Volume Title: Cost Behavior and Price Policy

Volume Author/Editor: Committee on Price Determination

Volume Publisher: NBER

Volume ISBN: 0-87014-190-2

Volume URL: http://www.nber.org/books/comm43-1

Publication Date: 1943

Chapter Title: Allocation Of Costs Among Products

Chapter Author: Committee on Price Determination

Chapter URL: http://www.nber.org/chapters/c2096

Chapter pages in book: (p. 170 - 188)

Chapter VIII

ALLOCATION OF COSTS AMONG PRODUCTS

IN THE preceding chapters of this report it was assumed, for the purposes of discussion, that an enterprise produces and sells but a single "product." This assumption simplified the description of cost functions and the analysis of allocation of overhead costs through time by eliminating some of the complexities of the conceptual measurement of output. A somewhat more general, although still restrictive, assumption could have been employed instead, namely, that the proportion of each of the "products" constituting output remained unchanged.[1] The fluctuation in the output of any "product" is then treated as an adequate index of the variation in total output. This device, however, is of limited applicability even for the purpose of measuring output, and is useless in determining costs for such decisions as pricing, output determination, internal control and consideration of the range of "products" to be carried by an enterprise. It is patently evident that almost all enterprises today make and sell more than a single "product," according to most definitions of this term. The development of by-products, different sizes, models, colors, lengths, finishes, and the tendency to carry complete "lines" of products, point to the prevalence of the multiproduct firm.[2] The United

[1] As was noted in Chapter V, this was the assumption implicit in the Steel Study undertaken by Professor Yntema, at least if the device of a production index of output is rigorously interpreted.

[2] The definition of a "product" will be discussed in Section 1. "In reality . . . (cases of joint supply) occupy a large, perhaps the largest, part of the field of production." Knut Wicksell, *Lectures on Political Economy*, tr. by E. Classen and ed. with an introduction by Lionel Robbins (George Routledge, London, 1935), Vol. I, p. 26.

States Steel Corporation, for instance, is reported to be making over 50,000 different steel products, not to mention a multitude of nonsteel products and services.[3] Chapter III and Appendix D specify in detail the variety of products of the paper industry. In industries producing on order or specification, each unit of output could frequently be designated a separate product—each containing, of course, many of the elements of other products. The focus of this chapter, therefore, is cost determination for a limited range of decisions under conditions where an enterprise turns out many products.

Under these less abstract circumstances, the determination of the costs of a single product is more than an academic issue, as is attested by the public debate on "loss leaders," resale price maintenance and costs to be used in determining power rates by the Tennessee Valley Authority when flood control, electric power, and transportation facilities are "joint products." Business executives are frequently beset by a range of problems requiring cost allocation among products in decisions involving pricing, the relative output schedules of different products and the inclusion or exclusion of items from the range carried by an enterprise. None of these problems would arise in the manufacture of a single product, and the more diversified the line of products, the more complex are the problems.

1. *Matters of Definition*

A great deal of confusion concerning multiproduct problems in both economic literature and accounting practice has resulted from verbal pitfalls, lack of clarity in basic ideas of products and costs, and failure to designate a specific purpose for which costs are separated. It is unwise to proceed to an examination of business practices until these sources of confusion have been eliminated.

A general purpose allocation of costs among products is

[3] Testimony of Melvin G. de Chazeau before the Temporary National Economic Committee, January 23, 1940.

just as barren as a general purpose allocation of costs over time was observed to be (Chapter IV) for such diverse purposes as tax returns, rate regulation, Securities and Exchange Commission registration, income determination, inventory valuation and replacement decisions. Each type of judgment requires a cost calculation that may be irrelevant to other decisions. In precisely the same way, the allocation of costs among products (while not pertinent to most of the decisions just indicated) must be directed toward specific problems. For the determination of total income, for instance, only total costs are required; their allocation among "products" is entirely immaterial. Some of the particular decisions for which "product" costs are vital have already been suggested: the price relationships of two or more products; their relative outputs; expansion or contraction of a line of products; internal control, which may require an appraisal of the relative efficiencies of several departments or processes. Again, in some industries the computation of the costs of supplying a particular order or job lot raises questions analogous to those involved in a simultaneous production of many products. It may be necessary, finally, to *justify* a structure of prices on the basis of "costs" for a group of closely related "products" under proceedings before the Federal Trade Commission or state Fair Trade Practice Boards.[4] While part of the discussion to follow will be devoted to cost allocation between products for all these purposes, the central emphasis will be on decisions concerning relative prices and schedules of output.

The mere attempt to define a "commodity" or a "product" has raised some of the most elusive of all problems in economics. A definition in terms of a "marked gap between itself and its closest substitutes"[5] meets the criterion of logical elegance, but the search for empirical applications

[4] Walton H. Hamilton, "Cost as a Standard for Price," *Law and Contemporary Problems*, IV (June 1937), pp. 321-33. The issue is entitled "Price Discrimination and Price Cutting."

[5] Joan Robinson, *The Economics of Imperfect Competition* (Macmillan, London, 1934), p. 17.

encounters numerous obstacles. For the present purpose it will be adequate to adopt any arbitrary but generally accepted demarcation between products in a single market (an exchange between buyers and sellers in which prices are equal or differ only by the "costs of transportation"). With this view of a product or commodity, a distinction vital to the present interest in cost allocation can be drawn between products that differ primarily because of market conditions and those distinguished by technical conditions of production as well. For instance, commodities may differ only because they are sold in different "markets"; the well known phenomenon of price discrimination involves the classification of buyers in separate market groups. Electrical energy sold to industrial, as distinct from residential, users constitutes two different products. Products that are differentiated only because of the type of market separation exemplified in price discrimination do not raise any serious problems of cost allocation.[6] The costs of the several differentiated products are identical except for those involved in separation of the markets. Such costs are usually not large and theoretically can be readily identified with the separate markets in question.

But products may be differentiated for other reasons than market separation directed toward price discrimination. Price discrimination implies technically substitutable physical goods, whereas frequently an enterprise produces goods or services which no one regards as interchangeable. General Motors Corporation, for instance, manufactures automobiles as different as a Chevrolet and a Cadillac; the International Harvester Company produces a line of farm equipment varying from binder twine to combines; and the products of petroleum refining companies range from tar to high grade gasoline. If the individual costs of any one of these products is to be determined for pricing purposes, a distinction must be carefully drawn between *separable* and *common* outlays. The sum of the two is equal to total

[6] The accepted solution of pricing and output under such circumstances is presented in *ibid.*, pp. 179-202.

costs during a given accounting period. In most operations involving the production or extraction of many products there are usually stages in the processing that are separate for each product, and there are processes and expenses common to all. After various petroleum products have been separated, additional operations, peculiar to each separate product, are undertaken. The separate costs, readily identifiable with individual products, obviously present no new difficulties. The more vertically integrated an enterprise or the wider the range of products manufactured by a single enterprise, the smaller in general is the proportion of separable to total costs, or the larger the proportion of common costs. It is these common costs that make allocation difficult and therefore constitute the central concern of this chapter. In terms of earlier chapters these common costs in any single accounting period may usually be supposed to consist of three parts. The first is that portion of costs which is *allocated* to the period, i.e., depreciation on plant, and not directly identifiable with particular products. Not all "depreciation" is included, however, because a machine may be so specialized as to be used exclusively for a single product. Second come the recurrent fixed[7] costs incurred in the period; these are relatively fixed with respect to output and cannot be identified with particular products. The salary of the president of the corporation would fall within this category, although other salaries might be entirely identifiable with particular products. The third component of common costs is the proportion of the variable outlays of a single period (largely labor and materials) that is not directly attributable to particular products.

It is sometimes thought that joint costs are synonymous with common costs.[8] It is true that all joint costs are com-

[7] See Chapter IV, Section 3.

[8] A. C. Pigou contends that such a view was held by F. W. Taussig in 1913. See *The Economics of Welfare* (4th ed., Macmillan, London, 1938), p. 298. Professor Taussig's views were set forth in *Principles of Economics* (1st ed., Macmillan, 1911), p. 381, in a controversy with Professors Pigou and Seligman over costs appropriate to railroad rates. See also J. M. Clark, *Studies in the Economics of Overhead Costs* (Uni-

mon, but the converse is not a correct statement under accepted definitions. Two or more products are said to be supplied jointly when a variation in the supply of one alters the supply of others in the same direction. "Articles will be considered joint-cost products only when a variation in the facilities for putting out one product or one set of products brings about a variation in the same direction—somewhat so, though not necessarily in any definite ratio—in the facilities for putting out another product or another set of products." [9] A number of different products can be turned out, and a change in the amount of the output of one product can alter the output of others, without justifying the use of the term "joint costs." It is only when a variation in the output of one product involves a change in the output of other products *in the same direction* (although not necessarily in the same proportion) that joint costs can be said to exist. Implicit in this notion, although seldom recognized, is the proposition that every possible technical change or alteration of plant and equipment be explored in the determination of joint costs. If the output of one product is decreased while others increase in output, joint costs are not present. The classic instances of joint costs occur in the production of wool and mutton, raw cotton and cotton seed.[10]

It is customary to subdivide joint costs into two types, according to the way in which a variation in the "facilities" [11] for the output of one product affects the output of others.

---

versity of Chicago Press, 1923), p. 59, note 1. Professor Taussig held that "whenever a very large fixed plant is used, not for a single purpose, but for varied purposes, the influence of joint cost asserts itself" (1st ed., Vol. I, p. 221). An almost identical statement is found in his 3rd ed. (1921), Vol. I, p. 217, but in the 4th ed. (1939), Vol. I, p. 193, the paragraph containing this statement is deleted. See also Alfred Marshall, *Principles of Economics*, 8th ed., p. 376.

[9] T. J. Kreps, "Joint Costs in the Chemical Industry," *Quarterly Journal of Economics*, XLIV (May 1930), pp. 418-19. Professor Pigou gives a similar definition, *op. cit.*, p. 298.

[10] Hubert D. Henderson, *Supply and Demand* (The University Press, Cambridge, Eng., 1922), Ch. V.

[11] The term is that of T. J. Kreps, *op. cit.*

Joint costs with fixed or invariable proportions exist when no fluctuation in the rate of output of one product or no change in facilities can alter the proportion in which the products are produced. All other cases of joint costs can be designated as instances of variable proportions, although wide differences can be expected in the range of variability among groups of joint products. In the extreme case in which proportions are completely variable, costs cease to be joint, for the output of one product may be increased without a corresponding directional change in the output of others. Instances of joint costs with variable proportions therefore lie somewhere between this limit and that of absolutely fixed proportions.

There has been some disagreement among economists as to how particular examples of joint costs should be classified. The case of variable proportions presents no problems: the examples of mutton and wool, poultry and eggs, bacon and lard, scrap materials and metal products are readily acceptable on all sides. The controversy arises over the possibility of instances of fixed or invariant proportions. Professor Kreps contends that such cases are frequently encountered in industry at large and are especially prevalent in the chemical processes. He suggests "the cutting of leather in a shoe factory, or of cloth in tailoring establishments, or the bark, saw kerf, edgings and trimmings in saw mills and furniture factories." From the chemical industry he mentions "niter cake and nitric acid, salt cake and muriatic acid . . . by-product ammonia and coke or illuminating gas."[12] Professor Viner, on the other hand, holds that in all cases of joint product it is possible to vary the proportions, at least to some degree, so that there is no instance of absolutely fixed proportions.[13] An increased use of skilled labor, for instance, may be able to alter in some degree the amount of scrap and finished product. "However, where the expenses of varying the proportions

[12] *Ibid.*, pp. 419-20.

[13] Article on "Cost," in *Encyclopaedia of the Social Sciences*, Vol. IV, p. 473.

of output are large per unit of variability, the supply curve is so discontinuous and so relatively inelastic, and the increase in marginal prime costs is so abrupt, that joint costs with relatively invariable proportions may be predicated." [14] For present purposes it is sufficient to conclude that while cases of *absolutely* fixed proportions may be nonexistent, the proportion in which some products are produced may be variable only within very narrow limits and at great expense.

The purpose of this section has been to attempt to isolate the issues involved in a consideration of common cost by eliminating at the outset products that were differentiated only by classification of buyers into several market groups. For the remaining group of products produced or sold together, the costs that are separable appear to raise no fundamental problems of allocation. In certain cases the costs common to these products may be designated as joint costs when an alteration in the facilities for turning out one product is found to vary the output of other products in the same direction. These products are probably always manufactured in proportions that may be varied, although in some instances the limits may be very narrow and the costs of variation large.

2. *The Theory of Cost Allocation*

A rational basis can be established for price and output decisions under conditions where joint products are made in variable proportions.[15] In such circumstances it is theoretically possible, through a continuous variation of these proportions, to estimate the marginal costs of each separate product. Strictly, the marginal costs of a product thus determined would vary for different levels of total output. An enterprise will reach the correct economic combination of products for profit maximization when the mar-

[14] T. J. Kreps, *op. cit.*, p. 420.

[15] The applicability of the theoretical solution is discussed in the next section.

ginal cost of each product equals the revenue increment from its sale.

This theoretical solution suggests at least two issues that may radically alter the results. The first is the costs of varying the proportions. While all costs may be variable with respect to changes in output proportions over the long run, the inflexibility of plant and equipment in many cases imposes serious cost limitations on short period variations in these proportions. Within the framework of a "plant," outlays involved in varying the combination of products may have to be treated as an item to be depreciated over several accounting periods. Outlays of this sort would not be undertaken unless the additional receipts exceeded the large additional costs.[16] It is clear, therefore, that instances may arise in which the costs of varying proportions are so large that technologically variable combinations of products become cases of economically fixed proportions.

The second question raised by the theoretical solution to a decision concerning relative outputs pertains to the discreteness of the change in proportions. If the relative proportions in which products are turned out can be varied only within narrow limits, or if only a few discrete combinations can be made,[17] it may be virtually impossible to measure accurately the marginal costs attributable to the products separately. Here one is confronted not only by a conceptual problem but also by the kind of statistical difficulty encountered in an empirical approximation of marginal cost functions. Although the difference in total costs between two widely divergent combinations of products may be obtained, this cost difference may bear no relation to the incremental cost of any of the constituent products. Detailed empirical work is of course necessary to a judgment as to the relative weight of the costs of changing out-

[16] See Chapter VII for a more precise statement of the costs involved.

[17] There must be at least as many proportions in which the products can be combined as there are products, for otherwise there will be some products in fixed proportions.

put proportions and the discontinuities and relative fixity of plant investment, but there is little doubt that these limitations to output variations in multiproduct firms are frequently important.[18] The lack of any satisfactory theoretical solution does not obviate the business executive's need to make decisions concerning relative outputs and prices under these conditions.

In view of the difficulties mentioned above, it should be evident that there can be no principle, rational within the framework of theoretical economics, for the allocation of joint costs under conditions of invariable or fixed proportions. Where the combination of products is inalterable, the calculation of the marginal costs of any product is impossible. If variation can occur only within narrow limits and at high costs, the shape of the cost function, even when it can be determined, may have little relevance to business decisions. Within the short run, relatively fixed output proportions may be fairly frequent. In such conditions the principle is still true that in the long run total revenue from all products must cover total costs, but this is not very helpful to decisions about relative outputs or relative prices. At least two general rule-of-thumb methods of isolating the cost of a single product have been suggested.

(a) *The By-Product Method.* The cost of a single product A (in practice, the principal product) may be conceived as the aggregate cost of producing all the joint products minus the realization on all the other products except A. Such a formula reduces itself to an absurdity under conditions where the realization on all products other than A exceeds the total costs of producing all joint products, for the cost of A would then be a minus quantity.

[18] Frequently relative invariance in output proportions is due to recalcitrance of the material. In the lumber industries logs of certain sizes are sawn into lumber of certain types, so that the quantitative relations of the classes and dimensions can be varied only within limits. In the bituminous coal industry, extraction yields coal of varying grades and sizes in proportions likewise difficult to vary.

Another failing of this method of allocation shows up when it is applied to problems of internal management and cost control. Variations in the prices of products other than A would give rise to changes in the cost of A. Cost changes resulting from changes in efficiency are hopelessly confused with changes in market prices.

(b) *The Sales Value Allocation Method.* It has sometimes been suggested that total costs be allocated among products in proportion to their market price. This procedure obviously cannot be utilized for decisions affecting price and relative outputs. These limitations are not surprising since it has already been shown that no logical allocation is possible under the condition of completely fixed proportions.

3. *Accounting Practice and Cost Allocation among Products*

The cost accountant does not ordinarily make distinctions between common costs and joint costs; nor does he in turn subdivide joint costs into fixed and variable proportions in the fashion of economists. He must create a detailed system of general purpose cost records which can be integrated into the financial accounting records of the whole enterprise by means of "controlling accounts." [19] A general purpose system cannot be equally adequate to the demands of all types of decisions respecting the relative costs of products,[20] and consequently special cost computations may be made as the occasions for particular decisions arise. It may, therefore, be impossible to ascertain from general cost accounting records what data were actually considered in any particular decision.

Cost accounting systems make the distinction between common and separable costs, and allocate the latter to particular products, for no serious difficulties arise in this process. In the meat-packing industry, for instance, it is

[19] W. B. Lawrence, *Cost Accounting* (Prentice Hall, 1933), p. 3.

[20] See Section 1 of this chapter.

possible to segregate those costs incident to the finishing and packing of each product. All costs that cannot be readily segregated (i.e., common costs) are treated alike; in effect they are regarded as joint costs in invariant proportions and some arbitrary standard of allocation is adopted to satisfy the requirements of a cost accounting system. To contend that such standards are "arbitrary" does not imply that they are useless or erroneous. Individual product costs, calculated in such systems, may be invaluable for purposes of internal cost control and for providing some way of justifying existing price relationships.[21] In fact, it may not be a serious error to regard these as the specialized functions of cost accounting systems.

The reasons why cost accounting systems treat nonseparable costs as if they were joint costs in fixed proportions are readily understandable. Consider the typical case of a machine being used to process a common raw material which will eventually enter into several different products (a case of common but not joint costs).[22] The total amount of depreciation costs on the machine for the current accounting period was the concern of Chapter IV; here the interest is in how this cost is to be divided between the processed products. Theoretically, for a decision respecting relative outputs, it would be necessary to estimate the marginal cost function of each use of the machine. If depreciation were solely a function of time, the decision would have to take into consideration the marginal revenues of the alternative products. The impracticability of calculating the increment of cost with each change in the composition of the products processed is obvious. The rule-of-thumb allocation will be used for cost control purposes, leaving

[21] The system of allocation may be selected for just this purpose. The objective may be to equalize the "profits" from each "product." For instance, see Norman R. Webster, "Pricing and Costing Graded Products," *N.A.C.A. Bulletin,* XX (November 1, 1938), p. 290.

[22] The products might here be called in *rival production,* since an increase in the output of one will decrease the possible output of the other when the operation of the machine is at capacity.

the decision respecting relative output to executive judgment or special engineering calculations.[23]

Again, to go through the correct economic calculation with every single item of "overhead"—salaries, lighting, taxes, etc.—would require an excessive amount of work relative to the returns. The cost of making cost calculations cannot itself be neglected. Some rule of thumb, lumping all these items together, is therefore utilized. The magnitude of these difficulties is enhanced in cases of genuine joint costs where the costs incident to variations in the proportions of products would have to be incorporated into the accounting system. Finally, in cases of fixed proportions or where the costs of varying proportions are large (see Section 2), some arbitrary allocation will have to be used if separate product costs are to be found. It is not surprising, therefore, that cost accountants have adopted a number of rule-of-thumb devices (to be noted shortly) for allocating common costs among products. While these standards of allocation simplify the accounting task of *finding a cost figure for each product* (which may be useful for many purposes), they do not really make the decisions of executives on pricing and relative outputs any easier. If such cost data are initially used as the basis of decisions, it may usually be possible to improve the profit position of the enterprise by judicious modification. No doubt this type of revision is constantly being made; it explains, in part, the well known fact that the translation of costs into prices is never mechanical.

The most commonly used devices or rules of thumb for allocating costs among products in accounting systems, according to a Research Study of the National Association of Cost Accountants, are shown in Table 13. The table refers only to "overhead," but there can be little doubt that most common costs would be included in this category.

[23] Interesting problems of cost allocation among various "products" arise in pickle manufacturing, where costs of common processes must be allocated to pickles of different sizes and grades. The sales value method (p. 180) is ordinarily used. W. Albert Bush, "Pickle Costs," *N.A.C.A. Bulletin*, XX (November 1, 1938), p. 277.

Comments on the questionnaire revealed that the replies were not "limited to productive departments but referred as well to service departments, such as the storeroom, the boiler room, etc. Material cost is used as a basis for applying stores' department overhead. A weight basis is used for the same purpose in applying foundry overhead."[24] The table

TABLE 13

BASES USED IN APPLICATION OF OVERHEAD[a]

Bases Used	*Number of Companies* Using as Major or Only Base	Using as Secondary Base	Total
Actual direct labor cost	96	13	109
Actual direct labor hours	27	21	48
Actual machine hours	30	13	43
Weight basis	7	39	36
Standard machine hours	13	22	35
Standard direct labor hours	29	4	33
Unit of product	11	18	19
Material cost	..	11	11
Prime cost	5	5	10
Standard direct labor cost	5	..	5
Miscellaneous	1	2	3

[a] "Practice in Applying Overhead and Calculating Normal Capacity," *N.A.C.A. Bulletin*, XIX (April 1, 1938), Section III, p. 922.

confirms the impression that the relative amount of direct labor costs separately attributable to each product is the most popular basis upon which common costs are allocated to various products within an enterprise.

One of the most instructive instances of accounting technique adopted to allocate costs among products is provided by an examination of the petroleum industry.[25] The refining of crude petroleum into its principal products—gasoline, kerosene, distillate fuel oils, and residual fuel oils—provides a vivid illustration of joint costs with variable proportions.

[24] *Loc. cit.*

[25] See *Hearings before the Temporary National Economic Committee*, Parts 14, 14A, 15 and 15A. In particular, see the excellent "Statement of Witness Robert E. Wilson," Exhibit 1194, Part 15, *Petroleum Industry*, Section II, pp. 8619-65.

An increase in the facilities for refining gasoline results in an increase in the production of other items. The fact that the proportions in which the various products are refined has changed substantially is attested by the increase from 25 percent to 44 percent in the gasoline yield from average crude in the period 1919–31.[26] It is significant to note that there have been rather marked changes in these percentages over the twenty-year period, but that in each case the changes are smooth and almost always in one direction.

Before the introduction of the internal combustion engine, oil was distilled largely for its kerosene and "the more volatile fractions were partly included in kerosene and partly discarded."[27] With the advent of the automobile, the relative demand for crude products shifted from kerosene to gasoline and the reverse incentive was given to increase the relative gasoline yield.[28] The development of cracking processes greatly increased the amount of gasoline yields and enhanced the flexibility or the possible variations in proportions of products. "By the use of carefully controlled high temperatures and pressures, [these processes] soon were able to convert excess kerosene and relatively low-value gas oil into 60 or 70 percent gasoline."[29] The development of polymerization processes has been another method by which the yield of gasoline has been increased and the flexibility of proportions enhanced.

In view of the discussion of Section 2 concerning the theoretical problems of allocating joint costs, the accounting practices of the petroleum industry merit particular attention.[30] Both the sales value allocation method and the by-product method have some following in practice. Another method, which attempts to eliminate some of the limitations of these systems of allocation is the "gasoline value"

[26] See Exhibit 1199, submitted by Robert E. Wilson, *ibid.*, p. 8660.

[27] "Statement of Witness Robert E. Wilson," *ibid.*, p. 8623.

[28] *Report of the Committee on Oil Price Research* (National Bureau of Economic Research, mimeographed), p. 11.

[29] "Statement of Witness Robert E. Wilson," *op. cit.*, p. 8623.

[30] For a general treatment see Raymond Walter McKee, *Handbook of Petroleum Accounting* (Harper and Bros., 1938), pp. 316 *et seq.*

or "replacement value" method, essentially a modification of the by-product system. "The fundamental precept of the *Replacement Value* method . . . is that gasoline is the principal product desired, and that its cost, therefore, should be as independent as possible of the amount produced and the price received from other products derived from crude." [31] Here the essential idea is that those variables which affect the costs of refining gasoline (and are beyond the control of an enterprise) can be reduced in number if the primary distillation products, kerosene and distillate fuel oil, are costed at their gasoline conversion value rather than at their market price. This method prevents the fluctuation of the price of kerosene and distillate fuel oil in the market from influencing the accounting cost of gasoline. Kerosene and distillate fuel, it will be remembered, are "distinguished from residual fuel oil in that they have a *potential* gasoline yield, whereas residual fuel oil is the product remaining after *all* the potential gasoline has been recovered." [32] Under the replacement value scheme, the by-product method is modified to the extent that only the heavy fuel oil is subtracted from total costs on the basis of its actual realizations. The intermediate products like kerosene are converted into their gasoline yields. Each crackable product is valued according to the amount of gasoline it will yield in comparison to the gasoline yield of raw crude. In addition to eliminating the price of the intermediate products as determining factors of the cost of gasoline, the method has the advantage of indicating whether it is profitable for an enterprise to convert kerosene into gasoline or to sell it at prevailing kerosene prices.

There can be no doubt that costing of gasoline by the replacement value method provides the closest approximation to the correct economic allocation of joint costs under varying proportions of any of the accounting methods in

[31] "Statement of Robert E. Wilson," *op. cit.*, p. 9646. It is noteworthy that this statement should include the remark, "as independent as possible of the amount produced." The method assumes implicitly that the total cost function "ought" to be linear.

[32] Wilson, *op. cit.*

general use. Since the proportion of gasoline to total refined products can be varied widely, as a technological fact, the decision respecting relative proportions is an important one. The replacement value method facilitates this decision by providing information as to how much of the intermediate products of kerosene and distillate it will be profitable to convert into gasoline in view of the existing relative market prices of gasoline and the intermediate products. The chief hindrance to a valid theoretical solution arises from the subtraction of the realization on the residual fuel oil from the total cost as provided under the by-product method. If there were no residual fuel oil or if its price were determined in a perfectly competitive market, the replacement value method would appear to provide a very close fit to the theoretical standard under varying proportions. In actual practice it permits a closer fit than any other method and could be improved upon only by elaborate special studies.

4. *Cost Research under Multiproduct Conditions*

The preceding discussion of multiproduct costs certainly demonstrates how much simpler cost analysis would be if each enterprise produced a single homogeneous "product" or even if it processed a number of "products" that were not in joint production. In particular, the determination of the shape of the cost function and the method of measuring the rate of technical change from cost data would be enormously facilitated. Previous chapters have shown that basically only two alternatives are open for cost studies under multiproduct conditions, regardless of whether the products are separable, common or joint. Either an attempt must be made to allocate costs to single products, which becomes a progressively more difficult accounting technique as the number of joint products is increased, or the device of an index of production must be utilized. The limitations and difficulties of the first solution have just been examined, and the production index device

was discussed in Chapter V. Neither of these techniques is entirely adequate to the purpose of measuring the cost function or the rate of technical change. Ordinarily, the fewer the number of "products," the larger is the proportion of costs that are separable; and the greater the constancy in the proportion of products manufactured, the more valid are both devices. In some instances one technique may be superior to the other. For example, under conditions of many "products" (grades, models, sizes, etc.) produced in relatively constant proportions, the production index would prove to be superior to the allocation of costs to each "product." On the other hand, the device of cost allocation among products might preferably be employed where there is one main "product" and where many lesser ones are produced in fluctuating proportions and yet reducible to the main product by manufacturing processes.

The choice between production indexes and cost allocations to particular "commodities" in multiproduct firms must depend in part upon the amount of time and effort involved. There can be no doubt that far more accurate cost allocation than has been accomplished is in fact possible. Probably a larger proportion of costs is separable than would appear from accounting practice. The current approach, as has been noted in Section 3, is to allocate "overhead" among products on some rule-of-thumb basis. A great deal of work—which probably would not be worth while to the enterprise as a regular feature of its cost accounting system—could separate a considerable portion of these costs in many instances. In some enterprises special tabulations are constructed for decisions on relative output; these make no attempt to employ the technique of allocating all costs to "products" by a single formula. In fact the general allocation by "machine hours" or "direct labor" is frequently employed almost exclusively for purposes of internal cost control. The objective of "product costs"—calculated on any system of allocation—is to provide a standard which lesser officials can attempt to "beat." More detailed studies which at least segregate separable

costs are made on the occasions of specific decisions. These data are not, of course, generally available. Yet one must not conclude from the cost allocations made in the general purpose system of costing that all executive decisions are based on these data.

(1) Among the most significant opportunities for research in the field of product costs is the possibility of examining specific purpose cost allocations and comparing these costs with those derived by the general purpose system. What costs do executives secure when it becomes necessary for them to act on questions of relative output and prices? Such an inquiry would no doubt require special cooperation on the part of business executives and particular insight by the analyst.

(2) An empirical study requiring some technical background in engineering could formulate a judgment as to the relative frequency in actual practice of instances of fixed and variable proportions. Are cases in which proportions are fixed, or can be varied only at great costs within narrow limits, the more typical?

(3) The formulation of relative prices for closely allied products, that is, those differing in size, model, color, etc., in a single enterprise might be made much more intelligible if the separable costs could be specified. A study in this direction could inquire into the character of the cost information available to business executives on differential costs between allied products.

(4) Of special interest also are the kinds of cost calculations that business executives make in deciding whether to add another product to an existing line or whether to take another order. It will be found that such "product costs" may diverge from those indicated by the general purpose product allocation.