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Chapter IV

COSTS AND RATE OF OUTPUT: THE ALLOCATION OF FIXED COSTS OVER TIME

IT WAS noted in Chapter II that although many conditions actually influence costs, economic theorists have selected a few simple relationships as significant to depict the decisions of business executives. Thus costs per unit of output for an existing enterprise are treated as dependent upon (a) the rate of output, (b) the prices of input factors, (c) the physical productivity or efficiency of management, labor, and the other factors which combine to produce output, and (d) selling expenditures. If business executives are considering the building of a new enterprise or the acquisition of additional equipment, costs are made to depend further on (e) the size or scale of plant and firm and (f) the stage of technology of which the executives and their engineers are aware. It must be remembered that this list is by no means exhaustive—the size of orders, the rate of change of output (that is, how quickly the firm moves from one level of output to another), and the labor policy of a firm are a few of the many other factors affecting costs which might be examined separately.

The task of this chapter, and of Chapter V as well, is to examine the single relationship between costs and the rate of utilization of an existing plant (or a group of operating units under a single management group),[1] and to isolate from others the effects of this particular influence upon costs. Subsequent chapters in Part Two are concerned with segregating and measuring the effects of other factors in the

[1] Chapter X discusses the problem of setting a boundary to a firm and thus distinguishing one enterprise from another.

economist's scheme of cost determinants. These chapters are all developed along similar lines. In each a brief introductory section defines terms and indicates the importance of the particular influence on cost. Succeeding sections appraise existing studies of these influences and the methods used to measure their effects. A final section is intended to evaluate the research possibilities in the field under discussion.

1. *The Short Run Cost Function*

If an enterprise is to maximize its profits over any period, or increase the current value of the ownership equity,[2] its executives must formulate (at least implicitly) some judgment of the way in which total costs can be expected to vary with the degree of utilization of individual machines, plants, and indeed the entire business organization.[3] The cost at which an additional order can be filled must exert some influence not only on the pricing of the order but also on the decision whether to accept the order. The more accurate the information at the disposal of business executives, the greater will be their understanding of the causes of cost changes and their control over costs.

Economic theory has ordinarily designated the relationship between total cost and output as the *short run cost function.*[4] The character of this function is the subject matter of the present chapter. A cost function implies that all other considerations which have been specified as determining costs are assumed to be unchanged.[5] More particularly, any measurement of the relationship between costs

[2] See Albert G. Hart, *Anticipations, Uncertainty and Dynamic Planning*, Studies in Business Administration, Vol. XI, No. 1 (University of Chicago Press, 1940), pp. 14, 89-92.

[3] A manufacturing enterprise is implied by the above language, but the argument would apply equally well to trading and service industries.

[4] The expression *cost function* in this and the following chapter is to be understood as *short run cost function.*

[5] See p. 51, above. Output is typically taken as the independent variable.

and rate of utilization, for an existing enterprise, is intended to show what costs would be at various rates of output if there were no change in factor prices, selling costs, and the level of physical input-output relationships.[6] Such a cost function excludes not only autonomous variations in these other determinants of cost, but also any secondary or derived influences, in particular cost fluctuations induced by simultaneous changes in the output of other firms. Although factor prices and selling costs might be initially constant, a variation in output could be so significant to the particular factor markets as to influence factor prices and thus indirectly affect costs. An increase in output may lead to the paying of overtime wage rates or to a rise in the whole rate structure, while materials may be purchased at a lower "price" because of larger quantity discounts as orders increase in size. Costs may also vary with output owing to induced changes in the productivity of the variable factors. For instance, at high levels of output it may be necessary to hire less able workers. A proper determination of cost functions would eliminate such indirect or induced effects on costs of variation in the rate of plant utilization.

It may well be contended that one should adopt a cost function incorporating the effects induced by variations in output because business decisions must take into account the total effect of changes in the rate of utilization. Such a hybrid cost function can be defended as more accurately portraying what executives have in mind when they contemplate the effects on costs of output variations. This concept would be useful if particular variations in output always were associated with specified induced variations in cost. Under such circumstances it would be impossible to separate, either conceptually or statistically, the changes in costs induced indirectly by variations in factor prices or

[6] When it is said that there is no variation in the level of physical input-output relations, the proportions of the factors are not considered constant irrespective of changes in output. What is meant is that the production function for the firm has not altered. This thought is sometimes expressed by saying that the technological horizon is unchanged.

productivity through changes in output from those cost changes that are directly attributable to variations in output. Since the indirect effects are not always associated with variations in output (or are not always of the same magnitude), it would seem wise to separate their influence on costs and to measure their effects separately if possible.

Although the total cost function refers to the relationship between total costs and the rate of operation of an enterprise,[7] it is of considerable interest both to business executives and to economists to know how the main components of costs are related to variations in output. Any total function may be made up of divergent and conflicting elements. Business executives must reach some judgment of the ways in which labor, materials, fuel, depreciation, supervision and other expenses vary with the rate of plant utilization if they are to evaluate the relative merits of different means of varying output.[8] Before the total costs of any single level of output can be specified, however, the allocation of "fixed" costs over time must be examined.

2. *The Meaning of "Fixed Costs"*

For accountants and economists alike, the meaning of such terms as "burden," "overhead," and "fixed costs" has not always been unequivocal, although in a very general sense these terms refer to costs that cannot be traced precisely to individual units of output.[9] In his classic study J. M. Clark uses the term "overhead" to refer to "costs that cannot be traced home and attributed to particular units of

[7] Unless otherwise specified, discussion of the relationship between output and costs assumes that other influences on costs are inoperative —in Marshallian terms, impounded in *ceteris paribus*

[8] In order to determine the lowest cost combination of factors for a given output, it will frequently be convenient to discuss how particular elements of cost vary with output rather than to deal with total costs directly.

[9] Part of the confusion arises because the percentage of costs that must be allocated will vary with the size of the output unit selected. For instance, fixed costs in the railroads will vary depending on whether output is measured in pounds or in trainloads.

business in the same direct and obvious way in which, for example, leather can be traced to the shoes that are made from it. And most of the real problems involve one other fact; namely, that an increase or decrease in output does not involve a proportionate increase or decrease in cost."[10] Cost accountants, as a general rule, consider as "overhead" any "indirect cost" regardless of the way in which it varies with output.[11] These costs boldly outline the contrast between facilities made *available* and those *utilized*.[12] Some more detailed examination of the content of "fixed costs"[13] is a necessary prelude to the determination of a cost function for a specified period.

Any designation of "overhead costs" must imply an economic unit to which the costs pertain. There are wide differences between "overhead" to a department, to a firm, to an industry, or to the community as a whole. Direct labor, for instance, may not be "overhead" to a firm, whereas the maintenance of the unemployed becomes an overhead charge on the community. Again, costs that are "overhead" to a department may not be "fixed" for a plant or the whole enterprise. For purposes of internal management and cost control, it is frequently important to specify those elements in costs that are "overhead" to each division of managerial authority. In this context, "overhead costs" are synonymous with those beyond the control of the particular unit of management. This is apt to be a fruitful connotation when reference is made to internal problems of an organization. It is questionable, however, whether one can say that the "overhead" of the firm consists of those costs that are beyond its control, at least in the "short period."

[10] *Studies in the Economics of Overhead Costs* (University of Chicago Press, 1923), p. 1.

[11] W. A. Paton, *Accountants' Handbook*, 2nd ed. (Ronald Press, 1935), p. 1282.

[12] C. Reinold Noyes, "Certain Problems in the Study of Costs," *American Economic Review*, XXXI (September 1941), pp. 473-92.

[13] The terms "overhead" and "fixed" costs are here used interchangeably; a more rigorous definition is attempted later in the text. The term "burden," however, will be regarded as an accounting summary including all expenses that are not direct "labor and materials."

Such a statement would be valid only if these costs were entirely uninfluenced by managerial decision.

The term "fixed costs" is also commonly interpreted to mean costs that are constant from one accounting period to the next within the customary range of output variation. The conventional use of the straight line formulae in the allocation of costs that contribute to the output of more than a single period gives support to this usage.[14] By analogy other costs which are constant from one period to the next, such as executive salaries, are often called "fixed costs." But regardless of the way in which these words are used, costs that are constant from period to period because they are so allocated must be distinguished from out-of-pocket expenses incurred regularly.

Cost accountants frequently classify costs as "directly variable" (varying in proportion to output), "semifixed" (varying with output but not proportionately), and "fixed" (not varying with output at all). Both "fixed" costs and costs that are, strictly speaking, "directly variable," are probably of rare occurrence; usually there are incurred many kinds of semifixed expenses which typically vary more or less than proportionately to a given change in output. For purposes of making decisions within an enterprise, however, a number of expenses can be regarded (within the usual range of variation of output) as typically "fixed" or "directly variable." Some of these "fixed costs" are not incurred solely for the period in which the outlay is made; hence the method of allocating these costs over time is one of the principal influences on variations of total costs with changes in the rate of output.

There are at least three distinct reasons why certain elements of costs are classified as "fixed" in the very general sense of being untraced to individual units of output. (a) A variety of products may be processed by the same plant and equipment. (b) An organizational apparatus, consisting of personnel and services, may be customarily maintained within wide fluctuations of output. (c) Outlays in one

[14] W. A. Paton, *op. cit.*, p. 1282.

accounting period may be expected to contribute to the output of future periods.[15] For any one of these three reasons it may be impossible to follow precisely the incidence of a particular outlay. The main preoccupation of this chapter will be "allocable fixed costs"; that is, the outlays that are expected to contribute to the output of more than a single accounting period. Costs of the second type, identified with a particular period but which cannot be traced to individual units of output, will be designated "recurrent fixed costs" and will constitute the subject matter of Section 3 of this chapter, a detour from the main discussion. In Chapters IV–VII it is assumed that each enterprise processes a single "product," and it is not until Chapter VIII that the complexities introduced by the manufacture of many products by one firm are considered in any detail.

The emergence of "allocable fixed costs" depends upon the expectation of an outlay contributing to future output, the time distribution of this contribution, and the length of the accounting period. The shorter this latter period, the larger the proportion of total costs that would ordinarily be labeled "allocable." If the accounting period were synonymous with the life of the enterprise, there could of course be no "allocable fixed costs." These costs will be considered below in Sections 4 and 5; the former will envisage allocation through time under conditions of an unchanged volume of output, and the latter will treat the more complex case of variations in output from period to period.

3. *"Recurrent Fixed Costs"*

Elements of total cost that are readily identifiable with a single accounting period (say a year) and more or less invariant with respect to output are exemplified by such items as real estate taxes, executive salaries, earnings of salaried sales personnel, insurance, rent, heating, light and

[15] Certain taxes, of which local property taxes are typical, are usually independent of output. Of increasing importance in the cost structure, they involve out-of-pocket expenditures and are here treated as recurrent fixed costs.

other utilities. According to present customary accounting practice, research and development costs would fall into this same category,[16] although they contribute materially to future output and belong in the class of allocable fixed costs. Under certain types of industrial situations, where equipment and machinery are rented, almost all "overhead" costs are recurrent fixed costs. Insofar as shoe machinery is rented per unit of time, such rentals are fixed with respect to output. But to the extent that royalties are charged per unit of processed material, these costs are not "overhead" in any sense.[17] Another item of cost, largely classifiable under the heading of this section, consists of expenditures for clerical work and record keeping, which have increased in very large proportions in recent years. These items of costs, invariably classified under "burden" in accounting practice, range from those that are absolutely fixed with respect to output to those that approach proportional variation.

It is a pertinent question whether these elements of "overhead" costs have increased as a proportion of total costs in recent years. The lack of specific information on this matter is a large gap in cost information, and one which offers opportunity for a really significant study. There is general evidence, however, that the kinds of costs that are "fixed" with respect to output (or at least undergo only small changes) in a single accounting period have become somewhat more important. Some of the considerations that lie behind this tentative conclusion may be noted briefly.

(a) The great increase in record keeping since 1929, partly a result of social and tax legislation and partly in consequence of new techniques of business management, has raised clerical costs.[18]

[16] National Association of Cost Accountants, "Present-Day Practice in Accounting for Research and Development Costs," Research Study, *N.A.C.A. Bulletin,* XX (March 1, 1939), Section III, p. 896.

[17] Except insofar as minimum stand-by charges are required.

[18] Any increase in machines involves a contribution to future periods and therefore belongs with the main discussion of this chapter rather than with this somewhat digressive section.

(b) Increases in property taxes have had a similar effect.

(c) Operating in the same direction also have been the wider grants of vacations with pay and the spread of workers' compensation on an annual wage basis. Insofar as these costs, rather than increased basic wage rates, are incurred, the difference in impact on costs deserves a thorough study. Suffice it to indicate that an annual wage is a cost invariant to small changes in output during the course of a year.[19] In the framework of economic theory, a cost increase of this sort may not be expected to influence short run price decisions because the marginal cost curve remains unaffected, while, on the other hand, prices would be expected to increase as the result of a rise in wage rates with a shift in the marginal cost curve.

(d) The division of workers between salaried employees and wage earners has probably shifted in recent years in the direction of a higher proportion of the former.[20] Among other factors, the growth of labor organizations and the necessity of certification of employee bargaining groups by the National Labor Relations Board have probably tended to extend the coverage of salaries to all workers

[19] Wage earners with hours of work below a certain limit may be ineligible for vacations with pay. See "Vacations with Pay in Union Agreements 1940," *Monthly Labor Review*, 51 (November 1940), pp. 1070-77.

[20] John W. Riegel, *Salary Determination, Common Policies and Selected Practices in Forty American Corporations*, Bureau of Industrial Relations, Report No. 2 (University of Michigan Press, 1940), p. 5.

W. S. Woytinsky, *Labor in the United States, Basic Statistics for Social Security* (Social Science Research Council, 1938), p. 24, finds 20 percent of the gainfully employed under the 1930 census to be "salaried employees and officials (including salaried professional persons)." This excludes "employers and self-employed persons."

H. A. Millis and R. E. Montgomery, *Labor's Progress and Some Basic Labor Problems* (McGraw-Hill, 1938), p. 32, present a table showing "Changes in Relative Importance of Major Economic Groups 1870–1930." "Lower salaried" workers increased from 2.5 percent of the total in 1870 to 9.6 percent in 1920 and 14.6 in 1930.

Similar tendencies toward growing importance of salaried workers can be seen in studies of the proportion of salaries to wages plus salaries. For manufacturing industries see Simon Kuznets, *National Income and Capital Formation, 1919–1935* (National Bureau of Economic Research, 1937), Appendix Table 1, p. 62.

classified as full-time supervisory.[21] While not all salaried workers are supervisory, nearly all supervisory workers are now probably on salary. Operating to counteract in some degree these tendencies toward expansion of the proportion of workers in salary groups has been the Fair Labor Standards Act of 1938, which eliminated one advantage of the salary basis of routine workers in interstate commerce. Previously many such persons worked overtime, occasionally without extra compensation.[22] It should be noted that salaried workers, such as draftsmen, are sometimes directly "productive," i.e., assigned to a specific job, and that such salaries are to be treated as direct labor costs.

(e) The increase in the importance of selling expenses and advertising is frequently of a character to magnify the proportion of costs which are relatively fixed with respect to small changes in output.

One factor that has been operating to decrease the proportion of fixed costs to total costs in the enterprise has been the substitution of hired labor for family labor. The family-operated retail store must regard its entire labor costs as fixed. The growth of chain and department stores has changed these fixed costs into variable costs.

An integral part of any inquiry into the changes in the fraction of costs that are relatively fixed in relation to output is the matter of the variation in the "prices" of these factors—salary scales, tax rates, etc. Sample studies have been made of changes in the compensation to executives,[23] but there has been no comprehensive treatment of the whole gamut of salary rates. The change in the distribution of employed workers through the entire range of salaries during the course of the business cycle is as yet largely

[21] The fact that employees are paid by salary rather than wages does not remove them from the jurisdiction of the Board. See Joseph Rosenfarb, *The National Labor Policy and How It Works* (Harper and Brothers, 1940), pp. 48-49.

[22] John W. Riegel, *loc. cit.*, note 1.

[23] John C. Baker, "Fluctuations in Executive Compensation of Selected Companies, 1928–36," *Review of Economic Statistics*, XX (May 1938), pp. 65-75, and *Executive Salaries and Bonus Plans* (McGraw-Hill, 1938).

unexplored. Studies of tax rates, insurance prices, and utilities for various classes of purchasers have seldom been sufficiently detailed to aid in an investigation of the costs of particular types of enterprises.

Certain "recurrent costs"—some salaries, advertising expenditures and research costs—may represent outlays more appropriately charged against the output of a future period. This is particularly evident when a staff and organization is kept constantly available but is utilized only partially in some periods. Such outlays, although formally recurrent, must logically be regarded as allocable costs. These recurrent expenditures are almost never capitalized in accounting practice, largely because of the accepted rules of thumb and the additional costs of making the decisions and allocating the outlays. Accounting procedure must always be placed in the context of the decisions it is intended to facilitate.

4. *"Allocable Fixed Costs" and Constant Output*

The discussion now returns to the principal concern of the present chapter, a consideration of the outlays of a single accounting period which are intended to contribute to future output. These expenditures are exemplified primarily in the use of durable capital goods, plant, machinery and equipment. Since these factors of production sooner or later wear out, or are abandoned, they must be replaced if production is to be continued. Because the accounting period is typically shorter than the "life" of these producers' durable goods, it is appropriate to set up "depreciation reserves" and to charge a part of the cost against current revenue. A primary purpose of cost accounting has been the formulation of working rules and techniques to specify both the total period over which the cost of an asset may be distributed and the appropriate charge against the income of each period. The economist has been much more interested in the fact that changes in technology, output, and demand conditions for the products as well as the durable equipment materially alter the value of the enter-

prise, the costs of a period, and consequently the decisions as to replacement. The contrast between the primary preoccupations of the two professions, and the concomitant difference in views with respect to knowledge of the future, result in these divergent emphases, both require further examination.

The allocation of costs to specific accounting periods is itself a decision, and one that must be reached before others involving cost calculations can be formulated. Decisions as to dividend policy or income tax payment, for instance, presume this cost allocation. To the extent that pricing decisions are influenced by the profit record of the past period, income calculations are important determinants of price. Even more relevant are prospective profits, and hence prospective costs. It is thus evident that a pricing decision necessarily involves a complex time distribution of these "allocable fixed costs," which may well vary from decision to decision. To specify the "allocable fixed costs" for a single period, even under conditions of constant output, requires a brief examination of the nature of "depreciation."

As a durable asset is used up or ceases to contribute to output, its value diminishes. If there were no autonomous changes in the prices of assets arising from shifts in demand, no general variations in all prices or supply conditions (including technical changes), the reduction in valuation would clearly be designated as *depreciation.* Under such simple circumstances the amount of depreciation per accounting period presents no logical difficulty. It would be a function of the rate of output alone, of time, or of some combination of the two. "Wear and tear" and "weathering" would be the sole causes of the decline in discounted present value of the expected net receipts from the asset.[24, 25]

With the relaxation of the rigid assumptions just de-

[24] J. B. Canning, *The Economics of Accountancy* (Ronald Press, 1929), Chs. XIII and XIV.

[25] The term depreciation is expanded below, p. 65, to include an expected rate of obsolescence.

scribed, there emerge a number of serious problems involved in the designation of "allocable fixed costs" per accounting period. In addition to depreciation (defined as a function of use and "weathering") the valuation of assets can be altered by: (a) changes in the prices of interchangeable new assets due to any of a large number of possible circumstances such as relative shifts in demand, "monetary factors" and factor price variations; (b) a change in the effectiveness of new types of the asset, i.e., a "technical change"; (c) a change in the rate of interest. It is futile to debate whether the term "depreciation" should be expanded to include changes in the valuation arising from these factors. But there can be no doubt that they do impinge on the economically correct calculations of "allocable fixed costs" for a single period. If assets have risen in price along with a "general increase," the depreciation reserve will not be adequate for the purchase of a new machine when the old one has been exhausted (as a result of use and "weathering") unless depreciation rates are increased. The rise in price is logically a cost to be added to that of the period in which the increase took place, and to that of future periods in the same proportion in which depreciation is allocated between periods. The most straightforward procedure, perhaps, is to regard depreciation as unchanged by the price rise and to treat the increase logically as a separate element of cost rather than to vary the "depreciation" charge. Similarly, a decline in asset prices involves a decrease in the costs of the current and future periods. The emergence of a technically superior asset may be treated here simply as synonymous with some change in the price of the old asset; the economically correct solution of the effect on cost can thus be made equivalent to that just indicated for price changes. For these purposes, a change in the rate of interest can also be reduced to an equivalent change in the price of the asset.[26]

[26] The relation between the preceding discussion and J. M. Keynes' concept of user costs (see his *The General Theory of Employment, Interest and Money* [Macmillan, London, 1936], Chapter VI, and

The accountant, concerned with the practical problems of computing the costs of a period for income purposes, allocates the total cost of an asset by taking into account the expected time or service life of the asset as affected by weather and use, and recognizing that the lives of the same types of assets present a frequency distribution. Only a few of the other factors that may induce changes in valuation are typically included. In particular, "obsolescence" is combined with the costs of "wear and tear" (function of output) and "weathering" (function of time). That is, some expected average rate of decline in valuation due to "technical change" is added to the theoretical concept of depreciation. This is illustrated by the definition of "depreciation" indicated in the Income Tax regulations of the Bureau of Internal Revenue:

> A reasonable allowance for the exhaustion, wear and tear, and obsolescence of property used in the trade or business may be deducted from gross income. For convenience such an allowance will usually be referred to as depreciation, excluding from the term any idea of a mere reduction in market value not resulting from exhaustion, wear and tear, or obsolescence. The proper allowance for such depreciation of any

"Appendix on User Cost," pp. 66-73) merits brief examination. User costs are the "reduction in the value of the equipment due to using it as compared to not using it, after allowing for the cost of the maintenance and improvements which it would be worth while to undertake and for purchases from other entrepreneurs" (p. 70). It is the "nonfactor" (nonlabor) cost incurred in the substitution of current output for some future output (J. R. Hicks, *Value and Capital* [Clarendon Press, Oxford, 1939], p. 198), and as such is made up of many elements we have chosen to distinguish. Its components are as follows: (a) The difference in materials costs between their utilization at present and the discounted value of their use at some future date. This difference would, of course, be due to expected variations in the price of the material. (b) User costs include the costs of additions to fixed plant that would not have been made until a later date except for the necessity of producing the current output. (c) Maintenance is in the same category. While such a concept is useful as a collective category in the context of the "short period supply price," it seems dangerously similar to a notion like the "falling-overness" of buildings. Depreciation includes a part of user costs just as the latter include a part of depreciation.

> property used in the trade or business is that amount which should be set aside for the taxable year in accordance with a reasonably consistent plan (not necessarily at a uniform rate), whereby the aggregate of the amounts so set aside, plus the salvage value, will, at the end of the useful life of the property in the business, equal the cost or other basis of the property.[27]

One of the widely used handbooks for accountants lists the following "principal causes of depreciation": [28]

> Ordinary "wear and tear" in use.
> Unusual damage or deterioration.
> Exhaustion.
> Limited possibility of use.
> Inadequacy of existing equipment due to such factors as governmental regulations, change of ownership, and growth of the enterprise.
> Obsolescence.
> Cessation of demand for the product.

In order that it may conform more readily to general usage, the meaning of the term "depreciation" will be expanded, in the discussion to follow, to include an average or expected average rate of obsolescence, regarded as a uniform function of time. Changes in value of durable assets due to "use," "weathering" or "obsolescence" will be designated as depreciation; the first is a function of the rate of output, the other two are functions of time.[29]

To determine the economically correct "allocable fixed costs" for each period requires accurate knowledge of the following factors at the time of purchase of an asset. (1) The value of the asset, which at the time of purchase is identifiable with price paid plus cost of installation and similar outlays. (2) The time rate of depreciation due to

[27] U. S. Treasury Department, *Regulations 101 Relating to the Income Tax under the Revenue Act of 1938*, p. 77.

[28] W. A. Paton, *op. cit.*, p. 579.

[29] See Joe S. Bain, "Depression Pricing and the Depreciation Function," *Quarterly Journal of Economics*, LI (August 1937), pp. 705-15.

"weathering" and "obsolescence," that is, "time deterioration." (3) The use rate of depreciation. (4) The fact that the time rate is independent of the use rate, or that they are related in some specified pattern. It must not be assumed that the time rate of depreciation is necessarily a linear function; "weathering" or "obsolescence" may be an increasing function of time. Nor must it be supposed that simply because the depreciation reserves exactly equal the cost of a new asset (even with no asset price changes) that the depreciation charges (and income calculations) are correct for any single accounting period. Counterbalancing errors may have served to correct the total charges of the whole period. (5) If an asset has been held for a period, the economically correct allocation requires a knowledge of any change in the value of the asset due to such developments as price changes, technical innovations, etc., during the past period.[80]

Because it is impossible to make such an economically correct allocation, the usual determination of depreciation rates by businessmen practically discards the successive valuation approach altogether. They do know exactly what a machine or building costs initially and, within a small margin of error, what its salvage value will be at the end of its service life. Again, reasonably reliable estimates frequently can be made of probable life and, in the case of a machine, of probable units of output. It is therefore considered reasonable to spread the "wearing" value (cost less salvage) of the building or machine systematically over its years of life or units of output, without any attempt to say what its value is at some intermediate date.

Business practice frequently includes a safety factor in depreciation calculations which sometimes distorts the most probable value in the direction of higher "allocated fixed costs." On the other hand, the desire to show a net income which will justify dividends and be a credit to the manage-

[80] The calculation of depreciation is related to decisions on replacement. For a discussion of the methods commonly used in determining the replacement of an asset, see Appendix C.

ment sometimes causes depreciation rates to be pushed below sound economic figures.

The most obvious and the simplest way of distributing "allocable fixed costs" is the "straight line" method, whereby the difference between the cost of an asset and estimated disposal value is divided by the number of periods of the expected life of an asset and an equal charge is made for each period. The overwhelming popularity of this method for income accounting is indicated by 24 out of 28 replies to a questionnaire distributed by the National Association of Cost Accountants[31] and by 126 out of 138 responses to an inquiry into depreciation policies conducted by the Machinery and Allied Products Institute.[32, 33] Although the straight line method is almost invariably used for income calculation purposes, one should not infer that it is equally popular in costing and budgeting systems. A study by the National Association of Cost Accountants showed that only 30 percent of those who answered the questionnaire adopted the straight line basis for "costing purposes."[34] There is reason to believe, however, that this represents a rather more progressive group of companies than would be found in a strictly random sample.[35]

Despite the widespread use of the straight line method, its inadequacy is readily apparent. One popular handbook says:

> The method neglects at least three important facts: (1) the amount charged to operation, if placed on interest, will ac-

[31] *N.A.C.A. Bulletin,* XVII (May 1, 1936), Forum Section, p. 1055.

[32] Machinery and Allied Products Institute, "Income Tax Return Examination of Depreciation Rates," *Bulletin No. 183* (May 4, 1940), quoted in *ibid.*, p. 1059.

[33] Solomon Fabricant, *Capital Consumption and Adjustment* (National Bureau of Economic Research, 1938), p. 65, found the straight line method to be overwhelmingly prevalent in calculations of business depreciation.

[34] *N.A.C.A. Bulletin,* XIX (April 1, 1938), Section III, pp. 924-25 and 933-34. In addition, about two thirds of these charge idle equipment costs directly to profit and loss or cost of goods sold.

[35] For coverage of the questionnaire, see *ibid.*, p. 916.

> cumulate to more than the amount to be depreciated; (2) the asset will usually require heavier repairs in later periods and, therefore, the method will not result in uniform operating charges, including maintenance; (3) the product may vary from season to season and year to year, with resulting relatively high cost per unit of output when production is low. Nevertheless it is the commonest method and its simplicity is deemed to offset its theoretical weaknesses.[36]

The first two of these limitations are to be considered in the remainder of this section; the third is treated in Section 5.

Should a firm, say a small hydroelectric establishment, have no occasion for expansion or for frequent periodic replacement of its depreciable assets, it might prefer to accumulate depreciation reserves as an actual cash fund. In such a case the interest on this fund obviously affects the cost calculations. This interest effect is just as truly present for the enterprise which has opportunities to use the accumulating funds itself. The scheme of cost allocation most commonly utilized to take this interest element into account is the sinking fund method. Under the usual procedure, equal periodic payments are accumulated at compound interest to provide a fund equal to the cost, less estimated scrap value of the asset. The amount is set aside as depreciation in each period, and interest on previously recorded depreciation is credited to this reserve account.[37]

The second difficulty with straight line depreciation is the assumption that the rate of decrease in value of the asset will be constant. Even if output were constant, this assumption is usually invalid because repair costs increase with age, and slightly less efficient operation is to be expected as the asset grows older. On general grounds explored earlier in this section it is probably correct to presume that depreciation is not constant over time even with

[36] Paton, *op. cit.*, p. 628, adapted from Cole, *Fundamentals of Accounting.*

[37] Paton, *op. cit.*, pp. 632-34. See also, Brown and Runner, *Engineering Terminology*, p. 72, quoted in Walter Rautenstrauch, *The Economics of Business Enterprise* (John Wiley and Sons, 1939), p. 139.

output unchanged. But it is impossible to determine *a priori* the precise way in which depreciation will vary over time on all assets. In general, a relatively greater obsolescence would be expected in the early years with the repair and interest elements working in the opposite direction. The assumption that the asset will lose each year the same percentage of its remaining value is made in the Matheson method of depreciation allocation. The greatest difficulty with this method, from the theoretical standpoint, arises from the extreme importance it gives to scrap value. This limitation is evident in the following table which compares depreciation charges under alternative methods. Suppose a machine with an eight-year "life" costs $1024 and has a scrap value of $64, then the depreciation rate, according to the Matheson method, is approximately 29 percent. If the old machine was worth only its melt-up value, say $4, the depreciation rate would increase to 50 percent.

The Gillette method of depreciation attempts to combine the sinking fund approach with recognition of the fact that cost of repairs and operation increases as a machine grows older. The repairs and costs of operation are estimated directly. Then, by means of the sinking fund principle, depreciation is calculated to make the cost per unit of output (with given factor prices) the same throughout the expected life of the asset. If output is held constant, the method results in total cost being equal for each period (all other things remaining equal).

Mention should be made of a system of depreciation developed by Edwin B. Kurtz; it is based upon the fact that there is a skewed distribution about the average lives of machines just as there is about the average span of human life.[38]

Accordingly, the depreciation charges are slightly different from those which would be appropriate if all "identical" machines had the same life. Logically, any scientific

[38] Edwin B. Kurtz, *The Science of Valuation and Depreciation* (Ronald Press, 1937), especially pp. 42 *et seq.*, and *Life Expectancy of Physical Property* (Ronald Press, 1930).

TABLE I

ANNUAL DEPRECIATION CHARGES UNDER ALTERNATIVE METHODS OF ALLOCATION

Eight Year Life: Original Cost $1024

Year	*Straight Line Scrap Value $64*	*Straight Line Scrap Value $4*	*6 Percent Sinking Fund Scrap Value $64*	*6 Percent Sinking Fund Scrap Value $4*	*4 Percent Sinking Fund Scrap Value $64*	*4 Percent Sinking Fund Scrap Value $4*	*6 Percent Sinking Fund, Unequal Payments, Scrap Value $64*	*Matheson Method Scrap Value $64*	*Matheson Method Scrap Value $4*
1	120	127.50	97	103	104	111	80.00	300	512
2	120	127.50	97	103	104	111	84.50	212	256
3	120	127.50	97	103	104	111	89.50	150	128
4	120	127.50	97	103	104	111	95.00	106	64
5	120	127.50	97	103	104	111	101.00	75	32
6	120	127.50	97	103	104	111	107.00	53	16
7	120	127.50	97	103	104	111	113.00	37	8
8	120	127.50	97	103	104	111	120.00	27	4

analysis of questions of depreciation must be based on such machine mortality tables. In particular, the determination of average life from recorded experience should use actuarial methods, though as long as we have such gross inaccuracies in our estimates, elaborate refinements are inappropriate. Moreover, sound depreciation accounting must be based on a homogeneous group of items rather than on a single item.

5. *"Allocable Fixed Costs" and Varying Output*

The preceding section considered the allocation of those costs which contribute to the output of more than a single period, and then discussed business practice on the assumption that output remained unchanged. Under conditions of varying output, however, it is a matter of common knowledge that per unit "overhead" costs will vary inversely with output, if the straight line method of allocation is employed. For this reason modern accounting practice has developed techniques of allocation which are intended to compensate for the obvious limitations of the straight line method.

In order to facilitate internal decisions such as those affecting location or department of work, type of material utilized, and purchase or manufacture of parts, as well as to improve control over all costs, systems of normal or standard costs have been adopted.[39] They are also widely used in the preparation of cost data for pricing decisions. It will be recalled from Chapter II that the "burden" element of these costs starts with an estimation of probable production[40] over the future, including "good" years and

[39] Chapter II (pp. 25-26) summarizes the distinguishing characteristics of these systems. One of the important functions of "normal costs" is to provide information as to the cost of producing particular goods. This involves the allocation of "burden" to individual items, a subject treated in Chapter VIII. Only one aspect of "normal burden" is considered here.

[40] The difference between production, sales and capacity is commented upon in Chapter II, p. 26.

"bad,"[41] frequently expressed as some percentage of "capacity." These estimates will, of course, be influenced by past production records, modified in the light of major changes that may be thought probable. Enterprises whose output is markedly affected by cyclical swings will be certain to include a period with these major movements. Concerns with fairly constant output may simply estimate a year or two in advance. The "normal burden" cost is based on *the average* of expected outputs over this future period. The effect of "normal burden" is to provide, for costing and planning purposes, an equal per unit "burden" cost over different accounting periods, as contrasted with the inverse movement, under the straight line allocation method, of per unit "depreciation" costs with output.

This difference is readily apparent in the hypothetical asset examined in Table 2, where "depreciation" costs per unit of output are shown under various systems of cost allocation. As compared with the straight line method, the normal costing system results in a higher per unit "depreciation" cost in periods of large output and a lower cost in periods of contracted output. The effects of both these methods on "depreciation" are compared with two cases of "technical" costing based on changes in value, not due to price changes, which are attributable to the period. In Case 1 the "allocable fixed costs" per period are presumed to be a linear function of time, while in Case 2 those elements of "depreciation" that are an increasing function of the rate of use are treated as the sole determinants of cost. As output expands, the "depreciation costs" per unit under the straight line method always show a decrease; under a normal costing system they remain constant; but under "technical" costing they may decrease or increase, depending on the relative importance and character of use (rate

[41] The use of the term "burden" implies that normal costing systems typically combine under "normal burden" recurrent "fixed costs" with costs that contribute to the output of more than one period.

of output) and time ("weathering" and obsolescence) elements of depreciation.[42]

The "depreciation" elements in "normal burden" will vary with whatever constitutes the basic estimate of "normal capacity." This might be "expected production and sales" over the future, as presumed in the above paragraph, or it could be "productive capacity" alone. It might even

TABLE 2

"DEPRECIATION" COST PER UNIT OF OUTPUT UNDER VARIOUS SYSTEMS OF ALLOCATION[a]

Year	*Output in Units*	*Straight Line Costing Per Unit Costs*	*Normal Costing (6000 unit = normal)*	*"Technical" Costing* Case 1[b]	Case 2[c]
1	8000	$.125	$.166	$.157	$.188
2	7000	.141	.166	.160	.178
3	6000	.167	.166	.166	.166
4	5000	.200	.166	.175	.15
5	4000	.250	.166	.187	.10
6	4000	.250	.166	.187	.10
7	5000	.200	.166	.175	.15
8	6000	.167	.166	.166	.166
9	7000	.141	.166	.160	.178
10	8000	.125	.166	.157	.188

[a] An outlay of $10,000 is assumed to purchase an asset with a "life" of 10 years which is completely allocated under each system.

[b] Case 1 envisages a constant time depreciation of $500 and a use depreciation in which changes in the amount of output are accompanied by equal changes in the amount of use depreciation.

[c] Case 2 assumes only use depreciation at a rate of $500 for output levels of 4000 units, and increasing $250 for each 1000 units.

include stand-by equipment. A questionnaire sent out by the National Association of Cost Accountants revealed that 22 percent of the responding firms used ability to produce as the sole base for calculating normal costs, while 78 percent (177 relevant replies) took into account probable sales

[42] Although one can say that "depreciation" which is a function of time is necessarily a part of "correct depreciation" for income purposes, it is not certain that the "depreciation" which in this sense is attributed to the period is actually attributable to the *output* of this period.

as well. The 22 percent were presumably in industries turning out consumers' goods or other products characterized by fairly constant output.[43] The same study showed that 18 out of 224 companies used "actual" rather than "normal" burden rates in making cost calculations. This is somewhat surprising in view of the fact that these 18 included 4 manufacturers of metal products and 3 of iron and steel. There is, of course, little indication of how these costs were used, or that they entered in any way into decisions affecting price.[44]

The use of "normal depreciation" in cost data prepared for pricing decisions has the advantage over "depreciation" costs from income accounts in that it is better geared to the future. Since a pricing decision applies to the next period, it should certainly be based on "costs" likely to prevail in that period. Ordinarily "depreciation" charges in financial accounting must be less relevant, because they refer necessarily to the past period. This advantage of "normal" costs is especially important in periods when output fluctuates violently; at such times the difference between the two sets of "depreciation" costs will be large.

[43] "Practice in Applying Overhead and Calculating Normal Capacity," *N.A.C.A. Bulletin*, XIX (April 1, 1938), Section III, p. 925.

[44] An interesting type of problem in the allocation of "overhead" is encountered in the motion picture industry where the rentals for pictures are spread over time. For any accounting period shorter than the "life" of the picture, costs must be allocated against that proportion of the income received in the period. "In the early days, the simple rule was adopted that all rentals were applied against the cost until the cost was recovered, and thereafter all rentals were profits. . . . After careful research it was discovered that the earnings of the ordinary picture followed a more or less well-defined curve, being greatest in the early days of presentation. . . . The practice became general of computing income on the basis of writing off the cost of the picture against the rentals on the basis of such curves." (George O. May, *Twenty-Five Years of Accounting Responsibility, 1911–1936* [Price, Waterhouse and Co., New York, 1936], Vol. II, p. 105.) This would appear to be a form of normal costing for income purposes where it was relatively easy to establish time patterns of use.

For an application of "normal costs" to the automobile industry, see Homer Vanderblue, "Pricing Policies in the Automobile Industry," *Harvard Business Review* (Summer and Autumn, 1939).

The contrast between financial accounting and "normal" costs is important also when an asset has been completely depreciated on the records of an enterprise but is nevertheless still in use. Such a circumstance could, of course, arise for several different reasons. It might occur, for example, if the initial rates of depreciation were deliberately or inadvertently set so high as to overestimate costs, make for higher prices, and underestimate profits. Such an enterprise would be interested primarily in "playing safe." Or, in another case, the asset might still be in use, despite the recognized necessity for replacement, because of the cash or credit condition of the enterprise. Again, the asset which, as noted above, should logically be treated as one in a group, might be the member of the group which had a longer than average life and be counterbalanced by the retirement of other items before they reached average life. While mere honesty requires that no further depreciation charge be made for income purposes (in the absence of asset price changes), it is not so clear whether such costs should be included for pricing purposes.[45] The correct economic solution would be to include the costs of depreciation on the basis of correct valuation rather than to adopt the valuation indicated on the books. But to continue "depreciation" charges at the initial rate is to perpetuate the initial mistake, and is perhaps a more serious error than to neglect this element entirely in costing for pricing purposes. To leave it out completely is to underestimate costs; to include "depreciation" at the old rate is to exaggerate costs.

This problem of pricing and completely depreciated assets is of more general applicability than one might suppose. For reasons of caution and "safety," business executives prefer "high" rates of depreciation, part of which would be designated a risk cost. When the chance of loss fails to materialize, the company can still use its completely

[45] *National Association of Cost Accountants Year Book 1939*, p. 199. It might be noted that for income tax purposes, oil well operators are allowed to deduct depletion indefinitely.

"depreciated" assets; if it does materialize, the asset may have been completely "depreciated." Only in extreme cases may capital write-offs be used for such risk costs. Completely "depreciated" assets may also be a reflection of postponed replacement, especially during periods of reduced output.[46]

Although the question of changes in cost attributable to variations in asset prices is still a serious one, it would not be crucial in industries with comparatively little technical change and relatively constant prices of new assets. Certainly such circumstances would be most favorable for the approximation of the theoretical costs. But there is virtually a complete void of public information on specific "normal depreciation" and "burden" costs; the lack is understandable, because such information is used exclusively by the enterprise in the formulation of decisions and would not generally be of interest even to governmental agencies. This would, therefore, appear to be a most fruitful problem of research via the case study method.

The preceding discussion of the allocation of fixed costs over time suggests two observations for the statistical measurement of cost functions and indicates the relevance of such results to explanations of the pricing decisions of business executives. In the first place, since studies of cost-output relations have relied on financial accounting data which typically utilize straight line methods of "depreciation," there is introduced into the cost function an important element of linearity which is solely attributable to the accounting techniques. An "economically correct" allocation might yield significantly different results. Second, the purpose for which cost allocations are made must ever be borne in mind. "Allocated fixed costs" may not be equally pertinent to such decisions as income calculations, tax pay-

[46] For pricing purposes the inclusion in costs of "depreciation costs" for assets that have been completely "depreciated" has interesting inferences for the problems of cyclical price "flexibility," especially where postponed replacement is possible.

ments, dividend policy, registration with the Securities and Exchange Commission, insurance valuation, and particularly price formation. It is immediately evident that the Bureau of Internal Revenue may prescribe somewhat different depreciation rates from those adopted by business executives. In fact, 11 out of 28 concerns, each in a different industry, replying to a questionnaire of the National Association of Cost Accountants reported that they kept different records of depreciation for "cost accounting and tax purposes."[47] This practice need not be condemned as inconsistent or as constituting a double standard. In a similar way statements filed with the Securities and Exchange Commission may, because of the special purposes of these registrations, contain still other valuations of assets than those used in either tax reporting or income accounting.[48] Under such circumstances the primary function of the income account pertains less to history than to "the light which it throws upon expected earnings in the future."[49] It must be recognized that these special purposes would revise even correct economic valuations, although perhaps not as much as those involved in the conventions of straight line "depreciation" charges.

6. *Research Possibilities*

There can be no doubt that the subject matter of this chapter, with special reference to pricing decisions, constitutes one of the most important fields of empirical study. But it is correspondingly difficult. At least two fundamental distinctions must be drawn if a start is to be made. For one

[47] *Op. cit.*, p. 1053. There can be little doubt, however, that the conventions introduced for one purpose frequently affect others. Depreciation rates prescribed by the Bureau of Internal Revenue may come to be adopted by enterprises in cost and financial accounting. See debate on this point: *National Association of Cost Accountants Year Book 1939*, pp. 197-99.

[48] Jerome N. Frank, Address to the Controllers Institute, reprinted in *Journal of Accountancy* (November 1939).

[49] George O. May, *op. cit.*, p. 5.

thing, there can be little sense to a general purpose allocation of "overhead" over time. Each type of decision—pricing, income calculation, taxation, replacement, and dividend policy—may require its special purpose concepts of costs "properly assignable to a given period." Secondly, every calculation of "depreciation" costs for a single period involves a particular set of expectations about the future performance and price of the asset. Such costs cannot depend upon "past performance" alone.

(1) The tendency of those costs that are fixed relative to output in any single accounting period to change as a proportion of total costs needs examination. On general grounds there are reasons to suspect that the proportion tends to increase. This variation, both within the business cycle and over long periods, could be the subject of a valuable study.

(2) For certain types of "factors" there is almost no generally available information as to "price" variations. For instance, indexes of tax rates (real estate) and insurance scales are scarcely available at all. An empirical study would have to try to surmount the exceedingly difficult problem of different bases of valuation; yet the movements of such "rates" are not generally known. It probably would be necessary to present a great many classifications rather than a single index number.

(3) There is need for studies of the "depreciation policy" of individual enterprises. Most work so far has emphasized the relation between reserves and investment expenditures. But the role of "depreciation" in other decisions—pricing and dividend disbursement—needs much more empirical data.

(4) With engineering assistance a worth while investigation could be made of the relative importance of use and time depreciation for various types of assets in different industries.

(5) Although a few studies have dealt with the "depreciation" policies of a small number of relatively large enterprises by the questionnaire technique, little evidence

has been brought forward to show how typical these policies may be considered. In particular, information concerning the practices of smaller enterprises is scarce. A detailed study of the practices and regulations of the Bureau of Internal Revenue would be enlightening in this respect.