they analyze cost.

a. Implicit and Explicit Costs

Implicit costs are a form of opportunity cost. They are the value of certain services that are consumed in the production process, but for which there is no corresponding direct market transaction. Although this kind of cost may not actually be associated with a monetary expense during the period in question, it still reflects the income a resource could be earning in another employment. Therefore, when

economists are concerned with full opportunity costs, implicit cost is also included.

When most people think of cost, they consider only the explicit cost. That is, the actual payment by firms for labor, capital, and other factors of production. While most accounting costs are the explicit costs of carrying on an operation, there is also an important example of implicit costs in the accounting framework. This is depreciation, which does not involve an actual cash outflow in the current time period. When the accountants calculate the net income or profit after taxes, it represents what is left after all explicit costs have been paid and the implicit costs related to depreciation have been accounted for.

To summarize these two concepts, we can say that implicit costs are those amounts that could be earned by the resources owned by the firm in a best alternative use, or in the case of depreciation the decline, in the value of the asset that results from its use during the current time period. Explicit cost is a payment made by a firm in a market transaction for the use of factor inputs (labor, capital) not owned by the firm.

b. Market and Historical Value

Another important aspect that differentiates economists and accountants is their consideration of the measurement of a firm's assets. The measure of the cost of

employing different assets available to the firm in a production process is done in historical terms by accountants. This reflects a concern for objectivity in the process of evaluation. The estimation of the depreciation of land, machinery, and other assets by accountants is usually based on rates that are not directly connected to the decline in market value. For example, a machine might be depreciated by an amount equal to 10% of the original purchase price per year, based on the determination that the machine has a ten-year life.

Economists, in their analysis, use the decline in market value to measure depreciation, because this is the real cost of employing the machine during the period in question. In addition, the economists determine the opportunity cost of the usage of assets in production on the basis of what the land, machinery, and buildings might have earned in alternative employment, or on the basis of the interest which the funds tied up in those assets could have earned in alternative investment, whichever is greater. [Ref. 8]

c. *Economic and Accounting Profit*

In order to understand the idea of economic profit, it is necessary first to introduce the concept of normal profit. Normal profit is the implicit cost of using the firm's own entrepreneurial resources, net of depreciation. As land and labor owned by the firm must be paid respectively,

implicit rent and implicit wages, for the owner - the necessary return - is called normal profit.

Economic profit can now be defined, since we have seen that normal profit is really a cost. Economic profit is a return to the owner of the resource, over and above the necessary normal profit. It is the difference between total revenue and total economic cost, which includes both explicit and implicit costs.

Accounting profit is a profit that is obtained from the difference between revenue and accounting cost, where this cost is both the explicit cost resulting from market transactions and the implicit cost resulting from depreciation. Figure 2 summarizes our discussion about the Economists' and Accountants' view of cost.

A final comment about Figure 2 is related to implicit costs as viewed by accountants and economists. Accountants compute a part of implicit costs when calculating the depreciation of capital, but even in this case, this computation does not necessarily coincide with depreciation as measured by economists. As we have discussed, the economic depreciation for economists is the decline in the market value of the asset. In contrast, as we have seen above, accountants calculate depreciation using certain rules of thumb.

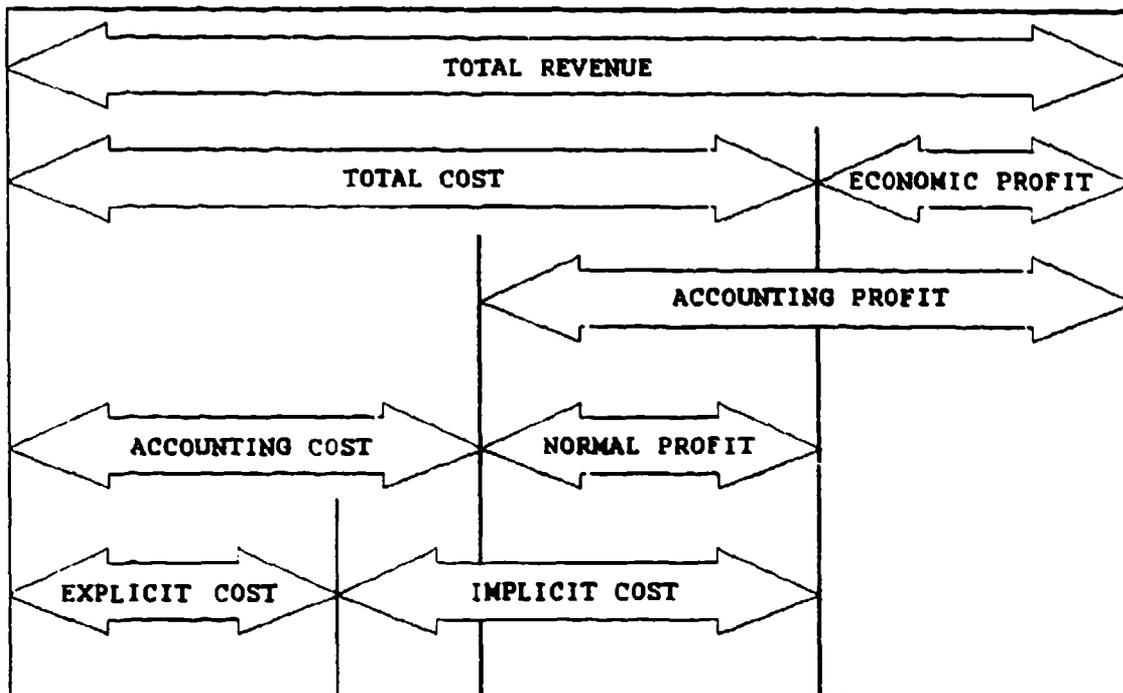


Figure 2. Economists' and Accountants' View
Source: Principles of Microeconomic Reading Work Book
Economics 221, U.S. Air Force Academy, 1981

Appendix A provides a useful example of the different aspects of cost from the view of economists and accountants.

3. Other Cost Concepts

Since the concept of cost from the economic view point has been developed, we can turn to the different types of cost to understand their meaning in the firm's environment.

a. Total Cost

Total Cost (TC) denotes all costs involved in producing output. Each firm has its production function that, generally speaking, involves capital, labor, and other inputs.

In order to maximize profits, total cost is always a concern of the firm, which must purchase these inputs from the market place.

Total costs vary for every level of output, since it takes more input to produce more output. One of the tasks of a manager is to keep total cost as small as possible for any level of output (q) produced.

b. Fixed Cost

Fixed cost (FC) is the cost that cannot be varied with level of output, during a given period of time in which inputs are fixed. This period may be relatively short, and happens when a firm cannot get more of certain resources, and is limited to what it has on hand.

There is a portion of overhead cost that is fixed, and sometimes this type of cost is also called sunk cost, because the firm must incur this cost even if it produces no output.

Average fixed cost (AFC) varies for each level of production, because the fixed cost per unit decreases as the number of units produced increases.

c. Variable Cost

Variable cost (VC) equals those costs that vary with the level of output. There are several examples of variable overhead cost, such as indirect labor, the cost of

utilities, etc. By definition, variable cost equals zero when the quantity produced (q) is also zero.

d. Marginal Cost

The concept of marginal cost (MC), or incremental cost, is so important in the economic landscape that it will be considered in several parts of this work. But for now, the objective is only to provide the concept involved. Marginal cost denotes the extra or additional cost of producing one additional unit of output. Since fixed cost does not vary with output, marginal fixed cost is always zero; therefore, marginal costs are necessarily marginal variable costs.

[Ref. 5]

e. Average Cost

Average cost is also a concept that must be understood in this work because, of the managerial tendency to employ this measure when making decisions.

Average cost (AC), represents the total cost of producing any given output, divided by that output. Average cost may be divided into average fixed costs (AFC) and average variable costs (AVC).

Table 1, Figures 3 and 4 summarize the important cost concepts that we have seen so far. It is useful to analyze them together.

- Column (1) of table 1 is the quantity produced for a given product. It is also represented by the x axis in Figure 3 and 4.

- Column (2) represents fixed cost that never changes as the quantities rise. In Figure 3, fixed cost is shown as a horizontal line.
- Column (3) represents variable cost, and the shape of the curve is shown in Figure 3. As the quantity increases, variable cost also increases.
- Column (4) represents the total cost that consists of (TVC) and (TFC). The total cost curve in Figure 3 shows that as the quantity increases, total cost rises.
- Columns (5), (6), (7), and (8) in Figure 4 are the important ones to focus on: Incremental cost (or marginal cost) starts at the same point as the average variable cost per unit, because the marginal cost to produce the first unit is the variable cost of this unit. In Figure 4, we can see that as the level of production increases, *MC* decreases, reaches a minimum, and then increases and intersects the *AC* curve at its minimum level. This key fact is due to an important relationship between marginal and average cost. [Ref. 9]

f. Minimum Average Cost

As we can see in Figure 4, point *M* is the point where the *MC* curve intersects the *AC* curve. This point is the minimum average cost. This happens because when the *MC* is below the *AC* curve, *AC* must be falling, because it is pulled down by the *MC* curve below it. However, at point *M*, where $MC = AC$, the *MC* is neither pulling the *AC* curve down nor pulling it up.

TABLE 1 Important Cost Concepts

(1) QUANTITY Q	(2) FIXED COST FC	(3) VARIABLE COST VC	(4) TOTAL COST TC=FC+VC	(5) MARGINAL COST PER UNIT MC	(6) AVERAGE COST PER UNIT AC= $\frac{TC}{Q}$	(7) AVERAGE FIXED COST PER UNIT AFC= $\frac{FC}{Q}$	(8) AVERAGE VARIABLE COST PER UNIT AVC= $\frac{VC}{Q}$
0	55	0	55	30	Infinity	Infinity	
1	55	30	85	25	85	55	30
2	55	55	110	20	55	$27\frac{1}{2}$	$27\frac{1}{2}$
3	55	75	130	30	$43\frac{1}{3}$	$18\frac{1}{3}$	25
4	55	105	160	40*	40*	$13\frac{3}{4}$	$26\frac{1}{4}$
5	55	155	210	50	42	11	—
6	55	225	280	90	$46\frac{4}{6}$	$9\frac{1}{6}$	$37\frac{3}{6}$
7	55	—	370	110	$52\frac{6}{7}$	$7\frac{6}{7}$	45
8	55	—	480	130	60	$6\frac{7}{8}$	$59\frac{1}{8}$
9	55	555	610	150	$67\frac{7}{9}$	$6\frac{1}{9}$	$61\frac{6}{9}$
10	55	705	760		76	$5\frac{5}{10}$	$70\frac{5}{10}$

*minimum level of average cost.

Source: Samuelson, Paul A. *Economics*

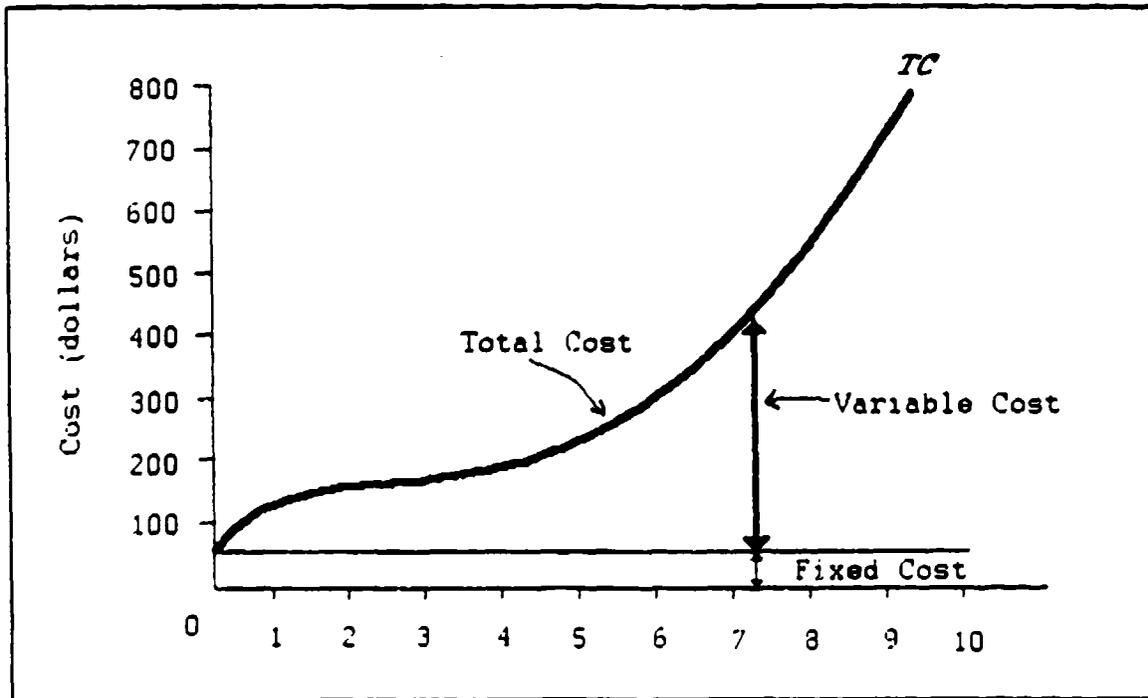


Figure 3. Total, Fixed, and Variable Cost
 Source: Samuelson, Paul A. Economics

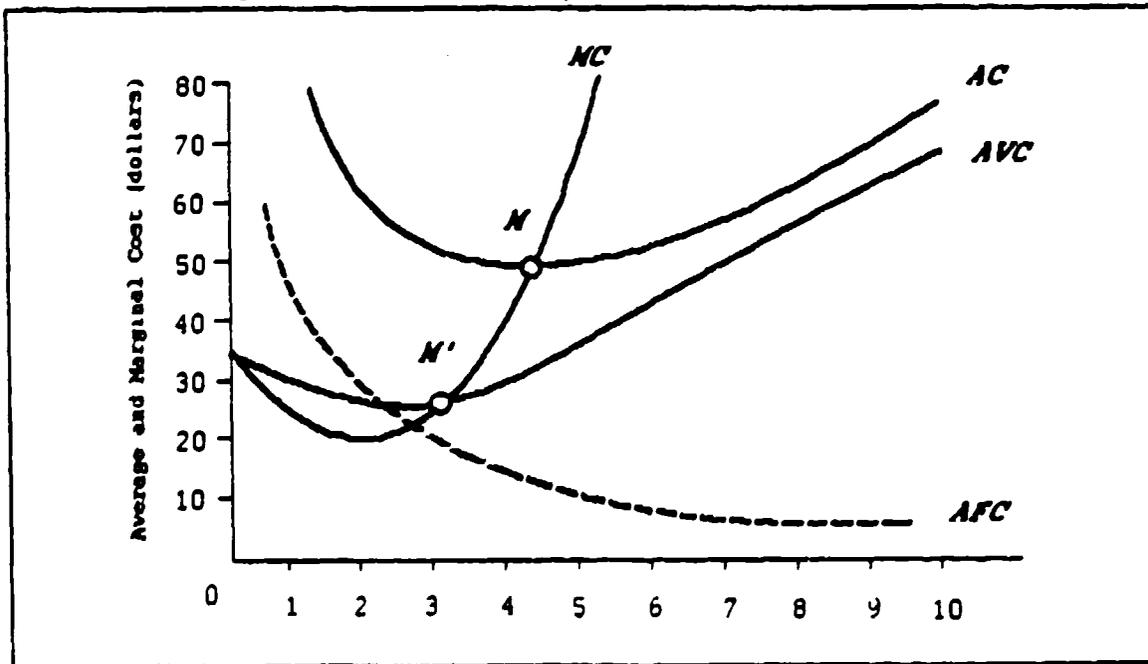


Figure 4. Average Cost
 Source: Samuelson, Paul A. Economics

B. COST AND PRODUCTION

We now turn to the linkage between cost and production. The main idea linking cost and production is that for each level of output, firms must choose the least costly combination of inputs. This least-cost combination has broad applicability, since firms must decide how to combine inputs in the most fundamental of decisions, such as the establishment of plant size, the technology that will be used, and the combination of inputs that will be applied to the day-to-day plant operations.

1. Long-Run and Short-Run Costs

The total cost for a given firm to produce at a given level of output depends very much on the period of time under consideration. This happens because, at any point in time, many input choices are limited by past decisions. For example, if the company purchased equipment some years ago, it is likely to be economical to use that equipment for the remainder of the equipment's economic life.

An input to which the firm is committed for a short period of time, however, is no longer fixed when a longer planning horizon is considered. For example, equipment that is one-year-old with a ten year economic life may be considered fixed during the selection of output decisions that occur month-to-month. In the plans that are developed each year, however, the equipment may be modified or replaced. From these

ideas arises the notion of two different "runs" for decision making - the short run and the long run. [Ref. 10]

These two important decision making periods will be considered extensively in this work, because of their relationship to the shape of the cost curve. In the short run, there is relatively little opportunity for the firm to adapt its production process to changes in the level of output, because the size of the plant and technology have largely been determined by its past decisions. Over the long run, however, all inputs that are technologically variable become adjustable.

a. Cost and Production in the Short Run

In the short run, a firm will have a certain stock of fixed resources: a plant with machinery, an office building, and salaried administrative personnel (overhead fixed costs). These resources are fixed in the short run, because plants and equipment cannot be expanded or cut back very quickly.

Along with its fixed resources, the firm will employ variable resources that can be adjusted fairly quickly, depending on the level of production required. By and large, the short run is considered the time period over which fixed resources cannot be changed.

(1) **The Principle of Diminishing Marginal Product.** In order to better understand production, the concept of diminishing marginal product must be introduced. First of all, the idea of marginal product is not very different from the idea of marginal cost. Marginal product is the contribution to output of the last unit of a variable resource employed. Diminishing marginal product is a principle which states that eventually the extra output obtained from additional input must decrease as we apply more and more resources in the production process.

(2) **Total Fixed Cost in the Short Run.** In the short run, total fixed cost is the sum of the short-run fixed costs that must be paid, regardless of the level of output. As we have discussed above, total variable cost is the sum of the amounts spent for each of the variable inputs used. Total cost in the short run is the sum of total variable cost and total fixed cost.

b. Cost and Production in the Long Run

In the long run, all inputs are variable to the firm. Therefore, one of the first decisions to be made by the owner is the scale of operation (that is, the size of the firm). To make this decision, it is important to know the cost of producing each relevant level of output. Firms have a choice of different amounts and combinations of inputs to produce different levels of output in the long run. In this

situation, nothing is fixed except the set of technological possibilities and the price at which a firm can purchase inputs.

2. The Relationship Between Short-Run and Long-Run Costs

We can summarize the discussion of short and long run costs by relating the costs involved in both decision-making periods. Firms plan in the long run and operate in the short run. The long-run cost function gives the most efficient (the least cost) method of producing any given level of output, because all inputs are variable. But once a particular size firm is chosen and the process of production begins, the firm is operating in the short run. If the firm wishes, at this point, to change its level of output, it is not possible to vary usage of all inputs. Some inputs, the plant and so forth, are fixed to the firm. If the firm cannot vary all inputs optimally, it cannot produce this new level of output at the lowest possible cost. Figures 5 and 6 summarize this discussion.

In Figure 5, we can see that the firm designs its plant to produce Q_0 units of output per period. The optimal combination of inputs is obtained by the least average cost (AC_0). At this output level, the short-run average cost ($SRAC$) of producing Q_0 is the same as long-run average cost ($LRAC$).

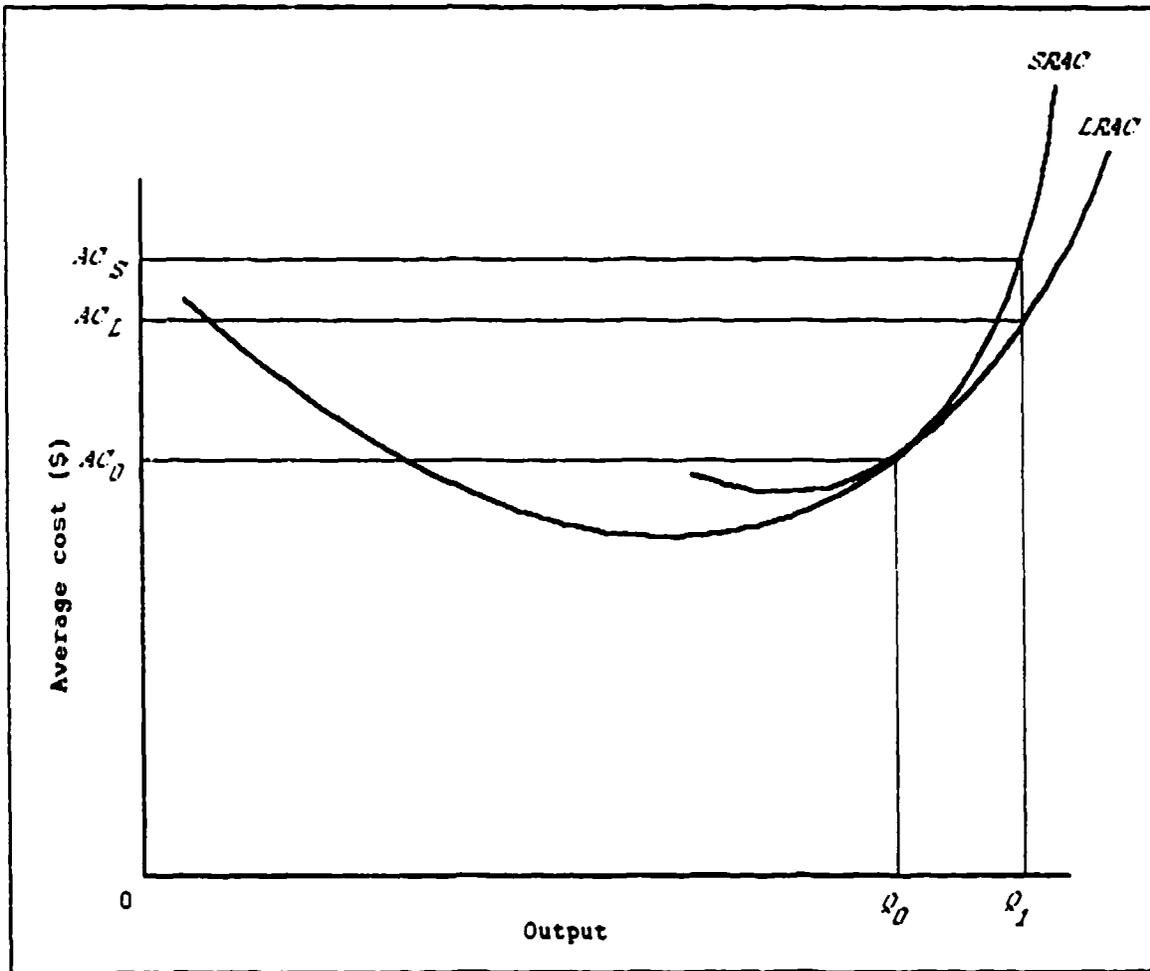


Figure 5. Long-Run and Short-Run Cost Curves

Source: Maurice, Charles S. and Charles W. Smithson, *Managerial Economics* p. 296

If the firm wants to increase the level of output from Q_0 to Q_1 and all inputs were variable, it could produce this output at average cost AC_1 . But if the plant size and certain other inputs are fixed, SRAC gives the average cost of producing Q_1 . This average cost is AC_s , which is higher than AC_1 .

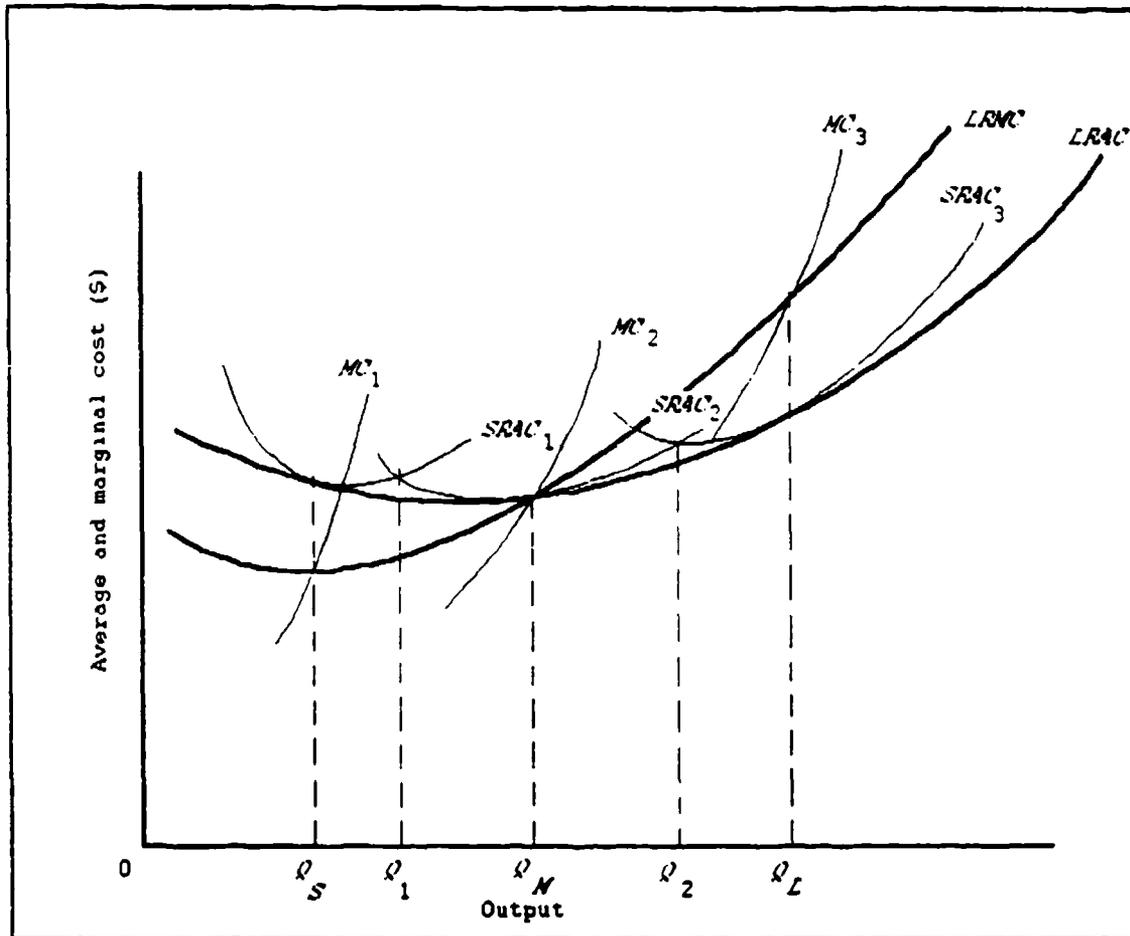


Figure 6. Long-Run and Short-Run Average and Marginal Cost
 Source: Maurice, Charles S. and Charles W. Smithson, *Managerial Economics* p. 296

Figure 6 shows the typical relationship between short-run and long-run averages and marginal cost curves. In Figure 6, we can see that LRAC and LRMC are long-run average and marginal curves. Three short-run situations are indicated by the three sets of curves: SRAC₁, MC₁; SRAC₂, MC₂ and SRAC₃, MC₃. In Situation 1, we can see the short-run curves for the plant size designed to produce Q_s optimally. The long run and

short run average cost curves are tangent at this point. Considering that the marginal cost, dC/dQ , is given by the slope of the total cost curve, long-run marginal cost equals short-run marginal cost at the output level given by the point of tangency, Q_s . This level of output is a decreasing portion of LRAC. As a result, SRAC1 must also be decreasing at the point of tangency. Situation 3 shows another short-run situation at a different plant size, where the level of output is not achieved at the lower LRAC.

Finally, Situation 2 is the short-run average cost curve corresponding to the output level - plant size - at which the long-run average cost is at its minimum. In this situation, Q_m would be produced at least cost, because $LRAC = SRAC2 = MC2 = LRMC$.

3. Other Issues of Cost and Production

The objective of this work is not to discuss every aspect of cost and production. So far, we have seen some considerations about cost and production that are sufficient to develop the framework needed for this analysis. However, there are other issues that should be at least mentioned because of their importance.

a. Cost Effect of Volume

A large volume of output, for some given initial period, will cost more than a small volume of output, but the total cost will not increase in the same proportion as the

increase in volume. This results from economies in mass production. It happens because different techniques of production are used for large volumes of outputs, and the result is a lower cost per unit. As a result, people who want individually styled or custom-built goods will face higher prices than they would have to pay for mass-produced goods, because in large-volume production, standardization of products and the resulting lower per-unit costs occur.

b. Economies of Scale

While economies in mass production are obtained by increasing the volume of production, economies of scale are associated with the production rate. The scale of operation of a business enterprise is defined by the quantities of the various inputs it uses each period.

We say that economies of scale occur when a doubling of all input quantities results in a more than double quantity of output produced during the period in question [Ref. 11]

c. Varieties of Techniques and Learning Factors

These are two reasons why average cost declines as cumulative production increase. This happens because the reduction in machine setups and increased efficiency resulting from experience both reduce average cost. The decline in average cost is great at first, but then tends to have a

smaller effect in reducing average cost as cumulative production increases.

C. MARGINALISM

The most common example given to explain the idea of marginalism is the paradox of the value of water and diamonds. Diamonds are frivolous and clearly not essential. Their price of exchange, however, is far higher than that of water.

The great insight that transformed economics in the nineteenth century was the distinction between total and marginal utility.

The total utility, or satisfaction, of water exceeds that of diamonds. We would all rather do without diamonds than without water. But we would prefer to win a diamond as a prize, rather than an additional glass of water. To make this choice, we ask ourselves not whether diamonds or water gives more satisfaction in total, but whether one of them permits more additional benefit than the other one.

As water is abundant, the additional benefit from one more unit of consumption is small. One additional unit of water or diamonds is called the marginal unit by economists. The benefit from this unit is called marginal utility. The marginal utility of one more unit of diamonds, for anyone that has enough water, is of much greater significance than one more unit of water.

1. Diminishing Marginal Utility

Another important concept brought by the marginalist revolution is the idea of diminishing marginal utility. The marginal utility continues to decrease as we consume more and more. Therefore, if the quantity of diamonds was the same as the quantity of water, the marginal utility value of diamonds would be low, since everyone could easily have diamonds.

2. Marginalism and Opportunity Cost

These concepts flow from the same insight. Marginal cost is defined as opportunity cost, and opportunity cost means alternative benefits - alternative marginal benefits - foregone. [Ref. 6]

Marginalism and opportunity cost play an important role in cost-benefit analysis. Marginalism helps us explain in detail the costs and benefits of various alternatives.

[Ref. 6]

In this work, the concept of marginalism is used extensively because it has proven to be very useful. The concepts of marginal cost, marginal profit, and marginal revenue all play a fundamental role in achieving optimal decisions.

D. MARGINAL ANALYSIS

Every decision in our life is expressed in the apparently trivial question "Is it worthwhile?". The bottom line is whether the alternative selected will add sufficient benefits to compensate for the cost (or benefits foregone) from the alternatives that are not selected. This is the heart of marginal decision making: Is the actor better off than he was before taking the action? [Ref. 6]

Although this idea seems obvious enough, there are several pitfalls in decision making that lead to apparent logical and optimum actions, but end in undesirable results. Consider the following example: A manager has to hire an additional salesman. He sends this new employee to Los Angeles rather than to San Francisco, because last year's orders per salesman were \$70,000 in San Francisco and \$30,000 in Los Angeles. But it is possible that the difference in returns per salesman in the two cities occurred just because the size of the sales force in the former was well adapted to the number of retailers, whereas the sales force in the latter was spread too thinly. If so, the new salesman may add little to the company's orders in the salesman-saturated San Francisco market, but in Los Angeles he might produce a substantial increase in sales. So it would be better to send the man to Los Angeles.

This is why some techniques and tools are needed to overcome these pitfalls and reach the optimum solutions in real world problems.

In economics, marginal analysis constitutes a general principle that must be considered by any firm deciding whether to expand an activity, increase profits, reduce costs and, ultimately, to make optimal decisions. [Ref. 10]

1. Firm and Profit

In this section, we assume that the objective in business is to make profits as large as possible. The objective of marginal analysis here, therefore, is to maximize total profits.

Total profit (Π) is equal to total revenue minus total cost ($\Pi = TR - TC$). Profit in this case is economic profit. As discussed before, it is different from accounting profit, since economic profit takes into account the opportunity cost of the owner's inputs. Maximizing economic profit is the goal of the firm.

a. Profit Maximization

Considering that the main goal of the firm is to maximize profit by producing and selling products, let's suppose that the firm introduces a new product into the market. The first questions that arise are how many units should be produced, and what price should be charged for them.

There is no way to answer this question without more information.

Suppose that a survey about demand for the new product has been done, and the data analyzed. If the firm sells one thousand units, suppose the price is \$25 per unit. The total revenue, then, would be \$25,000.

Suppose now that the total cost is \$18,000 and the total profit is \$7,000. $\$25,000 - \$18,000 = \$7,000$. As the goal of the firm is to maximize profit, the question now is: is this the best level of profit? To answer this question, we have to gather more information about how the revenue and cost react as different prices are charged.

Now, let's make this problem as simple as possible, and suppose that the costs of production are not important. All inputs, therefore, are free. Then, if costs do not change as output changes, to maximize profit the firm must simply maximize total revenue.

The process of maximizing profits by maximizing revenue means changing the price of the product and detecting the level of price and demand that will achieve maximum revenue. This type of pricing decision can be done with knowledge of the elasticity of demand for different versions of the product in the market, and the incomes of the individuals who would be buying the product. In our discussion price elasticity of demand is not considered, but it is

important to understand that it constitutes another vital part in maximizing profit.

b. Profit Maximization When Costs Vary With Output

When costs vary with output, maximizing profit means finding the output level where the difference between total revenue and total cost is greatest. Marginal costs and marginal revenue show what is happening to total cost and total revenue as output is increased. In fact, marginal cost is the rate at which total cost changes, and marginal revenue is the rate at which total revenue changes. [Ref. 12]

2. Inputs and Costs

An input should be expanded, so long as its marginal net yield (difference between marginal benefit and marginal cost) is a positive value, that is, until this marginal yield is zero. The firm that stops hiring inputs at the level where the difference between marginal benefit and marginal cost is positive is missing an opportunity to increase its profits. Thus whenever possible, the marginal net yield of any input should be reduced to zero.

If the firm has more than one input, for optimal results activities should, wherever possible, be carried to levels where they all yield a marginal net yield equal to zero. [Ref. 12]

An important question arises when we talk about inputs: how much of each input should be employed to produce different levels of output at least cost? To achieve the least cost combination of inputs, we begin by calculating the cost per unit and the marginal product of the inputs.

At this point, we can establish a useful rule to decide this question: to produce a given level of output at least cost, a firm must employ inputs until it has equalized the marginal product per dollar spent on each input used in production. [Ref. 10]

3. Output-Price Decision

The output-price decision is important to maximizing profit and sometimes is misunderstood by those who want to choose the optimum point of production.

When a producer can affect the price, the price and quantity (output) are selected simultaneously, because the manager must pick one point in the demand curve related to a price, and a correspondent quantity bought by consumers.

As we have seen earlier, profit maximization occurs when total revenue minus total cost is greatest. If managers pick the point in a firm's profit curve where this condition has occurred, they can identify the level of output that maximizes profit.

Even if managers do not know the firm's entire profit curve, a marginal analysis can help to identify the level of

output-price where profit is maximized. A new concept must be introduced in order to understand this technique. It is the concept of marginal profit. Marginal profit (MP) is the addition to the total profit resulting from one more unit of output.

If the marginal profit from increasing output by one unit is positive, then output should be increased. If the marginal profit from increasing output by one unit is negative, then output would not be increased. Therefore, an output level can maximize total profit only if at that output marginal profit equals zero. [Ref. 10]

Considering the statement above, we can also say that profit can be maximized if marginal revenue is equal to marginal cost: $MP = MR - MC$, if $MR = MC$, $MP = 0$. As marginal revenue is the extra revenue of selling one unit more, we can conclude that a firm will maximize its profit or minimize its loss if it produces that output at which $MR = MC$.

4. The Importance of Marginal Analysis

Marginal analysis can be applied in any decision making situation. It means that the important figures to be considered in optimizing decisions are incremental (marginal) figures, rather than average or total values.

The logic of marginal analysis has extensive applications and can be used as a powerful tool in non-profit organizations, who must make economic choices about scarce

resources. Using average value can provide an erroneous view of the real world, and can lead to costly and undesirable results.

E. MARGINAL ANALYSIS AND MULTIPLE-PRODUCT FIRMS

So far, we have seen marginal analysis applied to a single product firm. A firm's output decisions are usually more complicated, because almost all companies produce a variety of products, and these various products typically compete for the firm's investment funds and productivity capacity.

At any given time, there are usually constraints that the company must take into account to optimally produce both products A or B, it cannot simply expand product A to the optimum level without taking into account product B. [Ref. 13]

1. Profit Maximization

For a profit maximizing decision which takes both products into account, a simple marginal rule can be applied: Any limited input should be allocated between the two outputs A and B, in such a way that the marginal net yield of the input, i , in the production of A equals the marginal net yield of the input in the production of B.

The condition above is straightforward. If it is violated, the firm cannot be maximizing its profits, because the firm can add to its earnings simply by shifting some input

out of the product where it obtains the lower return, and into the manufacture of the other.

In this discussion, we have considered only the output decisions of a profit maximizing firm. But we know that the firm has other decisions to make. In particular, it must decide on the amount of inputs (labor, material, overhead) that will be applied to producing both products. There are similar procedures for this decision, but the main result here is that profit maximization requires that for any input i and j that can be varied, the marginal profit contribution of input should be set to zero.

In order to maximize the profit of the firm, the level of output and price for both products must be determined jointly. Hence, for a two-product firm we have the following condition: $MRA = MCA$ and $MRB = MCB$. However, the marginal cost of A will be the function of the quantities of both A and B, as will the marginal cost of B. Thus, these marginal conditions must be satisfied simultaneously.

2. Long Run and Short Run

As we have already seen, profit maximization depends on several constraints related to the short- and long-run behavior of the firm. In the long run, the firm can adjust its production facility in order to produce the profit-maximizing level of each product. However, in the short run, the firm

must determine how to allocate its limited production capacity among the competing products in order to maximize profit.

We recognize that the short-run case is another example of constrained optimization. Suppose that only two products are produced using the same production facility, and the cost of operating this facility is invariant with output (short-run fixed cost). In this situation, profits will be maximized when the level of production of the two products are such that $MRa = MCa$ and $MRb = MCb$.

3. Common Versus Separable Costs

A distinction between these two kinds of costs is important when companies are producing more than one product. It is often difficult to attribute costs to a particular product, since the result reflects the two products, rather than one product taken at a time. In decision making, much of the confusion stemming from trying to determine which costs are common and which are traceable to a particular product can be solved by applying incremental reasoning. It is easier to determine how much a change in output of a single product causes a change in a particular input, than it is to determine a product's fair share of that cost. In any case, it is the change in cost, rather than the traceability of cost, that is relevant. More complex situations come up when an increase in the output of product A results in an increase or decrease in the marginal cost of product B. [Ref. 14]

4. Cost Analysis

For this analysis, the central issue is cost analysis and the role that it plays in achieving the firm's objective. Marginal analysis has been demonstrated to be a useful tool to identify the relationships among components like inputs, level of output, revenue, and profit.

a. Cost Analysis in the Long and Short Run

The cost framework that we have presented this far shows that the firm's production decisions involve the determination of both its rate of output and the manner of combining variable and fixed inputs. Thus the firm must decide the optimal utilization rate of inputs, such as labor and raw material, and its optimal stock of plant and equipment. In other words, the company must know how to identify and allocate accurately the total cost involved in production in both dimensions - short and long run.

(1) **Single Product Firms.** In our cost framework, we have seen that firms will produce at least cost when the short-run average cost (*SRAC*) is tangent to the long-run average cost (*LRAC*), and the short-run marginal cost (*SRMC*) is equal to the long-run marginal cost (*LRMC*). In summary we have:

In the short run, cost C is a function of quantity q and capital (fixed cost) \bar{K} . Then, $C(q, \bar{K})$. $SRMC = \partial C / \partial q$. In the long run, cost is a function of q and K , but K

is variable, and is selected to depend optimally on q . As a result, $K^* = K(q)$, and we have: $C(q, K(q))$. Now $LRMC = dC/dq = \partial C/\partial q + (\partial C/\partial K dK/dq)$. If we evaluate this at a specific level of output q^* and its associated optimal plant size $K^* = K(q^*)$, we know that $\partial C/\partial K = 0$, because this is the necessary first condition for K^* to be the cost minimizing plant size at q^* . Thus, the second term in the expression cancels out and we find that $dC/dq = \partial C/\partial q$. In other words, at the output level associated with the tangency between the $LRAC$ and $SRAC$, $LRMC = SRMC$.

The discussion of long-run and short-run marginal cost curves is very clear geometrically and mathematically, but it is important to understand what this means in reality. The marginal cost of production is just the change in cost that arises from changing output by one unit. In the short run, the fixed costs are kept constant, while in the long run we are free to adjust them. So the long-run marginal cost will consist of two parts: how marginal costs change when the holding plant size is fixed, and how marginal costs changes when the plant size is adjusted. [Ref. 15] But if we calculate short- and long-run marginal cost for the plant size that is optimal for the output level in question, the additional costs resulting from the larger plant will be offset by the reduction in costs from being able to adjust the labor force to the new optimal plant size.

In cost analysis, it is important to concentrate on those costs that influence marginal cost in the long run and short run, as well as to accurately allocate them to the product. In the next chapter, we will see how this is done in accounting when we analyze the different approaches to product costing used in identifying cost in the long and short run.

(2) **Multiple-product Firms.** In the multiple-product firm we have seen that the optimum level of production occurs when the marginal revenue (or benefits) of product A is equal to the marginal cost of product A, and the marginal revenue (or benefits) of product B is equal to the marginal cost of product B. In summary we have: In the short run, cost C is a function of the quantity of products A and B and the fixed cost K . Thus, $C(q_a, q_b, K)$. Therefore, $SRMC_a = \partial C / \partial q_a$, and $SRMC_b = \partial C / \partial q_b$. As in the single good case, K is selected to minimize the cost of producing the two outputs, and we have $K^* = K(q_a, q_b)$ in the long run. Therefore, in the long run, $C(q_a, q_b, K(q_a, q_b))$. $LRMC_a = \partial C / \partial q_a + (\partial C / \partial K \, dK / dq_a)$ and $LRMC_b = \partial C / \partial q_b + (\partial C / \partial K \, dK / dq_b)$. Short run marginal cost of products A and B are $SRMC_a = \partial C / \partial q_a$ and $SRMC_b = \partial C / \partial q_b$. Because $dC/dK = 0$ as before, the point of least cost production occurs where $LRMC_a = SRMC_a$ and $LRMC_b = SRMC_b$.

Again, the task of identifying these costs and allocating them to products must be performed, and in this case it is more difficult than with a single product. This

happens because in traditional commercial accounting practices, only a relatively small fraction of costs are directly charged to products. The remaining costs are grouped together into overhead pools and allocated across products, usually in proportion to directly charged labor use. [Ref. 16]

b. Cost Measurement

Now that we have pointed out those important elements required to perform cost analysis and marginal analysis, the accurate measure and allocation of the different types of costs will be considered in the next chapter by discussing the work of accountants.

III. ACCOUNTING CONCEPTS AND BACKGROUND

In the preceding chapter, several concepts about cost and marginal analysis as effective tools to aid in the decision making process were considered. Firms calculate their cost of production by measuring, analyzing, and planning each significant step. Cost accounting plays a vital role in the process by optimizing a firm's ability to make decisions. This chapter presents several pragmatic approaches developed by accountants for the identification and allocation of cost in both the short and long run, as well as their differentiation in relationship to cost behavior. Special attention is given to overhead cost, since this can represent a significant portion of total cost, and is often a source of disagreement between contractors and governments.

This chapter is divided into four major divisions. The first part, product costing approaches, considers variable and absorption costing as ways to cost a product. The second part, manufacturing cost, explains how overhead cost is obtained by discussing the cost accounting concepts used in the United States and by Embraer. In the third part, non-manufacturing costs will be explored. Finally, specific procedures will be considered in order to understand how organizations record and

allocate overhead costs. In this part, the procedures used by Embraer to record and allocate overhead will also be described.

A. PRODUCT COSTING APPROACHES

Most organizations cost their products in two ways. The first way is known as absorption costing, or full cost; the second way is called variable or direct cost.

These two ways are not mutually exclusive and can be used together in the same organization, depending upon the objective of the accountants. The variable costing approach more effectively meets internal requirements because it provides better insight into cost relationships, while absorption costing meets external reporting requirements. [Ref. 17]

Considering that the analysis of cost is performed by the government in situations where it is not possible to have a competitive procurement, cost information can be furnished by the firm using both methods, since they provide different details about the cost of the firm's product.

1. Variable Approach

In the direct costing approach, only the variable cost, or those costs that vary with the changes in units produced, are treated as product costs (costs matched against products). All other costs are treated as being period costs (costs matched against revenues on a time period basis). This

approach, therefore, considers direct labor, direct material, and variable factory overhead product costs as the product cost.

This costing method can also be viewed as a method for estimating marginal cost, since variable cost is also the portion of the cost that changes for each unit produced.

2. Absorption Costing Approach

The absorption costing approach considers direct labor, direct material, and factory overhead, both fixed and variable, as well as product and non-manufacturing costs (marketing or selling costs and administrative cost) to be period costs. This method is also called the full cost method, because it includes all production cost as product cost.

3. Unit Cost

The computation of unit cost is different for each method and can be seen in the examples given in Tables 2 and 3. A company has the information of production given in Table 2:

TABLE 2 Company Production Information

Number of units produced each year	6,000
Variable cost per unit:	
Direct materials	\$ 2
Direct labor	4
Variable manufacturing overhead	1
Variable selling and administrative expenses	3
Fixed cost per year:	
Manufacturing overhead	30,000
Selling and administrative expenses	10,000

Source: Garrison, Ray H. *Managerial Accounting*, p.266

The computation of the cost per unit of production under each approach is given in Table 3:

TABLE 3 Absorption and Direct Costing

Absorption Costing	
Direct material	\$ 2
Direct labor	4
Variable overhead	<u>1</u>
Total variable production cost	7
Fixed overhead (\$30,000 ÷ 6,000 units of product)	5
Total cost per unit	<u>\$12</u>
Direct Costing	
Direct material	\$ 2
Direct labor	4
Variable overhead	<u>1</u>
Total variable production cost	7
Total cost per unit	<u>\$ 7</u>

(The \$30,000 fixed overhead will be charged off in total against income as a period expense along with the fixed selling and administrative expenses.)

Source: Garrison, Ray H. *Managerial Accounting*, p.266

As we can see, the direct cost approach considers only variable costs to be product cost and all others to be period costs. Under absorption costing, the notion of total cost per unit is closer to the average total cost, while the variable cost method gives us an approximation of the average variable cost and also the marginal cost if the average variable cost is constant. As demonstrated in the previous chapter, this information is useful in analyzing the firm's cost curve and minimizing input cost, and the optimizing output-price.

As stated in Chapter II, it is most common for firms to produce more than one product, which requires allocating indirect costs across all products. This is known as product-diversity. There are various ways that indirect costs (fixed

and variable) can be allocated, and these procedures will be considered in Section E.

4. Controversy

There is some controversy among accountants as to whether fixed overhead cost should be included as part of product cost. The fact is, the separation of total cost between variable and fixed cost is vital for making economic choices among resources.

Even though there is some disagreement about how to treat fixed overhead cost, both methods agree that fixed selling and administrative costs are period costs and must be charged off in their entirety against revenue each period.

[Ref. 18]

a. Long Run and Short Run

In Chapter II, cost in the context of long versus short run was discussed from the standpoint that decision making must involve this variable. In the accounting environment, this is also an important aspect to be considered, and the choice between full absorption and direct costing must be weighed carefully.

Opponents of variable costing approach argue that all costs are variable in the long run; therefore, variable costing generates product figures which provide little basis for long-run pricing policies. They further argue that classifying a cost as fixed or variable is misleading, because

even strict fixed costs have some variable characteristics.
[Ref. 17]

As we saw in Chapter II, one argument that supports absorption costing relies on economic theory and suggests that if fixed costs are relevant in long run (all costs are variable), then full cost per unit (an accounting measure) is the best measure today of the long-run average cost of product. Another argument is that it is not clear where the short run ends and when the long run begins, and that strategic decisions are more related to the long run than the short run.

The arguments presented by those who defend the use of variable cost approaches point out that the absorption approach makes fixed costs appear to be variable, which may confuse managers, and that economic theory suggests that fixed costs are irrelevant for short-run decisions. [Ref. 17]

b. Combined Approach

The cost framework built in Chapter II took into account both the long and short run. Considering this, it is advisable to combine cost accounting systems where both contribution margin and full cost data can provide useful information in marginal analysis and decision making. This dual approach provides useful information that managers need for making decisions (direct costing approach), and still follows generally accepted accounting principles (full absorp-

tion costing approach). A system combining variable costing and absorption costing approaches also provides more effective cost control.

5. Fixed Overhead Cost

Over time, fixed overhead cost has gained more attention, as it has registered the most growth during the past two decades and is considered a variable cost in the long run. Labor and material have become a small part of the total cost of producing and delivering the product. For example, direct labor is currently only three to five percent of sales for the Hewlett-Packard Company. [Ref. 19]

In Chapter II we have seen that managers have to know the long-run marginal cost of a given level of production to make a decision about the least costly production method. The fixed overhead cost constitutes a component of this marginal cost, since it varies in the long run. This implies that the accurate measure of this component can be vital to decision making. In the case of a multiple-product firm, the identification of common and separable costs, as well as their allocation, is vital for making decisions. Later in this chapter we will see how accountants perform this task.

B. MANUFACTURING COST

An understanding of the cost structure of a manufacturing company in the United States can be helpful in making a

comparison with the Brazilian aerospace industry. In turn, this will aid in understanding both industries, which should lead to conclusions and recommendations.

Manufacturing costs exist because converting raw material into finished products requires labor, capital, and equipment. The cost of manufactured products is made up of three basic elements: direct material, direct labor, and manufacturing overhead.

The aerospace industry in the United States considers these elements in determining its product cost. The manufacturing cost is built in a different fashion in the Brazilian aerospace industry. In the case of overhead cost, for example, the application and calculation is very different.

1. Direct Material

Many materials go into the manufacture of a final product. For a particular final product, all material that can be directly traced to the final product is referred to as direct material. In the Brazilian aerospace industry, it is usual to consider two kinds of direct material; one is raw material and the other is major components. The raw materials are those materials that need to be transformed and processed such as sheet carbon, sheet steel, and aluminum. Major components and materials of the final assembly are those materials bought as a final product from other sources and do not need to be transformed. Such items include avionics equipment.

The cost of materials considered by Embraer in order to charge the government is the price of raw material and the material bought from the suppliers, the cost of insurance, the cost of warehousing, and an additional cost called handling. Handling includes transportation, procurement, a profit for these activities, and all charges imposed by government legislation.

2. Direct Labor

Direct labor are those labor costs in manufacturing that can be physically traced to the creation of the products in a "hands on" sense. For example, in the case of aircraft manufacturing, direct labor includes all labor costs incurred for transforming raw materials, installing major components, and completing final assembly. The total cost of direct labor plus direct material is called prime cost in accounting.

In the case of Embraer, direct labor is considered a part of the total cost needed to manufacture an aircraft. The company works on the same concepts that are found in the United States. In the specific case of manufacturing an aircraft, Embraer chooses some key activities related to the production of an aircraft and creates an hourly labor rate for these activities. For example, one key activity is the assembly of structural components. The company identifies the cost centers involved with this activity and considers all costs from those centers to be direct costs.

3. Manufacturing Overhead

Manufacturing overhead includes all costs of manufacturing, except direct materials and direct labor. This classification includes indirect materials, indirect labor, air conditioning, lights, property tax, insurance, depreciation, repairs, maintenance, and other indirect costs needed to operate the manufacturing division of the company. It is true that the company also incurs indirect costs for its selling and administrative function, but these costs are not part of manufacturing overhead. The total cost of manufacturing overhead plus direct labor is called conversion cost in accounting.

In the United States, manufacturing overhead is divided into manufacturing overhead expenses, factory expenses, overhead, and factory overhead or factory burden. All of these terms are synonymous with "manufacturing overhead". [Ref. 18]

Although this kind of cost has the same treatment in the Brazilian aerospace industry, it is not known as manufacturing overhead cost. All indirect costs related to the operation of the factory are spread among cost centers directly related to manufacturing. These items are then included in the hourly rate that the company presents as the cost of an hour of key activities. For example, a key activity may be

assembling of major components. The third part of this chapter deals with overhead cost in more detail.

C. NON-MANUFACTURING COSTS

Non-manufacturing costs are subclassified into two categories: marketing or selling costs, and administrative costs. Contracts in the Brazilian aerospace industry also include the cost of money - financial costs - as being a non-manufacturing cost, because the Brazilian economy experiences high rates of inflation.

Marketing or selling costs include all costs necessary to secure customer orders and deliver the finished product into the hands of the customer. Since marketing costs relate to the process of obtaining contracts and subsequently providing for customer needs, these costs are often referred to as order-getting and order-filling costs. All organizations have marketing costs, whether or not the organizations are manufacturing, merchandising, or service in nature [Ref. 18].

Administrative costs include all executive, organizational, and clerical costs that cannot logically be included under either production or marketing. As with marketing costs, all organizations have administrative costs. [Ref. 17]

Financial costs are those costs that the company has to incur to obtain capital. For example, the manufacturer may have to obtain monetary resources in the market or acquire

financing in order to buy raw material or even to pay the employees. In the case of Embraer, this kind of expense is common and the company considers this expense in building its overhead cost when charging the government.

Other kinds of financial expenses considered by the company may originate from delays of payment by the government, for which there is no compensation.

Figure 7 summarizes the terms and concepts used in cost accounting from the full absorption costing approach. Note that there is overlap between prime cost and conversion cost, so that the manufacturing cost is not the simple sum of these two cost categories.

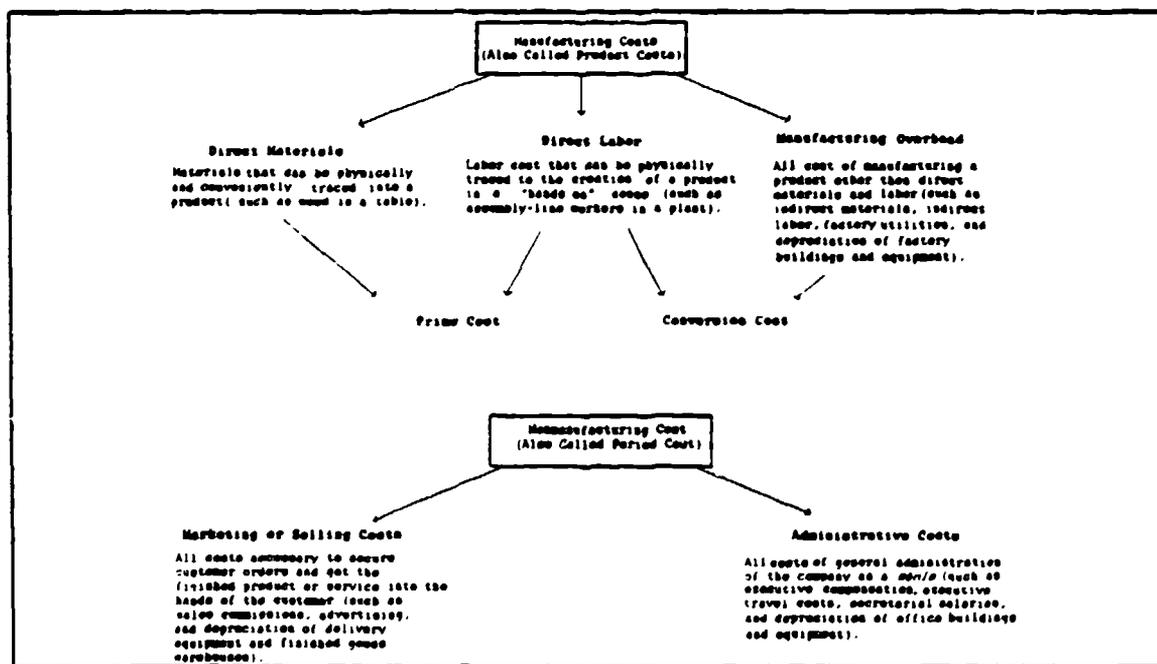


Figure 7. Summary of Cost Terms.
 Source: Garrison, Ray H. *Managerial Accounting*

D. OVERHEAD COST

Overhead costs, or indirect costs, are those costs that cannot be identified with a single final cost objective. This kind of cost is identified with two or more cost objectives; therefore, indirect or overhead costs consist of many different costs.

In this part, overhead cost concepts will be addressed in more detail. Examples of overhead costs from Embraer and from one of the aerospace industries in the United States will be described. To Embraer, the term overhead does not coincide with what has been described in this work.

1. Distinguishing Among Types of Overhead in the U.S.

Overhead or indirect expenses are segregated into two basic categories: manufacturing overhead and selling, and general and administrative expenses. This section provides a brief overview of the types of expenses in each category and how those expenses are accounted.

Manufacturing overhead represents those costs not directly attributable to a particular product that are incurred in support of a product's production. The basis for allocating these costs can be chosen so that the costs are equitably distributed to the products in relation to the benefit received. In other words, these costs are distributed to those cost objectives which received benefits in a rational and logical manner. [Ref. 20]

Selling expenses are another type of overhead and represent costs associated with the physical distribution of the product, as well as advertising and related marketing expenses. These costs are typically not allocated to the product, though they must be considered when pricing the product. [Ref 15]

General and administrative expenses refer to those expenses necessary for the general overall operation of the business. These costs are allocated on the basis of the cost of goods sold or total cost input - the total cost incurred in a fiscal year exclusive of the general administrative expense. In the U.S., the Cost Accounting Standards Board excluded cost of sales as an acceptable basis. Therefore, the only acceptable basis for allocating costs on government contracts is total cost input. [Ref. 20]

2. Overhead in Embraer

At this point, it is important to describe what is known as overhead cost in Embraer, because it includes only administrative, selling, and financial expenses.

The overhead rate is obtained by first developing an estimate of the year's administrative, selling, and financial expenses. This sum is then divided by the estimated revenue for the year. After this rate is multiplied by the hourly labor cost rate, an hourly labor price rate is found.

The procedure used by Embraer considers the period costs - administrative, selling, and financial costs - as a product cost and then charges these costs over the cost of the product manufactured.

3. Categories of Overhead Cost

Chapter II discussed costs considering short-run and long-run dimensions, and defined fixed and variable cost in both situations. Accountants also consider both conditions and breakdown overhead costs into three different categories: variable, fixed, or mixed (semivariable), even though overhead cost behavior is harder to determine, because some overhead costs vary erratically with production. However, these concepts are very important in the determination of the organization's cost structure.

Variable overhead costs are those costs that vary in direct proportion to changes in production. Examples of individual variable manufacturing overhead costs are given in Figure 8.

VARIABLE MANUFACTURING OVERHEAD	
Overtime premium	Fuel
Power	Indirect material
Lubricants	Supplies
Utilities	Setup time
Communication	

Figure 8. Examples of Variable Manufacturing Overhead.

Fixed overhead costs are those costs that remain fixed within a relevant output range. When referring to a

relevant output range, the accountants typically mean a short-run period, i.e., a specific period and a designated range of production. Within this range, fixed cost per unit decreases with an increase of production. Examples of fixed overhead costs are shown in Figure 9.

FIXED MANUFACTURING OVERHEAD

Depreciation	Property Tax
Rent	Insurance
Patent Amortization	

Figure 9. Example of fixed manufacturing overhead.

Mixed (semivariable or semifixed) overhead costs vary with volume changes, but no linear relationship is found. These costs contain characteristics of both fixed and variable costs. Examples of semivariable overhead costs are given in Figure 10.

MIXED MANUFACTURING OVERHEAD

Supervision	Inspection
Factory Office Service	Maintenance and Repair
Heat and Light	

Figure 10. Examples of mixed manufacturing overhead.

Figures 11 and 12 illustrate the relationship between the three different categories of costs as volume changes.

4. Relationship

Total fixed cost is constant, regardless of how many units are produced. Therefore, unit fixed cost decreases as the number of units produced increases.

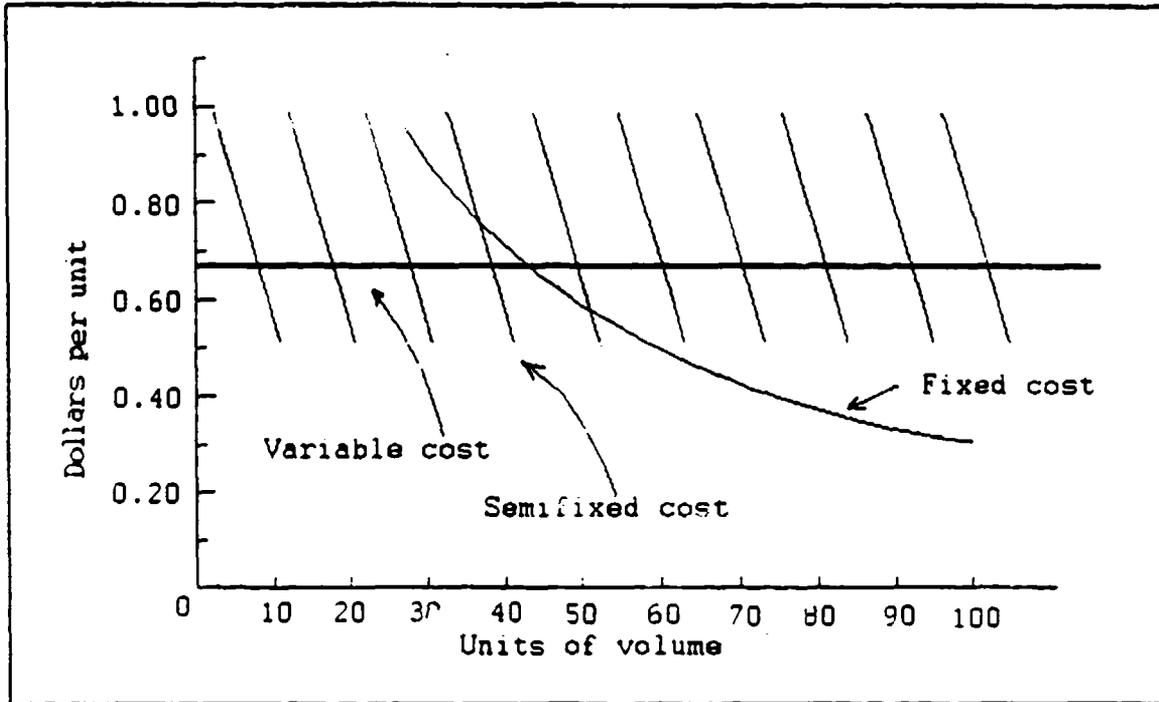


Figure 11. Per Unit Relationship for Fixed, Semifixed and Variable Cost

Source: Rayburn, L. Gayle *Cost Accounting - Using a Cost Management Approach*

The relationship between total variable cost and volume is linear or near linear. Total variable costs increase in proportion to volume increases; however, unit variable costs remain constant.

Semifixed or mixed costs vary with volume changes, but the linear relationship found in variable cost is missing. Semifixed cost can take several forms; a step-type semifixed cost is the form illustrated in Figures 11 and 12. As the number produced increases, the cost increases, and then remains constant until the volume increases by some significant number at which level semifixed cost increases. [Ref. 17]

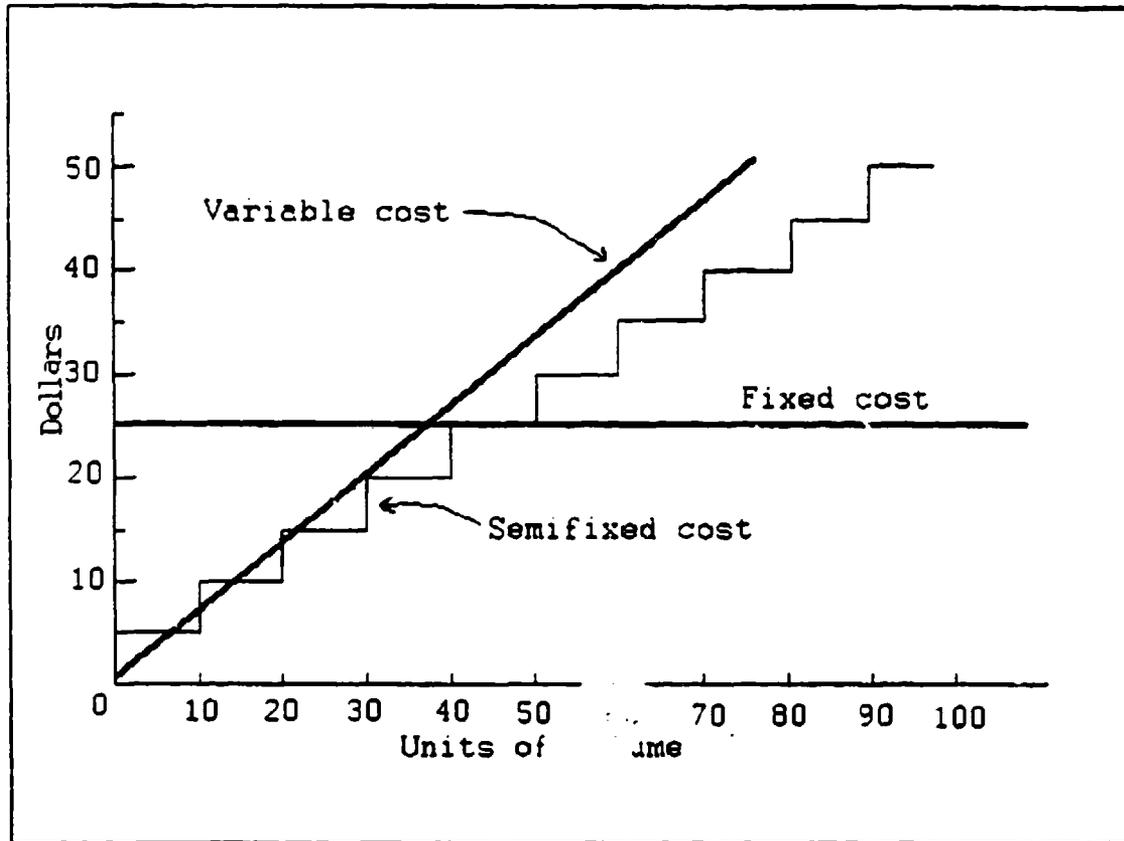


Figure 12. Total Relationship Of fixed, Semifixed and Variable Cost
 Source: Rayburn, L. Gayle *Cost Accounting - Using a Cost Management Approach*

A simple example of a step-type semifixed cost is a company that hires an inspector who has a salary of \$1,000 when the company produces 100 units of a product. Beyond 100 units, it hires another inspector and pays an additional \$1,000. The \$1,000 paid to the first inspector is the fixed part of the mixed cost, because it is the minimum cost of supplying inspection. The second \$1,000 is the variable part of the total cost of inspection.

Various tools are available to separate a semifixed cost into its fixed and variable components, such as high-low method and regression analysis. Further discussion of these methods is, however, beyond the scope of this thesis.

E. ALLOCATION

One aim of management is to obtain better control of expenditures in order to reduce cost. As overhead becomes a greater portion of total manufacturing cost, management turns its sight toward controlling these specific costs.

Allocation plays an important role in controlling overhead costs, and a large number of organizations use the concept of cost centers to keep the area of control as localized as possible. Considering that overhead costs do not have a direct relationship with the product like direct material and direct labor costs, they must be accumulated by the cost center and applied to production through a process of cost allocation and absorption.

1. Process Of Allocation

- At the first step, overhead expenses are accumulated by their nature or objective.
- They are then assigned or allocated to cost centers. Cost centers are the smallest areas of responsibility for which cost is accumulated. A cost center may be a department or a grouping within a department. Cost centers can be classified in different ways, but usually they are classified into service centers and production centers. This step represents the primary allocation of manufacturing overhead. [Ref. 17]

- Finally, the costs are allocated to the final product by using some equitable basis. This final step is known as absorption of overhead costs.

2. OVERHEAD POOLS

This is an alternative method for assigning costs to service and production centers. The cost pools are usually broken down into major and supporting pools.

Overhead rates are found and applied to the final cost objective by using this method. For example, a common overhead pool is engineering, so to find the rate to be applied, the pool must be related to some activity that has a relationship with the expense. If, for example, direct labor is used, then the overhead rate = engineering pool ÷ direct labor.

3. ACTIVITY BASED COSTING

Traditionally, the rate of overhead cost considers the volume-related cost drivers, but a new approach called activity-based costing (ABC) could be used. This approach, rather than applying factory overhead costs based on departmental overhead rates, recognizes that the performance of activities consuming resources can be used to allocate costs. [Ref. 17]

Activity-based costing involves a two-stage allocation process. The first stage assigns overhead costs to cost pools. Rather than being defined as departments, the pools represent activities. In the second stage, costs are assigned

to jobs, according to the number of these activities required to complete the job. [Ref. 18]

Examples of activities that drive costs are shown in Figure 13.

ACTIVITIES THAT ACT AS COST DRIVERS	
Machine Setups	Maintenance Requests
Purchase Orders	Scrap/Rework Orders
Quality Inspections	Machine Time

Figure 13. Examples of Activities That Drive Costs.

The number of these activities in one organization depends on the complexities of the operation. In Japan, most organizations do not use this method, because it is more complex than a volume-related procedure. The great advantage of this method over other costing methods is that it improves the traceability of overhead cost and helps decision making.

A simple example of cost that is not volume-related is the cost of purchasing and receiving material. In this case, the number of purchase orders generated would be a good basis upon which to allocate costs.

a. How Activity Based Costing Works

A numerical example is useful in explaining how activity base costing works in practice. Let's assume that a company manufactures two products, A and B. Each year the company manufactures 1,000 units of A and 10,000 of B. Both

products require three labor hours for completion; therefore, the company works 33,000 direct-labor hours (DLH) each year as shown in Figure 14:

Figure 14. Company Direct-labor Hours

	HOURS
Product A: 1,000 * 3 hours =	3,000
Product B: 10,000 * 3 hours =	<u>30,000</u>
Total hours	<u>33,000</u>

Cost of material and labor for each product are given in Figure 15:

Figure 15. Cost of Material

	Product	
	A	B
Direct Materials	\$ 20	10
Direct Labor (at \$5 per hour)	15	15

Also assume that product A is more complex than product B and requires more inspections, machine setups, etc. Finally, the total manufacturing overhead (MOH) of the company costs \$660,000 each year. If the company uses a volume-related rate to compute the overhead for each product, then we have:

$$\text{Manufacturing Overhead Rate} = \frac{\text{Estimated MOH}}{\text{Estimated DLH}} = \frac{660,000}{33,000} = \text{total direct-labor hours} = \$20/\text{DLH}.$$

Using this rate, the cost to manufacture each product is in Figure 16 :

Figure 16. Cost of Manufacture

	Product	
	A	B
Direct Materials	\$ 20	10
Direct Labor	\$ 15	15
Manufacturing overhead(3 hours * \$20)	60	60
Total Cost to manufacture	95	85

As both products require the same amount of labor, an equal amount of overhead is assigned to each of them.

To illustrate activity-based costing, assume that the most relevant activity in the company is machine setup; therefore, it represents the company's cost driver for overhead cost. As product A is more complex, it needs more setups. Figure 17 summarizes the analysis of cost regarding machine setups in the company:

Figure 17. Company Manufacturing Setup Costs

Activity of machine setups:	
Traceable cost	\$ 660,000
Product A	3,000 setups
Product B	2,000 setups
Total	5,000 setups

From Figure 17 it is possible to compute the rate per activity (setups): $\$ 660,000 / 5,000 \text{ setups} = \$ 132/\text{setup}$.

With this new rate, we can assign the overhead cost to products A and B by multiplying the rate per setup by the number of machine setups for each product. For product A we have $\$ 132 * 3,000 = \$ 396,000$, which, when divided by the

number of units produced yields $\$ 396,000/1,000 = \$ 396/\text{unit}$. For product B we have $\$ 132 * 2,000 = \$ 264,000$. When divided by the 10,000 units we obtain $\$ 26.4/\text{unit}$. The cost of manufacturing each product can be found with this information. Figure 18 summarizes this new approach and compares it with the assignment of overhead using direct labor hours as the allocation base.

By comparing the two methods, we can see that the difference can be significant, as is the impact on product cost. Of course, this example simplifies the process by choosing only one kind of activity that drives cost. In practice, activities like quality inspections, production orders, and maintenance can also be considered together.

Figure 18. Summary of Activity and Direct Labor Base Costing

Products	Activity Base		Direct Labor Base	
	A	B	A	B
Direct Materials	\$ 20	10	\$ 20	10
Direct labor	15	15	15	15
Manufacture Cost	<u>396</u>	<u>26.4</u>	<u>60</u>	<u>60</u>
Total cost to manufacture.	\$ <u>431</u>	\$ <u>51.4</u>	\$ <u>95</u>	\$ <u>85</u>

It is important to note here that these manufacturing overhead rates are predetermined, that is, established at the beginning of the year. Since all costs are not known until the end of the year, estimates of the year's costs must be used in establishing the rates. This holds true for both

traditional overhead allocation method and activity-based costing.

4. Allocation of Cost and Governmental Acquisitions

Several accounting procedures practiced by the private sector are subject to government regulation when companies are involved in public supply. These regulations attempt to provide standardized procedures for both the government and contractors.

The next chapter will discuss several rules and procedures imposed by law which deal with cost allocation for those companies that have contracts with the government. As in this chapter, overhead cost will be emphasized.

IV. GENERAL OVERHEAD COST REGULATIONS IN MILITARY PROCUREMENT

Chapter III presented the basic accounting procedures used to determine product cost in a manufacturing environment. In this chapter, special attention will be given to the representative regulations that support cost analysis in the military environment. Once more, overhead cost will be emphasized since it is a great concern in DoD.

Overhead costs constitute a substantial portion of DoD dollars spent in the procurement of defense systems, representing 30 to 50 percent of total cost for most aerospace contractors. [Ref. 21] Overhead control has become an area of special concern to Government Contract Management in DoD. There are many regulations that deal with these costs, and theory often diverges from practice as to how best to allocate and recognize overhead, or indirect, costs.

In this chapter, several theories of overhead cost (or indirect cost) allocation will be considered in the light of current regulations. The chapter then considers regulations that provide procedures and principles to be followed by contractors and contract offices who deal with cost analysis in the DoD.

A. DoD

Overhead costs under government contracts can be approached in several ways. The focus here will be on manufacturing overhead. Other indirect costs not considered include engineering, research and development, selling, and general and administrative expenses.

1. Cost in Governments

The importance of controlling cost in government contracts is reflected by constraints and special considerations in measuring and monitoring a contractor's cost. For example, various accounting procedures are used when accounting for government contracts which are not applied in commercial businesses, and vice-versa. Also, costs that might be proper for commercial businesses are sometimes considered unallowable under government contracts. These requirements, which deviate from Generally Accepted Accounting Principles (GAAP) work to limit the cost to the government. To further explain how the government deals with cost, one United States Federal Court has observed: "Government's cost policies are not liberal; they forbid allocation to government contracts of some true costs of doing business". This is why it is important to understand all the regulations and practices relating to overhead cost (indirect cost).

2. Indirect Cost

The allowability of indirect cost under government contracts has posed difficult problems and generated much controversy. Given the great difficulties in managing indirect costs, the executive agencies have devoted large amounts of coverage to them. Indirect costs have been the major source of the litigation and legislation related to contract cost principles. The enactment of Public Law 91-379 brought cost accounting standards, designed to enhance uniformity and consistency, to cost accounting practices. However, the cost accounting standards have generated their own controversies, disputes and litigations. [Ref. 22]

Despite this, it is advisable to consider the accounting standards that determine how indirect costs are handled. Reviewing the Federal Acquisition Regulation (FAR) is the first step that must be taken in order to understand how the government deals with overhead cost. Section 31.203 defines indirect cost:

(a) An indirect cost is any cost not directly identified with a single, final cost objective, but identified with two or more final cost objectives or an intermediate cost objective... [Ref. 22].

After defining indirect cost, the FAR gives the general procedure to accumulate indirect cost:

(b) Indirect cost shall be accumulated by logical cost groupings with due consideration of the reasons for incurring such cost. Each grouping should be determined so as to permit distribution of the grouping on the basis of

the benefits accruing to the several cost objectives. Commonly manufacturing overhead, selling expenses and general and administrative (G&A) expense are separately grouped [Ref. 22].

A general guideline is also given to the contractor allocating indirect cost:

(d) The contractor's method of allocating indirect cost shall be in accordance with standards promulgated by the Cost Accounting Standard (CAS) Board, if applicable to the contract; otherwise, the method shall be in accordance with generally accepted accounting principles which are consistently applied [Ref. 22].

The next step is to understand what the FAR means by "logical cost groupings", "standards promulgated by the Cost Accounting Standard (CAS) Board" and "generally accepted accounting principles" in order to understand how the DoD deals with overhead cost.

3. Logical Cost Groupings

There are several controversies about the meaning of "logical cost groupings", as there is no specific definition in the regulation. One interpretation is that each cost grouping should contain only costs that are similar, in the sense that they are comparable to each other. For example, personnel-related costs, material-related costs, and machine-related costs may not, in a given situation, be logically grouped together and spread among objectives by a single common base. Considering that most manufacturing overhead pools contain all three of these categories, the CAS

Board issued procedural standards that can be applied to different groups of cost in order to better clarify the idea of logical cost groupings. The focus here is on CAS 418 which deals with overhead cost.

4. Cost Principles

What are commonly referred to as cost principles are set out in Part 31 of the FAR. They are the primary means of defining the costs which will be considered allowable by the government in the negotiation and administration of its contracts. [Ref. 23]

Specifically, FAR 31.203 summarizes all principles that must be followed in contracting goods and services for the government. One of the most important principles is that allocation of indirect cost must be in accordance with cost accounting standards, though some flexibility is allowed. Section 31.203 states:

When substantially the same results can be achieved through less precise methods, the number and composition of cost groupings should be governed by practical considerations and should not unduly complicate the allocation [Ref. 22].

Therefore, cost principles establish basic guidelines for the allowability of costs, and also delineate specific categories of allowable or unallowable costs.

a. Applicability

The applicability of cost principles can be found regarding indirect cost when contracts with the government

involve the evaluation of a contractor's judgment factor used in estimating costs; that is, when cost analysis is performed by the government.

At this point, it is important to emphasize that the FAR is the primary source for cost principles, but not the only source. Individual agencies may (in their own individual agency regulation) deviate from the FAR cost principles, though such deviation is minimal. [Ref. 22]

b. General Allowability Rule

Cost principles are the guidelines for identifying those indirect costs which are allowable. Factors for determining allowability include reasonability and allocability.

c. Reasonability

The criteria for determining allowability are somewhat vague and subjective. The FAR provides that:

a cost is reasonable if, in its nature and amount, it does not exceed that which would be incurred by a prudent person in the conduct of competitive business [Ref. 23].

d. Allocability

In determining the allocability of indirect cost, the FAR says:

indirect costs shall be accumulated by logical cost groupings with due consideration of the reasons for incurring such cost [Ref. 23].

and advises that

commonly, manufacturing overhead, selling expense, and general and administrative (G&A) expenses are separately grouped [Ref. 23].

5. Cost Accounting Standards

The Cost Accounting Standards (CAS) are a set of standard procedures covering broad areas of cost measurement, cost assignment to cost accounting periods, and allocation to cost-to-cost objectives within a cost accounting period. It is important to understand that the government is concerned with contractor (company) cost accounting practices, because it cannot buy all the goods and services it requires in an open competitive marketplace. The majority of defense procurement dollars are based on negotiated contracts.

In May of 1980, the Cost Accounting Standard Board issued CAS 418, "Allocation of Direct and Indirect Cost". The objective is to provide criteria for the accumulation of indirect cost, including service center and overhead cost in indirect cost pools. Other purposes are to provide guidance in order to better define the relationship between an indirect cost pool and cost objective.

CAS 418 deals extensively with indirect costs, giving general guidelines and specific considerations, as well as techniques to deal with overhead costs. For example, Section 418.40 (b) states: "Indirect costs shall be accumulated in indirect cost pools which are homogeneous." It gives a general

idea of how indirect cost must be accumulated. More specific is the following paragraph in the same section:

(c) Pooled costs shall be allocated to cost objectives in reasonable proportion to the beneficial or causal relationship of the pooled cost to cost objectives as follows: (1) If a material amount of the costs included in a cost pool are costs of management or supervision of activities involving direct labor or direct material costs, resource consumption cannot be specifically identified with cost objectives. In that circumstance, a base shall be used which is representative of the activity being managed or supervised. (2) If the cost pool does not contain a material amount of the costs of management or supervision of activities involving direct labor or direct material costs, resource consumption can be specifically identified with cost objectives. The pooled cost shall be allocated based on the specific identifiability of resource consumption with cost objectives by means of one of the following allocation bases: (i) a resource consumption measure, (ii) an output measure, or (iii) a surrogate that is representative of resources consumed. The base shall be selected in accordance with the criteria set out in 418.50(e). [Ref. 22]

In paragraph 418.50, "Techniques for Application", CAS gives specific procedures and definitions about indirect costs. Finally, in selecting a better method to allocate indirect cost, it must be:

based on a criterion that requires the government to be satisfied. The allocation base used is the best available representation of resource consumption [Ref. 22].

In other words, the government has the final say as to how overhead costs can be allocated.

After the consideration of theoretical regulations, it is important to understand how those regulations are used in actual practice. Next, additional guidance as to how to deal with overhead costs will be examined.

6. Identifying Overhead Cost

This section will consider those principles, tools, and techniques used in practice by procurement personnel in DoD for evaluating and analyzing indirect costs. Also, this section analyzes the nature of overhead cost behavior in terms of fixed, variable, and semivariable costs.

In order to define indirect cost, a statement found in an Armed Services Pricing Manual (ASPM) is useful:

An indirect cost is any cost not directly identified with a single final cost objective. It is identified with two or more final cost objectives or with at least one intermediate cost objective later allocated to final cost objectives. [Ref. 24]

It is apparent that there are few differences between the principles expressed by the FAR and CAS. The definition just given comes from those general regulations, but with the commitment of making an interface between theory and practice.

Additionally, the manual gives a comparable definition regarding indirect cost as a supporting effort to the main business of the company and notes that it is accumulated by logical cost groupings, as seen before. The manual also lists three logical cost groupings: manufacturing overhead, engineering overhead, and general and administrative expense (G&A). Additionally, the manual lists separate groupings which are commonly found, such as:

It also is common to find separate overhead pools for material, tooling, selling, and off-site labor. Overhead

pools may be set up on a company wide basis or may be accumulated by division, plant, department, or cost center. Practical considerations should govern the number and composition of the groupings [Ref. 24].

7. Analysis of Overhead

The Armed Services Pricing Manual (ASPM) states that the analysis of overhead is based on three important components, considering that the rates of overhead are based on past data:

- 1 The reasonableness and necessity of the company continuing to expend that overhead cost in the future period of a contract performance.
- 2 The base to which the overhead has been applied and the degree to which the base will or should change in the future.
- 3 The final overhead cost that could be considered based on information from 1 and 2. [Ref. 24]

It is important to keep in mind that if the base is increasing, the overhead rate should be decreasing, and vice-versa.

The ASPM analysis of overhead cost has two aspects: to evaluate the projected overhead dollars, and to review the basis of allocation to government contracts. This analysis takes into account concepts that have already been considered in this work: reasonableness, necessity of proposed expenditures, allocability, allocation methods in accordance with accepted accounting principles, congruence with cost account standards, and the particularity of the business involved.

8. Information from the Company

Allocated overhead expense usually results from an estimated overhead rate multiplied by an occurrence of the allocation base. The rate to be used is developed by dividing the estimated total indirect cost by the estimated total cost in the base. This process results in a ratio that is then applied to calculate applied overhead expenses.

The contractor should furnish all data needed to perform the analysis properly; according to the FAR, this information is to:

Indicate how offeror has computed and applied offeror's indirect cost,.... ...including cost breakdowns.... ...showing trends and budgetary data.... Indicate the rate used.... [Ref. 24]

Finally, the contractor must provide an appropriate explanation to aid in the understanding of all processes that drive overhead costs.

The ASPM provides several examples of how to calculate overhead cost in accordance with FAR requirements. One example (Table 4) of the computation of manufacturing cost is provided in order to illustrate the data that must be furnished by the contractor. In this example 40 units are being provided by the contractor.

TABLE 4 Manufacturing Overhead

COST ELEMENTS (1)	PROPOSED CONTRACT ESTIMATED-TOTAL COST (2)	PROPOSED CON- TRACT ESTIMATED-UNIT COST (3)	REFERENCE (4)
Manufacturing Labor	\$29,191	\$729.77	
Manufacturing overhead	\$91,688	\$2,292.20	Attachment 7

The column headings are specified in FAR Table 15-2

The Attachment 7 referred to in Table 4 is reproduced below in Table 5. Its objective is to support the proposed expense of \$91,688.

TABLE 5 Attachment 7

	FY 19X3	FY 19X4*	PROJECTED FY 19X5
Manufacturing overhead (see schedule) (A)	\$3,416,816	\$3,545,336	\$3,979,858
Manufacturing labor (B)	\$1,340,887	\$1,407,931	\$1,267,200
Manufacturing overhead rate (A)÷(B)	254.8%	251.8%	314.1%

*Includes budgetary estimate for last two months.

The proposed value of \$91,688 was obtained by applying the projected rate of 314.1% to the \$ 29,191 of manufacturing labor of the contract. The contractor should be ready to justify the labor charge, as well as explain the procedures used to obtain the manufacturing overhead (\$3,979,853), and manufacturing labor (\$1,267,200) for the year ending in December of 19X5.

This information is provided by Table 6, where actual numbers for the years of 19X3 and 19X4 come from company files. The company is also to provide a statement, where the procedures used to obtain the projected numbers for 19X5 are outlined. Most of the projected numbers come from the standard budgetary procedures established in accordance with GAAP.

9. Importance of Indirect Cost

The ASPM, in giving instructions for analyzing indirect cost, emphasizes that a thorough analysis cannot be limited to understanding those tables provided as examples. The ASPM emphasizes that the ability to control overhead costs and apply it in an optimal way also depends on understanding its behavior in the long and short run. Concerning this matter the ASPM says:

Fixed expenses include those items that are relatively constant and do not vary with changes in production volume in the short run, with reasonable limits of plant capacity [Ref. 24].

TABLE 6 Manufacturing Overhead

ACCOUNT TITLE	YEAR ENDED DEC 31, X3	YEAR ENDED DEC 31, X4*	PROJECTED YEAR ENDING DEC 31, X5
Salaries and Wages:			
Additional compensation	90,302	93,950	98,000
Overtime premium	13,214	11,296	4,500
Sick leave	65,575	67,742	72,130
Holidays	79,164	83,006	87,080
Suggestion awards	310	423	500
Vacations	140,272	147,891	154,300
Personnel Expense:			
Unemployment insurance	50,115	52,692	51,500
FICA tax	70,493	73,907	77,850
Group insurance	153,755	161,401	169,130
Travel expense	11,393	12,725	13,900
Dues and subscriptions	175	175	175
Recruiting and relocation - new employees	897	574	250
Relocation - transfers	4,290	3,562	1,825
Employees pension fund:			
Hourly	62,321	65,497	64,200
Training, conference and technical meetings	418	539	575
Educational loans scholarships	400	400	400
Supplies and Services:			
Maintenance	9,102	12,318	15,700
Stationery, printing, and office supplies	23,052	24,125	25,500
Material O/H on supplies	56,566	62,071	62,500
Maintenance	9,063	10,875	15,000
Rearranging	418	3,523	500
Other	3,314	2,635	2,500
Heat, light, and power	470,946	489,123	517,200
Telephone	32,382	33,874	35,000
Fixed Charges:			
Equipment rental	<u>7,633</u>	<u>7,633</u>	<u>7,633</u>
Total manufacturing expense (A)	<u>82,416,816</u>	<u>82,948,216</u>	<u>82,272,828</u>
Total manufacturing direct labor dollars (B)	<u>31,240,887</u>	<u>31,497,221</u>	<u>31,267,280</u>
Manufacturing overhead rate (A) ÷ (B)	254.8%	251.8%	314.1%

*Includes budgetary estimate for last two months

In this paragraph, the concern of the regulation in identifying the behavior of cost in short run and its allocation can be seen, since the volume-price can be changed depending on changes in this relation. However, as discussed in Chapter III, the behavior of overhead cost is erratic, which is also addressed by the ASPM:

The true behavioral pattern of overhead costs is not necessarily predictable....A volume consisting of extensive production of a single item may generate less overhead than the same volume representing a diverse operation devoted to many projects, including development items. [Ref. 24]

a. Volume Projection

The concern of the ASPM about volume is related to the computation of the overhead rate. Tables 5 and 6 show that the overhead rate is obtained from the indirect cost (numerator) and the base (for example, direct labor or production cost). These bases are derived from production volume, which means that the rate can vary as the projection of production volume varies. Also production projections are often driven by sales forecasts.

As seen in Chapters II and III, the level of output is an important issue in determining the optimum level of fixed and variable overhead, because it is related to the combination of inputs (costs) in the long- and short-run. What is important to realize here is that if the regulation requested procedures for companies in applying marginal

analysis in order to define least costly levels of output and inputs, better results could be achieved in reducing overhead cost.

b. Functional Organization

DoD regulations present some guidance on the functional organization of a company, in order to achieve more efficiency cost allocation:

The functional organization of the company should be analyzed to determine whether lower total cost or better efficiency could be obtained by organizational changes that would increase the number of indirect functional breakouts [Ref. 24].

The regulations also deal with the allocation of cost among different products. These procedures play a vital role in identifying those cost, related to marginal analysis:

The contractor should be aware of the characteristics of different products or services, as well as the relationships between sales price and measured cost. It is likely that, in designing cost accounting system, the offeror will have attempted to assign at least a fair share of cost to those products or services that are most often priced on the basis of cost [Ref. 24].

In analyzing overhead, the ASPM finally says that closer attention should be given to the company as a whole. Any long-run inequity in the existing system has to be discussed internally with the DoD, and, if it is determined that a problem does exist, a discussion with the contractor should occur, with the goal of changing the accounting system of the company.

9. Ambiguous Federal Acquisition

Even though regulations covering overhead cost are vast and diverse, there are still many areas of uncertainty. A report from the Director of the United States General Accounting Office to the Secretary of Defense explains some of the problems in dealing with the ambiguity of the law regarding the practical applicability of overhead cost:

Overhead negotiations between the government and the contractors are complex and differences concerning the allowability of certain costs are not easily resolved. We believe that overhead negotiations could be improved if FAR was less ambiguous in its definitions on the allowabilities of specific overhead costs especially those costs which are the subject of these hearings. [Ref. 25]

This ambiguity in FAR causes contractors and contracting officers to have different interpretations of allowability. This makes it all the more critical for government agents to fully understand the contractor's business environment and accounting system.

10. Improved Efficiency in Analyzing Overhead Costs

In addition to passing more regulations, great effort has been made by DoD to reduce overhead cost and to find tools that can help meet this goal:

In 1984, the Deputy Secretary of Defense emphasized the need for DoD to reduce overhead costs by using evaluations tools such as overhead should-cost reviews, cost-monitoring reviews, and operations audits, each of which measures the economy and efficiency of contractors operations. [Ref. 26]

These tools have demonstrated efficiency, and can be helpful in understanding overhead cost. The idea behind these procedures is that a better understanding of what has been done before and what should be done in the future, will bring improvements in both short and long.

11. Overhead Cost Rates and Marginal Cost

Considering the regulations that have been discussed so far, one important aspect is that marginal cost analysis can be useful in understanding overhead cost. It is important that marginal cost not be addressed solely on a theoretical basis, but also in a way that puts tools in the hands of the decision makers. For example, for different pools of overhead costs and for different volumes of purchase, the knowledge about the portion of the overhead cost that is included in the total marginal cost is helpful for predicting the behavior of overhead cost in total cost.

The ASPM instructs the Contracting Officer (CO) that there is a tight relationship between overhead (indirect) cost and units produced, but the same manual says, "With declining volume you want to know that company management is reducing indirect costs as rapidly as prudent judgment dictates." At this point, a concern about the relationship between volume of units and overhead cost exists. In this case, marginal analysis could be helpful in dealing with optimum level of price-output.

Marginal analysis can also help to clarify some aspects of overhead rates, as mentioned in the ASPM: "The danger here is not that the rate is too low, but the unit cost of a product...[is not excessively high]. To summarize, any given overhead rate can be too high or too low, depending on what costs are classified as direct, what costs are included in overhead, and the actual situation depicted by the nature of the costs in both categories". What this means is that the rate itself does not indicate if the expense is high or low. For example, a rate of 90% can result in a higher expense than a rate of 400%, depending on the base. The point here is to know the portion of overhead cost that is included in the total marginal cost and understand the overhead cost of one unit.

B. MARGINAL ANALYSIS, ACCOUNTING AND REGULATION IN BRAZIL

Chapter II built a conceptual framework for understanding and presenting marginal analysis as a effective tool in cost analysis. Chapter III presented a pragmatic procedure applied by accountants to allocate and measure cost. Finally, Chapter IV discussed the regulations related to indirect cost analysis. Chapter V will consider these concepts and examines how they relate to the Brazilian Air Force.

V. BRAZILIAN AIR FORCE OVERHEAD ANALYSIS

Given the cost analysis needs of the Brazilian Air Force (BAF), and using information, concepts, and principles discussed in previous chapters, this analysis will show possible alternatives that could be useful to the BAF in analyzing and understanding contractor's cost structure.

The analysis presented here emphasizes marginal analysis as a useful tool to make economic choices expressly related to overhead costs.

The organization of this chapter is made up of four major parts. In the first part, the background and actual status of cost analysis in the BAF is discussed with reference to the previous chapters. Secondly, cost analysis is focussed on in more detail, and some weaknesses and strengths are identified. The third part constitutes the center of this chapter and discusses marginal analysis as an effective tool in analyzing overhead costs since it provides useful information for decisions about inputs and price-output. Finally, the fourth part presents activity-based costing, and some ideas on the support that should be provided by accounting and regulations to make marginal analysis effective.

A. BACKGROUND

In the BAF, cost analysis is used for those acquisitions that cannot be done under competitive procurement. By and large, this procedure involves acquisitions that, given the nature of the products or strategy established by the Minister of Aeronautics, can only be procured from a specified supplier.

This procedure became more important in the BAF when the decision was made to contract with Embraer (an aircraft manufacturer in Brazil) for a specified type of aircraft needed by the Air Force. At the same time, the Minister of Aeronautics decided to nationalize the production of several components of the new aircraft. The production, would, therefore, involve more Brazilian companies. As result, the number of contracts grew and cost analysis began to take on greater importance.

1. Cost Concepts and Account Procedures in the BAF

With respect to cost analysis, the concepts used in the BAF are not significantly different from those we have seen in Chapters II and III. Basically, the personnel involved in performing cost analysis have expertise in cost accounting, but the procedures of analysis are limited by short deadlines and superficial verifications. For example, during the cost analysis only a small part of the indirect manufacturing costs is verified.

As Chapter III showed, the cost elements considered in cost analysis are material, labor, manufacturing, and non-manufacturing overhead. In the BAF, cost analysis is performed separately for material. Labor and overhead costs are analyzed together because overhead is included as part of the hourly labor rate.

The companies involved in contracts with the BAF presently use a full absorption costing approach to measure the cost of their products. During the analysis, Government personnel are not involved in decisions concerning the level of output or optimum combination of inputs applied in the government contract.

2. Regulation in the BAF

Presently, the cost analysis in the BAF is done with a lack of regulation and standard procedures. The experience of the personnel involved in cost analysis has played a vital role in improving the process of analysis.

The regulation followed by the BAF for acquisition is based on Federal Regulation, the Air Force Administrative Regulation (Regulamento de Administração da Aeronáutica-RADA), and several procedures and rules that were made by experienced military and civilian personnel responsible for cost analysis. In the Air Force Regulation, there is a section that deals with procedures regarding contracts without competitive procurement; however, this section deals only with some

special cases of noncompetitive procurement, cost analysis and cost allocation are not considered.

As we have discussed in chapter IV, there are a number of regulations that exist in the DoD to support and orient its personnel and contractors: the Federal Acquisition Regulation (FAR), the Cost Accounting Standard (CAS), the Armed Service Price Manual (ASPM), the Accounting Guide for Government Contracts, and the Government Contract Guidebook. In contrast, the BAF has no regulation that deals with such specific issues as direct and indirect cost analysis.

The analysis of total labor cost has been difficult because there is no standard format, and each company has its own way to present the necessary data to perform the analysis. These companies have made a great effort to meet the BAF needs to analyze cost, but the lack of standards has been an obstacle that must be overcome.

B. COST ANALYSIS IN THE BRAZILIAN AIR FORCE

The process of cost analysis in the BAF starts when the prospective contractor presents a proposal. This proposal presents the price of the contract, as well as all of the steps that were taken to determine that price.

The proposed price is made up of cost plus profit. Total cost is made up of total material costs and total labor costs, which are contracted for separately. Thus, the contractors

usually present two proposals. Total material costs are straightforward to analyze; on the other hand, total labor costs are more difficult and an object of great discussion, particularly since they include a rate for overhead.

1. Direct Material Cost

The cost analysis of two types of material, raw material and major components, is considered here. Major components are also divided into major components for structure assembly and major components for final assembly.

The procedure to analyze total direct material cost is simpler than total labor cost because the cost of the material is the price charged by the supplier plus material overhead. In the case of Embraer, the indirect costs related to the cost of material is called handling, and it comprises all indirect costs related to operating the purchasing department, incoming transportation charges, receiving and inspection, and storage. Because it involves a small number of variables, the overhead costs of materials are easy to understand and allocate.

2. Direct Labor Cost

The major concern of the Government in performing labor cost analysis is the composition of the hourly rate built by the company. Total labor costs are obtained by multiplying the hourly labor rate of each significant activity defined in the acquisition by the total hours of this activi-

ty. For example, if the activity of final assembly has an hourly rate of \$100 and the time needed to finish this activity in a given contract is 5,000 hours, the total cost is $\$100 * 5,000 = \$500,000$.

Each hourly rate is built by computing the direct labor cost of each cost center involved with the activity and incorporating an amount to cover the indirect cost. The indirect cost of these hourly rates is called overhead costs in the United States and, therefore, in DoD. Considering that this is a high portion of total cost in DoD, there are a great many regulations, manuals, and publications covering this subject. Analyses, recommendations, and orientations are continuously prepared in order to support the contracting offices and contractors involved in the determination of overhead costs.

In the BAF, the analysis of this indirect cost is conducted by personnel who have some experience in the subject. However, they perform this analysis without support or standards from regulations, and without the support of evaluation tools like those employed in DoD (should-cost reviews, cost-monitoring reviews, and operation audits).

3. Overhead Costs

In those companies with which the BAF has contracts, indirect costs are also a large portion of the total cost. In the case of Embraer, those indirect costs make up an increas-

ingly significant portion of total cost. As an example, a list of five different cost centers (cc) from the manufacturing sector of Embraer are shown in Table 7, where direct and indirect costs are compared.

TABLE 7 Summary of the Total Cost of Part of Manufacturing Sector of Embraer (Cruzeiros Oct 89)

cost center	Name	Direct Cost	Indirect Cost		Total
			Other Ind CC	Selling, Adm. Exp	
006	Internal Side	447.426,30	227.962,30	379.937,47	597.904,77
027	Compound Material	462.340,00	501.491,06	674.672,87	1.276.163,93
028	Acrylic Mo	176.824,32	143.192,75	185.543,46	328.736,21
029	Forge	331.238,39	468.977,17	1.026.191,96	1.895.171,21
33	solder	237.928,69	145.372,60	383.301,29	518.673,89
Total		1.425.817,70	1.867.009,88	1.649.649,05	4.516.649,93

These numbers were collected from a report that summarized the analysis of the hourly labor rate. The values are presented in Brazilian currency. The most important information is in the ratio of indirect to direct cost. Accordingly, Table 7 shows that the indirect cost is about 65% of total cost and 86% greater than direct cost. The experience of the personnel involved in cost analysis in the BAF demonstrates that, over time, the percentage of indirect costs has increased.

a. Computation of Overhead Cost

The analysis of indirect cost in the BAF arena is divided in two parts. In the first part, all manufacturing overhead cost is analyzed. In the second part, administrative, selling, and financial costs are considered.

During the analysis of manufacturing overhead specialized personnel are involved with aspects such as the allocation of indirect cost, the allocation base, and the logical relationship between the cost objective and the indirect cost. The importance of this part of the analysis is sometimes forgotten, because neither regulations nor standards exist to help the personnel involved.

The second part of the analysis is a major source of disagreement, because this part is presented by the company in the form of a rate that must be combined with the labor cost. This is what the company calls overhead. Again, it is important to clarify what Embraer calls an overhead cost, how they compute the rate, and how this rate is applied.

The overhead costs considered by Embraer are those non-manufacturing costs that the company cannot trace directly to the products: administrative expenses, selling expenses, financial expenses and advertising. Effectively, these costs are added to the total estimated direct labor cost for the period. This is done following three steps: First the company sums up administrative, selling and financial expenses of the prior year. Secondly, the company divides the total value, from the first step, by the revenue of the same prior year. Finally the company finds a rate that is then applied to the direct labor hourly rate.

The procedure used by Embraer to compute overhead cost rate related to nonmanufacturing cost, is quite different from those established by FAR for contracts with the United States Government. In the specific case of nonmanufacturing overhead cost, the procedure required by the FAR is that those costs must be pooled with the company's own expenses and allocated on a contract's total cost input base (cost input is total cost except G&A). As we have seen in Chapter IV, this procedure is detailed in CAS 410, "Allocation of Business Unit General and Administrative Expense to Final Cost Objective".

b. Manufacturing Overhead Cost

In contrast to nonmanufacturing overhead costs, the procedures used by Embraer to allocate those indirect costs not included in the labor rate are not very different from those established by the FAR. The company follows the general rules of accounting since there is a lack of regulations from the Government regarding the identification and allocation of indirect cost.

(1) **Indirect Material Cost.** Indirect material costs are incorporated in the hourly rate by different methods and different ratios, but companies do not consider it to be, or even call it, overhead cost. Once more, in Brazilian regulations, allocation of indirect material cost is not addressed, and several doubts and questions are raised in the light of current account procedures.

In the case of DoD, the regulation is very extensive and several considerations about indirect material cost can be found at different levels in FAR, CAS, and other manuals.

(2) **Indirect Labor Cost.** This is another kind of indirect cost that the lack of regulation from the Government allows the contractor to follow general accounting rules to allocate it.

The experience of the personnel involved in cost analysis in the Brazilian Air Force has demonstrated that most of the rules followed by companies are acceptable in allocating indirect labor cost.

4. General Procedures

To allocate indirect cost, Embraer follows the principle of reasonableness and applicability, and the main idea is that those costs which are not directly identified with a single final cost objective are identified with two or more separate cost objectives.

The procedure described above meets accounting requirements in Brazil, but negotiating with international clients requires quite a different procedure, and this procedure will not be considered here because it is not authorized for government acquisitions.

The methodology used by Embraer to compute its overhead cost and other indirect costs has been a subject of

many discussions and disagreements between the company and the Brazilian Government. The Brazilian Air Force is still concerned with analyzing this kind of cost because it is difficult to identify, and constitutes a significant amount of the total cost of manufacture in the aerospace industry. Despite the awareness of the BAF of the role of overhead cost, there has not been, so far, any procedure or action developed to reduce it.

There is no specific regulation about how to apply overhead cost in government contracts in Brazil, but an analysis of these costs are performed for each contract.

It is generally acknowledged that the allocation of overhead cost is primarily normative, rather than logical. As a result, the lack of regulations cause discussions and disagreements on the subject. In the case of the Brazilian Air Force, those acquisitions that are made by cost analysis almost always bring up points that are not covered by the government regulation.

C. MARGINAL ANALYSIS

The fundamental role of marginal analysis is to make economic choices for the use of scarce resources, such as selecting the best level of some input, selecting the best products mix, and selecting the least cost combination of inputs. Thus, it is a tool that should be incorporated into

the process, because it can be useful and provide efficiency in the decision-making process.

Another important role of marginal analysis is related to benefit-cost analysis. Benefit-cost analysis in government programs is oriented toward determining the maximum that can be achieved with a given amount of resource. This work, therefore, will address how marginal analysis can be applied in the corporate/government environment when conducting cost-benefit analysis, since both environments are of concern to the BAF when it comes to the manufacture of airplanes.

1. Companies

Besides those contracts that Embraer has with the BAF, several other important orders have been placed. Recently, Embraer and Northrop Aircraft Division have finalized a cooperative agreement for joint participation in the JPATS (Joint Primary Aircraft Training System) for the U.S. Air Force and Navy. With this contract, Embraer should be conducting marginal analysis in order to find optimal ways to combine inputs for multiple products.

a. Input Decisions And Production Cost

When the BAF decided to contract with Embraer to produce the AMX aircraft, the company had to determine the cost of resources that would be needed, as well as the level of each one of these inputs in order to determine the total manufacturing cost of the aircraft ordered. As we have seen in

Chapter II, there are different options available to a firm producing a particular level of output.

In the case of Embraer, the BAF usually determines the number of aircraft that will be bought. With this information it is possible to determine the ideal combination of inputs that is the least costly to produce those aircraft. As we have discussed in chapter II, the ideal combination of inputs occurs when the last dollar spent on each of the inputs yields the same marginal return.

In most cases, when the government contracts Embraer to carry out a new project, this decision involves several actions by the company related to long-term planning and congruency with other products currently manufactured by the company. The government is involved in these actions from the very beginning since it represents choices about the level of output affected by long-term decisions, and, therefore, choices regarding levels of capacity.

b. Possible Applications

Given a level of output ordered by BAF, the analysis of the least cost combination of inputs used by Embraer could involve direct labor, indirect labor, and material. Indirect costs as a whole are an important input that should be considered in this analysis.

As we have seen in Chapter II, the ideal level of input occurs where the marginal benefits obtained from the

input equal its marginal cost. In the case of labor, the company will maximize profits if it employs labor at the level to which the value of the marginal product of labor equals the cost of an additional unit of labor, that is, the wage rate.

Since the company has negotiated the price per aircraft, the value of marginal product is equal to the price of the company's output times the marginal product of labor. The wage rate is determined in the aggregate labor market, so the company treats the wage rate as given.

To implement the decision, three important elements must be present:

- Market wage rate.
- Price of output.
- Marginal production function for labor.

In the case of Embraer, as in any other real case, the company uses several variable inputs. In this case, profit maximization conditions require that the value of the marginal products for the inputs be equal to the respective input price.

One of the biggest concerns of the BAF is overhead cost. The company should be asked to identify the optimum point of producing an aircraft and then show the level of indirect cost that has to be used. This kind of information is not enough in itself, but it can help to analyze the level of inputs needed to produce different levels of output.

Another useful result that comes from this procedure is the real cost of the inputs involved in manufacturing the aircraft. The procedures also provide information that can be used to measure the status of the company in relationship to its costs. Finally, this procedure also helps the company to better understand its cost curve.

c. Level Of Output

When the BAF makes a determination about the acquisition of a product, it has several options about the number of products and the quantity of each that should be produced. The company that is contracting to manufacture the product has an idea about the price that will be charged for the specified level of output.

The optimum level of output is important, not only for the company but also for the government, because this information can lead to alternative levels of acquisition that help to reduce cost.

For example, suppose that the BAF orders a number of aircraft to meet its needs and sets the price to be paid for each aircraft. For the sake of argument, suppose 50 aircraft have been ordered. After conducting marginal analysis, the company finds that the optimal level of output, given the price that was set, is 60. In this case, the government should determine whether it is appropriate to change the production quantity to a total greater than 50.

d. Possible Applications

In Chapter II we saw that firms plan in the long-run and operate in the short-run, so an example of how marginal analysis might be applied in both instances is given here.

Suppose the government wants to contract Embraer to develop and manufacture a new airplane. Several investments have to be made in order to make Embraer capable of manufacturing the aircraft. The investments for industrial capacity and technological capacitation might total hundreds of millions of dollars. The decision on the level of investments to be made can be understood with the aid of Figure 19 to better understand how marginal analysis is helpful in this case.

Suppose that Embraer already knows the level of output required by the government and the price that will be paid, and the company has to plan its infrastructure in order to meet the new requirements. In this case, all inputs are variable, and the company has to find a new plant sized for a new product.

Figure 19 shows the long-run average cost (*LAC*) and the long-run marginal cost (*LMC*). The demand curve (*D*) indicates the price (p_0) the government will pay Embraer and it is equal to marginal revenue. At any output between q_0 and q_1 the company can make a profit, because price is greater

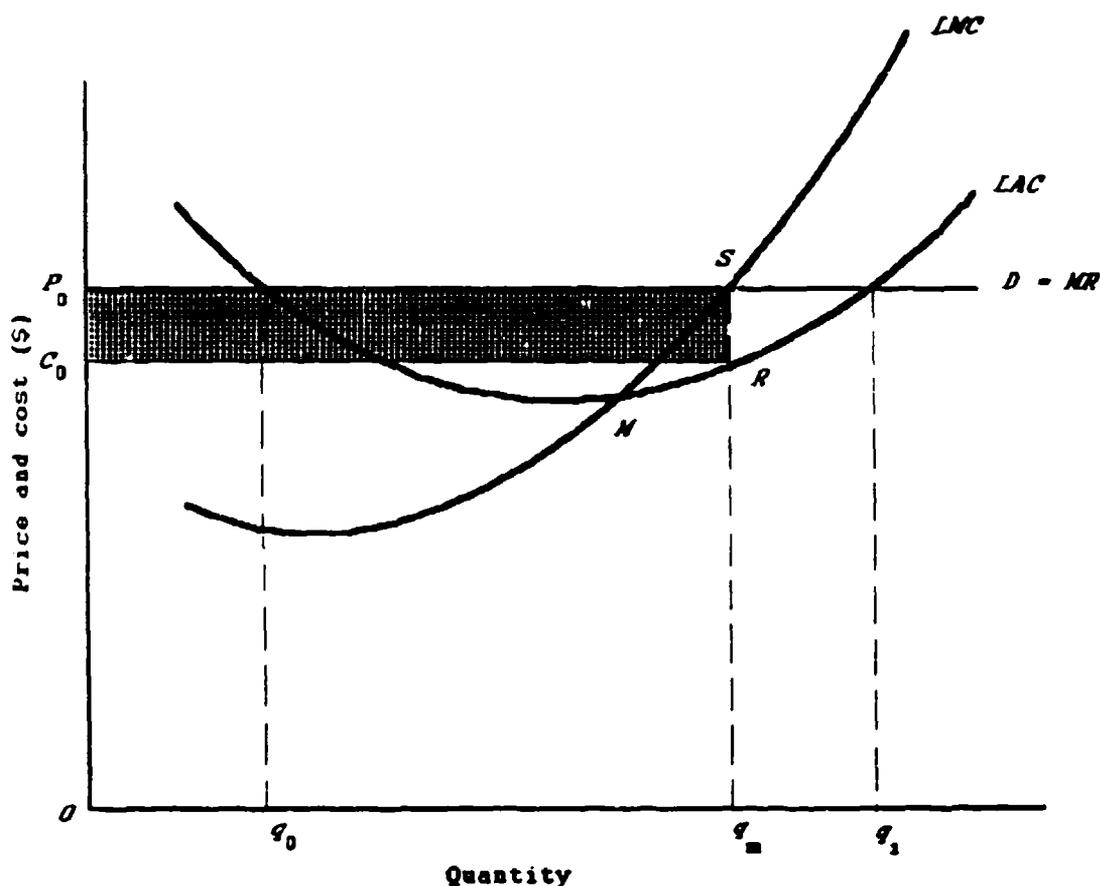


Figure 19. Profit Maximization in the Long-Run

than long-run average cost. Only at point q_m can the company maximize profits, because marginal revenue is equal to long-run marginal cost. In this case, the total cost is the area $0c_0Rq_m$ and the total profit is the shaded area $c_0p o S R$. If q_m is not the output level selected by the government, marginal analysis should be conducted to determine whether an alternative price-output combination better serves the interest of the country.

e. Marginal Analysis and Overhead Cost.

In the long run, overhead cost can be considered a kind of input that must exist to manufacture an aircraft. If this perspective is employed, its marginal product can be found and then it can play the same role of other inputs when the marginal analysis is performed.

This information is useful, because as we consider overhead cost separately, several conclusions can be made. For example, as an input, indirect cost activities can be varied in relationship to other inputs. These include the implementation of training for total quality management, reduction in inspection activities, and increased prevention of errors.

One vital role in this process of marginal analysis is to provide reliable data that can be used by those involved in performing the analysis. In the case of Embraer, the government can require this analysis in order to make sure that the ordered product is being manufactured at the optimal level of cost.

At this point, suppose that the company has already made its decision about the size of the plant to build and is preparing to produce production quantities effectively. Then, to conduct marginal analysis it is necessary to find that portion of the total cost that represents indirect cost and that portion that represents variable cost.

The short-run marginal cost relationship can then be estimated from the variable cost component. In other words, overhead cost must first be eliminated to determine short-run marginal cost.

2. Government

In general terms, cost-benefit analysis is a tool for systematically developing useful information about the effects of a governmental program. In a sense, cost-benefit analysis is the public sector analog to the private sector's profitability analysis. Examples of cost-benefit analysis include studies on safety in the work place, the evaluation of military manpower policies, and studies of the appropriate levels for strategic stockpiles.

Applying marginal analysis to cost-benefit analysis does not require a logic that is different from what we have seen so far. For a given program activity, the relevant cost must be identified; therefore, the marginal cost will be derived as well. The benefits obtained from the program must be estimated.

Marginal analysis will be helpful in comparing the changes in total cost with the changes in total benefit. As we have seen before, the optimum point of the program will be at the point where marginal cost is equal marginal benefit.

D. OTHER INSTRUMENTS TO HELP MARGINAL ANALYSIS

There are several changes in accounting procedures and regulations that will aid the minimization of cost and maximization of profit. One of the innovative efforts in accounting geared to achieving performance excellence is activity-based cost (ABC).

1. Activity-Based Costing

Marginal analysis deals with information about cost that is provided by the accounting system of the company. It is important that this information reflect reality as much as possible, because good results from marginal analysis depend on the data gathered. In the case of Embraer, for example, full absorption cost and volume-related overhead cost present some distortions about the cost reality that could be overcome if a new approach were applied.

Absorption costing includes fixed production cost and could be helpful in long-term planning. On the other hand, a variable costing approach excludes fixed production cost and is helpful in identifying marginal costs in the short run.

As we have seen in Chapter III, much more reliable information for costing can be achieved by activity-based costing. Several companies in the U.S. have found that traditional costing systems tend to be biased in favor of low-volume specialty products and against high-volume standardized products [Ref. 3].

Another important feature of ABC is that it demands constant and intensive review of all costs in the organization. "The incremental costs associated with additional work tend to become much more visible than with traditional cost analysis. ABC's view of costs evolved as managers came to realize that traditional accounting systems were not providing relevant information...in an era when overhead has become as critical as direct costs, and is growing apace". [Ref. 3]

Most of the companies that deal with the BAF apply volume-related allocations of overhead costs. Therefore the probability of having reliable information is small. This leads to faulty decision making when applied in marginal analysis.

Examples of this situation have already happened at Embraer, as in discussions about the allocation of advertising costs. We have already seen that this cost is a periodic cost and, in the case of Embraer, part of the overhead cost. What happened is that Embraer charged the BAF an overhead cost including advertising costs that was not related to the aircraft that had been contracted for by the BAF. The government cost analyst stated that those costs could not be charged to Embraer, since they were not related to the aircraft of the contract in negotiation. The company, on the other hand, assumed the position that overhead cost is a plant-wide concept and could not be separated out for different products.

What really matters in this case is that activity-based costing has the potential for presenting information that is closer to cost reality.

2. Regulation

Procurement by negotiation has always been considered a very sensitive point with governments. Efforts have been made by those involved in this activity to keep the regulations as easy to work with as possible.

In the BAF, the process of cost analysis has changed over time as new requirements arise, because of scarce resources and constant reducing budgets. The companies involved in contracts with the BAF have also recognized those changes by implementing innovative efforts to be more competitive and productive.

As Embraer downsizes, total quality management and other methods have been used to meet those needs and achieve better performance. In the government, however, the changes have occurred more slowly. As we have seen, the quantity of regulation in the U.S. regarding cost analysis and overhead is far greater than what exists in Brazil. The demand for procedures and standards that support the process of cost analysis play a vital role in the effectiveness of analysis. Many of these procedures might become useful to the Brazilian Government.

VI. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study is to analyze the possible applications of marginal analysis as a tool for improving the application of cost analysis and to emphasize understanding of the role of overhead cost in total cost. The lessons learned in this study will be applied to the BAF.

This chapter is divided into two main parts. In the first part, a set of conclusions drawn from this study will be described to address the questions presented in the Introduction. In the second part, some recommendations will be offered for improving cost analysis in the BAF.

A. CONCLUSIONS

This work considers those issues that could be useful to the BAF in performing a cost analysis of those firms not involved in competitive procurement.

1. Cost Framework and Accounting Procedures

In Chapter II we have presented a cost framework. We identified those elements of cost that are essential to decision making by applying marginal analysis. Chapter III discussed two different ways used by accountants to estimate the cost of a product, and the procedures that they employ to

measure total cost and allocate overhead cost. In this section, we will relate both chapters and conclude with useful information which can be drawn from their relationship.

a. *One-Product Firm*

We will start this discussion by considering a firm that produces only one product from different inputs.

In Chapter II, we investigated profit maximization by a firm. We have also seen that, in the short run, capital plant size, for example, is fixed; in the long run the producer is free to adjust it.

In practical terms, firms identify and measure their total costs by the accounting procedures they have selected. By applying the absorption costing approach and/or a direct costing approach, firms can obtain different information with which to construct the cost curves needed for decision making.

Recall that the direct costing approach is basically a short-run planning tool. As such, it is especially valuable when used in making decisions related to the use of capacity that is temporarily fixed. Decisions related to the short run usually involve only variable cost, so the direct cost approach is more probably related to average variable cost in the short run.

The direct costing approach considers only variable cost as a product cost. Direct material and direct

labor are traceable directly to the product, and variable overhead costs are allocated by the methods discussed in Chapter III. On the other hand, the absorption costing approach captures both fixed and variable costs as product cost. This approach, therefore, is most closely related to the long-run average cost.

Although decisions based on average cost data are not likely to be anywhere near optimal, average data can give a good approximation of marginal figures. Marginal data collection is difficult to obtain, and most of the accounting information is either average or total, rather than marginal figures [Ref. 13].

As outlined in Chapter II, economic analysis suggests that all costs are variable in the long run. The absorption-costing approach is the best measure today of long-run variable costs. But it is also true that the absorption-costing approach distorts the short-run perspective. Analogously, the direct-costing approach distorts the long-run view. [Ref. 19]

b. Multiple-Product Firm

As we have seen in the previous chapters, the typical firm is a multi-product enterprise, and employs a large variety of inputs. Again, the marginal rules in Chapter II state that to maximize profit, firms have to equate the

marginal revenue of each product to the marginal cost of the same product.

In multiple-product firms, the direct costing approach is useful in determining the marginal contribution of each product. The decision about the optimum mix of products depends on the accurate measure of the costs related to each product.

In the direct-costing approach, variable overhead costs must be allocated among the products produced. Admittedly, allocations are somewhat arbitrary. However, more companies are improving their cost allocation techniques and this problem will be overcome in time.

The problem of allocating costs by the absorption-costing approach is more delicate still, since indirect fixed costs are also considered a product cost. The accountants consider that activity-based costing is helpful in assigning overhead costs to products when cost drivers are more related to specific activities than to volume-based or unit-based drivers.

Activity-based costing methods play an important role in the allocation of common costs to products. To avoid cross-subsidy, such allocations should be based on the relevant cost drivers and not on simple allocation rules, such as direct labor hours.

Those elements essential for applying marginal analysis to multiple-product firms should also be gathered from the accounting procedures when measuring costs. As we have indicated, absorption costing is the best approach for identifying average costs in the long run, while direct costing is the best approximation for short-run average variable costs.

Finally, it is important to recall from our cost framework that accounting procedures fail to capture all costs, since great amounts of implicit costs are not considered by accountants.

2. Marginal Analysis

The cost framework discussed in Chapter II is a good approximation of the real situation of the companies that have contracted with the BAF. Marginal analysis plays a vital role in the cost analysis of those firms, because the government can understand, in more detail, the cost curves of the company and can also segregate those costs that influence the long and short-run production decisions.

Since overhead cost constitutes more than half of the total cost in most situations relevant to DOD, marginal analysis helps to identify those parts of overhead that are variable costs in both the short and long run. In the long run, all costs are variable, and firms can plan in the long run by applying marginal analysis. This plan can meet the

needs of the government, as well as find optimal output-price combinations.

If the firm is a multiple-product firm, marginal analysis can help it to find the optimum level of output-price and the optimum combination of inputs. For the BAF, it is important that firms present an accurate picture of cost, and that the firms segregate cost by product in order to make sure that the government programs are not overrun and that the firm receives appropriate payment.

In a multi-product firm the degree to which different categories of cost will vary depends upon the particular characteristic of each product. In addition, the degree to which cost will be altered by variations in the quantity of any one product will often depend upon the quantities of all the other products required at that time. In this matter, the personnel involved in cost analysis need to be knowledgeable about marginal analysis in order to better define the cost of the government contract.

Today, many defense programs are competing against many other programs for scarce resources. The BAF must allocate its resources in such a way that the greatest possible benefit is realized from its actions. Once more, marginal analysis can be an effective tool, since the maximization of the total benefit occurs when marginal cost equates to marginal benefit.

3. Measure and Allocation of Cost

The measure and allocation of cost in any firm has to meet both those needs that are required by the law, as well as those that are functions of decision making.

The full-absorption cost approach is related to the long-run identification of cost because it considers all overhead fixed costs as product cost.

Fixed costs are becoming a larger share of total manufacturing costs, and the competitive environment is forcing companies to produce an increasing variety of products. This in turn makes different demands on equipment and support departments. Some accountants argue that in this cost accounting environment, absorption costing becomes the only meaningful costing method.

Differentiating between fixed and variable costs as plants become more automated is the first step in controlling costs. In Embraer, there are large numbers of numerical control machines, and more modernization takes place every day. Considering that it is a company that manufactures aircraft, the direct cost approach should be applied.

The total unit cost concept has emerged recently within in DoD in order to improve the efficiency and effectiveness of government operations. From this perspective, the Activity Based Costing (ABC) approach is appropriate, because its view is that all costs are activity rather than volume

related, as we have seen in Chapter III. The ABC improves the measurement of overhead costs and assigns true cost to each product. This procedure shows marginal cost in a more realistic way.

4. Regulation

The set of regulations that support cost analysis in DoD is very extensive. These regulations provide the tools and procedures for DoD personnel to perform cost analysis in a standardized manner. Due to a lack of regulations in the BAF, cost analysis is conducted in many different ways. Also, civilian contractors do not possess any guidelines that prescribe standardized procedures for providing the government with the data it needs for cost analysis.

The regulation on cost analysis used in the DoD has useful information about how the analyst can, if necessary, make suggestions and analyze the cost structure of the company in order to achieve better results. The procedures established by the DoD regulation to assign period costs, such as market and selling expense, are different from those used by the BAF. In DoD, these period costs are based on the total input cost of the contract, as discussed in Chapter IV. In the BAF, the assignment of this cost constitutes the rate of overhead cost and it is applied directly in the hourly labor rate. The procedure applied by DoD seems to be clearer, since it is

incorporated in the final cost at the end of the cost analysis process.

B. RECOMMENDATIONS AND IMPLEMENTATION

Based on this analysis, several recommendations can be made for the BAF to improve its process of cost analysis. The first step is to create regulations, manuals, and instructions to establish standardized procedures for government personnel and for contractors.

1. Implementation

This regulation should be an instruction from the Ministry of Aeronautic (Instrução do Ministério da Aeronáutica - IMA) with the following format:

- Objectives of Cost Analysis: This part could follow the models existing in the U.S.
- Cost Analysis: In this part the process of cost analysis should contain those main tasks involved in cost analysis and the steps to be accomplished. The main activities of cost analysis should be:
 - Structural Analysis: The analysis of how the structure of cost in the company is organized. This structural analysis should also involve an analysis of the organization of the companies themselves. The importance of considering this aspect is to make sure that the companies' incorporated inputs (such as the number of administrative persons) coincide with the size and operations of the company.
 - Marginal Analysis: The presentation by the companies of data that will certify the analysis of possible levels of output-price, the optimum combinations of inputs, and the fixed versus variable overhead costs. Then, it

should be verified whether the companies are applying a variable costing approach in order to provide useful data for decision making.

- Technical Analysis: In this part of the regulation, those issues related to technical aspects should be considered. The development of a learning curve in computing reduction in costs as functions of cumulative production is an example of where technical analysis is relevant.

- Requirements for the Companies: This part should provide those actions that the companies submitting cost analysis to the government must take in order to provide all the needed data to perform the relevant analysis. This data should also provide the government with its own database to perform cost-benefit analysis.

APPENDIX A ECONOMISTS AND ACCOUNTANTS VIEW OF COST

Another simple way to visualize the idea of opportunity cost is to approach a Balance Sheet and Income Statement for a company with the concepts of cost from both economists' and accountants' perspectives.

This example starts with a person who decided to run his/her own business and forego a salary of \$50,000. This person started the business with his/her funds of \$110,000. The balance sheet of the firm is shown in Table 8. Table 8 indicates the status of the firm as of December 31, 1986.

TABLE 8 Balance Sheet, December 31, 1986

Assets		Liabilities and equity	
Cash in bank	\$10,000	Owned to suppliers of factors	\$10,000
Plant and equipment	160,000	Bank loan	80,000
Raw materials and supplies	<u>30,000</u>	Equity	<u>110,000</u>
Total assets	\$200,000	Total liabilities and equity	\$200,000

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

During the year of 1987, the firm made several transactions that resulted in the status by December 31, 1987 as shown in Table 9. One of these transactions was the purchase of a new machine with a value of \$10,000 that was incorporated in Plant and Equipment.

TABLE 9 Balance Sheet, December 31, 1987

Assets		Liabilities and equity	
Cash in bank	\$65,000	Owed to suppliers of factors	\$20,000
Plant and equipment	146,000	Bank loan	80,000
Raw materials and supplies	<u>10,000</u>	Equity	<u>141,000</u>
Total assets	\$241,000	Total liabilities and equity	\$241,000

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

The Income Statement of the firm for the year 1987 is shown in Table 10.

TABLE 10 Accountant's Income Statement for the Year 1987

Sales		\$200,000
Cost of operation		
Hired services and raw materials	\$115,000	
Depreciation	24,000	
He/She, Proprietor	20,000	
Interest to bank	<u>10,000</u>	<u>-169,000</u>
Profit		\$ 31,000

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

Tables 8, 9 and 10 give us a good overview of changes that happened from December 31, 1986 to December 31, 1987. For example, the value of plant and equipment on December 31, 1986 (Table 8) was \$160,000. On December 31, 1987 the value changed to \$146,000 (Table 8) because the firm purchased a new machine with the value of \$10,000 and reduced Plant and equipment with depreciation expense of \$24,000 ($\$160,000 + \$10,000 - \$24,000 = \$146,000$).

In the economist's view, the numbers shown in the last two tables present some distortions that could be explained as follows:

- In the Income Statement from Table 10 the value of depreciation is arbitrarily set by the firm at \$24,000, but the market value of the plant and equipment with an original value of \$160,000 (Table 8) is now, on December 31, 1987, \$124,000. This means that the correct depreciation should be \$160,000 - \$124,000 or \$36,000.
- The owner should have charged the company a salary that he/she could have earned (\$50,000).
- The owner should have charged the firm for the use of the \$110,000 of his/her funds. If the funds had been left in the stock market, he/she would have earned \$11,000.

The new Income Statement presenting the economist's view has the form indicated in Table 11.

TABLE 11 Economist's Income Statement for the Year 1987

Sales		\$200,000
Cost of operation		
Hired services and raw materials	\$115,000	
Depreciation ^a	36,000	
Interest to bank ^b	10,000	
Imputed cost of capital	11,000	
Services of Proprietor	<u>50,000</u>	<u>-222,000</u>
Loss		\$ (22,000)

^a Market value on January 1 less market value on December 31.

^b Because the bank loan is secured by the factory, its opportunity cost seems to the economist as properly measured by the interest payment.

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

The new Income Statement in Table 11 shows a loss of \$22,000 instead of the profit indicated in Table 10, therefore, a new Balance sheet was prepared as shown in Table 12.

TABLE 12 Economist's Balance Sheet, December 31, 1987

Assets		Liabilities and equity	
Cash in bank	\$65,000	Owned to suppliers of factors	\$20,000
Plant and equipment	134,000	Bank loan	80,000
Raw materials and supplies	<u>30,000</u>	Equity (see Exhibit)	<u>129,000</u>
	\$229,000		\$229,000

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

TABLE 13 Exhibit to Balance Sheet, December 21, 1987: Equity to Proprietor

Original investment		\$110,000
New investment by Proprietor		
Salary not collected	\$30,000	
Return on capital not collected	<u>11,000</u>	<u>41,000</u>
		151,000
Less loss from operations		<u>32,000</u>
Equity		\$129,000

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

Finally, the difference between the situation before, as an employee, and after, operating his/her own business, can be demonstrated in Table 14. The numbers indicate that opportunity cost is always present in each decision that we make because the decision means choosing something and foregoing others.

TABLE 14 Situation Before and After

	(1) As employee in formerly held job	(2) As owner-manager of his/her Com- pany	(3) Difference (2) - (1)
Salary paid	\$50,000	\$20,000	-\$30,000
Earnings on capital, invested in stocks	\$11,000	0	-11,000
Assets owned	110,000 (stock)	129,000 (equity in his/her Co.)	+19,000
Net change			-22,000

Source: Lipsey, Richard G., Peter O. Steiner and Douglas D. Purvis, *Economics*

Because the person left his/her job before starting his/her own business, they lost \$30,000 in one year. Considering that if this person had bought stock instead of investing in a new business, he/she could have earned \$11,000. This value is also computed as benefit lost. Finally, the assets owned by the person are greater than they would have been.

The net change in the situation of this person is less \$22,000, which means that this person is worse off.

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