

**PRICE STUDIES**  
**Number Four**

# Cost Behavior and Price Policy

A STUDY PREPARED BY THE  
COMMITTEE ON PRICE DETERMINATION  
FOR THE CONFERENCE ON PRICE RESEARCH

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*(Resolution adopted October 25, 1926 and revised  
February 6, 1933 and February 24, 1941)*

## FOREWORD

This volume is the first report of a Committee established by the Conference on Price Research to study the process of price determination in business firms. The focus of the present study is on the behavior of costs in the firm. The Committee on Price Determination expects in subsequent studies to investigate other aspects of business price making.

EDWARD S. MASON, *Chairman,*  
*Conference on Price Research*

## PREFACE

THE CONFERENCE ON PRICE RESEARCH, organized by the National Bureau of Economic Research and other institutions, set up in October 1938 a Committee to investigate the possibilities of empirical research in the field of cost-price relationships and price determination. This report, which is the Committee's first publication, is concerned principally with certain aspects of cost behavior. In subsequent reports the Committee expects to cultivate other parts of this field.

The Conference on Price Research has already published a series of studies designed to explore the opportunities for research in several industrial areas—coal, iron and steel, oil and textiles.<sup>1</sup> It is hoped that the work of these “exploratory committees” may now be supplemented by the reports of standing committees charged with the task of surveying somewhat larger areas from a different point of view. At the present time three such committees are cooperating in the research program of the Conference. They are concerned respectively with cost-price relationships and price determination, with governmental price regulation and with business price policies.

The mandate of the Committee on Cost-Price Relationships and Price Determination calls for study of the origin of price

<sup>1</sup> *Report of the Committee on Prices in the Bituminous Coal Industry* (National Bureau of Economic Research, 1938), *Price Research in the Steel and Petroleum Industries* (National Bureau of Economic Research, 1939), and *Textile Markets—Their Structure in Relation to Price Research* (National Bureau of Economic Research, 1939).

policies and pricing procedures, and of the processes of price determination. Its primary concern is with prices set through the enforcement of private business policy and by the play of competitive forces. Within this area the Committee is interested in the forces and conditions, both internal and external to the business enterprise, that determine prices, rather than with the consequences for the economy as a whole of price policy and behavior. Its central function, hence, is to study why prices are what they are, how prices are made, what role costs play in explaining them, what other factors (such as demand shifts and elasticity, substitute competition, structure of markets and other aspects of business environment) influence the setting of prices.

The immediate task of this Committee is to study the role played by costs in determining prices. In this study it is examining the kinds of information about costs possessed by businessmen, the way costs behave in response to changes in size of firm, rate of output and prices of input factors, and the relationships between cost behavior and observed price behavior. Since costs are only part of the explanation of decisions concerning prices, the Committee will be led eventually into an analysis of demand considerations, and of market structure and industrial characteristics conditioning prices and determining the range of administrative discretion.<sup>2</sup>

This mandate formulated by the Conference on Price Research is interpreted by the Committee on Price Determination to require in the present report (1) an examination of the available material relevant to the behavior of costs and the relation of costs to prices; (2) an appraisal of existing studies of cost behavior and cost-price relationships; and (3) a discussion of research methods which seem appropriate to the problems in this field.

Obviously in an area as broad as this, and with material of such diversity, the Committee has been compelled both

<sup>2</sup> Statement by the Executive Committee of the Conference on Price Research.

to select and to simplify. The focus of attention has been on cost and price adjustments within individual firms. The kinds of cost-price problems studied and the particular firms and industries discussed have been determined largely by the availability of material. Consequently the findings of this report cannot be regarded as either comprehensive or typical. They are, however, illustrative of some important types of cost behavior and cost-price relationships in certain important sectors of the economy.

The work of the Committee has been furthered substantially by Professor Joel Dean of the University of Chicago, who formulated research problems and prepared memoranda on research techniques, and by Dr. John T. Dunlop of Harvard University, to whom the original draft of a large section of the report is to be credited. Dr. Roswell H. Whitman of R. H. Macy and Company contributed the chapter on "Selling Costs." Mr. Caleb A. Smith, Teaching Fellow and Tutor in Economics at Harvard University, has been of great assistance not only in the collection of material but in the preparation of the manuscript. Appendix A on "Cost Surveys by the Federal Government" was prepared by Mr. Mark Massel in connection with his work for the Bureau of Research and Statistics of the Office of Production Management. Appendix B on "Cost Accounting and Price Determination in the Soviet Union" was written by Mr. Paul Baran, formerly a graduate student in Economics at Harvard University. Appendix C on "The Replacement of Depreciable Assets" is the work of Mr. Caleb A. Smith. The Committee is indebted to Thor Hultgren, of the Research Staff of the National Bureau of Economic Research, for his critical reading of the manuscript and his constructive suggestions; to H. Irving Forman for drawing the charts; and to Bettina Sinclair for editing the report and supervising its publication. The manuscript of this study was finished in substantially its present form in the spring of 1941.

The Conference on Price Research wishes to acknowledge the financial assistance of the Harvard Committee on Research in the Social Sciences in connection with a part of the research.

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**PART ONE**  
**THE NATURE OF COSTS**  
**AND PRICES**

## Chapter I

### INTRODUCTION

PERHAPS in no area of economic inquiry is there so wide a gap between theoretical and empirical work as in the field which has long been considered the core of economic analysis—the formation of prices. The study of variations in output, employment, national income, investment, savings and interest rates, and the multiplier effects of income-creating expenditures has proceeded in recent years on the basis of hypotheses which have permitted rather extensive empirical examination. Changes in these and in other variables embraced within the hypotheses can be and have been measured. In many cases, no doubt, the statistical procedures have been extremely venturesome, and the resulting averages and aggregates probably hide many holes into which rash investigators have fallen and will continue to fall. Nevertheless, in studies of this sort theoretical concepts are not usually formulated without regard to the possibility of actual application, whereas in the field of price analysis until recently there has been very little attempt to coordinate practice with hypothesis.

Price theory has placed increasing emphasis on the operations of the individual firm under various assumed demand and cost conditions. While some theorists are of the opinion that this trend has gone too far and that approximately accurate and useful results can be obtained only so long as firms can be grouped into markets or industries which are treated as substantially competitive,<sup>1</sup> it seems safe to say

<sup>1</sup> J. R. Hicks, *Value and Capital* (Clarendon Press, Oxford, 1939), p. 84. "It is, I believe, only possible to save anything from this wreck—and it must be remembered that the threatened wreckage is that of the greater part of economic theory—if we can assume that the markets confronting most of the firms with which we shall be dealing do not differ very greatly from perfectly competitive markets."

#### 4 NATURE OF COSTS AND PRICES

that with respect to most industrial market situations the competitive assumption involves serious distortion. Here the individual firm must be recognized as the principal unit of study.<sup>2</sup> Although contemporary theory emphasizes this point of view, little attention has been given by economists to the application of their "tools" of price analysis. Furthermore, theoretical speculation on the reaction of individual firms to assumed changes in cost and demand conditions has far outrun any possibility of testing by investigation.

Empirical work in the price field has, in the main, fallen into two groups of studies. On the one hand, investigations have been made of the changing relationship over time of the prices of broad groups of commodities and services in a "price system." The data used are the prices of "representative" commodities, collected and published by the government; and despite all the difficulties connected with the divergence between actual and published prices, changing commodity specifications, index compilations and the like, such studies have adequately revealed some broad and significant aspects of economic behavior.<sup>3</sup> On the other hand, there have been numerous surveys of output-price-sales relationships of particular commodities. The monumental demand studies of Henry Schultz<sup>4</sup> belong in this category, as do the investigations by the Department of Agriculture into the relationship between price changes and fluctuations in the volume of sales and output of agricultural commodities. The statistical approximation of the price-sales relationship (demand function) of a commodity is, of course, easiest for a standard product sold to ultimate con-

<sup>2</sup> The most recent and effective survey of the theoretical literature on the market relations of the individual firm is presented in Robert Triffin, *Monopolistic Competition and General Equilibrium Theory*, Harvard Economic Studies No. 67 (Cambridge, 1940).

<sup>3</sup> See, e.g., the works of Frederick C. Mills; in particular, *The Behavior of Prices* (National Bureau of Economic Research, 1927), and *Prices in Recession and Recovery* (National Bureau of Economic Research, 1936).

<sup>4</sup> *The Theory and Measurement of Demand* (University of Chicago Press, 1938).

sumers. As for the price-output relationship (supply function), statistical approximation is frequently possible for agricultural products and such commodities as lumber, standard cotton textile fabrics and bituminous coal, for which production conditions are close to those of pure competition.<sup>5</sup>

Remarkable for their scarcity, however, are empirical studies of the cost and demand conditions confronting a firm. It is true that business "case studies" of price, output and investment decisions are fairly numerous and frequently illuminating,<sup>6</sup> and that a wealth of pertinent, though usually unanalyzed, material is to be found in business, accounting and management publications. When available, engineering estimates of the relation between size of machine or plant and costs, or between rate of operations and costs, are also often enlightening. Business research itself is being directed increasingly toward the type of question in which the economist is interested.<sup>7</sup> Finally, there have been in recent years a number of attempts at statistical approximation of the total cost-output relation for particular firms.<sup>8</sup> Yet despite these developments, it remains true that examination of cost and demand conditions as they exist in practice has limped sadly behind the venturesome constructions of price theorists.

Such investigation is presumably of particular interest to business management, to the economic observer and to the government administrator. An understanding of how costs

<sup>5</sup> For an interesting attempt to derive a statistical supply function in a noncompetitive market, see J. Tinbergen, "Bestimmung und Dentung von Angebotskurven, Ein Beispiel," in *Zeitschrift für Nationalökonomie*, I' (1929-30), pp. 669-79.

<sup>6</sup> Perhaps the best collection of such case material is that of Malcolm P. McNair and Richard S. Meriam, *Problems in Business Economics* (McGraw-Hill, 1941).

<sup>7</sup> See National Resources Planning Board, *Research—A National Resource*, Vol. III, "Business Research" (Washington, 1941).

<sup>8</sup> Certain of these investigations are surveyed in ensuing chapters. A careful study is Joel Dean's "The Relation of Cost to Output for a Leather Belt Shop," *Technical Paper 2* (National Bureau of Economic Research, 1941).



vary with changes in output, factor prices, technology, methods of management, size of plant, distribution channels, size of order and so on, and of how revenue is affected by changes in volume of sales, advertising expenditure, product variation, and different merchandising methods, is certainly helpful in the formulation of output, price and investment decisions. Rational business action, interpreted as a maximization of the present value of the investment or of the proprietorship interest, is dependent on a correct forecast of the costs and revenues associated with possible lines of endeavor, and such a forecast presupposes a knowledge of the manner in which costs and revenues have been determined in the past. The focus of management interest is on the business decision and the factors basic to decision. As for the conceptual schemes of price theory, insofar as empirical research can invest them with content, they are relevant to executive decision.

For the economic observer who seeks to explain price behavior, the utility of an attempt to apply the "tools" of price analysis must obviously depend largely on the extent to which the cost and revenue variables pertaining to profit maximization are determinable or actually approximated in current business practice. Do businessmen really act from the considerations embraced within the conceptual framework of individual enterprise analysis, or is this analysis beside the point? Although examples of price and output decisions reached on the basis of economically rational cost and revenue calculations are not lacking, it is clear also that business policies are frequently dependent in part on conventional, rule-of-thumb methods, or may be directed toward objectives not envisaged in the simplified models of economics. To the argument that marginal cost and revenue calculations play a relatively small role in the price, output and investment decisions of business practice, there are various stock replies: first, that even though the available accounting and operating data are not adapted to such calculations, these data are filtered through the business judgment of management and emerge as decisions conforming

closely to the line of action which would be followed if marginal cost and revenue calculations were undertaken; second, that although management operates with unit costs and prices rather than with marginal calculations, the net result may be no different; third, that in general those firms which approximate maximum profit calculations most closely will survive while others fail. Points one and two may be valid, but there is little factual evidence either for or against them. And the third point, although it may be sound, does little to show how maximum profit positions are approached in the absence of marginal cost and revenue calculation. In an interesting article on business price policy the authors, after a study of some three dozen firms, are forced to conclude that the majority think "in altogether different terms: that in pricing they try to apply a rule of thumb which we shall call 'full cost,' and that maximum profits, if they result at all from the application of this rule, do so as an accidental (or possibly evolutionary) by-product."<sup>9</sup>

The interest of the public administrator is very similar to that of the economic observer. His aim is to determine what considerations are actually taken into account by business firms in formulating decisions on price, output, investment and related matters. Both the initial impact and the ultimate consequences of an administrative ruling will depend on current business practice, which may or may not conform to the principles of contemporary analysis of the individual firm. It may be said, then, that business management has a direct concern in the empirical determination of the variables upon which the maximum profit position of the firm depends. Economists and public officials are interested also, insofar as business practice can be explained by such a determination. It is true, of course, that some public administrators charged with fixing prices have an immediate interest in the determination of the variables.

The primary purpose of this volume is to examine the

<sup>9</sup> R. L. Hall and C. J. Hitch, "Price Theory and Business Behavior," *Oxford Economic Papers*, No. 2 (May 1939), pp. 18-19.

possibilities of isolating the effects on costs of certain important cost-determining influences. Part One is devoted to a preliminary consideration of the character of costs and the dimensions of price. Since the conceptual framework of this study is provided by the current theory of costs in the firm, a brief summary of this theory is presented in Chapter II. The actual cost data available to management and to the economist are limited to accounting and statistical records. Such records, however, do not yield magnitudes that are directly applicable to the purposes with which we are concerned. Indeed the adaptation of accounting data to these purposes is the principal problem confronting empirical cost analysis, and for this reason an examination of the character of costs as viewed by economics and accountancy is necessary to the analysis that follows. Chapter II concludes with a brief survey of some of the uses to which accounting data have been put in cost studies that are outside the main current of the discussion.

Recent consideration of the "dimensions" of price has indicated how complex may be the meaning of the price of a product sold by a particular firm. As represented in a demand or marginal revenue curve, price is presumably a net realization to the firm after deduction of all discounts and allowances. An understanding of the price-making process, however, requires an examination of the "structure" of a price, including a multitude of selling terms. Chapter III is concerned with various meanings of price and its dimensions and with the relation between the internal organization of a firm and the process of pricing.

The substance of the volume is represented by the analysis of Part Two. The thread of this analysis, to which the discussion of the various chapters is tied, is a consideration of the problems of isolating the influence of a single variable among the many which simultaneously affect costs. It must be admitted that the thread is a tenuous one, that its frequent breaks are patched up only with difficulty, and that the authors wander on occasion into other fields. Their excuse must be that the material is in many places scanty

and that very little systematic work has been done in this area. A common structure is apparent in all the chapters in Part Two and serves to focus attention upon the principal objectives with which all are concerned: a consideration of the statistical problems involved in the study of the influence of certain factors on costs, a critical evaluation of existing materials and studies, and suggestions of further research possibilities.

The analysis of costs here attempted is something less than comprehensive, for many of the important influences on the cost of a product to a firm have had to be neglected. A perusal of the chapter headings will indicate that attention has been concentrated mainly on those elements which have been emphasized in traditional individual firm analysis. Given fixed plant and equipment, the production costs of a product to a single-product firm may be considered as determined, within the framework of a given technology, by the rate of plant utilization and the prices of the input factors. Chapters IV and V are concerned with costs and rate of output. With respect to changes in the rate of output, certain costs must be treated as fixed and others as variable. The conventions of accounting and record-keeping with respect to the distribution of fixed costs over time and the implications of the conventions for the short run cost function are examined in Chapter IV. Chapter V is devoted principally to a critical examination of recent statistical studies of the cost function. Chapter VI deals with the effect on costs of changes in factor prices.

The empirical study of the effects of technical change on costs, which is the subject of Chapter VII, is beset by serious difficulties which the authors cannot pretend to have met, much less to have solved. Theoretical analysis is accustomed to distinguish between induced changes, which are mere adaptations of known techniques applied in response to variations in output or factor prices, and substantive changes, which involve a shift in the cost function. This distinction, unfortunately, eludes statistical application. The attempt to isolate the effects of a technical change on costs

from the effects of changes in factor prices and in rate of output on costs is a hazardous undertaking.

Chapters VIII, IX and X abandon the restrictions of a single product and fixed plant and deal, in turn, with the allocation of common costs among products, with the behavior of selling as distinguished from production costs, and with the relation of size of plants and of firms to costs. As in the case of previous chapters, the consideration of these problems is confronted on the one hand with clear-cut and meaningful economic distinctions which are largely inapplicable to the material at hand and, on the other, with accounting data which usually, and often necessarily, represent rule-of-thumb judgments and arbitrary conventions. Empirical research has the dual responsibility of adapting theoretical constructions to the character of the data and of adjusting and modifying the arrangement of the statistical and accounting material in such a way as to make it applicable to economically significant questions.

A fruitful consideration of the relation of cost behavior to price determination by the firm awaits further work on costs. Equally essential is further investigation of demand conditions, to which it is hoped the Committee may presently turn. Chapter XI, as the title indicates, is limited to a few remarks on the implications of cost behavior for price analysis. It has been thought useful to present in the appendices to the main discussion a considerable amount of supplementary material which lies somewhat outside the central theme of this volume.

In conclusion, the authors wish to emphasize that this report in no sense represents a complete study of the principal cost problems confronted by the individual firm. They are acutely aware that in many places in the discussion the difficulties associated with the isolation of the influence of one variable on costs from others operating simultaneously have not been countered effectively. In addition, many other cost problems just as significant as the ones treated here have perforce been neglected for lack of time. The Committee will be content, therefore, if this

## **INTRODUCTION**

**II**

report is accepted as an introduction to a body of imperfectly known material, as a critical appraisal of existing studies of cost behavior, and as a presentation of suggestions for further research.

## Chapter II

### THE CHARACTER OF COSTS

THE term "costs" has been interpreted so diversely by accountants, businessmen and economists that a preliminary statement on the relation of cost investigation to the process of price formation becomes a necessary basis for further discussion. At the outset one must recognize a distinction between: the concepts and conventions of those who contribute actively to such managerial decisions as pricing, calculation of income and tax determination, and the intellectual constructs of those who attempt to describe, explain or appraise the process and results of these decisions, particularly for the economic system as a whole. The former are primarily the working rules and habits of thought of the accounting profession; the latter are the attributes of economists. Reflecting these differences in objectives, accounting practices are influenced by the accepted rules of income statements and balance sheets, by managerial convenience, and by the expense of accounting records, whereas economic concepts ordinarily presume rather simplified situations conducive to logical elegance.<sup>1</sup>

An understanding of the central tenets of both cost accounting and the economic theory of costs is especially imperative for an appraisal of the results and methods of empirical research, because ordinarily inquiries of this sort must utilize accounting data. In general terms, economic analysis specifies a limited number of determinants of costs—the rate of utilization of plants and other facilities, the prices of the factors and agents employed by the firm in the

<sup>1</sup> Differences in objectives or terminology should not, however, obscure the common ground (to be examined later) between these two disciplines.

production of goods and services, the technical efficiency of these factors, and the size and scale of the enterprise. This framework has the advantage of providing channels through which circumstances affecting costs may be conceived to flow. Logically, changes in costs may be broken down along these lines, so that the economist can set up useful categories for the study of both the sources and the consequences of cost variations. Such a model of economic theory fails, however, to resolve the difficulties of actually distributing changes in costs among these elements: satisfactory techniques for splitting up specific cost variations into categories of theoretical origin have not yet been devised. Accounting practice, on the other hand, has usually confined itself to the measurement of total costs or of statistically convenient subdivisions; in many cases its conventions and concepts are designed primarily to facilitate measurement rather than to supply the most pertinent information for managerial judgment. Thus incremental or marginal costs, which are of admitted importance to many decisions, have received scant attention from accountants, perhaps largely because of the complexities of measurement.

The hiatus between economic theory and accounting has diminished somewhat in recent years. There is less desire for a complete divorce, less mutual repudiation of the legitimacy of the other field of investigation. Accountants have been developing special techniques, such as "break-even charts," "specific costs," and "budgeting," to provide information that an economist would regard as germane to business decisions. At the same time economists have been compelled to reformulate their theoretical framework to include advertising expenditures and extremely diverse market conditions. But a great deal remains to be done in the process of translating theoretical structures into statistically measurable concepts, and of expanding accountancy into a more logical and useful system. The present volume is intended as a step in that direction.

The first two sections of this chapter are given over to



summary descriptions of the respective approaches to "costs" of economists and accountants. These sections are necessarily preliminary to the lengthier discussion of particular aspects of costs in Part Two of this report. A third section of the chapter is devoted to a brief exposition of the chief types of empirical cost studies thus far undertaken; this material, too, will be examined in greater detail in later chapters.

### *1. Economic Theory and Costs*

The central problem of traditional economic theory has been to explain the allocation of a fixed quantity of productive resources among possible alternative uses and to determine whether the total product is thereby maximized. Yet before one distribution of resources can be found superior to another, it is necessary to know not only the physical productivities of possible combinations of resources but also the "importance" of one kind of product as compared with others. Since the first is a matter of engineering measurement, and the second, in our institutional setting, a question of the tastes and preferences of individuals (conditioned in part by the distribution of income in the community), it is customary to consider quantitative determination of these factors as beyond the province of economics. At the same time a formal knowledge of both factors for the central problems of allocation is presumed when input-output relations (production surfaces), scales of preference (indifference maps or utility surfaces), and the distribution of income are regarded as given.

With these data as the starting point, there have been formulated certain principles of "economizing" which characterize two types of decisions: first, the choices of consumers in assigning their income among alternative expenditures<sup>2</sup> and the preferences wage earners exercise between leisure and work; and second, the decisions of

<sup>2</sup>"Savings" can be regarded as an alternative "expenditure"; the choices are between present and future income.

enterprises concerning the size and scale of plant and equipment, the amount and proportion of the factors, and the volume of sales. Decisions of the first type are designed, of course, to secure optimum conditions of existence, those of the second to maximize profits. For the consumer with a specified income, these judgments indicate that the marginal rate of substitution among goods (including future goods and leisure) is equal in all directions and equal to price ratios. The businessman is supposed to combine factors in such a way that the ratios between their marginal productivities are equal in all directions and that the contribution of an additional unit of a factor to the value of output is equal to the price of the incremental unit. These decisions impinge on each other through markets in which prices are established and exchanges transacted for finished goods and services as well as for factors of production. As a result of these decisions by consumers, businessmen and wage earners in this simplified model, the allocation of productive factors among possible uses is formally achieved.

When attention is concentrated on the conduct of a single enterprise operating in a total system, each decision concerning scale of plant and equipment, combination of factors and amount of output is predicated upon a series of expected<sup>3</sup> cost-price relations. Costs indicate the terms on which raw materials, various kinds of labor, and other factors may be acquired *and* processed. Prices represent the terms on which the fabricated goods may be disposed of to others. Any change in these cost-price structures involves a change in the profit alternatives open to producers or the consumption alternatives available to purchasers.<sup>4</sup>

Costs are a barrier to the use of resources; the greater the cost the greater the resistance. The cost of a factor per unit of product depends not only on the factor *price*, but also on

<sup>3</sup> Since every decision is directed toward the future, although not necessarily toward the same point in time, "expected" is to be implied in similar instances.

<sup>4</sup> E. S. Mason, "Price Policies and Full Employment" in *Public Policy*, edited by E. S. Mason and C. J. Friedrich (Harvard University Press, 1940), p. 28.

its *physical productivity*. The physical productivity of resources in turn is influenced by the rate of their use and the general state of the industrial arts.<sup>5</sup>

Competitive economic theory has operated upon the highly restrictive assumption that the decisions of the single enterprise could neither affect the prices at which factors were secured or processed goods disposed of, nor influence the amount demanded at any price by the market as a whole. The only way in which a firm could influence the part of the structure of cost-price relations immediately confronting it would be through the physical efficiencies in combination of the factors it employed, or through varying its output. Unable to exert any effect on prices, the firm would devote itself to determining the most profitable scale of plant and the rate of output.

If many decisions of businessmen are to be explained or appraised, this simplified model must be supplemented by more complex patterns. The process of making decisions within a firm is complicated (as is any explanation) by the fact that many contemplated activities do have repercussions on cost-price relations. For instance, an increase in output may change the price at which products may be sold as well as that at which factors may be purchased. Although the decision has its origin in the context of a given system of cost-price relations, one must first appraise the effects of contemplated actions on these relations, and then reconsider the proposed decision which may be expected in turn to alter the system of cost-price relations.

The extent of the repercussions on cost-price structures that might arise from a contemplated decision depends on the character of the markets in which the firm buys and sells.<sup>6</sup> In certain types of markets, particularly those with a few sellers, it may be virtually impossible to systematize the complex interactions between a contemplated decision

<sup>5</sup> "Factor prices," "rate of use," and "state of the arts" are discussed in some detail in Part Two of this report.

<sup>6</sup> Some effects of different types of market and cost situations on price formation are discussed in Part Three of this report.

of one enterprise and the probable responses of others. Where cost-price relations may be affected by a single firm's influence on prices of finished goods or of factors, not only do the decisions as to the scale of plant and lowest cost rate of output become more complex, but new ones confront the businessman. The firm now has some choice (the range of alternatives may be large or small) as to prices for disposing of finished goods or for purchasing supplies.

In order to develop a simple and tractable explanation of the way in which these decisions are made, economists have selected a few among many possible relationships and integrated them into a logical system. In the light of this group of relationships the business executive is regarded as making his decision. One of the tasks of later chapters will be to evaluate the usefulness of such a system for an understanding of business practices; this will require appraisal of the variables included in ordinary economic analysis and those usually excluded by the *ceteris paribus* assumption.

The relationships which—in contemporary theory—the firm is depicted as knowing in the process of formulating its decisions are: the way in which receipts from sales can be expected to vary with alternative schedules of output and with alternative outlays on selling costs; how costs of building plant and organization may vary with alternative schedules of output; how costs of producing output with given equipment may vary with alternative schedules of output; and how factor prices, in particular, can be expected to change with output. The firm is then presumably in a position to maximize its profits by building that scale of plant and organization at which the cost of a slight addition to plant is just equal to the added revenue, and by operating the enterprise at the level of output at which marginal costs equal marginal receipts. This last decision necessarily involves a simultaneous solution of the price at which the output is to be sold and factors obtained.<sup>7</sup> Selling

<sup>7</sup> Unless price discrimination between customers requires a further decision.

costs will be incurred (with prices determined) up to the point at which an additional expenditure will add to revenue an amount just equal to the selling costs plus the cost of manufacturing the additional units to be sold.<sup>8</sup>

Thus the economist provides a formal solution<sup>9</sup> to the decisions that confront the business executive by selecting a limited number of relationships upon which the final judgment is to be based and making certain restrictive assumptions as to the objectives of the business enterprise. The character of this solution to entrepreneurial decisions will emerge more clearly after a brief review of several *general* misapplications and limitations of the logical model.<sup>10</sup>

In the first place, the logic of economic theory cannot and should not purport to describe closely and accurately the practices of business in making decisions. What it can hope to do is call attention to the data which pertain to particular decisions on the assumption that executives seek to maximize profits or, more accurately, the value of the proprietorship interest in the firm. Yet business objectives may, in fact, be concerned with such matters as maintaining the firm's share in the market, in building up a powerful enterprise or in politically expedient action. And human conduct, even as exemplified in business decisions, certainly has many aspects other than profit motivation which deserve serious study.<sup>11</sup> In short the profit maximization assumption

<sup>8</sup> If output is provisionally determined, selling costs will be increased up to the point where the increment to the revenue due to increased price will equal the selling expenditure necessary to achieve the higher price.

<sup>9</sup> This solution is ordinarily represented graphically in terms of marginal and average cost curves (rather than total functions). See Edward H. Chamberlin, *The Theory of Monopolistic Competition* (Harvard University Press, 1933); Joan Robinson, *The Economics of Imperfect Competition* (Macmillan, London, 1934); and Jacob Viner, "Cost Curves and Supply Curves," *Zeitschrift für Nationalökonomie*, III (1932).

<sup>10</sup> Particular aspects of the economic theory of costs are scrutinized in greater detail in the appropriate chapters in Part Two of this report.

<sup>11</sup> See the work of R. A. Gordon, "Ownership and Compensation as Incentives to Corporation Executives," *Quarterly Journal of Economics*, (May 1940), pp. 455-73.

must not be taken as a description of all business motivation, although it may serve as a useful first approximation. ✓

Second, the economic theory specified above is based on the notion of a businessman making decisions. Actually most important decisions in modern business are probably the products of a group. Interests and considerations which in a small individual proprietorship are concentrated in a single person are institutionalized, in a large firm, in departments and "pressure groups." The importance of this fact in the process of decision has not ordinarily been appreciated, and is certainly a matter requiring further study. A related fact is the extent to which effective units of economic control fail to correspond directly with the usual concepts of a firm or an enterprise. A company or corporation may be part of a larger unit of control, and subject to decisions based upon the cost-demand-rate-of-output relations for the entire cluster of enterprises.<sup>12</sup>

It is equally imperative, in the third place, to understand that the logical structure of economic theory assumes that the executives of a control unit have accurate and complete knowledge of the relationships indicated above. They are presumed to know the manner in which their costs vary with output, how receipts can be affected by advertising outlays, and the character of the dependence between volume of sales and receipts. While later chapters consider in more detail what business executives "really" know about these relationships in their enterprise, it is probably safe to say that in general they have very little precise information, and at best only certain broad ideas derived from experience. The accounting records cannot be very revealing as they are the results of many divergent factors during a single period. It is an exceedingly difficult task to isolate the effects of a single relationship in the total picture, and one seldom undertaken by accountants. For instance, it is

<sup>12</sup> G. F. Shove of Kings College, Cambridge, has developed this line of thought. He uses the term "interest group" rather than "firm." See also Paul M. Sweezy, "Interest Groupings in the American Economy," Appendix B, *The Structure of the American Economy*, Part I, Basic Characteristics (National Resources Planning Board, Washington, 1939).

possible to learn from accounting records how sales and advertising expenditures have varied. But sales may have fluctuated because of factors other than advertising expenditures: changes in the income of the community, the policy of competitors, factor price variations, etc. The simple relation between advertising outlays and sales, which economic theory presumes the business executive to know, is far from easy to isolate in quantitative terms.

As these relationships can hardly be expected to remain constant in a world of changing tastes and technology, economic theory takes it for granted that executives are able to recognize these changes and make suitable adjustments. But perception and subsequent readjustment take time; frequently they are impeded by mistakes of judgment, partly because in actuality the number of variables is larger and the character of relationships is vastly more complex than the postulates of economic theory would suggest. One could scarcely expect, therefore, that an enterprise would be optimally adjusted to the cost-price structure at any or every instant of time. Despite the lack of direct conformity between economic theory and the activities of business executives, the observer may find the simple set of selected relationships adequate for his general purposes of explanation and appraisal. They may not, however, be directly usable by the business executive who has to make decisions from day to day, or by those concerned with revising business practices by legislation or preachment. Such revision must necessarily presuppose a knowledge of the actual alternatives which present themselves to the business executive. One of the aims of Part Two of this report will be to examine the methods by which these relationships can be approximated empirically. It will then be necessary to appraise the usefulness of such data to both the economist and the businessman.

### *2. Accounting Practice and Costs*

Accounting is a tool of business management. It was evolved from double-entry bookkeeping with the growth

of machine production and the corporate enterprise, particularly in the nineteenth century. These changes in technique and business institutions brought with them large capital outlays, professional management, and diffused ownership which required the tools of cost and financing accounting. With the advent of modern manufacturing, knowledge of the cost make-up of a product became indispensable to "efficient" operations. This information required "a revolution in commercial bookkeeping, in which an article's cost was simply the purchase price."<sup>13</sup>

Since accounting is not an automatic machine, its use frequently requires decisions which the firm's executives alone can make. "Accounting must be regarded as a process involving the recognition of custom and convention and the use of judgment, rather than as the application of rigid and unvarying rules."<sup>14</sup> At one time, for instance, it was not general practice to take into account depreciation on buildings in calculating "costs." The United States Supreme Court supported this view by holding in a railroad case that "only such expenditures as are actually made can with any propriety be claimed as a deduction from earnings."<sup>15</sup> The conventional (though not arbitrary) character of accounting practice is illustrated by the problems of depreciation and obsolescence allocation, inventory and asset valuation, reserves for contingencies, and cost allocation among products. Much has been done in recent years by the accounting profession, the Securities and Exchange Commission, the Bureau of Internal Revenue and other agencies of government, and by teachers of accounting, to standardize and integrate these conventions.<sup>16</sup>

<sup>13</sup> A. C. Littleton, *Accounting Evolution to 1900* (American Institute Publishing Co., New York, 1933), p. 367.

<sup>14</sup> George O. May, *Twenty-Five Years of Accounting Responsibility, 1911-1936* (Price, Waterhouse and Co., New York, 1936), Vol. II, pp. 306-07.

<sup>15</sup> *U. S. v. Kansas Pacific Ry. Co.*, 99 U.S., 459 (1870). See also May, *op. cit.*, p. 307.

<sup>16</sup> See T. H. Sanders, "Proposed Reforms of Accounting," *Business and Modern Society* (Harvard University Press, 1938), pp. 113-51.



Cost accounting, in particular, has introduced many new and refined techniques—standard costs, break-even charts and budgets are only a few—to provide business executives with more accurate information on which to base decisions. The development of these types of analysis is not surprising in view of the complex and diversified decisions business executives must reach. Cost information pertinent to one problem may be inadequate for another. For instance, the costs used in calculating income for dividends or taxes may be inadequate for the setting of a price on an additional order, or may fail to indicate whether it would be profitable to add an additional plant or machine.

To the extent that costs enter into such decisions, the business executive is interested in costs to be incurred, “those that lie ahead, those which are contingent on the particular proposal being considered; not those which have already been incurred, those to which the business is already committed. This distinction between the expenses which *have been* incurred and the expenses which *are to be* incurred is important to the reasoning of the business executive who is trying to determine a policy.”<sup>17</sup>

It will be useful to identify certain types of decisions that businessmen make and to indicate briefly the differences in the character of cost calculations involved in each. In one class, one may group a number of decisions, such as declaration of dividends, profit sharing, and tax payments, which depend directly on measures of the *income* of the enterprise in a given period. Other decisions, such as expansion, wage increases, S.E.C. registration, and pricing, may be more indirectly related to income figures of a past accounting period. Aside from recording revenues and costs (outlays), the determination of income must involve the matching of costs against revenue for a specified period. Since the use of durable goods involves outlays in one period with the intent that they bear “fruit” in subsequent periods, any income calculation must be “conventional” for

<sup>17</sup> R. S. Meriam, “Some Notes on Cost” (mimeographed). The economist makes similar distinctions in the terms “short” and “long” run.

a period shorter than the life of the enterprise.<sup>18</sup> "If the accounting period were increased from the customary year to a decade, most of what is now treated as capital expenditure would become chargeable to income; while if the period were reduced to a day, much of what is now treated as current maintenance would become capital expenditure."<sup>19</sup> The late Justice Brandeis once suggested that there could be no wholly dependable computation of net income until the particular enterprise had run its course.

In recent years interest in the calculation of income for periods much shorter than a year has increased greatly. Not long ago the Committee on Accounting Procedure of the American Institute of Accountants adopted as a text the dictum that "a fair determination of income for successive accounting periods is the most important single purpose of the accounting reports of a corporation."<sup>20</sup> The crux of income accounting is to match costs and revenues for a short period in order to determine income. The problem is to decide what costs should be regarded as incurred in earning the revenue of the period. Some costs, like direct labor expenses, raise no serious problems because they are incurred in the period and present no reasonable basis for being applied to prospective revenue.<sup>21</sup> Others, such as outlays for plant, equipment, research, and patents, are directed almost entirely toward prospective rather than current revenue. For the current period such costs depend on estimates of the performance of the acquired asset in future periods.

<sup>18</sup> For an interesting view of assets as "prepaid expense" see Wyman P. Fiske, "Amortization, Depreciation, Obsolescence and Replacement," *Transactions of the American Institute of Chemical Engineers*, XXX (1933), p. 1.

<sup>19</sup> George O. May, *Improvement in Financial Accounts*, Lecture on the G. Lowes Dickinson Foundation, Graduate School of Business Administration, Harvard University (April 12-14, 1937), p. 4.

<sup>20</sup> William A. Paton, "Recent and Prospective Developments in Accounting Theory," *Business Research Studies No. 25*, Publication of the Graduate School of Business Administration, Harvard University, XXVII, No. 2 (March 1940), p. 5.

<sup>21</sup> *Ibid.*, p. 7. Periods of conventional length are implied.

Costs for the calculation of current income are made up of these two groups: those which are not intended to contribute to future revenue and *some* part of the outlays which do. Hence the determination of income is not only a starting point for other decisions but an important decision in itself. The costs employed to calculate income of an enterprise and as a basis for dividend payments may be different from those used in income calculation for tax purposes. The Bureau of Internal Revenue may prescribe depreciation rates quite other than those adopted by a firm. Or the firm itself may feel that depreciation rates used in calculating income are not satisfactory for the decision whether or not to expand or re-equip a plant. A manufacturer of a standard cotton fabric, for instance, follows the practice of charging depreciation at the rate of one cent per pound of finished product. This results in a lower total depreciation charge than is permitted by Internal Revenue regulations and employed in tax reporting.<sup>22</sup> The difference arises largely from the fact that the use of the Internal Revenue depreciation rates overestimates costs and underestimates income (for dividend policy) under conditions of chronic partial utilization of plant and equipment. In other instances, especially in firms whose equipment is affected by rapid obsolescence, the Internal Revenue rates may be lower than those the enterprise uses for its own purposes.

A second important area of executive decision in which cost records play an important part is the internal control of operations. Decisions of this nature require a type of cost information different from that used in the determination of income. Here the problems are whether to purchase a new machine, how to reduce costs of operation, how to improve a product to given performance standards in the cheapest way, and whether to add or discontinue a line of products. To assist management to make these and similar decisions numerous techniques have been developed

<sup>22</sup> A survey of the many methods of allocating depreciation through time is made in Chapter IV. The Bureau of Internal Revenue has permitted other methods than the straight line for tax purposes.

in cost accounting, many of them specialized to the particular problems of the industry or firm. Reference may be made to the general use of budgets, standard costs, and specific or incremental costs.

A distinction must be drawn between those techniques—for example, standard costs—which are regular features of the accounting system of the enterprise and those involving estimates only as problems arise. For instance, the decision to take an order at a particular price, or at what price to submit a bid, requires an estimate of the cost of this single transaction. The distinction drawn above between costs that have already been, and those which would be, incurred by the contemplated transaction is important in this connection.<sup>23</sup>

Standard costs are intended to provide the management with a norm by which to judge the "efficiency" of current operations. By a very detailed breakdown of cost elements, involving for a complicated product thousands of individual items, management can concentrate on the elements that show wide deviations from the standard. This focusing of attention upon particular operations is one of the central points in favor of a standard cost system.<sup>24</sup> It is not entirely a simple matter, however, to select the most satisfactory standards. To what extent should these standards represent past achievement and to what extent, for instance, hopes of future performance? No general answer can be provided; the judgment of the executives decides each particular case. As a matter of practice, the standards set up for labor and materials costs are frequently the equivalent of engineering estimates of performance that "should" be achieved when operations have been mastered by wage earners.<sup>25</sup>

The "burden" used in standard costs is based on an allo-

<sup>23</sup> See Eugene R. Nevins, "Estimating the Special Order," *National Association of Cost Accountants Bulletin*, Vol. XVI, No. 8 (December 15, 1934), Section I.

<sup>24</sup> William A. Paton, *Accountants' Handbook*, 2nd ed. (Ronald Press, 1935). Section 26 discusses standard costs.

<sup>25</sup> At given wage rates and prices of materials, these costs amount to estimates of the input-output relations the economist regards as data.

cation of fixed costs to a level of output for which there is reasonable expectation of achievement on the average over the future. This, at least, is the prevailing practice, although some firms have used simply the technical capacity of the firm to produce as a basis for standard burden costs. For instance, out of 177 replies to a questionnaire of the National Association of Cost Accountants, 138, or 78 percent, based the normal or standard burden on ability to produce *and* sell while the remaining 39, or 22 percent, used capacity to produce.<sup>20</sup> Furthermore, these 39 firms were concentrated, for the most part, in industries with fairly stable demands. When actual rates of operation in a period vary from the average of expected rates, this difference is frequently written off to profit and loss through an underabsorbed and overabsorbed burden account. The important thing to be noticed about these standard costs for the present purpose is that they are not strictly historic costs; they involve a standard of expected performance.

A third field of executive decision to which cost records are important embraces the problems that cluster about price determination. As the next chapter shows, the price decisions of an enterprise interact not only with the level of the structure of prices, but also with differentials by region, size of order, terms of credit, model, etc. Cost information may be used in setting these differentials as well as in determining the level of prices.

While the kinds of costs relevant to pricing decisions and the way in which they influence price structures are briefly considered in (Part Three) of this report, it should be noted for this general summary that costs which help to determine price structures may be quite different from those customarily applied to problems of income or internal management and control. In periods of depression, the executives may find that some price which will not cover all

<sup>20</sup> National Association of Cost Accountants Research Study, "Practice in Applying Overhead and Calculating Normal Capacity," *National Association of Cost Accountants Bulletin*, XIX, No. 15 (April 1, 1938), Section III, p. 925.

costs but which is higher than one that would justify a temporary shutdown, will minimize losses. Thus any price may be accepted that covers variable expenses and contributes something to overhead without spoiling the market too much for the future. In such cases the costs most relevant to the pricing decision are the variable expenses.<sup>27</sup>

A decision with respect to price structures applies to a future period; the costs significant to this price decision are not those which prevailed in the past (income calculation). Nor are costs based upon engineering or technological standards decisive for pricing. The significant costs, rather, are those which may be expected to prevail in the period for which prices are being considered. In the preparation of costs for pricing decisions, standard costs or those of the past period may be taken as a starting point and modified in view of probable changes in factor prices, technical efficiencies, and conditions of operation.<sup>28</sup>

Finally, some types of cost records may be useful to management in providing a rationalization for a policy or decision. It may be necessary, for example, for a business organization to justify an action before the courts, an arbitration board, or certain other concerns. This function of costs has developed particularly since the N.R.A., the growth of Fair-Trade Practice laws, and the Robinson-Patman Act. Costs have a precise and final appeal to legislators and the public, to whom the ambiguities and shades of possible meaning are not always apparent. Hence an appeal to costs (a supposedly unprejudiced piece of evidence) may frequently serve the useful purpose of justifying a policy or action.<sup>29</sup>

<sup>27</sup> Even in markets where the enterprise has no choice as to the prices which may be charged, these variable expenses will significantly influence the decision whether to operate or close down.

<sup>28</sup> For a discussion of the cost accountant's role in industrial pricing see *Cost Accounting and Industrial Pricing* (National Association of Cost Accountants, 1939), pp. 41-81.

<sup>29</sup> See Herbert F. Taggart, *The Cost Principle in Minimum Price Regulation*, Michigan Business Studies, VIII, No. 3 (University of Michigan Press, 1938), Chs. 1 and 2. "A business man may be content with

### 3. *Empirical Cost Studies*

The concluding section of this introductory chapter on costs is intended to indicate briefly certain types of empirical cost studies to which there has been extensive reference. Among this group, the analyses that may be used by persons who make price decisions or by those who seek to understand or appraise price structures (particularly the latter) will receive detailed critical examination in Part Two of this study. Cost inquiries of this sort do not, however, readily fit into the scheme of cost determinants suggested by economic theory. They are not primarily intended to isolate the independent effect of the rate of plant utilization or technological progress on cost variations. Nevertheless, they do reveal important information about the cost practices of business enterprises and provide some check on other inquiries more directly related to the framework of economic analysis.

(1) One of the simplest types of cost studies is a comparison of the items in profit and loss statements of single firms or groups of firms for a single period or over time. It is quite easy, for example, to calculate the ratio of labor expense to sales, or of advertising expense to sales. The most highly developed of such studies are those on variety chains, drug stores and department stores made regularly by the Harvard School of Business Administration, and the cost analyses frequently undertaken by trade associations. The significance of these investigations is limited, however, by the fact that market positions and methods of conducting business may vary extensively. Differences in accounting breakdowns, too, may make accurate comparisons difficult. One would expect such studies to be most satisfactory in

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rules of thumb when he himself is the only one to use the information, and he is free to superimpose on the cost data as much of his own experience and judgment as he pleases. When he is to be held accountable for his actions before a public tribunal, however, he must needs demand that the guides furnished him be explicit and the limitations be equitably adjusted to his own circumstances" (pp. 5-6).

fields where firms are fairly similar in size, technique and market situation. The results can then be used by business executives to provide a general picture of at least a few elements in the costs of an entire market. By comparing its costs with the average costs of competitors or of comparable firms in other markets and observing whether it spends more or less per dollar of sales on advertising, labor, or transportation, a firm may obtain some notion of its relative position. Again, since these costs give an over-all picture of a market, they may exert some influence on price. Thus an individual firm may be influenced to set its price more in conformity to average costs. Although surveys of this sort have been little used by students of cost-price problems, those which are yearly investigations could be utilized to special advantage in studies of the cyclical behavior of cost components.

A recent investigation of the uniform accounting, cost statistics and studies of trade associations<sup>30</sup> shows that such activities are usually directed toward cost control or pricing policies, or both. The comparison of the cost ratios or individual items of expenditure in one firm with those in others may reveal striking instances in which costs are out of line. A lumbermill, for example, discovered by comparing wastage ratios that its machines were being run faster than the most economical rate. Comparative costs for firms utilizing different methods of doing business may indicate profitable changes in organization. In one case, the issue of paying expenses for salesmen per mile or furnishing them with cars was studied with profit. There are many different ways in which cost inquiries by trade associations may influence price structures. An ink company discovered, for instance, that its practice of distributing free samples of printer's ink was rather expensive, and it thereupon discontinued the custom. A more direct relation is seen in the following statement of purpose from the paper

<sup>30</sup> C. A. Pearce, "Trade Association Survey," *Monograph No. 18*, Temporary National Economic Committee, Ch. VI. A sample of uniform cost systems was drawn from thirty industries.



box industry: "The main idea we kept in mind in preparing this manual was to make it as fool-proof and simple as possible. A person without much knowledge of the business can figure prices on this manual."<sup>21</sup>

(2) A great many bulk-line cost studies of markets have been made. They show for a group of firms at one time (with comparable factor prices among firms) the average costs of turning out a unit of product. A bulk-line cost curve is obtained by arraying the firms from the lowest cost to the highest. Sometimes the costs are weighted by the relative importance of the firm judged by the proportion of the total output produced. Bulk-line cost curves are always approximately J-shaped.

A number of these studies were made years ago by the Price Section of the War Industries Board to serve as a partial guide to the setting of prices. Prices had to be high enough to call forth the required output; hence they had to cover the costs of the "bulk-line" producer.<sup>22</sup> In the period 1920-33, the Tariff Commission made approximately 120 such investigations.<sup>23</sup> These studies are of limited significance not only because of questions of comparability among firms as to products and accounting practices, but also because of diverse rates of operation and different factor prices.<sup>24</sup> They have sometimes been used, however,

<sup>21</sup> C. A. Pearce, *loc. cit.* In reference to these same activities of another association, it was said: "The principal achievement of the association has been the preservation of competition in its original sense of 'to strive together for common interests.'"

<sup>22</sup> F. W. Taussig, "Price Setting as Seen by a Price Fixer," *Quarterly Journal of Economics* (February 1919), p. 205.

<sup>23</sup> *Range and Variety of Costs of Production*, Part III, Economic Analysis of the Foreign Trade of the United States in Relation to the Tariff, 72nd Congress, 2nd Session, Senate Document No. 180, Part III. For a discussion of the method utilized by the Tariff Commission see Appendix A.

<sup>24</sup> For an application of bulk-line cost curves to some of the questions asked by economists in the field of cost-price relations, see Kemper Simpson, "Price Fixing and the Theory of Profit," *Quarterly Journal of Economics* (November 1919). "A Statistical Analysis of the Relation Between Cost and Price," *Quarterly Journal of Economics* (February 1921), and "Further Evidence on the Relation Between Price, Cost, and Profit," *Quarterly Journal of Economics* (May 1923).

by purchasing departments of large concerns to secure some idea of the cost structure of the market. ✓

(3) Before decisions can be made by business executives on such matters as expansion of plant, the introduction of new machines, or a variation in product or process, the alternatives open to them must be canvassed. All the relevant data on these alternatives, including costs, are frequently prepared by the engineering and accounting departments of a firm or by a consultant firm that specializes in such work. These cost estimates on which actual decisions are based are another source of cost information, and one seldom explored by economists.<sup>85</sup>

(4) There have been some attempts at studies of costs for the system as a whole, or for large sections of it, based upon aggregates. For instance, an index of labor costs per unit of output can be found by dividing a payroll index by a production index.<sup>86</sup> For particular industries such studies suffer from the lack of comparability in the coverage of payroll and production indexes. Although they are useful for some general purposes, the over-all figures can hardly throw much light on the process of decision formation.

(5) There have been a large number of studies in the field of agriculture which should be differentiated from studies of industrial enterprises because of the peculiar problems and treatment of data occasioned by the proper valuation of owner or family labor, home-grown factors of production (e.g., manure), and the valuation of farm products to the farmer's family.<sup>87</sup> Studies have been made also of the costs of obtaining one particular factor, such as

<sup>85</sup> E. H. Phelps Brown, "Cost Categories and the Total Cost-Function. Second Report of the Econometrica Committee on Source Material for Quantitative Production Studies," *Econometrica*, IV (July 1936), pp. 242-63.

<sup>86</sup> See Chapter VII, below.

<sup>87</sup> The importance of these problems is apparent in such studies as *An Economic Study of Dairy Farming in Grafton County, New Hampshire, 1930*, New Hampshire Agricultural Experiment Station, Bulletin 260.

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power.<sup>88</sup> These investigations are similar to those classified under (1) above, in that they are derived from income statements, but they warrant separate mention because of the special features of agricultural enterprise.<sup>89</sup>

<sup>88</sup> See L. A. Reynoldson, W. R. Humphries, S. R. Speelman, E. W. McComas, and W. H. Youngman, *Utilization of Power on Corn Belt Farms*, United States Department of Agriculture, Technical Bulletin 384.

<sup>89</sup> See M. K. Bennett, "The Development and Purposes of Farm-Cost Investigations in the United States," *Quarterly Journal of Economics* (February 1926), pp. 273-94.

## Chapter III

### THE DIMENSIONS OF PRICE

A STUDY of cost-price relations requires a preliminary examination of some of the complexities in the meaning and measurement of "price," along the lines of the preceding discussion of costs. This is essential not only because "price" is so frequently treated as a simple and unequivocal fact, but also in view of the central role that the price mechanism is alleged to play in the contemporary economic system. Actually, when one attempts to specify those terms of a transaction that are part of the price of a commodity, serious questions, both accounting and theoretical, arise. Furthermore, any concern with the meaning of price soon reveals how closely attached are the difficulties of providing, for a product or a commodity, a definition that is at the same time theoretically valid and empirically useful. The problems involved in the endeavor to give precise meaning to the concept "price" will be the subject matter of the first section of this chapter. A second will explore the mechanism within an enterprise through which pricing decisions are formulated.<sup>1</sup>

#### 1. *The Concept of Price*

Economic logic presumes that each individual in the community endeavors "to satisfy his tastes as far as is possible in view of the obstacles to satisfaction which confront him."<sup>2</sup> For a community as a whole these obstacles are

<sup>1</sup> For these purposes pricing decisions will include the acceptance or rejection of a "market price."

<sup>2</sup> J. R. Hicks, "The Foundations of Welfare Economics," *Economic Journal*, XLIX (December 1939), p. 698.

largely technical; that is, the total product is limited by the available human and natural resources and by the productive processes utilized. For any individual or group within the community, the limitations to a fuller "satisfaction of wants" are not only technical but consist also in the wants and tastes of others.

The "prices" of all goods and services and all agents of production can be regarded as an "elaborate indicator" of the alternatives open to individual consumers and producers. "To the consumer the structure of prices indicates the terms on which he can acquire the goods for which he spends his money income. To the producer the structure of prices indicates the terms on which he may dispose of his goods and services or acquire the goods and services of others."<sup>3</sup> A variation in "price," affecting as it does the alternatives open to producers and consumers, is bound to influence both the wants selected by consumers for satisfaction and the size of incomes going to those who participate in the productive process.

An exchange of "goods and services" between a buyer and a seller takes place on the basis of agreed terms of sale. In a formal sense, therefore, price must be the amount of money, or the present value of the credit instrument or other agreement, exchanged between the buyer and the seller per unit of the "goods and services." Price is here made equivalent to average revenue per unit of product at the point at which transfer of ownership takes place.<sup>4</sup> Any such definition obviously involves a particular view of a "product"; it includes all services such as transportation, credit facilities and guarantees furnished by the seller, but excludes any undertaken by the buyer. Alternatively, price may be defined as revenue net of any services or discounts rendered or granted to the buyer. The first definition of

<sup>3</sup> E. S. Mason, "Price Policies and Full Employment," in *Public Policy*, edited by E. S. Mason and C. J. Friedrich (Harvard University Press, 1940).

<sup>4</sup> Revenue is averaged only over the units of a single transaction. A differentiated price is said to exist when the average revenue to a seller varies as between transactions consummated at or about the same time.

price implies that services rendered and discounts granted are properly regarded as costs involved in the sale of a product. The second treats such services and discounts as deductions from revenue.

This last definition has the advantage of being equivalent to that used by economists in the usual concept of a firm's demand function; in addition, it approximates the accounting term of net realization (sales minus discounts). The construction of index numbers of "price" requires some standard and readily applicable notion of both price and product if variations in the index are readily to be understood. The definition of price in terms of net realization would be appropriate to an index that attempts to measure changes in revenue per unit obtained by sellers. With such an index, the effect of variations in transport charges would be largely excluded. The construction of index numbers is made difficult, except perhaps for raw materials, by this definition of price, for net realization data are not as generally available as list prices at the point of ownership transfer.

Although the term price will ordinarily be used in this report to denote net realization per unit of product in a single transaction, there are instances in which it will be of advantage to adopt terminology which defines the product more broadly and focuses attention on the list price and other terms of transactions. Important features of price determination may be neglected if one concentrates too narrowly, in particular situations, on net realization. The focus of price-making forces is generally at the point at which ownership transfer takes place. The seller may absorb freight, and offer in connection with a sale a variety of discounts and services that combine to form a price structure which will be difficult to understand if one is preoccupied with price defined narrowly as net realization. There can be little doubt, therefore, that especially in the study of related transactions it may be instructive to regard price not simply as revenue per unit but rather as comprising a whole series of terms of sale. Under such circum-

stances the concept of product must be correspondingly enlarged.

Price in the sense of net revenue may be close to quoted or list price in certain markets, and in others the variations may be wide. Such list or quoted "prices" are frequently but one of the many provisions in a contract of sale. Other features of the transaction, such as discounts, allowances and credit provisions, materially alter the per unit cost to buyers and the per unit revenue to sellers. In the pages to follow the term *price structure* will be considered to include the list price and the other provisions of the transaction that result in a divergence between net revenue per unit of product to sellers and the list price. It will be employed with reference to the sales of a product of a given firm rather than to a single transaction;<sup>5</sup> and it therefore comprises, in addition to the many dimensions of price to a single buyer, the terms whereby one buyer or group of buyers is differentiated from others. The average net revenue from sales to a buyer or a group of buyers may be changed without affecting the list price simply by a variation in other items in the price structure, such as discounts and allowances.<sup>6</sup>

In addition to the list price, the most recurrent components of the price structure of a product are:

1. Cash discounts
2. Quantity discounts and volume discounts
3. Freight allowances
4. Seasonal discounts
5. Advertising allowances

<sup>5</sup> Since the main orientation of this study is the enterprise, the term "price structure" is used with respect to a single firm. The term is used in a narrow sense to mean the dimensions of a single product; in a wider context it may also include the differentials among products. "Price structure" can also denote the complex of prices, among a group of firms or even all firms. The term "price system" may be more appropriate in the latter case.

<sup>6</sup> Measures of price flexibility, in terms of either amplitude or frequency of price change, will be distorted just as price indexes are if they are based only on list prices.

6. Promotional allowances
7. Trade-in allowances
8. Price guarantees
9. Quality guarantees
10. Trade discounts
11. Credit terms
12. Delivery acceptance discounts

A number of these terms of sale can be illustrated from the price structure of products sold to dealers in a recent period by the International Harvester Company.<sup>7</sup> Contracts drawn up once a year designate a list price, f.o.b. Chicago or factory, at the option of the buyer. A cash discount of 5 percent is allowed for payment within a stipulated period, which varies with the machine or implement; for some of the more expensive machines this period may be as long as the whole yearly season. A quantity discount, discontinued in 1935, depended on the size of the orders for particular machines. For instance, spring tooth harrows were reduced \$.25, \$.50 or \$1.00 on orders of 20, 40, or 100 or more sections. A volume discount is granted on the total dollar volume of business a dealer transacts with the company. Between 1926 and 1932 there was in effect a vendor's option discount which provided that dealers accepting delivery of orders before specified dates, depending on the region and implements involved, would receive a 2 percent discount. The discount was intended to reduce the cost to the company of storage of completed machines and implements. In addition, special allowances were made on certain items. Thus in 1926 if a dealer met certain service requirements for tractors, his account was credited to the amount of \$50 per tractor sold. In 1933 each dealer was credited with \$80 for each combination sale of a Farmall tractor with one of several machines, provided this reduction was passed on to the purchaser. During 1932 and 1933 a crop guarantee plan tied 40 percent of the price of certain implements to the

<sup>7</sup> "Industrial Wage Rates, Labor Costs and Price Policies," Part II, Temporary National Economic Committee, *Monograph No. 5* (Washington, 1940).



price of cotton, corn and wheat. If the price of these commodities fell below a designated amount, prices of the implements were reduced. During 1930-33 the credit position of dealers received especially careful scrutiny and since 1933 prompter settlement of claims has been required, the volume of obligations allowed each dealer by the company has been cut, and stricter terms on carry-over accounts have been instituted. Dealer's contracts carry a price guarantee clause which provides that the company, if it reduces prices before the cash discount dates, "agrees to adjust to such lower basis the price of any complete machines . . . which were purchased . . . and remain unshipped or on hand unsold." Finally, it may be noted that contracts carry warranties or guarantees as to the satisfactory performance of the implement or machine. Broken or defective parts will be replaced at the expense of the company.<sup>8</sup>

The preceding summary of price structure changes in a single company indicates clearly how risky it is to presume that list price variations are an adequate index of the change in average net revenue. Although the presumption may prove valid in some instances, it cannot safely be invoked

<sup>8</sup> A similar array of illustrations could be presented for a number of industries. "Collateral terms of sale" are exemplified by the case of the fertilizer industry, in Saul Nelson, "A Consideration of the Validity of the Bureau of Labor Statistics Price Indexes," Appendix 1, *The Structure of the American Economy* (National Resources Committee, 1939), pp. 173-85. See also Willard L. Thorp and Ernest A. Tupper, *The Potash Industry, A Report submitted to the Department of Justice by the Department of Commerce* (multigraphed), pp. 62-67.

The importance of dimensions to price structures other than list price can be illustrated by instances from the steel industry. If changes in price structure made in 1938 had been in effect in 1937, the revenue of the Youngstown Sheet and Tube Company would have been reduced by 8% percent. Approximately 15 percent of this reduction would have been due to changes in differentials and basing points. "All Steel Companies Adversely Affected by Basing Point Changes Says Youngstown Sheet and Tube," *Iron Age* (August 25, 1938), p. 51.

The importance of discounts in quotations of the "official price" is illustrated in the testimony of representatives of the American Can Company, *Hearings before the Temporary National Economic Committee, Part 20, Iron and Steel Industry* (Washington, 1939), pp. 10775-78.

unless specific investigations have previously been made. The above illustration suggests also that *reference to a "price" must always rigorously designate the corresponding "product"* if clarity is to be maintained. An implement delivered with a guarantee of performance is a different "product" from one delivered without such a guarantee. Even though the goods may appear to be physically identical, the fact that they are not interchangeable (because of the guarantee) makes it advisable to regard them as separate "products." Specification of "products" solely in terms of their physical characteristics is likely to neglect some important terms of their sale.

A very careful study of product specifications has recently been made of "book paper." At least seven main characteristics of book paper must be specified before an order can be filled. Since there are 40 product classes (drawing, envelope, rotogravure, etc.), 12 grades (A, B, C, etc.), 33 finishes (antique laid, dull, lacquer, etc.), 9 sizes and trims (regular deckle, irregular untrimmed, etc.), 8 colors (natural, white, ivory, etc.), 8 quantity classes (less than ream, carton, carload, etc.), and 19 packings (banded rolls, sealed bundles, etc.), over 170 million different specific "products" can be designated by these physical characteristics of the paper alone.<sup>9</sup> If account is taken of the differentiation that can be introduced by the "nonprice"<sup>10</sup> terms of the agreement of sale (dates of delivery, guarantees, etc.), it would be possible to specify over a billion different book paper "products." Fortunately, the bulk of book paper sales are concentrated in relatively few of these categories.

A consideration of the "dimensions" of price, exemplified by discounts, has raised the question whether such discounts

<sup>9</sup> The complete classification is presented as Appendix D to this report.

<sup>10</sup> There are undoubtedly instances when it will be debatable whether a term of the sales contract can most usefully be regarded as distinguishing one "product" from another or changing the revenue (price) from a "product" already specified. The problem becomes even more acute in the case of the labor contract (below, p. 42).

should be regarded as increases in cost rather than deductions from revenue to the seller and as increases in revenue rather than deductions from cost to the buyer. Either view of these "dimensions" is logically permissible if consistently followed, and each has certain practical merits and demerits. The problem is an aspect of how selling costs should be treated, for discounts can be regarded, like advertising, as part of the cost of selling products.<sup>11</sup>

To treat discounts and similar allowances as costs would facilitate the calculation of "price" indexes, since list prices would more closely approximate average revenue. List prices are readily available, and the problem of collecting data on so many "dimensions" and estimating their effects on revenue could thus be avoided. To consider these terms of sale, on the other hand, as deductions from revenue, is apparently in conformity with the practice of most business enterprises in calculating "net realization" as the list price minus discounts and similar allowances to purchasers.<sup>12</sup> Furthermore, this procedure appears to be a closer fit to the theoretical concept of revenue, interpreted to mean money income. On balance, therefore, it will be more convenient to regard such terms of sale as were enumerated above (pp. 36-37) as deductions from revenue, and to continue to speak of them as "dimensions" of price. This practice can be justified further if a narrow definition of "market" is adopted, for then the theory of discrimination can usefully be applied. The various "dimensions" of price can be used to set different prices (in the sense of average revenue) in different markets, and yet maintain an equal list price in all markets. A volume discount, for instance, is a way of discriminating between different types of buyers according to the amount of business they do with a firm. The average revenue in each such market will be determined, theoretic-

<sup>11</sup> See Chapter IX, "Selling Costs."

<sup>12</sup> A study of accounting practice in this connection would be useful. Even more important is the way in which the responsible executives formulate their decisions on the amount and character of discounts and allowances.

cally, at the point where marginal cost and marginal revenue are equal.<sup>13</sup>

The foregoing discussion of price structure by no means exhausts all the terms of sale in current use between buyers and sellers. Other terms may be equally important to the successful culmination of the sale and to the significance of those terms which have been classified as part of the price structure. Typical of such provisions are the following which are as frequently implicit as they are expressed in a formal contract:

1. Provision for dates of delivery
2. Guarantees of performance
3. Legal and other services
4. Agreement to repurchase
5. Agreement of exclusive dealings by one party

At times it becomes extremely difficult to separate the terms of sale which are to be regarded as a part of the price structure from those which are not. For instance, guarantees have been used to reduce the money outlay of the buyer and thus cut the revenue of the seller. "Extravagant quality guarantees were at one time a favorite method of cutting prices on automobile tires without any change in the nominal list. Similarly, in the coal industry, certain producers endeavored to evade code price restrictions by issuing guarantees of heat content which they knew were impossible of fulfillment."<sup>14</sup>

While this discussion of price structure and other terms

<sup>13</sup> To regard price structure in terms of discrimination between different types of buyers suggests a field of study about which very little is known. Upon what considerations are discount structures and similar terms of sale determined? To what extent are such terms largely conventional trade practices influenced in recent years by such legislation as the Robinson-Patman Act and Fair Trade Practice laws? Is there any information relevant to the costs in different "markets" and to the costs of separating markets from each other? Is there a tendency for more or less differentiation? See Walton H. Hamilton, "Cost as a Standard for Price" in "Price Discrimination and Price Cutting," *Law and Contemporary Problems*, IV (June 1937), pp. 321-33.

<sup>14</sup> Saul Nelson, *The Structure of the American Economy*, p. 175.

of sale has centered, at least by implication, about processed goods and services, it is equally applicable to the wage contract. A collective bargaining agreement not only stipulates "wages, hours, and working conditions" but also may provide for the form of union recognition, the handling of grievances, regulation of apprenticeship and dues collection, to mention only a few items. Since the whole agreement provides for the terms under which labor services are sold, what is the "price" of labor? As in the case of price, it is useful to speak of a "wage structure," distinguishing the particular clauses in a contract which affect most directly the money income of the group of wage earners and the payrolls of the employer. The wage structure would include not only time and piece rates, overtime rates, bonuses, but also vacations with pay, pensions, special provisions for the purchase of products at discount, etc. Illustrative of other terms would be clauses on union recognition, shop stewards, arbitration and seniority. It is exceedingly difficult in practice to invest such a distinction with precision, probably even more difficult than in the case of the contract for "goods," because there are many more clauses in a trade agreement which do not relate *directly* to money income of wage earners but which may influence it indirectly in numerous ways.<sup>15</sup>

## 2. *The Formulation of Pricing Decisions*

The price structure of an enterprise is a result of its pricing decisions and "price policy." In certain types of market situations<sup>16</sup> this combination may amount to little more than acceptance of the prevailing market price or rejection of certain orders. Even under these circumstances, analogous to the pure competition of economic theory, an enterprise may have a "price policy" and make decisions which vitally influence its average revenue per unit of

<sup>15</sup> The meaning and measurement of factor prices, particularly wage rates, are treated in some detail in Chapter VI.

<sup>16</sup> See Chapter XI.

“product.” In line with its appraisal of prospective as compared to present price levels, it may buy or sell more or less than it produces. Under the most realistic conditions of competition, a firm typically has some discretion as to the prices it charges and the precise character of the products it sells. This choice among prices and products may reflect very narrow or rather broad alternatives to a single enterprise. The choice between these alternatives represents a second sense, in more common usage, in which a firm may be said to have a price policy.

It is customary to think of decisions as formulated by an “entrepreneur.” Customarily, however, at least in the large firm, they are made by a group of officials who seek to balance the diverse, and often conflicting, interests of various departments in the company. The internal politics of business organizations requires much more attention in a study of the process of price determination than is usually devoted to it. In conferences on pricing policy, the sales representatives may stress the importance of lower prices and attractive products, the sales credit department the desirability of favorable discounts and terms of credit to customers, the legal department the dangers of larger discounts to different types of customers and the general importance of relationships to the public and to governmental agencies and departments in particular, the manufacturing department the technical difficulties of producing the quantity and quality specified for the desired dates of delivery, the accounting department the need for larger profit margins, and the research department the danger, attributable to technical imperfections, of introducing such innovations as the sales representatives may request. Similarly, decisions as to the volume of production and employment may involve compromises between the desire of the production and the industrial relations departments to maintain the working force, the treasurer’s concern over cash position, the accounting department’s view of the probable fluctuation in inventory values, and the sales department’s concern over style or technical obsolescence.

The compromise adopted between such divergent interests is apt to be materially influenced by the personalities involved, the accidents of the moment, and the "bargaining" strength and abilities of the various departments. To be sure, the individual entrepreneur must make decisions which amount to compromises between different interests, but in a large corporation these interests have "organized representatives." To be able to predict price changes from variations in costs or demand, one must be familiar with those rules of thumb, accounting practices, and special interests that impinge on decision-making within individual companies. Only meager specific information is generally available about the pricing process within firms in market situations with quoted or bargained price structures. One of the most fruitful research undertakings would appear to be in this field of the process of decision formation within companies. From a limited number of investigations,<sup>17</sup> at least one type of price structure decision seems to conform to the following general pattern. A different pattern apparently prevails where prices are made for contract or custom work.

(1) In companies that manufacture more than a few standardized products, the executive officials can be concerned only with pricing certain typical products in each general class. Prices for different styles, sizes, models, and other variations from the typical product are set by subordinates on the basis of generally accepted geographical, dollar, or percentage differentials. It would be a valuable addition to the knowledge of pricing practices if one could learn the number or the proportion of products on which price decisions are made by the main executives of the company in firms producing thousands of separately listed "products."

(2) Price decisions really represent a choice among a few alternatives, and not from an indefinitely large number of possibilities, as might be supposed. In the pricing of established products, the executives are confronted with an ex-

<sup>17</sup> Temporary National Economic Committee, *Monograph No. 5.*

isting or prevailing price, charged by the company. Three sets of possibilities ordinarily confront the price setter. First, the price levels may be increased, left alone, or decreased. In most specific situations only two of these possibilities can be regarded as real alternatives. Second, variations in price structures seem ordinarily to be made in fairly specific and conventionalized intervals, for instance, 5 or 10 percent, or similarly discrete monetary units such as 5 or 10 cents. As previously observed, only a few such possibilities are actually present. Third, the executives must choose the terms of the price structure to be varied: the list price, the discount structure, or the terms of credit.

(3) Markets may be classified according to the time characteristically consumed between reconsiderations of price quotations. In many markets price structures remain unchanged during such periods, so that a revaluation of price structures is made by executives at specified and regular intervals. In other market situations where "products" are usually very specialized and produced only on order, a list or quoted price may be used simply to save time and expense on small orders. Larger transactions will receive the attention of important executives.

(4) The choice between the alternatives listed above is made after the information available for decisions has been examined. It is probably most usual to start with the variation in costs during the preceding period, that is, since the last decision as to price structure was formulated. Costs provide the point of departure for pricing decisions because more detailed information is available concerning them than for such factors as demand conditions, costs of competitors, and competitive sales and price tactics. The accounting departments of companies prepare, in many instances, different "cost" statements which are relevant to different decisions.<sup>18</sup>

Knowledge of the pricing process would be considerably enhanced if the investigator could learn what kinds of "cost" information are used by firms in formulating pricing


<sup>18</sup> See above, Chapter II.



decisions. As matters stand, it is unlikely that one can know more than that practices differ widely among firms. Some take average costs from the income statement of the last period with customary straight line methods of allocating overhead. Others consider "budgeted" costs which envisage some normal rate of operations for allocating overhead. Still others estimate costs with "normal" or "reasonably expected" rates of labor efficiency and machine performance. The different ways of handling inventory valuations must also influence materially the "costs" used in pricing. The extent to which such "arbitrary" accounting conventions *alone* serve to shape pricing decisions is a problem requiring extensive additional study.

(5) Starting with the price that may be suggested from the change in costs, the next step in this formalized pattern of decision is to revise the estimate in the light of the expected volume of sales, price, quality and sales programs of competitors, and similar demand considerations. For items of this sort information must be much less definite than for costs. There may, therefore, be wide differences in the judgment of pricing executives concerning the magnitude and importance of such demand factors. In examining and evaluating demand considerations like the expected price and sales policy of rivals, the income of prospective purchasers and their disposition to buy, the pricing executives of the company frequently come to adopt certain rules of thumb which may be peculiar to their department or company, or to the industry and even the business community. These rules are usually the product of business experience, which may or may not be applicable to the particular circumstances under consideration. Thus, it may be accepted that the demand for the products of the company is, in effect, inelastic. Or, the price may be varied simply to follow that of another company on the assumption that the latter, with its higher-priced executives and elaborate research department, should be in a better position to judge the market.

Chapter XI examines further the ways in which the data

available to management regarding costs and demand conditions are used in pricing decisions. It is important to emphasize here that, at least in the large corporation, whatever data are at hand are not ordinarily transmuted into an entrepreneurial decision through a single mind guided by a total view of the situation; rather they are interpreted by various interests and emerge as a group decision influenced in important ways by the internal organization of the firm in question. 

**PART TWO**  
**COST BEHAVIOR**

## 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),<sup>1</sup> 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

<sup>1</sup> 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,<sup>2</sup> 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.<sup>3</sup> 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*.<sup>4</sup> 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.<sup>5</sup> More particularly, any measurement of the relationship between costs

<sup>2</sup> 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.

<sup>3</sup> A manufacturing enterprise is implied by the above language, but the argument would apply equally well to trading and service industries.

<sup>4</sup> The expression *cost function* in this and the following chapter is to be understood as *short run cost function*.

<sup>5</sup> 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.<sup>6</sup> 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

<sup>6</sup> 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,<sup>7</sup> 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.<sup>8</sup> 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.<sup>9</sup> 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

<sup>7</sup> 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*

<sup>8</sup> 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.

<sup>9</sup> 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."<sup>10</sup> Cost accountants, as a general rule, consider as "overhead" any "indirect cost" regardless of the way in which it varies with output.<sup>11</sup> These costs boldly outline the contrast between facilities made available and those utilized.<sup>12</sup> Some more detailed examination of the content of "fixed costs"<sup>13</sup> 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."

<sup>10</sup> *Studies in the Economics of Overhead Costs* (University of Chicago Press, 1923), p. 1.

<sup>11</sup> W. A. Paton, *Accountants' Handbook*, 2nd ed. (Ronald Press, 1935), p. 1282.

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

<sup>13</sup> 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.<sup>14</sup> 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

<sup>14</sup> W. A. Paton, *op. cit.*, p. 1282.

accounting period may be expected to contribute to the output of future periods.<sup>15</sup> 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

<sup>15</sup> 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;<sup>16</sup> 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.<sup>17</sup> 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.<sup>18</sup>

<sup>16</sup> 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. 806.

<sup>17</sup> Except insofar as minimum stand-by charges are required.

<sup>18</sup> 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.<sup>19</sup> 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.<sup>20</sup> 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

<sup>19</sup> 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.

<sup>20</sup> 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.<sup>21</sup> 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.<sup>22</sup> 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,<sup>23</sup> 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

<sup>21</sup> 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.

<sup>22</sup> John W. Riegel, *loc. cit.*, note 1.

<sup>23</sup> 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.<sup>24</sup> <sup>25</sup>

With the relaxation of the rigid assumptions just de-

<sup>24</sup> J. B. Canning, *The Economics of Accountancy* (Ronald Press, 1929), Chs. XIII and XIV.

<sup>25</sup> 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.<sup>26</sup>

<sup>26</sup> 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

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"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.<sup>27</sup>

One of the widely used handbooks for accountants lists the following "principal causes of depreciation":<sup>28</sup>

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.<sup>29</sup>

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

<sup>27</sup> U. S. Treasury Department, *Regulations 101 Relating to the Income Tax under the Revenue Act of 1938*, p. 77.

<sup>28</sup> W. A. Paton, *op. cit.*, p. 579.

<sup>29</sup> 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.<sup>30</sup>

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-

<sup>30</sup> 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<sup>31</sup> and by 126 out of 138 responses to an inquiry into depreciation policies conducted by the Machinery and Allied Products Institute.<sup>32, 33</sup> 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."<sup>34</sup> 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.<sup>35</sup>

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-

<sup>31</sup> *N.A.C.A. Bulletin*, XVII (May 1, 1936), Forum Section, p. 1055.

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

<sup>33</sup> 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.

<sup>34</sup> *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.

<sup>35</sup> For coverage of the questionnaire, see *ibid.*, p. 916.

accumulate 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.<sup>36</sup>

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.<sup>37</sup>

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

<sup>36</sup> Paton, *op. cit.*, p. 628, adapted from Cole, *Fundamentals of Accounting*.

<sup>37</sup> 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.<sup>88</sup>

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

<sup>88</sup> 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

COST BEHAVIOR

<i>Year</i>	<i>Straight Line Scrap Value \$64</i>	<i>Straight Line Scrap Value \$4</i>	<i>6 Percent Sinking Fund Scrap Value \$64</i>	<i>6 Percent Sinking Fund Scrap Value \$4</i>	<i>4 Percent Sinking Fund Scrap Value \$64</i>	<i>4 Percent Sinking Fund Scrap Value \$4</i>	<i>6 Percent Sinking Fund, Unequal Pay- ments, Scrap Value \$64</i>	<i>Matheson Method Scrap Value \$64</i>	<i>Matheson Method Scrap Value \$4</i>
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	73	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.<sup>39</sup> 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<sup>40</sup> over the future, including "good" years and

<sup>39</sup> 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.

<sup>40</sup> The difference between production, sales and capacity is commented upon in Chapter II, p. 26.



"bad,"<sup>41</sup> 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

<sup>41</sup> 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.<sup>42</sup>

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 :

Year	Output in Units	Straight Line Costing Per Unit Costs	Normal Costing (6000 unit = normal)	"Technical" Costing	
				Case 1 <sup>b</sup>	Case 2 <sup>a</sup>
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

<sup>a</sup> An outlay of \$10,000 is assumed to purchase an asset with a "life" of 10 years which is completely allocated under each system.

<sup>b</sup> 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.

<sup>c</sup> 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

<sup>42</sup> 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.<sup>43</sup> 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.<sup>44</sup>

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.

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

<sup>44</sup> 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.<sup>45</sup> 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

<sup>45</sup> *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.<sup>46</sup>

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-

<sup>46</sup> 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."<sup>47</sup> 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.<sup>48</sup> 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."<sup>49</sup> 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

<sup>47</sup> *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.

<sup>48</sup> Jerome N. Frank, Address to the Controllers Institute, reprinted in *Journal of Accountancy* (November 1939).

<sup>49</sup> 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

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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. ✓



## Chapter V

# COSTS AND RATE OF OUTPUT EMPIRICAL STUDIES OF COST FUNCTIONS

THE preceding chapter explored the problems of designating, for any single accounting period, those costs arising from the use of resources and equipment which contribute to the output of more than one period. Such a discussion is a necessary introduction to measurement of the cost function in particular enterprises. The present chapter will examine some of the other problems which arise in an empirical study of cost functions, survey the investigations that have been made thus far, discuss the techniques utilized, and attempt to appraise the significance of the results that have been obtained.

How costs are influenced by variations in the rate of utilization of plant has been the subject of two principal types of inquiry. The first depicts a relationship existing over preceding accounting periods; the second, while necessarily based on the experience of the firm, attempts to show the probable relationship in the next period. Studies in the first category consist largely of investigations undertaken by econometricians with the purpose of "approximating" the cost functions of economic theory; they usually include break-even charts constructed for investment analysis. Those in the second group are developed by accountants, engineers and business managers; these are designed to provide constructive information for the formulation of decisions concerning output, costs and prices.

### 1. *Problems in the Measurement of Cost Functions*

Since controlled experiments relating to costs have not been undertaken on any appreciable scale,<sup>1</sup> it has been necessary for investigators to rely almost entirely on the accounting records of particular firms. These data show in accounting form not only the components of cost but the total cost for successive accounting periods. The variation in these costs from one period to the next is ordinarily the result of a large number of influences. Any statistical approximation of the cost function in specific instances must, therefore, involve these two steps: (1) elimination of the effects of those factors, other than variations in output, which impinge on costs, and (2) measurement of this residual relationship between costs and the rate of utilization.

The task of approximating a cost function might appear superficially to be simply a question of choosing the appropriate statistical technique whereby the influence of one variable may be isolated from among many. But before any particular statistical methods can be used, a large number of questions of definition and interpretation must be recognized and possible sources of confusion clarified. Issues of this sort arise when one attempts to translate accounting data into the simplified conceptual scheme of a cost function and to adapt them to statistical analysis. In the pages immediately following, these difficulties are discussed and an endeavor is made to indicate the limitations of

<sup>1</sup> A number of experiments in the field of agriculture have measured the relations between such input factors as seed, labor, and fertilizer on the one hand and product on the other. See U. S. Department of Agriculture, *Input-Output Relationships in Milk Production*, Technical Bulletin 815 (May 1942). From input-output functions with given factor prices, total cost functions can be derived. For a summary of some of these studies, see E. H. Phelps Brown, "The Marginal Efficacy of a Productive Factor—First Report of the Econometrica Committee on Source Materials for Quantitative Production Studies," *Econometrica*, IV (April 1936), pp. 123-37. It must be remembered that studies of input-output relations are not equivalent to inquiries concerning cost functions.

possible solutions in order that particular studies may be evaluated critically in the next section.<sup>2</sup> At the outset, cost studies are presumed to refer to a single enterprise as the unit of decision formation in order to avoid arbitrary allocations of cost among component departments.

(1) The familiar cost function of economic theory applies only to one point in time and under equilibrium conditions is strictly timeless. All statistical approximations to such relationships must, however, be based upon observations in different periods. Consequently statistical cost functions, like statistical demand curves,<sup>3</sup> must proceed on the assumption that the theoretical relations being approximated are either unchanged during the period of observation or change in a definable and measurable way. If the theoretical cost function does vary during a period, but no correction for a particular pattern of change is made in the statistical analysis, the statistical cost function must be an average for the period. The longer the period of observation (i.e., the greater the number of values), the more confidence can be placed in the derived statistical relationship, but the less relevant are the results for a picture of the cost-output relation to be met in a particular decision of the enterprise. The tendency on the part of some interpreters of statistical demand and cost curves to regard the derived results as valid for every instant in a period is an unfortunate one. For a statistically derived cost function must be either an average relationship for a period, a relationship constant through a period, or one that changes according to a specified pattern.

<sup>2</sup> The issues discussed here have been treated in a study by Joel Dean, "The Relation of Cost to Output for a Leather Belt Shop," *Technical Paper 2* (National Bureau of Economic Research, 1941). See also, Hans Staehle, "Statistical Cost Functions: Appraisal of Recent Contributions," *American Economic Review*, XXXII (June 1942), pp. 321-33.

<sup>3</sup> Many of the difficulties and limitations encountered in the derivation of statistical cost functions are common to any attempt to approximate statistically the concepts of comparative statics. Others are peculiar to empirical cost studies. See Henry Schultz, *The Theory and Measurement of Demand* (University of Chicago Press, 1938), pp. 3-152, for a discussion of the measurement of demand curves.

(2) Related to the problem just described is a second one—the choice of the period of observation—which arises in the attempt to determine an empirical counterpart to a cost function. The period should be long enough to permit a number of observations covering a wide variation of output; but it is true also that the longer the period, the greater is the possibility of technical change, affecting both processes and products, for which existing statistical methods do not make adequate allowance. Furthermore the relationship between costs and the rate of utilization of plant for an increase in output may differ from that prevailing when output is decreased. Such a cost function would be said to be irreversible. If the interpretation of statistical cost functions is to be clarified, both the length of the period of observation and the reversibility of the function require careful study. One may then check the reliability of the results by taking different periods of observation and comparing the effects of expanding and contracting output in particular periods.

(3) Certain restrictions on the interpretation of statistically derived cost functions arise from the fact that observations are not continuous. The accounting data apply to discrete intervals, which in some instances may be as long as a year, in others as short as a fortnight. Values for a single observation (e.g., a year) which sum the cost and output from day to day cannot reveal the relationship existing at any time within the year unless the assumption is made that the cost function remains constant, or changes in a definable pattern during the interval embraced by a single statistical observation. As was analogously argued above in (1) for the total period of observation, the practical result of these alternatives is to make the derived relationship an average for the discrete interval. The statistical function must ignore the problem of the extent to which the value for any discrete interval is determined by the rate of change of output *within* the interval. It begs the question of the behavior of total costs at differing

rates of output *within* the interval of observation.<sup>4</sup> Two periods may have exactly the same output but the costs may differ simply because of the rate of expansion or contraction of output during the period. The longer this interval the more serious the limitation.

(4) A related problem encountered in the transition from the cost function of economic theory to its statistical approximation is the difficulty introduced by variation in the sizes of orders.<sup>5</sup> The output of two periods might be the same, except that in one case it consisted of a large number of small "runs" which might increase costs. Or output might be increased from less than "capacity" to "capacity" by gradual steps or by a single step; in either case the cost-output relations could hardly be expected to remain unchanged. It is possible to recognize the influence of this factor by making the size of orders or the rate of change of output explicit determinants of costs along with the level of output itself.

(5) A rather simple, but sometimes neglected, limitation to the interpretation of any statistical cost function is the fact that it can apply only to the actual range of output. It is probably even more dangerous to project cost functions to volumes of output that have not been achieved than to project trends into the future. Furthermore, since extremes in the volume of output seldom occur as frequently as more "normal" values, and hence do not offer as many points of observation, less confidence can be placed in the shape of the derived cost function at its extremes. This conclusion is of particular importance, because the costs for extreme values of output attract the

<sup>4</sup> To a certain extent the effect on costs of the rate of change of output—calculated from outputs in successive periods—may be accounted for and eliminated from the cost function, but the available techniques are not adequate to deal with all the variations which can and do take place within the accounting period.

On some of the effects of change of output within the interval, see Caleb A. Smith, "Cost-Output Relation for the United States Steel Corporation," *Review of Economic Statistics* (November 1942).

<sup>5</sup> This point is listed separately because output is ordinarily varied in increments larger than a single "unit" of product.

most comment from business executives and persons interested in the consequences of business decisions. #

(6) It is often a rather difficult task to make certain that the observed values of output and costs apply to the same period. A cost function in which the costs of one period were related to the output of another would ordinarily be meaningless. The longer the time during which goods are in process, the greater is the likelihood of this type of distortion. Expenditures may be recorded most heavily while goods are being processed, whereas output may not be recorded until the goods have undergone finishing operations on which expenditures are smaller. Thus costs may be accounted in one period and the output to which they contributed in another. When the volume of output is being varied rapidly, this lack of synchronization in the cost and output records may introduce serious distortions, unless lag corrections are adopted. Again, lack of comparability may arise because of variations in the time between the *incurrence* of expenses or completion of output and the *recording* of these events.<sup>6</sup>

(7) One of the most perplexing aspects of the attempt to approximate cost functions is the question of the units in which output is to be measured. If each firm produced a single, homogeneous product, as is so frequently assumed in simplifications of economic theory, the measurement of output would be only a matter of counting these units. But (as was noted in Chapter III) in reality firms or even plants produce many different styles, grades, models, and sizes of a "product" as well as many different "products."<sup>7</sup> When output is heterogeneous and composed of items which pass through substantially the same production process, so that their individual costs cannot be isolated by separate study of various divisions of the plant, a com-

<sup>6</sup> The fundamental difficulty of calculating costs (and income) for a period short of the life of an enterprise, discussed in detail in the previous chapter, is again relevant.

<sup>7</sup> The problems of calculating the costs of specific "products" are discussed in Chapter VIII.

mon denominator must be found if the relation between cost and "output" is to be examined.<sup>8</sup>

The major alternatives in the measurement of output for comparison with costs can be briefly surveyed. (a) The units of input factors may be an acceptable index of the volume of output in some instances. In oil refining, for example, the input of crude oil is fairly homogeneous, while the output is composed of highly heterogeneous joint products produced in varying proportions. If the rate of activity of the plant is satisfactorily reflected by the rate of input of the major homogeneous raw material, and if the range of variation in the proportion of different products is not wide, the use of input factors may be taken as an index of output. (b) Since it may be impossible to reduce the measurement of output to a single dimension, more than one measure of output may be used as separate independent variables in multiple correlation analysis. For example, in a study of the relationship between cost and railway traffic volume, it might be necessary to measure "output" in terms of passenger miles, freight ton miles, movement of mail and express, etc. (c) A composite index of output necessarily involves the determination of the relative importance or weight to be attached to the various products making up the composite unit. The weights suggested in particular cost studies include: the relative prices of the products, the amount of raw materials entering into the different products, and their variable or total cost.

<sup>8</sup>For a general discussion of production index problems, see Wassily Leontief, "Composite Commodities and the Problem of Index Numbers," *Econometrica*, IV (January 1936), pp. 39-59; Arthur F. Burns, "The Measurement of the Physical Volume of Production," *Quarterly Journal of Economics*, XLIV (February 1930), pp. 242-62; Edwin Frickey, "Some Aspects of the Problem of Measuring Historical Changes in the Physical Volume of Production," *Explorations in Economics, Notes and Essays contributed in honor of F. W. Taussig* (McGraw-Hill, 1936), pp. 477-86, and "The Theory of Index-Number Bias," *Review of Economic Statistics*, XIX (November 1937), pp. 161-73; O. N. Anderson, "On the Question of the Construction of an Internationally Comparable Index of Industrial Production," *Publications of the Statistical Institute for Economic Research*, No. 1 (State University of Sofia, 1937), pp. 121-31.

In addition to empirical studies of cost functions, output indexes have been made to measure "productivity" and industrial activity, and to serve as a basis for some national income estimates. A system of weights adapted to one of these types of study may be quite misleading if applied to another. For instance, output weighted by the relative prices of constituent items may be useful for national income purposes but inadequate for cost purposes. If relative prices differ because of variation in the character of competition, national income as a flow of services which satisfy given tastes can be regarded as affected by this fact; but it makes little sense to argue that output is any different for purposes of calculating a total cost function. The best weights for individual products, in the construction of composite indexes of output for cost functions, would usually appear to be their direct costs. Only if relative prices were a reflection of difference in relative costs would price weight be theoretically valid for output in the calculation of cost functions.

Regardless of the system of weighting used for indexes of output, the assumption must be made that the weight of each individual element in the composite unit remains unchanged throughout the period of observation. The longer the period of observation the less likelihood there is that any proportion of component products will remain unchanged.

When indexes of output for all the products of a firm are utilized in the calculation of cost functions, the results are not directly applicable to individual products. If an attempt is made to analyze the pricing policy for a single commodity, it is necessary to investigate the extent to which the composite output unit is typical of the fluctuations in output of that commodity. Since the index of output is a weighted average, it is possible that it will not be typical of any particular commodity. This may be a serious limitation where the relative proportion of various commodities in total output fluctuates a great deal.

(8) If the influence upon costs of variations in the rate



of plant utilization is to be isolated statistically, other influences must be measured and eliminated. The designation of the other influences that may be expected to affect costs substantially, and the choice of the methods for eliminating their influence are both vital steps. The former is important because the residual relationship is assumed to be the cost function. If the impact of certain factors is not removed, the cost-output function is distorted. Strictly speaking, it is impossible to be certain that the effects of all other factors have been eliminated. After corrections have been made, the residual variations in cost are assumed to be solely the result of variations in output. The effect of "technical changes" can be expected to present particular difficulties; one cannot be certain that plant, equipment, supervision and products have remained exactly the same even over short periods,<sup>9</sup> for in many industries they are subject to frequent and constant modification. As for the choice of methods for measuring and deflating the effects of factors other than output, it is important because of the different shapes of cost functions that may result. If, for instance, the influence of factor price movements is to be eliminated from costs, the investigator will have to decide on the extent of detail in the classification of factors, and on what constitutes a change in factor prices.

(9) The reliability of a measurement of a cost function must depend also upon the selection of the equation to summarize the cost-output relationship. Since marginal cost is the slope of the total function, the adoption of a linear regression necessarily results in constant marginal costs. Extreme care must be utilized, therefore, in the choice of the mathematical function or the freehand curve used to summarize the observed relation between costs and output. While the adoption of higher order equations will improve the statistical fit, the crucial question is whether the greater number of constants results in a "significantly" improved summary relationship. Statistical tests can be used to weigh the relative merits of proposed equations.

<sup>9</sup> See Chapter X.

Perhaps the simplest of these tests would plot the paired differences between successive observations of costs and output. Some clue as to the shape of the marginal cost function is then derived independently of deductions from a mathematically fitted total function. Or the "no hypothesis test" can be applied; this is a device for calculating the probability of obtaining the observed results from the several suggested functions. If the observed results could have been obtained only with small probabilities from a fitted function, the particular hypothesis can be discarded. Finally, the analysis of variance technique permits a judgment on the relative "goodness of fit" of several functions.<sup>10</sup>

The preceding points indicate most of the important questions involved in an empirical approximation to a cost function. These problems arise in the *process of attempting to approximate the cost function of economic theory*. They have been enumerated, not in order to suggest that it is futile to try to derive exactly the cost function of the economist, but rather to focus the issues on which empirical studies must be appraised. One study may be adjudged superior to another, or an investigation in one industry more feasible than in another, according to the way in which the issues outlined above are treated.

Since the complexities of experience cannot be compressed into the simplified models of economic theory, some way must be found to evaluate statistical results. The acceptable tests of the significance of such results fall into two categories. First, there are the statistical tests of the extent to which the derived relation between output and costs fits or "explains" the observed costs. In the period of observation the cost function permits a "prediction" of costs from output. Tests of this sort indicate the degree of reliability that may be credited to such "predictions." The second type of test is much less definite, though equally

<sup>10</sup> For further discussion and illustration of this technique, see Joel Dean, *Statistical Cost Functions of a Hosiery Mill* (University of Chicago Press, 1941), pp. 37-59.

important; it gauges the significance of empirical results in terms of consistency with other types of information—the impressions and opinions of business executives, and logical deductions from information that can be accepted with greater confidence.

## 2. *Empirical Studies of Cost Functions*

Two distinct types of investigations have attempted to determine the cost function of economic theory; they are to be differentiated by the methods employed. One group of studies has applied to the cost records of preceding periods statistical techniques of varying refinement in order to isolate the effects of variations in the rate of output from other factors presumed to influence costs. Kurt Ehrke<sup>11</sup> in Germany, Theodore O. Yntema,<sup>12</sup> Joel Dean<sup>13</sup> and Roswell H. Whitman<sup>14</sup> in the United States have derived a number of these empirical cost functions from the accounting records of particular firms. Such cost functions will be designated as "statistically derived" to distinguish them from another group of empirical cost-output studies. The second type of inquiry lies between that just indicated

<sup>11</sup> *Die Überzeugung in der Zementindustrie von 1858-1913* (Gustav Fischer, Jena, 1933).

<sup>12</sup> *United States Steel Corporation T.N.E.C. Papers, Comprising the Pamphlets and Charts Submitted by United States Steel Corporation to the Temporary National Economic Committee* (United States Steel Corporation, 1940), Vol. I, pp. 223-301. See also citation in footnote 19, below.

<sup>13</sup> *Statistical Determination of Costs, with Special Reference to Marginal Costs* (University of Chicago Press, 1936). Chapter II contains a summary of cost studies concerned with the effects of variations in output. See also *Statistical Cost Functions of a Hosiery Mill* and "The Relation of Cost to Output for a Leather Belt Shop" and "Department-Store Cost Functions," *Studies in Mathematical Economics and Econometrics*, edited by Oscar Lange, Francis McIntyre, and Theodore O. Yntema (University of Chicago Press, 1942), pp. 222-54.

<sup>14</sup> "Cost Functions in the Department Store" (in manuscript). See also "Round Table on Cost Functions and their Relation to Imperfect Competition," *American Economic Review*, Supplement, XXX (March 1940), pp. 400-02.

and break-even charts, discussed in Section 3. Studies of this sort are estimates by engineers and accountants, presented as cost functions and focused on past experience. A number of these inquiries have been made in Germany by E. Schmalenbach,<sup>15</sup> Reinhard Hildebrandt,<sup>16</sup> Herbert Peiser<sup>17</sup> and others.<sup>18</sup> Cost functions derived in this fashion will be labeled "estimated" in order to distinguish them from those "statistically derived"; the terms are in no wise intended to reflect upon the relative accuracy of the empirical cost functions.

Attention will be directed first to the "statistically derived" relationships between cost and output, for which Professor Yntema's study of the United States Steel Corporation will be used as an illustration. This choice follows from the fact that the Steel Study<sup>19</sup> is the largest and one of the most complex yet undertaken and has received wide attention through the hearings of the Temporary National Economic Committee. If a problem as perplexing as the cost function for the entire United States Steel Corporation can be solved satisfactorily, the same methods may well serve in simpler cases. The use of Professor Yntema's study will also permit comparisons with two other inquiries based only upon published quarterly and annual statements of the United States Steel Corporation: the investigation

<sup>15</sup> *Selbstkostenrechnung und Preispolitik* (Gloeckner, Leipzig, 1934).

<sup>16</sup> "Geschäftspolitik auf Mathematischer Grundlage," *Technik und Wirtschaft*, XXIV (1931).

<sup>17</sup> *Der Einfluss des Beschäftigungsgrades auf die industrielle Kostenentwicklung* (Gesellschaft für Betriebsforschung, Berlin, 1929).

<sup>18</sup> H. Müller-Bernhardt, *Industrielle Selbstkosten bei schwankendem Beschäftigungsgrad* (Berlin, 1925). A Danish author, Ivar Jantzen, has made several studies, among which "Voxende Udbytte i Industrien," *Nationaløkonomisk Tidsskrift*, LXII (1924) appears to be the most important. Also see the study by Hans Bolza, "Kostenstudien mit Erfahrungszahlen aus der Praxis," *Nordisk Tidsskrift for Teknisk Økonomie* (June 1937), pp. 97-109.

<sup>19</sup> "Steel Study" will refer to the investigation presented by the United States Steel Corporation to the T.N.E.C. For this reference see, *Hearings Before the Temporary National Economic Committee, 76th Congress, 3rd Session, Part 26, Iron and Steel Industry, January 23, 24, and 25, 1940.*

of Kathryn H. Wylie and Mordecai Ezekiel,<sup>20</sup> which "statistically derives" a cost function, and the break-even chart adopted by Walter Rautenstrauch.<sup>21</sup> The present discussion deals with the Steel Study as an example of techniques that may be used to meet the difficulties (inherent in any empirical study) mentioned in the preceding section, and does not attempt to be a comprehensive critique of this particular investigation.

The procedure followed in the Steel Study can be summarized in three major steps:

(1) From the annual profit and loss statements of the corporation, summarized for the Federal Trade Commission (February 17, 1939), annual total cost figures for the period 1927-38 were obtained by the summing of the following items:

Operating Costs, including cost of goods sold, operating expenses of transportation, etc., selling and administration, taxes (other than income and profit),<sup>22</sup> depreciation and depletion

Idle Plant Expense

Interest on Mortgages and Bonds

The total cost figure<sup>23</sup> was corrected for the duplication involved in inter-company transactions between subsidiaries of the United States Steel Corporation. This was a necessary adjustment, since "the inter-company sales of any one company constitute the costs of the other, and since inter-company profits are eliminated from inventory valua-

<sup>20</sup> "The Cost Curve for Steel Production," *Journal of Political Economy*, XLVIII (December 1940), pp. 777-821.

<sup>21</sup> *The Economics of Business Enterprise* (John Wiley and Sons, 1939), pp. 303-09.

<sup>22</sup> Income and profit taxes are not considered "costs"; they vary with profits rather than in any independent way with output. In this section the term "taxes" will always refer to nonincome and profit taxes.

<sup>23</sup> Discounts from purchases were first subtracted from the above total. Accounting practice charges the corporation or its subsidiaries the list price of purchased materials and supplies, regarding discounts as a debit item. Costs for the present purpose required the correction, providing a net figure on purchases involving discounts.

tions in making inventory adjustments, both costs and sales and revenue are inflated, from a consolidated viewpoint, by the amount of the inter-company items . . ." <sup>24</sup>

(2) Since the output of the United States Steel Corporation consists of at least fifty thousand steel "products" and a multitude of nonsteel items such as cement, coal and iron ore, and transportation services, a major step in the study was the construction of a measure of output with which to compare costs. This was accomplished by correcting the actual tons of each product shipped in each year by the ratio of its average mill costs to the average mill costs of all rolled and finished steel products in the period 1933-37. Each ton of a product whose 1933-37 average mill cost was less than the average of all rolled and finished products was weighted proportionately less than a full ton, while products whose average mill cost was above average counted proportionately more than a full ton. The number of tons of all products was converted into equivalent tons of "average cost rolled and finished steel products." In similar fashion the output of rolled and finished products was adjusted to include "the equivalent tons of steel represented by the products other than steel which are sold on a tonnage basis by the Corporation's subsidiaries." <sup>25</sup> One further aspect of the measurement of output must be noted; the data used in constructing this composite index refer to tons *shipped* (rather than *produced*) in the year. <sup>26</sup> This gap was "bridged" in the Steel Study by the statement that "the amount of inventory fluctuation is relatively small . . . and the effect on the ultimate cost computation is negligible." <sup>27</sup>

(3) Since variations in these total costs were obviously due in part to fluctuations in the prices and efficiencies of input factors, a series of corrections had to be used to re-

<sup>24</sup> United States Steel Corporation, *T.N.E.C. Papers*, I, pp. 237-38.

<sup>25</sup> *Ibid.*, p. 239. Cement products are apparently excluded.

<sup>26</sup> That such a problem would arise was noted in Section 2; the cost data refer to the goods produced in the year.

<sup>27</sup> *Ibid.*, p. 241.

move the effects of these influences on total costs. To this end 1938 was adopted as a base, and costs were reconstructed on the assumption that factor prices and efficiencies then prevailing had been constant through the whole period. Four corrections were made: (a) Total payrolls were adjusted to the 1938 level of average hourly earnings.<sup>28</sup> (b) "Other expenses" than payrolls and (nonprofit) taxes were presumed to be largely purchased supplies and materials, and one half of this total was corrected by the Bureau of Labor Statistics index of wholesale commodity prices other than farm and food products related to a 1938 base.<sup>29</sup> (c) To correct tax costs for variations in tax rates during the period, the 1932-38 relation between taxes and "output"<sup>30</sup> was projected to the 1927-31 period. Two linear relationships between taxes and output were found in the data if the period was split at the year 1931. The 1932-38 relationship was projected backward to the earlier period to eliminate the consequences of tax rate changes. Actual values were used in the 1932-38 period. (d) Since numerous changes in the techniques of production took place in the period, it was important to eliminate their influence. Total costs, corrected as just indicated, were plotted against "output" and the deviations from a least-squares straight line were plotted with time as the independent variable. A straight-line fit through these deviations was presumed to measure the influence of changes in technique. Elimination of this effect on cost resulted in the final relationship between costs and output. A straight line summarized the relation with only small deviations, as can be

<sup>28</sup> Throughout the discussion wage rates and average hourly earnings are identified. The correction is made for variations in wage rates for which an index of average hourly earnings is tacitly presumed to be a suitable measure. For instance, see *ibid.*, p. 246 and Table 12, entitled "Adjustment of Payroll to 1938 Wage Rates." The caption in the table is "average hourly earnings."

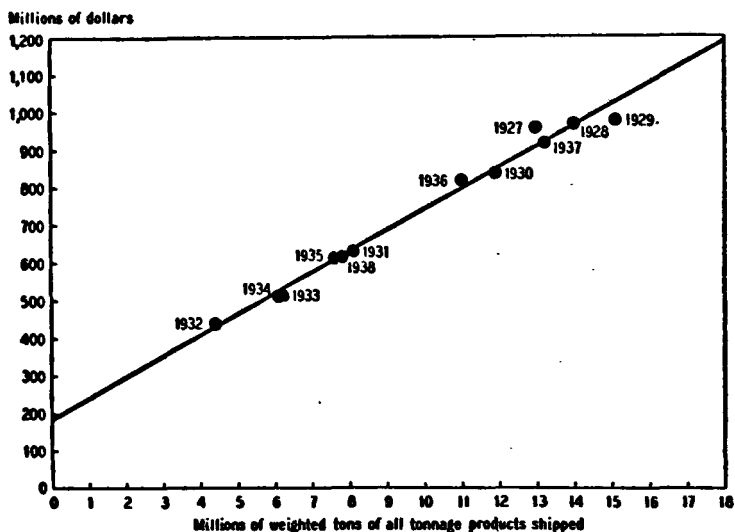
<sup>29</sup> No argument for this procedure was given except, "in order not to overadjust, only one half of the 'other expense' items have been adjusted." *Ibid.*, p. 249.

<sup>30</sup> The measure of output was discussed under (2) above.

seen from Chart 1, indicating a linear empirical cost function or a horizontal empirical marginal cost function, within the range of observation.<sup>21</sup>

Substantially similar results were found by Kathryn H. Wylie and Mordecai Ezekiel. "Even with the more accu-

Chart 1  
RELATIONSHIP BETWEEN TOTAL COSTS OF OPERATION  
AND VOLUME OF BUSINESS - 1938 CONDITIONS  
U. S. Steel Corporation and Subsidiaries



Note: Total costs adjusted to 1938 interest, tax, pension, and wage rates; to 1938 price level; and to 1938 efficiency.

Reproduced from TNEC Hearings, Part 26, Iron and Steel Industry (January 23-25, 1940), p. 13773

rate data . . . the results secured by the Corporation [Yntema's study] were very similar to those secured by our study." Perhaps the only significant difference is the

<sup>21</sup> It is important to note that the effect of all these corrections did not substantially alter the shape of the cost function calculated from unadjusted data. In the form  $y = a + bx$ , the latter was  $\$120,530,000 + \$54.51x$ , where  $x$  is a "weighted ton" of output. The corrected function was  $\$182,000,000 + \$55.73x$ . The corrected function fits the observed values better, but the difference in the fit between the two functions is not striking. Compare Chart 1 (*ibid.*, p. 240) with Chart 7 (p. 255), which is reproduced above.



fact that the Wylie-Ezekiel investigation found "there was evidence of a sharp downward trend in labor requirements per ton, for given rates of output from 1920 to 1934, with little change thereafter." Even this difference must be viewed as tentative since the regressions of costs on wage rates and efficiency in the Wylie-Ezekiel study were subject to a wide range of error.<sup>22, 23</sup>

While a comprehensive critique of the procedure of the Steel Study is beyond the scope of the present survey,<sup>24</sup> it is important to form some judgment as to the reliability of the results. The present concern is with the degree of confidence that can be placed in the shape of the statistically derived cost function. There is evidence that the techniques used in the Steel Study to meet the problems which arise in every such inquiry (Section 1) have introduced some linear bias into the cost function. Hence, the methods of investigation alone may account for a linear cost function in place of the conventionally assumed, inverted ogive. The possible sources of this sort of bias can be examined briefly.

<sup>22</sup> Two of the Wylie-Ezekiel analyses (based on annual data) show slightly declining marginal costs throughout the range of observed output; the quarterly data reveal a linear total cost function.

The study of Bernard H. Topkis and H. O. Rogers, "Man-Hours of Labor per Unit of Output in Steel Manufacture," *Monthly Labor Review* (May 1935), p. 1161, is interesting in this connection. Manhours plotted against percentage of capacity in the range of 20-60 percent yield a negative average relationship but a rising incremental (marginal) relationship.

<sup>23</sup> The United States Coal Commission developed a formula in 1923 for the determination of "incremental" costs. Although apparently no elaborate calculations are made, there is reason to believe that variations in the rate of output in certain ranges would materially affect costs because of the importance of pumping charges and ventilation. See W. C. Trapnell and Ralph Ilsley, *The Bituminous Coal Industry with a Survey of Competing Fuels*, Federal Emergency Relief Administration (multigraphed, December 1935), pp. 84-86.

<sup>24</sup> For a detailed discussion of the techniques used in the study, see the testimony of Melvin G. de Chazeau, Louis H. Bean, Mordecai Ezekiel and Martin Tainel before the Temporary National Economic Committee, January 23, 1940. See also Caleb A. Smith, *loc. cit.*, where the linearity bias is discussed at length.

(a) In order to correct costs for changes in the efficiencies of input factors, a straight line was fitted to the deviations from a cost-output regression line. Employment of this device is equivalent to assuming that changes in "technology" affect costs in a constant fashion through all phases of the business cycle.<sup>25</sup> Chapter VII will demonstrate that this is probably not the case; technical changes can be expected to reduce costs by a larger extent at some phases of the cycle than at others. If these changes reduce costs most when output is largest, as there seems some reason to believe, then the observed cost values at high levels of output are "too low" compared to what they would have been without the technical change. To make larger corrections for technical change at higher levels of output would introduce an increased slope into the cost function.

(b) The influence of variations in wage rates on payrolls was removed by an index of average hourly earnings. This presumes that both series show equivalent patterns with respect to variations in output. A consistent tendency for average hourly earnings to increase more than rates with increases in output (and vice versa for decreases in output) would result in an overcorrection of payrolls and an underestimate of costs at the higher output levels. That such a relative pattern of earnings and rates is probable for the United States Steel Corporation follows from the discussion in Chapter VI. Earnings may be expected to rise faster than rates because of better coordination between piece workers at higher output levels, graduated bonus payments for increasing output (important in the steel industry), greater effort of wage earners when large backlogs of orders exist, and technical changes which can operate directly on earnings under piece rates. Variations in the composition of the working force between different

<sup>25</sup> The scatter in Chart 6, *ibid.*, p. 253, where the technical change correction is made, fits the regression line very poorly. The regression line drawn in the chart is markedly influenced by the single year 1927.

pay levels at different rates of output are certain to affect payrolls. But no simple pattern can be deduced.<sup>36</sup>

(c) The effects of changes in tax rates were eliminated by extending the linear relationship for the period 1932-38 to the years 1927-31. Such a technique really assumes a linear function for at least this single element of cost and tends to introduce linearity into the total cost function by restricting the segment of costs in which any nonlinear relationships can be found. If the same methods had been used to deflate all "factor" prices, the total function would necessarily have to be linear.<sup>37</sup> The aggregate effect of this method of eliminating tax rate variations is probably not large in the Steel Study.

(d) The acceptance of the Steel Corporation's allocation of overhead over time can also be expected to introduce a bias into the cost function, and in general a linear bias. As was noted in Chapter II, any specification of "fixed" costs to accounting periods shorter than the life of the enterprise must involve estimates of the future performance of the firm, and hence rule-of-thumb methods in the calculation of costs. The conventional methods of

<sup>36</sup> It is commonly supposed that as output expands the occupational composition of the working force contains a smaller *proportion* of higher paid positions, an idea probably derived from the notion of a skeleton work force that is not discharged at low levels of output. But this presumption overlooks the extent to which a large plant can lay off men in each pay level and still maintain skeleton crews without changing the relative proportion of men at each pay interval. Furthermore, account must be taken of promotion and "degrading" policies, seniority or division of work provisions of trade union agreements, etc. A comparison of the proportion of wage earners in various occupational groups reveals no clear cyclical pattern for the industry as a whole. See Bureau of Labor Statistics, "Wages and Hours of Labor in the Iron and Steel Industry," 1929 and 1931, *Bulletin 513* and 567.

Chart E-17, United States Steel Corporation, *op. cit.*, II, p. 187, shows a slightly negative relation between average hourly earnings and output. The payrolls data, however, include the salaries of management. At low levels of output the weight of management salaries is higher than at capacity output. Average hourly earnings consequently show the slightly negative relation to output.

<sup>37</sup> Except under the circumstances that any element of cost was zero or negative before the common lower limit of output.

straight line allocation tend to underestimate total costs in periods of large output and to overestimate them in times of low output. This bias may be balanced partially by the fact that on some occasions of large output the corporation has written off larger amounts as reserves for amortization of investments. Only half of the usual depreciation was typically charged to completely idle plant. But such corrections are partial and sporadic and make allowances in one period that should be spread over a longer time. The cumulative effect of these four factors is to suggest a more conventional cost function than that derived statistically by Professor Yntema. On the other hand it is impossible to say how much curvature these factors would introduce into the marginal cost function. In view of the similarity between the adjusted and unadjusted functions, the first three of the limitations to the Steel Study just noted probably would not greatly change the derived function, although they do detract somewhat from the confidence to be placed in the empirical results.

Further difficulties of interpretation arise in the Steel Study from the way in which other problems listed in Section 1 were handled. Crucial among these are the measurement of output, the number and frequency of observations, the selection of the form of the cost function, and the comparability between periods of cost and output data. The output of all of the diversified products of the Steel Corporation was measured in terms of tons, weighted by the ratio of average mill costs of any product to the average mill costs of all rolled and finished products. Because of the change in the relative importance of such products as "sheets" through the period 1927-39, this measure of output is not entirely satisfactory. The independent variation in the output of such nonsteel products as coal, transportation, and iron ore raise essentially similar difficulties, although the direction of the impact of these ambiguities upon "output" is not readily apparent.

The Steel Study does not reveal whether any tests were made of the reliability of the selection of a linear regression

between the twelve annual values for output and total costs. A cubic or higher order equation might have been more appropriate. The fact that a higher order equation must necessarily fit the observed values of cost and output within narrower limits does not, however, render the linear regression invalid. The difference in "closeness of fit" of the linear and higher order equations must be large enough to be statistically "significant." Perhaps of even greater importance, the difference must be sufficiently large so that the higher order equation indicates more accurately the view of cost behavior which figures in decision formation.

On the basis of the foregoing critical appraisal, it would appear that while a linear function may be the best single estimate of the cost function, the degree of confidence that may be placed in the results leaves quite a range for possible curvature in the total cost function and, *a fortiori*, in the marginal cost function.<sup>38</sup> The statistical function may give a reasonably accurate estimate of the effect on costs of a variation in output from year to year on the average. It should not be presumed, of course, that the derived function is necessarily relevant to decisions regarding output and price for particular products at specific times.

Other studies of cost functions have yielded, in many cases, very similar results.<sup>39</sup> Although methods analogous to those utilized in the Steel Study have been adopted, the peculiar features of each firm and industry have substantially influenced the character of the available data and the techniques employed in each case. For instance, the study of the cement industry by Kurt Ehrke and E. Schneider<sup>40</sup> had a fairly homogeneous product with which

<sup>38</sup> Richard Ruggles, "Linear Total Cost-Output Regression," *American Economic Review*, XXXI (June 1941), pp. 332-34.

<sup>39</sup> J. M. Clark, "Basing Point Method of Price Quoting," *Canadian Journal of Economics and Political Science*, IV (November 1938), p. 479 n., remarks that in the cement industry marginal cost "does not appear to change much with changing rates of utilization."

<sup>40</sup> Kurt Ehrke, *op. cit.*, pp. 275-310. Dr. Hans Staehle reports that calculations based on these cement data reveal rising marginal costs at levels of output above rated capacity.

to deal, whereas Joel Dean's investigations covering firms in the furniture, leather belting, and hosiery industries and a firm in the department store field<sup>41</sup> presented problems in output measurement more complex than those in cement but less involved than in the case of the Steel Corporation. Roswell Whitman's study of a department store is one of the few to show other than a completely linear cost function; he found marginal costs rising sharply at the Christmas season peak in output.<sup>42</sup> Throughout the rest of the range of fluctuation in output there appeared to be a virtually linear cost function.

In addition to "statistically derived" cost-output relations, as was noted at the beginning of this section, a number of studies of "estimated" cost functions have been made, particularly by German writers. These inquiries differ from those typified by the Steel Study in that they utilize cost estimates rather than the direct accounting experience of a firm. The estimates must rely, of course, on the actual cost experience of the enterprise, but not in any simple and automatic fashion. In many ways "estimated" cost functions resemble break-even charts, and for this reason much of the discussion in the next section (3) will apply to them. Both characteristically measure output in terms of percent of "capacity," identifying, at least implicitly, "economic" and "physical" capacity; both frequently require the collaboration of engineers and accountants. The estimated functions are to be distinguished, however, from break-even charts, since they are cast in the form of a cost function, usually are unaccompanied by estimates of revenue so that they cannot indicate a break-even point, and are strictly historical.

The studies of estimated cost functions invariably arrive at a linear function.<sup>43</sup> Reinhard Hildebrandt, for example,

<sup>41</sup> *Loc. cit.*

<sup>42</sup> *American Economic Review*, Supplement, XXX (March 1940), p. 401.

<sup>43</sup> See estimates of the way in which costs for power stations vary with rate of utilization of plant, in Walter Rautenstrauch, *op. cit.*, pp. 109-11.

regards this relationship as typical: "The repeatedly observed phenomenon that, in addition to materials and labor costs, common indirect costs also show themselves as a linear function of rate of plant utilization, and always at similar rates and accompanied by similar values, cannot be regarded as an isolated phenomenon characteristic of only a few plants."<sup>44</sup> The linearity conclusion is somewhat surprising in that the estimated functions, like break-even charts, cover the range of output from zero to full capacity. It is difficult to tell whether this is simply a matter of projecting the relationship expected in the "normal" range of fluctuation to upper and lower limits, or a result of careful calculation. In the absence of extensive experience with levels of output at either extreme, the former possibility appears the more plausible.

### 3. *Relationships Between Sales and Costs*

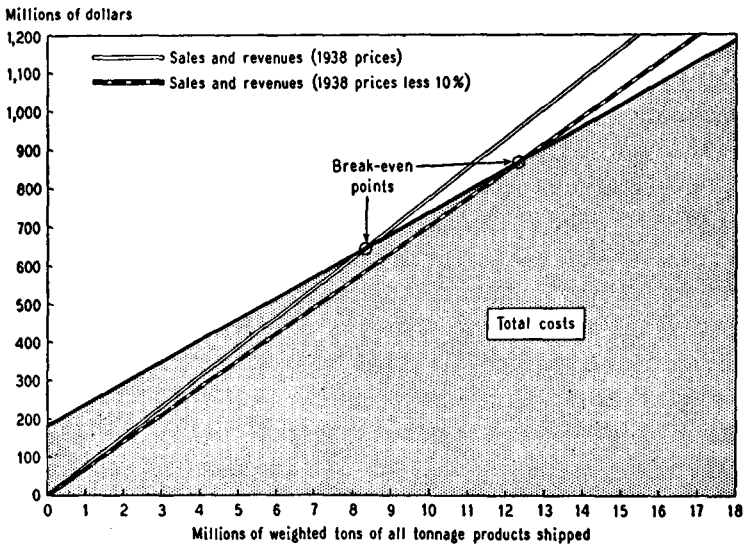
The relationship between sales and costs is frequently presented in break-even charts. They are a relatively recent addition to the tools of business analysts, engineers and executives, and are widely used as an aid to many different sorts of decision. Such charts are of interest here because they contain estimates of the way in which costs vary (or are expected to vary) with sales at constant prices and hence with output. The X-axis shows output (usually measured in percentage of capacity); the Y-axis is labeled in dollars. A line indicating total costs and another indicating revenue at various rates of output are plotted according to this system of coordinates. This kind of chart takes its name from the fact that the lines intersect where costs equal revenue, that is, the "break-even" point of plant utilization. Total cost is sometimes broken down into its component elements, at least into fixed and variable costs. The Steel Study discussed in the preceding section is presented in

<sup>44</sup> *Op. cit.*, p. 127.

the form of a break-even chart by the addition of two revenue lines as is shown in Chart 2.<sup>45</sup>

At least two types of break-even charts are constructed;<sup>46</sup>

Chart 2  
 RELATIONSHIP BETWEEN SALES AND COSTS:  
 EFFECT OF REDUCTION FROM AVERAGE 1938 PRICES  
 U. S. Steel Corporation and Subsidiaries



Note: Costs are based on 1927-1938 experience, adjusted to 1938 conditions.  
 Reproduced from TNEC Hearings, Part 26, Iron and Steel Industry (January 23-25, 1940), p. 13777

one, the historical, is based on the income and expense of an enterprise over a period of years as shown in the profit

<sup>45</sup> United States Steel Corporation, *op. cit.*, Vol. II, p. 57.

<sup>46</sup> In addition, some firms draw up detailed budgets showing costs and realizations for different outputs, and consequently the break-even point, without any chart being drawn. See, for instance, Samuel H. Selman, "Going to Make a Profit?", *Factory Management and Maintenance*, 96 (1938), p. 92. Similarly, the rate of utilization of a particular machine is recognized as relevant to the decision whether or not to buy new equipment. See, for example, E. M. Richards, "To Buy or Not to Buy Equipment," *Factory Management and Maintenance*, 91 (December 1933), p. 499.



and loss statement.<sup>47</sup> The other, the budgeting break-even chart, is based on an estimate of the relationship which may be expected to prevail for an ensuing period. The historical break-even chart is used by investors in choosing between alternative issues, as is evidenced by the fact that the term "break-even point" has become a commonplace in investment analysis.<sup>48</sup> Adjustments for factor price changes and certain problems of measuring output are skirted by the use of dollar sales to measure output. Break-even charts of this type must be employed with extreme caution. In particular, long periods of observation should be avoided, especially when there is a rather steady increase in the volume of output, as the chart may become in effect a curve showing how costs behave under conditions of expanding plant rather than of the fluctuations of output in a relatively constant plant. A break-even chart of this sort is most valuable when the enterprise has not introduced any fundamental changes in the scale of operations in a period during which there has been sufficient variation in output to establish the expense line clearly. The two following break-even charts, one for the First National Stores (Chart 3),<sup>49</sup> and the second for the Granite City Steel Company (Chart 4),<sup>50</sup> illustrate respectively a case in which output was expanded virtually throughout the period, presumably through an expansion in the number of operating units, and a case of apparently unaltered plant until the last year covered.

The budgeting type of break-even chart based on esti-

<sup>47</sup> Break-even charts summarizing profit and loss statements do not make explicit corrections for changes in factor prices. The use of dollar sales as a measure of output serves as a partial corrective. For illustrations of historical break-even charts, see Walter Rautenstrauch, *op. cit.*, Ch. 7.

<sup>48</sup> The term is used at least four times in the Standard Trade and Securities Analysis of *Steel and Iron Companies*, Basic Survey, Part II (March 31, 1939), Vol. 91, No. 26, Sec. 3.

<sup>49</sup> Rautenstrauch, *op. cit.*, p. 311.

<sup>50</sup> *Ibid.*, p. 308. The most significant change was the installation of a continuous strip mill in 1936. The point for this year is the farthest from the regression line.

mates is used by executives in making decisions. Such a chart provides a simple and convenient way in which to estimate the effects on profits of changes in wage rates or material prices; the cost line need only be moved appropriately. One set of cost and revenue lines must be drawn for each level of wage rates, material prices, and price realizations from goods for sale. It has been suggested that these charts are useful also for comparisons of the performance of plants of different companies.<sup>51</sup> When various price structures are being considered, break-even charts provide a convenient way of presenting the effects on profits of different revenue lines (arising from different prices).<sup>52</sup> Such charts purport to provide direct answers to a question like the following: With given factor prices, what must sales return to provide a profit of a specified amount? Charts relating output and specific elements in costs may afford important help when budgets are drawn up for a subsequent period, in view of expected levels of output.<sup>53</sup>

The present interest in break-even charts is centered on the shape of the cost lines—the way in which costs vary with different amounts of output. Almost all break-even charts, whether historical or budgeting, appear with linear total cost-output relations. The historical break-even charts show straight line relationships partly because of the bias of investigators in looking for a simple relation, such as a fixed cost plus a constant variable cost per unit of output, but also because the points plotted on the chart for a period

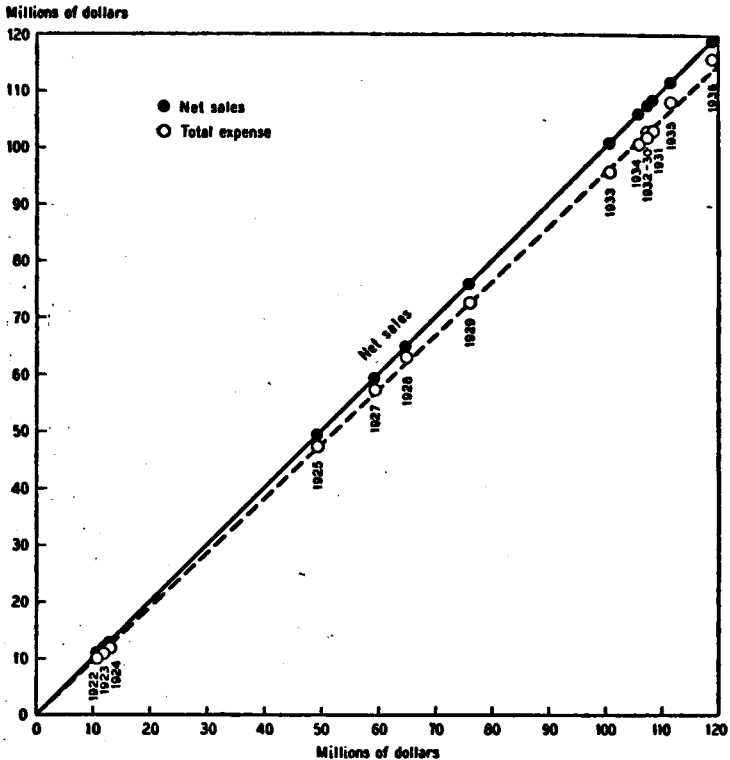
<sup>51</sup> For example, a chart comparing Chrysler, General Motors and Packard is presented in Rautenstrauch, *op. cit.*, p. 303.

<sup>52</sup> Chart 2 (*supra*) from the Steel Study is drawn to show the effect of a 10 percent price change. It should be noted that revenue lines are ordinarily drawn as if the price of goods sold were independent of the amount sold, in spite of the fact that interest in the break-even point implies a realization that the market will not automatically take any output the firm can produce.

<sup>53</sup> Charles Reitell, "Merchandising Operations," in *Corporate Finance Statements, Proceedings of the Accounting Institute, 1940* (Columbia University Press, 1940), pp. 31-32, illustrates the estimation of delivery costs from a scatter of costs and volume.

during which the plant has not been fundamentally changed usually reveal an essentially linear relationship. In the case of budgeting break-even charts this result would appear

Chart 3  
THE BREAK-EVEN CHART  
OF FIRST NATIONAL STORES, INC.



Reference: Moody's financial manuals.

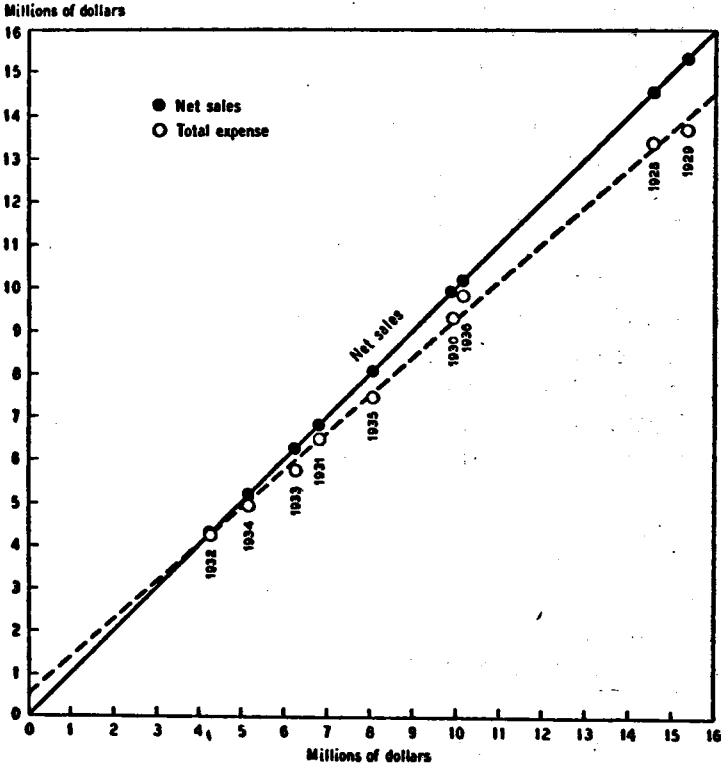
Note: The solid line represents sales plotted against sales for reference purposes. The broken line shows expenses on the vertical axis and sales on the horizontal axis.

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to be determined in large part by the way in which they are constructed. Total costs (either estimated or historical) are very sharply divided between the fixed and the variable. The former are presumed to be absolutely invariable with

respect to output, whereas the variable costs, in the absence of more specific and detailed information to the contrary, are held to be directly proportional to output. As a critic of

Chart 4  
THE BREAK-EVEN CHART  
OF THE GRANITE CITY STEEL COMPANY



Reference: Moody's financial manuals.

Note: The solid line represents sales plotted against sales for reference purposes. The broken line shows expenses on the vertical axis and sales on the horizontal axis.

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this linearity points out, "The conventional break-even chart is based on the assumption that all variable expense has a straight line relationship or is in direct proportion to activity, and that all the items classed as fixed expense

remain as constant fixed expense for the whole range of plant activity."<sup>54</sup>

The budgeting break-even chart in the hands of a careful cost executive becomes a delicate tool which must be adjusted frequently for greatest accuracy.

The modified break-even chart constitutes a variable budget. As labor rates change and methods are improved, costs change so that the chart should be revised at least twice a year at six-month intervals, and more frequently if necessary. During the period of time for which the chart is effective, the relationship between expense, income, and activity should be as shown on the modified break-even chart, provided the average of selling prices remains the same. When the average of selling prices is changed, it is a simple matter to superimpose a new income line on the break-even chart.<sup>55</sup>

It would be very helpful to the study of cost-price relationships if the part played in pricing decisions by these charts could be appraised in a number of firms. Unfortunately such charts are extremely confidential business documents and are not as readily available as historical break-even charts.

The fact that linearity is implicit in the customary methods of making budgeting break-even charts is in itself significant to the purposes of this study. If decisions are made on the assumption of a linear relationship between costs and output, this fact alone is basic to any explanation of such decisions as pricing, quite apart from the "real"

<sup>54</sup> H. R. Mallory, "A Silk Mill," *Mechanical Engineering* (August 1933). According to this executive, variable costs start out at a certain rate and then decrease at a declining rate, approaching a constant per unit of output figure. Rautenstrauch, who uses straight lines, points out (*op. cit.*, pp. 268-69) that the results obtained by this varied variable cost are substantially linear for a range of output from about 25 percent of capacity to capacity. In the chart for the United States Steel Corporation given on page 305 of his study the points for the years 1928-33 clearly present a slightly curved line for the cost relationship, with variable costs decreasing as output increases. Rautenstrauch draws no line for these years alone.

<sup>55</sup> *Ibid.*, p. 271.

shape of the cost function. Although the actual cost function of an enterprise at a given time may be of the inverted ogive shape, as is customarily assumed by economists, unless the curvature is sufficient not only to be recognized in the experience of the business but also to alter a decision substantially, the linearity assumption on the part of the business executives may be entirely valid. The implicit assumption in most break-even charts that the cost function is linear may be simply a reflection of the fact that for all practical purposes of decision formation such an assumption is adequate. In view of the uncertainties and range of indeterminacy surrounding decisions, it would require a rather large curvature in the total cost functions to modify any decision. Except for extreme levels of output, linearity may be an adequate working conception of the cost function for the business executive.

#### *4. Significance of the Empirical Studies*

Empirical studies of the relation between variations in output and costs, of the types just examined—statistical cost functions, estimated functions, and cost-revenue charts—indicate with few exceptions a linear covariation, that is, a linear cost-output relationship. These results are of particular interest, since economic theory has usually presumed an inverted ogive for total costs and marginal costs that are markedly U-shaped. This view has been supported by rather common-sense propositions. As variable factors are applied first to a fixed factor, the incremental cost may be expected to decline with improvement in the combination of factors; after a great many units of one factor have been applied the combination is bound to worsen and the incremental costs will increase. The belief that marginal costs between these extremes of output describe a smooth U-shaped curve reflects a bias in economic theory. If marginal costs approach the horizontal over large ranges of output, small changes in demand make for larger changes in output. An economic system with linear cost

functions is more unstable than one with markedly U-shaped marginal cost functions.<sup>56</sup>

The marginal cost curve was generally held to be U-shaped throughout the whole range of output on the ground that the conditions implicit in discussions of the "law of diminishing returns" were typical of industrial production. (a) That is, the fixed factor or combination of fixed factors were assumed to be entirely indivisible; plant and equipment had to be operated as a whole or not at all. (b) Within the framework of the Marshallian "short run," as output varied plant and equipment (fixed factors) were thought to be invariable except for adaptations to insure the optimum combination of all factors. The "form" of the fixed factors was envisaged as changing to permit the technical optimum combination, but the "quantity" of the "fixed" factors was unchanged. With given factor prices, marginal costs would be U-shaped with variations in output under these two conditions.<sup>57</sup>

The examination of empirical studies in Sections 2 and 3 concluded that in the cases explored a linear cost function was the most probable relation within the observed range of fluctuations of output, although basic difficulties in the

<sup>56</sup> "Economists who make use of the competitive analysis of value have a strong unconscious bias in favor of rising and falling supply price, simply because, if supply price is constant, their analysis has nothing interesting to say." Joan Robinson, *Economics of Imperfect Competition* (Macmillan, London, 1933), p. 118.

<sup>57</sup> The general acceptance of U-shaped *cost curves* was supported by empirical studies of *production functions* in agriculture. E. H. Phelps Brown, *op. cit.*, *Econometrica*, IV (April 1936), pp. 123-27. Marshall (*Principles*, Book IV, Ch. III) refers to a study of the Arkansas experiment station comparing yields per acre with the amount of ploughing and harrowing. In this connection see Bernard F. Haley, "A Preliminary Study of the Laws of Varying Costs" (Harvard Ph.D. thesis, November 1932).

It is also probably true that this view of a U-shaped marginal cost curve has been supported by arguments not strictly applicable to the cost function. For instance, some writers have pointed to the importance of overtime rates, poorer workers, etc., at high levels of output as proof of the U-shape of the curve. These may be induced changes in cost, but they are not precisely related to the cost function.

method and techniques made it impossible to place sufficient confidence in the solution to preclude marginal cost curves with considerable curvature. This conclusion certainly does not justify the statement that all cost functions are linear, but it does suggest that the conditions underlying discussions of "diminishing returns" not only need to be re-examined, but may not be as typical as presumed. Indeed, even so cautious a conclusion as this must be qualified. The results of the several types of empirical studies designed to measure cost-output relations may be substantially influenced by the accounting conventions for allocating costs over different periods (see Chapter IV).

It is quite possible, however, to construct a simplified model of production that is consistent with linear cost functions. In fact, the ordinary discussion of the conditions affecting diminishing returns may be so generalized and modified as to include both linear and U-shaped marginal cost functions as special cases.<sup>58</sup> Only empirical research, of course, can indicate the relative representativeness of the various possible cases.<sup>59</sup> One element in the explanation of linear cost functions may be the fact that fixed "factors" are more or less divisible. The more divisible the plant and equipment, the more it is likely that the variable costs may be linear. When a small volume of output is being produced, it is possible in many firms to shut down completely parts of the plant or groups of machines.<sup>60</sup> Within wide limits the fixed factors may be compared to small units whose combined costs are simply proportional. But divisibility may be achieved in yet another way with fixed

<sup>58</sup> George Stigler, "Production and Distribution in the Short Run," *Journal of Political Economy*, XLVII (June 1939), pp. 305-27. The discussion uses the terminology suggested in this article. See also Joel Dean, *Statistical Cost Functions of a Hosiery Mill*, Ch. I.

<sup>59</sup> Such reformulation of theoretical tools and designation of the typicality of special cases illustrate the importance and usefulness of the coordination of empirical studies and theoretical analysis.

<sup>60</sup> For political or humanitarian reasons the firm may refrain from a complete shutdown, particularly when plants are in a one-factory town.



plant and equipment that cannot be operated in "units." Where starting or stopping costs are not large it may be possible to operate a plant more or fewer hours per week, with one or more shifts. As a matter of practice this factor is very important, although it really involves a cost function with a meaning different from that implied in the timeless functions of comparative statics.

A second element in an explanation of linear cost functions has been suggested most clearly by George Stigler, but like the second type of divisibility just discussed this analysis involves a concept of a cost function different from that implied in comparative statics. Plant and equipment are frequently constructed to produce either a fluctuating output or different types of output rather than a single specified volume or product. "Were it not for the flexibility built into plants, outputs in excess of optimum would involve prohibitive marginal costs, while those at less-than-optimum outputs would be very unprofitable."<sup>61</sup> As output changes, minor variations are made in the plant and its equipment. With the expansion of output in a shoe factory, for instance, it may be possible within wide limits to add identical machines.<sup>62</sup> Or, in a paper mill, instead of making only one width of paper, a machine may be *flexible* to the extent of making several widths, thicknesses and types, or may run at two or three different speeds. A lathe may be used to turn out material of varying lengths. If a single type of product or a specified amount were certain to be produced, no flexibility would be required. It is the possibility of other outputs or types of products which introduces the need for flexibility. The flexible equipment could not produce the designated output or product as cheaply as equipment entirely specialized, but for other outputs or products costs would be lower. The

<sup>61</sup> *Op. cit.*, p. 316.

<sup>62</sup> An electric power generating system may be so built as to combine hydroelectric power and steam, permitting relatively more constant costs as output varies. See A. H. Markwart, "Aspects of Steam Power in Relation to a Hydro Supply," *Transactions, American Society of Mechanical Engineers* (1926), p. 187.

expectation of variations in output introduces flexible (and less specialized) fixed factors and hence relatively more linear cost functions than could be anticipated for more specialized plant and equipment.

Several of the explanations just offered with reference to possible linearity in the cost function involve a concept of a cost function different from that presumed by comparative statics. This traditional function of economic theory shows the way in which costs vary with output, when all other relations are assumed to be unchanged. One could formulate still another concept, which would simply be the way in which business executives at any one time expected costs to vary with output, regardless of the source of the impact on costs. The concept would include changes in cost due to factor price changes arising from output variation, the variation in costs attributable to flexible plant, minor technical changes, etc. In any system of determinants of cost, the concept would include the effects on costs of cross-derivatives with respect to output. It could be argued that such a function would be more relevant to actual decisions. But there can be little doubt that this concept would also be difficult to measure statistically, because the part of the change in costs which would be correlated with output would have to be separated from any total change in costs.

For the present it is important to note that the statistical linearity of cost functions could be explained by the divisibility and flexibility of fixed plant and equipment. This would mean, strictly speaking, that the U-shaped marginal cost function of economic theory is not invalid. However, if empirical studies should show that conditions of divisibility and flexibility were typical, only a linear function could be both pertinent and useful for the interpretation of economic phenomena.<sup>63</sup>

<sup>63</sup> The significance of a marginal cost function of this shape for pricing in an individual firm and in various types of market structures is discussed in Chapter XI.

### 5. *Research Possibilities*

Since only a limited number of studies have been made of the effects of variations in the rate of plant utilization on costs, and because of the importance ascribed in economic theory to this relationship, the field appears to be a very important and rewarding area for research. The survey of difficulties inherent in the problem, and the appraisal of the Steel Study of Professor Yntema in Sections 1 and 2, support this impression. The sample of studies that have been made so far depends largely on the chance of personal contacts, the cooperation of particular firms, and the convenient availability of data. A large number of useful inquiries could be made by investigators with some statistical sophistication in a wider and more representative group of enterprises. There is need for additional studies to test the present meager sample in firms confronted by different types of circumstances. For instance, the new studies should include firms with wider fluctuations in output, those allowing more frequent observations, those in service and mining industries; and more attention should be paid to smaller scaled industries and to areas of industry with less technical change.

As research projects these individual studies of cost functions would have the advantage of narrow scope. A number of such inquiries might profitably be undertaken by university candidates for degrees where business contacts are available, or indeed by business enterprises themselves. In the latter case, there would certainly be an occasion for more cooperative research between universities and business firms.

It is appropriate here to make a suggestion with respect to the method of research which will be applicable to all the topics of succeeding chapters. Since costs and prices are both influences on, and results of, business decisions, much more than we now know can be learned about the process of reaching these decisions. Explanations could be pitched on various levels of abstraction, from economic

theory to psychoanalysis. But in view of the present state of knowledge of the motivation and direction of conduct, it appears most advisable that studies of business decisions proceed along the following lines: (a) Case studies of particular firms should combine qualitative material from interviews with statistical techniques. (b) Attempts should be made to ascertain what information is available to those who make decisions. (c) In every enterprise certain persistent patterns of policy or working rules-of-thumb can be identified. (d) Individual instances of action should be examined, and not merely issues of broad "policy." While such studies cannot give definite answers to all questions, or "explain" all actions of the firm, they can provide a useful and almost indispensable counterpart to statistical inquiries.

In conclusion, we may venture several suggestions which are even more specific. Since the measurement of output presents one of the most difficult tasks in cost function studies, those types of industries in which firms produce relatively homogeneous products that are not altered substantially through time offer the simplest cases for investigation. Although it is true that a firm seldom, if ever, produces for any considerable period a product completely homogeneous with respect to size, model, style or orders, there are enterprises in industries like cement, electric power, gold mining, grey goods, bread baking, etc., which present much simpler cases than firms producing agricultural implements or women's dresses. It would be valuable, too, to extend such studies to nonmanufacturing industries such as mining, the service trades, wholesaling and retailing. In some cases attempts to measure output would encounter insuperable obstacles, but in mining or trucking, for instance, the problems ought not to be too difficult. In this field a rather useful study would be the collection and analysis of a group of engineering estimates of the way in which costs vary with output. The assumptions underlying such calculations might prove significant for explanations of business behavior.

## Chapter VI

### PRICES OF INPUT FACTORS AND COST BEHAVIOR

THE costs of an enterprise, it has been noted, are the result of the interplay of a large number of factors. For reasons of tractability, economic theory has singled out a few simple relations to depict the determination of costs. These determinants, for a functioning enterprise, are the rate of utilization, the prices of the factors of production, and their physical productivities. The influence of the first of these factors was discussed in the two preceding chapters with emphasis on the techniques that can be used in empirical studies in the endeavor to isolate the effects of variations in the rate of operations. The present chapter will deal with correlate issues arising from the role of factor prices in cost determination—in particular, the meaning and measurement of factor prices, the impact of their variation on costs in the several phases of the business cycle, and the methods and possibilities of empirical investigation in this field.

The general term “factor of production” implies no particular classification of the agents combined by business executives to produce goods and services. The familiar trinity of land, labor and capital is amenable to almost infinite subdivision, should such detailed designation be desired. For instance, labor may be subdivided according to various degrees of skill and occupation, and again into categories of specific operation; for the whole economy such a classification would be approximated by the occupational codes of the Employment Service.<sup>1</sup> No classification of

<sup>1</sup> United States Employment Service, *Dictionary of Occupational Titles*, Part I, “Definitions of Titles” (Washington, 1939).

factors can be entirely adequate for all purposes. Any attempt to determine the rewards to factors, in terms of receipts to individuals or classes of society, requires that the very closest attention be paid not only to the classification of factors but also to the translation of factor earnings into personal or group receipts. Such regroupings are beset with acute difficulties, as is readily apparent in the effort to identify the separate rewards of "factors" combined in the single person of an owner-farmer or classical entrepreneur. Of itself no classification of factors can go very far toward specifying individual or group returns. Here the interest in a classification of factors is concentrated solely upon the way in which fluctuations in their "prices" affect the costs of an enterprise. To this end it will be useful to adopt the following categories: (a) wage earners; (b) raw materials, purchased parts and supplies, containers, fuel and freight services; and (c) all other factors, including executive direction, plant and equipment. The present chapter will be concerned with the first two of these groups; the most important aspects of the third were treated in Chapter IV.<sup>2</sup>

Although it might be supposed that the influence of factor prices on costs would be entirely simple and direct, the sections to follow will show that customary measures of "factor prices" are influenced materially by considerations other than "price." Since the elimination of the effects of factor price variations is a major step preliminary to the measurement of the short run cost function, the inadequacies of customary measures of "factor prices" for these purposes require detailed attention. For if costs are deflated by factor price indexes that reflect considerations other than the "price" of these factors, not only will errors be introduced into the cost function, but a disproportionate share of cost variations will be attributed to factor prices. Some methods of deflation, analogously, may underestimate the influence of factor price variation. In the discussion below, the techniques of deflating costs for factor price

<sup>2</sup> No separate treatment of tax costs is included in this volume.

variations will be treated in brief, since they present few fundamental problems; major emphasis will be devoted to the meaning and measurement of "labor and materials" prices.

### *1. The Measurement of Factor Prices*

It was noted in Chapter III that a contract of sale for goods or services typically contains a great many terms, some directly affecting the amount of money (or the current value of the credit instrument) exchanged between buyer and seller, and a large number with no direct influence upon the pecuniary terms of the contract. Terms of the first type were designated as the "dimensions" of a price structure. It is extremely important to recognize these complexities in the terms of sale, particularly as applied to the "price" of "labor and materials," if one is to appraise and interpret the customary measures of these "prices." A common practice, for instance, is to accept average hourly earnings as a measure of the "price" of labor, and indexes of these earnings as adequate gauges of the variation in this price.

The complexities in the terms of sale of labor will be apparent from a brief examination of a relatively simple and well-known trade union agreement, that between the Packard Motor Car Company and Local 190 of the United Automobile Workers of America, effective September 30, 1939.<sup>3</sup> It contains twelve articles and fifty-four sections, all of which could be construed either as part of the "price" of labor or an influence upon it resulting from the bargaining preliminary to the drafting of "price" and "nonprice" sections of the contract. The terms of the agreement readily identifiable as dimensions of price are those covering overtime rates by day and week, Sunday and holiday rates, minimum rates for new employees, students, apprentices or

<sup>3</sup> A copy of this agreement is included as Appendix A in William Heston McPherson, *Labor Relations in the Automobile Industry* (Brookings Institution, 1940), pp. 161-67.

improvers, afternoon or night shift rates; the speed of production;<sup>4</sup> the minimum hours of work possible in a day if a wage earner is required to report for work; and the status of demoted foremen. Other provisions of the agreement describe the form and character of union recognition, the procedure for the handling of grievances, the seniority of union representatives, and in great detail the provisions affecting discharges, transfers and layoffs. This last group of provisions may influence very materially the earnings of any wage earner or group of the working force, and indirectly may even affect future "wage rates" by reflecting the bargaining strength of the union. Nevertheless these provisions have been designated as nonpecuniary, because in general they do not directly condition the size of wage payments to the total group of employees. Such "nonprice" terms of the contract provide the institutional and "legal" framework for the employee-corporation relationship. In many instances, however, it is impossible to make a neat and clear-cut division between the "price" and other terms of an agreement.<sup>5</sup>

With so many dimensions to the wage structure, it is evident that indexes of basic wage rates can be valid only if variations in the base rate are not accompanied by other changes in the wage structure. Overtime rates and Sunday rates, for instance, must be presumed to remain "reasonably" fixed while the base rate is varied. But trade unions and even unorganized wage earners are usually more concerned with maintaining the basic rate than with other terms of the wage structure. Concessions made in the latter respect are probably easier to regain and more easily "sold" to the membership. The basic rate stands as a symbol of the strength and achievements of the union; furthermore, changes in terms other than the base rate can be more easily

<sup>4</sup> Important in this connection for wage earners on piece rates. Perhaps one third of the wage earners in the industry are on piece rates in spite of recent shifts back to hourly rates. *Ibid.*, pp. 94-97.

<sup>5</sup> This is especially true in the case of more complex agreements. For a compendium of clauses from trade union agreements, see Elias Lieberman, *The Collective Labor Agreement* (Harper and Brothers, 1939).



restricted in their effects on earnings. Overtime, for instance, cannot be reduced below straight time. Business executives follow precisely similar policies when special discounts and concessions are granted more readily than revision of the basic list prices. It is little wonder, therefore, that indexes of wage rates are not generally available for the United States<sup>6</sup> and that there has developed a tendency to designate average hourly earnings as the "price" of labor.

Average hourly earnings data are cited almost invariably in discussions of the "price" of labor or wage rates, if for no other reason than that they are easily obtained. Variations in these earnings cannot, however, be interpreted correctly unless the types of influence which can independently induce changes in average hourly earnings are clearly recognized. These channels of impact, equally applicable for any grouping of wage earners, may be summarized conveniently under four headings. (1) Changes in the basic wage rate or any other dimension in the wage structure, such as overtime rates, shift rates, or minimum guarantees. (2) Variations in the number of hours of work performed at each wage rate, or other dimensions to the wage structure. Changes in the relative distribution of wage earners among "rates" may be illustrated by a change in the proportion of women workers or apprentices at lower rates, a change in the proportion of overtime, and a change in the proportion of wage earners at starting rates within each occupation. Some of these changes may be correlated with fluctuations in the rate of output in the firm or the entire system. (3) Changes in technique and organization of the plant or other factors that result in a change in rate of output by piece-rate workers. At a given structure of wage rates changes in the rate of output may be brought about by coordination of different operations, the wage earners'

<sup>6</sup> In the construction of indexes of wage rates for England inadequate attention has as a rule been paid to these problems. There can be little doubt that discussions of wage-rate flexibility have underestimated the significance of other terms of agreement than the basic rate.

own intensity of effort, and the technical qualities of the machine and material with which they work. (4) The period of time *itself* over which average hourly earnings are calculated. This will affect the results of any of the above three factors independently. Perhaps the point can be stated more accurately by reference to the way in which payments are made on such accrued items as vacations with pay, profit sharing, and pensions. If payrolls per year or wage income over the lifetime of a worker were divided by hours worked, average hourly earnings would reflect these items. But since most averages are calculated over the payroll period (usually one or two weeks), they may not be affected by variations in these items.<sup>7</sup> With the spread of paid vacations and pension plans for wage earners in recent years, this limitation has become increasingly serious. Thus the variations in important terms in the wage rate structure will affect average hourly earnings according to the period over which earnings and hours worked are matched.

To identify average hourly earnings and wage rates (or variations in the two) is thus likely to give rise to serious error unless there is reason to believe that the other factors which could affect average hourly earnings are "virtually"<sup>8</sup> inoperative. The central argument of the following quotation is not relevant to the present discussion, but it does provide an instance of the confusion that results from unqualified comparison of wage rates and average hourly earnings:<sup>9</sup>

<sup>7</sup> Where employees nominally on vacation continue to work, the Bureau of Labor Statistics does not allow the vacation pay to influence average hourly earnings although average weekly earnings do reflect the vacation wages.

<sup>8</sup> Relative to the problem at hand.

<sup>9</sup> That the difference between the movement of average hourly earnings and wage rates for Great Britain during this period may have been appreciable is indicated by the fact that after correcting for some of the differences between these series, Professor A. L. Bowley reported an index of wage-rate variation for the period 1930-36 of 191 to 197 instead of the uncorrected 191 to 190 (1914 = 100). *Wages and Income in the United Kingdom since 1860* (Cambridge University Press, 1937), pp. 18 and 30, Appendix B.

Between 1929 and 1938 the average hourly earnings of American workers (according to the figures of the National Industrial Conference Board) increased by 23 percent. . . . To place two figures in juxtaposition is not to prove that the one is the cause of the other. But it is at least suggestive that, while wage rates in Great Britain rose over the same period by less than a third of the American increase, British payrolls . . . increased by 20 percent.<sup>10</sup>

Six studies by the Bureau of Labor Statistics of particular firms in the agricultural implement, cotton textile, boot and shoe, and paper industries provide some information on the relative magnitudes of the movements of wage rates and average hourly earnings.<sup>11</sup> As in all indexes of wage rates, the term was used to refer only to changes in the base rate; other dimensions of the wage structure were assumed to be constant. The comparisons are, therefore, strictly between changes in average hourly earnings and variations in the base rate. The comparative variations over the period of observation (1930-37) and in the phases of the business cycle are summarized in Table 3 for different plants of the same firm in the agricultural implement industry. The data show wide discrepancies in the relative variations in "rates" and earnings.

Data for a firm in the paper industry are presented in Table 4 by months for the period 1936-38 inclusive. Average hourly earnings and an index of the number of employees are divided into five periods during which "wage rates" were constant. The rates were increased 10 percent in December 1936, 5 percent more in August 1937, and decreased 7 percent in September 1938. It is clear from an analysis of the data in Table 4 that there is an inverse correlation between average hourly earnings and the total

<sup>10</sup> "Laggard Recovery in America," *The Economist*, CXXXVI (July 1, 1939), p. 3. This quotation was reprinted and endorsed editorially by the *New York Times*. Also see, Waldo E. Fisher, "Union Wage-Hour Policies and Employment," *American Economic Review*, XXX (June 1940), pp. 298-99.

<sup>11</sup> Temporary National Economic Committee, *Monograph No. 5* (Washington, 1940).

number of employees, explained in part by the policies of the company. New employees, or old employees transferred to other jobs, were started at the beginning rate for the particular job. These rates were automatically increased by 2 cents an hour every three months until the full rate for the job was reached. This process took nine months on

TABLE 3

RELATIVE MOVEMENTS OF "WAGE RATES" AND  
AVERAGE HOURLY EARNINGS IN TEN PLANTS  
OF AN AGRICULTURAL IMPLEMENT COMPANY<sup>a</sup>

Plant	Percent Change 1930-33		Percent Change 1933-37		Percent Change 1930-37	
	Wage Rates	Average Hourly Earnings	Wage Rates	Average Hourly Earnings	Wage Rates	Average Hourly Earnings
1	-18.1	-15.9	+48.4	+50.3	+21.5	+26.4
2	-18.1	-19.2	+41.3	+47.5	+15.7	+19.2
3	-18.1	-13.3	+43.8	+72.3	+17.8	+49.4
4	-18.1	-13.5	+42.6	+52.6	+16.8	+32.0
5	-18.1	-18.2	+48.4	+68.6	+21.5	+37.9
6	-15.6	-20.8	+50.8	+77.8	+27.0	+40.8
7	-18.1	-16.5	+40.9	+52.2	+22.0	+27.1
8	-18.1	-25.6	+53.0	+61.3	+25.3	+20.0
9	-18.1	-11.9	+46.8	+43.4	+20.2	+26.3
10	-18.1	-19.3	+40.7	+57.9	+15.2	+27.4
11	-15.8	-12.1	+51.3	+68.3	+27.4	+47.9
12	-18.1	-23.6	+46.5	+68.1	+20.0	+28.4

<sup>a</sup> Temporary National Economic Committee, *Monograph No. 5*, pp. 107-14.

the lower paid jobs and as long as eighteen months for highly paid work. While the study found a relatively close covariation of "rates" and earnings, this tendency was modified by changes in the volume of employment and, to a lesser extent, by changes in the ratio of female employees to the total working force.

In the cotton textile study there was almost perfect correspondence in the variations of "rates" and average hourly earnings, whereas in the boot and shoe firms the divergences were relatively small. The firms in the four industries present a heterogeneous picture; at one extreme the

**TABLE 4**  
**EMPLOYMENT AND EARNINGS IN A PAPER**  
**MANUFACTURING COMPANY<sup>a</sup>**

<i>Year and Period Number</i>	<i>Index of Total Number of Employees 1936 Average = 100</i>	<i>Average Hourly Rate (cents)</i>
1936 1	88	57.6
2	94	57.0
3	102	55.5
4	107	55.4
5	109	55.5
6	101	56.2
7	96	57.2
8	95	57.4
9	95	57.1
10	100	57.2
11	105	57.3
12	110	55.6
<i>First group average for twelve periods</i>	100	56.4 <sup>2</sup>
1937 1	112	59.9
2	115	59.5
3	116	59.8
4	117	59.5
5	117	59.9
6	117	60.1
7	116	60.4
8	116	60.4
<i>Second group average for eight periods</i>	116	59.93
1937 9	116	63.2
10	116	63.1
11	116	63.3
12	115	63.9
13	113	64.4
<i>Third group average for five periods</i>	115	63.54
1938 1	111	64.2
2	111	64.4
3	111	64.4
4	110	64.9
5	109	65.0
6	107	64.7
7	107	64.5
8	105	64.8
9	104	64.8
<i>Fourth group average for nine periods</i>	108	64.64
1938 10	104	60.3
11	106	60.1
12	107	60.0
13	132	60.1
<i>Fifth group average for four periods</i>	112	60.10

<sup>a</sup> Temporary National Economic Committee, *Monograph No. 5*, p. 32.

agricultural implement firm showed marked deviations in many instances, while the cotton textile firm, at the other extreme, showed none. Although it is impossible to generalize as to the representativeness of these cases in industry as a whole, they do suggest that without special information it is unjustifiable to presume equivalence in movement of "rates" and earnings.

The preceding discussion has been focused on wage structures as the price of the services of wage earners, but correlate points can be made also for raw materials, purchased parts and supplies, fuel and freight services—that is, for the second group of "factors" classified above (p. 117). (a) The "price" of these items is composed of a number of terms or dimensions. (b) Indexes of these "price structures" are almost always confined to list prices;<sup>12</sup> as measures of changes in "what the buyer pays or seller receives" they are as inadequate as average hourly earnings are with reference to wage rates.

Finally, it is important to recognize that certain types of expenditures which are a part of wage costs are not usually considered a component of the wage structure. Except for these items the total labor costs of a firm would equal the total wage and salary payments. They correspond to freight and sales taxes, noted in Chapter II as considerations which make the receipts of the seller unequal to the amount paid by the buyer. Connected with the purchase of labor services are payroll taxes and social services that may be required by law in addition to all expenses incurred in behalf of wage earners, such as uniforms, medical care and all types of welfare expense.

## 2. *The Influence of the Individual Enterprise on Factor Prices*

The evidence just examined leads to the conclusion that, at least under some important conditions, the customary

<sup>12</sup> For a more detailed discussion of these problems, see Chapter III, above.

measures of factor prices may prove inadequate for appraisal of the effect on costs of changes in these prices. Accepted measures of factor prices, such as average hourly earnings, may be influenced substantially by considerations other than price. The present brief section discusses three ways in which the individual enterprise may affect factor prices.<sup>18</sup> Sections 3 and 4 are concerned with a more explicit description of the influence of factor price changes upon costs. Section 4 examines particular instances of cost variation and indicates some of the problems that arise when one attempts to specify the extent to which the influence of factor prices can be isolated. Section 5 continues the same discussion with particular reference to the cyclical setting.

The ways in which a single enterprise may affect the price it pays for factors are summarized *seriatim*. (1) From the standpoint of the enterprise, the elasticity of demand for the factors it employs depends in part on their relative importance in total costs. The larger one factor's share of total costs the greater is the resistance to a rise in its price—in other words, the more elastic the demand. But the proportion of labor to materials costs obviously depends on the scope of the activities of the firm, or the degree of vertical integration. If the whole economy were completely integrated into a single corporation, the proportion of labor to total costs in that "enterprise" would equal the proportion of labor to total income. At the other extreme, with almost infinite subdivision of the productive process between firms, labor costs would be a very small part of the costs of any enterprise. The more frequently the productive process is cut by the limits of individual firms, the smaller the proportion of labor to materials costs. Vertical integration in industry necessarily operates in the opposite direction. It is evident, therefore, that the degree and character of the existing industrial organization and structure are important

<sup>18</sup> Any attention to the ways in which an individual enterprise can influence factor prices presumes market conditions which are not those of pure competition.

considerations which affect the pricing of factors for particular enterprises by influencing the elasticity of their demand.<sup>14</sup>

(2) An enterprise may influence the "price" it pays for factors by a process of bargaining among the "price" and "nonprice" terms of a sales contract; greater possibilities for such substitution probably exist in connection with the labor contract. A concession dealing with the kind of union recognition or seniority status of wage earners may be traded for a wage change. This kind of substitution is apt to be of greater importance in periods when unionization is expanding rapidly. In many instances wages have been increased simply to prevent the expansion of a trade union; such moves are more properly regarded as means of purchasing a preferred kind of industrial relationship than simply as payment for services. There can be little doubt that a concern's wage structure is not independent of its other policies. The American Federation of Hosiery Workers, for instance, accepted wage reductions on the condition that the funds be used to modernize the plants and purchase new machinery. Other wage earners have accepted a yearly guaranteed volume of employment in lieu of a change in the wage structure.<sup>15</sup> In a certain sense the welfare emphasis of many personnel departments in the

<sup>14</sup> In an economic system with considerable division of the productive process at different "stages" among firms, the pricing policies pursued by individual companies are of crucial significance because of the large proportion of total costs (of a single enterprise) represented by "materials." In a less divided productive process, wage policies would play a still more vital role.

The importance of this fact for interpretations of the policies of enterprises or trade unions has ordinarily not been given sufficient recognition. It would be worth while to explore the thesis that large *integrated* corporations have been opposed to union organization at least in part because a rise in wage rates among all employees makes a much larger proportionate increase in total costs than it would for a less integrated company.

<sup>15</sup> Wage changes of this character have been frequently urged for the building trades. See Thurman Arnold, "Agreement Between Labor Union and Employer to Establish Weekly Wages in Place of Daily or Hourly Wage Rates," Public statement (October 2, 1940).



1920's can be held to have affected the price of labor by substituting recreational and social facilities. The complicated and detailed specifications of a trade union agreement offer innumerable openings for substitution between "wage structure" and other terms of the contract, and similar opportunities arise for changes in the price structure of purchased parts or materials. Bargaining may be applied as between elements of the price structure and such other terms of sale as dates of delivery and penalties for cancellation of orders.

(3) A third way in which a single enterprise may influence the price of the factors it purchases—in addition to varying its degree of vertical integration and effecting a substitution among items in the price structure and other terms of sale—is through the impact of fluctuations in its output. If the firm is a sufficiently important purchaser in the market, an increase in its orders may induce a price rise in the whole "market" or a decrease result in a price reduction. And if business executives recognize the possibility that a rise in their output may increase price, and there is no reason why they should not, they may take steps to prevent such a development. For instance, the automobile industry is alleged to have attracted a large force of wage earners to Detroit not only to insure a labor supply for peak periods but also to forestall a demand for wage increases that might arise if there were no unemployment. An agricultural implement company was influenced in its choice of a new plant location by consideration of the probable effect on wage levels of additional workers in a certain city. In "markets" where a few large buyers purchase from a number of relatively small suppliers, such induced price changes may be minimized by the threat of ruptured relations. Prices may be relatively stabilized in such circumstances as a result of a very long view—the buyer desiring a continuous source of supplies and the seller confronted with the total loss of sales in the event of a refusal on the part of the buyer. Changes in factor prices induced by variations in the output of a single firm are

probably not as important as might be supposed, primarily because the possibility of such changes is anticipated by business executives, who take steps to prevent their occurrence or to minimize their extent.

### 3. *The Modus Operandi of Factor Price Variations*

This section is intended to trace the impact of changes in the price structure of factors on the costs of firms, regardless of the influence of a particular enterprise in inducing the variation. In general terms, this is a simple matter; the costs of a particular factor vary directly and proportionately with changes in factor prices, in the absence of induced or concomitant influences. If the prices of all factors are doubled, the costs to an enterprise double. If the price structure of a single factor is doubled, the cost of the factor will double only if there is no induced substitution between the resource and all others.

It must be made clear that substitution refers to the interchange of amounts of one factor in the productive process of a firm for amounts of another at a given state of knowledge and level of output. It does not cover cases of new techniques or changes in "the state of the arts."<sup>16</sup> For instance, a change in the price of mechanical loading equipment for bituminous coal relative to wage rates of loaders, brought about by an increase in loaders' rates, probably extended the use of the mechanical process.<sup>17</sup> This "substitution" is to be distinguished from the original introduction of the machinery or from any changes in its efficiency or technical effectiveness. The term substitution will always refer here to a change in a combination of factors of given effectiveness. If the change in the efficiency of one factor leads to its wider use and consequently a lowering of its price, the increased employment of this factor is made

<sup>16</sup> Problems associated with the meaning and measurement of technical change are treated in Chapter VII.

<sup>17</sup> Waldo E. Fisher, *Economic Consequences of the Seven-Hour Day and Wage Changes in the Bituminous Coal Industry* (University of Pennsylvania Press, 1939), pp. 67-75.

up of two logically distinguishable elements—the substitution arising from a change in relative prices of the factors and a technical change which increases the productivity of the factor.

In the framework of economic theory, the only situation leading to a change in the way in which factors of given productivity are employed would be a change in relative prices. From the standpoint of simple description of business practice, it is of course true that substitutions are made for many other reasons. For example, a manager in the automobile industry has been quoted as saying he had introduced machinery wherever possible because “machines don’t strike.”<sup>18</sup> Business executives may regard a particular arrangement as more convenient, or as necessary because of health standards enforced by law or agreement.

The substitution of one factor for another is certain to alter the composition, and most probably the level, of costs. The proportion of costs that are “materials” or “labor” or “overhead” will change according to the direction of the substitution. In the case of a classification of factors that is more than twofold, it is especially important not to draw inferences from a substitution between any two factors as to the net effect of the substitution on the amount of the factors employed. If, for instance, the threefold classification suggested at the start of this chapter were adopted, “overhead” might be substituted for “labor,” but the total effect on the quantity of labor employed would depend also on the relative substitution between “materials” and “labor,” and “materials” and “overhead.”<sup>19</sup> Similarly the effects on relative costs will depend on all substitutes, rather than on the initial two alone. The purchase of such factors as machines, which are expected to last over several periods, results in a larger outlay in the current period and perhaps even in a greater total cost after the problem of allocation over time has been decided.

<sup>18</sup> William Heston McPherson, *op. cit.*, p. 147.

<sup>19</sup> The solution depends on the relative elasticities of demand compared to the elasticities of substitution.

If an attempt were made to observe historically the relative movements of a factor price and its cost to an enterprise, the above discussion of substitution would suggest that correspondence in variation should not be expected. Studies by the Bureau of Labor Statistics of wages, costs and prices in four industries (pp. 122-25 above) were directed toward these comparative movements. The results for the firm in the agricultural implement industry are shown in Table 5, with marked differences in the relative variations of labor costs and wage rates.

For a firm in the paper industry, neither direct nor in-

TABLE 5  
CHANGES IN WAGE RATES AND LABOR COSTS IN AN  
AGRICULTURAL IMPLEMENT FIRM, 1929-37<sup>a</sup>

<i>Implements</i>	<i>Wage Rates</i> <sup>b</sup>	<i>Labor Costs</i>
(Percent)		
<i>Group I</i> <sup>c</sup>		
Spring tooth harrow	+15.7	+18.7
Cultivator	+15.7	+20.1
Tractor plow	+17.8	-3.7
Grain binder	+22.0	+13.2
Corn binder	+22.0	+20.0
Side delivery rake and tedder	+20.2	+20.5
Disk harrow	+20.2	+6.5
<i>Group II</i> <sup>c</sup>		
Mower	+22.0	+24.9
Manure spreader	+22.0	+20.1
Tractor	+21.5	-15.2
Cream separator	+25.3	+47.7
Grain drill	+15.2	+5.2

<sup>a</sup> Temporary National Economic Committee, *Monograph No. 5*, Table 15, p. 119.

<sup>b</sup> Wage rate figures are for 1930 rather than 1929, but probably this is not important as there were no major changes in rates during the year. They refer to the wage rates paid to all employees of the plant in which the implement is made, rather than to the wage rates of employees working only on the implement. Since the wage rate changes were all plant-wide, this fact should not affect the comparisons made.

<sup>c</sup> The design of implements in Group I was not changed appreciably between 1929 and 1937; that of implements in Group II was changed.

direct labor costs advanced as much as wage rates over the period as a whole. As a result of the two increases, wage rates were approximately 19 percent higher in 1938 than they had been in 1936. Direct labor costs (per ton of product) were only 6.4 percent higher, and indirect labor costs 14.5 percent higher. Had the volume of production been as great in 1938 as in 1936, it is probable that indirect labor costs per ton would have been even lower in the latter year. The boot and shoe firms also indicated some divergence in relative movements, although not of such magnitude. The cotton textile firm alone showed almost complete equality in the variation of wage rates and labor costs.

These studies are of limited value, since it is impossible to ascertain from them whether the divergences are to be attributed to different rates of output, substitution of other factors for labor with the increases in wage rates, or "technical change."<sup>20</sup> Even acceptance of the linearity of each element of the cost function leaves a choice between the relative roles of the last two factors. The discussion of technical change in Chapter VII will return to this problem.

#### 4. Cyclical Setting

The comparative movements of factor prices and costs are particularly significant when placed in the context of cyclical fluctuations. Not only have costs been a very important element in many "explanations" of price inflexibility, but factor prices have been specified as the determinant of costs which has the greatest bearing upon the

<sup>20</sup> The policy of inventory valuation will also certainly affect the costs in an accounting period for those factors which are carried over from one period to another. For instance, the choice of the lower-of-cost-or-market principle of valuation in periods of rising prices will "understate" costs compared to other methods and "overstate" them in a period of falling prices. George O. May, *Twenty-Five Years of Accounting Responsibility, 1911-1936*, Vol. I, pp. 86-88. See also *The New York Certified Public Accountant*, Vol. X, No. 5 (February 1940), Henry B. Arthur, "Inventory Profits in the Business Cycle," *American Economic Review*, XXVIII (March 1938), pp. 27-40, and Carl Thomas Devine, *Inventory Valuation and Periodic Income* (Ronald Press, 1942).

cyclical variation of costs.<sup>21</sup> In keeping with the focus of this chapter, the present concern is only with prices and costs of labor and materials. Two types of empirical studies are relevant in this connection: (a) case studies of individual firms, and (b) inquiries covering whole industries or the total system.

(a) The comparative movements of wage rates and average hourly earnings in the course of the cycle are influenced primarily by the changing composition of the work force in an establishment and the amount of overtime payments. In general, hourly earnings may increase more than "rates" on the upswing due to overtime, changes in technique favorably affecting the earnings of piece workers, etc. This tendency, normally expected to be dominant, might be counterbalanced by offsetting changes in the composition of the working force with expanding production and with many workers at starting rates. On the downswing, average hourly earnings may lag. With seniority provisions and discharge of the lower paid in each occupational group (most recent additions to employment), average hourly earnings could be expected even to rise for a period. Such an initial rise of average hourly earnings at the downturn has mistakenly been interpreted as an instance of reverse wage flexibility. When the boom has been associated with a great deal of overtime, average hourly earnings may well decline before reductions in rates. These expectations as to the cyclical pattern of earnings and "rates" are confirmed by Table 6 for a sample of six plants from the firm in the agricultural implement industry for the period 1930-37. The other studies in this group undertaken by the Bureau of Labor Statistics, although covering shorter periods, indicate similar patterns of less intensity.

The cyclical pattern of wage costs and "rates" for the same firm in the agricultural implement industry is shown

<sup>21</sup> See, for instance, Rufus S. Tucker, "Reasons for Price Rigidity," *American Economic Review*, XXVIII (March 1938), p. 51. For further discussion: Alfred C. Neal, *Industrial Concentration and Price Flexibility*, (American Council on Public Affairs, 1942).

in Table 7 for the years 1929-33 and 1933-37. While wage costs per implement fell less than the decline in wage rates, they also rose much less than the increase in wage rates in the upswing period. This disparity must suggest that factors other than the variation in wage structures influenced

TABLE 6  
WAGE RATES AND HOURLY EARNINGS IN AN  
AGRICULTURAL IMPLEMENT FIRM, 1930-37<sup>a</sup>  
1930 = 100

Year	Wage Rates <sup>b</sup>	Average Hourly Earnings	Wage Rates	Average Hourly Earnings	Wage Rates	Average Hourly Earnings
	<i>Plant 1</i>		<i>Plant 2</i>		<i>Plant 3</i>	
1930	100.0	100.0	100.0	100.0	100.0	100.0
1931	97.5	101.6	97.5	100.9	97.5	102.1
1932	82.9	89.6	82.9	86.4	82.9	89.2
1933	81.9	84.1	81.0	80.8	81.9	86.7
1934	97.3	99.0	96.3	94.2	96.3	102.3
1935	106.1	109.6	97.0	98.6	97.0	112.5
1936	108.6	111.0	104.4	105.2	104.5	124.3
1937	121.5	126.4	115.7	119.2	117.8	149.4
	<i>Plant 4</i>		<i>Plant 5</i>		<i>Plant 6</i>	
1930	100.0	100.0	100.0	100.0	100.0	100.0
1931	97.5	102.9	97.5	102.8	97.5	98.9
1932	82.9	89.0	82.9	89.5	82.9	86.3
1933	81.9	86.5	81.9	81.8	84.2	79.2
1934	96.3	99.8	96.3	96.1	109.5	107.5
1935	97.0	105.5	105.0	108.9	113.3	117.3
1936	104.4	113.5	108.6	116.2	114.0	117.2
1937	116.8	132.0	121.5	137.9	127.0	140.8

<sup>a</sup> Temporary National Economic Committee, *Monograph No. 5*, p. 114.

<sup>b</sup> Weighted average for each year of percentages of 1930 wage rates.

labor costs during these years. From the framework of economic analysis only three possibilities present themselves —“technical change,” substitution both as between other factors and labor and among different types of labor, and variations in the rate of plant utilization. No effort was made in these studies to allocate statistically the divergences in move-

ment between wage rates and costs among these three factors. It must be noted, however, that the relative variations on the upswing are consistent with "technical change" and/or substitution (of a magnitude to offset any increase in cost from an increase in output) only if the traditional shape of the cost function is still accepted. If the statistical findings in Chapter V are generalized, then only substitution and "technical change" can be consistent with the observed results, unless the marginal cost function is assumed to slope downward throughout the observed range of output variation.

The observed covariation between wage costs and "rates" during the downswing period (Table 7) presents a more difficult problem. At first sight they would appear to

TABLE 7  
CHANGES IN WAGE RATES AND UNIT LABOR  
COSTS IN AN AGRICULTURAL IMPLEMENT  
FIRM, 1929-33 and 1933-37\*

Implements	1929-33		1933-37	
	Wage Rates <sup>a</sup>	Labor Costs	Wage Rates	Labor Costs
	(Percent)			
<i>Group I<sup>a</sup></i>				
Spring tooth harrow	-18.1	-13.9	+41.3	+37.9
Cultivator	-18.1	-15.0	+41.3	+41.2
Tractor plow	-18.1	-23.5	+43.8	+25.8
Grain binder	-18.1	-12.6	+49.0	+29.6
Corn binder	-18.1	-11.8	+49.0	+35.9
Farmall tractor	-18.1	..	+48.4	..
Side delivery rake and tedder	-18.1	-5.8	+46.8	+27.9
Disk harrow	-18.1	-10.9	+46.8	+19.6
<i>Group II<sup>a</sup></i>				
Mower	-18.1	-6.9	+49.0	+34.2
Manure spreader	-18.1	-17.9	+49.0	+46.1
Hammer mill	..	..	+49.0	+6.3
Cream separator	-18.1	-0.7	+53.0	+48.7
Grain drill	-18.1	-7.4	+40.7	+13.6

\* See notes to Table 5.



be consistent only with the conventional notion of the shape of the cost function. But the year-to-year data reveal the same relationship throughout the whole downswing period. Studies of entire industries or the total system show very different patterns with the possible exception of the automobile industry. If it is true for even the initial period of contraction of output, the marginal cost function would have to be presumed to slope downward throughout its whole range if it is to be used as the only explanation of the observations. Since "technical change" is usually regarded as "irreversible," "substitution" provides the only other formal explanation for the data in Table 7. From a study of the policies of the company, several circumstances combined to bring about the observed result: (1) The wage earners with longest service and highest earnings were kept on, thus tending to raise average labor costs per unit of product at the start of the downswing. (2) At low levels of output skeleton forces were maintained without full work on current output. Repairs and changes in plant, which could not be measured in the units of work they performed, were undertaken. (3) Certain types of substitution took place as tasks that would have been performed by machine for larger lots were done by hand. These considerations do not easily fit the theoretical determinants of cost, but they might be classified under substitution and the shape of the cost function, particularly at exceptionally low levels of output. The relative movements of wage costs and "rates" probably do not present as uniform a picture in individual firms on the downswing as on the upswing. The comparative variations depend on the absolute volume of output at the peak relative to plant capacity, the employment and seniority policy of the enterprise, and the extent of substitution and "technical change." The larger the initial output and the more important the latter factors, the more certain it is that costs will decline more sharply than "rates."

(b) Several studies have attempted to indicate the comparative variations of labor costs and "rates" for industries as a whole or for the total system by utilizing generally

available indexes of payrolls and production. Since payrolls divided by production should yield labor costs per unit of production, indexes of these series should show the variation in labor costs. A study published by the Brookings Institution gives the comparative movements for "unit wage costs" and average hourly earnings in manufacturing industries (Table 8).<sup>22</sup> The study includes similar figures for mining, steam railroads, construction, and the following separate manufacturing industries: automobiles, iron and

TABLE 8  
WAGE COSTS AND AVERAGE HOURLY EARNINGS  
IN MANUFACTURING INDUSTRIES, 1929-38

Year	Average Hourly Earnings, in Cents	Unit Wage Costs, 1923-25 = 100
1929	57.2	86.4
1930	56.5	83.0
1931	52.7	73.4
1932	46.5	65.8
1933	46.0	63.0
1934	54.8	74.6
1935	56.8	73.6
1936	57.5	71.5
1937	64.3	82.5
1938	64.6	82.5

steel, paper and allied products, cotton textiles, and tobacco. While each industry showed distinctive characteristics, the general pattern brought out in Table 8 is typical of the

<sup>22</sup> Spurgeon Bell, *Productivity, Wages, and National Income* (Brookings Institution, 1940), pp. 234 and 270. The Brookings study covers the period 1919-38. See the discussion of Mordecai Ezekiel, "Productivity, Wage Rates, and Employment," *American Economic Review*, XXX (September 1940), pp. 507-23. Similar calculations for the total of manufacturing industries have been made by the National Industrial Conference Board, "Manufacturing Relations: Prices, Production, Wages, and Employment, 1929-39," *Conference Board Graphic Business Trends* (October 1939), Chart 9. See also U. S. Department of Labor, *Productivity and Unit Labor Cost in Selected Manufacturing Industries, 1919-1940* (Washington, 1942), p. 1.

group.<sup>23</sup> It is interesting to note also that these patterns of relation between labor costs and average hourly earnings are similar to those indicated by the agricultural implement case study of the Bureau of Labor Statistics except, as noted, on the downswing.

If wage costs consistently decline more than "wage rates" or average hourly earnings on the downswing of the cycle, the accepted notion of the cost function may be used to explain the initial fall in costs, but would apparently be inapplicable at the very lowest levels of output. The persistent tendency of the industry studies to show larger falls in costs than in wage rates, particularly at the very bottom of a depression, would be consistent with the overwhelming importance of "technical change" or substitution as compared with fluctuations in the rate of utilization. This statement should, however, be qualified by the limitation noted under (d) in the next paragraph.

This type of study is logically a derivation from the more basic calculations of output per manhour.<sup>24</sup> Hence, it is important to recognize: (a) The limitations of output per manhour series (explored in Chapter VII) are inherent in such general indexes of labor costs. (b) Calculations for segments of the economy must meet a further difficulty, that of matching payroll and production series. On the basis of available series, it is impossible to be certain that industrial classifications include the same enterprises. (c) Logically these calculations of labor costs must neglect some labor items which are neither paid out directly to

<sup>23</sup> One possible exception should be noted; in several of the particular industry calculations, notably automobiles and iron and steel, unit labor costs increased in the first year or two after the peak only to fall considerably during the depths of the depression. The pattern for all manufacturing industries shown in Table 8 indicates a drop in unit labor costs through the downswing.

<sup>24</sup> Deflated labor costs per unit are the inverse of output per manhour. Since manhours times average hourly earnings equals payrolls,

$$\frac{\text{Payrolls}}{\text{Production}} = \frac{\text{Manhours} \times \text{Average Hourly Earnings}}{\text{Production}}$$

Division of both sides by average hourly earnings yields deflated labor costs per unit equal to manhours per unit of output.

wage earners nor entered into payrolls; items like payroll taxes, social services, uniforms, and recreational and sanitary facilities (noted in the previous section) cannot influence such estimates of labor costs. However, insofar as *variations* in labor costs are the central interest and these items vary in proportion to payrolls, they do not represent a serious limitation. (d) When the data for a number of firms are combined, it is very dangerous to reason from the aggregate results to a particular firm, especially when the firms which compose the group are constantly changing. Thus labor costs may fall for an "industry" with decreased output simply because the "least efficient" firms are no longer producing or have a smaller share of the total output. As output is increased by the addition of these same firms, costs may rise for this reason alone. Where the turnover of enterprises in an industry is large during the course of a business cycle, this consideration may be of major importance for an interpretation of the statistical cost series.

Investigations of particular firms, or those based upon general indexes for the whole economy or for separate industries, show important deviations between labor and materials prices and labor and materials costs. Both types of inquiry reveal that wage rates (average hourly earnings are usually substituted) increase much more rapidly than wage costs on the upswing of the cycle and over the cycle as a whole. On the downswing, as has just been observed, there are deviations that present no absolutely clear tendency. The statistical studies for industries indicated that costs decreased more than "rates" in almost every case, but the only case study through a whole cycle showed an opposite tendency. None of the studies made thus far attempts to allocate the divergences statistically among rate of plant utilization, "technical change," and substitution. A certain amount of substitution is to be expected as a result of relative price changes, i.e., as an induced change in costs from factor price variations.

Most of the difficulties of isolating the effects of factor price changes on costs, indicated in this chapter, arise *from*

*inadequate measures of factor prices.* Were indexes of wage rates more readily available, the deflation of costs for further analysis would be considerably simplified. Similar limitations apply at present to the availability of "price" data for raw materials and other cost components purchased by buyers. Studies of individual firms may well offer the most fruitful opportunity for overcoming these deficiencies. Even after factor price changes have been accurately measured, issues arise as to the techniques of eliminating their influence for purposes of further analysis, such as measuring the short run cost function or the rate of technical change. The major difficulty is a problem in index numbers: each change in a factor price must be weighted by its relative importance in total costs. This proportion obviously changes over time, necessitating the adoption of some base period. The problem, however, is common to all index number constructions.

### 5. *Research Suggestions*

Useful information on the questions raised in this chapter could be gained from case studies of the experience of particular firms. Special emphasis is needed on the following topics:

(1) It is important to know more about the classification of costs adopted by firms and about the methods used as a rule-of-thumb by executives in the process of making various types of decisions. In a vertically integrated company, what proportion of labor costs is generally classified as "labor"? Are special types of calculations made in appraising the effects of factor price variations on costs, and do these calculations involve a reclassification of items from their usual grouping? Payroll taxes are ordinarily included in "burden"; an appraisal of the impact of wage rate changes in cost would need to shift this item over to "labor" expenses.

(2) The adequacy of average hourly earnings indexes as measures of the variations in wage structures needs further

study with special reference to the magnitude of the differences between earnings and rates in various phases of the cycle. Again, much too little is known of the accuracy of wholesale price indexes as measures of what enterprises pay for the parts, materials and supplies they purchase. From the perspective of the seller, the question involves the reliability of these indexes as indicators of "net realization" from sales. Since the general wholesale index numbers are made up largely of list prices, their variations from "net realization" may be of special importance in the course of the cycle.

(3) The ways in which individual enterprises are able to influence and affect the price of the factors they purchase is a matter of considerable importance. A study of vertical integration in these terms might be a step toward an understanding of the problems of size of firms. The greater certainty of the price of supplies under integration may be an incentive influencing the scale of operations.

(4) The costing of materials carried over from one period to another presents many problems that are receiving increased attention. It would be of great value to determine the effects of various types of accounting methods on the amplitude of fluctuations in costs.

(5) A larger number of issues connected with factor prices is raised in Part III of this report, which deals with patterns of cost-price relationships. Such issues as the role of factor prices in price flexibility and the way in which individual firms handle factor price changes (e.g., price increases) will be deferred to the last section of this study.

## Chapter VII

### TECHNICAL CHANGE AND COSTS

IT HAS been observed repeatedly that in the framework of economic theory the costs of a single enterprise with established plant and equipment are held to depend upon three factors. One, the impact of variations in the rate of operations on costs, was the subject matter of Chapters IV and V; a second, the effects of changes in factor prices on costs, was treated in Chapter VI. The present chapter is focused upon the third, the physical productivity of the factors employed by the firm and the technical effectiveness of their combination.

In our society, characterized as it is by spectacular and rapid innovations, "technological change" has become a byword. The widespread, and at times almost romantic, interest in technological developments is intensified by the highly important fact that for the first time an economy is "organized" to accept and encourage them. With a large volume of resources employed in research, technical changes can no longer be attributed to haphazard individual initiative. Perhaps the most popular theme in general discussions of technology has been the effect of innovations on the displacement of labor. This topic is not, however, directly of major concern to this study,<sup>1</sup> which seeks rather to observe the impact of innovations on the various elements of costs. This aspect of "technical change" has certainly also received considerable emphasis, especially in debates over "stagnation." It has been maintained that cost re-

<sup>1</sup>For a rather comprehensive summary of discussions concerning the effects of technological changes on the volume of employment, and for references to the main works, see Alexander Gourvitch, *Survey of Economic Theory on Technological Change and Employment* (National Research Project, Philadelphia, 1940).

ductions brought about by "technical change" offer a substantial medium through which idle resources may be reabsorbed.<sup>2</sup>

### 1. *Matters of Definition*

It is rather surprising that in most discussions of technology, even among economists, so little attention has been paid to what constitutes an innovation. At times "technical change" is identified with mechanization. This misconception is associated with the notion that innovations occur infrequently but in a spectacular fashion, with shattering effects. That the identification of technical change with mechanization reflects a narrow view is evident as soon as one considers instances of the effect of increased skill and training of wage earners on output, and the consequences of improved organization, techniques of management and coordination of factors. Empirical studies, moreover, easily disprove the contention that technical change is infrequent and spectacular. The Bureau of Labor Statistics study of a firm in the agricultural implement industry revealed that over 600 changes were made in an operating tractor model within a period of two years.<sup>3</sup>

In this discussion the terms "technical change" or "innovation" will be used to imply *any change in input-output relations which is not to be attributed directly to changes in factor prices or variations in the rate or scale of production of the enterprise in question.*<sup>4</sup> "Any change in input-

<sup>2</sup> Sumner H. Slichter, "Business Looks Ahead," *Atlantic Monthly* (November 1939), p. 596.

<sup>3</sup> Temporary National Economic Committee, "Industrial Wage Rates, Labor Costs and Price Policies," *Monograph No. 5* (Washington, 1940), pp. 131-37, 141.

<sup>4</sup> This definition is in accordance with economic analysis; ordinary usage of the term is much more ambiguous. *The Handbook of Labor Statistics* (Bureau of Labor Statistics, *Bulletin No. 616*, 1936, pp. 709 *et seq.*) defines "technological change" to "include all change . . . which results in higher productivity per manhour." This latter term is held to mean "work done in a given time." The *Handbook* recognizes, however, that this use of "productivity" must be distinguished from the "effi-



output" relations is intended to cover variations in amount of output from the same input factors, in quantity of input factors producing the same output, in the combination of factors employed, or in the quality of input factors or product under conditions of given "plant." An innovation may arise from a change in the effectiveness of a single factor or from the way in which the various factors are combined. It is very important to observe that this definition excludes changes that might have arisen from variations in the two other determinants of costs in the system of economic theory. However, as will be indicated later in this chapter, substitution among factors as a result of price changes and variation in the rate of utilization give rise to very serious problems when one attempts to measure the rate of technical change. An increase in output per unit of labor input may be caused not by any change in the technical effectiveness of wage earners, or by any variation in the intensity of their effort, but simply by a substitution of other factors for human services as a result of wage increases. For instance, raw material of better quality, which requires a smaller amount of finishing or takes less time to process, may be purchased at a higher price.

In any study of the single enterprise it is important to recognize that technical changes may originate in other sectors of the economy, particularly in earlier stages of the productive process, and yet vitally influence the input-output relations of the firm. Whether or not these transmitted technical changes will affect the factor prices paid by the firm depends on both the effect of the technical change on the costs of the supplying enterprise and the character of the market in which the firm purchases the factor. In any event a single enterprise at the end of the productive process may be but the point at which technical changes made in other enterprises emerge. A change in the

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ciency' of labor, or any other term which is narrowed down to express only the output due to the ability and willing cooperation of the workers themselves." See footnote 6, p. 53 above.

input-output relations of a publishing firm, for instance, may arise from changes in the making of pulp, the metal used in the type, the skill of typesetters, or the managerial techniques of transportation companies. Since the productive process is the result of a number of interdependent forces, a technical change introduced at one point may have marked ramifications throughout the system.

It is necessary, too, to draw a distinction between technical change and invention. A technical change implies some actual variation in the productive process, whereas an invention merely indicates the possibility of change. The invention must be put into operation in an enterprise before it can become a technical change. This is perhaps an unusually broad view of invention; ordinarily the discovery of a way in which to increase the skill of wage earners, for instance, would not be designated an invention. It cannot be inferred, of course, that every invention becomes a technical change. Indeed the fact that many inventions have not eventuated in technical changes is an indication of the new technical opportunities open to an enterprise. The extent of the gap between invention and utilization is a subject about which much might be learned.

Identification of technical change with mechanization sometimes implies a one-to-one correspondence between a patent and an invention. Even if this were true a patent could be no more than a phase of the invention, for "invention is a process, the granting of a patent being only an incident in the process."<sup>5</sup> But not every invention is patented; some may not meet the standards of the Patent Office in their interpretation of an invention; in other instances patent fees and litigation may be prohibitive compared to possible benefits; and in still other cases inventors may regard a patent as unnecessary. There can be little doubt that many technical changes (as defined) are never

<sup>5</sup> National Resources Committee, *Technological Trends and National Policy* (June 1937), p. 6. See also, *Hearings before the Temporary National Economic Committee*, Part 3, "Patents, Proposals for Change in Law and Procedure" (January 16-20, 1939).

patented at all; and many patents are, of course, never embodied in operating techniques.

Any definition of technical change is bound to raise the crucial question of the meaning of "fixed plant and equipment." The preceding chapters have been set in the context of the "short run": plant, equipment, and organization are assumed to be unchanged. (Chapter X discusses the way in which costs vary with the *size* and the *scale* of an enterprise.) However, since many technical changes, such as improvements in cutting tools, result in a change in "plant" as measured by technical capacity or the least-cost rate of output, the issue arises whether the impacts of such changes on costs are to be related to technical change or to variations in size of plant. It is clear that this problem is not involved in all technical changes. An improvement in the skill of wage earners or the quality of purchased materials and supplies would not be regarded as a possible change in "plant." Strictly speaking, it is impossible to assume "fixed" plant and, at the same time, to separate from accounting records the cost effects of technical changes in factors that constitute overhead (in the sense developed in Chapter IV) from variations in size of plant. Since interest in the effect of size of plant on cost is usually specified in rather large changes in output (relative to the industry in question), the influence of size of plant—with technique varying as size increases—will be neglected in this discussion when changes in potential capacity or the lowest-cost point are small. That is, plant is regarded as "fixed" unless the technical change causes output to vary "significantly."

It has been customary in economic thinking to classify technical changes as either labor saving or capital saving.<sup>6</sup> While this dichotomy is useful for general theoretical purposes, it does not lend itself very readily to empirical work, partly because the diverse types of agents that contribute to output are compressed into the two categories of capital and labor. Substitutions among various types of capital or

<sup>6</sup> See J. R. Hicks, *The Theory of Wages* (Macmillan, London, 1935), Ch. VI.

kinds of labor have no place in this scheme of classification. Since a great many technical changes undoubtedly are characterized by intra-capital and intra-labor substitution, a wider classification of factors would be necessary for empirical studies.

A further difficulty with this capital-labor saving category emerges from its reference to the effects of a technical change on the whole economic system. An innovation can be classified only after the initial effects in a single enterprise have worked themselves out through the entire economy. A technical change might at first be labor-saving, but finally come to be designated capital-saving when the total effects were appraised. Instances of technical change do not readily fall into these theoretical pigeonholes, first because an innovation is classified by its effects, and second because these effects are the total or net effect on the whole system. In view of these difficulties it would be useful for empirical investigation to distinguish between a classification of technical changes and an appraisal of the immediate or ultimate effects of the innovations.

It is suggested that types of technical change be classified according to the character of the substitution involved among factors *in a single enterprise*. Although the detail in factor classification will vary with special interests, the division will certainly be finer than simply "labor" and "capital." The following breakdown of productive factors provides an example of classification of substitutions whereby innovations in industry could be grouped more readily: (1) unskilled labor, (2) skilled labor, (3) supervisory labor and management, (4) clerical workers, (5) salesmen, (6) purchased materials, (7) fuel, (8) plant, (9) equipment and tools, (10) containers, (11) variable or circulating capital. Substitutions probably could be made between any two of these factors, so that in this example 55 types of technical change are possible. If changes in proportions involving more than two factors are considered, these types are multiplied many times. Only detailed empirical study could reveal which of these substitutions were most typical. Such

an inquiry would not be simple because the designation of a technical change, as defined in this section, is in itself difficult. One would have to make certain first that the observed substitution was not due exclusively to changes in the rate of output or to variations in factor prices. The problems involved in eliminating the influence of these two determinants of cost will be considered in the next section. For an empirical study of typical patterns of substitution, however, it is not necessary to measure precisely the magnitude of technical change. What is required is to recognize that there has occurred a substitution which is not to be attributed entirely to factor price changes or to changes in the rate of output. Such a task, though far from easy, is not impossible, for similar output levels can be found and factor prices may have moved against the change or may have remained relatively constant.

A few specific cases will illustrate the usefulness of the concept of technical change that has been developed in this section, and in particular the diversified types of substitutions that actually take place. It has been impossible, on the basis of the information available, to ascertain that these substitutions did not arise in part from changes in factor prices and rates of output, but the presumption is that they were not controlling influences.<sup>7</sup> (a) The great increase in the use of instruments to maintain constant temperatures or pressures in blast furnaces and in similar operations seemingly represents a substitution of instruments for fuel. (b) The replacement of the bundle system by the line in the making of cotton garments is a more complex innovation, involving the substitution of skilled labor and some equipment for circulating capital. It is unnecessary under the line system to have as large an inventory of goods in process. (c) In iron ore mining the use of special dynamites instead of black powder appears to be an instance of the substitution of purchased material for

<sup>7</sup> These examples are taken from the studies of the National Research Project.

skilled labor, since with the dynamites a smaller number of holes must be drilled per ton of ore mined. (d) The adoption of induced drying fans in the manufacture of bricks provides an interesting substitution of equipment for circulating capital. This equipment reduces considerably the amount of time required to manufacture bricks, since it is no longer necessary to wait for sun and atmosphere to dry them. (e) The substitution of rotary for churn or cable drilling in petroleum oil well drilling involves both a shift from one type of skilled labor to another and a replacement of one kind of equipment by another.

## 2. Measures of Technical Change

An increasing number of studies in recent years have purported to measure the rate of variation in "technological change."<sup>8</sup> Without an exception these statistical investigations have taken the change in "output" per manhour, or per employee, as a measure of the rate of "technical

<sup>8</sup> The following studies may be mentioned: Spurgeon Bell, *Productivity, Wages and National Income* (Brookings Institution, 1940); National Research Project, *Production, Employment, and Productivity in 59 Manufacturing Industries* (Philadelphia, 1939); Witt Bowden, "Wages, Hours and Productivity of Industrial Labor, 1909 to 1939," *Monthly Labor Review* (September 1940, Reprint Serial No. R1150); Bureau of Labor Statistics, *Productivity and Unit Labor Cost in Selected Manufacturing Industries, 1919-40* (Washington, 1942); Mordecai Ezekiel, "Productivity, Wage Rates, and Employment," *American Economic Review*, XXX (September 1940), pp. 507-23; John Dean Gaffey, *The Productivity of Labor in the Rubber Tire Manufacturing Industry* (Columbia University Press, 1940); Nahum I. Stone, Alfred Cohen and Saul Nelson, "Productivity of Labor in the Cotton-Garment Industry," Bureau of Labor Statistics *Bulletin No. 662* (1939); W. D. Evans, "Mechanization and Productivity of Labor in the Cigar Manufacturing Industry," Bureau of Labor Statistics *Bulletin No. 660* (1939); Boris Stern, "Productivity of Labor in the Glass Industry," Bureau of Labor Statistics *Bulletin No. 441* (1927). Other studies by the Bureau of Labor Statistics have been made in the boot and shoe, plumbing and heating supply, woolen and worsted, cement, lumber, cotton textile, and clay products industries. See also, *Technology on the Farm*, A Special Report by an Interbureau Committee and the Bureau of Agricultural Economics of the United States Department of Agriculture (1940).

change.”<sup>9</sup> Professor Mills has suggested a measure of “physical output per unit of productive effort” as an indication of the change in “productivity.”<sup>10</sup> In actual statistical work, however, he approximates this concept by output per manhour. Thus indexes of the change in “productivity” of industries or the total system have been calculated simply by dividing indexes of output or production by indexes of manhours or number of wage earners employed. The rather wide and indiscriminate use of these statistics in wage negotiations,<sup>11</sup> in popular discussions, and even in technical economic journals calls for a scrutiny of the meaning of such an index and its relation to the definition of technical change set forth in the preceding section.

It will be convenient to start such a critical appraisal by designating the situations under which an index of output per manhour may vary. First, a change in the rate of plant utilization may influence output per manhour, depending on the character of the input-output relations. Second, a change in relative factor prices may induce a substitution among labor services and other factors; for instance, a rise in the price of high quality raw materials may mean that a cheaper material requiring more labor is used. Third, since all skills of labor are equally weighted by the hours of employment, a change in relative wage rates may induce a substitution among different types of labor and a change in output per manhour. Fourth, a special difficulty arises when data for more than one firm are combined to present industry figures (and all indexes of “productivity” are of this character). The addition of less “efficient” firms at high levels of industrial output, coupled with their disappear-

<sup>9</sup> Numerous devices have been used to measure “output.” For instance, Gaffey, *loc. cit.*, adopts number of tires, tire miles, and pounds of crude rubber as measures of “output” in a study of “productivity” in the rubber tire manufacturing industry.

<sup>10</sup> F. C. Mills, “Industrial Productivity and Prices,” *Journal of the American Statistical Association*, XXXII (June 1937), pp. 247-62.

<sup>11</sup> For an instance of judicious use of such statistics, see: Steel Workers Organizing Committee, *Brief Before a Panel of the War Labor Board*, Cases No. 30, 31, 34, 35 (1942), pp. 55-80.

ance from business in periods of depression, introduces another factor which may induce changes in output per manhour or per wage earner. Fifth, variations in the size and scale of plant may result in an altered combination of factors and hence a change in output per manhour. Sixth, an index of output per manhour may vary because of technical changes, as defined above, resulting from the substitution of other factors for any type of labor included in the manhour data. This heading includes the impact of "undermaintenance" of equipment and other resources upon output.<sup>12</sup>

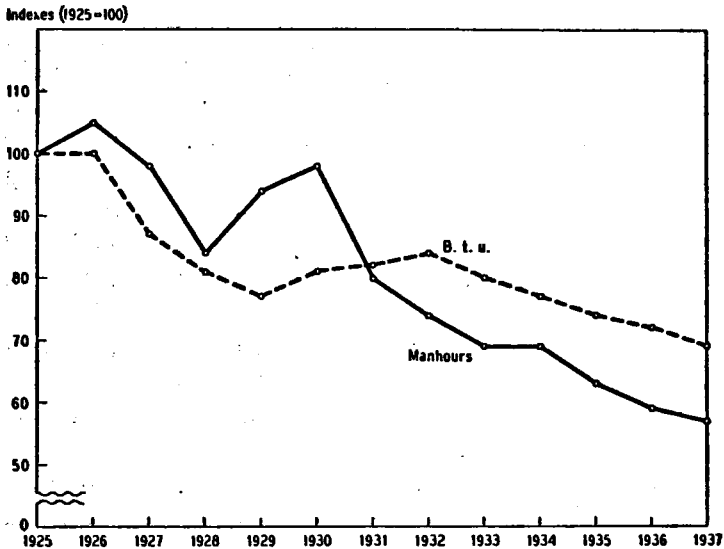
To designate as a change in "productivity" the variation in output per manhour arising from the first five of the above factors is certainly a mistake, or at best a peculiar conglomerate useful only for specialized purposes. For the system as a whole there may be some sense in indicating the way in which output per manhour has fluctuated. A study of the path of output per manhour may be useful in predicting the probable increase in output for small changes in increased manhours of application. Such data might be especially interesting for war economies, but certainly they could hardly be expected to give an accurate picture of the variation in technical change as defined here. In addition to including the effects of too many factors, indexes of output per manhour may ignore certain types of technical change or give rise to incorrect inferences concerning their magnitude. As far as final effect is concerned, a substitution between two nonlabor factors resulting in increased output is indistinguishable from more intensive labor effort or training, which also brings about an increase in output. Indeed, the attempt to measure in terms of a single factor the change in the input-output relations of a combination of factors is necessarily misleading. If the same number of manhours produced the same amount of product with one half the raw material or one half the amount of plant, it would be absurd to say that no technical

<sup>12</sup> The phenomenon of "undermaintenance" cannot be readily handled within the framework of traditional economic analysis.



change had taken place simply because output per manhour remained unchanged. The fundamental difficulty of measuring input-output relations in terms of a *single* input factor is illustrated in Chart 5. It is presumed that output is roughly equivalent to crude oil input in the petroleum refining industry. Then input of labor per unit of "output" is compared to input of BTU (heat) per unit of "output."

Chart 5  
INPUT OF LABOR AND HEAT  
PER BARREL OF OIL REFINED, 1925-1937



B. t. u. from TNEC Hearings, Part 15, p. 8635.

Manhours from WPA National Research Project, PETROLEUM AND NATURAL GAS PRODUCTION, p. 329.

As would be expected, the two curves show materially different movements for the period 1925-37. Another drawback associated with indexes of output per manhour is that such measures take on all the limitations of production indexes noted above in Chapter V. Technical change which eventuates as improved quality of product, for instance, defies statistical measurement.

These difficulties raise the question of how indexes of output per manhour could ever have been presumed to

measure technical change. Some explanation is required because changes in output per manhour would appear to bear little necessary relation to technical change, particularly for the short run. It can be suggested that this emphasis on output per manhour is consistent with the labor theory of value. If capital goods and all other factors can be reduced to units of stored-up labor power, then the relative change in manhours required to produce a unit of output (factor prices and output unchanged) is a measure of the effectiveness of the input factors. All factors are reduced to the single denominator. This view would, however, require the inclusion, in the estimates of manhours employed, of the manhours "stored up" in other factors, a procedure which has not been adopted in statistical work. If it were adopted, indexes of output per manhour would be meaningful, at least within the framework of the labor theory of value.

The wide use of indexes of output per manhour as measures of "productivity" is still somewhat perplexing in view of their potential divergence from the theoretical concept of technical change developed in Section 1. Yet available measures of this sort show an upward trend, indicating largest increases at the points where they might be expected in the course of the cycle; in brief, they seem to work. This is not entirely inconsistent with the above criticisms. Should the dominant pattern of substitution be that between other factors and labor, and should this tendency be very pronounced, indexes of output per manhour would be significantly influenced by this movement. While such indexes would still overestimate and underestimate technical change in the ways suggested immediately above, the "errors" could be relatively small compared to the major movement. The indexes might serve as rough approximations to technical change where the rate of substitution between other factors and labor came close to the rate of substitution in all other cases. Since no way exists of verifying the importance of these possibilities, one cannot place much confidence in indexes of

output per manhour as measures of technical change. The mere fact that they move in the direction that might be expected cannot instill any faith in the magnitudes they indicate.

Series of per unit cost or total cost and output offer an opportunity for measuring technical change which has not as yet been exploited. Apparently the basic problem in measuring changes in input-output relations is to find common denominators for the diverse factors combined to produce different kinds of output.<sup>13</sup> Aside from money costs, there are no units with economic meaning whereby diverse inputs may be combined into a unit of productive factors. Hours of labor service, tons of steel, miles of wire, and yards of cloth can be amalgamated only through costs. In fact it is precisely this problem, in its practical aspects, that confronts business executives. They must seek the least cost combination of factors at each alternative output level, given the technical productivity of each possible grouping. If all the influences affecting costs other than technical change are measured and their impact is removed from the series of per unit cost, then the remainder may be attributed entirely to technical change. Specifically, the effects of factor price movements and variations in the rate of operation would have to be eliminated.<sup>14</sup> For this purpose the following data in addition to the per unit cost series would have to be available: (a) all factor price variations, (b) a cost breakdown showing the relative importance of each factor in total costs, and (c) the shape of the cost function. The first two series make possible the removal of the effects of factor price changes and the third permits elimination of the effects of varied output.

<sup>13</sup> Since output indexes were considered in Chapter V, only the problem of a common denominator for input is considered here.

<sup>14</sup> Costs are made a function of three variables: rate of output, factor prices and technical change. If technical change is made a statistical residual, it cannot exactly approximate the formal definition of Section 1. Factors not specified as determinants of cost, such as rate of change of output and size of order, will influence this statistical measure of technical change.

Among other difficulties, this procedure involves a logical snag. The measurement of technical change is required before the cost function is approximated. But the shape of the cost function itself is a prerequisite to the measure of technical change proposed above. After the effects of factor price variations have been eliminated from a series of per unit costs, no entirely satisfactory method is available to "split" the time series into the component attributable to output fluctuation and that derived from technical change. If some shape be assumed for a cost function—for instance, a linear relationship between costs and output—then the residual pattern can easily be ascribed to the influence of technical changes. Only if a specific relation between output and costs is presumed can the influence of technical changes be isolated. Unless the technical change and output components are presumed to fluctuate in precise and *different* patterns, no separation is possible. The difficulty is identical with that involved in splitting output per manhour series into output and technical change components. The comparative patterns are imposed on the data since the effects of technical change are presumed to be linear.

An index of the rate of innovation derived from cost data would seem to have many advantages over the usual output per manhour series. In the first place, the effects of all possible types of technical change would be included, whereas, as has been noted, series on output per manhour attempt to measure the change in input-output relations for all factors in terms of a single one, namely manhours of labor services. Second, the effects of changes in factor prices would be eliminated from cost data; in output per manhour series no correction is ever made for substitutions between factors attributable solely to relative price changes.<sup>15</sup> Third, the difficulty arising from the influence

<sup>15</sup> The deflation of costs to remove the influence of factor price changes does not indicate exactly how costs would have varied when factor price changes have caused substitution. It is not ordinarily practical in dealing with empirical data to separate precisely the influence of technical change and substitution.

of variations in the rate of plant utilization is not peculiar to cost data. Moreover this problem may be circumvented in several ways. Engineering estimates of cost, showing different elements in cost over time, can be made for the same rate of utilization.<sup>16</sup> Or spot comparisons can be made for two similar levels of output. Again, as has been suggested above, an assumption can be made as to the shape of the cost function, based upon specific estimates of management or general knowledge of the enterprise. Several estimates of the rate of technical change may be derived on the basis of different assumptions concerning the shape of the cost function. If two extreme estimates of the shape of the cost function are reached, they will at least establish limits for the rate of technical change. There is no guarantee, of course, that these limits will be narrow enough to be useful.

A final point relevant to the subject matter of this section concerns the *direction* of technical change. It is usually asserted that technical change is irreversible, moving always in the direction of increased output per unit of input.<sup>17</sup> This statement is not without ambiguity. It may simply imply that once a technical change has been made the experience is not forgotten by the enterprise. But much more is usually intended—that input-output relations always vary in the direction of a larger product with the same “amount” of factors or the same product from a smaller “amount” of factors. From the perspective of the enterprise, of course, no decision to worsen the input-output relation would be made unless there were serious price changes. In this sense technical change is always positive. From the viewpoint of an observer, however, the input-

<sup>16</sup> Boris Stern, “Mechanical Changes in the Woolen and Worsted Industries, 1910 to 1936,” *Monthly Labor Review* (January 1938), used such engineering estimates to calculate output per manhour changes between the two years at 100 percent of “capacity operations.”

<sup>17</sup> This proposition is inconsistent with output per manhour series as a measure of technical change, for some series show decreases in output per manhour, at least for short periods in certain phases of the business cycle.

output relations of an enterprise may become less favorable in response to considerations other than the rate of operations. The technical productivity of wage earners, for instance, may be deliberately reduced in a "slow down" or fall as a result of excessive hours of work under war conditions. The quality of available raw materials may become poorer. Or, because of the immediate financial position of an enterprise, plant and machinery may be retained in use for such a long period that the "same" input factors result in a smaller output. In this report, nevertheless, positive technical change will be considered the normal case.

### *3. Decisions Concerning Technical Change*

The translation of inventions into technical changes, it has been noted, requires the active decision of business executives. This section discusses the kinds of calculations and the types of considerations involved in the formulation of such decisions. Since technical change has been regarded in this chapter as much broader than mechanization alone, more decisions are associated with it than with, say, the purchase of a new machine.<sup>18</sup> A number of innovations concern only those factors which have been classified under the major headings of labor and materials, and may contribute, moreover, only to the output of the current period. For instance, the substitution of one type of steel for another or the introduction of a bonus wage scheme presents a relatively simple problem to be decided on the principles of comparative marginal costs and marginal receipts. No "capital" expenditure is involved in the sense that the output of more than a single period is necessarily affected. Any such change is completely reversible for the next period without "loss." Few changes, in fact, are confined in their effects to a single period.

In addition to these technical changes which affect only current receipts and costs, certain innovations may involve no change in either current or prospective costs but are

<sup>18</sup> See Appendix C.

expected to influence the stream of receipts. Variations in style and minor changes in design are frequently of this character. Here the innovation will be adopted whenever the present value of all prospective receipts is increased. The corollary case of a technical change affecting costs alone and leaving the expected stream of receipts unchanged will arise whenever the present value of all future costs is lowered. This type of technical change may be illustrated by variations in the methods of production which do not appreciably alter the product. It is possible to give a much more detailed statement (as is done below) of the circumstances under which technical changes will be undertaken by an enterprise, and at the same time keep the statement broad enough to include the case in which both prospective costs and receipts are altered. But added details in no way affect the fundamental proposition, ordinarily stated with reference to replacement, that "a producer continues to use existing equipment as long as, *ex ante*, it is cheaper to operate equipment in use than to buy and operate replacement equipment"<sup>19</sup> or that "replacement occurs whenever enterprise value is enhanced thereby."<sup>20</sup> Any decision involving technical change consists of a comparison of cost and revenue prospects under current methods of production and existing styles and designs of products with cost and revenue prospects under all possible alternative methods, styles and designs.

The test of the desirability of a replacement is made on the basis of the present worth, at a specified date, of prospective payments and receipts. The payments and values which are affected by purchase or nonpurchase, and should therefore be included in any formula, are as follows:<sup>21</sup>

<sup>19</sup> Joe S. Bain, "The Relation of the Economic Life of Equipment to Reinvestment Cycles," *Review of Economic Statistics*, XXI (May 1939), p. 82. See also John B. Canning, *The Economics of Accountancy* (Ronald Press, 1929), Ch. XIV.

<sup>20</sup> Canning, *op. cit.*, p. 83.

<sup>21</sup> All payments or receipts which remain unchanged whether or not the new machine is purchased have been canceled from the formulation. The term "machine" is used in this context to refer to any technical

(1) The expected operating savings in each future year. Let us call this saving in the first year  $T_1$ , in the second year  $T_2$ , and so on up to  $T_n$  in the  $n$ th year, where  $n$  is the number of years in the period of comparison. This period is the interval between the proposed date of purchase and the date at which a reconsideration of the problem will be required if no machine is purchased, ordinarily the end of the expected life of the old machine or machines. It should be noted that because of (a) variations in the volume of business, (b) possibilities of still newer machines or different methods of production, and (c) changes in wage rates or other factor prices, the different  $T$ 's will usually not be the same, and the error of estimate will almost always be larger for later years than for those in the near future.

(2) The total present worth of expected operating savings for the next  $n$  years, discounted at the interest rate " $r$ ," is:

$$\frac{T_1}{1+r} + \frac{T_2}{(1+r)^2} + \dots + \frac{T_n}{(1+r)^n} = \sum_{i=1}^{i=n} \frac{T_i}{(1+r)^i} = P_n, \text{ say.}$$

(3) Designate the cost of the new machine " $C$ ."

(4) The net salvage value ( $V$ ) of the new machine at the end of its normal life,  $N$  years hence.

(5) The net salvage ( $v$ ) of the old machine or machines to be replaced by the new machine, at the end of its or their expected life  $n$  years hence.

(6) The net salvage value ( $v + e$ ) of the old machine or machines if sold at date of purchase of new machine. If the old machine is not sold, but is transferred to other uses in the plant, an imputed value of not less than what it could be sold for should be used.

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change involving a commitment in one period designed to contribute to the output of future periods. For instance, expenditures on a training program for foremen or the installation of "improved" lighting facilities are included in this term in the following pages.

The discussion of the next few pages is drawn from a memorandum entitled "Theoretical and Actual Criteria for Purchase of a New Machine" prepared by R. W. Burgess of the Western Electric Company, a member of the Committee.



(7) The residual value (R) of the new machine at the end of  $n$  years. If, as is usually the case, available engineering and economic information is not adequate to justify a real estimate of residual value, R may be taken to be

$$C - \frac{s_n}{s_N} (C - V)$$

where  $s_n$  is the compound amount of \$1 per annum at the end of  $n$  years,  $s_N$  at the end of  $N$  years.

The purchase of the new machine will therefore be desirable if the present worth of the net gains resulting from its purchase exceeds the present worth of the net costs, that is to say, if

$$P_n + v + c + \frac{R}{(1+r)^n} > C + \frac{v}{(1+r)^n}$$

If we neglect the salvage values of the old machine and the residual value of the new  $n$  years hence (as may often be done without significant error), this formula reduces to the statement that the new machine will be profitable if the present worth of the operating savings in the period of analysis ( $n$  years) exceeds the cost of the machine.<sup>22</sup>

The above discussion has been presented specifically in terms of replacement of a "machine" (see footnote 21, above), but a modification in form will allow for instances of technical change that cannot be construed to involve any "replacement." Although a consideration of the question is beyond the province of this chapter, an investment expenditure will be undertaken if the present value of the net proceeds from the expenditure exceeds by a small margin the rate imputed to funds on hand on the basis of alternative uses.<sup>23</sup>

<sup>22</sup> This is the end of the material drawn directly from Mr. Burgess' memorandum.

<sup>23</sup> See J. M. Keynes, *General Theory of Employment, Interest and Money* (Harcourt, Brace, 1936), pp. 135-64. Michal Kalecki, "The Principle of Increasing Risk" in *Essays in the Theory of Economic Fluctuations* (Farrar and Rinehart, 1939), pp. 95-106. Also Walter Rautenstrauch, *The Economics of Business Enterprise* (John Wiley and Sons, 1939).

It would require much empirical study to estimate the extent to which the economically correct calculations represented in the above formulae are approximated by business executives who are considering a technological change.<sup>24</sup> The formulae assume that accurate and precise knowledge is available for each of the magnitudes influencing the decision,<sup>25</sup> but these magnitudes at best can only be estimated, and with varying degrees of confidence. Logically, the allowance for the difficulties of estimation could be made by a single average probable error after the calculations had been carried through with the most probable value of each magnitude, *or* each separate item could include an element of uncertainty in estimation. Under the second alternative the most probable operating savings would be deflated and the service life of the new assets reduced in proportion to the confidence in the most probable values. What is known of the actual thought processes of business executives indicates that the latter procedure is generally followed. Mr. Burgess suggests<sup>26</sup> that these "safety factors" are characteristically introduced into calculations in the following ways: (a) The possible salvage or residual value of the new machine at the end of the period of analysis is neglected. (b) In calculations an interest rate is used that greatly exceeds the rate at which an enterprise may borrow in the open market or at banking institutions.<sup>27</sup> Insofar as such a rate is simply that which

<sup>24</sup> Appendix C surveys some of the numerous "methods" and "formulae" suggested as guides to replacement by engineers and business managers.

<sup>25</sup> This discussion does not imply that actual decisions are made by the steps indicated in the above formulae. The models only provide a logical construction of the factors which would explain technical change decisions within the framework of ordinary economic theory.

<sup>26</sup> See footnote 21, above.

<sup>27</sup> If the interest rate or credit terms change with the amount of borrowing of a firm, as may very well happen, "we must distinguish a marginal cost of outside funds higher than the interest rate paid. This marginal cost then becomes the rate appropriate for calculations within the firm." Albert G. Hart, *Anticipations, Uncertainty, and Dynamic Planning* (University of Chicago Press, 1940), p. 43.

the enterprise can earn on its funds in other uses, no "safety factor" or allowance for errors of estimation is involved. Essentially the same sort of calculation is applied when a profit rate is added to the "market" rate of interest. (c) The use of the straight line method of depreciation as compared to the sinking fund involves an overestimation of the probable depreciation costs of the new machine. "The investment which is entitled to draw interest should be reduced by the accrued depreciation." A factor of conservatism may be added in this fashion. (d) The most probable service or time life of the new asset may be reduced by an amount proportionate to the degree of confidence in the calculation. What will determine this confidence will be the possibility of shifts in demand, style obsolescence, the emergence of superior assets within a relatively short period and the amount of previous experience with the particular machine. The rates of depreciation so employed in the calculations preliminary to the adoption of a "machine" thus may be higher than those carried on the books of the enterprise for income accounting. While the validity of this differential is certainly questionable, the device of changing the most probable estimate of service life by an amount to correct for the reliability of estimation is not subject to debate. Allowances for the degree of confidence that can be put in estimates may be introduced into calculations of "replacement" in at least these four ways.

There is considerable scattered evidence relating to the kinds of calculations business executives make in introducing technical changes that involve outlays for *equipment* lasting "over" several periods. This evidence is frequently in the form of answers to the question of how long new equipment will take to "pay for itself." A questionnaire sponsored by *Manufacturing Industries* in 1927 reveals that of 88 companies replying, 37 had no definite period in which new equipment must pay for itself, 12 allowed varying periods depending on the type of equipment, and 39 had fixed periods. Of the last 39, twelve companies had

set 2 years as the period, six companies 3 years, eight companies 5 years, and a single company  $7\frac{1}{2}$  years.<sup>28</sup> The weighted average of the companies specifying definite periods was about 3 years. This kind of evidence is ambiguous, however, because the types of plant or equipment are not specified.

The Bureau of Labor Statistics study of an enterprise in the agricultural implement industry showed the necessity of distinguishing between various types of assets which were purchased for a single plant in the period 1930-39.<sup>29</sup> Certain minor appropriations, shown in Table 9, "paid for themselves" very rapidly. The same story can be told from

TABLE 9  
COMPARISON OF SELECTED APPROPRIATIONS  
AND "SAVINGS"<sup>a</sup> IN AN AGRICULTURAL  
IMPLEMENT FIRM

<i>Year of Instal- lation</i>	<i>Appropriations on which Estimates of Specific "Savings" were Calculated</i>	<i>Estimated Annual "Savings"</i>	<i>Actual First Year "Savings"</i>
1935	\$ 61,900.00	\$ 66,853.80	\$ 48,697.00
1936	160,160.00	124,027.80	102,645.00
1937	180,260.00	326,059.40	250,217.00

<sup>a</sup> The specialized meaning of "savings" must be noted. The volume of "savings" effected is greatly influenced by the volume of production—the larger the production the larger the "savings" from an appropriation. Furthermore, estimated and actual "savings" are calculated for only the first twelve months rather than over the expected life of the machine.

an array of 23 of these appropriations by the length of time in which it was estimated they would "pay for themselves." The annual savings anticipated on 18 of these 23 appropriations were sufficient to return the investment involved in two years.

<sup>28</sup> Questionnaire sent out by L. P. Alford, editor. Volume XV (January 1928), pp. 27-30.

<sup>29</sup> Temporary National Economic Committee, *Monograph No. 5* (Washington, 1940).

But these appropriations were almost exclusively for such items as tools, minor equipment, rearrangements of assembly line or parts manufacture in keeping with a change in design of the product, and adjustments in storage facilities and plant organization. The appropriations that "turned themselves over" so rapidly were largely, although not ex-

TABLE 10  
 APPROPRIATIONS FOR WHICH ESTIMATED  
 "SAVINGS" WERE CALCULATED, 1935-38

<i>Time Required to "Pay for Themselves"</i>	<i>Number of Appropriations</i>
Under six months	9
Six months to one year	4
One year to two years	5
Over two years	5

clusively, for items on which one would expect very rapid obsolescence because of changes in style or design, new methods of production, or contemplated changes in lines of production. In the language of the discussion above (pp. 161-62), the confidence in the estimates of the service life of these types of assets would be very low. This need not be true for all appropriations which are similarly expected to "pay for themselves" in periods of one to three years. Rules of thumb, resulting in errors, may develop in an enterprise. Under such circumstances a proposal for technical change may be rejected although a more careful inquiry by the firm could have shown that the change would be profitable.

Decisions respecting technological changes, even more than most decisions, are in any modern corporation the joint product of a number of people. Such changes require the coordination of research engineering, sales and financial departments of an enterprise. Among these groups there may well be friction and conflict of interest. The sales department may want an innovation at once to "capture" a particular segment of the "market" while engineering officials prefer to wait until it has been perfected. Or the

financial powers may regard outlays as too uncertain on the scale recommended. There is evidence to suggest that the cash position of the enterprise may have a decisive influence on expenditures for innovations. Joint discussion among these departments may be important only for major changes. An innovation may be introduced on the initiative of a single department if the change is small enough. Various types of technological change undoubtedly require different degrees of coordination among the organizational units within an enterprise. Here the steps and processes whereby technical changes are introduced constitute a field for useful study.<sup>80</sup>

#### 4. Cyclical Pattern

It is not the purpose of this brief section to explore the relations between technological change and the business cycle.<sup>81</sup> The emphasis is rather on collecting the available evidence that would illuminate the question of the rate of innovation in different phases of the cycle. If adequate indexes of technical change existed, this would be a relatively simple matter, but Section 2 demonstrated the severe limitations of series on output per manhour. More scattered and less directly applicable bits of evidence must therefore be utilized. A variety of these isolated data suggest a cyclical

<sup>80</sup> See Ruth P. Mack, *Business Funds and Consumer Purchasing Power* (Columbia University Press, 1941), pp. 237-305.

<sup>81</sup> It must be noted in passing that many authors have linked the business cycle directly to technical change. Professor Schumpeter, for instance, contends that "[Economists] have a habit of distinguishing between and contrasting, cyclical and technological unemployment. But it follows from our model that, basically, cyclical unemployment is technological unemployment . . . Technological unemployment . . . is of the essence of our process, and, linking up as it does with innovations, is cyclical by nature. We have seen, in fact, in our historical survey, that periods of prolonged supernormal unemployment coincide with the periods in which the results of inventions are spreading over the system and in which reaction to them by the system is dominating the business situation, as, for instance, in the twenties and eighties of the nineteenth century." *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process* (McGraw-Hill, 1939), Vol. II, p. 515.

cal pattern in which the most rapid rate of technical change occurs during the middle of the expansion phase, with a slackening off toward the peak, some increase in the rate in the earlier part of the contraction, and another slackening off toward the trough. Variations in this pattern are to be expected, of course, from enterprise to enterprise. The separate pieces of evidence, statistical and qualitative, that support this cyclical pattern of technical change are discussed *seriatim*. Very few of the following items "demonstrate" the suggested thesis, but all of them are consistent with it.

(1) The expenditures on research in industry seem to follow the cyclical pattern for the rate of technical change outlined above. A questionnaire distributed by the National Research Council,<sup>22</sup> relating primarily to the personnel of research departments and agencies of business enterprises, was sent to a sample list of companies in the years 1920, 1921, 1927, 1931, 1933 and 1938. The number of research employees<sup>23</sup> in 575 identical companies for the years since 1927 is shown in Table 11. While these data do not refer directly to the volume of expenditures, it is probable that they show an essentially similar pattern.

TABLE 11  
RESEARCH PERSONNEL OF 575 IDENTICAL  
COMPANIES<sup>a</sup>

Year	Number
1927	15,439
1931	22,342
1933	19,255
1938	26,956

<sup>a</sup> Perazich and Field, *Industrial Research and Changing Technology*, p. 65.

<sup>22</sup> George Perazich and Philip M. Field, *Industrial Research and Changing Technology* (National Research Project, Philadelphia, 1940), p. 55. The statistical data are based on the several surveys of the National Research Council, analyzed by the National Research Project. See also, National Resources Planning Board, *Research—A National Resource*, "Industrial Research" (Washington, 1940).

<sup>23</sup> Research employees included chemists, physicists, engineers, metallurgists, biologists, bacteriologists, and research assistants and technicians.

(2) A much less direct piece of evidence is contained in figures on patent applications filed. Although not so marked in regularity, a cyclical pattern is discernible in periods of wide fluctuation in income.<sup>34</sup> Table 12 shows patent applications for the period 1924-39.

TABLE 12  
APPLICATIONS FOR PATENTS FILED, 1924-39<sup>a</sup>

<i>Year</i>	<i>Applications Filed</i>
1924	79,689
1925	82,213
1926	85,279
1927	89,360
1928	93,592
1929	92,029
1930	96,227
1931	88,707
1932	77,792
1933	64,244
1934	60,363
1935	62,414
1936	66,339
1937	70,830
1938	74,485
1939	74,153

<sup>a</sup> *Reports of the Secretary of Commerce.*

(3) The Bureau of Labor Statistics study of an agricultural implement firm suggests that since the research personnel fluctuates less than output, during periods of reduced output additional efforts can be directed toward basic research and the working out of plans for innovations. At high levels of output a great deal of semiroutine work is necessary. But in slack periods more coordinated attention can be given to plans for innovation which can be

<sup>34</sup> See, *Hearings before the Temporary National Economic Committee, Part 3, "Patents, Proposals for Change in Law and Procedure"* (Washington, January 16-20, 1939), Exhibit 179, p. 1123.



made effective as output increases again. This temporary diversion of routine personnel in research and engineering departments can be rather important.

(4) In general, the tendency to postpone replacement during depression periods and the disinclination to make financial outlays result in a bunching of innovations with the recovery phase of the cycle. In fact, it is frequently contended that this bunching is the core of the recovery. While it is commonly recognized that enterprises do postpone replacements at low output, this tendency can be explained on other grounds than the desire to conserve a cash or credit position. "User costs" (the nonlabor cost incurred in the substitution of current output for future output)<sup>35</sup> of replacement might be very large because of the possibilities of improved equipment at a later date. Since replacement is not necessary to current output in times of depression, user costs can be reduced by postponement of replacements. As output expands in the recovery phase, technical changes are introduced in the form of accumulated replacements as well as through additional expenditures on new equipment and other factors.

(5) The brief increase in the rate of technical change in the earlier part of the contraction phase of a cycle, suggested in the above pattern, is to be accounted for by attempts of business executives and departmental representatives to reduce costs with rapidly falling output. The "wastes and inefficiencies" of the boom are singled out for elimination. Such innovations are apt to be of a character that would not require large capital expenditures.

### *5. Research Suggestions*

(1) As indicated in Section 2, an important contribution can be made to the measurement of technical change by the calculation of indexes based upon cost data with the technique suggested in the text. A comparison of these results with series on output per manhour could then be made.

<sup>35</sup> See Chapter IV, above.

(2) One of the topics relating to the impact of technological change on costs and prices that deserves empirical study is the way in which an innovation spreads from enterprise to enterprise in a market area. The circumstances surrounding the rates of acceptance of technical changes would undoubtedly show wide disparity between innovations. Some gain complete acceptance by all enterprises soon after they are first introduced; others spread much more gradually. Any persistent patterns of the rates of introduction among different types of innovations or types of market situations would be a discovery of considerable importance.

(3) A series of case studies could reveal the kinds of calculations made by business executives when they consider innovations. With reference to particular changes, it would be instructive to show all the data that were presented to those making the decisions, the length of time the project was debated, and the chief pressures for change both within the firm and outside it.

(4) As suggested in Section 1, a more extensive study of innovations could render a useful service by discovering typical patterns of substitution. Labor saving and capital saving categories of economic theory are not amenable to empirical use. It is possible to develop a more useful classification scheme which would encourage comparative studies of innovation in different firms and industries.

## 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.<sup>1</sup> 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.<sup>2</sup> The United

<sup>1</sup> 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.

<sup>2</sup> 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.<sup>3</sup> 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

<sup>3</sup> 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.<sup>4</sup> 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"<sup>5</sup> meets the criterion of logical elegance, but the search for empirical applications

<sup>4</sup> 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."

<sup>5</sup> 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.<sup>6</sup> 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. <sup>6</sup>

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

<sup>6</sup> 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<sup>7</sup> 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.<sup>8</sup> It is true that all joint costs are com-

<sup>7</sup> See Chapter IV, Section 3.

<sup>8</sup> 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."<sup>9</sup> 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.<sup>10</sup>

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

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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.

<sup>9</sup> 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.

<sup>10</sup> Hubert D. Henderson, *Supply and Demand* (The University Press, Cambridge, Eng., 1922), Ch. V.

<sup>11</sup> 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."<sup>12</sup> 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.<sup>13</sup> 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

<sup>12</sup> *Ibid.*, pp. 419-20.

<sup>13</sup> 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."<sup>14</sup> 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.<sup>15</sup> 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-

<sup>14</sup> T. J. Kreps, *op. cit.*, p. 420.

<sup>15</sup> 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.<sup>16</sup> 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,<sup>17</sup> 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-

<sup>16</sup> See Chapter VII for a more precise statement of the costs involved.

<sup>17</sup> 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.<sup>18</sup> 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.

<sup>18</sup> 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."<sup>19</sup> A general purpose system cannot be equally adequate to the demands of all types of decisions respecting the relative costs of products,<sup>20</sup> 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

<sup>19</sup> W. B. Lawrence, *Cost Accounting* (Prentice Hall, 1933), p. 3.

<sup>20</sup> 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.<sup>21</sup> 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 non-separable 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).<sup>22</sup> 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

<sup>21</sup> 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.

<sup>22</sup> 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.<sup>23</sup>

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.

<sup>23</sup> 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."<sup>24</sup> The table

TABLE 13  
BASES USED IN APPLICATION OF OVERHEAD<sup>a</sup>

<i>Bases Used</i>	<i>Number of Companies</i>		<i>Total</i>
	<i>Using as Major or Only Base</i>	<i>Using as Secondary Base</i>	
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

<sup>a</sup> "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.<sup>25</sup> 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.

<sup>24</sup> *Loc. cit.*

<sup>25</sup> 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.<sup>26</sup> 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."<sup>27</sup> 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.<sup>28</sup> 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."<sup>29</sup> 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.<sup>30</sup> 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"

<sup>26</sup> See Exhibit 1199, submitted by Robert E. Wilson, *ibid.*, p. 8660.

<sup>27</sup> "Statement of Witness Robert E. Wilson," *ibid.*, p. 8623.

<sup>28</sup> *Report of the Committee on Oil Price Research* (National Bureau of Economic Research, mimeographed), p. 11.

<sup>29</sup> "Statement of Witness Robert E. Wilson," *op. cit.*, p. 8623.

<sup>30</sup> 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."<sup>81</sup> 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."<sup>82</sup> 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

<sup>81</sup> "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.

<sup>82</sup> 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.

## Chapter IX

### SELLING COSTS

NEITHER classical nor neoclassical economic theory, concerned as they were with working out the problem of equilibrium under conditions of perfect competition, recognized the existence of selling costs. In a state of perfect competition all buyers have perfect knowledge of the market, there is a homogeneous product, only one price prevails, and numerous competitive sellers can dispose of whatever amount they wish at the market price. Under these circumstances, selling costs are obviously so uneconomic as to be ruled out by definition.

#### 1. *The Problem and Its Setting*

Recently economic theory has been exploring markets which are more complex than those of perfect competition or pure monopoly. In the course of this exploration the existence of a problem of selling costs has been recognized and an attempt has been made to include the behavior of selling costs among the factors that will enter into the determination of the equilibrium position of an individual firm. As it has finally been worked out, the formal solution of the selling cost problem states that "selling costs will be incurred (with prices determined) up to the point at which an additional expenditure will add to revenue an amount just equal to the selling cost plus the cost of manufacturing the additional units to be sold."<sup>1</sup>

This formal solution, as has been noted in Chapter II, is

<sup>1</sup> For a stimulating treatment, see Norman S. Buchanan, "Advertising Expenditures: A Suggested Treatment," *Journal of Political Economy*, (August 1942), pp. 537-58.

severely limited both from the standpoint of the businessman who is trying to maximize profits and from the standpoint of an observer attempting explanation and appraisal. The problem of the present chapter is to evaluate possibilities of measuring empirically the type of cost-sales relationship basic to the logical theoretical model. The chapter will also discuss how the businessman approaches the problem of selling costs, and the relation of common business practices to the theoretical model.

Selling cost may arise under any form of imperfect market, but particularly in those characterized by lack of perfect knowledge and mobility on the part of the buyer. In a retail market, the differences in the location and convenience of various stores, as well as in management and services, all foster the existence of selling costs. When a new product is introduced, selling costs may have the primary purpose of increasing the knowledge of the public about the new product. A very interesting and much discussed basis of selling costs is the existence of product differentiation. This includes cases in which directly competing products are not identical, yet each has various advantages and disadvantages difficult for a buyer to appraise. Products that are practically identical are differentiated also by packaging and naming.

Selling costs may exist even when the buyers' knowledge is advanced; the imperfection of the market is then due to paucity of sellers rather than to nonstandardization of product. In this type of market imperfection, however, the selling costs cover mainly the costs of competing salesmen. The function of such salesmen may be to impart information, or to act as the instrument through which secret and discriminating price cutting occurs; in some instances their activity may degenerate into commercial bribery. The concrete situation and the theoretical issues, when selling costs exist in spite of perfect knowledge on the part of the buyer, appear so confused as to justify restriction of the discussion to other types of selling costs.

The relation between product differentiation and selling

cost is brought out by an examination of some market facts. *A priori*, one would expect that serious imperfection of the market would be associated with considerable expenditure for selling efforts. The complete test of this hypothesis is not available, but data on relative advertising expenditures for various kinds of firms are interesting. One such advertising analysis, and probably the best, is the periodic survey by the Association of National Advertisers. The last years for which a survey was made were 1934-35.<sup>2</sup>

This study shows, first, that the consumers' goods industries generally have higher advertising costs than those selling to industrial users. Furthermore, the consumers' goods industries selling merchandise about which consumer information is notoriously lacking—cosmetics, proprietary medicines and so forth—have advertising costs as high as 35 percent of net sales volume. These industries have attained a high degree of product differentiation and spend advertising money to maintain it. At the other end of the scale are such items as textiles and hardware, for which the markets are less imperfect, differentiation of product by brand name is less important, and the selling expenditure on advertising is much lower. Thus there seems to be some empirical evidence for an association between product differentiation and selling cost.

Another preliminary consideration is the importance of determining the role of selling costs in the behavior of our economy. While the facts on the wide existence of imperfect markets are being recognized more and more, the question of the net effect of this imperfection on the economy, the allocation of resources, the flow of capital, and the long run trend in prices has yet to be appraised thoroughly. The formal solution of Chamberlin and Robinson shows that selling costs will result in less than optimum use of resources. On the other hand, it is not possible completely to disregard the opinions of a considerable group who claim that, given the basic imperfection of

<sup>2</sup> "A Survey of 299 National Advertising Budgets, 1934-1935" (New York, 1935).



buyer knowledge and marked economies in large scale production, the existence of selling costs will actually improve the allocation of resources and reduce the net social effort involved in the production and distribution of a commodity.

It would appear, then, that useful as the theoretical solution is to guide further study, we need to know much more about the actual functional relations between selling costs and sales and how the businessman uses selling costs as a tool for the maximization of profits in concrete situations. Only then will it be possible to appraise the forces determining market equilibrium, to set in proper relation to each other the two market weapons—the manipulation of selling costs and the manipulation of price—and finally to determine the real result of product differentiation in the economy.

This chapter cannot pretend to give the answers to the problems raised above. It will, however, attempt to explore the question of how empirical studies might contribute toward some answers to the broader question.

## *2. Problems of Definition*

A proper definition of selling cost is essential for a meaningful investigation. It is most important to point out that selling costs are not coextensive with the costs of distribution or marketing. For the purposes of this chapter, selling cost is considered to exclude those marketing costs, such as transportation, warehousing and order-taking, which are necessarily related to the physical handling of commodities between the factory and the final consumer. Many of these costs are similar in character to production costs. This does not mean that the behavior of these costs in relation to volume or other factors is insignificant, or that the entire problem of distribution costs should not be studied. Yet important as these problems are, they have less independent significance than do those of pure selling costs.

In individual cases, the proportion of distribution or mar-

keting costs which are properly selling costs may be hard to establish. While this will lead to problems in empirical investigation, the distinction can be made in theory. Selling costs are defined as costs incurred in the effort to obtain those sales which would not have been made without the impetus lent by the selling expenditure. In other words, selling costs are to be considered an independent variable which, along with price, the businessman can use to vary his volume of sales. Indeed, the determination of the selling-cost-to-sales relationships is much more analogous to a study of the demand function than it is to the study of the usual production function. Thus, empirical study should be directed to the manner in which volume varies as a function of such selling expenditures and to the ways in which the businessman can use a knowledge of this function to guide his policy decisions.

A consideration of the main kinds of selling costs will clarify the definition adopted. The first and most readily distinguishable selling cost is advertising, which can be defined broadly to include the expenditures so classified by the National Association of Advertisers. The list includes a number of media—newspapers, magazines, direct mail, outdoor advertising, premiums and so forth.<sup>3</sup> All of these items are properly part of selling cost.

It is more difficult to define the second major type of selling cost since the problem is to determine what part of the expense of the sales organization is a pure selling cost. From the definition given above, it is obvious that a great deal of this expense is not "pure." For example, there is the expense of keeping the records, the expense of keeping salesmen on

<sup>3</sup> *Loc. cit.* The study shows that in 1934 the following percentages of the total number of concerns studied used these media: dealer helps 77 percent, trade papers and industrial publications 74 percent, direct mail 74 percent, magazines 65 percent, newspapers 57 percent, sales and service literature 50 percent, conventions and exhibits 48 percent, outdoor 33 percent, publicity 32 percent, radio 32 percent, house organs 28 percent, free goods and allowances 20 percent, motion pictures 19 percent, samples 20 percent, price lists 18 percent, business papers 16 percent, farm journals 13 percent, car cards 11 percent, premiums 8 percent, miscellaneous 33 percent.

the road merely for order-taking, the overseeing of shipments, and warehousing. Much of this is an expense that would have to be incurred in moving merchandise from a central point to the spot where the customer can buy it.

Although it is extremely difficult to determine exactly how much of the cost of any particular marketing organization is pure selling cost, a number of distinctions can be made. One possibility of obtaining a measure of selling costs exists when a number of methods of distribution are available in an industry. The cheapest method may be taken as an approximation to the costs of distribution without selling effort. The difference between this and any higher cost method can be considered pure selling cost. In other cases it may be possible, by an analysis of a sales organization, to separate the costs of order-taking from the costs incurred in making additional sales.

Another type of selling cost arises from a decision to expand the selling territory, and particularly a decision to undertake national distribution. This expense may take the form of an added margin allowed the wholesaler, or extra salesmen hired to open up new retail outlets. While this type of expenditure is an absolutely necessary step prior to an intensive national advertising campaign, it is not necessarily a continuing cost, since once the distribution is secured and advertising has created and is maintaining a general demand, the merchandise can usually be distributed at a normal wholesale margin. This does not mean that "extra" marketing costs may not still be desirable to stimulate dealer interest. The expenditure, nevertheless, may be classified as part of regular advertising.

Another category which is sometimes included in selling cost is style cost. Style costs, however, have been treated frequently as production costs and it will readily be apparent that in many, if not in most, instances it is impossible to disentangle costs of style creation from costs of production, at least in any empirical investigation. Thus the dies for a new automobile body as well as the research and engineering for the creation of the model are style costs, and

more akin to selling than to production costs. Other examples include many of the costs of packaging, additions of vitamins to cosmetics, and so forth.

It appears preferable to keep style costs as a separate category similar to selling costs and distinct from production costs. The difference between advertising or market selling costs and style costs is essentially that the former are directed to creating and selling the idea to the consumer that a product is "different" and "better," whereas style costs are the costs which are necessary to create the physical basis for a "different" and "better" product. Style costs may include not only costs involved in the creation of a certain product but also costs in buying. The costs of a buyer in a department store, for example, consist in part of an outlay for the selection of merchandise "different" and "better" than those of competitors—in other words the cost of styling the store's assortment of merchandise.

Style costs, being closer to selling costs than to production costs, should be a part of the general selling cost problem. Because of the difficulties of empirical investigation, however, they will be neglected in the discussion to follow.

### *3. Types of Selling Cost Problems*

The first selling cost problem is a factual and historical one: how much of the final consumer's dollar goes for selling costs, and to what extent has this proportion changed in recent years? While these issues are of importance, they are of less theoretical and methodological interest than problems of relationships between volume and selling cost. Attention will be concentrated, therefore, on these more complex aspects of the broad question.

The traditional cost theory developed a classification of problems: costs and rate of output for a single plant or firm, short and long run cost functions for a firm and for an industry, etc. But the selling cost problem has as yet had no such work of classification applied to it; furthermore the traditional classifications of cost problems are not easily

adapted to the analysis of selling cost. Distinctions of short versus long run, for example, mean one thing for production costs and quite another for selling costs. An attempt to work out a final comprehensive classification for selling costs is beyond the scope of this chapter, but some preliminary attempt must be made if any direction is to be given to empirical investigation.

The usual classification of production cost problems is based upon the different types of decisions open to the entrepreneur; to expand output of an already existing plant, to bring a standby plant into operation, to build a new plant, and so forth. A classification of selling cost problems can be made along the lines of different types of entrepreneurial decisions.

The crucial business decision is whether to incur sizable selling costs at all. The need for this decision arises in practically all lines of manufacture and in retailing as well. Even in a field such as drugs and cosmetics, firms spending more than 35 percent of gross sales for advertising costs exist side by side with firms selling competing products with comparatively negligible direct selling costs. In retailing, to cite a New York example, the firm of S. Klein which has used no advertising competes directly with the Hearn Department Store—located only two blocks away—carrying similar price lines and advertising heavily.

The first selling cost problem, then, is just what happens when firms with little selling cost compete with firms that have heavy selling cost. This is not a pure selling cost-volume problem, but a distinction between the firm which depends on prices to build volume and maximize profit and the firm which relies on selling cost. The question the economist should answer is how price versus selling-cost competition in the same field influences a firm's profits, volume and market position, the resulting character of the market equilibrium or lack of it, and how the final consumer fares in this type of market.

If the first decision has been answered in favor of using selling cost to produce a profit, it is still possible to have

different selling cost problems, depending upon whether the enterprise is content with approximately the present share of the market or whether it seeks a big increase in its market position. In practice, of course, the two situations may not be clear cut, but the fundamental distinction is extremely important. If a firm is not attempting a sharp change in its market position, there will be a relatively straightforward selling cost-volume problem. The business decisions involved will include such matters as somewhat more advertising versus somewhat less, the covering of additional outlets by salesmen, or neglect of relatively unprofitable outlets.

The decision to attempt a big increase in a firm's share of the market, on the other hand, creates quite a different set of selling cost problems. A firm which is selling in a local market only may decide to expand into the national market. It must then spend money to obtain national distribution, which involves opening up new outlets so that merchandise is available to a larger share of the potential customers. This plan involves either payment of an extra wholesale margin or the resort to salesmen. In addition to the money spent for national distribution, the firm must start advertising on a national scale. A variant of this case may occur when a firm already has a national distribution but decides to buy a big increase in its market by doubling or trebling its advertising expenditure if necessary. A parallel type of situation exists when a retailing establishment decides to expand beyond the limits of its neighborhood. It must then start to spend advertising money in an attempt to draw people to a central location.

In all these circumstances, the selling cost-volume function is no longer short run, nor is it reversible. Even if a firm abandons the attempt to expand from a local to a national distribution, it will be unlikely to return exactly to its original position. Furthermore, many concerns will continue current heavy selling cost expenditures even though the initial outlay may not be regained, since current effort may bring in more profit than complete aban-

donment of the venture would do. The initial expenditure of advertising money is in the nature of a sunk cost. Obviously, there will be no simple relationship between volume and selling cost. The expenditure at the beginning of the expansion program cannot be related directly to the immediate sales volume, for if the venture is successful there will be an accumulated effect from the initial expenditure. Examples may frequently be found in which, after the first push, advertising is decreased below the levels of the initial expenditure while sales continue to expand. Thus the only valid volume-cost relationship will be a comparison between the position of a firm before an expansion program and its position over a number of years after the scale of operations has been changed.

Another type of business decision which distinguishes selling cost problems has already been touched upon. An enterprise may decide to change the marketing organization from a relatively low-cost to a relatively high-cost arrangement or vice versa, or within a given marketing organization it may apply more or less sales pressure by altering the number of calls made by salesmen. In the latter case, a short run reversible function will probably exist, whereas in the former case the selling cost-volume relationship is long run and probably not reversible.

The above classification of selling cost problems, while undoubtedly incomplete, indicates not only their multiplicity but also that even in the relatively restricted field of selling cost-volume relationships, problems differ essentially with the types of business decisions under consideration. This preliminary classification, moreover, emphasizes the need for an extensive knowledge of the actual market conditions and character of firms under comparison before an attempt is made to analyze or to interpret empirical data. Clearly the proper technique of analysis and interpretation of a given set of data on volume and selling expenditures will differ considerably according to the type of business decision involved.

#### 4. *Methods of Empirical Investigation*

The complexity of the selling cost problem requires a variety of methods for empirical investigation. Further study of the historical problem of changes in the size and importance of selling costs in the economy involves the collection of data rather than the use of unusual techniques. In the analysis of a market in which a group of firms depends on price competition and a competing group of firms depends on selling cost efforts, there is need chiefly for the collection of the significant material rather than for the application of elaborate methods. In general, the technique will be that of cross-section analysis treated later. The third problem discussed above centers about the relation between selling cost and volume. Since this involves a short run as well as a long run problem, and separate study of both advertising and marketing, a number of approaches should be considered.

The main obstacle to be surmounted in the identification of significant selling cost relationships is the difficulty of finding situations which are identical or similar except for the amount of the expenditure for selling cost. Basically, then, the major problem is the same as that encountered in a study of production costs. The difference is that production-cost-to-rate-of-output problems have been proven susceptible of statistical correction for "other factors" such as rates paid for input factors and trends in efficiency; here considerable use has been made of statistical techniques such as multiple correlation. The study of selling costs has not, however, proceeded far enough to utilize such elaborate methods. The major problem of method, therefore, is not one of finding suitable statistical techniques but one of showing how data can be gathered and arranged in such a manner that a significant selling cost-volume relationship is disclosed. The best approach, generally, is to find information on market situations which are similar except for



the amount of selling cost, rather than to devise statistical techniques for eliminating the influence of other factors. Probably the best that can be hoped for under present circumstances is to obtain some idea of the character of the selling cost-volume function even if a precise mathematical measurement cannot be achieved.

There are at least three approaches which may disclose a functional relationship between selling cost and volume:

(1) The first possibility is a cross-section analysis which compares, at a given time, the selling cost and volume of a number of firms competing and selling the same kind of merchandise. The assumption in this approach is that data can be obtained for firms which are sufficiently similar so that the differences in their expenditure for selling cost can be taken to be a basic cause for observed differences in volume.

(2) The second approach is through a historical analysis of a particular firm. The assumption here is that conditions for a given firm are sufficiently similar from one period to another (or can be made so by correction of the data) to permit attribution of the observed differences in volume to changes in selling expenditure.

(3) The final approach is an internal analysis of a firm's experience with selling costs and volume. Records may be available or experiments feasible on the volume resulting from specific selling cost schemes. One variant is to compare sales results in different territories which have varying amounts of selling pressure. The assumption in this approach is that sales results in different territories can be adequately corrected for influences of factors other than selling cost, so that the remaining variation in volume can be attributed to differences in selling expenditure. This approach requires the use of more formal methods than the first two.

The first and second methods for empirical investigation of selling cost-volume relationships are, of course, basically the same. In one case the comparison is between firms at the same time, and in the other between different periods of

time for a single firm. In both approaches there exists the basic problem of making certain that the differences among firms, or points of time, are only those that can be attributed to differences in the amount of selling expenditure.<sup>4</sup> The analysis of production costs also uses both approaches, but for the study of quite different problems, since in one case the subject of investigation is the relationship between cost and rate of output, and in the other the relationship between cost and size of firm. Such a distinction does not hold for a study of selling costs.

Both the cross-section and the historical approach are suitable for analyzing the long run, irreversible selling cost-volume function. In both approaches there is the major difficulty of obtaining data on firms which are similar except for the size of the selling expenditure. The investigator will run into the following problems, among others:

(1) Any comparisons which involve firms with different price policies must be avoided. A comparison of this sort may be significant for many purposes, but no definitive clue can be given to selling cost-volume relationships. For this specific problem the firms compared at one period of time or the same firm at different periods of time must have the same basic price policy. For example, the selling expenditure and volume of firms selling by brand name cannot be directly compared with firms selling on a price basis.

(2) Other variations in basic policy make selling cost ratios of competing concerns difficult to compare directly. In retailing, for example, one group of stores spends little on selling cost, strictly defined, but spends a high proportion of sales on rent. The high rent enables the store to take advantage of a confluence of traffic, whereas it might otherwise have to attract its customers largely by advertising. It is customary, in comparing stores of this type, to lump rent with selling costs to secure a proper comparison between concerns.

(3) Careful allowance must be made for possible lags between initial expenditure for selling cost and the resultant

<sup>4</sup>This problem is discussed also in Chapter X.

sales volume. In the cross-section analysis this means that comparisons cannot be made between long-established enterprises and the firms which have just begun an effort to increase their share of the market. Comparisons must be made either between established firms or between firms with local markets and firms which have exploited the national market for some time. A *pro rata* share of the initial costs of obtaining the national distribution should be added to the year-to-year costs to make the comparisons valid. Similarly, in a historical study of a single firm, if comparison is made between the period before the intense exploitation was begun and the period after, costs which were responsible for the increase in the firm's position must be spread over the volume for a number of years. The determination of the proper periods to be compared will be crucial for any investigator using this approach.

(4) When the nonadvertising selling costs are studied, it is necessary to include the entire selling costs of this type for the firms compared, or for the same firm at different periods of time. If one firm is using its own marketing organization and the other is marketing through a wholesaler, the wholesale costs in the second case must be included. Nonselling distribution costs such as warehousing and transportation must, however, be carefully excluded.

(5) In a study of nonadvertising selling cost, it must be ascertained that the different firms (or the same firm at different periods of time) are operating in comparable markets. It is not possible to obtain significant results on selling cost-volume relationships by comparing a firm selling through salesmen in sparsely populated territory with one selling through a number of large outlets in a densely populated area. Nevertheless, it may be significant to compare costs and volume for the firm whose sales effort is confined to a more concentrated part of the market with those of the firm which is selling to the entire market.

Once the data are obtained, the obvious technique will be to arrange them according to the volume, or the percentage of selling costs to sales, and then to examine the behavior of

the other variables. Arranged in proper order, the data may immediately disclose the apparent general character of the selling cost-volume function. The investigator who is particularly fortunate may uncover data suitable for actual computation of a functional relationship.

For the analysis of the short run problem, which was defined as the relationship between selling cost and volume when a firm is merely trying to improve its profits by relatively minor fluctuations in the amount of selling expenditure, the historical study of the single firm is probably the most suitable. The method is to correct the annual volume figures for influences of factors other than selling expenditure and then to relate the corrected figures to the amount spent on selling. In practice, of course, this correction may well be difficult. Some of the specific problems involved include the following:

(1) Factors other than selling expenses will obviously affect the year-to-year changes in the firm's volume. There may be changes in national income, changes in the acceptance of an item attributable to trends in public taste, or changes in the advertising effort of competitors. There are two different ways of correcting for these factors. One would be some kind of trend correction similar to that used in demand studies; the other would be measurement of a firm's volume against the total market available. If a change in relative market position can be measured, it can be translated into the dollar figure and then compared with selling expenditure.

(2) Comparison of year-to-year changes in volume and selling expenditure for a single firm is complicated by the budgeting practices of the typical established firm. It will be remembered that the functional relationship of greatest interest is that in which the selling expenditure is the independent variable and volume the dependent variable. Yet when the budgeting of the selling expenditure by the individual firm is studied, it is found that tradition strongly influences the setting of the advertising budget, and that a majority of such budgets are set on the basis of general

agreement on the percent of sales which should be spent for advertising.<sup>5</sup> The fact that a majority of firms set advertising budgets in this manner was disclosed in a survey by the Association of National Advertisers.<sup>6</sup> If it is assumed that a firm knows what proportion of the sales dollar to spend on advertising, the budget can be drawn up very simply on the basis of an estimate of future sales, of which a certain percent will be allocated to advertising. This method of budgeting will result, of course, in a close correlation between advertising and volume, but a correlation in which advertising must be considered as the dependent variable, rather than an independent factor which influences sales volume. Whether or not this method of setting the advertising budget is a sound one from the standpoint of maximizing profits, it means that in empirical investigation attention should be focused on cases where by accident or design this traditional method of setting the advertising budget has not been followed.

The third approach to the selling cost-volume relationship is the internal analysis of the individual firm. While such a study can be made only from within the firm, it has great possibilities, particularly if controlled experiments are feasible. At the same time it has certain limitations which must also be taken into account. In the first place, the method cannot easily be applied if the firm is selling only one product or in only one territory. Second, it cannot directly handle the problems which arise when the selling cost expenditure of a firm covers the entire market as it does in national advertising. Third, it may be difficult to obtain, from studies of individual phases of a firm's operations, an over-all selling cost-volume function for the total firm. These limitations should not, however, obscure the appreciable advantages of internal analysis. With this approach many types of advertising and a variety of market expenses, such as cost of salesmen, can be handled. More-

<sup>5</sup> This tradition is discussed at length in various articles in *Printer's Ink*.

<sup>6</sup> *Loc. cit.*

over, the problems of homogeneity are simpler here than in the other approaches, and technical corrections for non-homogeneity are at least possible. Finally, this method keeps the analyses as close as possible to the basis of specific business decisions.

Technically, internal study of individual firms involves a well known method of market analysis.<sup>7</sup> The first step is to set up accurate sales potentials for the different territories. This is done mainly on the basis of per capita income and total population. Next, it may be necessary to correct the sales potentials in the light of competitors' selling efforts. The actual sales volume in each territory is then compared with what it should be on the basis of the sales potential and competitors' efforts, and the resulting volume above or below the expected level is compared with variations in selling effort. The selling effort measured may include various advertising media, the number of calls made by salesmen or the type of wholesale outlet used. This comparison should disclose the volume effect of increased selling expenditure and under favorable circumstances may permit a measurement of the selling cost-volume function.

### 5. *Empirical Studies of Selling Cost*

This section will attempt to survey some of the available data rather than to report on finished and satisfactory studies. The first selling cost problem mentioned was the historical one: has selling cost become a greater part of the cost of merchandise to the consumer in recent years and what is its share at present? It is commonly held that there has been a rise in selling costs, a greater degree of product differentiation, growing imperfection in the market structure, and an increase in the share of the consumer's dollar used for "wasteful" advertising. It is widely claimed also that the costs of distribution, of which selling cost is a part,

<sup>7</sup> Detailed methods of setting such sales potentials are described in various marketing books and articles. See, for example, Albert E. Haase, "Isolate for Profits," *Printer's Ink*, Vol. 180, pp. 16 and 69; and Harry Tosdal, *Problems in Sales Management* (4th ed., McGraw-Hill, 1939).

are too large and in fact interfere with the functioning of the economy.

A study by the Twentieth Century Fund calculates that nearly 60 percent<sup>8</sup> of the consumer's retail dollar goes for costs of distribution. No attempt is made in the study to determine exactly how much of this is selling cost. Advertising, however, which is pure selling cost, is estimated at \$2 billion for 1937. This estimate includes the cost of producing advertising as well as expenditures for media. If this figure is accurate it means that advertising averages about 3 percent of the consumer's retail dollar and about 5 percent of the cost of distribution. A large part of the balance of distribution costs consists also of selling costs, and the proportion of production costs assigned to purposes of styling may be considered in the same category. Detailed study would be required before any estimate of aggregate selling costs could be reached.

The trend of selling cost over time has not been accurately measured. It appears that distribution costs per unit of merchandise handled have not fallen in the past twenty-five years as compared with a large drop in manufacturing cost per unit of output.<sup>9</sup> It would be interesting to know the comparative behavior of pure selling costs. For advertising alone, estimates prepared by *Printer's Ink* are available for the period since 1921.<sup>10</sup> Advertising costs may have increased in the 1920's as compared with the pre-war situation, but the *Printer's Ink* index shows no similar trend since 1921. The amplitude and timing of the series for advertising expenditure and for national income paid out are practically identical. In the decade of the 1930's expenditure on advertising was, if anything, a smaller proportion of national income paid out than in the 1920's. It is

<sup>8</sup> *Does Distribution Cost Too Much?* (New York, 1939). For a lower estimate of distribution costs, see: Wilfred Malenbaum, "The Cost of Distribution," *Quarterly Journal of Economics* (February 1941), pp. 255-70.

<sup>9</sup> *Ibid.*, pp. 8-14.

<sup>10</sup> L. D. H. Weld, "P. I. Advertising Index," *Printer's Ink* (January 1935).

possible, of course, that the same dollar expenditure in advertising has had a cumulative effect, and that markets have become less and less perfect even though the annual effort of enterprises to foster product differentiation has remained about constant relative to national income. It is interesting to note, however, that in the twenty years during which economists have become increasingly interested in selling costs and their effect on the economy, the actual selling cost effort through advertising, as measured by its share of national income, has shown little change.

The second problem—the question of what happens when one group of firms competes on a price basis with another group making greater selling effort and selling at higher prices—should be of particular interest because of its relation to the whole controversy on retail price maintenance. One would expect to find considerable discussion of this topic in marketing texts and some records of empirical studies, but examination of the literature on marketing and that which has grown up about the subject of price fixing<sup>11</sup> discloses that the fundamental economic problem has been passed by. The literature includes discussions of the problems of manufacturers who sell through different types of retail outlets, and their attempts to avoid trouble by price fixing and by creating superficial changes in their products when selling to more than one type of outlet. There is some discussion also of the retailer's interest in developing sources of unbranded merchandise on which he can put his own private brand. The problem of competition of one type of seller as against another has not, however, been analyzed. Additional theoretical work needs to be done, and the entire terrain is open for original empirical investigation.

The field of selling cost-volume relationships has been treated somewhat more thoroughly, although generally not

<sup>11</sup> See, for example, Albert Haring, *Retail Price Cutting and Its Control by Manufacturers* (Ronald Press, 1935), and Ewald T. Grether, *Price Control Under Fair Trade Legislation* (Oxford University Press, 1910).



by econometricians. With some exceptions, the studies are the work of business statisticians and are reported only in broad outlines, for the most part in such business periodicals as *Printer's Ink*. In many cases the published reports supply little more than rough data and offer no refined analysis.<sup>12</sup>

Cross-section analysis has been attempted in both the retailing and the wholesaling field. The annual reports of the Harvard Business School on operating results of department stores give data on advertising costs as percentages of sales for stores in different size groups. The general usefulness of these reports has already been discussed in Chapter III. Inspection of the data on selling costs reveals that advertising cost as a proportion of sales tends to rise somewhat irregularly as the size of the store increases up to about \$10 million volume. For larger stores, the percentage decreases. These figures are difficult to interpret because stores of different sizes operate in different markets, smaller stores generally being located in smaller cities. The extent to which the size of the market influences advertising cost has not been appraised, and some correction for this factor would have to be made before any direct relationship between size and selling expenditure could be determined. Even if size of the market is not an independent factor and the observed relation of advertising costs to volume is indeed meaningful, it is still difficult to explain why there should be a reversal in the relationship when a sales volume of \$10 million is reached. One must conclude, therefore, that the Harvard data are inconclusive, and that more research is needed for their interpretation.

An article by Walter L. Mitchell in *Dun's Review*<sup>13</sup> presents a more informative cross-section analysis of volume

<sup>12</sup>In the preparation of this chapter, no attempt has been made to cover the entire field of business publications and no doubt there are additional studies and many more amateur analyses than are reported here. It seems unlikely, however, that any significant economic analyses have been made.

<sup>13</sup>"How Retail Advertising Expenditures Vary With Sales Volume in the Size of City," 1941.

and advertising. This study shows how advertising costs vary with both sales volume and size of city for a number of types of specialty stores. It is apparently the first study of its kind. By a rough but probably fairly accurate elimination of the influence of the size of the city, Mr. Mitchell was able to obtain a typical relationship between volume and advertising cost. The results show that for every size of city, expenditure for advertising rises faster than increases in volume. The author concludes that this relationship is, at least in part, one of causality, i.e., that the larger stores are larger because they advertise relatively more. This conclusion is probably an oversimplification. In general, a specialty store can grow to a certain limited size by virtue of its location and natural traffic. In these circumstances, little more than window advertising is required. If, however, it seeks a marked increase in volume, the store may have to move to a shopping center, enlarge its capacity and perhaps step up its merchandising efficiency. The interesting point to be noted from Mr. Mitchell's data is that increases in advertising proportionately greater than the increases in volume were apparently also required to obtain the volume results. In a limited sense, then, this is evidence of diminishing returns for specialty store advertising. It is doubtful that the data are adequate to support the conclusion that an actual functional relationship exists, but in a field in which research has been so slight, Mitchell's contribution is valuable.

Cross-section analyses of wholesaling also have been attempted. The results of the 1935 Census were studied by the Twentieth Century Fund in its volume, *Does Distribution Cost Too Much?* These cost figures do not separate strict selling cost from costs of warehousing, transportation and order-taking. The actual results<sup>14</sup> show that costs decline as a percentage of sales as volume increases, except that after a certain volume range is reached, costs in some wholesale lines go up. This finding suggests strongly that the markets and functions of various sized wholesalers differ so

<sup>14</sup> *Op. cit.*, p. 191.

much that the comparison becomes meaningless.<sup>15</sup> To date, the problem of selling cost-volume relationship has not been aided a great deal by a study of Census results, but further work with the 1939 Census may prove useful.

Comparison of costs of various types of wholesalers may also make possible a determination of volume-selling cost relationships. It has been suggested that if the cost of performing a wholesaling function is higher than the least-cost method of wholesaling, the difference can be regarded as pure selling cost. This spread, of course, is not necessarily the whole selling cost. It is interesting to examine the compilation made by the Twentieth Century Fund<sup>16</sup> from this point of view. The comparison which seems the most significant is that between a wholesale merchant and a manufacturer's sales branch with stock. In both cases, the costs of the physical handling of the merchandise should be similar, and the assumption that cost differences should arise from differences in selling effort—provided market conditions are similar—seems to be a reasonable one. However, it appears that in certain lines manufacturers' sales branches make the greatest selling effort while in others the wholesaler carrying private brands without the aid of national advertising exerts the stronger pressure. These differences make it impossible to derive a general selling cost-volume relationship until the problems of homogeneity have been explored and settled.

There has been some use of the historical approach to the single firm. Perusal of *Printer's Ink* discloses a number of discussions of a firm's situation before and after an intensive campaign. Unfortunately, the analyses are not precise and the fundamental data are frequently suggested rather than stated explicitly. A very interesting though inconclusive case is that of the promotion of Kotex by International Cellucotton Products Company.<sup>17</sup> Unfortunately, there

<sup>15</sup> Further discussion of the problems of using Census data is included in Chapter X.

<sup>16</sup> *Op. cit.*, p. 176.

<sup>17</sup> Arthur M. Howe in *Printer's Ink* (August 18, 1939).

is no indication of what would have happened without the intensive advertising promotion, but the data do afford a very vivid illustration of the cumulative effect of a promotional campaign. A promotion of the product was first attempted in 1920 and the advertising cost was \$60 thousand for a sales volume of \$200 thousand, or 30 percent. The relative advertising cost continued high for the next two years although sales began to increase faster than advertising. The peak in advertising expenditure was \$2 million in 1927, when sales reached \$11.3 million. After 1932 advertising expenditure ran less than \$1 million a year but sales volume remained higher than in 1927. Between 1936 and 1939 two to three times the 1926 quantity was sold annually; it should be pointed out, of course, that the price in the meantime declined from 65 to 20 cents at retail.

These data illustrate what might be discovered about the long run selling cost-volume relationships if a sufficient number of valid examples could be found. Various short run studies provide rather limited evidence on this point. In one instance a study of a building material manufacturer employed a rather ingenious correction of company sales for probable secular and cyclical changes in demand, so that the resulting figures could be related to advertising expenditure. The findings, unfortunately, were not very conclusive, although the report claimed to have proven the need for increased advertising expenditure. Issues of *Printer's Ink* in 1938 and 1939 describe the sales benefits obtained when concerns in the year 1938 disregarded the traditional method of making an advertising budget. In view of the general expectancy of sales decline in that year, the typical concern was reducing its advertising budget. A number of concerns moved counter to this tendency, augmenting their expenditure and enlarging their share of the market at the expense of competitors. Whether the resulting over-all advertising cost as a percentage of sales was higher than normal is not disclosed, so that there is no indication of the character of the function. More precise information might well have yielded significant results.

It seems likely that short run advertising-sales relationships are most evident when a company fails to follow the traditional methods of determining the advertising budget. The facts concerning such a policy in the Lydia Pinkham Medicine Company were brought out as a result of a family controversy which ended in the courts. Thanks to the attendant publicity, unusually detailed figures on sales and advertising are available. This case has been reported in a number of writings.<sup>18</sup> For many years the Lydia Pinkham Company had a "conservative" (*sic!*) method of budgeting advertising—spending each year about 50 percent of its gross sales for this purpose. Until the peak sales of 1925, advertising expenditure, if anything, lagged behind growth in sales volume. Beginning in 1925, a decline in sales set in, apparently as a result of a change in public taste or some similar factor, since the decrease cannot be attributed to a relaxation of promotional effort. The concern attempted "to buck" this sales decline until, at one point, it was spending as much as 80 percent of gross sales for advertising and suffering a severe loss. If a rough correction for trend is made for the decline in sales volume from 1925 to 1935, it will be found that fluctuations in volume around the basic downward trend show a definite correlation with the fluctuations in advertising. Furthermore, increases in advertising brought less than proportionate increases in sales (after rough correction for trend). It would appear that these data might well be subjected to more intensive analysis.

The approach to the selling cost function through analysis and experiment within a single firm has apparently been somewhat neglected despite the obvious usefulness of such information as an aid to immediate business decisions. Considerably more analytical work has been done with reference to the sales force than to advertising, but results of such analysis have not generally been published. There is one published study, however, which illustrates the ap-

<sup>18</sup> See, for example, Neil H. Borden, *Problems in Advertising* (McGraw-Hill, 1937).

proach.<sup>19</sup> Swift and Company, in order to determine the relative profitability of selling to different sizes of customer accounts, made a study of one week's direct out-of-pocket selling costs for each individual customer, keeping a record of every telephone call, delivery, invoice, interview by a salesman, and other relevant services. The total direct selling cost of doing business with each firm for that week was then compared with the volume and profits of the week's business with the firm. It was found that smaller firms buying relatively little poundage supplied no profits to Swift and Company because the selling expenses were extremely high. Such diminishing returns are undoubtedly common when volume is increased through coverage of the small distributor. The working out of this particular problem required a very simple technique; examples of the use of a more complex technique for more difficult problems of this sort might be found upon careful investigation of the literature.

Another type of internal analysis can be applied to a firm's use of specific advertising programs and sales experience. *A priori* it might be argued that increase in the intensity, frequency and coverage of advertising efforts will eventually bring diminishing returns. In specific cases this contention has been minutely tested by many advertising agencies and business firms, and considerable empirical evidence has been found to support it. But the evidence, unfortunately, is not generally available for publication. It should be pointed out, moreover, that these results do not necessarily prove that the over-all advertising-volume function for a firm shows diminishing returns.

### 6. *The Significance of Empirical Research*

Even though empirical studies of production cost and rate of output have been relatively rare, the results have been so similar as to justify some tentative generalizations

<sup>19</sup> D. R. G. Cowan, "Differential Selling Cost in Relation to Wholesale Prices," *Advertising and Selling* (January 1938).

with regard to the probable character of the production function. In the field of selling costs, however, fewer studies have been made, the approaches have been dissimilar, and, in many cases, the treatment of the material is too sketchy to permit even a tentative conclusion as to the character of the selling cost-volume function. Although for this reason one cannot properly discuss the significance of actual empirical results obtained up to the present time, it may still be worth while to consider the probable value of empirical results which might be attained by more thorough study. Up to this point attention has been concentrated on the technical aspects of procuring evidence on the character of the selling cost-volume function. Research will be most rewarding, however, if the study of the character of this function, based on concrete evidence, seeks also to determine the way in which the businessman actually approaches the problem of maximizing profits through a manipulation of selling cost. Consideration of his approach to the problem, limited as it must be, may nonetheless give greater point to the need for research in this field.

With regard to the problem of the long run selling cost function of an individual firm, there are strong *a priori* reasons for believing that it must show decreasing returns because of the nature of markets and selling efforts. Furthermore, the empirical evidence from the Mitchell study of costs in various sized specialty stores supports the idea that a larger volume can be obtained only by a proportionately greater increase in selling expenses.

It would not be surprising, however, if further study were to show that actually the largest concerns in some fields have much lower costs than the smaller concerns, or that after a business concern had spent greater sums for advertising, thereby buying a big increase in its market position, it did end up with a lower ratio of selling cost to sales than had prevailed before the campaign was started. The case history of International Cellucotton Products Company has already been noted. This company now has a comparatively low selling cost-sales ratio, probably actu-

ally below that of a number of much smaller competing concerns.

Even if further research were to provide these results, the notion of a diminishing selling cost-volume function would not be effectively contradicted. Selling cost is not just a matter of the dollars spent, for the results obtained from a given expenditure can differ greatly. The fact that one concern can grow to a certain size by spending, say, \$1 million, does not mean that another firm can reproduce this result. An enterprise, confronted with the necessity of deciding whether or not to attempt to buy an increased share of the market, cannot base the decision solely on the fact that another concern succeeded in doing so and ended up with a low cost ratio. There will be a factor of uncertainty in this situation, and the selling cost-volume function upon which the firm will act must be quite different from that based upon the actual results obtained by successful concerns.

Thus, while empirical results may not throw any direct light on the basis for a business decision, they will nevertheless supply one of the missing factors in an analysis of this type of market. Considered in association with other known factors in the competitive situation, they will help to show the nature of the market forces at work.

Certain strong *a priori* expectations for decreasing returns also exist in the short run problem. Here it is assumed that the businessman is reasonably well satisfied with his present share of the market and is trying to decide whether he should spend a little more or a little less for selling cost. Up to a certain point, an increase in the number of advertising impressions, for example, may have a cumulative effect on the consumer, but thereafter the benefit to be derived from additional impressions will decrease. The empirical evidence for this conclusion was noted above. Further, there are a limited number of ways in which a firm can spend its advertising dollars. For example, a large national advertiser, say one of the major cigarette companies, may start off its advertising schedule with a page a



week in the major weekly magazines. From that point on, it must necessarily run into diminishing returns. It can hardly derive twice as much benefit from two pages a week as it does from one. If the company then turns to the use of daily papers it begins to cover some of its audience a second time. The same thing happens when the medium of the radio is employed. On the other hand, if the advertising is concentrated in the monthly magazines or the weekly magazines with more limited circulation, the costs of reaching a reader climb sharply because here the advertising rates are higher. In addition to the foregoing argument, some slight empirical evidence has been adduced in support of the idea of diminishing returns. The record of the Lydia Pinkham Company provides the clearest illustration of this point.<sup>20</sup> The question then arises: if there is a functional relationship between selling expenditure and volume, knowledge of which should enable a concern to maximize profits, why should advertising budgets be determined on the basis of a traditional or correct percent to sales which should be spent?

Interestingly enough, the businessman is generally firmly convinced that increased advertising brings decreasing returns. (This attitude shows up clearly in discussions such as those found in *Printer's Ink*, e.g., 1941.) He believes, further, that his spending has come fairly close to the point at which profit will be maximized, and he expresses this opinion by stating that increased advertising will come out of profits. At the same time, he hesitates to reduce his spending below the traditionally "correct" amount. Frequently he can see the possibility of increasing his immediate profit by decreasing the amount of selling effort. He refrains from this step, however, because he fears that a relaxation of his selling pressure will enable his competitors to drive him from a certain part of the market which he might lose permanently or regain only at great expense. There is also a considerable degree of doubt in the businessman's mind as to just what the over-all selling cost-volume

<sup>20</sup> Neil H. Borden, *op. cit.*

function is. In view of this uncertainty he may be wise in following a traditional pattern of behavior. It should be noted that direct mail concerns which can measure results accurately probably manage effectively to equate marginal returns from advertising to marginal revenue from sales.

The apparently irrational and unimaginative approach to the advertising budget may nevertheless result in maximum long run profits. What empirical investigation should seek to do, then, is to determine whether the selling cost-volume function as measured by the econometrician behaves as does the one on which the businessman bases his decisions. Does an examination show that the businessman is coming reasonably close to the selling expenditure which in fact maximizes profits? Here again, empirical research will be most valuable if an analysis of the factual data is focused directly on the entire market situation.

### *7. Research Possibilities*

There is no part of the field of selling costs that does not merit further research, and little of it is completely closed to a resourceful investigation. Probably the whole historical problem of the trend in selling costs is beyond the scope of a single investigator. Even an individual student might, however, do some valuable work in tracing the effects of increasing product differentiation and greater selling costs on the price structure of a particular industry.

The problem of competitive relationships between firms which use price primarily as a competitive weapon and those which employ selling cost instead is a very important research field, as yet largely uncultivated. Here, moreover, an investigator can find a considerable amount of case material already gathered for other purposes. Concentration on a selected industry should bring the problem within manageable limits.

From the standpoint of economic theory the crucial problem is that of the selling cost-volume function. One approach involves a historical analysis of an individual firm.

Such a study is within the competence of an individual student provided the satisfactory business contacts are available. Published information can also be used to a considerable extent. Cross-section analysis requires the compilation of a wider group of data, but it may still be within the scope of the individual investigator who takes advantage of published information as a starting point. The internal analysis of a firm requires especially close business contacts, and these may be difficult to arrange. Perhaps business statisticians concerned with the problem might be persuaded to make public material which would not disclose confidential information. The final aim of researchers in the field of selling costs should be to combine an analysis of the market, and a case study of the way in which crucial business decisions are made, with a statistical measure of selling costs and sales.

## Chapter X

# COSTS AND THE SIZE OF PLANTS AND FIRMS

ECONOMIC theory designates a limited number of variables upon which the cost of producing an output is held to depend. At the beginning of Part Two (Chapter IV) these were divided into two groups: influences affecting costs for an existing enterprise, and influences operating through a change in plant or firm. The intervening chapters have examined in turn each of the first group of factors, appraising the possibilities and evaluating the techniques for measuring their individual effect. The two cost factors which comprise the second group are considered in this chapter: the relationships between cost and scale of fixed plant and size of firm. In the preceding chapters the assumption of an existing enterprise has served as a measure of economic time; the "short run" is the period in which plant and firm are unchanged, while the "long run" abandons this restriction.<sup>1</sup> This chapter is concerned with a study of the "long run" problem.

### 1. *Preliminary Considerations*

The concepts used in the analysis of the relation of costs to size must be clarified and the forces that tend to obscure empirical observation of the relation must be pointed out before one can well examine the factors that cause cost to vary with size.

(a) Failure to distinguish carefully among the problems of size of machine, plant and firm has led to confusion and

<sup>1</sup> See Redvers Opie, "Marshall's Time Analysis," *Economic Journal*, XLI (1931), pp. 199 *et seq.*

inability to arrive at significant results. Obviously a plant, even at the very minimum, is something more than a single machine. Similarly a firm is always more than a plant, even though in some instances the two may be distinguished only by whatever part of his time the owner or executive devotes to buying materials, hiring labor and selling output. It cannot be assumed, moreover, that the lowest cost firm is composed of lowest cost plants, or that lowest cost plants employ lowest cost machines.

A plant is an integration of various fixed factors of production, typically machines, building, production layout, organization, etc. The businessman or engineer who builds or plans new plant must consider the cost-size relations of the various machines in order to determine optimum plant and the variations in average cost attendant on departures from that optimum.<sup>2</sup> The long run cost curve thus drawn for a plant is based on short run curves which assume constant factor prices and homogeneity of the various factors as well as absence of change in the technological possibilities that lie within the horizon of the businessman or his engineers.<sup>3</sup> Such a *ceteris paribus* long run cost curve would seldom be directly relevant to the problems confronting an enterprise, since the prices of input factors for any given output will depend upon the quantity of input factors required for that output. When the *ceteris paribus* long run cost function is thus combined with the directly induced changes in prices of factors, we have a cost function with a more direct relation to business decisions. However, the possible effects of changes in scale of plant on the price received for a unit of output are still ignored. In the remainder of this chapter the term long run cost function, when used without qualification, will describe the relation between cost and size of plant, including directly induced changes in factor prices. The problem of the effect of scale

<sup>2</sup> The complications introduced by desire for flexibility and by additions to existing plant will be considered later in this section.

<sup>3</sup> The relations of short and long run cost curves are considered in more detail below, Section 2.

on the price received per unit of output is not, strictly speaking, part of the subject discussed in this chapter.

A firm represents the integration of two or more economic operations. Each separate operation of a business may, of course, have a different cost-size relation. Thus a manufacturing concern which has marketing and financing functions in addition to numerous lesser activities may have one minimum cost size for production and quite a different minimum cost size judged by the criterion of marketing or financing cost. Hence, the problem as it presents itself in theory to the entrepreneur is to determine the various component cost functions and so to balance them as to achieve the lowest total cost function for each specified demand condition. A partial solution appears to lie in control by one corporation of a number of operating units. Thus a large chain store has retailing, wholesaling, buying, manufacturing, supervisory and financing units of varying size.<sup>4</sup>

The cost-size relation for the firm depends not only on the costs which the firm would incur if it carried on each stage of production, but on costs of purchase in the market. A decision must be made as to whether or not a particular function should be incorporated in the firm or whether the goods or services should be purchased in the market. The criterion is the relative cost of acquiring on the market, all things considered, compared to the cost of producing under the aegis of the firm.<sup>5</sup> This criterion, it will be observed, provides a basis for decision on both balance and vertical integration problems, although it is much more serviceable for the latter type.

The relation between cost and size of firm is frequently given a theoretical statement, but just as the *ceteris paribus*

<sup>4</sup>For a discussion of interest groups (to be distinguished from firms) see Paul M. Sweezy, "Interest Groupings in the American Economy," *The Structure of the American Economy* (National Resources Board, 1939), pp. 306-17. Also see a forthcoming work of R. A. Gordon.

<sup>5</sup>See R. H. Coase, "The Nature of the Firm," *Economica*, IV (NS, November 1937), pp. 387 *et seq.* The author assumes "that the distinguishing mark of the firm is the supersession of the price mechanism."

long run cost function for a plant is only one of the factors relevant to investment decisions, so the present relation provides only one element in the explanation of the size of existing firms. F. H. Knight suggests that "the relation between efficiency and size of firm is one of the most serious problems of theory, being in contrast with the relation for a plant, largely a matter of personality and historical accident rather than of intelligible general principles."<sup>6</sup> For even a partial explanation of the observed sizes of firms, many cost factors other than the cost-size relation would have to be considered. The most fundamental difficulty, however, lies in another direction.

The differences in cost occasioned even by wide variations in size of firm are probably small when compared to cost variations due to historical accident and entrepreneurial ability or to differences in price received for the product attributable to monopoly power. The dynamic force of the individual entrepreneur and the historical accidents that confront his business overshadow the variations in cost resulting from differences in size of firm. Forces outside the framework here outlined tend to overbalance those included. The problem of the most economical size of aggregates of plants is, however, important for public policy. The nature of the problem is such that the only possible approach involves a complex analysis of the economies, buying, financing, supervision, market control, etc., that accompany large scale corporate control.<sup>7</sup>

(b) The study of cost-size relations is widely held to lead to a determination of optimum size. The question immediately arises, optimum for what? The businessman is not primarily interested in lowest cost per unit. Modern economic theory depicts the entrepreneur as seeking to maximize the present value of his future expected earnings. If profits for a period are defined as the difference between

<sup>6</sup> *Risk, Uncertainty and Profit* (London School of Economics and Political Science, 1933), Preface to 2nd ed., p. xxi. What Professor Knight suggests for firms is also true, though in less degree, for plants.

<sup>7</sup> This approach is outlined in Section 2 of this chapter.

the valuations of the streams of earnings expected at the beginning and the close of the period, this statement of the entrepreneur's objective is equivalent to the more familiar proposition that he tries to maximize profits. Under conditions of monopolistic competition, or more broadly, whenever an increase in sales involves a decrease in unit revenue, the size of firm that will yield greatest profits is different from the size that will incur lowest average cost.<sup>8</sup> The empirical investigator of cost-size relations should not expect to find a least cost size in many cases. For when there is not a perfectly elastic demand, there may not be enough firms of the lowest cost size and of larger size to determine with any assurance a least cost size, even if adequate data are at hand. The effect of sloping demand curves on size of plant is not so evident. Insofar as the sloping demand curve really relates to the plant, as in the case of chain stores, there will be so few plants of the least cost size, and *a fortiori* of larger size, that empirical determination of the minimum point of the long run cost function will be impossible. In cases in which the firm rather than the plant faces the demand curve, the tendency to keep plants so small that least cost size is seldom reached or exceeded will not be as strong and more definite results can therefore be expected.

The empirical difficulties just described with respect to least cost size do not, however, detract from the importance of determining the relation of cost to size of firm and plant. The departures from least cost size of observed size and of profit maximizing size raise significant questions concerning full use and optimum allocation of resources, but these problems lie beyond the scope of the present discussion.

(c) The empirical determination of the long run cost function is further complicated because plant is not usually built to produce a constant output either in the short run or over a longer period. Since variations are expected, the entrepreneur is interested in at least three types of flexi-

<sup>8</sup> See E. H. Chamberlin, *The Theory of Monopolistic Competition* (Harvard University Press, 1933), Ch. V.



bility.<sup>9</sup> The first consists of changes such as seasonal variations in output, the familiar weekly cycle of retail store sales, and the daily cycle of passenger transportation, all of which require a type of fixed plant that will be reasonably efficient throughout the range of variation rather than a plant that will have optimal efficiency at any given output. "A plant will often make its boilers, dynamos, vats, or what not, smaller than the most economical size, for the sake of the flexibility that goes with numbers."<sup>10</sup> This sort of flexibility may be built into a firm by differences in the number and type of plants constructed, or built into plant by the use of different sizes and types of machines. An interesting example of flexibility in a firm is found in the balancing of steam and hydro generating plants.<sup>11</sup> Hydro plants have higher fixed costs and lower variable costs than steam plants so that in many localities the hydro plants are lower cost for high load factor demand but more expensive for low load factor demand. Under these conditions it is most economical to have sufficient hydro generating capacity for the base load and to carry the peaks with steam plants. A similar application of the principle of meeting peak demands with low fixed cost equipment is the use of old freight cars to satisfy seasonal demand for increased volumes of transportation.<sup>12</sup> The most common way of obtaining this type of flexibility is by the use of many small identical machines rather than larger units which would be more efficient if regularly fully utilized.

A second type of desirable plant flexibility permits rapid adaptation to long term change in quantity of output demanded. Businessmen are particularly concerned that their plant be easily expanded. It seems obvious that the firm

<sup>9</sup> See Chapter V, above. Also George Stigler, "Production and Distribution in the Short Run," *Journal of Political Economy*, XLVII (June 1939), where the first two types of flexibility are discussed.

<sup>10</sup> J. M. Clark, *Studies in the Economics of Overhead Costs* (University of Chicago Press, 1923), p. 117.

<sup>11</sup> Practical applications of this principle have been pointed out from time to time in electrical engineering journals.

<sup>12</sup> See Appendix C.

which can most economically revise its scale has a competitive advantage; for instance, there is much to be gained from reducing scale in periods of prolonged depression or in secularly declining industries. The efficiency of a plant depends not only on the level of technology prevailing at the time it was built, but on the changes of scale then contemplated.

A third type of flexibility permits economical change to a somewhat different product or an alteration in the proportions of joint or allied products. It is obtained by the use of general purpose rather than entirely specialized machinery. Ford's plant for producing the Model T was an extreme illustration of the absence of this sort of flexibility, and of the reduction in costs that may result when it is sacrificed.

These three types of flexibility have a profound influence on the costs any firm or plant will incur. We must expect empirical study to indicate wide variations in cost among efficient plants or firms of the same size, even when for the moment they are faced with the same type of demand. In particular, there will be found among firms or plants differences in costs which depend on whether the plants were set up all at once, in stages but planned for growth, or haphazardly. Plants larger than the least cost size may be built if the costs for two plants of half the size are greater. Also, when machine units are large compared to size of plant, as in the steel and paper industries, flexibility may require larger plants in order that the various stages of production may be kept in balance when output is changed.

(d) The concern of this chapter is with costs at plant rather than with the competitive position of firms. It would be a mistake to presume that differences in plant costs among enterprises of various sizes adequately represent the variation in their competitive position. A more relevant comparison would be between the costs of placing products in the hands of purchasers in various markets. Competitive position, of course, depends on more than the cost to the firm of making the product and placing it in the purchaser's

hands, but such considerations lie beyond the scope of this study. Differences in plant costs by size of firms are not an inaccurate indication of the relative competitive advantages of different sizes of firms.

## 2. *Factors Influencing the Relation Between Size and Total Costs*

The factors which influence costs as size of *plant* is varied are more or less well defined. It was contended in Section 1 that these forces play a significant role in the determination of plant investment by businessmen. In this section these forces will be examined briefly and then contrasted, in terms of their importance for business decisions, with the forces that determine the relation of cost to size of *firm*. Special attention will be accorded the problems which arise when the relations of cost to size of firm are studied.

If we accept E. A. G. Robinson's *The Structure of Competitive Industry* as a representative modern treatment of the variation of cost with size of enterprise, the forces determining the relation may be considered to fall into five main categories: technical, managerial, financial, marketing, and risk and fluctuation.<sup>13</sup> The forces classified as technical occupy a central position in the usual textbook treatment of the subject.<sup>14</sup> The best known of the technical forces, the division of labor, is conceptually of two types—division into trades which occurred in prehistoric times and has persisted to this day in the crafts, and division into specific operations as on the assembly line of an automobile factory. The latter type of division of labor is intimately bound up with the factory system and has been both a cause and an

<sup>13</sup> Harcourt, Brace (1932), p. 16. The division of technical forces into four types in the next few pages also follows Robinson.

<sup>14</sup> Economic science is indebted to F. Y. Edgeworth for clarification of many of the concepts which are basic to a discussion of the variations of cost elements. See particularly "C: Laws of Increasing and Diminishing Returns" in Edgeworth's *Papers Relating to Political Economy* (Macmillan, London, 1925).

effect of the development of machinery.<sup>15</sup> Adam Smith dwelt on the advantages of this division of tasks in his famous illustration, pin making. The size when the maximum, or at least optimum, division of tasks has been reached is usually rather small and further growth entails mere duplication of the original setup. But, in Robinson's view, since plants typically enter this duplicating stage, other technical forces must be at work. Thus he notes a force which he calls the "Integration of Processes."<sup>16</sup> Here one specialized supermachine replaces a number of teams of persons performing in parallel a series of operations. Many examples are found in the automobile industry: the huge steel press for automobile bodies which replaces a series of processes in the smaller scale operation, or the machine for the Model T Ford, which simultaneously drilled in the cylinder block a number of holes of different sizes from three directions.

A further refinement of the concept of size is necessary at this point, for plants and firms have two dimensions which must be considered in any attempt at measurement. The first dimension may be stated in terms of units of output or any of the other measures suggested below.<sup>17</sup> The second dimension must be expressed in terms of the number of stages of production carried through in the plant or firm. When it is necessary to distinguish these dimensions the first may be called scale and the second depth. The item, "value of products," in the Census of Manufactures is a measure of scale, the item "value added by manufacture" is a measure of the product of scale and depth of any enterprise. As among enterprises producing the same article from different materials the quotients of these Census items would measure roughly the relative depth of the enterprises.

<sup>15</sup> For a good textbook treatment of this subject see F. W. Taussig, *Principles of Economics* (3rd ed., Macmillan, 1921), Ch. 3, especially p. 34.

<sup>16</sup> *Op. cit.*, p. 24.

<sup>17</sup> See Section 3. In the framework of Section 3 only this one dimension is considered, since the assumptions of homogeneous product and constant input factors make the other dimension constant.

It is apparent that the achievement of economies through division of labor and integration of processes depends in large measure upon scale of plant or firm.<sup>18</sup> Robinson points out that possibilities of such integration may lead to an expansion of scale in certain branches of an industry, together with a concomitant lessening of depth of plant or firm. Examples of this tendency are found in the textile finishing industry. Robinson calls this "Vertical Disintegration."<sup>19</sup>

The other economies of scale occasioned by technical forces are common enough in the textbook discussions of the subject: the economy of the large machine and the economy of balance of processes. The former, which has been singled out as a subject for independent study, depends on two factors. First, it is often possible for a man to control a very large machine as easily as he can control a small one when only his initiative and judgment are needed but not his physical strength. Second, in many cases output increases as the cube of some dimension while some cost factor increases only as the square. The reverse of this relation may operate to limit the size of machines. For example, heat losses vary with the area of exposed surface, hence as the square of any dimension, while volume varies as the cube. Blast furnaces, annealing furnaces, etc., have lower heat costs with increases in size; on the other hand, the size of vats in which chemicals are mixed is limited when large amounts of heat are produced because the loss of heat is slower in the larger vats. In Section 4 an example of the relation between size of machine and cost is considered empirically.

The standard textbook treatment of the size of enterprises discovers effective checks on size in certain of the managerial forces. Because important restrictions on size are to be found in this field economists have been prone to underemphasize the importance of managerial forces in promoting large size. Division of labor leads to managerial

<sup>18</sup> Except that an extremely shallow organization may be unable to integrate processes.

<sup>19</sup> *Op. cit.*, p. 25.

economy, although the ultimate difficulty of coordinating the specialists is an important restrictive influence on expansion. Another management economy associated with scale arises from the fact that proportional expansion of most elements of management is unnecessary. On the other hand, restrictive influences are found in the difficulty of coordinating a large management and in the inertia of a bureaucracy, as compared with the rapid action and flexibility possible with a single manager or small management.

The economies and diseconomies of size considered above cut across the distinctions between firm and plant—the term “plant” includes departments concerned with selling, research, etc.—and between scale and depth. If the usefulness of these distinctions is to be preserved, a different system of classification must be used. The forces which cause costs of firm to vary with size may be classified as operating through: (a) scale of plant—quantity of final output of the *plant*, (b) degree of horizontal integration—quantity of final output of the *firm*, (c) depth of plant—number of stages of production in the *plant*, (d) degree of vertical integration among plants—number of stages of production in the *firm*, (e) range of products, (f) geographic spread of plants, and, finally, for want of a more specific term, (g) relative position in the economy. Each of these categories represents a further departure from the model set up at the beginning of Part Two of this report and re-stated in this chapter.

We should expect simple relationships between cost and any of these factors only when all others are held constant or are allowed for in a satisfactory way by multiple correlation or similar techniques. The relation may be clear and meaningful when two or perhaps even three factors are allowed to vary at once, but when all seven factors are allowed to vary the relation is likely to be too complex to be discoverable empirically. An empirical study of the *ceteris paribus* long run cost function is a study allowing scale of plant (a) alone to vary. In the case of what has been called above the long run cost function for a plant,

only (a) and the assembly costs for input factors which are one of the elements grouped under (f) are variable in an empirical study. When a cost comparison of many firms is undertaken the investigator is confronted with data representing the effect on cost of variations in all seven factors, as well as of short run variables. In the remainder of this chapter, the rigorous distinctions among the seven elements of size noted above have been relaxed because of difficulties of measurement. From empirical data one can disentangle meaningful relationships only by the greatest good fortune.<sup>20</sup>

Another approach is through the meticulous analysis of the growth of a single firm. Under favorable conditions it may be possible to remove enough of the extraneous variations to reveal the relation between cost and size of firm. Kurt Ehrke and Erich Schneider attempted to discover such a relationship in their study of a cement mill.<sup>21</sup> The results are not conclusive, but they do indicate that costs decreased with increasing size of firm up to the limit of size attained by the firm. The position of the investigators was singularly favorable, since Ehrke was a member of the firm and thus obtained full access to all records kept by the business. Furthermore, the cement industry is a singularly convenient industry to study because of the relative homogeneity of the product over time. The effect of technical change is difficult to handle and the method (as distinguished from the case) offers no solution to the problem of isolating the relations between cost and the various factors enumerated above.

A more fruitful line of attack would seem to lie in the

<sup>20</sup> In Temporary National Economic Committee, *Monograph No. 13*, "Relative Efficiency of Large, Medium-Sized, and Small Business," the Federal Trade Commission attempts to discover relations under this tangle and even to discover profitability. The results, although interesting, are not reassuring as to the feasibility of such a straightforward attack on the problem.

<sup>21</sup> *Die Ueberzeugung in der Zementindustrie, 1858-1913* (G. Fischer, Jena, 1933). Also see Theodor Beste, *Die Optimale Betriebsgrösze als betriebswirtschaftliches Problem* (G. A. Gloeckner, Leipzig, 1933).

investigation of how variations in each of these factors, or in elements associated with them, affect cost. The simplest illustration of the application of this technique occurs in the analysis of how cost of long term borrowing varies with size (factor *g*). Larger firms are enabled to undertake financing at lower costs, partly as a result of superior bargaining position, and partly because of more complete information, but probably largely because they are better known by the investing public. One of the best studies of the effects on financing costs of such factors as size of issuer, size of issue, etc., is to be found in a report of the Securities and Exchange Commission from which Chart 6 is taken.<sup>22</sup>

The techniques and data for this oblique attack on the problem of least cost size of firm are not yet developed in many of the necessary fields. In one field, however—the relation of size of plant to cost—a great deal of theoretical and empirical work has been done. The remainder of the chapter will deal with the basis and results of this approach.

### 3. *The Measurement of Cost-Size Relations of Plants*<sup>23</sup>

What are the effects of differences in size of plant upon per unit production cost? Is there a single low area with a wide range of size, or are there several minimum cost sizes, separated by higher cost sizes so that the resulting long run cost curve is a complex function with several minima? Are there significant uniformities between industrial groups?

The theoretical framework of this problem can best be constructed under the usual static assumptions of atomistic competition, homogeneous product, constancy of input

<sup>22</sup> "Cost of Flotation for Small Issues, 1925-1929 and 1935-1938," Report of Research and Statistics Section of the Trading and Exchange Division to the Securities and Exchange Commission (May 1940, mimeographed), facing p. 10.

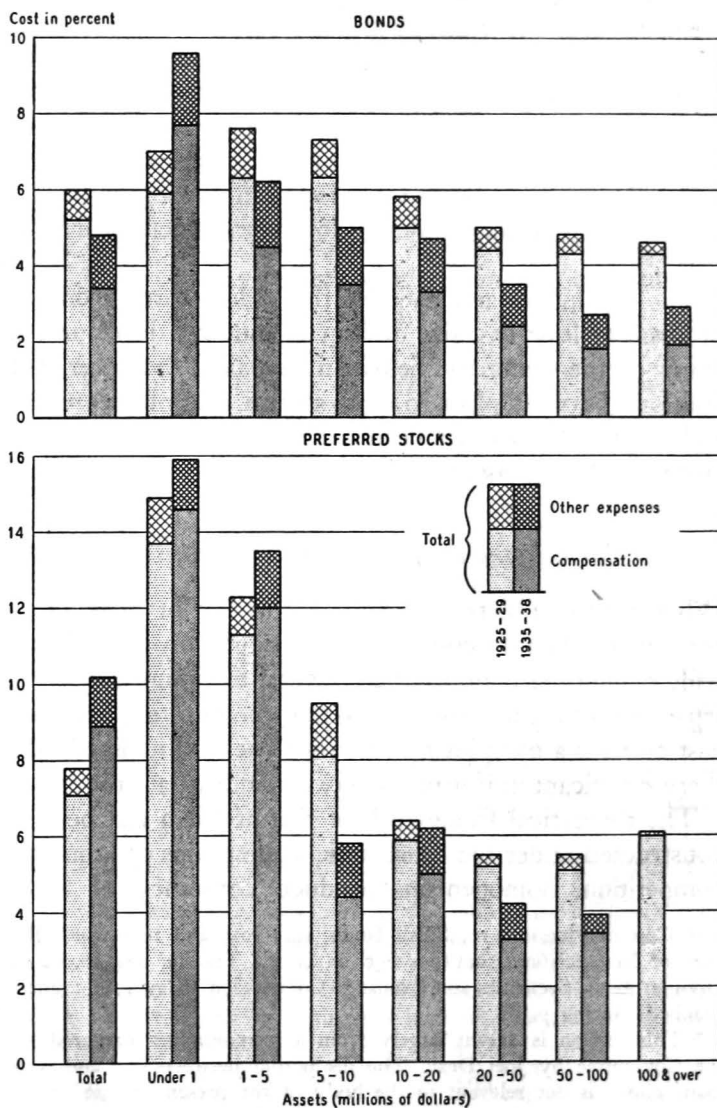
<sup>23</sup> This section is drawn largely from a memorandum prepared for the Committee by Joel Dean. The distinction between size and scale made above is not relevant to the body of the present discussion because homogeneous product and constancy of input factors are assumed.



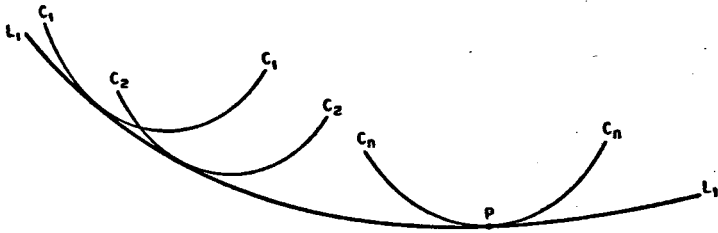
Chart 6

COST OF FLOTATION IN PERCENT OF GROSS PROCEEDS OF  
ISSUES LESS THAN \$5,000,000, 1925-1929 AND 1935-1938

By Size of Issuer



factors and their prices, and stability of the state of the arts. A diagrammatic representation of the hypothetical relationship between cost and scale of plant is shown in the figure below. A number of short run cost curves  $C_1C_1$ ,  $C_2C_2$ , etc., represent different rates of utilization of fixed plants of various sizes.



The envelope of these short run curves represents the *ceteris paribus* long run relationship between average cost and scale of plant  $L_1L_1$ . The least cost size of plant is the scale corresponding to the minimum point of this long run cost curve. The point P, therefore, represents the minimum average cost and is also the minimum point of the short run cost curve  $C_nC_n$  at this optimum scale. To determine empirically the relationship between cost and scale of plant requires careful consideration of alternative concepts of scale and cost, in order that those which are at once theoretically relevant and empirically measurable may be selected.

To find an appropriate concept of size of plant which will permit practical measurement is not an easy matter. It involves choice among several alternatives:

- (1) Amount of fixed equipment
  - in physical terms, e.g., number of spindles
  - in value terms, e.g., total assets, physical assets, capital assets, tangible net worth
- (2) Output capacity
  - maximum physical capacity, e.g., noted capacity of blast furnace
  - economic capacity, e.g., "efficient" capacity, "normal" capacity

## (3) Input capacity

physical capacity, e.g., size of "charge" of furnace,  
number of employees or manhours

economic capacity, e.g., "efficient" capacity, "normal"  
capacity

If the problem is stated as one of scale of plant, this implies measurement of plant size in terms of fixed factors not readily modified in the short run. The amount of fixed equipment is difficult to measure in physical terms that permit comparison unless the equipment is highly standardized and made up of a large number of homogeneous units. Railroads, for example, might be ordered in size on the basis of trackage or rolling stock, with very different results. Value measures of fixed plant make it possible to summarize and compare heterogeneous physical units, but they involve complex problems of determining the value of plants of varying ages, constructed at different price levels. Hence, measurement of scale of fixed plant by the amount alone is likely to prove unsatisfactory.

Another major alternative is to frame the problem in terms of output capacity of the equipment. Satisfactory measures of output capacity are difficult to find, partly because of lack of homogeneous output units, partly because of difficulty in determining actual capacity. Concepts of physical capacity appear to be inappropriate for this purpose, since the theoretical framework of the problem has been constructed in economic terms. Ideally, economic capacity, in the sense of the minimum point of the short run average cost curve, should be used. There are indications that in some industries physical capacity coincides approximately with economic capacity, for the total cost function is nearly linear over almost the entire range of output, and curves upward only as physical capacity is approached. This means that cost per unit declines over most of the range and reaches a minimum at, or near, the physical limit of the fixed equipment. Under these conditions the problem of measuring economic capacity is simplified.

But not even economic capacity is the theoretically correct concept for determining the long run cost function, for this curve does not pass through the low point of the series of short run cost curves, but is rather the envelope of these curves. Hence what is required is the point of tangency of each curve with the envelope of the entire series. Since it is practically impossible to locate the tangency point empirically, the inevitable discrepancy between theoretical and empirical long run cost functions must be recognized.

The actual observations of cost and output will represent points at various places along the short run cost curve of the individual establishments, rather than the single theoretically desirable point at which the envelope is tangent to the series of short run curves. Consequently, for each output level the statistical observations will lie above the theoretical cost function and will depart from this function by varying amounts, depending upon the shape of the short run curve and the position of the observations on this curve. Moreover, if the observation represents an annual average of several positions on the short run curve, it will necessarily be higher than the minimum point of this curve and probably higher than the envelope of the curve. Nevertheless a curve fitted to these statistical observations may have approximately the same shape as the theoretical function, although it may be higher as well.<sup>24</sup>

Another difference deserves attention. Some theoretical analysis implies that size of plant is a continuous series, whereas actually the series is discrete. Plants do not and cannot form a smooth gradation with respect to size, differing from one another by small and uniform amounts.

<sup>24</sup> Whether or not this is so depends upon whether the position of the observations on the short run curve differs systematically with the scale of output. If, for example, small plants were operated at a higher percentage of capacity than large plants, the functions would differ in shape. It may be that the responsibility for maintaining price will be borne by the firms with larger plants in the industry, allowing firms with smaller plants to shade price. In the absence of counteracting, non-price competition, this may result in fuller use of small plants.

Instead they form a discrete array with large and irregular differences in size. For this reason the empirical relationship differs inherently from the theoretical continuous curve.

Size can be measured by input capacity as well as by the amount of fixed equipment and the output capacity of this equipment, i.e., by the capacity use of workers or of raw material. Although theoretical analysis is not commonly made in these terms, the same basic discrepancies between theoretical and empirical relationships are involved. There are instances, however (notably when output is so varied that no satisfactory index can be constructed), when an input measure of capacity may prove desirable. Here again it is difficult to find the capacity point along the input scale. If size is measured simply by average input of major raw material over a period of time, it is assumed that all plants have operated at full, or at a uniform proportion of, capacity, and this is not likely to be true. Each study will require consideration of different alternative measures of size. In general, a measure which corresponds most closely to economic capacity would seem most satisfactory.

Recorded cost is affected by many factors other than size of plant. The removal of these variables in order to isolate the effect of size of plant is the central and most difficult problem of methodology. The most important of these irrelevant influences—some of which have been explicitly treated in earlier chapters—are changes in:

- (1) rate of output
- (2) prices paid for input factors
- (3) state of the arts
- (4) managerial skill
- (5) accounting valuations and procedures
- (6) locational advantages
- (7) character of products

Differences in percentage of production capacity utilized have an important effect upon cost per unit through the spreading of fixed factors and through the operation of the law of diminishing returns upon increased application of

variable factors. Thus, as indicated earlier, the position of a cost observation on the short run cost curve for a particular scale of plant obscures the relationship between scale and cost. Two methods of removing this irrelevant variation are: first, to introduce percentage of utilization as an independent variable in a multiple correlation analysis; and second, to use "normal" or standard burden rates.

Technical advance is likely to becloud the effects of change in size of plant because plants constructed at different dates along the growth curve of successful enterprises are likely to be associated with differences in the state of the arts. Moreover, as the firm grows it may obtain more competent technical advice. Hence the expanded plant is likely to embody more advanced technology, and size and technical progress may be inextricably intertwined.

A fairly clear theoretical distinction between these two factors may be made. At a given level of technology or state of the arts differences will exist between the various sizes of plant in respect to the type of machinery, the size of machines, and the organization of production; but these differences will be associated only with the scale of plant and will involve no technical improvements that were unknown when the smaller plant was designed.

This theoretical distinction is difficult to make in practice, because even when plants of various sizes are built at the same time, cultural lag and ignorance of the best current technical processes will result in variations in technology that are not solely attributable to differences in size. Furthermore, the science of plant design and of production organization and management is not exact. Hence a wide range of differences in technology may exist because of differences in opinion. Despite these difficulties, these two forces must be disentangled if the relationship between cost and size of plant is to be determined.<sup>25</sup>

Differences in accounting valuation and in accounting

<sup>25</sup> An empirical study of the relation between cost and scale might be made by analysis of a group of new plants constructed at about the same time.

procedures are likely to affect average cost as reported in the records of the several firms, and thus to obscure the true relationship between cost and size of plant. Two plants of identical size and technology may have been constructed at the same time under different types of promotion which may lead to the overvaluation of one plant on the books and thus result in higher recorded average cost. Furthermore, the way in which overhead is allocated to production may have considerable effect upon reported average cost. Differences in prices paid for plant and equipment may be considerable if they have been purchased at different times, under different solvency conditions, or in different regions. Removal of these distorting influences constitutes one of the more important research problems.

Differences in the prices paid for input factors, i.e., labor and materials, may tend to conceal the cost-price relationship. Geographic and chronological differences in wage rates and material prices, to the extent that these differences are not a function of the size of the firm (i.e., are not economies of large scale buying), should be removed from the data.

Differences in managerial skill may cause some distortion of the observed relationship between cost and size of plant, for a superior management may, to a degree, equalize the differential advantages of size.

Differential locational advantages not fully compensated by rent differences further complicate cost comparisons. Department store operating costs, for example, appear to be lower in small cities than in large. For this reason crude comparisons which fail to take account of differences in location are misleading.

Differences in products constitute one of the most serious obstacles to collection of suitable data on this point. The number of industries in which plants of varying size make the same product or comparable products in the same proportions is limited.

Four methods of approach to the study of the problem of cost and size of plant merit consideration.

- (1) Analysis of changes in actual cost which accompanied the growth of a single plant over a period of time
- (2) Analysis of differences in actual cost of plants of different sizes observed at the same time
- (3) Analysis of differences in the actual costs of different sized plants operated by one corporation
- (4) Engineering estimates of the alternative cost where the same technology of manufacturing is used in plants of different sizes

The first approach encounters what are perhaps insuperable difficulties in the way of correcting the data for changes in products, technology and management, unless the firm displays very little technical advance during its growth. Problems of rectifying cost data for changes in prices, and for differences in valuation and in accounting procedures also arise. Such a project requires complete information about one establishment over a period of continuous and substantial growth, and this is obtainable only by the closest cooperation with the enterprise.<sup>26</sup>

The second approach is more promising. It may be possible in a few industries to select establishments that differ in size but are acceptably similar with respect to other causes of cost variation. Even for the best samples, however, problems of differences in products, techniques of production, construction costs, valuation, price levels and managerial effectiveness will be serious.

Several sources of data should be explored. In some industries, associations like the United Typothetae, the Tanners' Council, the Knitting Machine Institute, and the National Association of Hosiery Manufacturers gather detailed information pertaining to cost, volume and capacity. Other associations might be willing to cooperate with the research agencies in collecting similar data for the special purpose of a study of cost and size, although the availability of data from such sources is questionable.

Again, it might be possible to obtain information directly

<sup>26</sup> See, above, the application of this technique to the problem of costs and size of firm.



from the individual firms in an industry, without working through the trade association. This procedure, however, would prove costly and might not be accorded the full cooperation of the firms covered. The National Research Project of the Work Projects Administration and the National Bureau of Economic Research gathered intimate cost and volume data for a large number of concerns in a few sample industries which had particularly homogeneous products. These data would doubtless be made available for research under proper sponsorship, and the experience and methods employed in collecting the information would be valuable if new data were to be obtained directly from individual firms.

Investigations of the Federal Trade Commission also have required collection of cost data for individual firms. Some of this information has been made public and a large amount of additional data remains in the files of the Commission, where it might be made available for this kind of study.<sup>27</sup> The cost studies of the Tariff Commission, which do not show data for individual enterprises, could perhaps be explored through special tabulations. Similarly, the detailed cost information collected during the National Recovery Administration for the bituminous coal industry is released only in the form of averages for groups of mines. Here too it is probable that records for individual mines, which would permit study of the relationship between cost and size of mine, could be obtained. The difficulties, however, are numerous. The commodity, which is apparently homogeneous, actually differs significantly from mine to mine. Furthermore, costs vary both geographically and with the position and character of the coal seam. Theoretically such differences are equated by rent cost. Yet it may be that those differences in cost that are attributable to size may also be equated and removed by this rent differential. Furthermore, there is wide range of variation in technology, wage rates and valuation.

<sup>27</sup> Temporary National Economic Committee, *Monograph No. 13*, cited above, is largely based on these data.

The Securities and Exchange Commission has for seven years gathered records of individual enterprises listed on the stock exchange. The sample is restricted to large firms and the cost data are not exactly the type desired. Nevertheless, this material deserves close examination. Several summaries of these data have been prepared by WPA projects. Willard Thorp's Census monograph dealing with trends in size of firms has been brought up to date by a WPA project. The Census of Distribution provides rough classifications of various types of distributing firms by size. The retail inventory prepared by Dun and Bradstreet shows more complete cost information but is based on too small a sample. Studies of the operating results of various types of distributing organizations by the Harvard Business School present various size classifications and give cost information in great detail.

Analysis of the data provided by the *Statistics of Income* holds some promise. The groupings, however, are likely to be too broad and the relationship between operating cost and net profit may turn out too equivocal. W. L. Crum's analysis of these data in his *Corporate Size and Earning Power*<sup>28</sup> probably achieves as much as is possible along these lines. The *Census of Electrical Industries* and the Public Utility Commissions provide information concerning size, capacity and operating costs of various types of public utilities. Similarly, the Interstate Commerce Commission collects detailed operating results for railroads. The Census of Manufactures does not give as complete information as might be desired, since its results appear only in the form of group averages. However, special tabulations could be obtained which would deal with more restricted industry groups and classify firms according to size. Some of the difficulties inherent in the use of these types of data will be mentioned and illustrated below.

In view of the numerous problems encountered in the comparison of plants of different ownership, the relationship between cost and size may be examined most easily by

<sup>28</sup> Harvard University Press, 1939.

study of individual units of multiple plant firms. Greater homogeneity with respect to products, accounting methods, valuation basis, technology and management is to be expected when several units are operated under a single ownership. Frequently, however, when a large firm makes a variety of products in several plants, each plant specializes in one group of products and cost comparisons become particularly difficult. Nevertheless, cases may be found in which isolation of cost-size relationships is much easier than for individually owned units.

This approach is not entirely satisfactory, however, since the units of a multiple plant organization are not only somewhat dissimilar under the best conditions but also not completely autonomous. To the extent that administrative functions are performed centrally, the costs of these activities must be omitted from analysis unless they can be satisfactorily allocated to the operating units. Furthermore, differences in managerial effectiveness, although likely to be lessened, are not entirely eliminated. In addition, if the services performed by the central organization are not proportional to the size of the constituent plants, the shape of the cost function will be different from that of independent organizations. Finally, the relationships of cost to price will, of course, be entirely different.

Some of the irrelevant variations due to differences in operating conditions can be removed by careful selection of the sample, rectification of data, cross-classification, and introduction of the source of variation as an independent variable. For example, one could select chain stores that are similar with respect to locality, maturity, and product proportions. By classifying stores according to nonquantitative characteristics such as supervisors, and introducing as independent variables measurable characteristics such as size of city, rate of stock turn, etc., the effect of store size on operating cost might be isolated and measured.

In canvassing sources of information consideration should be given to large, multiple unit firms whose product or service is fairly homogeneous. Oil refiners, brick, ce-

ment, flour and bread manufacturers, finance companies and chain stores are rather promising in this respect.

The difficulties encountered when one attempts to hold constant such influences as differences in technology, managerial efficiency, locational advantages, price levels and so forth, enhance the advantages, for the study of cost-size relationships, of engineering estimates of the alternative cost of plants of different sizes employing the same technology. Estimates of this type are frequently made when construction of a new plant is contemplated. The range of size, however, is likely to be narrow and the availability of such data is extremely problematical. Engineering firms regard the information not only as confidential but indeed as part of their stock in trade. Similarly, the manufacturer for whom the estimates are made is not likely to wish to release them unless they are out of date. There is always a question, moreover, as to how adequately such estimates take account of all operating circumstances that cause cost to vary with size of plant.

#### 4. *Empirical Studies of Size and Cost*

The present section is intended to illustrate the types of empirical study that can be made of the relation between size of machine or plant and cost. The final section will present an evaluation of such studies together with suggestions for research.

(A) The first inquiry concerns size of machine and cost. The costs as shown by the accounting records for 31 machines producing book paper were obtained from a comparative study of several firms in July 1936 by the American Paper and Pulp Association. The problems encountered are the measurement of size and the reduction of costs in the different firms to a comparable basis. The data are presented for each machine arranged according to width and speed classes. Size of machine, however, cannot be indicated adequately by this simple classification; an output measure of size which would take into account not only width and

speed but thickness or weight would seem more appropriate. Pounds per operating hour is a measure which, while not unambiguous, does take into account the three dimensions of paper.

The second problem is to obtain comparable measures of cost. An examination of the original data indicated a high degree of accounting heterogeneity, especially in relation to figuring the depreciation element of cost. Certain groups of consecutively numbered machines apparently were operated by the same mill or at least by the same company. If it can be assumed that within these groups accounting techniques were uniform, there appears to be a definite relation in each group between size and cost. Straight lines were fitted to the four scatters although a curve slightly convex to the origin would have given a better fit (see Chart 7). In each case the relationship represented by the straight lines gives a significant fit as measured by the standard error, and in each case the relationship has a negative slope.<sup>29</sup> If the sample of 25 machines is representative of the entire universe of paper machines, there is a definite relationship between the size of a paper machine and the "cost" of turning out a pound of the paper customarily produced on it. It must be remembered, however, that the "cost" involved in this relationship is that determined by the accounting policy of the companies involved.

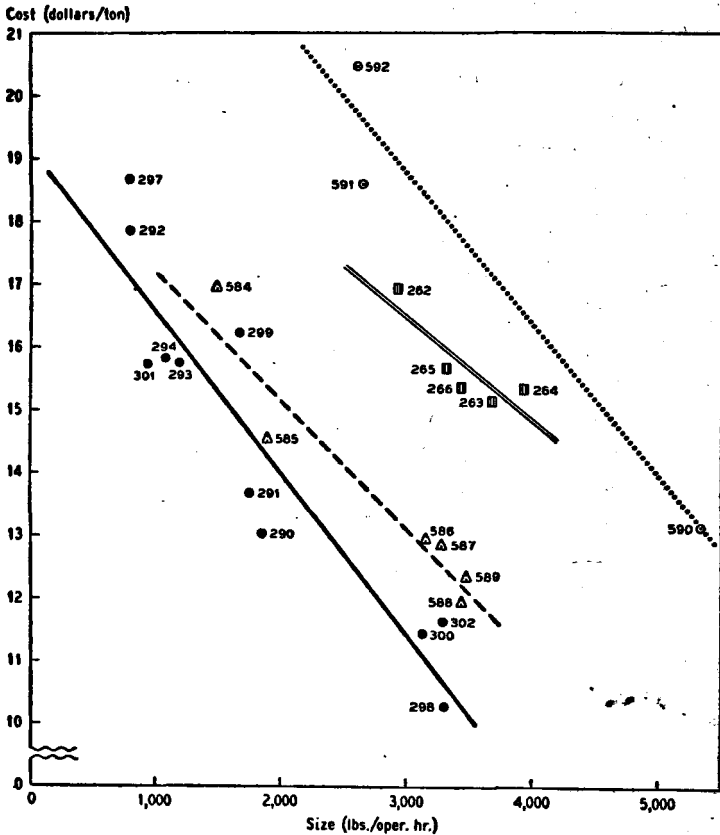
Considerable care must be exercised in interpreting the results of the regression for book paper machines. The two most serious limitations are: first, in most cases the new machines are larger and faster than the old machines; and second, it seems probable that the more expensive or spe-

<sup>29</sup> The size of machine was regarded as the independent variable, and lines of the form  $y = a + bx$  were fitted. Values of  $b$ , and values of  $r$  and  $\sigma b$  corrected for number of observations were found as follows:

	$b$	$\sigma b$	$r$
Case A	-0.2539	0.03325	-0.931
Case B	-0.2053	0.03211	-0.954
Case C	-0.1626	0.05814	-0.850
Case D	-0.2407	0.06534	-0.965
Weighted Average	-0.2224	0.04384	

cialty papers are made on the smaller machines, whereas the cheaper grades are turned out on the largest and fastest machines. It is possible that the entire regression may be explainable in terms of the age of the machines involved.

Chart 7  
 SIZE AND CONVERSION COSTS OF GROUPED MACHINES  
 IN THE MANUFACTURE OF PAPER



On the other hand, if there is a systematic variation in the type of paper produced on different machines, so that a perfect negative correlation obtains between the unit value of the paper manufactured and the size of the machine,

these results show only that it is more costly to produce a pound of high priced paper than a pound of low priced paper. It seems unlikely that either of these factors entirely explains the observed regression, but it is probable that both play a part.

(B) An instance of the use of engineering estimates of cost and size of plant is provided by the following data on petroleum refineries.<sup>30</sup> The estimates refer to the "approximate costs under present conditions of three modern refineries which might be built in three different typical locations"; they were presented to "show how present day refining costs compare with other elements in the cost of finished products at different locations. Of course estimates of this sort can only be made by making numerous assumptions, but the effort has been to approximate the actual possibilities as of June 1, 1939 in various localities."

As presented (see Table 14), the estimates show increasing cost with increasing size. A cursory examination of the breakdown of costs reveals, however, that this is mostly due to the item "pipe line rate to refinery." This charge is hardly relevant to the cost of production, since either the raw material or the product must be transported for sale in any given market. The apparently higher cost of the Gulf Coast refinery is explained also by a higher price of input factors. In the case of all other cost elements the cost either remains constant or declines as size increases.

(C) The electric generating industry offers an almost perfectly homogeneous and measurable output for study. In the survey for "A Superpower System for the Region between Boston and Washington," "a study of 196 steam-electric plants that use bituminous coal was made to ascertain their performance. These plants were selected from the 400 plants in the superpower zone because full and consistent data were available for each plant."<sup>31</sup> For purposes

<sup>30</sup> Testimony of Robert E. Wilson, president of the Pan American Petroleum and Transport Company, *Hearings before the Temporary National Economic Committee*, Part 15, Petroleum Industry, Section II, pp. 8636-37.

<sup>31</sup> U. S. Geological Survey, *Professional Paper 123* (1921).

TABLE 14  
ESTIMATED COSTS AND SIZE OF REFINERY

<i>Location of Refinery</i>	<i>Mid-Continent</i>	<i>Gulf Coast</i>	<i>Chicago District</i>
Size of refinery (bbl. crude capacity per calendar day)	5,000	15,000	60,000
Estimated capital investment	\$2,000,000	\$5,000,000	\$16,000,000
Kind of crude run	Mid-Continent	East Texas	Mid-Continent
Gravity of crude (API)	36.0-36.9	38.0-38.9	36.0-36.9
Field price of crude	\$1.02	\$1.10	\$1.02
Gathering charge	.05	.05	.05
Pipe line rate to refinery	..	.125	.345
Direct refinery operating expense (not including fuel)	.16	.11	.08
Taxes, overhead, insurance, etc.	.04	.035	.03
Depreciation (not including obsolescence) at average rate of 7 percent	.077	.064	.051
Miscellaneous charges	.06	.05	.04
Total cost per barrel of crude processed	\$1.407	\$1.534	\$1.616
Total cost per barrel of products	1.529	1.667	1.757

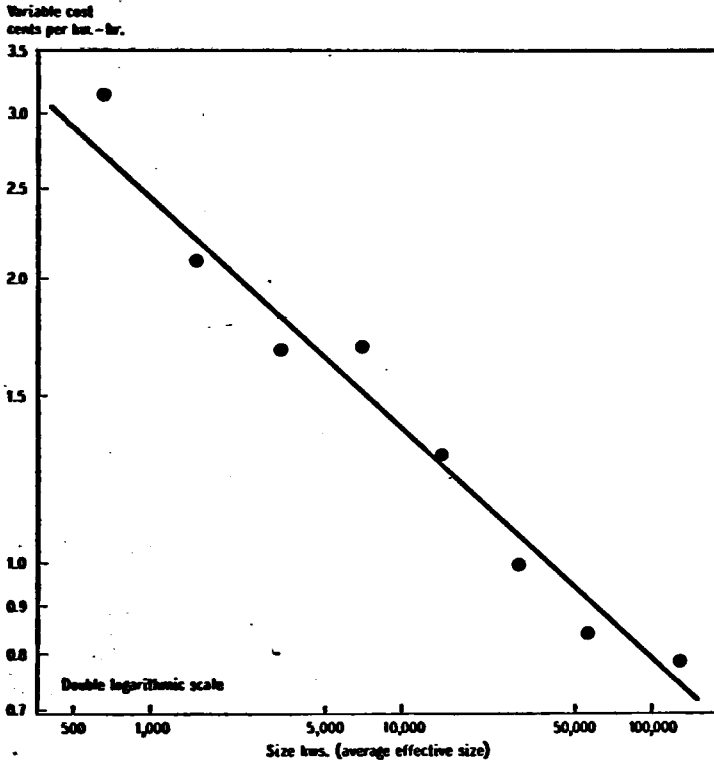
of computation, the cost of coal was taken as \$5.35 per ton, the average cost in 1919 for all plants in the superpower zone. The relation between size and variable cost per kilowatt hour for eight size groupings of plants is shown in Chart 8. No account is taken of costs of distribution or of fixed costs.

(D) A great mass of data on costs for size groups is available in the publications of the Census Bureau. In these studies size is almost universally measured in terms of value of sales, while the cost is frequently not given directly, but must be calculated as a percent of sales. The inadequacy of these measures is apparent. The use of Census of Manufactures data will be illustrated by studies of the paint and varnish industry and the manufactured ice industry for 1919 and 1929. The cost of materials, purchased electrical



energy, fuel, containers, etc., is the difference between value of products and value added by manufacture. Wages can be approximated by multiplication of the number of wage

Chart 8  
VARIABLE COSTS PER KILOWATT HOUR  
AND SIZE OF GENERATING PLANT



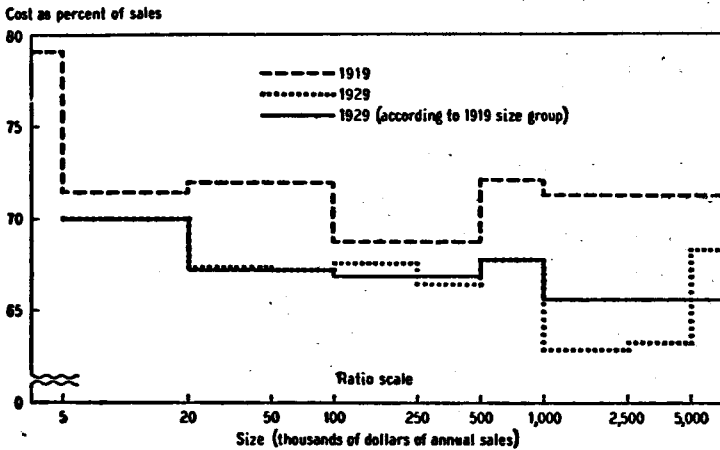
earners by the average wage payment per worker in the industry for the year.<sup>22</sup> The sum of these two items gives direct costs, which in Chart 9 are presented as a percent

<sup>22</sup> This procedure will yield an accurate wage figure only if the average skill is the same in each size group and the average time worked for each employee is the same. On the other hand, it has the advantage of automatically eliminating the effect of differences in wages paid for identical work.

of sales for each size group for the paint and varnish industry.

The shape of the solid and broken line curves of direct costs are strikingly similar. Costs decrease as size mounts up to \$500,000 annual output, then rise in the \$500,000 to \$1,000,000 group and finally fall off again after the

Chart 9  
DIRECT COSTS AND SIZE OF PLANT  
Paint and Varnish Industry, 1919 and 1929



Source: Calculated from Fourteenth Census, MANUFACTURES, Vol. X, p. 740; Fifteenth Census, MANUFACTURES, Vol. I, pp. 84-85.

\$1,000,000 mark, apparently showing a somewhat discontinuous decrease in costs as size reaches the highest category. The dotted line branching off from the solid line for 1929 shows the data for the narrower size groups tabulated in that year. Here costs apparently rise sharply in the largest size class. When the data are as unstable as this, it would be dangerous to try to draw many conclusions.

The ice industry is a better one to study because of its homogeneous product. For 1919 the direct costs decline regularly with increases in size until the largest group is reached, when they rise sharply.<sup>33</sup> In 1929 there is a steady

<sup>33</sup> *Fourteenth Census of the United States (1919)*, Vol. X, "Manufactures," p. 959.

decrease over the entire range of size, and with but one minor exception wages and materials costs decline as size increases.<sup>34</sup> The same tendency on the part of wages and materials is observable in the 1919 data, and further examination shows that the high cost of the largest group in that year was caused by an abrupt rise in materials costs. In view of the fact that there are only four firms of large size, it is probably safe to consider the costs of these firms as abnormal and conclude that in the manufactured ice industry cost fell as size increased up to the largest sized plants in operation.

Data for 1933<sup>35</sup> offer a check on the validity of the method of calculating wages paid. Comparison shows that for the size groups arranged in order of number of workers for the whole country the discrepancies between actual and estimated wages are not significant in either the paint and varnish industry or the ice industry; however, for the size groups arranged by size of city the differences between estimated and actual wages in the ice industry are considerable. It is not surprising that the results obtained from a study of these data are not conclusive. Many other factors influencing costs besides size of plant have not been accounted for in this analysis, and no data are available to permit a more detailed analysis.

(E) The Census of Distribution offers data which can be treated more fully. The Fifteenth Census, taken in 1930, in the volume on wholesale distribution presents data on size and cost for various groups of wholesale merchants for the year 1929. As in the case of Census of Manufactures data, the only available measure of output is dollar value of sales, and costs are measured as a percent of this value.

Summary figures for all wholesale merchants classified according to nine size groups (with no distinction according to type of commodity sold) are presented first. There is

<sup>34</sup> *Fifteenth Census of the United States (1929)*, Vol. I, "Manufactures," pp. 80-81.

<sup>35</sup> Published in "NRA Statistical Materials No. 43" (mimeographed, Washington, 1936), Table VII and *ibid.*, No. 71, Table XIII.

a steady and regular decrease in cost with increasing size. It would be easy to conclude from this that in wholesaling costs decrease regularly with increasing size. To test this relation, costs for the 21 trade groups were examined. These trade groups, which have a slight degree of homogeneity as to products handled, show only a general downward trend of costs with increasing size. Furthermore, in the 88 trades, which have more homogeneity of products handled, only about 60 percent show this downward trend, and for the 11 most homogeneous trades only 45 percent have the lowest cost in the largest size group. The decreasing proportion of groups showing the lowest cost in the largest size class, as the homogeneity of the groups studied increases, suggests a refutation of the assumption that costs decrease with increasing size.

In order that the problem might be studied under more rigid restrictions, two trades for which data could be obtained by states were examined (in these cases the trade and trade group are synonymous). The costs of wholesalers (exclusive of costs of goods sold) in petroleum and petroleum products decreased fairly regularly throughout the range of observed size from 21.7 percent for those in the class below \$25,000 to 13.2 percent for those with sales of over \$1,000,000. An examination of the data for individual states, however, shows no such trend. For California, with 86 establishments, costs decrease from 35.7 percent for establishments with sales under \$25,000 to 5.2 percent for those with sales between \$300,000 and \$400,000, and then increase rapidly again to 20.9 percent for those with sales of \$1,000,000 or over. For Colorado, with 74 establishments, the lowest cost group again appears in the \$300,000 to \$400,000 class. Other states, similarly, depart from the pattern shown by the United States as a whole, and the variations are so extreme and so irregular, even when the sample consists of a fairly large number of establishments, that considerable doubt is thrown on the validity of the assumption that the summary series for the United States shows how costs vary with size.

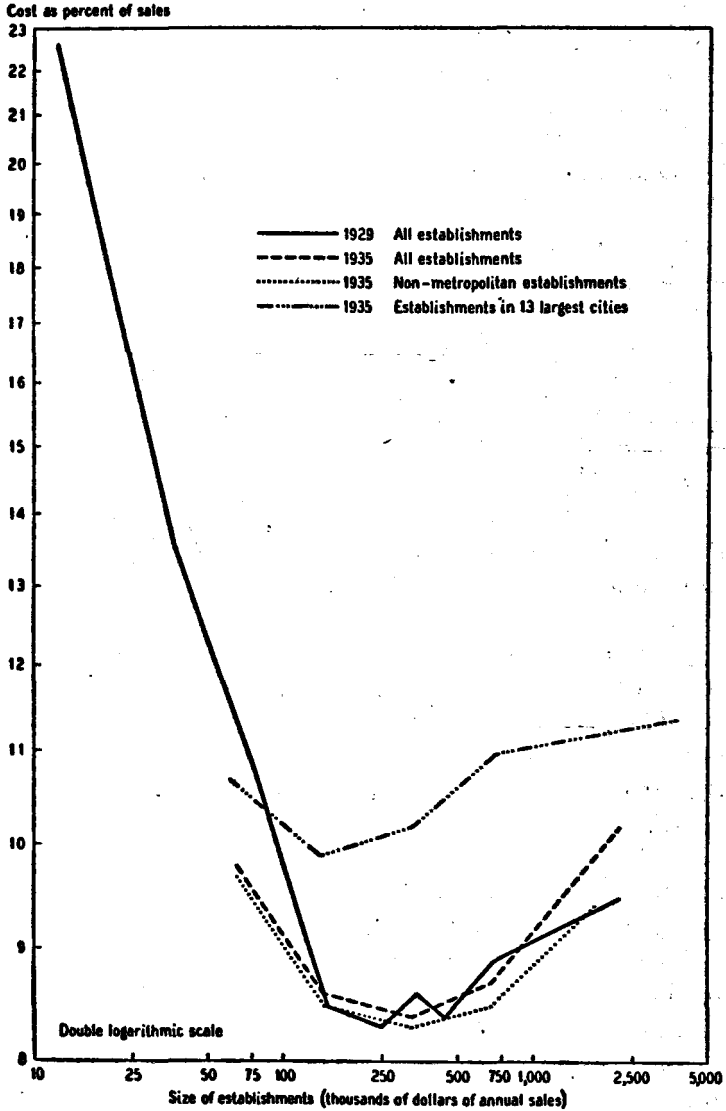
The second trade for which it is possible to secure data by states is the wholesaling of tobacco and tobacco products, which is somewhat more homogeneous than trade in petroleum and petroleum products. A detailed study reveals, however, that 11 large Manhattan merchants, performing apparently an essentially different function, account for an influence on the figures for the whole country which altered the basic pattern of size and cost. When the 11 merchants are omitted, the costs decrease with increasing size for every size group but one. Nevertheless, the figures for the individual states do not exhibit any such marked tendency, although the two largest states, New York and Pennsylvania, show a relatively steady downward relationship in costs. There seems to be a tendency here toward continuously decreasing costs with increasing size.

Finally, in order to obtain a more homogeneous trade with a larger number of establishments, data for the "full-line groceries trade" were utilized from the 1935 Census of Distribution. The breakdowns in this Census show data for 9 geographical regions and for the 13 largest cities of the country. Costs for the United States as a whole for the Census years 1929 and 1935 are shown in Chart 10, as are also costs for the 13 largest cities and for the remainder of the country in 1935. In all these cases the curves are markedly U-shaped. For 8 out of the 9 regions of the country the curve is also U-shaped; and when the establishments in the six cities for which there are complete data are excluded, 8 out of 9 regions show a U-shaped curve, the exception in this case being a different region. It appears probable that costs of doing business as a percentage of sales in the full line grocery wholesaling trade at first drop and then rise with increasing size as measured by dollar volume of sales.

In a number of respects the wholesaling studies are more refined than the studies from the Census of Manufactures. First, the depth of establishments in wholesaling is fairly well circumscribed, although the same is not true in manufacturing. Second, only one variety of wholesaler, the

Chart 10

SIZE OF ESTABLISHMENT AND COST  
IN FULL-LINE GROCERY WHOLESALING



Calculated from 1929 and 1935 Census of Distribution  
Fifteenth Census of U. S., DISTRIBUTION, Vol. II  
1935 Census of Business, WHOLESALE DISTRIBUTION, Vol. VI

wholesale merchant, is considered. Third, the effect of size of city can be tested and eliminated by means of separate compilations for the different city sizes as shown in the grocery analysis. Finally, the stability of the relationship can be tested by examination of results for a number of different geographical areas.

The tobacco trade study reveals a long run cost function which decreases rather steadily with increasing size to over \$1,000,000 of sales a year. There is some indication, from the case of the 11 Manhattan merchants averaging over \$10,000,000 in annual sales, that much larger size entails much higher costs. As has already been noted, however, these firms may not be closely comparable with the other firms. In the grocery trade a U-shaped long run cost function would seem to be quite well established.

(F) Retail trade with its extremely large number of units should offer a fertile field for empirical research in cost-size relations. Unfortunately the data have not been collected and published as abundantly as for wholesaling. Perhaps the most comprehensive collection of material is to be found in Dun and Bradstreet's *Retail Survey*. Here the cities are divided into three size groups: under 20,000 population, 20,000 to 100,000, and over 100,000. In an attempt to discover whether any relationship of cost to size could be shown, thirteen types of stores having the greatest number of representatives in the survey were studied for the two years 1935 and 1936. The results were erratic within each year and were seldom comparable for the two years. No clearly defined pattern emerged. The entire lack of conclusiveness is probably due to both the small size of the sample and the very broad population groupings used.

There are a few more complete studies of cost and size for isolated areas or individual trades. The Bureau of the Census made two such studies in connection with the 1930 Census. One was for drug stores in the Chicago-Milwaukee area (Chart 11). The other study covered combination stores (meat and grocery) in the Louisville-Cincinnati area (Chart 12). The charts showing the behavior of costs and

size may be interpreted in several ways, but in general the pattern shows declining costs with increased size until the largest size classification is reached, at which point higher costs are sometimes found.

For a number of years the *Hardware Retailer* has made a study of hardware store costs—perhaps the best single study of its kind. The population groups are fine enough to give a high degree of homogeneity to the type of city except in the case of the largest size group. The hardware study in 1937 showed a regular and steady decline in costs with increases in size for all city size groups except the largest. The discontinuity in the largest group may well be explained by the size of the group in question. We may conclude that in most cases there is a decrease in costs with increasing size of business in hardware stores.

Classification of stores by size of city and by similarity of type as well as by size should yield rather definite results, especially if the problem of imputed wages can be handled adequately. With the data available at present it would be dangerous to try to draw any conclusion other than that costs decrease with size up to a size considerably larger than the average. It would be particularly valuable to apply a correlation technique to retailing data, with special attention to the possibility of fitting a step function.

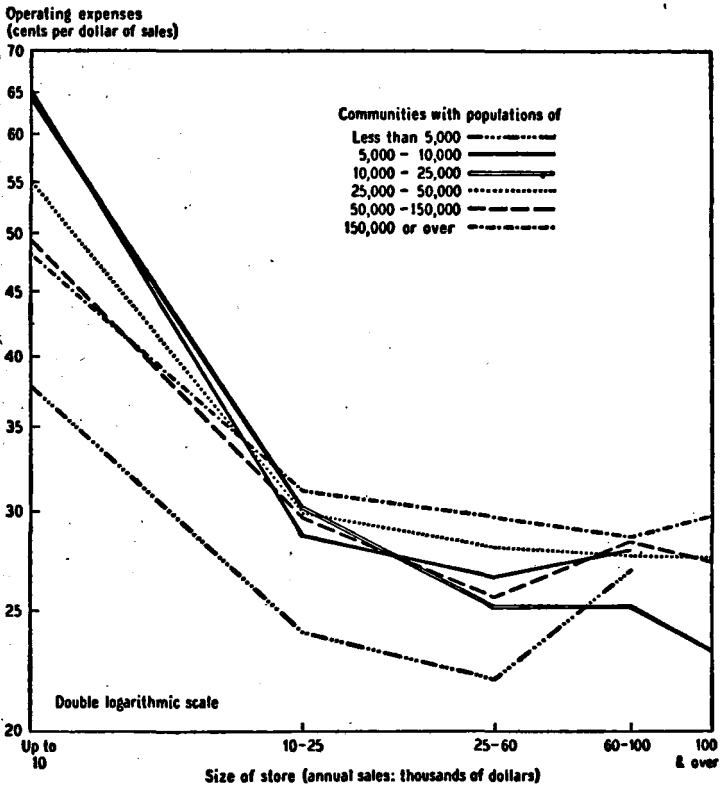
(G) A great many studies of the production of various crops have been made by the State Agricultural Experiment Stations and by the Bureau of Agricultural Economics.<sup>36</sup> A conspicuous difference between these studies and those of manufacturing industries is that the standard criterion of "efficiency" is the income the farmer receives for his labor and management services rather than the cost per unit of the goods produced. Fortunately in many studies the unit cost of production is given or can be derived from other data.

<sup>36</sup> The theory of input-output relations and cost of production studies were treated in *Bulletin 1277* of the United States Department of Agriculture by H. R. Tolley, J. D. Black and M. J. B. Ezekiel, "Input as Related to Output in Farm Organization and Cost of Production Studies" (1924).



A study of apple farms by the Maine Agricultural Experiment Station is typical.<sup>87</sup> Two measures of size are used by the investigators. The first, total capital invested, is a very poor measure. The other, total productive man work

Chart 11.  
SIZE OF ESTABLISHMENT AND COST IN  
3053 DRUG STORES IN CHICAGO - MILWAUKEE AREA



units (essentially a scheme for using arbitrary figures to reduce the various farm outputs to a homogeneous unit) is probably a rather good measure for similar farms. The farms in question are all in one county and derive a con-

<sup>87</sup> "An Economic Study of 93 Apple Farms in Oxford County, Maine, 1924-1927," *Bulletin 347*, Maine Agricultural Experiment Station (Orono, Maine, October 1928).

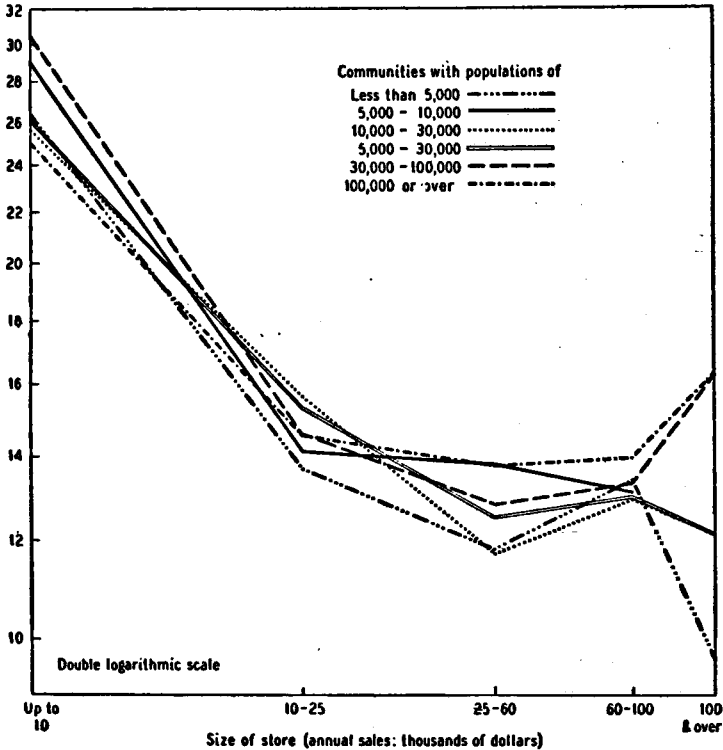
siderable part of their income from apples, although the secondary crops are varied.

Three sizes groups are set up: less than 300 p.m.w.u. (productive man work units), 300 to 599 p.m.w.u., and 600

Chart 12

SIZE OF ESTABLISHMENT AND COST IN 2521 COMBINATION STORES (MEAT AND GROCERY) IN LOUISVILLE-CINCINNATI AREA

Operating expenses  
(cents per dollar of sales)



p.m.w.u. and over. For a three-year period the annual labor income on the 93 farms studied varied with size as follows: small farms \$18, medium-sized farms \$227, and large farms \$484. Although the data for individual farms are not given, it is apparent from other data that there would be a very wide scatter about a regression line for labor income against

size of farm business in this apple-growing section.<sup>38</sup> Too many unobserved variables were allowed to influence the results.

A study by the Vermont Agricultural Experiment Station of 138 dairy farms attempts to measure the net effect of size of enterprise on labor income after the effect of other factors has been taken into account. The technique used is a seven-variable multiple and partial correlation analysis. The coefficients of partial and total determination are given in Table 15.

TABLE 15  
RELATIVE SIGNIFICANCE OF SIX FACTORS  
AFFECTING LABOR INCOME<sup>a</sup>

<i>Factor</i>	<i>Percentage</i>
x <sub>1</sub> Total work units per farm	11.2
x <sub>2</sub> Butterfat per cow	14.6
x <sub>3</sub> Yield of hay per acre	1.2
x <sub>4</sub> Man work units per man	21.3
x <sub>5</sub> Percentage of receipts from sources other than livestock	8.3
x <sub>6</sub> Ratio June to November butterfat production	0.9
TOTAL	57.5

<sup>a</sup> E. W. Bell, "Studies in Vermont Dairy Farming, V. Cabot-Marshfield Area," Vermont Agricultural Experiment Station, *Bulletin 304* (September 1929).

With this procedure it should be possible, by selection of the various factors which make large farms more profitable, to reduce a very high gross correlation between size and income to an insignificant partial correlation. To a certain extent this has happened here. The gross correlation of size of farm (total work units per farm) with labor income is +.49, but the greatest advantage of size of farm is the more efficient use of labor (man work units per man). When the effect of a linear regression between efficiency of labor utilization and labor income has been removed, as well as other variables with a slight correlation with size, the par-

<sup>38</sup> *Ibid.*, p. 136.

tial correlation between size and labor income falls to +.33. A proper statement of the relation revealed by this study is not that variations in size account for 11 percent of the variation in labor income, but that after allowing for a linear regression between efficiency of labor utilization and labor income (this efficiency is largely influenced by size), and for the other four factors which are, with the exception of butterfat per cow, somewhat influenced by size, there still remains 11 percent of the variations in labor income which can be accounted for by a linear regression between size and labor income.

Agricultural investigators have been concerned also with the effect of size on cost in industries that process agricultural products, particularly creameries. The relationship between size and cost is clearly shown by a Minnesota study made in 1920 (Table 16).

TABLE 16

## RANGE IN CREAMERY COSTS BY OUTPUT GROUPS\*

Output Groups	Costs per Pound of Butter (cents)		
	High	Low	Average
Under 100,000	8.1	4.6	5.75
100,000 to 150,000	6.6	3.7	5.05
150,000 to 200,000	5.2	3.5	4.31
200,000 to 250,000	4.6	3.3	4.05
250,000 to 300,000	4.1	3.3	3.77
300,000 to 400,000	3.7	2.8	3.55
400,000 to 500,000	3.4	2.6	3.20
Over 500,000	3.1	2.4	2.98
Average			4.07

\* "Economic Aspects of Creamery Organization," Minnesota Agricultural Experiment Station, *Technical Bulletin 26* (St. Paul, 1925).

A study of 78 Canadian prairie province creameries gives similar results (Table 17). The analysis by items of cost is particularly interesting in that it shows administration, a factor internal to the organization, increasing in cost after a certain size has been reached.

Such markedly decreasing average costs are theoretically incompatible with a system of pure competition and small units.<sup>39</sup> What, then, are the implications with regard to the observed prevalence of small units and the supposedly com-

TABLE 17

THE RELATION OF VOLUME OF OUTPUT TO COST  
OF MANUFACTURING A POUND OF BUTTER IN  
78 CREAMERIES—PRAIRIE PROVINCES, 1933<sup>a</sup>  
(Production per Factory in Thousands of Pounds)

	<i>Less than 100</i>	<i>100- 199</i>	<i>200- 299</i>	<i>300- 399</i>	<i>400- 499</i>	<i>500 and More</i>	<i>Average</i>
<i>Number of factories</i>	4	14	22	19	5	14	.78
<i>Items of cost in cents</i>							
Plant wages	1.36	1.32	1.05	0.90	0.79	0.76	0.91
Materials and miscellaneous	1.47	1.28	1.28	1.31	1.30	1.18	1.25
Overhead	1.26	0.73	0.66	0.70	0.52	0.48	0.60
Administration	0.73	0.56	0.53	0.71	0.76	0.76	0.69
TOTAL COST	4.82	3.89	3.52	3.62	3.37	3.18	3.45

<sup>a</sup> Department of Agriculture of the Dominion of Canada, *Technical Bulletin 13*, "An Economic Analysis of Creamery Operations in Manitoba, Saskatchewan and Alberta" (Ottawa, March 1938).

petitive nature of agriculture and allied processing industries? In the case of the farms themselves, the small scale is probably influenced by noneconomic factors such as the desire of the farmer to own his own farm and to be his own boss even at the cost of a lower income. In the case of processing or collection plants such as creameries or grain elevators the limit on size is the cost of collection as size increases. Furthermore, sales are in a competitive market<sup>40</sup> while purchases are in either monopsonistic or oligopsonistic markets. This may be why farmers have so often felt the

<sup>39</sup> See especially, J. R. Hicks, *Value and Capital* (Oxford University Press, 1939), Ch. VI.

<sup>40</sup> This is open to some question, but at least the price paid all processors is usually the same or nearly so for the same quality, quantity, etc.

need of setting up their own cooperative monopsonistic or oligopsonistic processor.

A few other studies which are crosses between engineering estimates and empirical research should be noted. The Minnesota Agricultural Experiment Station made a technical study of the possibilities of building different sized creameries and presented cost data based on the findings.<sup>41</sup> Similar data were calculated for local grain elevators.<sup>42</sup> A study undertaken by the New England Research Council attempts to discover the costs of handling milk at country stations of various sizes.

### 5. *Evaluation of Techniques and Research Possibilities*

From an analytical point of view the most important relationship between size and costs pertains to the firm, summarized in the concept of the long run cost curve. The relationship between size of plant and costs is of secondary significance as an explanation of decisions of the enterprise, although it is much more amenable to statistical approximation. An appraisal of the studies of the preceding section cannot be very enthusiastic about the adequacy of these investigations.<sup>43</sup>

He who attempts to employ the technique of cross-classification of plants in order to remove the effects upon cost of variables other than size is confronted by unpleasant alternatives.<sup>44</sup> If a great many classifications are made, i.e., by size of city, technique utilized and age of enterprise, the

<sup>41</sup> "Judging Creamery Efficiency," *Bulletin* 231 (St. Paul, Minn., August 1926).

<sup>42</sup> Hutzl Metzger and H. Bruce Price, "Economic Aspects of Local Elevator Organization," Minnesota Agricultural Experiment Station, *Bulletin* 251 (April 1929).

<sup>43</sup> The limitations to the interpretation of any empirical study of size and costs, noted in Section 3, are relevant in this connection.

<sup>44</sup> See Milton Friedman, "The Use of Ranks to Avoid the Assumption of Normality Implicit in the Analysis of Variance," *Journal of the American Statistical Association*, XXXII (December 1937), pp. 675-701.

sample may become too thin for further study or the total effect of "size" may have been removed in the process of cross-classification. "Size" may be correlated in various degrees with these other variables. In fact, it may be impossible to remove the effects of any variable, that is, to improve the homogeneity of the data because its relation to "size" is unknown. Moreover, it cannot be established with any certainty whether the process of classification has ever been carried far enough. What appears to be a relation between size and costs might turn out to be attributable to another variable if classifications were carried further. Several instances of this limitation were evident in the studies summarized in Section 4.

The empirical study of costs in existing plants does not permit a close approximation to the long run cost curve of economic theory. Not only may each plant be producing at some other level on its short run average cost curve than the tangency point with the envelope, but with changes in price in any period it is certain to be out of long run equilibrium. The fact that many establishments have grown piecemeal, and hence may have larger costs for a particular scale than a firm has if planned for that scale, will also distort the statistical relationship out of all resemblance to its analytical counterpart.

Even though these empirical relationships may be poor counterparts for analytical concepts, the relevant issue is whether they are worth while in themselves. The answer to such a question must depend on the purpose at hand and the range of error that can be tolerated. The importance of the relationship between size and costs for public policy as well as for business practice would seem to justify the effort to analyze any information available. Moreover, existing techniques of study can no doubt be improved and other sources of data examined. To this end, the following possibilities for useful research are suggested:

If the original Census data, both for distribution and for manufacturing, were made available for a research project, more refined statistical techniques, such as multiple corre-

lation and confluence analysis, could supplant rather crude cross-classification schemes. Similarly trade association and trade journal data could be more fruitfully analyzed by these more powerful tools.

Again, an inquiry requiring some technical background could delve into the technical changes that have tended to alter the boundary lines of enterprises. This could be either a cross-section study of many industries or a more intensive examination of single enterprises.

There are a number of manufacturing industries, such as shoe fabrication, job printing and hosiery manufacture, for which the investigation of cost-size relationships would appear to offer rather bright possibilities.

Some attempt should be made to apply and utilize the results of studies of the relation between size of plants and costs. It should be possible to estimate in various fields the economies to be achieved by a change in the size of plant. Fairly specific programs of public policy could be formulated in some cases. For instance, given certain value judgments about concentration of economic power, the development of public research in certain industries or the establishment of research activities by trade associations which would pool their resources could be encouraged.



**PART THREE**  
**PRICE POLICY**

## Chapter XI

# THE IMPLICATIONS OF COST BEHAVIOR FOR PRICE ANALYSIS

THE foregoing chapters have been concerned in the main with the analysis of some aspects of cost behavior in the individual firm. An empirical consideration of cost-price relationships would have to take account not merely of other aspects of cost behavior but, more particularly, of the demand situations encountered by the firm. This the Committee on Price Determination is not at present prepared to do. It is hoped that the preliminary analysis of cost behavior offered here may be followed by further investigations of demand considerations. In the meantime it may be useful to offer a few observations on the implications of the preceding discussion for price analysis.

### *1. The Utility of Cost-Price Theory*

Reflection on contemporary price theory in the light of the complexity of actual price situations leads to two conclusions: (a) the conceptual models in current use represent an extreme, and probably undue, simplification of the situations a firm has to meet, and (b) price analysis nevertheless provides a number of useful if not indispensable tools for empirical treatment of (at least) the cost side of cost and demand relationships.

Price theory usually envisages a firm producing a single product and confronted by one of the series of possible situations which emerge from a classification of markets based on a number of sellers and the presence or absence of

product differentiation.<sup>1</sup> This firm adjusts its price to short or long run anticipations and under certain circumstances may undertake to discriminate among buyers. The conceptual schemes which represent the various possible combinations of these elements usually constitute what is commonly known as the economics of the individual firm. This set of conceptual schemes has certain rather serious limitations. The industrial firm typically turns out a number of products to which a substantial percentage of the costs incurred are common. While the derivation of the cost function for single products presents no conceptual difficulty on the assumption that the quantitative relation of the commodities produced can be sufficiently varied, in fact the possibilities of variation are usually strictly limited. Common costs must necessarily be allocated among products on a basis which is, from an economic point of view, arbitrary. In some firms, e.g., oil refineries, the allocation is essentially on the basis of estimated relative elasticities of demand for the final product. Products with inelastic demands bear a high cost burden. Here it is the price that "determines" the cost, rather than vice versa. In most cases, however, costs are allocated on the basis of some technological factor such as machine hours, floor space or direct labor time. Whether an accounting allocation or a business judgment of cost is used in pricing decisions, it is not ordinarily the ascertainable incremental cost of a separate product which sets a limit below which the firm will not sell, but rather this plus some share of the common costs. In general, the statistical determination of the relation of output to cost is possible for a single product only in a single product plant. In other cases an investigation of the relation of costs to variations in an index of output may be useful, but not

<sup>1</sup> Such classifications have been presented by Fritz Machlup, "Monopoly and Competition: A Classification," *American Economic Review* (September 1937), pp. 445-51, and by R. L. Hall and C. J. Hitch, "Price Theory and Business Behavior," *Oxford Economic Papers*, No. 2 (May 1939), p. 15. Both of these classifications are based upon E. H. Chamberlin's *Theory of Monopolistic Competition* (Harvard University Press, 1933).

for the purpose of pricing the constituent products. Consequently a cost analysis which can serve for price determination must, in the typical case, take account of the various "noneconomic" conventional accounting procedures, rules of thumb, and habits of thought which relate to the allocation of common costs.

The conceptual schemes of price theory are weakest in their representation of the demand situations confronting the firm. The theoretical market classifications, which have as their principal purpose the demarcation of broad groups of demand situations, are useful but incomplete. Furthermore, the market structures which are relevant to industrial experience fall, in the main, into two classes: few sellers with, and few sellers without, product differentiation. (A small number of sellers implies that the sellers are mindful of the reaction of their rivals.) Competitive, monopoly and, probably, monopolistically-competitive markets lie outside the range of industrial experience. Typically there are a few close competitors of which an industrial firm always has to take account. Within the range of demand situations bearing upon this experience the attention of theorists has been concentrated principally upon two problems: (a) the types of reactions on the part of competitors which the firm must take into account in directing its own actions, and (b) whether and under what circumstances the demand function can be considered to be independent of the cost function, i.e., the problem of the relation of selling costs to demand. While the formulations of economic theory concerning both these problems—but particularly the former—are useful in empirical research, it seems probable that anticipated shifts in the demand curve, to which the firm must adjust its decisions, have more relevance for price policy than does its shape. Nor is research into the character of business anticipations regarding the variation of future demand situations by any means fruitless. Insofar as business anticipations are based largely on past experience, and this is undoubtedly the case, the kind of demand situation which will be expected by a firm in a durable

goods industry or in an industry undergoing secular expansion will be quite different from that expected by a firm producing nondurable goods or situated in a stable or declining industry. There seems to be no reason why a classification of demand situations that takes into account these and other considerations might not usefully supplement the unduly simple classification based on number of sellers and the presence or absence of product differences.

The distinction, traditional in price analysis, between short and long run adjustments is indispensable to empirical research. We are dealing here with a "planning period" definable as the length of time within which the anticipated results on the firm's revenues and costs that motivate a particular decision are exhausted. The distinction between short and long run does, of course, drastically simplify the problem. But, in the area of price decisions at least, it is generally valid to draw a rather sharp distinction between decisions made for a season or some other short period and those designed to hold for a much longer time. The length of the season will, of course, vary from industry to industry. In boots and shoes price decisions are ordinarily made by a large number of firms twice a year to apply to spring and fall sales. In the automobile and agricultural implement industries the "season" is a year. Long run price decisions are involved when a basically new product is introduced, a change is made in the channels of distribution, or a new price line is chosen for a range of products. Generally speaking, the shorter the time period the more stringent are the limitations on alternative lines of action. The role of cost considerations in pricing, furthermore, is apt to be very different for short than for long run decisions. Frequently the long run decision determines the price or the price range within which the product is to be sold; and the cost calculations, which are subsequent to the price decision, have to do with the kind of product that can be made to sell in the given price range. The practices in the dress industry illustrate this point. In any case the theoretical distinction between short and long run con-

forms closely enough to business practice to be useful in empirical research.

Finally, the conception of price current in theory is ordinarily so simplified as to eliminate a number of the issues the firm must face in determining what may be called its price policy. The price of the theoretical demand curve analysis is a "net realization" to the firm after deduction of freight charges and discounts. The focus of the price making forces, however, may be the delivered price in a number of consuming markets. Moreover, the "price" of a product, as discussed in Chapter III, may be a complex structure of related terms of sale, any variation of which will constitute a price decision and will cause a change in "net realization." In analyzing the price decisions of many large firms it is convenient to distinguish, with respect to all the firm's products, the price level from the structure of prices, and, with respect to an individual product, the price level of this product from its price structure. In a number of firms, e.g., in the iron and steel industry, a decision to increase the price of a few basic products may, through a system of fixed "extras" or price differentials, carry upward the price of thousands of related products. This would be a change in the level of prices. On the other hand, an alteration of differentials would be a change in the price structure. Similarly with respect to individual products the price decision may be directed to the price level or to the price structure embracing terms of sale.

Although the conceptual schemes of price theory have serious limitations for empirical research, they encompass a number of tools which are extremely useful for dealing with what is here the principal concern—cost behavior in the firm. The purpose of economic theory is not to supply factual answers but to pose the proper questions to the facts. With respect to a single-product firm the specific questions asked are: how do costs vary with the rate of plant utilization, with the size of plant, with technical changes and with changes in factor prices? The test of the "rightness" of a question is the relevance of the answer to

the phenomena to be explained, in this case prices or price changes. These questions *are* relevant, though for the price situations faced by the typical industrial firm they are not the only relevant ones. A "tool of economic analysis" is a correct statement of a relationship that bears upon the solution of a significant economic problem. Cost functions are "tools" in this sense. For useful empirical research, however, relationships must be more than relevant; they must also be amenable to quantitative, or at least factual, investigation. The extent to which cost functions, and other conceptual relationships which form the stock in trade of theoretical price analysis, can be subjected to empirical treatment has been discussed in previous chapters. With all the limitations there recognized, these conceptual devices still remain valuable tools for factual price analysis.

In bridging the gap between cost and demand functions and price determination, price theory conceives a shadowy figure called an entrepreneur who is busily and continuously engaged in "maximizing profits." The significance of this conception of the entrepreneur and of profit maximization for empirical price research deserves attention.

## 2. *Administrative Price Making*

It was pointed out in Chapter III that in large firms important decisions with respect to price are usually formulated by groups that frequently represent a compromise of varying points of view and conflicting interests within the firm. Furthermore, the price decisions which make up the pricing activity of the firm are apt to be distributed between various levels of the official hierarchy within a progressively narrower area of discretionary action as one descends the scale. A firm's salesman may have the power within limits to quote below the list price; these limits may be extended by his superior, while a change in the list price itself may require action by an executive group.

The conceptual schemes of price theory, moreover, tend to present price determinations as decisions made in the

light of a total situation. With every change in the shape or position of cost or demand curves there is supposedly a change in the price. For a firm selling a variety of products in many markets pricing activities require an administrative organization whose characteristics will of themselves affect the nature of the firm's price response to changing market situations. A decision to change the price of a leading article may not only persist over a season or some other considerable period of time, but may also affect the prices of many other articles related to it through a system of price differentials, with only such adjustments as come within the competence of administrative subordinates.

We are not here concerned with such profound questions as the nature or function of the entrepreneur, or of entrepreneurial activity. It may well be, as F. H. Knight and his followers insist, that "if the function is hireable it is not entrepreneurial in character."<sup>2</sup> The "entrepreneur" in the modern corporation may indeed consist simply of "those persons whose functional income is contingent and residual in the sense that no claim for income arises until all other functional claims are discharged,"<sup>3</sup> i.e., ordinarily the common stockholders. All we are concerned with is a recognition of the fact that price making in the typical industrial concern, whether or not it is an entrepreneurial function, represents a series of administrative decisions which are likely to be influenced by the way administrative functions are organized in the firm in question.

The term "administered price" is illuminating if it is not interpreted to mean a particular kind of price behavior and if it is not contrasted too sharply with market price.<sup>4</sup> "Price administration" is here used to denote the application, by officials of a concern, of a set of rules or policies relating to the pricing of the firm's products. The policies in question will be influenced to a greater or less degree by the

<sup>2</sup> Ben W. Lewis, "The Corporate Entrepreneur," *Quarterly Journal of Economics* (May 1937), p. 539.

<sup>3</sup> *Ibid.*, p. 537.

<sup>4</sup> See Temporary National Economic Committee, *Monograph No. 1*, "Price Behavior and Business Policy" (Washington, 1940), p. 15.



character of the market in which the firm operates, and by the kind of cost data available to executives. The meaning of price policy will be discussed presently.

Frequently it is necessary to examine with some care the administrative distribution of authority with regard to pricing—and this is the crucial point of the foregoing remarks. Typically in the large corporation the important price decisions are group decisions; they are made infrequently, while subordinates are charged with administering the customarily complex system of discounts, extras and other terms of sale which constitute the firm's price structure, with more or less discretion to make adjustments when necessary to secure or increase business.

The function of the entrepreneur in price theory is to choose among existing alternatives that line of action which will "maximize profits." Given the cost and demand functions, the price is supposed to follow as an automatic response. Nevertheless, in various recent formulations of pricing problems in monopolistically competitive markets the solution turns on whether the sellers are "aggressive" or "nonaggressive" competitors.<sup>5</sup> The particular degree of "aggressiveness" that is to be assumed in a given case obviously presents a problem for price analysis. And this problem, furthermore, is one which may frequently be clarified by an examination of the market environment in which the firm operates, a matter to be discussed in the next section.

A second difficulty is connected with the time period over which profits are to be maximized. The ambiguity occasioned by the possibility of choice among several time periods may be removed by substituting, for "profit maximization," the maximization of the current value of the proprietorship interest in the firm. Since this current value will be affected by any change in anticipated net revenue, the magnitude to be maximized will reflect both short and long run considerations insofar as they enter into business expectations. This view not only represents a more general

<sup>5</sup> See John Cassels, "Excess Capacity and Monopolistic Competition," *Quarterly Journal of Economics* (May 1937), p. 435.

and logically more acceptable formulation, but also for some purposes conforms to business habits of thought. However, the distinction between short and long run decisions must not be lost from view. In the field of empirical price analysis it is indispensable because it fits in with actual and observable differences in price decisions in a large number of business situations.

It is clear that empirical price analysis may, in certain circumstances, profitably include a detailed examination of the process of decision making in individual firms. A number of recent studies in this area have proved illuminating, and scattered through business literature are many contributions which repay investigation.<sup>6</sup> Certain firms, by reason of their size, their strategic position in important industries, or the standing of their management personnel, carry exceptional weight in the business community. It is fair to say that an important price decision by the United States Steel Corporation will influence policies not only in the steel industry but in a much broader sector of the whole economy. The more important the firm in this respect, the greater is the value of a detailed study of its activities. This does not mean, however, that the sole or the most important focus of price analysis should be the activity of the individual firm. While there is much to be said for the logical position that each firm should be viewed as a limited monopoly, that a market can be understood clearly only in terms of the situation confronted by a firm, and that the industry is a technical conception without much utility for economic analysis, this view imposes unnecessarily stringent limitations on empirical price research. One of the essential problems of such research is to assign approximate magnitudes to price determining variables, which frequently means to distinguish between a 5 percent and a 50

<sup>6</sup> In particular, see Homer Vanderblue, "Pricing Policies in the Automobile Industry," *Harvard Business Review* (Summer and Autumn numbers, 1939), and Temporary National Economic Committee, *Monograph No. 5*, Part II, "The International Harvester Company" (Washington, 1940).

percent "cause" of a given price change. For these purposes market and industrial data may well overshadow the influences peculiar to the position of any individual firm.

### 3. Price Policy

It has been indicated in preceding sections (a) that although the tools of analysis provided by price theory are useful in empirical research, particularly with regard to cost behavior, they are in some serious respects inadequate, and (b) that the response of price to changes in industrial market situations is ordinarily filtered through an administrative organization whose characteristics are frequently a proper subject of price research.

The inadequacies of our analytical tools for empirical price research are, perhaps, most conspicuous on the demand side. Although an appraisal of statistical efforts to calculate price elasticities for various products is not attempted here, it may be said that the results which command confidence have been limited for the most part to consumers' staple goods. One may, however, accept the facts that recent studies of producers' and consumers' durable goods have indicated low price elasticities<sup>7</sup> and that multiple correlation attempts to explain changes over time in volumes of sales, production or employment in a large number of important industries<sup>8</sup> have not ordinarily had to introduce price as an independent variable, as corroboration of the common business point of view that the short run demand for a large number of industrial products is probably inelastic. Shifts in demand curves appear to be much more important in explaining changes in volumes of sales of industrial products than price changes along a de-

<sup>7</sup> See C. F. Roos and V. von Szeliski, "Factors Governing Changes in Domestic Automobile Demand" in *The Dynamics of Automobile Demand* (General Motors Corp., New York, 1939), and United States Steel Corporation, *T.N.E.C. Papers*, I, pp. 165-222 (New York, 1940).

<sup>8</sup> See G. Means and L. Paradiso, *Patterns of Resource Use* (National Resources Committee, Washington, 1938).

mand curve. With respect to the demand situation which individual firms have to meet, there seems at present little possibility of a statistical calculation of demand elasticities except perhaps in markets exhibiting an unusually stable pattern of price relationships between the products sold by different firms in the market.

In view of the difficulties inherent in a statistical approximation of certain of the relationships which theorists consider relevant to price analysis, a resort to other, less rigorous, methods of empirical research appears to be desirable. Among these methods may be mentioned first, the attempt to discover through personal interviews with price making executives the premises with respect to cost or demand behavior on which executive action is based; and second, the effort to explain observed or defined "price policies" with reference to the structure of the market in which firms pursuing these policies operate.

As examples of the first method, the investigations into business behavior by various Oxford economists are perhaps to date the most successful.<sup>9</sup> As for the market conditions under which the firms covered by these investigations operated, it was found that the "typical" case was the one in which the firm recognized that it was in competition with a few rivals selling products somewhat differentiated from its own (monopolistic competition with an admixture of oligopoly). Less important were the cases of monopolistic competition in which the firm assumed that its demand curve was independent of the reactions of its rivals. In the "typical" case the authors conclude that the enterprises in question held the opinion that a price reduction, but not a price increase, would be met by rivals, and that the demand for the product or group of products of all sellers was inelastic. Consequently the demand curve "imagined" by these firms, and on which they based their price action, shows a sharp break in elasticity at the pre-

<sup>9</sup> In particular, R. L. Hall and C. J. Hitch, "Price Theory and Business Behavior," *Oxford Economic Papers*, No. 2.

vailing price.<sup>10</sup> An increase above the prevailing price would lead to a large loss in sales, whereas a decrease in price would not increase sales very much.

There is no doubt that this is a realistic picture of the demand situation as envisaged by individual firms in a great number of industrial markets a large part of the time. It goes a long way toward explaining some important aspects of industrial price behavior. There is rather strong reason for believing that leading firms in the automobile, steel, agricultural implement, and many other industries act upon approximately this view of the situation. As a working hypothesis, however, it is probably limited to industrial markets which have attained something like long run stability in the sense that the demand is mainly for replacement and the entry of new firms is unimportant. Within these limits the hypothesis is probably not applicable in periods of very high or very low rates of output, nor is it likely to be illuminating if secret price cutting or disguised price changes through alterations in terms of sale are effective competitive devices. Finally, if the foremost firms in a market gain or lose business at a very unequal rate in depression and recovery, the pricing practices of these firms are not likely to conform closely to what would be expected on the basis of the above hypothesis.<sup>11</sup>

In situations in which the products of different sellers are not close substitutes, firms may ordinarily be expected to gain or lose business at unequal rates. This is likely to be the case in markets which Messrs. Hall and Hitch describe

<sup>10</sup> See also Paul Sweezy, "Demand Under Conditions of Oligopoly," *Journal of Political Economy* (August 1939). This possibility had been indicated earlier in an article by R. F. Kahn, "The Problem of Duopoly," *Economic Journal* (March 1937), pp. 8-9.

<sup>11</sup> In a number of markets in which there are only a few sellers and the product is fairly well standardized, each seller tends to pay close attention to trade association statistics indicating his share of the total sales. If this share is being maintained even though total sales are decreasing or increasing, the disposition is to maintain prices. On the other hand, a decline in a seller's share in the market may quickly lead to a direct, or more frequently, to a disguised, price cut, which will be followed by rival firms only when their share shows a tendency to fall off.

as monopolistic. "Interviews suggest," they note, "that in the case of certain luxury and fashion goods cross elasticities are negligible and competitors' reactions are ignored even when the number of firms is small."

In any market that is not purely competitive the seller does not ordinarily know his demand schedule. Nevertheless when he prices his product he must act upon certain assumptions respecting demand elasticity; empirical research along the lines of the Oxford inquiry may be expected to throw light on the character of these assumptions.

A term that has recently come into use among writers on marketing and industrial organization is "price policy."<sup>12</sup> This term implies that the firm does not adjust its price automatically to every change in expected demand or cost conditions, but follows a line of action that is expected to persist over time in spite of considerable change in market conditions. Price policy consequently becomes a price determining factor and a legitimate subject of empirical research. The policies may be objectively described in certain instances, though usually not in the detail an exacting observer would desire. Frequently the firm acts upon rules of thumb, or semi-articulated conventions whose scope is hard to define and impossible to detect in statistical price behavior. The firms studied by Messrs. Hall and Hitch which followed the "full cost principle" were pursuing a price policy, though in periods of very low or high rates of activity they tended to depart from it.<sup>13</sup> Price stabilization, price discrimination, price decisions which rest upon what happens to a firm's share in the total market, may all be examples of price policy. If the scope of price decisions is defined to include terms of sale, the range of price policy is very broad indeed.

The effect of price policy upon price is the influence of a set of decisions made with reference to a larger environ-

<sup>12</sup> See E. G. Nourse, "The Meaning of Price Policy," *Quarterly Journal of Economics* (February 1941).

<sup>13</sup> Hall and Hitch, *op. cit.*, p. 18.

ment than that embraced by customary changes in demand conditions. This does not mean, however, that price policies cannot be explained in large part with reference to the broader market environment in which the firm operates. Price policies may be part of an adjustment process at work in the economy and capable of being expressed in terms of economic relationships, even though price is not a quantity which automatically adjusts to changes in conventionally depicted cost and demand functions. In a recent article E. G. Nourse has sought to envisage price policy as an autonomous "personal" force operating on prices in ways which lie outside the capacity of any "market analysis," no matter how broad, to explain.<sup>14</sup>

Over a large area of actual price-making deterministic factors do not operate directly or are not completely controlling. With the emergence and growth of price discretion linked with control of large blocks of production facilities, these forces operate indirectly, subject to the evaluation, adaptation, and manipulation of strategically placed executives. A "market situation" is not an entity which enters into the price-making process in ways entirely predictable by rigorous logic or statistical methods. To a significant extent the "situation" is what the executive—endowed with a certain measure of understanding, substantial limits of discretion, and a considerable amount of control of resources—makes of it.<sup>15</sup>

It is probably true, and if true, it is extremely important, that in certain areas the personal force of outstanding executives has produced results through certain of their price policies which would not have eventuated had these executives been other men. The profit motive expressed by an-

<sup>14</sup> E. G. Nourse, *op. cit.* Nourse explains, however, that "price policy cannot be usefully studied except as the accompaniment of meticulous analysis of market situations."

<sup>15</sup> *Ibid.*, pp. 186-87. Nourse continues, "the price-making process, besides being examined as to the deterministic elements of the situations in which the executive must function, requires examination also as to the personal, intellectual, and temperamental qualities which he injects into the production and pricing process to give it its ultimate and effective form."

other personality but operating in the given environment would not have led to the same policy. In this connection the name of Henry Ford leaps to mind, associated as it was in the early stages of automobile manufacture with a policy of price reduction designed to promote mass production and consumption by pushing the use of the product into continually lower income levels. A policy of this sort has been the rule rather than the exception in new and expanding industries—a contemporary example is the rayon industry—and would appear to be more closely connected with the age of the industry than with the unusual personality of a company executive. When the automobile industry had apparently exhausted the possibilities of rapid expansion through price reduction in the mid-1920's, there was a discernible shift from a situation which can be loosely described as price competition to an emphasis on product competition within fairly well defined price ranges.

The debate concerning the relative importance of the individual and the environment, an old one in the field of social studies, is apt to be fruitless. The principal question from the point of view of empirical price research is whether definable price policies that vary from market to market and are of admitted influence on the behavior of prices in these markets can be explained in terms of the structure of the market in which they occur. If similar policies with reference to price or other areas of business decision can be shown to be associated ordinarily with similar types of market structure, price policies may be said to be amenable to economic explanation and will not have to be relegated to the realm of what is, from the economic point of view, accident.<sup>18</sup>

<sup>18</sup> A listing of some of the elements which might be used for the construction of a classification of market structures is presented in a mimeographed pamphlet of the National Association of Manufacturers entitled "Prices and Price Determination in Manufacturing under the American Private Enterprise System." These elements are grouped under the general headings (1) Nature of the Product, (2) Nature of Supply Factors, (3) Nature of Demand, (4) Extent and Type of Government Control



Nourse, in the article mentioned above, would like to limit the meaning of price policy to the "constructive and innovating" contribution of the price-making executive.<sup>17</sup> This concept seems, however, neither practicable nor useful for price research. It would appear preferable to limit the meaning of price policy to the general principles and rules, if any, that are employed by a firm in making price decisions, regardless of whether or not these principles are rationally explicable with reference to a market environment in which the firm operates. These principles will be applied in the large firm by its administrative officials, and price administration should mean, in general, the observance by subordinates of whatever rules with respect to price are laid down by the executives who determine price policy.

#### 4. *Costs and Prices*

One of the important sets of data on which general principles relating to price making are based bears upon costs. What kinds of costs can and does the businessman know, and what account does he take of them in determining price? The firms investigated by Hall and Hitch, in default of knowledge of marginal revenue and marginal costs, appear in general to have followed what the authors call a "full cost principle."

In some cases this meant computing the full cost of a "given" commodity, and charging a price equal to cost. In others it meant working from some traditional or convenient price, which had been proved acceptable to consumers, and adjust-

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or Regulation. Professor Mason was engaged, with D. H. Wallace, in working on an empirical classification of industrial market structures before both he and Dr. Wallace were drawn into the work of war agencies.

<sup>17</sup> E. G. Nourse, *op. cit.*, p. 187, footnote 8. "Thus price policy is not co-extensive with price administration but is the personal as distinct from the impersonal aspect of that process. It cannot even be deduced from the study of the impersonal part, i.e., market situations."

ing the quality of the article until its full cost equalled the "given" price.<sup>18</sup>

Obviously "full cost" is not an unambiguous concept. Both the items included and the way they are calculated will vary between firms and industries. Furthermore, the application of a full cost principle is limited—as Hall and Hitch would presumably admit—to particular kinds of product markets. The relation of purchase to sale, and the cost calculation relevant to pricing, will vary markedly as between organized markets subjected to trading regulations, markets in which products are produced for sale to any buyer who will pay the price, markets in which bids for a specified article are asked by a given buyer from prospective sellers, markets in which supply contracts are negotiated with individual sellers on a fixed price basis, and markets in which supply contracts are negotiated on a cost-plus basis.<sup>19</sup>

Although various versions of the "full cost principle" are used by a large number of firms as a basis for pricing, at least in periods of good business; it would be a mistake to conclude that a calculation or estimate of something approximating the economist's marginal cost is of infrequent occurrence in business practice. In certain cases, discussed at length in previous chapters, it is possible to calculate the short run cost function for a particular product statistically.<sup>20</sup> There is no doubt, moreover, that refinements of

<sup>18</sup> *Op. cit.*, p. 18. Full cost as used here is defined as follows: "Prime (or 'direct') cost per unit is taken as the base, a percentage is made to cover overheads (or 'oncost,' or 'indirect' cost), and a further conventional addition (frequently 10 percent) is made for profit. Selling costs commonly and interest on capital rarely are included in overheads; when not so included they are allowed for in the addition for profits."

<sup>19</sup> Supply contracts negotiated on a cost-plus basis are much more frequent in private business than is ordinarily supposed.

<sup>20</sup> Although the examples with which economists are acquainted are those supplied by academic economists or statisticians, a familiarity with business practice would reveal a large number of attempts at a careful study of the relation of rate of output to cost. Certain cotton textile mills producing single standardized products, e.g., denims, ducks and wide sheeting, have undertaken such calculations.

cost accounting and cost analysis have as an important focus the relation of rates of output to costs. In many firms which make no attempt to calculate cost functions for particular products, these functions are calculated or estimated for particular operations or particular subproducts. The specific costs calculated by International Harvester and used as the basis of decision to produce or to purchase parts for various agricultural implements may be taken as an example.

The estimation of added cost of added output appears to be particularly common in production on a job or contract basis. A paper company in Massachusetts was asked by a buyer with an inferior credit rating to bid on a large lot of paper. The company calculated carefully what its net loss would be in case the customer failed to pay and submitted a bid calling for a cash payment covering the calculated net loss and the remainder of the price on the usual credit terms. Again, a job printer in Washington submitted a bid for a printing contract which included no labor cost; the existing labor force could carry the additional business without an increase in hours of employment. Many other examples of specific attempts to calculate what an economist would call marginal costs might be cited from business practice.

In many cases the business executive makes adjustments in the cost data supplied him by the accountant, adjustments which represent a judgment based on the executive's business experience of what, in view of the accounting figures, the extra cost of an addition to output is likely to be. In other cases although the firm may make no attempt to estimate marginal costs, it follows practices which tend to produce much the same result as would follow from a conscious attempt to estimate marginal costs and marginal revenue. A large book-paper firm, producing a number of classes of paper, bases its pricing upon something approximating the "full cost principle" described by Hall and Hitch. On this basis the different product classes show different "trading profits," and the firm is constantly attempt-

ing to rid itself of items showing low trading profits in favor of those which show higher profits. Obviously there are many influences on costs and revenue, as envisaged in economic analysis, that cannot be taken into account completely; but the process of selection and rejection here followed may well lead to a fair approximation of the maximum profit position aimed at in an estimation of marginal costs and revenue.

In a consideration of the relation of accounting costs to pricing one must, of course, recognize the fact that in a large part of the business world nothing deserving the name of cost accounts exists. Even in areas in which costs are kept the reported costs of identical items may vary amazingly between firms. During the period of the National Recovery Administration evidence presented concerning the paint industry showed that the range of cost variation for identical items was between 500 and 600 percent. In fields in which no cost accounts, or at best very sketchy ones, exist, the business executive may nevertheless estimate from his own intimate experience the added cost of an increase in output and apply such measures in his pricing and production decisions. More frequently, in all probability, he utilizes a rough rule of thumb, as a retailer does when he adds a uniform markup to all items in his store.

Recognizing that it is extraordinarily difficult and in many cases impossible in actual business practice to calculate cost functions for individual products, observers have attempted to explain the relation between costs and prices in various other ways. Some, while admitting the irrelevance of accounting costs to the economist's cost functions, have insisted that business executives and their production managers can and do estimate with fair accuracy the economic costs applicable to a rational pricing policy. Others tend to deny that costs have any important price-determining function except in the (very long run) sense that a failure of price to cover costs may eventually reduce supplies or that high profits may lead to the entry of new

firms. In a shorter period costs are, according to this view, more frequently a rationalization than a determinant of price.<sup>21</sup> Still others maintain that although the cost functions of economic analysis are not relevant to prices, accounting cost formulas and rules do serve as a basis for pricing. Abundant examples can be adduced to support each of these points of view, and there is little doubt that in the lifetime of a moderately large concern price decisions have been made in which costs have played each of these roles.

It is clear from a number of recent studies of large firms producing for sale (rather than to specification) that, for the firms studied, the economist's long run cost function more nearly approximates the costs that are taken into account in pricing than does the short run cost function. The standard cost calculations of General Motors and International Harvester are unit costs which, at standard volume of output (with respect to which the plant and equipment were presumably designed) and in the absence of changes in wage rates, material costs or factor efficiencies, may be expected to recapture the plant investment within its conservatively anticipated lifetime. This is one version of the full cost principle of Hall and Hitch, and it would seem to be in fairly wide use among business firms in this country as well as in England. The conventional accounting allocations of investment over time and of indirect costs among products must be arbitrary from an economic point of

<sup>21</sup> See Walton Hamilton, *Price and Price Policy* (McGraw-Hill, 1938), pp. 536-43, for a forceful statement of this attitude.

"The charges for a theatre ticket, a tube of toothpaste, or a checking account at the bank do not accord with the necessary expenses which attend them. The factory cost of a package of cigarettes is only a fraction of the price the buyer pays; and if the 6 cents in taxes is subtracted, the larger part of the residue still remains unexplained. A number of items can be made to account for the difference; but such expenses as high salaries, bonuses to management, and advertising are made possible by the spread. Their source lies in the ability of the concern to pay. Eventually they become established in the industry and are set down as costs. As a concern goes its way a continuing deficit forces reorganization or bankruptcy or somehow gets written off; and an assured surplus is appropriated and rationalized as an ordinary expense" (p. 538).

view, but the resulting unit costs are closer to the economist's long run, than to his short run, costs.

The use of standard costs in pricing is limited to certain types of markets, and within these markets the emergence of a new firm, the introduction of new techniques of production or marketing, or the financial weakness of certain of the existing firms may well disrupt established pricing techniques. Among a considerable number of industrial firms there appears, however, to be rather common use of standard cost, at least as a first approximation in price decisions. When prices conform to standard costs (with or without the addition of a trading profit) prices will tend to respond to changes in factor prices or efficiencies, but not to changes in volume of sales.

### 5. *The Field of Cost-Price Research*

In preceding chapters the discussion of particular aspects of cost behavior has been accompanied by an attempt at evaluation of further research possibilities. The empirical study of cost behavior and of cost-price relationships may be supposed to be of particular interest to the individual firm concerned with profit making, to the economist seeking an understanding of how the economy functions and to those whose province is the formulation and administration of public policies. To focus attention on these interests is not to deny that accountants, trade association officials and other groups have also a special interest of their own in cost-price studies.

For the individual firm, attempts to gauge the behavior of costs and revenue are implicit in every important business decision. In progressive American firms there is fairly frequent recourse to statistical studies and to careful engineering estimates of the relation to costs of location, size of plant, rate of output, change in wage rates and material prices, technical innovations, size of order, modifications of style and other variables, and of the relation to revenue of various types of advertising expenditures, discount struc-

tures, marketing methods and price changes. These studies constitute an important body of material which is relatively unknown to economists outside the firms in question and is, of course, frequently difficult of access. Needless to say, the publication of these data would contribute greatly to an understanding of current business practice and to the general functioning of the economy. The central problem in all these studies has provided the main thread connecting the various chapters in this volume: the problem of isolating the effect on cost (or revenue) of changes in one of many variables. Changes in cost accounting techniques and the application of the tools of economic analysis have made progress within the bounds of this problem area, and there is reason to believe that the empirical study of cost and revenue functions in the individual firm will continue to develop.

Somewhat paradoxically, the analytical tools of price theory are probably less useful to the economist or the government controller who seeks an explanation of price behavior than to the individual firm which strives to improve its profit position. For one thing, the data necessary to an empirical derivation of cost and demand functions are less accessible to the observer. Again, the problem is not merely one of an individual firm's adjustment to technical and market conditions; it concerns the interrelationships between firms in a market which is hard to define. Finally, account must be taken of the conventions, rules and administrative practices to be found in every concrete market situation. One of the principal tasks of empirical price research is to evaluate the magnitude of various "causes" of price change and to estimate from changes in these "causes" the probable effect on prices. The factual materials available usually include data relating to relatively broad classes of commodities, some data on the operations of important individual firms, and institutional and technical material of a more or less relevant character. Given such an assortment, he who undertakes empirical research must of necessity choose an eclectic approach.

**APPENDIX A**

**COST STUDIES UNDERTAKEN BY  
THE FEDERAL GOVERNMENT**



## Appendix A

### COST STUDIES UNDERTAKEN BY THE FEDERAL GOVERNMENT<sup>1</sup>

For many years various agencies of the federal government have engaged in the preparation of studies which now constitute a large warehouse of information on costs. Unfortunately only part of the material is available in published form; a tremendous amount of data has not been made public at all. The present summary is designed to show the general characteristics of such cost analysis, rather than to describe published material.

Although the earliest cost survey reported dates back to 1900, a large proportion of the studies were not undertaken until 1929. The approximate timing of the studies is shown by the following summary estimates of their number. The number of items was developed by counting each commodity or service and each year covered as a separate study. Thus, a study which covered hides and shoes in three separate years would be counted as six items.

<i>Years</i>	<i>Cost Studies</i>
1900-09	97
1910-16	644
1917-18	763
1919-28	1,472
1929-39	2,909

#### *Types of Surveys*

Cost surveys have been made by such a variety of agencies, for so many purposes, and following so many different methods, that proper use of their results requires an analysis of the

<sup>1</sup> This appendix is the outgrowth of a study undertaken by Mr. Mark Massel for the Bureau of Research and Statistics of the Office of Production Management. The basis of this report is an inventory of the cost studies of the federal agencies. The views expressed herein do not necessarily reflect the opinions of the Office of Production Management.

surveys themselves. For example, a study of weighted averages of total costs would not, in all probability, reflect the proportion of total costs represented by labor because a substantial amount of wages is included in overhead. The results of the same survey might require recasting to be useful in developing a cost formula for a government contract because it included collection expenses, which are not incurred in such contracts, in administrative costs. In like fashion, studies of national weighted average costs are unsatisfactory if costs reflecting regional or quality differences are desired, or if marginal, incremental, or bulk-line costs are needed. The following sections are illustrative of the limitations, methods, and scope of cost studies as revealed by the recent survey.

### *Purposes of Surveys*

Federal agencies have developed cost information to fill several needs: as parts of general economic inquiries into particular industries; as aids to procurement functions; as by-products of the agencies' own operation for administrative and budgetary analysis; and as elements in regulatory functions. Some agencies have conducted surveys for a number of such purposes. For example, the Federal Trade Commission has developed costs to support economic studies, and to reinforce its regulations of monopolistic influences and restraints of trade; the Tariff Commission has conducted studies of costs to supplement economic analysis, and to make cost comparisons for tariff adjustments.

General inquiries have served a variety of functions. Cost studies have been developed to supplement economic analyses of prices, industrial structures and production practices by such agencies as the Agricultural Adjustment Administration, the Alcohol Administration, and the Federal Trade Commission.

Some agencies, such as the Bureau of Foreign and Domestic Commerce, have related surveys to a program of educating business buyers and sellers on the general ranges of costs and on problems of cost finding. In this type of activity, as in the development of unit construction costs which the Tennessee Valley Authority publishes, statistical averages or norms are

set up to serve individual organizations as benchmarks for managerial measurements of efficiency.

The use of costs in government purchasing has been related largely, but not exclusively, to defense procurement. During the last war Federal Trade Commission cost surveys were utilized to help determine whether prices suggested for negotiated contracts were reasonable, and to set the final prices under some cost-plus contracts. Today cost information developed over a period of time serves the Maritime Commission in its formulation of shipbuilding contracts. One agency, the Tennessee Valley Authority, uses information on cement costs to adjust contract prices as a regular peacetime procurement practice.

The Forest Service makes cost studies as part of its selling policy. Determinations of fair selling prices for the standing timber in the National Forests are based largely on analyses of logging and milling costs.

A wealth of information, especially in the field of construction costs, has been developed as a by-product of the regular operations of several agencies. The Public Works Administration, the Rural Electrification Administration, the Bureau of Indian Affairs, and the Bureau of Reclamation analyze certain elements of operations on individual projects through cost data. A few agencies develop similar internal analyses for various services such as motor vehicle, building, central filing, and telephone switchboard operations.

The utilization of cost information in the development of regulatory functions has usually been focused on problems of price regulation for commodities and public utility services. Thus, the Tariff Commission has to compare the cost of production of domestic commodities with those of competitive foreign items as set down in a specific market. The Bituminous Coal Division must determine weighted average costs by districts and marketing areas so that these costs may serve as bases for setting minimum prices for bituminous coal. The Federal Trade Commission, in its "Robinson-Patman" investigations, examines differences among individual enterprises with regard to cost of manufacture, sale and delivery.

In the public utility field, costs have been studied as an aid in checking valuations of fixed property and prices paid for

equipment, and in analyzing the costs of the services themselves. For example, the Interstate Commerce Commission maintains a continuing program for the study of trends in construction costs to support its general valuation studies, while the Federal Power Commission has pursued construction cost studies in the power field. The Federal Communications Commission developed an intensive study of the manufacturing costs of communications equipment as a check on transactions between affiliated communications and equipment companies. In the service field, the Interstate Commerce Commission has investigated costs under various alternative methods of transportation for rate making purposes, and the Maritime Commission has conducted a continuing program of analysis of costs of ship operations under its contracts.

Cost information has been utilized in some fields of regulation where cost-price relationships are used only as evidence of underlying conditions. Thus in several antitrust cases the Department of Justice applied cost and financial data in developing evidence of monopolistic conditions. The unjust enrichment taxes necessitated cost and financial analyses in the Bureau of Internal Revenue. It might be noted, parenthetically, that in most problems of regulation and revenue the conventional focus is on the costs of the individual enterprise; while in some, such as the determinations of tariffs and minimum bituminous coal prices, statistical summations of industries are utilized.

### *Forms of Data*

The forms in which cost data are cast are too varied for a complete listing. In many instances, the agency is able to change the classifications of the final or published data by retabulating the original returns or by recapitulating sub-totals; in others, the present forms cannot be changed. There is no necessary consistency in the forms of the data for the surveys of the individual agencies.

Probably the most frequent method of averaging costs is the development of a weighted average of total costs for an entire industry. In some cases, ranges in costs are available; in many, frequency distributions may be worked out; in a few, estimates of "normal" costs can be made.

Most cost breakdowns follow functional lines: manufactur-

ing, selling and administration. Within these functions, the types of expenses may be broken down into labor, materials and overhead. It is unusual, however, to find such breakdowns under administrative and selling expense. Some surveys produce much finer detail by showing costs of the various labor operations or by dividing overhead into superintendence, power, depreciation, small tools, supplies, etc. These breakdowns are usually given in dollar figures, but some tabulations show them only as percentages of total cost or of sales.

The functional breakdowns of manufacturing, selling and administrative costs have been disregarded in those surveys which have confined classification to types of expenses such as labor, materials and overhead. However, such groupings may differ from one survey to another. Thus, indirect labor may be included either in overhead or in total labor costs. A few surveys are confined to one or two elements of cost, for example, labor costs or taxes.

Transportation is included in surveys of total delivered costs, but is accounted for only partially in those which derive f.o.b. factory costs. Further, studies of delivered costs may be restricted to one producing region, may concentrate on one marketing region, may include transportation costs in national averages, or may reflect them in regional averages.

The problem of estimating costs by stages of manufacture or for separate processes assumes significant proportions on many occasions. Some studies carry cumulative costs through specific stages, paying little or no attention to changes in ownership, and simply adding up the costs of the separate processes; others utilize the prices charged by the raw materials producer rather than his costs. Thus the costs of canned vegetables may be derived by adding to canning costs either the farmers' costs of growing the vegetables or the prices the canners pay for the vegetables.

Relating costs to specific products and sizes is another technique which has been developed in varying degree. Cost figures have been derived for differences in the qualities of certain commodities, such as the various grades of gasoline. Some surveys have covered specific articles with detailed specifications; others have covered average costs for the whole range of qualities of a specific item; a few have been set up to develop averages for large industrial groups such as nonferrous mining.

In most surveys of packaged products, average costs covering all sizes are usually presented. However, in some cases, cost differentials have been developed for different sizes of containers, for example, No. 2 and No. 10 cans of vegetables.

### *Types of Authorization*

Another element influencing the cost data is the type of authorization under which the survey is made. The instrument of authorization may consist of legislation, court decisions, Congressional resolutions asking for inquiries, directives from the President, requests from other agencies, or a combination of these demands. Unfortunately the effect of the authorization is not always clear. Moreover it is not practicable to classify them because of the variety of components: even the authority given the individual agency may undergo changes through time; and some agencies prosecute surveys under several authorizations during a single period.

Many authorizations contain only general reference to costs; some include no mention of cost; others list specific inclusions or exclusions. In a few acts, Congress has stated which types of cost shall be considered and how they shall be valued. For example, the Bituminous Coal Act provides for weighted average costs, including the depletion and depreciation charges used for purposes of determining income taxes. However, most agencies are free to decide how costs shall be estimated and how surveys shall be conducted, subject only to the review of the courts. Thus the Federal Trade Commission, except for its work on Robinson-Patman cases, determines the types of cost to be included and the bases for valuation. The Department of Justice, in utilizing costs in connection with antitrust cases, follows general rules of evidence in presenting such information, with no limitations on its treatment of costs other than the reactions of courts and juries.

General authority to conduct surveys is the basis for certain cost projects of several agencies such as the Federal Trade Commission, the Agricultural Adjustment Administration and the Commodity Exchange Administration. The cost technique employed in such projects depends on the purpose at hand. For example, a study dealing with labor costs might segregate all labor costs from other elements, lumping direct and indirect

labor together; while a Bureau of Foreign and Domestic Commerce survey of distribution costs would focus on the purchasing, storing, selling and delivering functions of the distributor, including labor as an element in each function.

The franchise for undertaking the cost projects of some agencies is implicit in the general authority to carry on non-regulatory functions. Thus cost information has been developed as a phase of administrative control over construction projects by the Public Works Administration, the Tennessee Valley Authority, the Bureau of Reclamation, the Rural Electrification Administration and the Soil Conservation Service.

Another aspect of authorization, with special bearing on the ability to secure information, is the power of an agency to compel disclosure of internal information or its ability to develop voluntary cooperation. Although private companies have supplied cost data freely in the case of most surveys, the authority of an agency to utilize the power of subpoena may on occasion have been very helpful.

#### *Methods of Conducting Surveys*

The composition of cost data is strongly affected by the methods followed in the underlying surveys. Control over the process of defining and estimating costs can be greatest when cost data are developed through an agency's own books, as in the cases of the Bureau of Indian Affairs, the Bureau of Reclamation, the Tennessee Valley Authority and the Public Works Administration. Similarly, control may be exercised to a considerable degree through field audits of the books of individual enterprises, as in certain surveys of the Agricultural Marketing Service, the Bureau of Agricultural Economics, the Tariff Commission and the Federal Trade Commission.

There is somewhat less opportunity to control cost methods when a study is based on mail questionnaires, and for this reason attempts have been made to provide safeguards. Mail surveys have been implemented at times with uniform directions for execution of the questionnaire. Some agencies, such as the Federal Trade Commission, have utilized spot audits to check the reliability of investigated items which differed widely from general averages; others have simply tabulated the mail returns.

During the first World War, the Federal Trade Commission occasionally employed private accounting firms to determine company costs through field audits. No other instance of such a procedure has come to light, since there has been no subsequent staff shortage comparable with that period.

Because of legal requirements, such agencies as the Tariff Commission and the Bituminous Coal Division hold formal hearings to permit interested parties to comment on previously released tentative findings of fact or to furnish new cost information. Such hearings may provide new data or additional checks on the material developed by the agency.

### *Representativeness of Sample*

In gauging how reasonable it would be to apply the results of a survey, the representativeness of the sample covered may bear great weight. There are wide variations in sampling practice. In the case of some surveys, notably those of the Bituminous Coal Division, substantially the entire industry is covered. At the other extreme are studies devoted to one company, sometimes during one brief period, sometimes over a series of years. In the prosecution of cases, the Department of Justice and Federal Trade Commission usually devote their analyses to one company. The Tariff Commission, in studying cost trends for its own analyses, may confine its data to one or a few representative companies, although it does not follow this procedure in its formal investigations. The Bureau of Mines has published many engineering cost studies of individual operations for comparative purposes.

Representativeness may be defined in terms of industrial coverage, geographical scope, types of operations, or types of qualities. The Tariff Commission's determination of representative costs is based upon the need to compare costs of competing foreign and domestic products. Thus a domestic product which has not been in competition with a foreign product for reasons of physical characteristics, region of origin or point of sale, would not be included in a representative sample. The problem of sampling is complicated further by the fact that one survey may cover companies which are representative of a particular producing region but not of the entire country; another survey may have covered companies which



are fairly satisfactory samples of the entire country although the companies included in any one region may not be representative of that area.

### *Definition of Cost*

There is wide variety in attitude and practice regarding what ought to be included in cost and how the various elements should be estimated. Some surveys have been affected largely by the individual businessman's opinions as to the proper components of cost. Under such conditions audits become mere checks on accuracy. Other surveys have been based on rules setting forth acceptable elements and methods of valuation. The manual *Uniform Contracts and Cost Accounting Definitions* was developed by an interdepartmental conference of the Federal Trade Commission, the Departments of War, Navy, and Commerce, and the Council of National Defense, for use during the last war. It should be noted, however, that the development of cost regulations has not been as extensive as the regulation of financial reports.

On occasion, rulings providing fairly close control over cost definitions may have been worked out for field studies that remain unpublished. Since many such instructions are formulated verbally or through the unwritten rules of practice of an agency, it is often quite difficult for the outside student to evaluate a survey properly.

The methods of investigation followed must be considered carefully if one intends to compare cost data pertaining to different periods and prepared by different agencies. For example, a number of cost surveys made in the bituminous coal industry have utilized such varying methods of information collection, classification, and valuation that comparative cost analyses of the data are subject to many qualifications. Cost surveys were made by the Federal Trade Commission for 1916-18 (a survey in 1920 was stopped by an injunction); by the United States Coal Commission for 1921-22; by the National Recovery Administration under the Bituminous Coal Code for November 1933 to January 1935 (with a special labor cost study in May 1933); and a continuing survey has been conducted by the National Bituminous Coal Commission and by the Bituminous Coal Division of the Department of the

Interior from 1936 to the present time. It should be noted, parenthetically, that some of this material was not tabulated and that all the tables were not published.

Examination of the pertinent forms, and of the data released through these studies, brings to light significant variation in the ways in which costs were classified and combined. It is not clear, for example, that each agency obtained total costs for mine labor. The same type of labor was classed as "Mine Supervisory" in some surveys and as "Administrative Expense" in others. In some, mine office expense was included in fixed charges and general expense, and in others it was shown separately. Some surveys included selling with total costs while others eliminated such costs; one included as a selling cost discounts allowed to wholesalers, i.e., the difference between the prices to retailers and to wholesalers.

In one survey, operator's statements were accepted at face value; in two others, they were corrected for items which seemed out of line with the general averages; in another, there were revisions based upon the judgment of the agency's staff. Differences in treatment are most apparent in the charges for depreciation and depletion; the Federal Trade Commission corrected such items on the basis of its own analysis; the U. S. Coal Commission accepted the operator's charges if they were based on the Bureau of Internal Revenue's valuations; while the National Recovery Administration, the National Bituminous Coal Commission and the Bituminous Coal Division of the Department of the Interior accepted the depreciation and depletion allowances permitted for income tax purposes, the latter two under Congressional mandate.

### *Conclusion*

The body of cost information in the various agencies has considerable potential usefulness. It can be employed to make direct estimates for price analyses of certain products; it can be made an integral part of economic analyses; it can help to determine which are the danger points in setting up cost or escalator provisions for negotiated contracts; it shows promise of use in labor mediation, as a source of information on what wages an industry can afford to pay and what would be the effects of changes in labor conditions on costs; it offers aid in

formulating, designing, and administering new cost surveys; it provides benchmarks of costs for use in promoting effective management.

The application of this information, however, is neither fool-proof nor simple. To obtain the full benefits of any survey one must make a comparative analysis of its background and determine the needs to be met. Some results may be used directly, some may be useful with modification, others may be valueless. Although much of the useful source material is not generally available at the present time, a considerable body of valuable information can be found in the published material. Utilization of the confidential data is, of course, confined to the federal agencies.

**APPENDIX B**

**COST ACCOUNTING AND PRICE  
DETERMINATION IN THE  
SOVIET UNION**

## Appendix B<sup>1</sup>

### COST ACCOUNTING AND PRICE DETERMINATION IN THE SOVIET UNION<sup>2</sup>

LENIN'S famous slogan, "accounting and control are the chief things necessary for the smooth and correct functioning of the first phase of the communist society,"<sup>3</sup> has wide currency among Soviet economists, and the better part of their thinking is devoted to problems of cost accounting and price policy. Without formulating them in terms of modern theory (or connecting their practices with the theoretical work done elsewhere), they conceive of these questions in a manner determined by the peculiar concept of economics which their literature has made familiar.<sup>4</sup> Unfortunately, a reliable judgment as to the efficiency of the Russian accounting system is rendered almost impossible by the frequent occurrence of "bottlenecks" which may be attributable as much to disproportions between

<sup>1</sup> This appendix is a segment of a larger study of the problems of economic planning in Soviet Russia by Paul A. Baran. In the large study, Mr. Baran attempts to show that deliberate socialist planning begins in Russia with the first Five Year Plan. The earlier period of War Communism was characterized by a system of emergency war regulations complicated by the political necessities of revolutionary action.

<sup>2</sup> The author would like to express his great indebtedness to Professor Edward S. Mason for his encouragement and suggestions in connection with this study. Dr. Abram Bergson and Dr. P. M. Sweezy made valuable criticisms which are gratefully acknowledged.

<sup>3</sup> *State and Revolution* (Vanguard Press, 1927), p. 204.

<sup>4</sup> "We do not have here a free play of prices as is usual in capitalist countries. We fix the prices of bread first of all. We fix the price of the industrial products. We are promoting a policy of lowering the costs of production of industrial output, endeavoring at the same time to keep stable the price of agricultural commodities. Is it not clear that such a particular and specific order does not exist on the market of the capitalist countries?" Joseph Stalin, *Voprosy Leninizma* (Problems of Leninism, 11th ed., Moscow, 1939), p. 235. (This and other passages from Russian books and periodicals are translated by the author.)

ambitious governmental aims and real possibilities as to erroneous calculations and false economic decisions. It is obvious, for instance, that the famine in the year 1932-33 had nothing to do with good or bad price fixing, or with correct or artificial accounting. It was caused by a political action of the government, which underestimated the peasants' power of resistance (slaughtering of cattle, etc.) and disregarded the short run economic consequences of its precipitous political action. On the other hand, clear cases of calamities which occurred only because of errors in establishing price relationships are just as customary.<sup>5</sup> Certain features of Soviet price and cost calculations can, however, be distinguished; they are then seen to represent a peculiar mixture of different methods, resulting in part from the tremendous strain under which the whole system works, in part also from rather dogmatic theoretical techniques.

## 2

Generally speaking, the Russian planning system is based on a set of fundamental decisions, according to which the production and allocation of goods and services are directed without regard to their monetary valuation.<sup>6</sup> The social product of a year, consisting of a certain quantity of various commodi-

<sup>5</sup> At the XVIIIth Congress of the Communist Party of the Soviet Union, V. M. Molotov reported: "In the year 1935 the Government had only to follow the suggestion of Comrade Stalin and to establish bonuses for delivery of cotton and tremendous successes were achieved in a very short time." (*The Third Five Year Plan, Report to the XVIIIth Congress of the Communist Party of the Soviet Union*, p. 26). Again, Trade Commissar A. Mikoyan remarked: "We had a muddle in the prices of textiles. The result was that the industry made surplus profits on some lines of output and incurred heavy losses on others. Our business managers were anxious to produce more than the planned quantity of the profitable goods and not to produce at all the commodities whose production caused them a loss. These 'loss lines' are, however, just as important for us as the 'profit lines.' Now all that has been corrected!" *Ibid.*, p. 24.

<sup>6</sup> "Accounting in money terms carried through the medium of prices does not suffice in a socialist economy. Accounting in terms of quantities and qualities of products of labor (per piece, per weight unit, etc.) and in terms of labor hours is just as necessary. Without this latter type of accounting it is impossible to safeguard the right proportions in the development of the material production of the socialist society. If the accounting in kind in capitalist countries has only a statistical

ties, is distributed by the authority among competing uses. After the desired capital investment has been determined and the expected quantity of consumer goods estimated, the prospective amount of money income to be paid out is computed. By deducting therefrom the envisaged proceeds of direct taxation and governmental borrowing, a figure is obtained which indicates the magnitude of the purchasing power remaining at the disposal of the population. For this purchasing power to be absorbed, the prices of goods and services offered to the consumer have to be fixed in such a way as to render their aggregate money value exactly equal to the amount distributed as income by the different governmental agencies. Since the general standard of living is extremely low, the resources allotted to the output of consumer goods are severely limited, and the list of these goods is accordingly short; thus the "freedom of choice" left to the population is almost illusory. While formally enjoying the right to select and to substitute, the population in fact has the alternatives of acquiring whatever goods are available or foregoing the satisfaction of its most fundamental needs. If these collections of goods were produced in planned quantities and qualities, the consumer—though obtaining less "ophelimity" (but perhaps more "utility") as compared with the state of affairs in which he could choose fully among various ways of spending his income—would still be able to transform his money income into *some* goods and services. Such an "ideal" situation has never been approached in fact. Even in the best periods since 1928-29 (the beginning of the first Five Year Plan) there has never been a time when ordinary consumers could spend their entire income on the limited list of commodities offered by the government stores.<sup>7</sup> Formal prob-

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importance and some interest from the viewpoint of business cycle research, in the socialist society it is of paramount practical significance. . . . The money income of the population being fixed, the prices fixed by the government determine the partition of the social product into a fund of consumption and a fund of accumulation." S. Atlas in *Problemy Ekonomiki*, No. 4, 1939.

<sup>7</sup> Hence the frequent appearance of large amounts of "floating" purchasing power which in the legal channels meet no regular supply and thus drive the prices on the "underground markets" up to fantastic levels. (See the dispatches of Mr. G. E. R. Gedye in the *New York Times*, September 11-22, 1940.) A simple "quantity equation" explains these inflationary phenomena.

lems are not separable from the material contents of planning. Where guns or machines are more important than butter, there is little butter. Freedom of choice, maintained by the distribution of "general purchasing power" which can be used according to individual tastes, has meant privation at a time when bare necessities have been unobtainable. To limit this "freedom" by offering only a certain number of commodities, but in sufficient quantities and qualities, may provide a more or less complete satisfaction of wants. Inasmuch as the part of the social product devoted to "Sphere A" (as the Russians call the investment goods industries, armament industries, etc.) was extended to the limit, while the quantities assigned to consumption (Sphere B) were confined to existence minima, difficulties would have arisen even if the planning mechanism had worked with the highest precision. Disasters like bad harvests and failures by some economic units to live up to their estimates would create gaps on the supply side that would upset all "proportions" even if these proportions had been calculated as carefully as possible. These gaps—which in a community working not for guns but for butter, or endowed with rich reserves from previous years, could easily be filled with the help of emergency stores accumulated for such purposes<sup>8</sup>—necessarily lead in Russia to shortages and "bottlenecks" which disrupt the planned exchange of income and commodities.

A correct solution of the pricing problem could create a system of relative prices which would direct the resources assigned to the satisfaction of consumer needs into their most effective employment. The quantity of these resources, however, and the extent to which the shortage of all consumer goods is permitted to prevail, depend on the preference scale of the authority, on the country's natural resources, and on the productivity of its labor. As long as the first condition persists as it has, and the last two factors are underdeveloped, the only function left to an adequate price and cost accounting

<sup>8</sup> This explains in part the comparative ease with which the German planners achieved their goal of rearmament. The Hitler government began work on the basis of large unused capacities, of idle reserves of qualified workers, and was able to take over an established economic system. The cooperation of all the economically dominant strata of the German population, aid from abroad, and the continuity of business management are other factors which also facilitated the huge investment of resources in armament industries.



system is to maximize the results of the economic activity *on the basis* of the fundamental decisions and conditions as given. It is difficult, therefore, to agree with A. P. Lerner<sup>9</sup> when he insists that the planning authority should confine itself to the enforcement of the basic principle that "price must be made equal to marginal cost." Such a policy would be appropriate only if the planning authority believed that its function should "wither away," and intended to leave the allocation of the nation's resources to the choice of the consumers. Desirable as it may appear, there is no reason to regard such a policy as a *sine qua non*. While it is true that consumer goods, once their aggregate quantity has been established, should be priced according to this principle in order to maximize the satisfaction derived from them, the decision about this aggregate quantity itself (or in other words, about the rate of accumulation which is desired) would have to remain at the discretion of the planning authority. The time preference of the community as a whole may be different from the time preference of its individual members; the government may refuse to rely upon voluntary savings attracted by a high interest rate (as proposed by Enrico Barone); or it may wish to make extra profits on some commodities (with a view to curtailing their consumption) and to incur losses on others (with the intention of sponsoring their consumption). Such decisions are to be expected if planning involves a certain definite economic policy, be it rearmament, industrialization, or some other change in the economic structure of the country. To deprive the planning authority of the right to pursue such a policy, to limit its function merely to the execution of consumers' ballots, would reduce to absurdity the whole idea of a centralized direction of economic affairs. Moreover, this centralized direction may possibly (but not necessarily) represent the more "rational" set of preferences, measured in terms of maximum welfare, as compared with the outcome of consumers' choices which could be (and are) governed by very doubtful "tastes."<sup>10</sup>

<sup>9</sup> *Economic Journal*, 1937, p. 270.

<sup>10</sup> See R. F. Kahn, "Some Notes on Ideal Output," *Economic Journal*, Vol. 45 (March 1935), pp. 1-35. Of course, it is an entirely different problem to determine what represents the optimum method of reaching the aims of state economic policy. It is quite possible that selling at marginal costs combined with strong propaganda campaigns designed to influence existing demand and to create new demand, with administra-

But even though *selling prices*, which represent governmental decision as to distribution of wealth and employment of resources, need not necessarily be identical or even proportionate to costs, the *proper calculation of these costs* is imperative. Only by carrying through this calculation can the planning authority obtain indispensable information as to how much every economic decision means in terms of alternative choices. Thus the Russians appear to be on the right track, in principle, in treating their prices as a sum of different elements. "The final retail price is composed of (1) the costs of production, (2) general oncosts of administration, wholesale distribution, etc., (3) profit of the enterprise, (4) turnover tax (sales tax), (5) retail expenses which again may be split into oncosts of doing business and profits."<sup>11</sup> All these items may be classified for our purposes into two main categories: costs within the broad meaning of the term, on the one hand, and contributions toward accumulation of capital, on the other. "The prices fixed by the Government and the extent of their deviation from costs thus depend on concrete considerations of economic policy in every given period,"<sup>12</sup> and the magnitude of the second component of price cannot possibly be treated except in connection with specific problems. The turnover tax, which is not uniform for all goods, is varied according to numerous considerations;<sup>13</sup> the profit rates for different industries also

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tive measures forbidding and permitting certain types of consumption, or with a system of taxation that redistributed the national income, would lead to the most desirable results. This question cannot, however, be dealt with theoretically; its answer depends on concrete conditions in different countries. Whereas the German authorities even under the Weimar Republic taxed wages at the source of income and made the employer responsible for the remittances (because the government was not certain of obtaining payment from the wage earner himself), the British tax morale permitted full wage disbursement without endangering fiscal receipts. In a country like Russia, all indirect devices like taxation, advertising, etc., would certainly prove less efficient from the viewpoint of the government than a direct policy of price fixing.

<sup>11</sup> S. Atlas, *op. cit.*, p. 84.

<sup>12</sup> I. G. Gorelik, *Metodika Planirovaniia Tshornoii Metalurgii* (Methods of Planning in the Metal Industry, Moscow, 1937), p. 94.

<sup>13</sup> The aggregate amount "syphoned out" by means of direct taxation and borrowing is very small compared with the total revenue derived from the turnover tax. The expedient of indirect taxation rather than of outright price increases or of higher income taxes is relied upon to

are fixed with regard to the desirability of their expansion; finally retail earnings vary with the character of the store and with the type of commodity. An investigation of such price fixing practices—very similar, by the way, to the policy in this field adopted in Germany—would require a broad examination of the development of different branches of the Russian economy and could be successfully undertaken only as part of a general appraisal of the way in which this development is regulated.

We are not, however, primarily interested in this aspect of the problem, for government influence upon the *final* price is obvious, and the fact that this price is set by *fiat* is frankly admitted. Of much greater concern is the far more complicated chain of problems connected with the notion of costs.

## 3

The devices employed in the calculation of costs—though widely discussed in the literature<sup>14</sup>—correspond neither to the behavior envisaged in the “pure theory of socialist economics” nor to the “rational attitude” assumed in “bourgeois” economics. They resemble rather the practical policy of businessmen as recently described.<sup>15</sup> This is particularly strange since the reasons which induce the private entrepreneur to deviate from the rationale elaborated by theory, and to attempt to maximize his profits and safeguard his investment according to institutional data and concrete market conditions, do not apply at all in a planned economy where the state as monopolist is in possession of the powerful tool of price fixing and not only could but should (for the sake of its own calculation) employ the most modern techniques of economic analysis. But as “bourgeois” economics is mercilessly condemned, even its formal achievements are widely ignored.

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eliminate excess purchasing power mainly for political and psychological reasons. Moreover, the flexibility of this tax, which varies from commodity to commodity, renders it a powerful tool for adjustment of prices to unexpected changes in conditions.

<sup>14</sup> Unfortunately accessible only to a limited extent in this country, and apparently difficult to discover even in Russia. The most important work in this field is embodied in governmental instructions and circulars which are very seldom published.

<sup>15</sup> See, for example, Hall and Hitch in *Oxford Economic Papers*, No. 2.

On the other hand certain difficulties which worry the economist outside the Soviet Union are easily disposed of in that country. The question of whether to calculate raw materials, for example, according to their original value (first in, first out) or their replacement value (last in, first out) is no problem at all. All raw materials are acquired at a *fixed* price and their valuation remains unchanged over an accounting period.<sup>16</sup> Original price and replacement price are equal (at least during this accounting period, which is long enough for all practical purposes) no matter what the changes in scarcity conditions may be.<sup>17</sup> The same applies to all labor and to all "purchases from other entrepreneurs," which are contracted for on the basis of fixed prices and therefore cause no cost accounting difficulties.

The problems arise exactly as they do in private enterprise. The proper allowance for depreciation and the task of determining joint costs are dealt with according to a rule of thumb, unsatisfactory though it may be.

The ruling formula, applied by practically all enterprises and enforced by the Soviet authorities, may be briefly expressed as follows:

$$\text{Amortization Rate} = \frac{(\text{OV} - \text{AV} + \text{RE}) \cdot 100}{\text{LT} \cdot \text{OV}}$$

where OV = original value, AV = actual value, RE = repair

<sup>16</sup> "Fixed prices of raw materials, semi-finished goods, fuel and power are established for the enterprise at the beginning of an accounting period and remain regularly unchanged during the year." D. S. Levin and M. G. Polyakov, *Kalkulirovanie sebestoimosti produktsii miasnoi promyshlennosti* (Cost Calculation in the Meat Packing Industry, Moscow-Leningrad, 1926), p. 37.

<sup>17</sup> In this connection an argument of Professor von Hayek in *Economica* (May 1940), is important. The adjustment of prices over a period of time is certainly less effective than an instantaneous adjustment. Professor von Hayek believes that only the market provides such an immediate reaction of price to changes in conditions. This would be true, however, only if the market were perfect. The same reasons which make it impossible for the planning authority to change prices "every fortnight" seem to inhibit large corporations from altering their price lists more frequently than is absolutely necessary. Besides, the technical difficulties which would arise in case of such frequent changes, the annoyance to the buyers, who would have to change their calculations unceasingly, seem to make a certain "rigidity" of prices unavoidable even in the market economy.

expenses,  $LT$  = lifetime of the equipment. This formula, however, involves the difficulty of ascertaining the actual value of the plant. It was solved in the first years of Russian planning by periodical (mostly annual) expert appraisal which established the actual value as well as the loss in the original value incurred by operation. It was soon discovered that this procedure, correct as it might appear, involved extremely arbitrary valuations, estimates and judgments, which not only yielded unreliable figures, but resulted in considerable red tape, interrupted normal work for the period of revaluation, etc.<sup>18</sup> On the other hand, it was the only possible way of calculating, as the plants had not been built or bought by their current proprietor (the state), but had originated before nationalization. Thus their value could not be established except by a new appraisal which would take account of far-reaching changes in general conditions.

As soon as new plants built by the planning authority went into operation, original cost data were readily available. The appraisal device, repugnant for many reasons, was given up, and the same formula was applied on a somewhat different basis.  $OV - AV$  came to be regarded as a fixed magnitude elaborated by the planning authority.<sup>19</sup> According to technological data (life of the equipment, its productive ability on the basis of a certain number of work hours) the central board fixes depreciation quotas which have to be added to the direct or prime costs, regardless of the real lifetime or the actual productivity of the plant in question. This approach, however, makes the quotas altogether arbitrary. The life of the equipment may be shorter or longer than assumed (depending heavily, among other things, on the care with which the workers handle it), its technical productivity smaller or greater,

<sup>18</sup> "There are three approaches to the valuation of fixed equipment: (1) original value, (2) replacement value, (3) original value less wear and tear. As yearly reappraisal of the fixed equipment is very difficult, and involves great expense in money, time and labor, the plants are appraised according to their original value, i.e., the value they had when they began to function." A. Arakelyan in *Problemy Ekonomiki*, 1938, No. 5.

<sup>19</sup> "In calculating the depreciation of the original value, a norm is used which is fixed by the government." See for details, D. S. Levin and M. G. Polyakov, *op. cit.*, pp. 24 *et seq.*

but the regulating authorities pay no attention to these fundamental questions in fixing their rules.<sup>20</sup> The enterprises may make additional profits if the equipment lasts longer than its assumed lifetime, or incur unexpected losses if the cumulated quotas fail to provide them with the value of the outworn plant.<sup>21</sup> It is evident that the remedy of adopting "technological" amortization quotas according to experience in capitalist countries is a questionable one. A machine which lasts ten years in this country may not be able to stand Russian treatment for longer than five years.<sup>22</sup> Great as this difficulty may be, the method itself would not be open to as much criticism

<sup>20</sup> "The obligatory inclusion of depreciation quotas in the calculation of costs of output leads to an accumulation of an amortization fund independently of the financial result of the activity of the given corporation." V. G. Dolgov, *Analiz Godovogo otcheta i balansa khoziaistvennykh organisatsii* (Analysis of Annual Reports and Balance Sheets of Business Enterprises, Moscow, 1937), p. 23.

<sup>21</sup> "Since the question of correctness of the amortization quotas is of great importance, as these quotas strongly influence the cost figures they have to be revised regularly. It is necessary to examine whether they really correspond to the effective wear and tear and, in cases of large deviations, the reasons for these disproportions have to be clarified." V. G. Dolgov, *op. cit.* Another author puts the question more strongly: "The acting norms of amortization are not revised and are calculated very often in accordance with foreign price lists. They do not correspond to a smaller or larger extent with the real technical wear and tear of the means of production. That is particularly true when they are taken over from accounting materials supplied by capitalist enterprises without being properly qualified and without due regard for the particular reasons for certain depreciation practice applied abroad. Our legislation adopting these high amortization quotas had in view the possibility of capital accumulation necessary not only for reproduction of the equipment in its original form, but sufficient for its reconstruction on a higher technical level. Such a viewpoint demands an increase of amortization quotas which have to finance the construction of new enterprises not only after the old ones are worn out, but much earlier than that, because of the higher rentability of more modern installations . . . That makes our solution of the amortization question rather a matter of definition agreed upon between economic authorities." A. I. Rothstein, *Problemy promyshlennoi statistiki v SSSR* (Leningrad, 1936), pp. 288 *et seq.* This book, which seems to be by far the best in this field in Russian literature, should be consulted on all questions connected with the problem at hand.

<sup>22</sup> Agricultural tractors serve in Russia at most 10,000 work hours, and need three general repairs, whereas in this country their term of service is usually estimated to be at least twice as great.

as the principle of exclusive regard for *original* values. To base depreciation calculations on these values (which in addition are corrected for changes in the "price level" and represent deflated figures of very doubtful accuracy) is to give a completely distorted cost picture which includes considerable amounts of outlay that are entirely unrelated to amortization. The Russian economists realize this quite well, but maintain that the procedure is rational by pointing to the necessity of capital accumulation. But even though the necessity exists, it is entirely inadmissible to work in additional profits and earnings under the heading of costs (first element of pricing) after profits, taxes, etc. (second element) have been accounted for separately.

Since the worn-out plant can usually be rebuilt at considerably lower cost than was incurred in the construction of the original one,<sup>23</sup> and since technical progress makes possible the introduction of better and more productive machines and tools, the system of calculating depreciation on the basis of original values obviously deprives the planning authority of correct information about the costs of producing a unit of output, and makes virtually impossible a valid comparison between different techniques of production. Cost figures which are regarded as low (in comparison with other enterprises) may in reality be very high, and include vast amounts of hidden profits; high cost figures may lead to an erroneous impression of real scarcity conditions, as their magnitude may be determined by overvaluation of an old plant. These mistakes might be corrected by the consumer if by shifting his demand from the "too expensive" goods to the "cheaper" ones he could force the authority to impute the resulting market price to the capital goods and thus reevaluate plant and equipment. But as under Russian conditions the better part of the demand is not consumer's demand, but demand originating within the four walls of the planning board, the problem can be solved only by "trial and error," by a very conscious application of the *tâtonnement* method, and by careful imputation of

<sup>23</sup> This statement, however, must be qualified in the case of the Soviet Union. Insofar as imported machines or parts of machines are necessary for the renewal of the plant, and foreign exchange is scarce, the renewal, in terms of Russian evaluations, may be more expensive than the original plant—depending on the given situation of the Russian balance of payments.

the value (however estimated) of the finished product to the value of capital goods. Since the entire capital accumulation is controlled by the central authority and technical innovations are directed according to its decisions, this practice would by no means exclude the possibility of sponsoring investment in industries which incur losses. It would, however, make it feasible to calculate how much this "protection" costs in terms of alternative uses. But it is precisely this application of cost calculation that the methods employed in Russia exclude. It is therefore entirely impossible to conclude whether the amount of waste is minimized, whether the desired aims are reached with the employment of the least investment of resources, or whether mobilization of the available resources could furnish better results. Once again the scarcity prevailing throughout the country (particularly as measured by the yardstick of governmental goals) precludes a proper appraisal of the adopted techniques. Since this scarcity is particularly marked with regard to capital goods, and since labor is cheap, all labor-saving devices have to break through the wall of adverse profitabilities. Even without taking account of interest on capital, which does not exist in Russia except for short term money and governmental loans, the expensiveness of capital goods, the extremely high valuation of machines and tools imported from abroad (they are still necessary for many new installations) tend to make the average total costs of a unit of output in new plants higher than in the old ones. Nevertheless they coexist; the most up-to-date plants working with heavy accounting losses are kept running alongside the old prewar establishments making high profits. The only progressive equilibration of this abnormal state of affairs is, in the opinion of the government, accelerated accumulation of capital, an independence of "expensive" foreign supplies, and an increase in the productivity of labor.

## 4

As Max Weber once remarked, historical materialism is not a horse-cab from which the passenger may alight whenever he pleases. The strong interdependence of the degree of development of *Produktivkräfte* and the corresponding *Produktionsverhältnisse* cannot be disregarded without heavy penalties.



The endeavor to impose upon a backward, agricultural country a highly organized, precisely functioning and thoroughly calculated economic system must necessarily involve stupendous losses in life and goods. No country can neglect with impunity the law of comparative costs; nor can it enforce a saving of over 50 percent of the national income without inflicting privation and suffering upon its population. This is particularly true if the productivity of labor (as Colin Clark demonstrated strikingly in his illuminating *Conditions of Economic Progress*) is as low as it is in Russia. Even if the time preference of the Russian population were not converted into its negative, but were allowed to underlie all the economic activities of the country, the nation would still live on a low level of income as compared with the industrially advanced countries of the world. All the details of planning technique, taken for what they are worth, are of secondary importance in the light of these basic facts. Many things could be done better, commodities that are needed could be produced and conveyed to the consumer, goods regarded as "necessary," but which pile up on the shelves of the shops, could remain unmanufactured. Yet all these improvements, important as they are, cannot decide the fate of the experiment. One of the most brilliant economists in the Communist Party, the late E. Preobrazhenski, remarked: ". . . in our country where the centralized planned economy of the proletariat has been established and the law of value has been limited or replaced by the planning principle, foresight and knowledge play an exceptional role as compared with the capitalist economy. Errors in foresight committed by our central leadership may have much heavier consequences than errors committed by managers of private enterprises where mistakes in one direction are often cancelled out by mistakes in the opposite direction according to the law of great numbers."<sup>24</sup> These words were prophetic. The mistakes and errors of the "central leadership" have been numerous. Its unwillingness to make use of advanced economic science, its indiscriminating adoration of the machine, its power to disregard the consumer as an economic as well as a political "voter"—may be only aspects of the backwardness of the country. But it is wrong to say that, "It is the ability to solve

<sup>24</sup> E. Preobrazhenski, *Novaia Ekonomika* (New Economics, Moscow, 1926), pp. 11 *et seq.*

in a lasting manner these various price problems rather than any technological accomplishments that will afford the test of the adequacy and feasibility of the Soviet program of economic expansion.”<sup>25</sup> Rather, the extent to which the system will be able to eliminate scarcity and to raise the productivity of labor will finally determine the success or the failure of the entire undertaking.

The economic theory of socialism is just as useless in matters of economic policy under a planned economy as the theory of pure competition is in capitalist countries. Free competition is incompatible with large scale enterprise. Economic liberalism is impossible in a world of monopolies, oligopolies and imperialism. Rational socialist planning cannot coexist with poverty, with armaments, with autarchy, with “primary accumulation of capital.” Formal questions of planning are inseparable from the material content of the planning.

The study of the economic policy of Russia, of the ways and means employed by Soviet planners, is thus not a study of socialist economics. Whether it is the study of failure to construct a socialist society in a single backward country, or the study of an early stage of socialist economics of the future may be left to the decision of history. It is, however, necessary and valuable. It can supply us with information as to how successes can be achieved (even if they could be reached in other countries, under more favorable conditions, more cheaply, with less sacrifices, less waste, less irrationality). It can provide us, moreover, with some indispensable knowledge of how mistakes and disasters can be avoided.

<sup>25</sup> A. Gourvitch, in *American Economic Review*, Supplement (1936), p. 282.

**APPENDIX C**  
**THE REPLACEMENT OF**  
**DEPRECIABLE ASSETS**

## Appendix C

### THE REPLACEMENT OF DEPRECIABLE ASSETS

Few branches of industrial practice are subject to greater confusion than that concerned with the replacement of durable assets. It is therefore appropriate, in a report on cost-price relations, to examine the principles of correct practice and survey customary procedures. Some of the difficulties result from *ex parte* preparation of estimates. Frequently both the suggestion and the cost estimates for replacing a machine come from a prospective salesman for the new machine.<sup>1</sup> Although the more reliable tool-makers<sup>2</sup> value the goodwill of the manufacturer too highly to sell him a machine which they have no reason to believe is economical, the *ex parte* position of the estimator is not conducive to the most objective study of replacement problems.

Not many firms have any adequate method of determining when the possibility of replacement should be explored. If direct or indirect costs of production move out of line, a budget may set the management looking for possible ways of reducing costs, but no budget in itself can show when a

<sup>1</sup> The term machine will be used throughout this appendix to denote any depreciable asset. In addition to machinery itself this usage will thus include such assets as buildings, production layouts, and process patents.

<sup>2</sup> The term includes construction companies, production engineers, etc. In this connection it is interesting to note the published advice of H. K. Ferguson, head of a large building construction firm, in an article in *Factory Maintenance and Management* (Vol. 95, No. 4, pp. 42-45) entitled "To Build or Not to Build." He repeatedly states that no firm should build if it can reasonably avoid building by simplifying the line, rearranging departments, leasing space, etc. Further, "it is never safe to build when more than half the cost of land and buildings must be borrowed." Finally, "no business should build itself into such a position that, because of heavy expenditures for plant and equipment it is impossible to . . . break even or better during the next depression on 50 percent of production volume."

machine is approaching the point of obsolescence. No automatic procedure will reveal the answer even to the simpler question of when to replace a machine with an identical machine which will have lower operating and maintenance costs. It would appear that usual practice is to maintain a machine until some person, master mechanic, foreman, superintendent or salesman, has a "hunch" that it might be well to replace it. Estimates are then made of the saving that could be effected, and if this amount is sufficient to "pay for the machine" in "a short period" the change is instituted.

The most casual examination of the files of a journal dealing with the problems of production executives (such as *Factory Management and Maintenance*) will convince the reader that this sort of procedure is unsatisfactory. Consider such a simple matter as the alteration of a low power factor. Unlike most wasteful practices, the existence of this "leak" is presented to business executives every month if the electric utility has the usual penalty clause for a low power factor. Yet over a period of about ten years, at least three or four articles or notes appear each year telling of the phenomenal savings some company has achieved by installing capacitors or synchronous motors. The technique for making the saving was well known, and it had been shown applicable to almost any plant using electric motor driven machinery. Nevertheless, a large number of firms postponed making any investigation of the possible savings for years,<sup>3</sup> when the usual experience was to find savings "paying for" capacitors in a very short time.

### 1. *The Age of Depreciable Assets in Use*

It is not possible to obtain an accurate picture of the age distribution of all machines in use, but the available data indicate that a very large proportion of the machinery that was functioning in 1939 was so old that its continued use was unlikely to be economical. Mere age, of course, is no evidence that a machine should be retired. Some types of machine may still be economical after fifty years of service; others may be obsolete after two or three years. Furthermore, the use made of the machine by different plants will influence the time of

<sup>3</sup> Replacement could conceivably have been postponed because of lack of funds or credit.

obsolescence markedly. A thirty-year-old freight car may be quite economical for meeting a short peak demand but excessively costly for continuous use. These variations between types of machine and usage are further complicated by the different "life experiences" of apparently identical units. With so many factors to be considered, any over-all examination of age of machines must not be understood to indicate the amount of obsolete machinery but rather to suggest the range of issues involved in the problem of replacement.

The most generalized approach to this problem is the study of the durable goods inventory as a whole. Terborgh has pointed out that the durable goods inventory comprises more than half of the total national wealth in the United States and more than three fourths of the wealth exclusive of land and natural resources. He estimates further that this inventory contains ten to fifteen years' consumption at the current rate. Since 1930 the age distribution of the goods in this inventory has altered markedly. Apparently there were in 1939 a greater number of durable goods than ten years previously, but the amount of service life remaining in these goods was on the average enough less to give the total inventory the same prospective stock of services.<sup>4</sup> Only a portion of the large stock of durable goods consists of instruments of production (and thus bears on the general problem of cost-price relationships). Of the estimated 360 billion dollars expended for durable goods during the twenty years from 1919 to 1938 only about 37 percent went into producers' plant and equipment.<sup>5</sup>

Turning from the over-all picture, which shows that "the gap between the average quality and condition of durable goods in use and the best that current technology affords is . . . much wider than before the depression"<sup>6</sup> to the case of specific durable goods, we get a more definite impression of over-age machines.

In 1925 only 44 percent of machine tools in use were more than ten years old; in 1930 this percentage had risen to 48; in 1935 it was 65; and by 1940 the proportion had risen to 70

<sup>4</sup> "Present Position of the Durable Goods Inventory," George Terborgh, *Federal Reserve Bulletin* (October 1940), p. 1041.

<sup>5</sup> Compiled from George Terborgh, "Estimated Expenditures for Durable Goods," *Federal Reserve Bulletin* (September 1939), p. 731.

<sup>6</sup> George Terborgh, "Present Position of the Durable Goods Inventory," *loc. cit.*, p. 1043.

percent.<sup>7</sup> The situation with respect to railway equipment is even more striking, and here the trend toward increasing amounts of old equipment is of even longer standing. In 1930 20 percent of railroad locomotives were *less* than ten years of age—a “normal condition” only if locomotives have a fifty-year life. By 1940 the proportion had shrunk to 6 percent<sup>8</sup>—a “normal condition” only with a locomotive life of one hundred and sixty-seven years!

The age distribution of freight cars falls within narrower bounds than that of locomotives, as is evident from the following table:

AGE DISTRIBUTION OF CARS ON HAND—  
JANUARY 1, 1940<sup>a</sup>

Class I Railways

<i>Present Age Group</i>	<i>Total on Hand</i>	<i>Percent of Total Owned</i>	<i>Cumulative Percent of Total</i>
1 - 5	152,787	9.34	9.34
6 - 10	76,863	4.70	14.04
11 - 15	327,422	20.01	34.05
16 - 20	377,164	23.05	57.10
21 - 25	301,638	18.43	75.53
Over 25	400,317	24.47	
Total Owned	<hr/>	<hr/>	
Jan. 1, 1940	1,636,191	100.00	

<sup>a</sup> American Railway Car Institute Bulletin, *Statistics of Car Building and Car Repairing* (1939).

This study by the American Railway Car Institute reveals that less than one seventh of the railway freight cars are less than ten years of age while three sevenths are between ten and twenty years old. Stated in another way, this means that half a million fewer railway freight cars were purchased during the 1930's than during the 1920's. It is shown also that the replacement rate in the 1920's was roughly equal to that of previous years. The virtual absence of replacement in the early 1930's was a result of the loss in railway traffic, and the replacements

<sup>7</sup> “How Industry, Labor and Government Can Help America,” *Factory Management and Maintenance*, Vol. 98, No. 8 (August 1940), p. A31.

<sup>8</sup> Terborgh, *loc. cit.*, p. 1042.

of 1934-39 were only half of normal. With increasing traffic the railroads must face the problem of determining whether it is cheaper to buy new cars or to run the old cars in the face of increasing repair costs. Since almost a quarter of the cars are over twenty-five years of age, the replacement problem is of major concern to the railroads; it seems probable that cars of this age are seldom economical for anything but peak loads or special services.<sup>9</sup>

When the effects of a secular decline in use are combined with the effects of cyclical depression the replacement of durable goods may be very seriously curtailed. This was the case with freight cars and is also the case with steam engines. Two thirds of the steam engines in use in 1940 were over twenty years old.<sup>10</sup> The maximum "life" for steam engines commonly accepted in the calculation of depreciation is twenty-five years.<sup>11</sup> Where technological advance is not only rapid but also of considerable magnitude, the situation is less striking in terms of age of machines than in terms of the proportion of machinery which could be replaced economically. Under such circumstances it is even more important that systematic and periodic studies of the possibility of replacement be made if profits are to be maximized.

## 2. Steps in the Replacement Problem

There are three phases of the replacement problem: (1) to determine whether any given machine should be replaced by

<sup>9</sup> Any study of the age distribution of assets must take into account the fact that the lives of individual assets of the same kind vary just as the lives of human beings. Robley Winfrey in a monograph entitled "Statistical Analyses of Industrial Property Retirements" (*Bulletin 125*, Iowa Engineering Experiment Station) presents retirement and survivor curves for 176 different sets of data. An example of the extreme spread of life is seen in three groups of small distribution transformers used by midwestern power companies (curves 145, 147, 149). One group of 216 had an average life of 5.8 years with the maximum life of any individual 13.5 years. A second group of 116 transformers with an average life of 11.0 years had a maximum of 23.5 years. An asset which would appear to be highly standardized but which had a wide life range is a sample of 939 cast-iron electric car wheels used by the Milwaukee Electric Railway and Light Company (curve 31). The average life was 30,500 car miles and the maximum 82,500 car miles.

<sup>10</sup> *Factory Management and Maintenance* (August 1940), p. A32.

<sup>11</sup> See W. A. Paton, *Accountants' Handbook* (Ronald Press, 1932).



some one of a number of other given machines (or the service the machine renders purchased as such), (2) to determine the possible alternatives to the continued use of any given asset, and (3) to determine when such studies of depreciable assets are needed. It can readily be seen that these questions must be answered in reverse order. Sometimes the need for studying the replacement of an asset is thrust upon the management by the breakdown of the machine, but such occurrences cannot be made the basis of a system of replacement. This problem of knowing when to study replacement possibilities can be solved arbitrarily by a rule that every asset shall be studied, say, once a year. Robert M. Gaylord, president of the Ingersoll Milling Machine Company, recommends a periodic check on equipment for replacement possibilities. Few firms have any systematic policy with respect to periodic checking for the possibility of replacement.<sup>12</sup> His company, producing machine tools, had been selling its machines on the basis of economy studies for years, but not until 1927 did the management consciously shift from a replacement policy of "Will it run?" to "Can it be done cheaper or better?" At this time the company adopted a policy of checking on every machine at the end of ten years. The difficulty with any arbitrary period for examination is that in some cases it will be much too frequent and in others not nearly often enough. Since there is considerable expense involved in making estimates, some balance must be struck between the cost of making more frequent examinations and the savings that can be achieved in this way. While some firms may habitually replace assets too soon, it is doubtful if any firm spends too much money in exploring the possibilities of replacing present assets.<sup>13</sup>

The problem of determining the possible alternatives is almost as difficult and as badly handled in practice as the whole subject of knowing when to study replacement possibilities. It is the responsibility of the engineering staff to know all the methods whereby the stream of services rendered by the asset can be obtained. The search for these possibilities requires at

<sup>12</sup> Robert M. Gaylord, "When to Buy New Equipment," *Factory and Industrial Management* (July 1932), pp. 272-74.

<sup>13</sup> This exploration of possibilities of replacement with presently known assets must not be confused with research and development work to discover new techniques.

times a high order of imagination, bordering on the realm of discovery. For instance, Grant<sup>14</sup> cites a town which in purchasing an old gravity feed-water supply employed an engineer who failed to imagine the possibility of pumping water from wells. Three or four years later the state Board of Health suggested this possibility.

When the management has decided to make a study of replacement possibilities and the engineering staff has determined the alternatives, the central problem of estimating whether or not it will pay to purchase new assets can be approached. The economist's answer to the problem is outlined in Chapter VII. The approach of the next section of this appendix will be that of the businessman or engineer.<sup>15</sup>

### 3. *When Is It Profitable to Replace a Machine?*

A sufficiently accurate answer to this question, when the replacements being considered are deemed to have about equal life, can be obtained by way of the three following questions:<sup>16</sup>

(1) What annual savings can be expected from using the machine at the expected level of output? (2) What will be the annual charge necessary to insure recovery of investment within the minimum expected life of the machine due to cessation of demand, obsolescence or wear and tear? (3) Does the profit, if any, remaining after subtraction of the charge for recovery of investment from the expected annual savings represent the most profitable way open, or likely to be open, for use of the capital involved? To answer these questions may not be as simple as would appear at first glance.<sup>17</sup>

<sup>14</sup> Eugene L. Grant, *Principles of Engineering Economy*, revised edition (Ronald Press, 1938), pp. 235-36.

<sup>15</sup> *Ibid.*, Chs. XIV and XV, outlines a system basically similar to that described in Chapter VIII of this report.

<sup>16</sup> This simplified procedure follows that proposed by Gaylord, *op. cit.*, pp. 272-73.

<sup>17</sup> These criteria are for competitive conditions and require some modification when applied to monopoly. In the case of unregulated monopoly, whether complete or partial, the question is not really any different except insofar as a fear of regulation or competition prevents profits from appearing too high. In the case of regulated monopoly, one of the costs to be considered is the change in rate base. J. M. Clark in his *Studies in the Economics of Overhead Costs* (University of Chicago Press, 1923), points out that this reduction of rate base deters public utilities from replacing obsolete equipment.

To determine the annual savings it is necessary to estimate only those costs which will be altered by the use of the new machine. For instance, there is no reason to assume that indirect labor cost will be decreased by the installation of a new machine which uses less direct labor simply because there is in operation a cost system which allocates indirect labor cost on the basis of direct labor cost. Similarly, no reduction of floor space charge should be made unless the freed space can be utilized to average advantage. When the problem is approached in this manner, it is obvious that there is no reason to be concerned about the book value of the replaced asset; the costs associated with this asset have been incurred and no action taken now will alter them. While it is true that under competition a firm cannot continue in business if it repeatedly fails to make sufficient provision for retiring its assets, it is doomed to failure even more rapidly if, having made unwise decisions about the purchase and depreciation of assets, it refuses to replace assets whose operation entails out-of-pocket costs higher than the total costs of new assets that render the same services. Since the problem is to determine the costs that will be altered, sunk costs cannot, by very definition, be considered. It is important, further, to bear in mind the limitation entailed by the fact that savings must be realized not at capacity output but at the expected level. Finally, no charge is to be made in computing the savings on account of depreciation or interest on the new investment, but any decline in salvage value of the old asset should be reckoned as a cost of continuing the use of that asset.

To estimate the service life of the investment requires even more careful judgment than to estimate savings. It is unfortunate that this entire question is ignored by the usual methods of replacement study. A common practice is to lay down a rule that an investment must "pay for itself" in a certain period of time, say two years. A study of replacement policies showed that the average period during which an asset had to pay for itself was about three years.<sup>18</sup> Apparently the meaning usually attached to the dictum that "a machine must pay for itself in two years" is that the savings during each of the first two years must be 50 percent of the cost of the machine. If a profit rate of 20 percent is expected, this means that the life of the ma-

<sup>18</sup> See Chapter VII above.

chine is arbitrarily set at  $3\frac{1}{2}$  years. If the "pay out" time is raised to three years, a profit rate of 20 percent yields a life of  $7\frac{1}{2}$  years, which is certainly not excessive for a conservative estimate in view of the rate of obsolescence today. Probably when "pay out" periods of five years or over are used the profit rate is first subtracted from the savings; we are then speaking of a concept very close to that of our "estimated life."

Since replacement studies are infrequently made on the basis of careful estimates of probable life, it is difficult to tell whether the third criterion (do the savings represent the most profitable use of the capital involved?) is given adequate consideration. Most concerns which are large and progressive enough to be considering a number of alternative types of investment in order to cut cost are probably able to borrow to carry out any changes that show good prospects of profit. In this case the criterion should be: will it yield a certain rate of return? This seems to be the idea of E. M. Richards, chief industrial engineer of Republic Steel, who says that in a choice between alternatives the criterion should be the rate of saving on the added investment of the more costly process.<sup>19</sup>

The type of examination outlined above, which has been put forward as a practical one by some progressive businessmen, has much to commend it. The freedom from highly technical considerations of present worth and interest rates should appeal to business executives. Its presentation of a rate of profit after provision has been made for capital recovery should emphasize the possibilities in any given investment.

<sup>19</sup> "To Buy or Not to Buy Equipment," E. M. Richards, *Factory Management and Maintenance*, Vol. 91 (December 1933), p. 499. His six points outline a method very similar to the one suggested above, except for his somewhat modified criterion of choice. He sets a three-year pay-out as proper for normal times and one year for depression in order to conserve cash.

**APPENDIX D**  
**SPECIFICATION OF BOOK**  
**PAPER PRODUCTS**

## Appendix D

### SPECIFICATION OF BOOK PAPER PRODUCTS

THE following classification of book paper products was prepared by Albert Sawyer of the New York law firm of Wise, Corlett and Canfield, in connection with a study of the relation of realized and quoted prices. The book paper industry is one among about fifteen branches of the paper industry, and as such represents a considerable degree of specialization. How much farther specification of paper products can be carried is indicated in this classification. Since there are 40 product classes, 12 grades, 33 finishes, 9 sizes and trims, 8 colors, 8 quantity classes, and 19 types of packing, a meticulous specification of product would distinguish between 170 and 180 million possible products in the book paper industry.

#### *Product Classes*

- Adding machine and cash register paper
- Bank stock
- Book—M.F., E.F., super, etc.
- Carbonizing
- Coated 2 sides
- Coated 1 side
- Coated bond
- Coated cover
- Coated embossing cover
- Coated box cover
- Coated shelf paper
- Coating raw stock
- Decalcomania
- Endleaf
- Drawing
- Envelope

French folio  
 Gumming  
 Hanging-wall paper  
 Lining  
 Litho and label  
 Machine coated  
 Music  
 Offset  
 Playing card  
 Postal card  
 Poster  
 Rag book  
 Soap wrapper and cardboard  
 Tablet  
 Text  
 Greeting card  
 Rotogravure  
 Postage stamp  
 Folder stock  
 Ditto  
 Tariff  
 Wrapper spec.  
 Uncoated box cover  
 Blanking paper

Papers in the above grades containing more than 25 percent ground wood and less than 35 percent bleached sulphite are in the "ground wood paper" division. Papers above these limits are in the "book paper" division.

*Product Grades*

A or 1  
 B or 2  
 C or 3  
 D or 4  
 E or 5  
 Extra strong  
 Extra quality  
 Publication

## BOOK PAPER PRODUCTS

Government  
All other special  
Seconds  
Job lots

### *Product Finish*

Antique laid  
Antique  
Bulking  
Eggshell wove  
M.F. or E.F.  
High bulk  
Super  
Glossy enamel  
Dull  
Felt  
Embossed  
Plater  
Laid  
Watermarked wove or laid  
Duplex  
Hard sized  
Titanium filled  
Vellum  
Eggshell laid  
Duplex enamel  
Brush finish enamel  
Tub or surface sized  
Special or fancy (unclass.)  
Ant. or Egg. W/M wove or laid  
Lacquer  
Varnish  
W/M super  
Super 1 side  
Ant. laid W/M  
Ant. bulking  
Hard sized antique  
High bulk eggshell  
Hard sized high bulk



## APPENDIX D

*Size and Trim*

Regular	untrimmed
	trimmed 1 or 2
	trimmed 3 or 4
	deckle
Irregular	untrimmed
	trimmed 1 or 2
	trimmed 3 or 4
	deckle
	round cornered

*Product Color*

White, natural  
 (also azure in envelopes)  
 India, ivory cream  
 Light color  
 Deep color  
 Duplex  
 Special

*Product Quantity Class*

Less than ream  
 Ream  
 125 lbs. (carton)  
 500 lbs. (4 cartons or 1 case)  
 2,000 lbs. (4 cases)  
 5,000 lbs.  
 10,000 lbs.  
 36,000 lbs.—carload

*Product Packing*

Rolls 500 lbs. or heavier  
 250 lbs.—500 lbs.  
 Less than 250 lbs.  
 Less than 6" in width and 9" in diameter  
 Banded

**BOOK PAPER PRODUCTS****337**

- Bundles** flat with or without cardboard protection  
skeleton frames  
soft fold or lapped  
sealed
- Cartons** ream marked  
ream sealed
- Cases** ream marked  
ream sealed  
cut and sealed
- Skids** ream marked  
ream sealed
- Crates**
- Cellophane wrapped rolls

**DIRECTOR'S COMMENT  
BY C. REINOLD NOYES**

## DIRECTOR'S COMMENT

### BY C. REINOLD NOYES

THIS report is subject to two limitations, one set by the mandate of the Committee and the other by the method of presentation adopted by the Committee. It seems to me that both of these limitations may lead to confusion, or help to continue confusion, in the minds of those who use the report—as many doubtless will—as a manual or guide to empirical studies of costs. A word of caution, here, may help to avoid such confusion and therefore help to make this admirable and constructive study even more useful.

1. The mandate of the Committee (see Preface) requires a behavioristic approach—that is, a study of the influence of costs on price decisions. This is, of course, a great improvement over the speculative or introspective method of imputing economic motivation. The result is, however, that the Committee is obliged to take as its data costs as these are conceived and recorded in current business practice. But the elements included in accountants' costs fit neither those of the economic theory of costs nor those of the theory of productivity. In fact they fit no better than the last two fit each other.

a. The theory of costs deals only with real costs—that is, factors made available—though these are convertible into terms of payment for factors and therefore into money costs.

b. The theory of productivity deals only with factors actually used, though again these are convertible into terms of payment and therefore into money costs.

c. Accounting deals only with contractual and imposed costs in terms of money.

The details of the differences in these three approaches were given in *Technical Paper 2* (National Bureau of Economic Research, 1941) and *American Economic Review*, 31 (1941), p. 473, and it is not necessary to repeat them here. Suffice it to say that the category of costs for each of these purposes excludes or includes certain elements which another

includes or excludes. Except as these differences are reconciled or allowed for, neither form of present theory can be applied without qualification to current accounting data, nor can conclusions from empirical studies of such accounting data be used without qualification to modify either form of theory. Until that is done the scientific utility of empirical studies in this field will be very limited.

d. In another respect there is a difficulty in the use of present theory in such studies. As I have shown in the paper cited above, the theoretical device called marginal cost theory is inconsistent with both the theory of costs (factors made available) and the theory of productivity (factors used) insofar as the marginal costs to be considered are limited to what the accountants call direct or "out-of-pocket" costs as against overhead (i.e. to variable as opposed to fixed costs). So-called variable costs exclude the returns on several factors which are made available and even those on some factors actually used. Nor is the device applicable in practice—except in a limited number of particular situations where more or less of the elements of cost are disregarded (see my paper cited above)—unless it is confined to use with reference to additions to a current output which is already covering all contractual and imposed costs. Thus any assumption that marginal costs, as usually defined, are or should be generally determining of price policies can only interfere with the attainment of successful results from empirical cost studies.

2. The other limitation is the consequence of the Committee's choice of approach, which treats the subject from the angle of the several causes of change in costs as these have been analyzed in past theory. These causes are:

Short run

- a. Changes in rate of output.
- b. Changes in prices of input factors.
- c. Changes in technique.

Long run

- d. Changes in size of plants and firms.

When the actual accounting data are dealt with I am of the opinion that it will not be found possible to distinguish the operation of these four causes of change of cost. This will be

largely due to the fact that some of these rubrics are not pure; they consist of mixtures which have not been adequately analyzed. It will also be partly due to the fact that some of these rubrics have been contaminated with a purely mystical supposition—the law of the proportioning of factors and its inference and basis, the declining marginal efficiency of each factor as its proportion is increased.

In the short run:

a. Changes in rate of output, with given and uniform technique and given prices of input factors, cannot change costs in terms of factors actually used. To the extent that costs are figured instead in terms of factors made available, the effect of changes in rate of output will depend wholly on the decision whether to allocate such costs one way or the other. This decision is necessarily an arbitrary or conventional one. If the decision is to allocate such costs only to the product upon which the factors are actually used, increased output will show an increase in such costs per unit. If the decision is to allocate such costs regardless of use, increased output will show a decrease in such costs per unit (see my paper cited above). Other changes in costs as a result of changes in rate of output are only apparently, not actually, due to this cause. That is, they are either due to the use of more or of less efficient machinery, etc., already installed (i.e., changes of technique) or to more or less efficient labor, etc., at the same price (i.e., changes in prices of input factors).

b. Changes in prices of input factors are only causative with relation to prices insofar as they do not result in changes of technique (for instance, only when labor cost changes to the same degree as wages). All other effects may be said to be *induced* by price changes of input factors, but what is actually induced is a change in technique. In such cases the induced change in technique is itself equally a causative factor on price decisions. Sometimes it works in the opposite direction from that of the change in price of input factors (i.e., compensatory). Sometimes it works in the same direction (i.e., substitutive). Thus rises in labor costs may induce better machinery (technique). But declines in machinery costs may also induce better machinery (technique).

c. Changes in technique properly include any changes in real input-output relations. It is impossible to define technique in

any narrower way if the various types of input are, as is necessary, classified by their kind and quantity of effect, not by their prices, and if output is measured in terms of an unchanged product. The committee recognizes this broad definition in the first paragraph of Section 1, Chapter VII. Then, in the following paragraph, an attempt is made arbitrarily to exclude those changes in technique which are induced by changes in price of input factors and those differences in technique which are due to changes in rate or differences in scale of production. There the constraining effect of theory appears. These effects are not separable from, and in fact are measured by, the change or difference in technique only.

It is also to be noted that the presupposition of short run analysis, that the plant remains unchanged, excludes all changes of technique other than changes from one to another technique *already installed* (i.e., changes in parts of plant used or in kinds of men hired or materials bought). Installations of new techniques are treated, in theory, as long run phenomena. The fact that both long and short run changes in cost are largely due to this one cause, changes in technique, does not, however, vitiate the value of separate studies of the two runs. For the potential variability of technique, and therefore the effect on price decisions, is obviously different in the two cases.

In the long run:

d. Changes or differences in size of plants and firms seem to me *not* to be, of themselves, causative of differences in cost. Under the necessarily broad definition of technique, as given above, and under the only possible definition of kinds and quantities of input, there can be no influences on prices, or differences in costs, proceeding from differences in the size of plants and firms other than differences in technique and in prices of input factors. The difference in cost due to scale of *individual* operations is either due to a difference in technique—the use of a machine or a method (e.g., straight-line production) which can be used economically only on a certain minimum scale—or to more continuous use which is the same thing as a change in the rate of output (see 2a above). The difference in cost due to scale of *aggregate* operations is either due to differences in technique (organization) or to differences in price of input factors (specialization, etc.).

e. There is in the minds of economists, generally speaking,

a prepossession, which crops up in this report, to the effect that there is some other influence on costs besides the above. This seems to be the idea that the marginal productivity of any factor declines automatically as its proportion in the mixture is increased. That, in my opinion, is purely imaginary. There can be no change in proportioning of factors without a change in technique. But changes in technique are specific, definite and definable. Apparent changes in proportioning require exploration until the actual change (in technique) is found. There is room for no notion of continuous and automatic fluxions in respect of the proportioning of factors, for the changes consist solely of discontinuous and deliberate steps.

The foregoing analysis leads to the supposition that, in the course of their investigations, empiricists in this field are likely to find that all influences on costs reduce to two, changes in technique (including techniques with minimum economical scale) and changes in the prices of input factors. To these two influences there may need to be added, for a behavioristic study in our present institutional environment, one other influence. In its theoretical aspect it is the effect of the decision as to the actual method of allocation of the costs of factors made available that are incurred while these factors are not in use. In its practical effect on price making this is but part of a larger question—the question as to the extent to which management must consider its contractual and imposed obligations for payment to factors not used or to nonfactors (not properly costs) and the extent to which it can ignore (and fail in) payment to factors used (properly costs). (Spatial relations to markets [transportation costs, etc.] are, of course, another influence on costs by themselves. But this influence is unrelated to those considered and is a separate field of study.)

So far as the influence of the two other apparent causes of changes or differences in cost is concerned, it would seem that the correct statement would be something like the following:

1. Changes in rate of operation *permit* differences in cost provided they enable or prevent the use of already installed techniques requiring a minimum scale of economical operation, or providing they enable or prevent economies in the price of factors. In the absence of these two elastic elements no



differences in costs for factors actually used result from changes in the rate of operation.

2. Differences in the size of plant or firm *permit* differences in cost provided they enable or prevent the use of actually available techniques requiring a minimum scale of economical operation, or providing they enable or prevent economies in the price of factors. In the absence of these two elastic elements no differences in costs for factors actually used result from differences in size of plant or firm.

If my tentative predictions turn out to be correct, attributing causation to other and secondary influences will merely have caused confusion and hunting of nonexistent causes will have resulted only in a waste of time. However, the proof of the predictions may require such a waste of time, though not so much if the investigators recognize in advance the possibility of the nonexistence of one of these theoretical causes, the possibly secondary character of two others and the certainly arbitrary, variable and institutional, character of allocation.

In my judgment, and for these reasons, only as the two limitations described are taken account of and adjusted for will it be possible to approach the Committee's very desirable goal of a "coordination of empirical studies and theoretical analysis."

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