On Measurement and Analysis of Standard Costs

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ALBERT DANIELSSON

On Measurement and Analysis of Standard Costs

FFI

THE BUSINESS RESEARCH INSTITUTE
AT THE STOCKHOLM SCHOOL OF ECONOMICS

P. A. NORSTEDT & SÖNERS FÖRLAG STOCKHOLM 1963

STOCKHOLM 1963. KUNGL. BOKTRYCKERIET P. A. NORSTEDT & SÖNER

FOREWORD

This volume will be submitted shortly as a doctor's thesis at the Stockholm School of Economics, where the studies have been carried out. Within the statutes of the Business Research Institute at the Stockholm School of Economics, the author has been entirely free to conduct his research in his own way as an expression of his own ideas.

The Institute is pleased that this work has been carried out inside its premises and environment.

Stockholm, March 25, 1963

T. Paulsson Frenckner

PREFACE

The research described in this book was begun in 1957. A mimeographed report was submitted as a thesis for the degree of ekonomie licentiat at the Stockholm School of Economics in 1960. The focal point of the present study is an extension of one of the findings of the former report, namely, that the analysis of variations from standard costs can be conceived as a procedure for testing predictions of the result. This implies that the individuals performing and utilizing the analysis are faced with a situation which in some respects is analogous to a scientific experiment.

In our research we consequently examined the possibilities of incorporating an assessment of the adequacy of predictions and explanations into the analysis. This led to the construction of a framework which describes the situation where the analysis is performed and utilized. We then used this framework as a foundation for arriving at the predictions. The extended analysis is termed here *measurement and analysis of standard costs*. The presentation of the material in the book, with regard to scope and sequence, has followed the evolution of this analysis.

Stockholm, March 25, 1963

Albert Danielsson

ACKNOWLEDGEMENTS

While working on this study, I have had the good fortune to be a member of the Business Research Institute at the Stockholm School of Economics. I acknowledge my indebtedness to that institution for the many forms of help and support, as well as financial aid, which have made this research possible. In particular I should like to thank the present and the former directors of the institute, Professors T. Paulsson Frenckner and Gunnar Westerlund. Professor Frenckner made the original suggestion that I should study the analysis of variations from standard costs and has followed the work closely through several manuscript versions. I have been continuously grateful for his constructive criticisms, from which the report has profited immeasurably in both clarity and precision. My attempt to incorporate scientific methods into the analysis has benefited greatly from Professor Westerlund's comments. I am also most grateful to him for his encouragement throughout the course of this work. I should also like to acknowledge my gratitude to Professors Sven-Erik Johansson, Folke Kristensson, Thomas Thorburn and Karl-Erik Wärneryd for their numerous suggestions.

Of my many colleagues and friends at the Business Research Institute who have helped and encouraged me, I should like to mention in particular Messrs. Bo Fridman, Bertil Kusoffsky, Bengt Magnusson, Bertil Näslund, Klas Wahlström, and Folke Ölander, each of whom has given generously of his time and interest. Klas Wahlström has furthermore been most helpful in the sometimes extremely tedious work of checking the material for, and in the presentation of, the survey of literature.

I have also received much help from colleagues outside the institute. Of these I recognize especially Professors Sune Carlson, Karl-Olof Faxén, Jan Hellner, Olle Hoflund, and Messrs. Magnus Hedberg and Dick Ramström; their help has greatly improved my conception of the problems involved.

Mrs. Nancy Adler translated the manuscript. She also aided me to a large extent in the editing, by her cooperation in the work of eliminating repetitions and clarifying the presentation.

Mrs. Ingrid Ekenäs and Mrs. Rita Holmberg typed the several manuscripts. Together with Miss Margareta Lundén, senior librarian at the Stockholm School of Economics, Miss Inger Hofverberg assisted me with the references. Mrs. Lillemor Ahlström has drawn the figures. Miss Ulla Hellström saw the manuscript through the press. I should like to express my warm thanks to all of them for their kind consideration.

From Kungafonden and Svenska Handelsbanken's Foundation for Social Science Research I have received generous grants which have facilitated the progress of the work. The Swedish Council for Social Science Research has financed the translating of the manuscript. To all these foundations I express my very sincere gratitude.

Lastly I would like to thank publishers of the works quoted herein for their kind permission to reprint certain passages.

Albert Danielsson

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CHAPTER 1

Introduction

1.1 THE ANALYSIS OF VARIATIONS FROM STANDARD COSTS AS AN AID TO CONTROL

Control

The concept *control* is usually given a very broad interpretation. The definition put forward by Kohler [1957] shows that a wide assortment of actions may be included in control:

Control: 1. The method and manner by which a person, or an organization, operation, or other activity is conformed to a desired plan of action . . . (*ibid.*, p. 123).

After giving this broad definition, Kohler goes on to say that control will cover fixing the goal, drawing up the plans, setting a standard of performance, studying the result of the plan on completion and finally altering the plan or its future execution.

In this study we shall conceive all these actions as stages in a flow of activities, as illustrated in Figure 1.1. The time axis in the figure illustrates only the order in which the measures occur. The distance between the points does not therefore indicate the length of the periods of time. The goal is fixed during time period t_0—t_1 and planning is instigated at t_1. Planning takes place during period t_1—t_2 and the resulting plan will be executed during period t_2—t_3. Following the study of results comes any corrective action: suggestions for changing the plan are passed on to the planning function at t_4 or suggestions for changing the way in which the plan is executed are released at t_5, when the (possibly) altered plan will also be presented.

We shall take Kohler's definition of control as a starting-point for our discussion of the analysis of variations from standard costs. This definition and our illustration in Figure 1.1 are both formulated in such a general way that they can be adapted to various types of goal, plan, execution, etc. In one company, for example, the goal

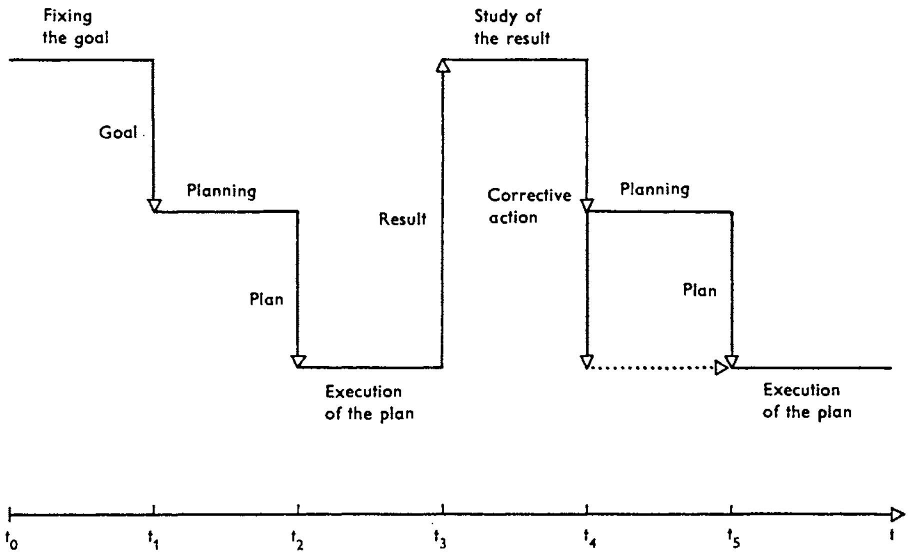

Figure 1.1 *The Flow of Activities: A Basis for the Following Discussion of Control*

may be a long-term increase in profits and the plan for one period may include the construction of a new factory to produce a new product. In a subsequent period, still with the same goal, the plan may be concerned with the volume of production and sales and with the method of achieving these with the resources available. Despite their different content, both these plans can be included in a flow of the type illustrated in Figure 1.1 and can be related to Kohler's definition of control, providing both execution and result have been suitably defined. The flow of activities which is to be controlled must be clearly specified with regard to the extent and content of the goal, the plan, the execution of the plan and the result, etc.

Review

The comparison between a plan and its execution constitutes one form of control, known as *review* or *evaluation*.[1] A review may be made with respect to several of the stages indicated in Figure 1.1, since the goal may be regarded as a plan in relation to the planning, the latter may be regarded as execution in relation to the goal and so on. A review may therefore cover all the stages in a control as defined by Kohler.

The completed review may be followed by corrective action, i.e. action of the kind alluded to in Kohler's definition and illustrated in Figure 1.1 at t_4 and t_5.

[1] The term *review* as used by Simon [1947], pp. 228 ff., seems to have the same meaning as the term *evaluation* in Rubenstein & Haberstroh [1960], p. 326. (Page references to Simon [1947] refer to the 2nd edition, 1957.)

The very fact that reviews are made is also likely to affect the way in which an individual fulfills his tasks, for

> . . . the anticipation of review and the invocation of sanctions secures conformity to authority of the decision made prior to review. It is for this reason that review can influence a prior decision. (Simon [1947], p. 234.)

It is usually necessary for purposes of review that the extent and content of the goal, the plan, etc. should be clearly specified. Simon [1947] discusses this problem by indicating three ways of carrying out a review: it may be concerned with the results of a subordinate's actions as seen in terms of his goals, or with the product (if any) or with performance (p. 231). The first way is used when the plan contains the goal of an organizational unit and consists of determining the degree to which the goal has been achieved. The second way presupposes that the plan includes specifications as to quantity and quality of products and that it is possible to evalute these when making the review. According to Simon the third way is probably the simplest and is the one that occurs most frequently at foreman level. (*Ibid.*, pp. 231 f.)

The three ways are not independent of one another. For instance the first presupposes that the plan is supplemented by a prediction of the result (see Figure 1.2), indicating the result expected if the execution agrees with the plan. The prediction presupposes (if we disregard pure guesswork) a fairly well specified model of the execution of the plan. In other words, if a review of the first type is to be possible, the execution of the plan must be so familiar that a model of it can be constructed. Otherwise it is difficult to see how a study of the result can be of any help in deciding what action might bring the plan and its execution into line with each other.

The study of results, which constitutes one stage in Kohler's definition of control, is one stage also in review. The other stages in Kohler's definition appear in a review in three respects: (i) a review may be made with regard to any of the stages in the flow of activities, (ii) a review, in the shape of a study of results, presupposes a prediction of results and (iii) the individual under review has anticipated this in the execution of his tasks.

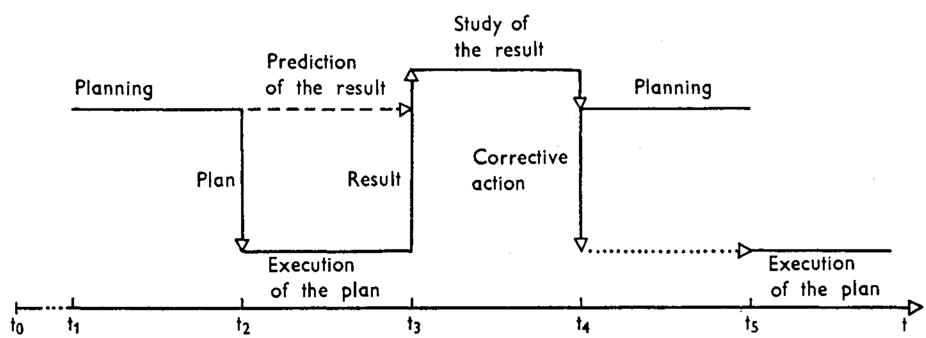

Figure 1.2 *The Flow of Activities: A Basis for the Following Discussion of Review*

The Analysis of Variations from Standard Costs

The *analysis of variations from standard costs*[2] is a review technique commonly met with in business enterprises. The analysis is made by means of a comparison between the result expected according to the plan and the result as revealed in the cost accounting. One distinguishing feature of this technique of review is the relation to the cost accounting, with the corresponding use of accounting terms. The result expected according to the plan is designated by the terms *standard* or *budget*. Standard is used mainly in the case of routine operations in the manufacturing departments, while budget refers to any of the activities of the company. A standard may be (i) the way in which a value of a variable is determined, (ii) the value itself or (iii) the variable to which the value refers. To distinguish these three meanings quite clearly we shall henceforth use the term *standard* in connection with (ii) only, i.e. standard value or, for short, *s-value*.

We are going to consider that part of the analysis of standard costs in which the result is defined in terms of the direct manufacturing costs. The variables considered will thus be the total direct manufacturing costs and their component parts.

Using the terminology introduced above we can now define the analysis of variations from standard costs as: (i) a comparison between the s-value and the observed value of the total direct manufacturing costs and (ii) the allocation of the difference between the s-value and the observed value of the total direct manufacturing costs to their component parts.

1.2 BACKGROUND TO THIS STUDY

The Aim of the Analysis of Variations from Standard Costs

The analysis of variations from standard costs provides a company with a control device or, as it has sometimes been expressed, the analysis forms one stage in *management by exceptions*. This latter interpretation seems to refer in particular to two aspects of the analysis: (i) no changes are made in the company's plans or the execution of their plans until and unless it has been demonstrated that the observed result is different from the s-value of the result; (ii) these differences, allocated to the various parts of the company, function mainly as signals for further investigations. Such investigations give some indication of possible future changes. This means that, unlike the flow of activities according to Figures 1.1 and 1.2 above, the analysis of the result is divided into two stages: first an analysis of variations from standard costs and, secondly, further investigations following the signals given by the analysis.

[2] Terminological note: We use the expression the *analysis of variations from standard costs* to designate the comparison between the result expected according to the plan and the result as subsequently revealed. We have expressly chosen the term *variation* to avoid confusion with the statistical term *variance*.

Some Trends in the Study of the Analysis of Variations from Standard Costs

The conception of the analysis, the determination of the s-values and the formulation of the analysis itself have all been discussed in the literature of the subject. Within these three fields the following trends can be perceived:

(i) Several writers[3] start by assuming that differences can always be expected as a result of mistakes in measurement, etc. Instead of seeking to improve methods of determining the s-value of the result or methods of observing the result as subsequently revealed or ways of making the analysis, they attack the problem by asking themselves when and under what conditions a difference shall be considered significant. Approaching the problem in this way they then investigate the possibility of applying methods of statistical quality control (in particular process control) to the analysis and try by these means to distinguish the differences for which an *assignable cause* might subsequently be discovered. It is possible that we have here the source of the above-mentioned view that the chief aim of the analysis is to provide signals for further investigations.

(ii) Stedry [1960] discusses the analysis of variations from standard costs in relation to motivation. Starting from specified assumptions as to how a person's performance is affected by the s-values of which he has been informed (and assuming that he understands that his performance will be evaluated in relation to these values), Stedry constructs a model of the person's behavior. With the help of this model he then discusses how the s-values shall be set. His conclusions differ from those put forward by previous writers.[4]

(iii) In the literature, a difference between standard and observed material usage is suggested as one explanation of a difference between standard and observed working time. The use of such an explanation implies the assumption of a relation between working time and material usage and, since this type of explanation occurs in connection with most of the variables concerned in the analysis, this in turn implies a network of relations between variables. How the analysis is formulated will of course depend on whether the variables are assumed to be related to one another or not. The first account of a method of formulating an analysis where relations between the variables are assumed, seems to be by Coward [1953]. One great difficulty in an analysis based on these assumptions is its dependence on the direction of the relations.

(iv) In all these approaches, the analysis of variations from standard costs is regarded from the point of view of company management. The writers are concerned with different ways of formulating the analysis to give management the best possible aid in running the company. In conclusion it should be mentioned that the subjects of control and evaluation have also been approached from other standpoints. For instance, Rubenstein & Haberstroh [1960] examine the shaping of systems of control and their influence on organization members (pp. 323 ff.).

[3] See for example Trueblood & Cyert [1957], including their bibliography.
[4] See pp. 13—5 ff. below where Stedry's conclusions are compared with conclusions reported in previous works.

The Analysis of Standard Costs

Every difference or, in view of what was said in (i) above, every significant difference[5] between a standard and an observed value of the result can in general be explained in different ways. The explanation will be of decisive importance for the choice of any corrective action. This is one reason why we consider it important to extend the analysis, if possible, to include an explanation of the differences.

As will be discussed in Chapter 3 below, there are great similarities between an explanation and a prediction. In fact when a predicted value agrees with an observed value the prediction can be used as the explanation of the latter. In this study, therefore, we shall concentrate also on the construction of the predictions. This wider approach can best be covered by the term *measurement and analysis of standard costs* (henceforth referred to simply as the *analysis of standard costs*).

Fields of Activity to be Considered

By taking the approach discussed above we have assumed that each comparison between a predicted and an observed value is made more than once, which in turn presupposes that the activities concerned are repeated. What is meant more exactly by saying that certain activities are repeated and what indicates in advance that a certain activity is repeatable, are questions all too comprehensive for us to embark on here. We shall simply note that certain characteristics of activities recur and that these characteristics can be incorporated into models.[6]

In some of the activities which will be the subject of review, the same plan is used repeatedly. In order to indicate clearly that we refer to a repeatable plan we shall in future employ the term *program,* as used by March & Simon [1958]. The term program rather than plan is applied, for instance, to the relatively routine operations performed by workers and foremen within the production departments, where the concept of standards applies. In the title of this report we have already indicated that our present study is limited to activities where standards (as opposed to budgets) are applied. If the field of application of this study is somewhat limited, the desideratum of repeatability seems justification enough. In any case, since many of the main points that we make (e.g. about how to formulate the problem, how to construct the models etc.) are applicable to all forms of review, this limitation does not seem too serious.

Plan of the Study

An analysis of standard costs as conceived in this study will contain the following main stages: (i) a prediction of the value of the result, (ii) a comparison between the predicted and the observed value of the result and (iii) an explanation of the differ-

[5] From now on, difference will be taken to mean significant difference.
[6] The reader is referred to Ofstad [1961], p. 51, for further details on this point.

ences between the s-values and the observed values of the result and of its component parts. We shall take as our starting-point the treatment of the subject in the existing literature, which we present in Chapter 2. In Chapter 3 we introduce our own theoretical notion of the analysis. An important feature here is the use of models in predictions and explanations. In our introductory discussion of control and review above, we made preliminary mention of the activities to be considered. Even at that stage we noticed some important questions concerning the formulation of the models, in particular the need for closer specification of plans, execution, result, etc. and the selection of characteristics by which to designate the result. The framework for the analysis is constructed in Chapter 4, while the construction of models for use in predictions and explanations of the result will be the subject of Chapters 4 through 6. Observations of the result and of its component parts will be discussed in Chapter 7. With the material from Chapters 2 through 7 in mind, we shall undertake in Chapter 8 a formulation and discussion of the analysis of standard costs. The comparison between the predicted and the observed values of the variables used to characterize the result, presupposes that the definition of the variables in the model is related to their definition in the observation. The difficulties involved can be most easily studied with regard to the direct manufacturing costs and their component parts: working time, material usage, material price and wage rates. It is our wish to keep the study within reasonable limits, which will lead us to restrict our definition of the considered result in this way. The report will, however, touch upon the definitions with regard to more comprehensive variables too, so that the views presented here will probably be of interest beyond the limits that we have set.

CHAPTER 2

The Analysis of Direct Standard Costs: Survey of Literature

2.1 PRESENTATION OF THE SURVEY OF LITERATURE

This chapter consists mainly of a literary survey. Our aim is not to describe the historical development of the analysis of standard costs,[1] but rather to provide a survey of the way in which the subject has been treated in recent literature.

As initiator of numerous studies in this field the American organization, the National Association of Accountants (previously National Association of Cost Accountants), holds a predominant position. This organization, aided by its own research staff, has carried out extensive studies and has also published in its bulletins numerous articles by other independent authors.[2]

The literature of standard costs reveals considerable uniformity in its conception of the analysis and of the variables to be included, and in its treatment of the s-values.[3] In the following survey two of the publications of the above-mentioned organization will represent these fundamental viewpoints. Other works have been quoted mainly in so far as they contain complementary or deviating views.

We have tried to avoid taking a stand or commenting on the views reported, but it is naturally unavoidable that our own conceptual framework and our own aim should influence our choice of citations.

The literature of the subject generally treats the analysis of variations from standard costs under three separate headings: (i) methods for determining the s-values, (ii)

[1] For a historical account the reader is referred to Solomons [1952], quoted below, and to two articles by Jackson, J. Hugh, A Quarter-century of Cost Accounting Progress, *N.A.C.A. Bulletin*, 28 (1947): 19 and A Half-century of Cost Accounting Progress, *N.A.C.A. Bulletin*, 34 (1952).

[2] We refer to the works of the organization by the initials N.A.C.A. and N.A.A. with the year of original publication in brackets. Works by independent authors are referred to by the author's name and the year of publication.

[3] Cf. for example Batty [1960], Bennett [1957], Cattela [1948], Chamberlain [1962], Frenckner [1953], Gillespie [1957], Henrici [1960], Horngren [1962], Kosiol [1956], Madsen [1959], Shillinglaw [1961], Sord & Welsch [1958], Stedry [1960], Vance [1952] and Welsch [1957].

how to carry out the analysis of variations from standard costs and (iii) how to use the analysis for purposes of control. We have followed this division here with the addition of a special section (iv) which covers the subsequently observed values of the variables.

2.2 TREATMENT OF THE VARIABLES

A Historical Line of Development

It is essential that we distinguish at any rate one of the sources of the development of standard costs and, indirectly, of the analysis of standard costs, although we shall in the main ignore the historical development within our field of study. We refer now to the relationship, which is pointed out in several works,[4] between our subject and the scientific management movement.

Solomons [1952] declares that any discussion of the origins of standard costing must take into account its close relationship with this movement. The determination of standard costs is based on standard processes and standard times for carrying out the operations concerned; both the concept of standard process and the methods of measuring the times etc. have been developed by Taylor and his successors. Solomons concludes his discussion of the importance of the scientific management movement by pointing out that it is not possible to read an article by Taylor from 1903

> . . . without seeing that many of the essential elements of standard costing are there, including what is perhaps the first reference to "management by exception". (*Ibid.*, p. 40.)

Our reason for pointing out the relation of standard costing and, indirectly, of the analysis of variations from standard costs to the scientific management movement is that the latter forms one of the lines of development within classical organization theory (March & Simon [1958], p. 12). In the following chapters we use this relation as a connecting link to more recent developments in organization theory.

The influence of the scientific management movement still makes itself felt, as can be seen from the following much quoted definition of standard:

> A standard under modern scientific management is simply a carefully thought out method of performing a function, or carefully drawn specification covering an implement or some article of stores or of product. . . . The standard method of doing anything is simply the best method that can be devised at the time the standard is drawn.[5]

There is, however, another side to the influence of the scientific management movement. The description of human behavior, on which the time and methods studies of Taylor and his successors are based, has also been adopted.

[4] See for example Bennett [1957], p. 4, Lang, McFarland & Schiff [1953], p. 3, N.A.C.A. [1948], pp. 2 ff., Solomons [1952], p. 3 and Horngren [1962], pp. 147 ff.

[5] Quoted from N.A.C.A. [1948], p. 2. The definition is also quoted by Kohler [1957], p. 447.

In time and methods study, the scientific management group was concerned with describing the characteristics of the human organism as one might describe a relatively simple machine for performing a comparatively simple task. (March & Simon [1958], p. 13.)

When the s-values are determined in a company, certain of the reactions of the people affected can be traced back to the scientific management movement.

After the standard is set tentatively by the technicians, it must be reviewed with, and approved by, the foreman in whose operation it will be applied. Unless the foreman agrees that a standard is fair, his reaction to variances will be defensive rather than corrective. (Keller [1957], p. 98.)

This attitude can be seen as a practical consequence of the ideas quoted above from March & Simon [1958].

The Variables Chosen

Review has been discussed in relation to all the spheres of activity of a company, i.e. purchasing, manufacturing and selling. In this study we shall deal only with manufacturing, as has already been explained, although some mention will also be made of purchasing.

The following are some of the possible variables by which a manufacturing operation can be defined for purposes of review: number of units manufactured (length of series), working time, wage rates, material usage, utilization of tools, price of tools, consumption of oil coolant, price of oil coolant, consumption of power, price of power, utilization of machines, price of machines, etc.; labor costs, material costs, indirect manufacturing costs and so on; manufacturing costs (we shall ignore the revenues, since we are limiting ourselves to manufacturing). We have already mentioned that in this study we are going to consider *working time*, *wage rates*, *material usage* and *material price* (i.e. *standards*) only, together with the *labor costs* and *material costs* (i.e. *standard costs*) which stem from these.

The necessity of the conversion from standards to standard costs, by means of pricing, is sometimes questioned on the grounds that a control of usage simultaneously implies a control of costs.

Conceptually, there is little difference between controlling input or output in physical units as opposed to dollar terms, although they may require different procedures.
... the choice of a common denominator ... is in reality fairly arbitrary, and hence the terms "standard" and "standard cost" can be used more or less interchangeably, at least in a theoretical document of this kind. (Stedry [1960], p. 7.)

However, Stedry points out that for practical reasons it may be necessary to choose one or the other type of variable.

The advantages of such a conversion are summarized in N.A.C.A. [1948]:

(i) The relative importance of the differences expressed in terms of costs is essential so that cost-saving action will not be misdirected.

(ii) Management needs summarized data for its own information. Costs furnish a good basis for comparison.

(iii) Physical standards cannot be used for inventory costing, pricing and so on.

(iv) Physical standards cannot be used as a basis for studying profit divided among classes of products, customers or marketing operations. (*Ibid.*, p. 24.)

Apart from arguing for or against the usefulness of the conversion, as in the quotation above, the literature of the subject has little to say about, for example, its premises or significance.

Methods of Determining the s-Values

Material Usage

Three methods for determining the s-value of material usage are distinguished in N.A.C.A. 1948:

(i) Engineering studies to determine the best type of material and the quantity required. It is assumed that attention will be paid to the methods of production, the quality of the finished product and so on.

(ii) Study of previous experience of the same or similar products (an average of previous usage or usage during one apparently typical period). This method is criticized among other things because previous usage may include indeterminable "past waste and excess uses". The most serious objection is that this method does not aim at "the best combination of quantity, methods, and product quality as does the engineering study method". The only advantage cited is that this method is cheaper than the previous one.

(iii) Test runs under controlled conditions. It is held that this method avoids some of the most serious disadvantages of method (ii), since manufacturing conditions can be standardized and "extraneous causes of variation eliminated".

The N.A.C.A. study cited here is based on an empirical investigation and concludes by saying that the majority of the companies studied use a combination of the methods, although approximately two-thirds of them relied mainly on engineering studies. (*Ibid.*, pp. 26—7.)

Working Time

The s-values of working time are usually fixed by means of time studies.

In determining the amount of time used in the different operations, the "surrounding conditions that influence the effectiveness with which the employee performs his task" have to be standardized. According to N.A.C.A [1948] this standardization process should include the following:

(i) Consideration of the workplace, machines, tools and transport facilities in order to standardize them and provide the worker with "the best practicable arrangement under existing circumstances".

(ii) Control of materials should be arranged so that the worker is supplied with the right quality and quantity "in the proper place". This requires that purchasing, receiving and storekeeping methods should be studied, as should also the plant transportation system and the placing of materials at the work place.

(iii) A system of planning, routing and dispatching work should be developed.
(iv) All the necessary instructions to the worker should be furnished either by means of general training or by directions for each specific job. (*Ibid.*, p. 37.)

Material Price and Wage Rates

Unlike material usage and working time, the material price and wage rates are also involved in other spheres of activity, e.g. the execution of purchasing and personnel matters. These spheres are more exposed to external influences than manufacturing. This means that it has not been possible to use the methods that have developed from the scientific management movement in determining the s-values of these two variables.[6]

Material price is thus usually given an expected value, i.e. an expected price rather than an "efficient or desired price". The majority of the companies in the N.A.C.A. study reported that their s-values of material prices were based on a forecast of the expected price. (*Ibid.*, p. 33.)

The s-value of wage rates is related to what are known as base rates, fixed mainly by collective agreement with the trade unions. Differences depending on changes in wage rates were reported as insignificant since the s-values of wage rates were revised when the wage rates were changed. Wage rates can aid in the control of costs since certain differences between standard and observed values do arise from circumstances which can be influenced by management. The two most common of these are: the use of overtime, trainees etc. and "using a man with the wrong rate for the job". (*Ibid.*, pp. 36 ff.)

The fact that material price and wage rates are related to more spheres than just production bears on the meaning of the conversion to the variables known as standard costs.

Some Critical Views on the Determination of the s-Values

One view of the advantages and usefulness of standard values is the following, quoted from N.A.C.A. [1948]:

> The reliability of standard costs stems from the fact that they have been based upon careful studies of material usage requirements, operation methods and times, variability of cost with volume, and the best arrangement of equipment. Furthermore the standards have been tested and performance under them has been recorded so there is a good basis for predicting what performance can be expected in the future. (*Ibid.*, p. 17.)

This view is not universally shared. One very detailed critical study of certain parts of the methods used for determining the s-values of working time has, for instance, been made by Abruzzi [1952].

[6] Cf. Kosiol [1956], pp. 55 ff. Kosiol states that an important German contribution to the analysis of standard costs lies in the separation of variables relating to production in the technical sense from variables that relate to market conditions. This distinction has resulted in the development of two types of cost accounting: a *Standardkostenrechnung*, containing the former type of variables and a *Prognosekostenrechnung*, containing the latter type of variables.

In the scientific management movement, *the best way* of carrying out an operation plays a predominant role. The concept of the best way has been taken over by standard cost literature; the quotation above provides an example of this. Abruzzi calls this "the one best way concept" and declares that ever since it was created by Gilbreth it has been incorporated in some version or other in almost every work on time and motion study. In general the one best way is said to be the most economical way as regards number and type of movements used in carrying out an operation. In practice this is usually understood to mean the method taking the least time "consistent with the results achieved by skilled workers, using a superior sequence of motions" (*ibid.*, p. 217). According to Abruzzi mere intuition is sufficient to reveal the weakness of this concept because a method which is "best" from a psychological point of view need not necessarily be the "best" also from the technical standpoint.

Abruzzi's main opposition, however, is based on the extensive empirical studies which he carried out in two companies. He says that what he learned from these

> . . . conclusively shows that each worker organizes both the gross and the minute aspects of the work method in a characteristic manner. (*Ibid.*, p. 217.)

He interprets this result as showing that the best way is an idealization, and that its only justification lies in the fact that the work methods used by a group of workers have certain rough features in common.

> To illustrate this point, the element breakdowns for all the operations in plant A were developed by the plant's time-study staff. These breakdowns were then taught to the workers in formal training periods and on-the-job instruction programs. In spite of that, workers were found to have substantially different work methods, especially at the element level. (*Ibid.*, p. 218.)

Abruzzi's results and his interpretation of them seem relevant to many of the questions discussed in the literature referred to above. In the following chapters, however, we shall make use in particular of one point, namely the difficulty of describing human behavior even in the relatively routine tasks usually performed by the industrial worker and forming the subject of time studies etc.

The Attainability of the s-Values

A certain amount of judgment is required in applying the s-values, cf. the discussion above. This judgment is usually discussed in relation to the attainability of the s-values.

In the literature of the subject three types of attainability are generally distinguished:

(i) An *ideal standard* represents "the best performance possible" with regard to the equipment available. Slight adjustments for rest pauses and personal needs are allowed for, but not "waste, spoilage, or lost time . . ." It is not expected that these values will be attained in actual operations, but the standards imply goals towards which one should strive in order to increase efficiency.

(ii) An *attainable good performance standard*, from which all waste, spoilage, lost time, etc. has not been eliminated, but has been included to the extent that management considers it "impractical of elimination during the time the standard is to be in effect." A standard of this type can be attained and even improved upon, but only by means of what is considered "efficient performance".

(iii) An *average past performance standard*[7] is based on previous performance without adjustments for possible improvements in method or previous "wastes and inefficiencies". A standard of this type is usually considered to be considerably "looser" than either of the previous types. (N.A.C.A. [1948], p. 8.)

In our discussion of the methods of determining the s-value of material usage, some critical views of the average past performance standard were mentioned. The point of these criticisms seems to be that it is not possible to determine the degree of attainability.

In the literature of the subject there seems to be agreement that an attainable good performance standard provides a goal that ought to be attained.[8] The train of thought behind this idea is related to the two possible effects of review on performance (cf. p. 3 above): (i) a review may be followed by action intended to bring performance into line with the program and (ii) the review and the subsequent action are anticipated and are therefore expected to affect the manner in which an individual will perform his work.

If these influences are to be effective, it is necessary that the individuals

> ... accept it [the s-value] as a fair and attainable yardstick of their performance. Generally, operating executives were inclined to accept a standard to the extent that they were satisfied that the data were *accurately recorded*, that the standard level was *reasonably attainable*, and that the variables it measured were *controllable* by them. When there were doubts as to the accuracy of recording or classification of data, when the factors causing variances were thought to be beyond their own control, the executives simply did not believe that the standard validly measured their performance. Then they were influenced by it only to the extent that they were forced to think about the reactions of their superiors. (Centralization [1954], p. 29.)[9]

This implies that the individual assumes that no action aimed at altering the program (i.e. also the s-value) will be taken as a result of the review.

Stedry [1960] presents the somewhat conflicting view that it is by no means necessary for an s-value to be attainable and in fact there can be situations where an unattainable s-value is a stronger incentive. His view seems to be based in the main on the postulate:

> ... the *aspired level of expenditure* will be lowered in response to a lowering of the *budgeted level of expenditure*. (*Ibid.*, p. 24.)

This postulate presupposes that the individual assumes that his performance will be evaluated in relation to the previously announced s-values. In other words he expects that every variation from the s-values will lead to action (sanctions, rewards) directed at him and not to action aimed at altering the program and, thus, the s-value.

[7] The term *basic standard* is also used by some authors. The method of approach in determining the s-values referred to by this term shows certain similarities with the method of approach according to *average past performance*.

[8] Cf. for example Henrici [1960], p. 347, Keller [1957], p. 99, Kohler [1957], p. 446, N.A.C.A. [1948], p. 8 for example, Schneider [1945], p. 77 and Stedry [1960], p. 9.

[9] Similar views with regard to attainability are put forward by Henrici [1960], p. 48, Keller [1957], p. 99 and N.A.C.A. [1948], p. 8.

An ideal standard is conceived throughout the literature as a goal to strive for. The use of s-values of this type seems to imply greater commitment on the part of the organization members than the use of attainable standards. Otherwise the fact that the goals were unattainable would probably exclude the two effects of review mentioned above. Apart from the question of motivation, however, ideal standards give rise to difficulties in the interpretation of a review. In this study we have therefore considered attainable standards only.

Testing and Changing the s-Values

Keller [1957] points out that the s-values fixed for attainable standards are often tested by the companies' accounting departments before they are used. The test is usually made by applying the values to the production result of a previous period, usually a typical month. The s-values are then compared with the actual values (already known) for the period in question. A difference of $\pm$ 2—3 % is regarded as reasonable while a greater difference must be explained by planned changes in method or abnormal conditions during the selected period. (*Ibid.*, p. 104.)

However, a more common subject of discussion in the literature is the necessity of changing the s-values to match changing conditions. It is pointed out in N.A.C.A. [1948], for example, that the s-values which are intended for purposes of control must be kept up-to-date if they are to supply reliable measures of the efficiency of work performance. Whenever considerable changes are made in production methods, labor efficiency or material specifications, the s-values must also be revised. (*Ibid.*, p. 12.)

Who Determines the s-Values?

Both technical and economic knowledge is considered necessary for determining the s-values. It should therefore be done in cooperation between a time and methods study department and the cost department of the company. The literature contains many essentially practical views on these questions. The presentation there seems to be based on the following basic principle as stated in N.A.C.A. [1948]:

> The production department itself rarely sets material standards since it is considered undesirable for the persons held responsible for meeting the standards to have final authority to set the standards (p. 29).

2.3 OBSERVED VALUES

In previous sections the s-values have been discussed in some detail. The observed values of the variables are just as important in any discussion of the analysis of variations from standard costs. And the study of observed values will be even more important if the conception on which we have based our aim in this study is accepted.

The following is quoted from N.A.C.A. [1948]:

Actual cost is used here to mean the cost which is accumulated during the process of production by the usual historical costing methods as opposed to the cost which has been determined in advance of the production process. The term "actual" is not intended to convey any implications as to the accuracy with which costs are measured. (*Ibid.*, p. 1.)

A similar view is put forward by Kohler [1957] in his dictionary under *actual cost* (p. 24).

Thus the observed values are obtained from the company's cost accounting department. In books on standard costs readers will usually find either a discussion on the various ways in which this costing can be arranged, or a reference to accounting literature.

If the observed values, as obtained from the cost accounting, are to provide a suitable base for testing the prediction and the model, it will be necessary, among other things, that the variables be defined in the same terms in the models and in the cost accounting.

On several occasions in the following chapters we shall touch upon the definition of the variables in the model and discuss the relations between the standard and the observed values of the variables. It would be going too far, however, to attempt any full treatment of the relations, thus becoming involved in the reformulation of the cost accounting which would be necessary.

2.4 THE TECHNIQUE OF THE ANALYSIS OF VARIATIONS FROM STANDARD COSTS

Both in literature and in practice different methods can be found for the analysis of the differences between the standard and the observed values. The analysis may take the form of a simple comparison between the two values of, for example, working time and material usage. It may also be developed into a complete analysis of the total result of the company, including a comparison between all the revenues and costs.

Statistical methods can be used both when the differences are determined and when they are evaluated.[10]

The technique for making an analysis of variations from standard costs can be illustrated by (i) diagrams, see, for example, Coward [1953] and Solomons [1951], (ii) a set of accounts, see, for example, Vance [1952] and (iii) algebraic expressions, see, for example, Frenckner [1958] and Schneider [1945].

[10] It has already been pointed out that it is desirable to test whether or not a variation from the s-value is significant, before it is made the subject of an analysis or the basis for action. The technique for analyzing variations from standard costs can be used for both significant and non-significant differences.

Analysis of Variations from the s-Values of Unrelated Variables

In this section we shall discuss how to go about an analysis of variations from the s-values of material usage, working time, material price and wage rates, when these variables are not related to each other. Our presentation is based mainly on Frenckner [1958].

Apart from the limitation in the number of variables, our analysis will cover only the total direct manufacturing costs for the whole company, one set of activities or one particular department in the company, etc. during a fixed period of time, for example one month. The total direct manufacturing costs thus represent the variable which is used to define the *result.*

In the literature of the subject it is usually assumed that the result is defined in terms of a more comprehensive variable, e.g. total manufacturing costs for the period. It is generally assumed that the *total manufacturing costs* (C) are obtained from

$$C = c_M + c_W + c_O, \qquad (2.1)$$

where c_M designates the total costs for direct material (to be referred to henceforth as *total material costs*), c_W total costs for direct labor (henceforth *total labor costs*) and c_O *total indirect manufacturing costs.* Formula (2.1) thus states that the value of total manufacturing costs consists of the sum of the values of total material costs, total direct labor costs and total indirect manufacturing costs.

We shall present the analysis of differences between the s-values and the observed values in stages. The first stage consists of a comparison between the s-value and the observed value of the result, in which the difference between the values, known as the total difference, is stated. When the result is defined in terms of total manufacturing costs, the second stage consists of dividing the total difference among the three variables included in (2.1), c_M, c_W and c_O. The next stages comprise separate comparisons for each of the three variables.

When the result is defined in terms of the *total direct manufacturing costs* (C_D), as it is in this study, (2.1) can be replaced by

$$C_D = c_M + c_W. \qquad (2.2)$$

Since the analysis of variations is carried out separately for each of the variables c_M, c_W and c_O, the fact that the result is limited to C_D does not affect the analysis of c_M and c_W.

Total material costs, c_M, and total labor costs, c_W, are usually defined as follows:

$$c_M = x q_M p_M \qquad (2.3a)$$

and

$$c_W = x q_W p_W, \qquad (2.3b)$$

where x designates *quantity manufactured,* q_M *material usage* per unit of x, p_M *material price* per unit of material (i.e. per piece, pound, yard, gallon etc.), q_W *working time* per unit of x and p_W *wage rates* per hour.

Stage 1: Determining the Total Difference

The analysis is carried out for the s-values and the observed values of the variables included in (2.2), (2.3a) and (2.3b). The s-value of a variable is indicated by the designation of the variable plus an index b and the observed value by the designation of the variable plus an index a (actual, see above). The difference between the s-value and the observed value of C_D can then, in accordance with (2.2), (2.3a) and (2.3b) be expressed as follows:

$$C_{Db} - C_{Da} = (c_{Mb} - c_{Ma}) + (c_{Wb} - c_{Wa})$$
$$= (x_b q_{Mb} p_{Mb} - x_a q_{Ma} p_{Ma}) + (x_b q_{Wb} p_{Wb} - x_a q_{Wa} p_{Wa}). \quad (2.4)$$

Stage 2: Variation from the s-Value of Total Direct Manufacturing Costs as a Result of Changes in the Value of the Quantity Manufactured[11]

With an observed value of x_a for the quantity manufactured, the expected value of C_D, which is designated $C_{Db'}$, will be $x_a(q_{Mb}p_{Mb} + q_{Wb}p_{Wb})$. The difference between C_{Db} and $C_{Db'}$ is the difference which can be distinguished when the observed value of the quantity manufactured has differed from the forecasted value.

$$C_{Db} - C_{Db'} = x_b(q_{Mb}p_{Mb} + q_{Wb}p_{Wb}) - x_a(q_{Mb}p_{Mb} + q_{Wb}p_{Wb})$$
$$= (x_b - x_a)\ (q_{Mb}p_{Mb} + q_{Wb}p_{Wb}). \quad (2.5)$$

Stage 3: Dividing the Remaining Variation from the s-Value of C_D between c_M and c_W[11]

There are two ways in which the remaining difference, $C_{Db'} - C_{Da}$, may be divided between c_M and c_W. According to the method which is more immediately simple, and which occurs in the literature of the subject, we start from the remaining difference and obtain

$$C_{Db'} - C_{Da} = x_a(q_{Mb}p_{Mb} + q_{Wb}p_{Wb}) - x_a(q_{Ma}p_{Ma} + q_{Wa}p_{Wa})$$
$$= x_a(q_{Mb}p_{Mb} - q_{Ma}p_{Ma}) + x_a(q_{Wb}p_{Wb} - q_{Wa}p_{Wa}). \quad (2.6)$$

Alternatively the division can be carried out in two stages. First the expected value of C_D is determined, given the observed value of c_M. This value of C_D, which is designated $C_{Db''}$, is subtracted from $C_{Db'}$, to give the difference in c_M. Then C_{Da} is subtracted from $C_{Db''}$, which gives the difference in c_W. This alternative method gives the same value as was obtained from (2.6).

Stage 4: Division of Differences in c_M and c_W into Quantity and Price Differences

In stage 4 the analysis is carried out in the same way for both c_M and c_W. This stage is thus illustrated for both variables together without indicating their designations.

According to (2.6) the difference which is divided between c_M and c_W is: $x_a(q_b p_b - q_a p_a)$. In a complete analysis it would be desirable to separate first the difference which is related to the variation between the s-value and the observed value of usage (quantity difference) valued at the s-value of the price, i.e. $(q_b - q_a)p_b$ and secondly, the difference which is related to the variation between the s-value and the observed value of the price (price difference) calculated in accordance with the s-value of the usage, i.e. $(p_b - p_a)q_b$. The sum of these two variations is not

[11] The order of stage 2 and stage 3 has been reversed to facilitate comparison with our later study of an analysis in which relations between variables are assumed.

however equal to $x_a(q_b p_b - q_a p_a)$. We can however add a residual (and for the time being unknown) quantity, k, and re-write the last formula:

$$x_a(q_b p_b - q_a p_a) = x_a[(q_b - q_a)p_b + (p_b - p_a)q_b + k]. \tag{2.7}$$

The residual k must be included in (2.7) since we are measuring the quantity difference at the s-value of the price without taking into account that there may have been a simultaneous price difference. The same will be the case with regard to the price difference. It is possible to find k from (2.7) as follows:

$$k = (p_b - p_a)q_a + (p_a - p_b)q_b = (q_a - q_b)p_b + (q_b - q_a)p_a. \tag{2.8}$$

k can be added either to the quantity difference or the price difference and (2.7) will then be replaced by either

$$x_a(q_b p_b - q_a p_a) = x_a[(q_b - q_a)p_a + (p_b - p_a)q_b] \tag{2.7a}$$

or

$$x_a(q_b p_b - q_a p_a) = x_a[(q_b - q_a)p_b + (p_b - p_a)q_a]. \tag{2.7b}$$

If the value of k is added to the quantity difference this will mean, as can be seen from (2.7a), that the latter is estimated at the observed value of the price and that the price difference is estimated at the s-value of the quantity. If on the other hand the value of k is added to the price difference, the price difference is calculated at the observed value of the quantity while the quantity difference is calculated at the s-value of the price.

The choice of approach can lend itself to various interpretations. If, for example, the quantity difference is calculated as in (2.7b) at the s-value of the price, this can mean that the person or department who is responsible for the size of material usage will have this responsibility evaluated at the s-value of the price. The situation may be, for example, that a certain department is in charge of purchasing and the person responsible for material usage is unable to influence the price. At the same time it is obvious that this type of division of responsibility does not contain any incentive towards trying to save materials when material prices rise. (This bears witness to a genuine difference between standards and standard costs.)

The first reference in the literature of the subject to the problems surrounding a variation which is related to simultaneous changes in price and quantity seems to have been made by Vance [1950], pp. 625—32. He mentions at the same time that the conventional way of making an analysis is that represented here by (2.7b). (*Ibid.*, p. 627.)

It may be of interest to point out that the problem of simultaneous changes in two or more variables is by no means limited to this type of analysis. In text-books on differential and integral calculus, e.g. Thomas [1956], pp. 489 ff., the change in a related variable resulting from changes in two unrelated variables is discussed as part of the introduction to partial differentiation.

The variables may be designated x, y, z and the changes as $\triangle x$ etc. If $\triangle x$ is represented by $(q_b - q_a)$ and $\triangle y$ by $(p_b - p_a)$, we get the following:

$$\triangle x \triangle y = (q_b - q_a)\ (p_b - p_a) = k \tag{2.9}$$

In conclusion we may note that it is naturally possible to distinguish a residual k

when analyzing changes in the volume of production. It appears however that the analysis of these differences is carried out in the way indicated by (2.5) above, cf. similarity to (2.7b), and we shall therefore abandon this point.

Analysis of Variations from the s-Values of Related Variables

Some of what has been said above about the method of determining the s-values of the variables, shows that it is assumed that at least some of the variables are related to each other; cf. for instance, the statement cited from N.A.C.A. [1948] (p. 11 above), where the s-value of working time is determined on the assumption of a fixed value of material usage. A further indication of the assumption that variables are related to each other can be seen in the suggested explanations that are put forward in the literature for a variation from the s-values. Thus in the case of working time, for instance, a simultaneous variation from the s-value of another variable, e.g. material usage, is one of the suggested explanations.[12]

Ideas which seem to have appeared first in Coward [1953], pp. 156—62, have provided the main basis for our presentation of an analysis with related variables. As an example of these relations and their importance for the analysis we can take the relation material usage/working time, where the value of working time increases (decreases) as the value of material usage decreases (increases). In general the relation can be given the following formulation:

$$q_W = f(q_M, \ldots). \tag{2.10}$$

For the purposes of the following discussion, (2.10) is assumed to have the form

$$q_W = \alpha - \beta q_M, \qquad (\alpha,\ \beta > 0) \tag{2.11}$$

Stage 1: Determinin, the Total Difference

Here too the total difference can be determined according to (2.4).[13] In view of our later presentation, however, we shall express it as

$$\begin{aligned} C_{Db} - C_{Da} &= (c_{Mb} + c_{Wb}) - (c_{Ma} + c_{Wa}) \\ &= x_b[q_{Mb}p_{Mb} + (\alpha - \beta q_{Mb})p_{Wb}] - x_a[q_{Ma}p_{Ma} + q_{Wa}p_{Wa}]. \end{aligned} \tag{2.12}$$

Stage 2: Difference in Total Direct Manufacturing Costs as a Result of Changes in Quantity Manufactured

This stage, too, can be carried out in the same way as before, i.e. according to (2.5).[13] Taking (2.11) into account, however, we express the difference between C_{Db} and $C_{Db'}$ as

$$C_{Db} - C_{Db'} = (x_b - x_a)[q_{Mb}p_{Mb} + (\alpha - \beta q_{Mb})p_{Wb}]. \tag{2.13}$$

[12] See, e.g. N.A.C.A. [1952], pp. 560 ff. (Cf. also Figure 2.1, p. 25 below.)
[13] According to (2.11) q_{Wb} will be equal to $\alpha - \beta q_{Mb}$.

Stage 3: Dividing the Remaining Variation from the s-Value of C_D between c_M and c_W

The remaining difference, $C_{Db'} - C_{Da}$, will, in accordance with (2.12) and (2.13) be

$$C_{Db'} - C_{Da} = x_a[q_{Mb}p_{Mb} + (\alpha - \beta q_{Mb})p_{Wb} - q_{Ma}p_{Ma} - q_{Wa}p_{Wa}]. \quad (2.14)$$

If it is assumed that q_M and q_W are related, then the third stage must be divided. Given the observed value of material usage, i.e. q_{Ma}, we shall expect according to (2.11) a change in the value of working time. If we do not wish to include this difference in that part of the total difference which is assigned to q_W, we must determine an expected value for the total direct manufacturing costs (C_D) in accordance with (2.3a), (2.11) and (2.2), given the observed value q_{Ma}. The expected value of C_D would have been the same as the s-value of C_D, if the s-value of q_M had been q_{Ma} instead of q_{Mb}. The difference between the s-value and the expected value of C_D therefore expresses the difference in total direct manufacturing costs resulting from the difference between the s-value and the observed value of q_M.

Stage 3a: Assigning the Remaining Variation from the s-Value of C_D to c_M

Since part of the total difference has already been assigned to the change in the quantity manufactured, we can estimate the expected value of C_D, which in the course of stage 3 in the previous subsection was designated as $C_{Db''}$, according to

$$C_{Db''} = x_a[q_{Ma}p_{Ma} + (\alpha - \beta q_{Ma})p_{Wb}]. \quad (2.15)$$

The difference between $C_{Db'}$ and $C_{Db''}$ will be

$$C_{Db'} - C_{Db''} = x_a\{q_{Mb}p_{Mb} - q_{Ma}p_{Ma} + [(\alpha - \beta q_{Mb} - \alpha + \beta q_{Ma})p_{Wb}]\}$$
$$= x_a[q_{Mb}p_{Mb} - q_{Ma}p_{Ma} - \beta(q_{Mb} - q_{Ma})p_{Wb}]. \quad (2.16)$$

As against (2.6) in stage 3 of the analysis of unrelated variables, we have here a negative term $x_a\beta(q_{Mb} - q_{Ma})p_{Wb}$, expressing the change in the value of C_D resulting from the change in the value of q_M.

Stage 3b: Assigning the Remaining Variation from the s-Value of C_D to c_W

What still remains of the total difference is now assigned to total labor costs.

$$C_{Db''} - C_{Da} = x_a[q_{Ma}p_{Ma} + (\alpha - \beta q_{Ma})p_{Wb} - q_{Ma}p_{Ma} - q_{Wa}p_{Wa}]$$
$$= x_a[(\alpha - \beta q_{Ma})p_{Wb} - q_{Wa}p_{Wa}]$$
$$= x_a[q_{Wb}p_{Wb} - q_{Wa}p_{Wa} + \beta(q_{Mb} - q_{Ma})p_{Wb}]. \quad (2.17)$$

It can be seen from this last step that the difference in total labor costs according to (2.17) differs from (2.6) by the positive term $x_a\beta(q_{Mb} - q_{Ma})p_{Wb}$, i.e. by the same absolute amount as the variation in total material costs.

The fourth stage, the division of the differences distinguished according to (2.16) and (2.17) into a quantity and a price difference need not be illustrated. Apart from the fact that the terms arising in (2.16) and (2.17) are assigned to the quantity difference, the division leads to the same result as in the previous subsection.

Dividing the Result into Components

Providing that the two methods presented in the two previous subsections start from the same values of the variables, the total difference will be the same. The question asked in a comparison of methods may therefore be: how is the total difference divided among the variables included in the analysis? The variables included in the analysis are sometimes referred to as *result components* and the division of the total difference as *decomposition*.[14] Making use of these terms we can say that this comparison concerns among other things the premises for decomposition according to one or the other method.

Madsen [1956], pp. 135 ff. and [1959], pp. 105 ff., says that for a decomposition according to the first of the two methods presented above, it is necessary that all the components be independent of each other. He then discusses the circumstances in which this condition can be fulfilled and takes as his example the case of the components included in total indirect manufacturing costs (c_O), which we have not discussed here. If all components are to be independent of each other, then the other method too must assume independence between some of the components, i.e. between quantity manufactured (x) and working time (q_W), between working time (q_W) and wage rates (p_W) and between material usage (q_M) and material price (p_M). In view of this it might seem desirable to look a little more closely at the circumstances in which the condition of independence is fulfilled.

However, given the formulation of the analysis of variations presented in the two previous subsections, the comparison between the two methods can instead concern itself with how the s-values of the variables are determined. In fact we have tried to present our material in such a way that it will be immediately obvious that we are not concerned only with two methods of making an analysis of variations but also with two ways of determining the values of the variables. Since there are indications, as was mentioned above, that at least certain variables are conceived as being related to each other, such a line of approach may well appear more fruitful.

Differences in the way in which the values of the variables may be determined have already been illustrated with regard to q_W in (2.10) where the connection assumed between q_W and c_M is expressed. Another formulation of this relation is represented by (2.11). Numerous questions arise from a study of these relations.

Coward [1953] claims that the result of the analysis depends on which of the variables has been taken as the starting-point, i.e. in which direction the relationship points. He therefore suggests that the analysis should be made several times and that each time a different variable should be taken as the starting-point. Since several relations may exist between variables, and the number of combinations of differences soon becomes very great, Coward concludes with the suggestion that for practical reasons the analysis of variations should be limited to the difference between the s-values and the observed values without regard to possible relations. (*Ibid.*, p. 162.)

Coward's conclusion is undeniable, so long as we cannot introduce some direction into the relations. We shall therefore return to this question in Chapter 6.

[14] The term *decomposition* has been translated from Madsen [1959], see e.g. pp. 103 ff.

Another group of questions which arises from the study of the relations (2.10) and (2.11) is concerned with the formulation of (2.11). For example, how is (2.11) obtained from (2.10)? How are the coefficients α and β in (2.11) determined? Does the existence of a difference between the expected and the observed value of working time, given the observed value of material usage (cf. stage 3b in the previous subsection), mean that the values of the coefficients α and β must be rejected? In order to be able to examine these and similar questions we must discuss in the following chapters, among other things, a framework for the analysis of variations and models which can be used as a base for determining the values of the variables, before we return in Chapter 8 to the analysis of variations from standard costs.

2.5 THE ANALYSIS OF VARIATIONS FROM STANDARD COSTS AS A CONTROL DEVICE

What Part Does the Analysis of Variations from Standard Costs Play in Control?

In N.A.C.A. [1952] we find a summary of the part that the s-values of the variables and the analysis of variations from standard costs play in control:

> While the primary aim of management should be to obtain compliance with standards, perfection cannot be obtained in either standards or practice and some variances will always arise. Past losses from failure to meet standards cannot be retrieved, but the study of variances is an important step toward improving performance in the future.
> However, before management can take effective action to realize the opportunities for improving control over costs, it needs to know not only the amount of variance, but also where the variances originated, who is responsible for them and what caused them to arise. In other words, analysis is necessary to bring out the significance of the variances in terms of sources, responsibility, and causes. (*Ibid.*, p. 1548.)

In this quotation several important questions are indicated which must be answered before action can be taken to alter the program or the execution of the program. The part which the analysis of variations from standard costs can play in the attempt to answer these questions is what we intend to study in this section. In our earlier discussion of the aim of the analysis of variations from standard costs we mentioned that the result of the analysis is intended to act as a signal for further investigations.[15] However when we defined the goal of this study we emphasized that the direction of further investigations would affect the choice of action to such an extent that different possible explanations must be taken into account.

A similar line of thought, together with a suggestion as to a course of action, is to be found in N.A.C.A. [1952].

[15] Cf. e.g. Cattela [1948], p. 108, Chamberlain [1962], pp. 299 ff., Frenckner [1953], p. 189, Gillespie [1957], p. 501 and Gordon [1951], pp. 539 ff.

Variances reflect the effect on costs which certain events or conditions have produced. Before management can decide whether or not action is called for and, if so, what should be done, it is necessary to know what caused the variance to arise. The analysis of variances by causes is therefore an important aspect of the use of standard costs to obtain improved cost control. (*Ibid.*, p. 1555.)

In the American companies studied for the two N.A.C.A reports [1948 and 1952], two approaches to the analysis of variations by cause were found.
(i) Special studies to investigate causes were made alongside the routine operations for accumulating and reporting costs.
(ii) The cost accounting system contains individual "variance accounts" for each of the main causes and periodical reports of variations, classified according to cause, are drawn up direct from the accounts. (N.A.C.A. [1952], p. 1556.)

In many of the companies, however, the reporting system functioned in such a way that very little information as to "variance causes" was obtained.

It might be of interest to study the method followed in an analysis of differences between standard and observed machine hours in accordance with a *list of causes* drawn up in advance. This analysis is one of the illustrations in N.A.C.A. [1952]. The list of causes, which was worked out together by the heads of the accounting and production departments, is summarized in Figure 2.1. In the original list there are ten types of "favorable variances" (of which four are considered to be controllable by the foreman) and thirty-one types of "unfavorable variances" (including eight controllable).

In preparation for the analysis the foreman, guided by the list, will give the reason for every variation of at least 10 % above or below the s-value of machine hours at the conclusion of every operation. If the foreman considers that the variation has more than one cause he will divide it between the causes. Supervision of the foremen is expected to prevent them from wrongly assigning variations to uncontrollable instead of to controllable causes. The company stated that

... supplementary explanations are seldom needed since the reports have been designed to answer most of the questions which arise in connection with labor variances causes. (*Ibid.*, p. 1561.)

N.A.C.A [1952] concludes by saying that although some items on the list might be questioned, its reliability is acceptable for practical purposes.

Several authors point out the difficulties of eliminating the causes of variations. For example, Henrici [1960] claims that one of the reasons for foremen reporting high costs is that "... they do not yet see how to reduce them ..." (*ibid.*, p. 253). He continues:

To eliminate ... the physical plant conditions ... and the cost variances that reveal them is not a quick job. Nor is it to be done by saying "Here is a variance. Wipe it out next month". (*Ibid.*, p. 254.)

When discussing the attainability of the s-values of the variables, Henrici also emphasizes the importance of fixing the values with available equipment and tried methods in mind.

Favorable Differences

U[1]: Estimated working time too high (divided into running time and setting-up time)
- New machine, new tools — standard time unchanged
- Change in methods — standard time unchanged
- Time clock does not register less than 0.1 hours

C[1]: Worker's qualifications and/or efforts above average
- Foreman: Us϶d set-up from previous job, work done under special supervision, time set for man operating one machine — ran two

Unfavorable Differences

U[1]: Estimated working time too low (no further division)
- Slow or obsolete machine us϶d, extra set-up due to break-down of machine, trying out new tools, tools not correct when job was started — had to be corrected
- Planning not correct — was changed, planning changed due to delivery requirements, time set for worker operating two machines — only one available, quantity manufactured too small, extra work
- Two workers necessary due to nature of job
- Inexperienced worker (particularly apprentices), worker must help another inexperienced worker on another machine
- Tools not available when job was started
- Material incorrect (divided into six kinds of fault)
- Blueprints incorrect

C[1]: First time job was done
- Operations in previous departments not performed as planned
- Worker's qualifications and/or efforts below average, operation not performed correctly — additional time required.
- Parts spoiled — additional parts must be manufactured
- Tools spoiled — time lost for repairs
- Improper supervision
- Differerent workers used due to difficulty of job

[1] C = controllable by foreman, U = uncontrollable by foreman.

Figure 2.1 *Summary of a List of Causes of Differences between Standard and Observed Machine Hours*

Source: N.A.C.A [1952], pp. 1558—9.

Yet another statement which throws some light on the close relation between the manner of determining the s-values and the possibilities of using a comparison between them and the observed values for explanations and further action is the following:

If standards are tighter than performance currently attainable, the lower cost will not necessarily follow unless the cost reduction program has first shown a practical method whereby the tighter standard can be attained. (N.A.C.A. [1948], p. 9.)

Action Taken as a Result of the Analysis of Variations from Standard Costs

An analysis of standard costs is an inefficient control device unless it includes measures for changing the program or its execution, once the differences between the s-values and the observed values have been stated (cf. p. 14 above). The type of action taken as a result of a difference will depend on how the difference is explained. It has, however, been considered that the aim of the analysis of variations is to provide a signal for further investigations and a signpost for their direction. It is then considered the task of the subsequent investigations to provide the explanation. In view of the mass of possible explanations (cf. for example the list of causes as presented in Figure 2.1) and the lack of published information as to how far and under what conditions the different possibilities have actually been used as explanations, there is little basis for any detailed discussion of resulting action. This is reflected in the literature of the subject where the main content is a summarized discussion of (i) the general attitude towards variations of various types and (ii) procedures for following up the variations.

Chamberlain [1962] affirms that the reaction to a variation depends among other things on whether it is favorable or not, and in the latter case on whether it is counterbalanced by other favorable variations. Favorable variations do not lead to any action in the short run; in the longer run the s-value will be altered in the direction of the observed value. Unfavorable variations which are not counterbalanced by favorable ones do lead to action, known as corrective action.

N.A.C.A. [1948] says that about half the companies studied used regular "follow-up procedures" in the case of variations in material usage and working time. Three types of procedures mentioned are (i) a discussion between "the executives concerned" about explanations for the variations, suggestions as to further investigations, recommendations of corrective action etc., (ii) the person or persons within whose area of responsibility the variation has taken place is given the task of carrying out investigations, taking action and reporting on it and (iii) a person or a department (for example, in the case of a variation in working time, the department responsible for time and methods studies) is given the task of studying the variations and suggesting corrective action. (*Ibid.*, pp. 32 ff.)

Who is Controlled? Who is Responsible?

The general belief in the literature of the subject is that the division of responsibility should follow the organizational structure of the company. The manner of conceiving and defining the organizational structure seems to be based on classical organization theory. In this way the analysis of standard costs is related to the second line of development within classical organization theory[16] mentioned by March & Simon [1958], i.e. the treatment of

[16] Its relation to the first line of development, the scientific management movement, was mentioned on pp. 9—10 above.

... the grand organizational problems of departmental division of work and coordination. (*Ibid.*, p. 12.)

If it is to be possible to assign the variations to the different parts of the company, the accounting must follow the organizational structure. The desirability of this is affirmed by several writers. N.A.C.A. [1948] words it as follows:

... a plan of cost classification which follows the organization structure in order that the costs which each individual can control may be assigned to him. (*Ibid.*, p. 10.)

One starting-point for discussing the structure of the accounting, the selection of the variables and the division of responsibility for them could, in view of the above, be the structure of the formal organization. However, instead of discussing the variables for which a department or a person is responsible, writers usually begin with the variables themselves and discuss which department, person etc. is responsible for each one of them. This choice of starting-point, and consequently of the questions asked, probably results from the fact that the variables are taken as given. Of the variables we are considering here, material usage and working time reveal the same aspects while material price and wages must be discussed separately.

According to N.A.C.A. [1948] the persons chiefly responsible for the extent of material usage and working time are the foremen. The foremen's superiors in production management are, however, regarded as being responsible for the foremen's ability to control variations between the s-values and the observed values of the variables and are therefore indirectly responsible also for material usage and working time.

The division of responsibility for price differences are thought to be more complicated. In so far as the company considers it possible to exact responsibility at all for variations from the s-value of material price, the responsibility is laid mainly on the purchasing department. The responsibility rests chiefly, however, on the ability of the purchasing department to make predictions and only to a small extent on its subsequent ability to purchase at the s-values (*ibid.*, p. 35). The difficulties involved in trying to divide responsibility may be seen from the following example: the purchasing department might influence transport costs by its choice of means of transport; even if it were possible to assign a variation from the s-value of the material price to transport costs — for example the choice of a quicker and therefore more expensive means of transport than the one originally assumed — this need not be interpreted as an error on the part of the purchasing department. The variation may instead for example

... reflect failure of the factory to anticipate its needs, acceptance of a rush order by the sales department, or disturbance of transportation facilities by strikes, congestion, etc. (*Ibid.*, p. 33.)

It would naturally be possible to push the explanation even further: the sales department may have accepted this rush order because the warehouse had told them that the materials were in stock, and so on. In actual fact this example points to one of the basic problems of the analysis of variations from standard costs: How far should investigations be pushed before breaking off the chain of explanations? Henrici [1960] discusses similar difficulties in dividing responsibility for material price, referring to the fact that many purchasing problems are related too intimately to company policy as a whole.

When it comes to dividing responsibility for variations from the s-value of wage rates, there are further complications because the individual company is limited in what it can do to influence wages. Only one-third of the companies studied by N.A.C.A. [1948] work out variations in wage rates. Of these companies about half reported that the foremen were assigned at least some of the responsibility for the size of the variations. The reason for this was their view that the cause of variations in wage rates was usually due to the foremen using

> ... a man with the wrong rate for the job, failure of operators to earn piece rates resulting in payment on a more expensive day rate basis, or having too many men per machine. (*Ibid.*, p. 42.)

In conclusion it should be pointed out that the analysis of variations from standard costs is regarded in the first instance as an aid in the control of foremen, their superiors, the purchasing department, etc. and not of the workers. Since certain of the variables included in the analysis (working time and material usage, at least) are attributes of the workers' performance, the foremen are thus controlled by means of a comparison between the s-values and the observed values of the performance of their subordinates.[17] It will therefore be worth returning to the question of how to deduce the performance of the foremen from that of the workers.

[17] Cf. Westerlund & Strömberg [1960], pp. 1 ff.

CHAPTER 3

The Analysis of Standard Costs: A Theoretical Notion

3.1 WHAT HAS TO BE EXPLAINED — THE EXPLANANDUM

In the introduction we stated that an important aim of this study was to see how far it is possible to try to explain variations from the s-values of the variables. There are great similarities between an explanation of a situation and a prediction of the same situation. The essential difference is simply that the situation constituting an explanandum (i.e. the object of the explanation) is known, whereas the situation of which a prediction is made is unknown.[1] We see from this that the prediction of the value of a variable (or, more correctly, the description or the model with whose help the prediction has been made; see below) may be used as an explanation of the observed value of the variable, provided that the two values agree.

The values of the variables, observed at a certain point in time, refer to a particular flow of activities. On the other hand, the s-values of the variables are intended for use on repeated occasions. They therefore refer to a description[2] of regularities between certain activities carried out in the company and certain values of the variables. An explanation of a variation from the s-values of the variables will therefore be closely connected with an explanation of a description of regularities between activities and the values of the variables.

We can distinguish three possible explananda in relation to an analysis of variations from standard costs: (i) a description of regularities between activities and the values of the variables, (ii) an observation of a particular flow of activities and (iii) differences between the s-values and the observed values of the variables.

The manner in which the explanation is made will depend on which of the three

[1] Cf. for instance Törnebohm [1957], p. 135 (the English Appendix) and p. 102.

[2] In the natural sciences in particular the term "law of nature" is used to denote (i) particular regularities in nature and (ii) the verbal description of these regularities, cf. Törnebohm [1957], p. 117 (cf. also pp. 67 ff.). In the social sciences the terms *regularity*, *correlation* and so on are used instead. We shall use here the term *regularity* for the non-verbalized phenomenon and the term *description* to denote the verbal presentation of a regularity.

explananda provides the starting-point. The methods are interdependent and we shall try in this chapter to examine them and the relations between them. Before we start it will be necessary to introduce some terms that have not hitherto been used and to define some others more precisely.

3.2 INTRODUCING THE TERMS

Several of the terms which we shall use here (e.g. description, explanation, model, theory) have been given different definitions and uses in various scientific works. It is therefore essential for writers to clarify the meaning of the terms and the way in which they will be used in any particular work. In the present study we have chosen to base our terminology mainly on Törnebohm [1957]. One of the reasons for this choice should be mentioned in particular: a special feature of Törnebohm's terminology is that he distinguishes between the content of a description and the term "theory".[3] In discussing the analysis of variations from standard costs it seems essential to distinguish between the content of a description and a conceptual superstructure. It is therefore convenient to have special terms at our disposal.

Description

In a full *description* five stages can be distinguished[4]:
(i) A formula, e.g. $Q_W = xq_W = x \cdot \text{constant}$.
(ii) A business economic interpretation of the formula: It is stated that Q_W denotes the total working time, x the number of units manufactured and q_W the working time per unit of x in a particular manufacturing operation.
(iii) An account of how the values of the variables are measured, i.e. operational definitions of the variables.
(iv) An account of the margins of error in the measurements.
(v) An account of the range of application of the formula. It may for instance be stated that the formula only applies within certain intervals of the value of x.

Business economic descriptions do not always contain all five stages. One or more of the stages are often left to be implied. In this respect business economic descriptions resemble physical ones. A business economic description refers to regularities, e.g. between the volume of production and working time, volume of production and material usage, volume of production and manufacturing costs.

[3] It should be added here that the other points of which we make use from Törnebohm's book are, as far as we can judge, in agreement with several other works on the subject. Cf. Cohen & Nagel [1934], in particular pp. 197—222, Hempel [1952], Hempel & Oppenheim [1948], Kemeny [1959], in particular pp. 96—121 and Quine [1953], in particular pp. 42—5.
[4] The division into five stages is Törnebohm's [1957] (cf. pp. 69 ff. and Appendix p. 118), but our presentation has been adapted to the purposes of this study.

Theory — Model

A *theory* is used in explanations of observed regularities, in other words in explanations where a description constitutes the explanandum.

We regard a theory as a set of rules, which are applied in explanations and in predictions which are particular modes of reasoning about what is and what may be a member of the physical world.
There are three kinds of rules in a theory:
1) Rules of schematization, i.e. construction of conceptual models of real physical systems together with rules pertaining to transitions between models and actual systems. All these rules are called the *schematism* of the theory.
2) Rules of reasoning about conceptual models. The principles of a theory are such rules. A model constructed for the purpose of a particular explanation is usually not the only model permitted by the schematism. Principles do not apply to models in the sense that they describe models, but only in the sense that they regulate reasonings about models. This is a point of fundamental importance. We should be careful to distinguish between principles and . . . descriptions of regularities in nature . . . In order to reason about models it is necessary to make use of special technical terms not previously available. The principles of a theory introduce such terms . . . and give rules of usage for them.
3) Rules of calculation or *calculi.* Applications of principles to models may involve calculations and do result in formulae, which are subsequently subject to mathematical transformations. (Törnebohm [1957], pp. 118 f.)

The above-mentioned distinction between a theory and the content of the description to which the theory is related, is revealed indirectly from the quotation. The distinction is developed in a footnote.

I have used the term "theory" in a restrictive sense in the above passage. The term is frequently used in a more inclusive sense, as it is when particular applications of a theory (in my sense) are said to be theories *about* what is explained, or as it is when descriptions of regularities in nature are said to *belong* to a given theory. (*Ibid.*, p. 119.)

We can summarize as follows, in a somewhat simplified manner, the three aids that we have discussed for describing, explaining and predicting real physical systems:
(i) Theories consist of different types of rules. A complete theory contains rules both for the construction of models and for the use of a model in explanations and predictions.
(ii) *Models* consist of relations between conceptual *schemata.* The models are constructed in accordance with the schematism of a theory.
(iii) Descriptions consist of accounts of regularities in real physical systems.

The differences between theories and models and between descriptions and theories have been illustrated above. An important difference between descriptions and models is that the former refer to real objects whereas the latter refer to conceptual schemata.

Explanation — Prediction

In conclusion we shall illustrate the use of the terms *explanation* and *prediction* by reproducing a pattern for predictions and explanations from Törnebohm [1957].[5]

[5] See pp. 135 ff.; also pp. 99 ff.

Since there is no completely formulated theory of business economics, we can neither separate nor use all the elements in a theory in the following presentation and we have therefore compressed Törnebohm's pattern.

(i) Choice of theory.

(ii) Construction of a model for the physical situation which is to be the subject of prediction or explanation in accordance with the schematism of the chosen theory.

(iii) Application of the principles and the calculus to the model in accordance with the chosen theory. By means of this step formulae referring to the model are obtained.

(iv) Transition from the model to a real physical system by applying the rules in the schematism of the chosen theory (reapplication). By means of reapplication the models obtained in the previous stage are redirected to refer to a real physical situation.

(v) Choice of operational definitions for the magnitudes in the model reshaped in accordance with (iv). The operational definitions are chosen with regard to the real physical system to which reapplication was made. By means of this last stage a theoretically derived description is obtained and this can be used as a prediction.

When the pattern is used for an explanation, the theoretically derived description is compared with a description obtained by empirical study (there is usually reference to experiments).

In the pattern presented here the term model has been given a wider meaning than in Törnebohm [1957]. The application of the principles and the calculus is carried out by him in two stages and leads to two types of formulae (designated as π-formulae and λ-formulae, where π refers to principles and λ to laws of nature). Reapplication and the operational definitions consequently concern the π-formulae. The incompleteness of business economic theory, however, makes it difficult to distinguish the formulae from the model.

In physics the formulation of a theoretically derived description often differs from the formulation of an empirical description.[6] The differences may concern any of the five stages of a description. As an example we can mention that the formula in the derived description may contain more variables than does the empirical description. One of the consequences of such differences is that the field of application is often more clearly demarcated in the case of a derived description.

3.3 EXPLANATIONS IN CONNECTION WITH AN ANALYSIS OF VARIATIONS FROM STANDARD COSTS

In view of the incomplete nature of the theoretical structure of business economics, it might seem natural to construct a theory as the first step in an explanation or a prediction in this field. However, we have chosen to set our sights lower and shall focus our attention directly on the construction and application of models. Instead

[6] *Ibid.*, pp. 117 ff. and 123 ff.; cf. also pp. 70—80 and 101 ff.

of trying to formulate a number of rules in a theory which could be used in the construction and application of several models, our presentation concentrates directly on the construction of (a few) models and their use.

This is not, however, to deny the usefulness of the above pattern. By keeping it as our ideal, even if a hitherto unattainable one, we shall get some help in determining what should be included in a complete explanation of a business economic description and in deciding where an existing explanation (or, more correctly, draft explanation) should be supplemented.

We shall now try to outline patterns for explanations in connection with an analysis of variations from standard costs, i.e. for the three possible explananda which we distinguished above.

A. Draft Explanation when the Explanandum is a Description of Regularities between Activities and Variables

In view of the limitations mentioned above, the stages have been partly reformulated. We start as before with the stages in a prediction:

(A1) Transition from real objects, i.e. from a company or departments or persons in a company, to schemata.

(A2) Construction of a conceptual model of the company studied (or the part of the company, etc.) with the help of the schemata.

(A3) Selection of attributes of the schemata (i.e. selection of variables in the model) and specification of the relations in the model.

(A4) Transition from the model back to the company etc. This reapplication constitutes a reversal of stage (A2).

(A5) Choice of operational definitions.

From the last stage we again obtain a derived description which can be used as a prediction. A draft explanation consists of a comparison between the derived description and an empirical description. The former may agree with the latter but this is not essential to the adequacy of the explanation. To illustrate this statement we shall assume that the formula found by empirical means is

$Q_W = xq_W = x \cdot \text{constant}$

and that the derived formula is

$Q_W = xq_W = x(\alpha - \beta q_M)$ (cf. p. 20 above)

where α and β are constants ($\alpha, \beta > 0$) and q_M is the material usage per unit of x. If the value of Q_W according to the derived formula agrees with the value of Q_W according to the empirical formula when the value of q_M is introduced into the former, then the explanation has led to a more general formula. The more general formula will in future be compared with new empirically obtained values and so on.

The lack of complete theory means that there are no formulated rules on how to tackle the five stages and there will be some risk that the choices made will be somewhat arbitrary. This in turn will affect the evaluation of the adequacy, i.e. the correctness, of a particular explanation — an evaluation which is elusive under any circumstances. Törnebohm points out that the criteria for the adequacy of explanations which he suggests do not represent a complete list. It is interesting to note in this context that most of them refer to the adequacy of the theory which is used in the explanation.[7]

Another important respect in which the lack of a formulated theory makes itself felt should also be mentioned, namely that the theory should govern the formulation of the operational definitions which are included in a description. (See for example Törnebohm [1957], pp. 120 f.)[8]

B. Draft Explanation when the Explanandum is an Observation of an Individual Flow of Activities

A characteristic feature of the analysis of variations from standard costs is that it is carried out with respect to one manufacturing series in a single operation immediately the latter is completed. The observed values of the variables which are included in the analysis therefore refer to one series in one manufacturing operation and do not constitute a description of regularities.[9] Before a single observation is compared with a derived description as one stage in an explanation in accordance with draft A, it should be compared with a description obtained from previous empirical investigations. In many cases the latter comparison will be found adequate, and the explanation is broken off here.

In order to illustrate the procedure in seeking an explanation of an observed value we can take as an example the total working time for a particular manufacturing operation, Q_{Wa}[10]; the following stages can then be distinguished:

(B1) Choice of description(s), e.g. the manufacturing operation from which the observed value has been obtained is described by means of the five stages presented above.

(B2) The formula is obtained from the description, e.g. $Q_W = xq_{Wb}$, where q_{Wb} is regarded as an empirical constant.

(B3) The initial conditions for the description are indicated, e.g. the formula is supplemented by the value of x for the manufacturing operation to which the observed value refers (x_a).

(B4) The value of x is introduced into the formula and an estimated value of Q_W is derived (Q_{Wb}).

(B5) The value derived from the description, Q_{Wb}, is compared with the observed value Q_{Wa}.

[7] Cf. Quine [1953], pp. 43 ff.

[8] Cf. pp. 76—80.

[9] These statements are not entirely correct. In practice the analysis is usually made with respect to the manufacturing operations carried out during a time period, e.g. a month, three months etc. The different series of observed values are treated, however, in such a way that they more or less correspond to an observation of an individual flow of activities in which the flow consists of the manufacturing operations etc. which have been performed during the relevant time period. In this report we shall disregard the difficulties which arise during the transition from a single manufacturing operation to a succession of manufacturing operations. (Cf. the discussion of repeatability, p. 6 above.)

[10] As in Chapter 2, the indices a and b denote, respectively, the observed values and the s-values of a variable.

This explanation pattern is for many reasons simpler than the one indicated by Törnebohm.[11] Even in this simplified form, however, it can give rise to some reflections.

We indicated above that an explanation can be broken off after the fifth stage, i.e. after a value derived from a description has been compared with the observed value. The main condition for this seems to be that the two values agree. If the description has previously been explained according to draft A, a reference to this explanation will suffice. Furthermore it is probable that in many situations it is enough to know that an observed value is consistent with a certain description without demanding that the description in its turn should be subjected to explanation.

The comparison in stage (B5) includes the whole description, i.e. all the five stages of a description which were distinguished above. This fact will be of importance mainly in cases where the description indicates a lack of agreement between the value derived from the description and the observed value. Since, for one thing, accuracy in measurement is always limited, small differences will hardly lead to a rejection of the explanation. However, if the difference between the values is great, the description at any rate in its original form must be rejected as an explanation of the observed value. There are several possible ways of changing the explanation. One is to find the empirical constant q_{Wb} incorrect and to replace it by a new constant in which the observed value Q_{Wa} has been taken into account. Another is to find that the measurements used for determining the empirical constant and for observing Q_W have been made in different ways — the former may have been made by a time study man and the latter by the worker on the time clock. These two examples can lead to different modifications in the explanation: the first may lead to a change in the description used in the explanation and the second to the introduction of a new method of making observations or to the conversion of one of the two types of operational definition. However, the two examples are alike in one very important respect, namely that the modification in the explanation involves a reconsideration of the adequacy of the description. The adequacy of the description is of course related to an explanation of the description, i.e. an explanation in accordance with draft A.

It seems suitable to conclude this discussion of attempts to explain observed values by noting that the cases showing a divergence between the value derived from the description and the observed value are just those cases which will be subjected to explanation as a result of an analysis of variations from standard costs.

C. Draft Explanation when the Explanandum is a Difference between an s-Value and an Observed Value

With the above discussion in mind we can distinguish two stages in an explanation of a difference between the s-value and the observed value of a variable.

(C1) Explanation of the observed value in accordance with draft B.

[11] *Ibid.*, pp. 97 ff.

(a) The difference is slight and the description obtained from previous empirical investigations is accepted.
(b) The difference is great and one or more of the stages of the empirical description are rejected and modified.
(C2) The description (the original one or the modified one) is explained in accordance with draft A.

As was mentioned before, the explanation may be broken off at the conclusion of stage (C1) or it may be continued to include stage (C2).

If the explanation is broken off at (C1 a), there may be a comment to the effect that stage (C2) has been carried out previously. Whether or not (C2) has been carried out before will affect the choice between (C1 a) and (C1 b). It seems unlikely, for instance, that a description that has been explained in accordance with draft A will be changed if one single observation differs from the description. We have already mentioned that the content of stage (C2) will affect the way in which the description is changed. A study of stage (C2) is therefore also important as a basis for explanations when the explanandum is an observation of an individual flow of activities.

It may be worth mentioning briefly that the recent tendency towards applying methods of statistical quality control to the analysis of variations from standard costs may be regarded as an attempt to provide definite premises for the choice between (C1 a) and (C1 b). We have already mentioned that we are mainly interested in questions related to stage (C2).

CHAPTER 4

The Framework of an Analysis of Standard Costs

4.1 SOME CHARACTERISTICS OF THE ACTIVITIES OF A COMPANY

Type of Activity which will be Covered by an Analysis of Standard Costs

An analysis of standard costs will cover the regular operations or activities of the manufacturing departments of a company and, to some extent, of the purchasing departments, with the limitations already discussed in Chapter 1. Chapter 2 contained an account of the way in which these activities have been treated in standard cost literature. Since this whole subject originated from within the scientific management movement, the focus of interest has always centered on such of the operations as are performed by the workers. Other sections of activity have been discussed only in connection with the division of the responsibility for variations from standard costs and any resulting action taken. Discussion of this type of action follows mainly the lines laid down in traditional organization literature and concentrates on departmental divisions and the formal system of authority.

The type of control which is exercised by an analysis of variations from standard costs is concerned in the first place, according to standard cost literature, with foremen or their superiors and not with workers. It therefore seems justified to incorporate in the analysis of standard costs characteristics of the activities performed by foremen.

In Chapter 1 we quoted the definition of control in Kohler [1957].[1] This definition seems representative of the concept of control — its meaning and its range — which is to be found in the literature of the subject. It includes, among other things, the concepts *goal, planning, plan* and *plan-execution.* These concepts have been used by March & Simon [1958] as the terms in which to define those activities in a company which are performed by foremen and their superiors, thus expressing the general shift in emphasis in recent organization literature with regard to the way in which the operations of a company are conceived.

We shall base our discussion on the concepts planning, program, program-execution etc. from March & Simon [1958] but, before we begin, a few general remarks about this shift in emphasis would not be out of place.

Different Ways of Conceiving a Company's Activities

In classical economic theory a company was conceived as an economic unit or a decision unit in which only one organization member was distinguished, i.e. the entrepreneur. The business economic study of organizations, which was mainly the work of practising administrators, was concerned to a marked degree with the advantages, from the company's or management's point of view, of a division of work and specialization and with the related questions of direction and coordination. Naturally it was necessary to distinguish more organization members than just the entrepreneur, but cooperation between entrepreneur and members and between members themselves was only studied on simplifying assumptions regarding human behavior.

The early study of organizations from the point of view of management led to the formulation of a number of principles which have met with criticism on two counts: they are not consistent with each other and the empirical base is defective. The principles themselves and the criticisms have been discussed in a number of works[1] and can therefore be passed over here.

Since research workers in other spheres, such as psychology, social psychology, and sociology have also made a study of the organization, the subject has been approached from other points of view than that of company management. The attitudes, knowledge, motivation, valuations etc. — here designated as the *frame of reference* — of the individual member of the organization have thus received attention. Within these spheres the importance of the frame of reference for a person's behavior had already been studied and reported. It had therefore become clear that the frame of reference of the organization members should be taken into account in the study of the structure, activities etc. of organizations. One result of this new understanding has been a change in the way of conceiving the organization. The earlier unit has been replaced by a number of parts which exist in complicated relations both to each other and to the outside world. This change can be illustrated by the following quotation from Carlson [1945].

> The institutional structure represents only the frame within which the individuals work together . . . the most important thing in the whole organization is not the frame but the people who work inside it (p. 71). (*Our translation.*)

The present situation in research with regard to the way in which an organization is defined is that the classical contributions of both business economics and general

[1] See, for example, Simon [1947], pp. 20—36. (Page references to this work refer to the 2nd Edition, 1957.)

economics have been abandoned, anyway as the main influences, while the new lines of development have not yet been molded into a consistent body of theory. The conception of the organization on which our study is based has nevertheless been influenced by the trends indicated above. We refer here in particular to the necessity for distinguishing the members or groups of members in an organization who are affected by the analysis of standard costs and to the desirability of somehow incorporating into the description of the organization the frames of reference of individual members and the relations between them.

4.2 ON THE SUBJECT MATTER OF AN ANALYSIS OF STANDARD COSTS

The Direction and Coordination of the Activities of a Company

Control constitutes one stage in the efforts of management to direct and coordinate the activities of a company. In more general terms these efforts can be regarded as an essential part of management's influence on its subordinates.

In Simon [1947] five "mechanisms of organization influence" are indicated, by means of which management can influence subordinates:

(1) The organization divides work among its members. . . .
(2) The organization establishes standard practices. . . .
(3) The organization transmits decisions downward (and laterally or even upward) through its ranks by establishing systems of authority and influence. . . .
(4) The organization provides channels of communication running in all directions through which information for decision-making flows. . . .
(5) The organization trains and indoctrinates its members. . . . (*Ibid.*, pp. 102 f.)

The five mechanisms are not wholly independent of each other. Before the organization can establish standard practices and see that they are followed, it must have divided the work and established systems of authority and communication channels, which in turn presupposes training and indoctrination.

It is interesting to compare these mechanisms with the following quotation from March & Simon [1958]:

If we wished to sum up in a single quality the distinctive characteristics of influence processes in organizations, as contrasted with many other influence processes of our society, we would point to the *specificity* of the former as contrasted with the *diffuseness* of the latter (pp. 2 f.).

The authors then illustrate the differences in influence by comparing the transmission of communications in a manufacturing company first with the spreading of rumors and then with communication by mass media. In support of their statement that influence in organizations differs to a considerable degree from influences in general, the authors refer to two sets of circumstances: (i) messages within an organization follow definite channels on their way to specific recipients and (ii) the content of such a message differs in several essential ways concerning the expected effect on the recipient from the content in other messages (messages in organizations presuppose the recipient's motivation and use a common language: they are more detailed but can nevertheless be formulated very concisely).

This quotation and the examples show that a study of the direction and coordination of the activities of a company may be concerned with (i) the construction and formulation of the institutions by means of which management seeks to influence its subordinates and (ii) the content and formulation of messages in the organization. Whichever of these provides the starting-point of the study, both questions will be of importance; it is a matter of emphasis and point of view. In Simon [1947] the emphasis is on the first type of question — see, for instance, mechanisms (1), (3), (4) and (5) — and the formulation of standard practices, which belongs to the second type of question, results from planning, which is

> ... a technique whereby the skills of a variety of specialists can be brought to bear on a problem before the formal stage of decision-making is reached (p. 228).

In March & Simon [1958] the central theme concerns the formulation and content of messages in an organization. In other words there has been a shift towards the second approach. Company planning and its results, different types of plan etc. form the elements around which their thesis has been built. In view of the fact that the concept of control, and thus also of the analysis of standard costs, has been defined with the help of the concepts planning and plan, it will be suitable to base our report on the latter approach.

Planning — Program

A necessary condition for the direction and, thus, the coordination of the activities of a company is that the main goal towards which the employees shall strive be clearly defined.[3] Over and above this it is often necessary to divide the main goal into subgoals and to divide these further once or more. One reason for the division is directly related to the need for coordination: the activities of a company are composed of specialized tasks performed by different people and the main goal is often regarded by these people or groups of people as non-operational (March & Simon [1958], p. 156). By an operational goal is meant in the first place a goal which is defined operationally, i.e. rules have been formulated for an empirical determination of the value of the goal. But for a goal to be defined as operational the authors make further requirements, e.g. that a relation can be constructed between the goal and the activities concerned (cf. *ibid.*, pp. 42, 61 ff. and 155).

By dividing the main goal in this way a number of goals of varying range are created, together with a number of inter-goal relations forming a goal hierarchy. The goals at each level in the hierarchy are means in relation to the goals on the

[3] The question of the general objectives of a company has been discussed from various points of view in several works. See, e.g., Faxén [1957], pp. 37—40 and 49—52 and Frenckner [1953*a*]. Cf. also the discussion of *satisficing* versus optimization in March & Simon [1958].

level above; goal (or end) and means are therefore relative terms. An analysis which starts from the goal at one level in the hierarchy and examines the means (at one or more lower levels) used to achieve it, is called a *means-end analysis*. A means-end analysis holds a predominant position in both Simon [1947] and March & Simon [1958] as one stage in planning. The authors indicate two necessary conditions for its use in this context: in the first place it is necessary to check at every stage in the analysis that the following more detailed steps will be feasible for each of the possible means. Secondly each of the means at each stage in the analysis must, in the main, be independent of the other means. There are two reasons for this: any one means must not influence more than one goal on the stage above nor must the feasibility of one means depend on which other means are being used in the program. If these conditions are not fulfilled, steps must be taken to develop a revised program in which relations between the parts of the program are taken into consideration. (March & Simon [1958], pp. 191 ff.)

The basic activity of a company, looked at in this way, will consist of problem-solving with the help of the means-end analysis. Since the organization has a memory, the problem-solving need not extend over all stages in the analysis every time; instead it can be broken off as soon as a stage is reached where earlier solutions, in the form of work instructions, can be reapplied. These instructions are known as *performance programs* or *programs*. As an example of a program we can cite the type of instructions for carrying out a manufacturing operation that are obtained from a methods study (cf. pp. 11 f.). Since a program is related to solutions in the means-end analysis, however, it might refer to instructions of varying detail and type. There can be programs at different levels in the goal hierarchy and programs for different branches of activities on the same level. If the concept program is to be used to describe the activities of a company it is therefore necessary to define precisely the individual programs, as to both content and extent, and the relations between them.

A comparison with some of the concepts which were used in an empirical study of the behavior of the management in ten companies (nine Swedish and one French) throws further light on the concepts discussed here. In that study, reported in Carlson [1951], each "executive action" was classified with respect to five characteristics. In the present context the fourth of these ("nature of question handled") and the fifth ("kind of action") suit our purpose. The "nature of question handled" was discussed from three points of view:

> . . . with regard to the material contents of the questions (the field of activity) . . .;
> with regard to questions of development and questions of current operation; and
> with regard to questions of policy and questions of application (p. 37).

With regard to the "kind of action", it is stated that the main tasks of an executive are to make decisions, to see that others make decisions and to see that the decisions are carried out.

> In order to take decisions he needs information and it is also necessary for him to systematize this information so that he will arrive at a decision. It is, I suppose, this phase of his work that in management literature often is referred to as "planning" (p. 38).

For this reason, among others, "kinds of action" are classified under nine headings. For the purposes of our comparison, a classification into three categories is sufficient: (i) obtaining and analysing information, (ii) decision-making and (iii) measures to see that decisions, when made, are in fact carried out.

The Location and Delimitation of Programs

Since goal and means (or ends) are relative terms and since a hierarchy of programs corresponds to a division into goals and means (or ends), two programs can be related to each other in such a way that the execution of the first serves as the stimulus that initiates the second. An example of this is that a requisition from the inventory department will initiate a purchasing program when it is received by the purchasing department (March & Simon [1958], p. 149). When programs are used in models of the activities of a company, it is important that both their extent and range in the company can be indicated. Both these aspects are related to the way in which the means-end analysis is carried out since the starting-point of the analysis, i.e. the main goal from which it starts, the number of stages that it covers etc., will help to determine the number of programs and thus even their extent and, in some degree, their range. March & Simon [1958] declare that little theory exists concerning the method of making a means-end analysis. The authors distinguish two groups of circumstances which may influence the factorization of the problem: (i) influence from the problem's "intrinsic" structure and (ii) social influences. In the latter case they claim that the existing organizational division of work, i.e. the institutional structure, will have great importance. (*Ibid.*, p. 193.)

Programs are consistently assigned to different organizational units in accordance with traditional divisions. With regard to the hierarchical interaction of programs it is claimed that these are parallel, to a great extent, with the hierarchical relations between organization members. Even in the case of people or organizational units on the same hierarchical level, the authors apparently assign programs according to traditional departmental division; see the example of the inventory and purchasing departments above.

In locating and delimiting a series of relative terms, the starting-point must always be based on a convention. That March & Simon [1958] were forced to base the assignment of the whole series of programs on conventions — a traditional classification of the organizational division of work — depended on the lack of a generally accepted starting-point for the means-end analyses and on the difficulty of defining precisely the relations between programs. The location and delimination of programs is therefore one point where the line of development in organizational research which we have discussed here, with the emphasis on program communication, meets traditional organization theory with its emphasis on the institutional structure of organizations.[3]

[3] Cf. also Carlson [1951], where he reports that executives generally found no difficulty in relating a question to its field of activity, but did find it hard to discover "... whether it was a question of policy or of application.... One may think at the beginning of a discussion that the item brought up is merely a trifling detail, while further consideration reveals that the decision taken turns out to be a most important precedent for the future." (p. 48).

The difficulties involved in locating and delimiting programs without reference to departmental division and hierarchical relations between organization members, will affect any attempt at incorporating the activities of foremen and their superiors into the analysis of standard costs. The serious problem from the scientific point of view is that the institutional structure with regard to departmental division and hierarchical relations varies from company to company. This makes it impossible to make any generally applicable statements, except possibly in quite unspecific terms. In the following sections we shall therefore address ourselves to general remarks and the specifications that we do make must be regarded as more or less illustrative examples. It need hardly be pointed out that our attempt should be supplemented by a number of empirical studies in individual companies.

The Frame of Reference of Individual Organization Members

The assignment of goals, subgoals and programs to the various organizational units may affect the frame of reference of unit members. The members tend to identify themselves with the subgoal assigned to their unit, at the same time ignoring the goals of the organization as a whole and the subgoals of other units (cf. p. 40 above). Furthermore, a person's frame of reference also includes the way in which he conceives a situation. March & Simon [1958] devote much space to limitations in knowledge on the part of organization members and they emphasize how important it is to take into account the knowledge-situation in any prediction of behavior. It is not enough to base a prediction only on a situation as it appears to an outside observer. It is necessary also to determine a member's motivation etc. with regard to the assigned goal, and the means that he regards as relevant for achieving that goal.

The distinction between a person's motivation and his knowledge will be important particularly when attempts are being made to change his behavior. Great difficulty will, however, face any attempt to incorporate the consideration of these frames of reference into a more specified model or into an empirical study of organizational behavior.[4]

A comparison between two recent studies of the direction and coordination of company activities will provide an illustration of the problems involved. The first, Rhenman [1961], considers a configuration of schemata embodying control impulses and develops ideas which can be found in servo-mechanism and information theory, and in Simon [1947], March & Simon [1958] and others. The second study, Strömberg & Wirdenius [1961], represents an attempt at utilizing in an empirical study some of the concepts used by, among others, March & Simon [1958]. In both studies the concept of control impulse holds a predominant position, but is defined in different ways:

[4] Cf. Carlson [1951], the discussion of "kinds of action". Any particular action may be interpreted quite differently by different people. For instance, "A conversation which from the point of view of the managing director merely means the getting of information may very well be regarded by the subordinates as decision-taking or even the receiving of orders." (p. 49).

If a message . . . influences the behavior of a unit, it is said that it is acting as a control impulse. (Thus the model does not include any assumption that all information received affects behavior.) (Rhenman [1961], pp. 67 ff.) (*Our translation.*)

Control impulses . . . are intended to initiate action in a decision center . . . (Strömberg & Wirdenius [1961], p. 15). (*Our translation.*)

The difference between the two definitions concerns the location of the frame of reference of the person receiving the message. Before Rhenman can determine empirically what constitutes a control impulse, he must have evaluated the frame of reference of the recipient and have been able to consider the content of the message in relation to it. After this step he can make a prediction of the recipient's behavior. Strömberg & Wirdenius, on the other hand, can determine straight away what constitutes a control impulse, but before they can use this knowledge to make a prediction of the behavior of the recipient, the frame of reference of the latter must be evaluated. In both cases the frame of reference includes both motivation and knowledge.

This is not the place for a discussion of the advantages and disadvantages of the two definitions. However, it is interesting to note that whichever of the two approaches is chosen, it is still extremely difficult to evaluate the frame of reference in a concrete situation. For explorative purposes Rhenman used his model to describe an organization, but it was not possible to distinguish the frame of reference of the recipient from the informal interviews on which he based his attempt. Strömberg & Wirdenius, who have devoted much attention to different methods of observation, show how difficult it is to observe a recipient's method of analyzing and evaluating the information he receives. It thus seems that there is room for further research into these problems, and that at present the need that we emphasized in our introduction for taking into account the frames of reference of organization members, creates demands that cannot as yet be wholly fulfilled.

Program — Control

If programs are to be utilized as a basis for control, they must contain observable and measurable variables. The content of a program can be characterized in two dimensions: (i) the actions or operations which, it is expected, will be carried out and (ii) the output of these actions. The relative difficulty of observing actions as against observing output therefore gives rise to the following hypotheses concerning program content: (i) programs contain specifications of actions when these are easier to observe and supervise than output, and when the relation between actions and output involves technical knowledge better known to the specialist than to the person performing the operation and (ii) programs contain specifications of the quality and quantity of output when this is easier to observe and supervise, and when the relation between actions and output is more a matter of common sense and involves the type of skill and knowledge better known to the operative than to the specialist (March & Simon [1958], p. 145).

In the following sections we shall be studying the content of programs, in relation to control, starting from other premises. We are concerned only with the form of control known as review. What we wish to find out is: how will a review help management to make decisions concerning changes in program, rewards, sanctions etc., if (i) the program contains variables for defining actions and the observations concern the values of these variables only or (ii) the program contains variables for defining output and the observations concern the values of these variables only?

If management wishes to change (the values of the variables that define) output, this can be achieved indirectly by means of influence on the program or the actions. In view of this, in case (i) we may ask how management can know that output is unsatisfactory although output has not been observed. Management must here assume that since the observed values of the actions have differed from the values specified in the program, then output too will differ from the standard desired. In case (ii) the opposite question can be asked: how can management know that it is possible to change the actions so that the values of the output will be more satisfactory, although the actions have been neither programmed nor observed? In this case management must assume that since the observed values of output have differed from the values in the program, then the actions too will differ from the standard desired. In other words it is assumed in both cases that the relations between actions and output are known within the company, in case (i) by management and in case (ii) by the subordinates. Indeed this seems to be the meaning of the constituents of the hypotheses cited above. Thus, before we can specify in a given situation the conditions in which these hypotheses can apply, we must make a prediction of output and actions, taking the program as our base. A necessary condition for this, however, is that both actions and output are defined in terms of variables which are either operationally defined or are related to other variables so defined.

However, output corresponds to the goal of an individual or organizational unit while actions correspond to the means of reaching that goal. Actions and output will therefore, like goal and means, be used as relative terms. This means (i) that the relation between the variables which define actions and those which define output will be dependent on a conventionally chosen starting-point and (ii) that if the activity of the individual or organizational unit concerned constitutes one stage in a larger activity, the starting-point, and consequently the whole relation, will be dependent on the delimitation which has been applied to the larger activity.

An example which illustrates the importance of (ii) was given above in connection with the division of responsibility for variations in material price (pp. 27—8). One of the factors which affect material costs is the chosen type of transport. A purchasing department may be required to obtain a certain quantity of material at the lowest possible cost. With this goal in mind the department may choose a cheap, and therefore often slow, means of transport (e.g. combined transport at truck freights). If this leads to material shortage in the factory, then the lower cost of transport may, from the company's point of view, be counterbalanced by orders missed or by the costs resulting from a standstill. The actions and the output of the purchasing department must therefore be determined with due consideration to their effect on other organizational units. The desired output, for instance, could be a certain quantity of material of a given quality at a certain time at the lowest possible cost.

4.3 THE CONFIGURATION OF SCHEMATA FROM THE POINT OF VIEW OF AN OUTSIDE OBSERVER

The material presented in the first two sections of this chapter will be used in constructing models of those activities in a company which are covered by the analysis of variations from standard costs. The models will be used in connection with explanations and predictions related to the analysis. Models can take into account only a limited number of the features which might characterize the activities. In evaluating the adequacy of the explanations and predictions based on the model — an essential part of the analysis of standard costs — the various stages in the construction of the model should therefore be considered separately.

In this section we shall take note of the transition from organizational units to schemata (cf. stage (A1), p. 33) and of the relations between schemata (i.e. the *configuration of schemata*) from the point of view of an outside observer (cf. stage (A2), p. 33). The configuration will cover all stages in the particular branch of activities, thus including the analysis of variations from standard costs. In the next section, taking this configuration as our starting-point, we shall construct a second configuration from the point of view of the person(s) making the analysis of standard costs. In the further construction of the models, this configuration will be used as the basis.

Transition from Organizational Units to Schemata

When we make the transition and must choose which organizational units to include, and how to delimit them, we meet the same type of problem that beset the location and delimitation of programs. Since we are forced to make the choice on a basis of traditional departmental division, further specifications have to be made before applying the model in a company, e.g. in regard to reapplication and the determination of the operational definitions.

The people or groups of people in a company who are directly or indirectly affected by an analysis of standard costs are, according to what has been said previously: (i) management, (ii) different types of planning departments (design department, technical production departments, time and methods study departments, production planning etc.), (iii) the purchasing department(s), (iv) departmental heads in the production departments, foremen, supervisors etc. and (v) the workers. To these must be added (vi) the person or persons who make the analysis.

When we make the transition we shall limit the number of organizational units to be considered. We distinguish the following schemata: (i) *Top Management*, (ii) *Planning*, (iii) *Purchasing*, (iv) *Foremen*, (v) *Workers* and (vi) the *Analyst*.[5] The main reasons for this further limitation are two: the first is that, as a result of the difficulties involved in seeking objective criteria for defining organizational units, further

[5] Henceforth schemata will be distinguished from organizational units by the use of capital initials.

subdivision will lead to an apparent specification only; the second is that the model shall be manageable.

Other aspects of the transition — the choice of attributes of the schemata — will be discussed in Chapter 5.

The Configuration of Schemata

The analysis of variations from standard costs constitutes one stage in the efforts of management to direct and coordinate the activities of a company. We are therefore interested in management's influence on its subordinates. Influence may be direct or indirect through other people, and may take many forms. For example, goal-setting for company activities and the shaping of the institutional structure of the company are regarded as two important forms of influence (cf. pp. 39—40). A third form of management influence which is often mentioned is the allocation of resources within the company. A common feature of these three examples of influence is that they are intended to indicate the frame within which the activities of the company shall be performed. Some assumptions about these types of influence must therefore be made not only before making the configuration but also before it is possible to select the schemata. The configuration illustrated in Figure 4.1 (see inside back cover) must be subject to the same reservations as the choice of schemata.

Management's influence on its subordinates is not limited to the general forms mentioned above. In addition there will be more specific instructions to the different fields of activity. Within any field of activity management's instructions will be passed on from superiors to subordinates. The individuals or organizational units serving as intermediaries often reformulate an instruction, for instance, by giving more detailed specifications, by adding data or by dividing it further etc. Common to all these instructions is the intent to influence the recipient. In Figure 4.1 this network of instructions has been illustrated for the schemata of the selected organizational units. We have used arrows to indicate that these are conceived as influence relations.

Instructions from management to the different planning departments may concern the volume of production, the choice and design of products, machinery etc. They are illustrated in Figure 4.1 by a solid arrow from Top Management to Planning. Instructions from top management to the purchasing department may be concerned with regulations for purchasing procedures, purchasing and payment conditions and sometimes choice of source of supply. (Solid arrow from Top Management to Purchasing.)

The planning departments transform the instructions from top management into plans and programs. The foremen receive programs for the execution of manufacturing operations. Examples of the kind of information a program may contain are:

(i) the design of the product (blueprints, quality norms etc.),

(ii) manufacturing procedures (choice of machine, data on machine speeds, tools, type of material, motion chart for workers etc.) and
(iii) the expected result of the execution of the manufacturing operation (i.e., with those limitations mentioned in the introduction, the s-values of the four variables working time, material usage, wage rates and material price). The foremen also receive information concerning
(iv) when and in what quantities a product shall be manufactured.
Instructions (i)—(iv) are illustrated in Figure 4.1 by a solid arrow from Planning to Foremen.

The purchasing department receives, in some form, information on the estimated usage of different types of materials for the manufacturing operations planned (solid arrow from Planning to Purchasing).

The activities of the purchasing department — its contacts with suppliers and its acquisition of material — exert influence felt in several ways. Information as to types of material available, qualities, quantities and prices can affect both product design and manufacturing procedures. The problem of determining the influence relations that affect Purchasing provides an example of the difficulty, mentioned above, of setting the limits of an organizational unit. The work of the purchasing department may be restricted to the acquisition of specified types of material on as favorable terms as possible, but it may also include investigations of the market and negotiations with suppliers on technical questions. In the first case a relation between Planning and Purchasing may be sufficient. In the latter case Purchasing will in its turn influence Planning, requiring the introduction of another relation in the opposite direction. We shall assume such a situation and therefore put in a solid arrow from Purchasing back to Planning. When the circumstances for the acqusition of material differ from the circumstances assumed in the instructions received, measures must be taken to adapt to the new situation. The quality or price of the material are examples of circumstances which might change, and a change in machining methods an example of measures of adaptation. These measures may be taken by planning or by the foremen. If it had been planning's task to obtain the relevant information, e.g. about quality and price, then the need for adaptation would have motivated the introduction of a relation from Purchasing to Planning. However, we shall let the relation which has already been introduced include the adaptation. In so far as the measures of adaptation are made by the foreman it may seem logical to introduce another relation from Purchasing to Foremen. It is worth pointing out however that instructions about adapting to changed circumstances would in all probability come from the planning function. A relation between Purchasing and Foremen would not therefore have quite the same meaning as the other influence relations. Despite this, one important reason for introducing the relation into this study is that the literature of the subject makes use of it. It is therefore better to study it explicitly. (Solid arrow from Purchasing to Foremen.)

The programs which are passed on to the foremen are to a great extent concerned with regulating the tasks of the workers. The foremen must therefore check that the programs can be executed (i.e. see that material, tools etc., are available), and then pass them on to the workers by means of training and supervision. (This relation is shown by a solid arrow from Foremen to Workers.)

Of all the ultimate effects of this network of relations, we are interested in this study in the four variables working time, material usage, wage rates and material price and in the labor costs, material costs and direct manufacturing costs derived from these. The values of the first three variables appear when the workers have completed an operation. The value of material price appears after the acquisition of material. Details of the values of the seven variables mentioned are passed on to the Analyst. The Analyst also receives information on the s-values of the variables (cf. the formulation of the analysis in Chapter 2). In the case of the schemata with which we are concerned, the latter information can be obtained from Planning and Purchasing. The information which the analyst receives on the standard and the observed values of the variables does not constitute an instruction in the same way and with the same meaning as does, for example, an order from the foreman to the workers. The instructions concerning analysis procedures come from top management and have therefore been shown in Figure 4.1 by a solid arrow from Top Management to the Analyst. In order to indicate that the information referred to above is not to be regarded as an instruction and is therefore not to be treated as an influence relation, we have used dotted arrows. We have also ignored the fact that the observed values of the variables will probably be reported by the foremen rather than the workers.

When the analysis of variations from standard costs has been made, by comparing the s-values and the observed values of the variables, top management is informed by the analyst of the result. There is no question of an instruction here either, and the report is therefore marked in the figure by a dotted arrow from the Analyst to Top Management.

As a result of this information top management can take action which may be directed towards planning, purchasing, foremen and possibly workers, or to more than one of these. This action seems to correspond to what is known in the literature as *corrective action(s)* (cf. p. 26 above). An attempt at incorporating corrective action into the configuration meets with great difficulties. In fact it can be questioned whether it differs from the instructions from top management which have already been included. This problem could perhaps be overcome by limiting corrective action to include only rewards and sanctions. However another difficulty then arises, namely that both the analysis and the corrective action have been anticipated and will thus affect the reaction of subordinate organizational units to the instructions they receive (cf. pp. 3 and 14 f.). This means, however, that corrective action can be included in the influence relations already discussed. In Figure 4.1 the further influence represented by corrective action is shown by dotted arrows from Top Management to Planning, Purchasing and Foremen and by a broken arrow from Top Management to Workers.

The configuration is now complete. It is immediately obvious that it must be supplemented and defined more precisely in a number of respects before it can be used as a basis for a model of the activities concerned. In fact it may be questioned whether the configuration is a suitable base for a comprehensive study of top management's influence on its subordinates. However we do not intend to try to develop it so as to cover a model of the company as a whole. Instead its function is to supply a background for the discussion of the models which an analyst can construct as a basis for explanations in connection with the analysis of variations from standard costs.

4.4 THE CONFIGURATION OF SCHEMATA FROM THE POINT OF VIEW OF THE ANALYST

The Analyst

In the previous section, the activities were being studied from the point of view of an outside observer. An analyst places himself in the position of observer when he constructs a configuration on which to base explanations of variations from standard costs, and we shall now discuss the choice of schemata, the relations between them, the construction of the model, etc., from the point of view of the Analyst.

According to the configuration the Analyst receives his instructions from Top Management. These instructions may be concerned with the scope of the analysis, the transition from organizational units to schemata, the choice of characteristics to define the schemata etc. An analyst will also be greatly affected in his interpretation and formulation of the different stages in the analysis by his own knowledge and valuations, in other words by his own frame of reference. In a theoretical study of this kind we naturally turn to the literature for an evaluation of the instructions received in the analysing department from top management and of the analyst's frame of reference, but we find that such questions have received scant attention. We have thus chosen to assume that the Analyst conceives the activities within the area to be studied in the way that has been presented in the two previous sections. While not necessarily restricted to the s-values in making his prediction, he will follow the patterns for draft explanations presented in Chapter 3.

Choice of Schemata

The choice of schemata will vary according to whether activities are studied from the point of view of an analyst/observer or of an outside observer. In the former case it would be reasonable to suppose that no schema would be needed for the analyst.[6] In the second place the value of retaining in the model a schema for top management is open to question. The analysis of variations from standard costs is intended

[6] It would of course be both desirable and possible to incorporate into the model a schema for the observer, and therefore also to include the relations between this and the other schemata studied, but we have not found any model of this type in micro-economic theory.

in the first instance to elucidate the activities of the foremen (cf. pp. 26 ff. and p. 37). The difficulties connected with the exact definition of top management's influence with the help of a schema Top Management will hardly diminish as a result of incorporating the observer in the area studied.[7] We shall therefore also abandon any schema for top management.

The remaining schemata are four: Planning, Purchasing, Foremen and Workers. We shall now turn to the study of the relations between these.

The Configuration from the Point of View of the Analyst

Since there are now fewer schemata, there will also be fewer relations. These are illustrated in Figure 4.2.

We have no additional comments to make with regard to Figure 4.2 over and above what we have already said in connection with Figure 4.1. In conclusion it should be noted that the influence relations include the anticipation of corrective action.

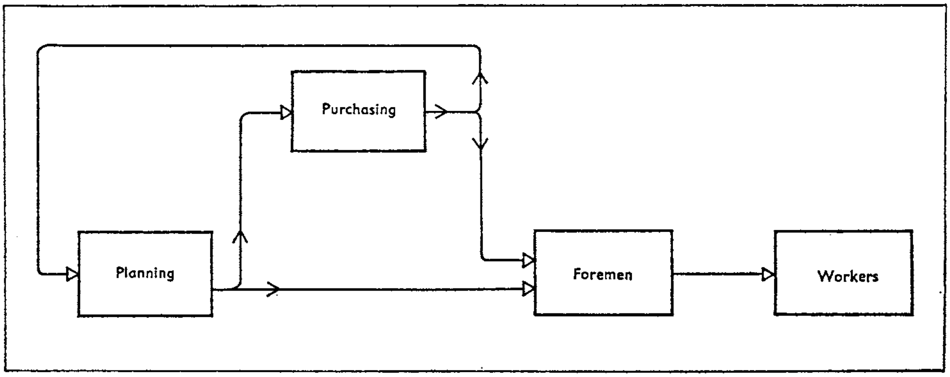

Figure 4.2 *The Configuration of Schemata from the Point of View of the Analyst*

Since Top Management has been excluded, the models which have been constructed on a basis of this configuration will be incomplete. Top management's influence must therefore be introduced as a datum or initial condition when this type of model is used for explanations or predictions. It can also be mentioned in passing that neither configuration (Figure 4.1 or Figure 4.2) is complete, since data relating to a number of external circumstances (e.g. market prices) must be added in both cases.

[7] Alternatively we can assume that top management does not wish to be the subject of an analysis of variations from standard costs.

Flow of Activities

The activities carried out by the individuals in a company are continuous. We have already seen the activities included in an analysis of variations from standard costs as a flow (see Figures 1.1 and 1.2). As the next step in constructing the model it would be suitable to compare the schemata and the configuration with the flow of activities discussed in Chapter 1. The comparison will consist of two stages, (i) from the point of view of an outside observer (study of the whole branch of activity) and (ii) from the point of view of the Analyst. For the sake of simplicity we have combined Purchasing and Planning in both the comparisons.

We can discuss the flow of activities, when a whole branch of activity is studied, in relation to Figure 4.3 (see inside back cover). The main rule for this example is that schemata are indicated by horizontal lines and the relations between schemata by vertical arrows. For technical reasons we have made two exceptions from this rule. The first concerns the illustration of corrective action from Top Management/ Analyst to Foremen or Workers. Corrective action may take place in the relevant organizational units at any time after completion of the analysis, i.e. any time after t_5 and t_k in the figure. Two alternatives are shown in the figure, (i) when the analysis has been completed and (ii) at the time the activity is started, i.e. (i) at t_5 and t_k and (ii) at t_6 and t_{k+1} or t_7 and t_{k+2}. Alternative (ii) is indicated by a horizontal dotted line.

The second exception concerns the Analyst's prediction and the prediction that may precede the issuing of instructions to a subordinate unit. This type of prediction has been indicated by a horizontal broken arrow from the same schema as the instruction.

The time axis illustrates the sequence of the relations between schemata and that the relations between schemata are introduced at definite points in time. The distance between the points on the other hand has no significance and indicates nothing about the length of the periods.

The schemata studied and the relations between them can be used for the construction of models of single manufacturing operations or of a number of operations. For several reasons we have chosen to study models of single manufacturing operations (cf. pp. 34 f.). The flow of activities shown in Figure 4.3 therefore represents only a part of the activity which is being performed, at each point in time, within the area concerned in a company. In order to illustrate all the operations in a branch of activities we should have needed several figures or a network of flows.

It is possible to construct various models from the flow of activities illustrated in Figure 4.3. A model of the flow from t_0 to t_n may at a first glance seem the most attractive. Such a model, however, must include the corrective action taken as a result of the analysis of variations from standard costs and the consequent changes in program, supervision or result. We have already discussed the difficulties involved in constructing a model of this type. Since the model is to be constructed from the point of view of the Analyst, we have decided to restrict it to the three schemata Planning, Foremen and Workers.

With this restriction we can only construct models of sub-flows, i.e. according to

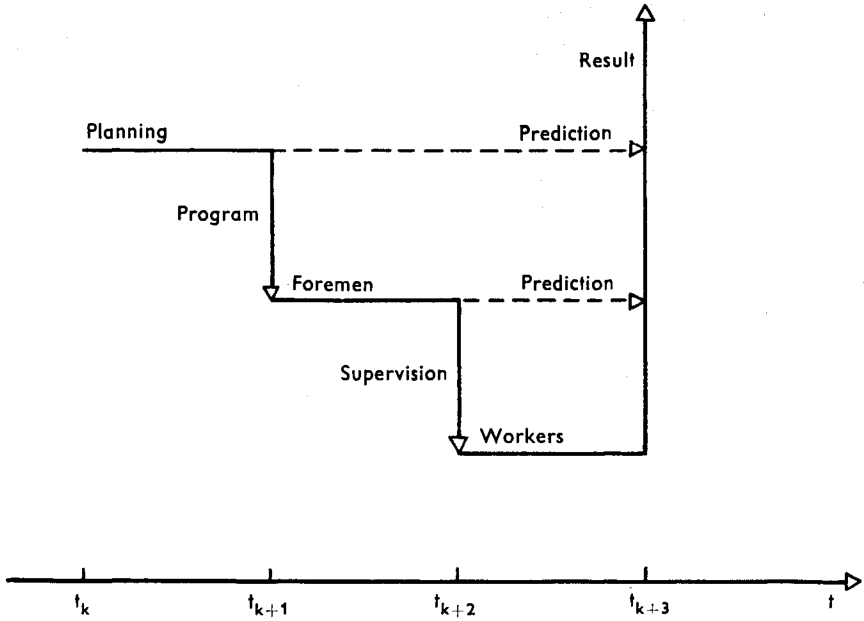

Figure 4.4 *The Flow of Activities during a Typical Period,* T_k, *from the Point of View of the Analyst*

Figure 4.3 from t_1—t_4, t_5—t_8, t_k—t_{k+3} etc. We shall henceforth discuss the construction of models of a typical sub-flow, e.g. from t_k—t_{k+3} according to Figure 4.3.

Figure 4.4 illustrates a typical sub-flow according to Figure 4.3. Apart from the restriction of the number of schemata and therefore of the number of relations, no changes have been made from Figure 4.3. For the sake of simplicity we shall in future refer to the sub-flow as *the flow of activities during period* T_k. This still implies nothing about the length of the period.

The flow of activities during period T_k corresponds to one manufacturing series in a single manufacturing operation. To find out the number of manufacturing series in a company during a certain (calendar) period two summations will be needed: (i) of the number of manufacturing series in each operation during the period and (ii) of the number of manufacturing operations. The analysis of variations from standard costs concerns groups of manufacturing series during a period of time (a month, three months or a year). Unlike the flow of activities during period T_k, the subject of the analysis has been added according to (i) and partially added according to (ii). Summation (ii) concerns, for every organizational unit under consideration, the manufacturing operations assigned to that unit. It should perhaps be mentioned that summation according to (i) is not the same as a transition from Figure 4.4 to Figure 4.3, since the analysis and the corrective action occur once for the whole period.

Our reason for limiting the scope of this study to single manufacturing series has already been indicated (cf. pp. 6 and 34 f.). A model is constructed for use on several occasions. In a fully constructed theory, the schematism will contain rules for the application of the models. Since no formulated theory exists for our area of study, we cannot define exactly the range of application for the models that we construct. However, it seems reasonable to assume that a model of the flow of activities during period T_k, in other words a model of one manufacturing series in a single manufacturing operation, will be more useful than a model of all the manufacturing series during a particular period of time, in the operations assigned to a particular organizational unit. (If the manufacturing series in each manufacturing operation are repeated during the period, our assumption is obvious.) It will be easier to test a model of the first type against empirical data and, as a result of repeated tests and modifications, the model should be suitable for predictions and explanations of limited flows. In our view this hope justifies the restricted scope of application which can result from basing the model on a single manufacturing series.

Further Definition of the Relations between Schemata

In view of the incomplete theoretical background we shall restrict ourselves to some general remarks about the relations between schemata which will be of importance for our argument.

With the exception of the influence relations between Planning and Purchasing, the relations have been drawn in one direction only, from schemata for superior to schemata for subordinate organizational units. In our discussion of review (cf. for example pp. 14 f., 49 and 51) we have already mentioned the assumption that a subordinate organizational unit anticipates the reaction of the superior unit to its actions and has adapted its behavior accordingly. It seems equally likely that a superior organizational unit anticipates the reaction of a subordinate unit to its instructions and adapts these in accordance with the expected reaction.[8] This means that the subordinate unit influences the superior one and it is thus reasonable to introduce in addition relations from the schemata of subordinate units to the schemata of superior units.

Since the relations illustrated have been included in a flow it would be convenient also to include the additional relations. One way of doing this is indicated in Figure 4.1 by means of the dotted arrows from Purchasing and Workers via the Analyst to Top Management. In Figure 4.3 the additional relations have not been shown separately but have all been included in the result. It appears from the latter figure that the additional relations always occur later in time than the others.

In the simplified model, constructed from the point of view of the Analyst, the additional relations do not appear. We can assume, however, that a superior has expectations of future reactions on the part of his subordinates and thus anticipates the reaction to attempted influence. Further, it can be assumed that these expectations are based on experience of previous reactions. In this way there can be justi-

[8] For instance, an organizational unit follows the suggestion made by Stedry [1960] and informs a subordinate of lower budgeted costs than those expected by the budgeting department (cf. pp. 5 and 14 ff. above).

fication for neglecting relations from the schemata of subordinate units to the schemata of superior units in the simplified model too. There will, however, be disadvantages. It will be necessary, when choosing the attributes of the schemata of the superior organizational units (Planning and Foremen in Figures 4.2 and 4.4), to take into account the expectations of the subordinates' reactions. Thus, even if a model constructed on the basis of Figures 4.1 and 4.3 could be regarded as an isolated system,[9] the same is not true of the simplified model.

[9] For several reasons even this is doubtful. In any case, relations will exist with for example, the purchasing and selling markets.

CHAPTER 5

Attributes of the Schemata of the Organizational Units

5.1 ON THE SCHEMATA OF THE ORGANIZATIONAL UNITS

Desiderata in the Choice of Attributes

We have already mentioned that in constructing the model a great many of the characteristics of the organizational units have to be disregarded. This was our reason for explicitly stating the transition from organizational units to schemata without, however, being able to indicate exactly the content of the schemata. The incomplete state of business economic theory (cf. pp. 31 ff.) has been our stumbling-block;[1] we shall have to base the choice of *attributes* on some generally formulated desiderata, rather than on detailed rules.

(i) The attributes chosen should be able to characterize the schemata of individual people and of organizational units.

(ii) It should be possible to include the attributes in relations representing influence between schemata.

(iii) It should be possible to construct a network of relations connected with the direct manufacturing costs. (By choosing the analysis of standard costs as the subject of this study, we have accepted that the ultimate effect of the influence relations will be defined in terms of the company's result[2], which in turn is characterized by the direct manufacturing costs, cf. p. 17.)

The models incorporating the attributes are to be used in the analysis of variations from standard costs and their adequacy may then be called in question. In any assessment of this, even an incomplete discussion of the choice of attributes and their subsequent operational definition may be of some help. We therefore feel justified

[1] It is worth noting how we differ here from Törnebohm [1957]. He is able to state that the schemata of, for instance, the earth and the sun are particles or mass-points (pp. 119 f.). Consequently he bases his choice of attributes on those which can characterize particles (p. 121). Cf. also pp. 18 f. and 20 f.

[2] We use the term *effect* to emphasize that a particular result refers to schemata. When we refer to organizational units or individual persons we use the terms *result*, *output* etc.

in discussing certain attributes and their operational definition even if we cannot incorporate them in specified relations or, in some cases, even specify them exactly. The possibility of operational definition has to some extent governed the choice of attributes to be included in the models.

Despite their incompleteness the three desiderata above, together with what has been said in the previous chapters, are of some help in choosing the attributes that we wish to consider. In the remaining part of this section we shall discuss some points concerning the choice of attributes which are common to all schemata.

Type of Explanation

Our choice of attributes for the schemata is based on a type of explanation which we have not had reason to mention until now. In explanations of people's behavior reference will often be found to the fact that a particular action was undertaken because the person wished to attain a particular goal. An explanation of an action which includes reference to a goal, is often designated a *teleological explanation.*[3] Although we have no room here for a lengthy discussion of teleological explanations we have already to some extent invoked one in our discussion of the configuration of schemata according to Figure 4.1. The configuration was based on the hypothesis (cf. pp. 40 f.) that a means-end analysis starting from the main goal of the company, is used in formulating messages within the organization. We shall therefore mention here some of the problems involved in the use of teleological explanations in connection with the construction of our type of model.

Teleological explanations have been exposed to sharp criticism, particularly in the natural sciences. According to Nagel [1953] one of the origins of this criticism is

> . . . the association of teleological explanations with the doctrine that goals or ends of activity are dynamic agents in their own realization, . . . (*Ibid.*, p. 540.)

On the other hand it seems to be generally accepted that purposes and goals do play an important part in conscious human behavior. Braithwaite [1953] has formulated the reason for this acceptance as follows:

> Teleological explanations of intentional goal-directed activities are always understood as reducible to causal explanations with intentions as causes; . . . the goal-directed behaviour is explained as goal-intended behaviour. (*Ibid.*, pp. 324 f.)[4]

We are still looking at the problem from the point of view of the Analyst and considering the choice of attributes of schemata as one stage in the construction of the model. We are considering the possibilities of predicting and explaining the

[3] See, for example, Braithwaite [1953] pp. 322 f., Bunge [1959] p. 19, Nagel [1953] pp. 539 f., Ofstad [1961] p. 96. Sometimes the term *finality* is used to denote the same phenomenon, cf., for example, Svennilson [1938] p. 15.

[4] See also Bunge [1959] p. 302, Nagel [1953] p. 540, Ofstad [1961] p. 130 and Svennilson [1938] pp. 15—24. (Svennilson refers in turn to Frank H. Knight, *Risk, Uncertainty and Profit,* Boston 1921, pp. 201—2.) Cf. however, the discussion of "the Hull-Tolman controversy" in Ofstad [1961] pp. 129 f. ("Some psychologists may assert that if Hull's theory is correct, behaviour may be explained without having to use independent variables which take such things as goals, values, ends in view as their values.")

actions of an organizational unit but are not concerned with what the people themselves think they are doing or what they ought to be doing. In view of what we have just said about teleological explanations we shall choose only such attributes as are related to intended goals. We must then also discuss how these goals are determined and how they are related to the actions.

Basis for the Choice of Attributes

In view of desideratum (iii) above, we shall take the ultimate effect as starting-point when we study the choice of attributes. In this study the emphasis will therefore be on those characteristics of a person which, it can be assumed, are related to the ultimate effect. The difficulty here will be to select and delimit an ultimate effect, since the activities which we are considering do not inherently have any final point.[5] We nevertheless decided to construct models of limited flows of activities, i.e. the flow of activities during period T_k, and have already discussed our reasons for doing so above (cf. pp. 52—4).

5.2 THE DIRECT MANUFACTURING COSTS AS ULTIMATE EFFECT

Limitations of the Study Resulting from the Choice of the Direct Manufacturing Costs as Ultimate Effect

By choosing the direct manufacturing costs as the ultimate effect in our model, we eliminate all effects which do not directly concern the company or its top management. Nor do we consider the revenues accruing to the company as a result of the actions concerned, nor all the costs. As a result we have excluded the possibility of using the model for explaining or predicting these results. However, we do not intend to discuss these restrictions any further in this context because, when we chose the analysis of standard costs as our subject, we accepted the fact that our study would be concerned with activities from the company's point of view. And we need say no more about the further restriction to direct manufacturing costs, apart from repeating that it serves a very important purpose in making it easy to observe the ultimate effect (cf. p. 7 above). We must note, however, that it may be difficult to explain and predict the direct manufacturing costs without reference to intended goals which are more extensive than these costs themselves are. In this

[5] Cf. Nagel [1953]. When he discusses these limitations, this author says that an "obvious reply to this objection is a *tu quoque*". The absence of an inherent final point is in fact equivalent to the absence of a starting-point. Similar adjustments must therefore be made in a study that takes certain actions or antecedent conditions for actions as starting-point. (*Ibid.*, pp. 553 f.)

section we shall discuss the definition of the direct manufacturing costs, while intended goals will be discussed in the following sections of this chapter, in connection with the choice of attributes for the various schemata.

The Direct Manufacturing Costs

In Chapter 2 (p. 17) the total direct manufacturing costs were designated C_D and defined in accordance with (2.2), (2.3a) and (2.3b) as

$$C_D = c_M + c_W = x(q_M p_M + q_W p_W) \tag{5.1}$$

Our study, however, is concerned with one manufacturing series in a single manufacturing operation and the direct manufacturing costs have therefore been assigned as the ultimate effect. In future we shall use C_D to designate the *direct manufacturing costs* for one manufacturing series in a single manufacturing operation. At the same time we give C_D a definition analogous to that in (5.1) but deviating slightly from it:

$$C_D = c_M + c_W = Q_M p_M + Q_W p_W \tag{5.2}$$

where c_M designates *direct material costs*, c_W *direct labor costs*, Q_M *total material usage* (for the manufacturing series), p_M *material price* per unit of material, Q_W *total working time* (for the manufacturing series) and p_W *wages per hour*.

The term *direct* is used to indicate that a cost, usage etc. is allocated in the company's accounting to a product or an order. By choosing the direct manufacturing costs as our ultimate effect, we have established a link with the way in which the effect is registered in the accounting (cf. Chapter 7). It should perhaps be added that this need not exclude an indirect consideration of the volume of production and the design and quality of the products. The *length of series* (x) will for instance be included in the model and, by inspecting the finished products, it is possible to check design, quality etc. It can therefore be assumed that each value of C_D applies for a given design and for the volume of production indicated by the value of the variable x.

5.3 ATTRIBUTES OF WORKERS

Of those variables which, according to (5.2), determine the direct manufacturing costs, the values of total working time, Q_W, and total material usage, Q_M, in particular can be influenced by the workers. These two variables are therefore regarded as effects in relation to Workers. The design and quality of the products, which can also be affected by the workers, are taken into consideration alongside the model, as was indicated in the previous section.

Total Working Time

Various ways of describing the total working time, Q_W, have already been mentioned (Chapter 2, pp. 17, 20 and 23 and Chapter 3, pp. 30 and 33—4). It is usually assumed that Q_W is obtained from

$$Q_W = xq_W \tag{5.3}$$

where x, within our limitations, represents the number of units in the manufacturing series under consideration, i.e. the length of the series, and q_W the working time per unit manufactured. In the literature the workers' influence on Q_W is discussed on a basis of the working time per unit manufactured, since it is assumed that the value of x is decided by other organizational units.

Working Time per Unit Manufactured

It is often assumed that a standard value of the working time per unit manufactured (q_W) for one manufacturing operation is related to a particular method of executing the task, i.e. *the one best way* (cf. pp. 9 and 12 f.). It therefore seems reasonable to find out whether an s-value of q_W can be included in a formula of the type

$$q_W = f(A_W) \tag{5.4}$$

where A_W represents the workers' actions. The s-value could then be regarded as an abbreviated expression of the formula in a description, providing the formula (5.4) could be supplemented by the other stages in a complete description (cf. p. 30 above). This would of course necessitate, among other things, that the actions, A_W, had been specified and so were measurable.

Abruzzi [1952] makes several critical comments about the time studies which provide the basis for the s-values of q_W in different manufacturing operations. One of his main arguments is that the concept (the one best way) is little more than an idealization based on the fact that certain gross characteristics are common to a particular operation as performed by different workers or by one worker on different occasions. Abruzzi's argument is based on extensive empirical studies of manufacturing operations, both as a whole and in parts. He found that both performance and working time differed from worker to worker and, for one worker, from time to time (see, for example *ibid.*, pp. 215 ff.). In view of Abruzzi's results it seems doubtful that an s-value of q_W based on time studies can be regarded as an abbreviated expression of the formula in a description. It is even doubtful that an adequate description can be obtained on the basis of a formula of the type (5.4). On the other hand it has been possible to observe some stability in the working time of manufacturing operations and this has been a prerequisite for the use — in the main successful — of time studies.

Workers' Frame of Reference

The stability in the working time of manufacturing operations will have to be explained also by attributes other than Workers' actions. In the previous chapter we used the term *frame of reference* as a comprehensive designation of the attitudes, knowledge, motivation, valuations etc. of individuals and organizational units. Abruzzi [1952] emphasizes the importance of introducing a concept of this type into explanations of workers' performance.

These examples suggest that all workers regulate their output according to financial, vocational, and other requirements of primary current interest to them. If this hypothesis is true, restriction of output can be considered a special case of regulation of output; regulation becomes restrictive when the workers' predominant requirement is to protect lenient production standards and wage-payment rates. (*Ibid.*, p. 69.)

Abruzzi reports several special studies of the hypothesis (cf. *ibid.*, pp. 107, 144 ff., 204 etc.). It should perhaps be mentioned that it has never been found easy to explain human actions with the help only of the type of concept which we have designated the frame of reference.

High morale is not a sufficient condition for high productivity, and does not necessarily lead to higher productivity than low morale. (March & Simon [1958] p. 48.)

Since neither of the two types of attribute that we have mentioned can alone explain workers' performance, measured in working time per unit manufactured, it seems reasonable to include both in the model.

Material Usage

The total material usage is the second of the effects that we distinguished above for Workers. The relation between total material usage and number of units manufactured is usually considered to be of the same type as (5.3), or

$$Q_M = xq_M \tag{5.5}$$

As in the case of total working time, we start from the assumption that the variable x will be attributed to other schemata besides Workers. The material usage per unit manufactured, q_M, can be relevant as an attribute of Workers.

Material usage per unit manufactured has received less attention as an expression of workers' performance than working time per unit manufactured. One result of this is that we know considerably less about its relation to workers' actions. In the survey of literature in Chapter 2 we indicated three ways of determining the s-value of material usage per unit manufactured, namely engineering studies, studies of previous experience and test runs under controlled conditions. Probably in the third of these cases only is there reason to investigate whether an s-value can be included in a formula of the type (5.4) and can constitute an abbreviated expression of the formula.

One reason for the limited interest in material usage as compared with working time in this context is probably that workers' wages are not related in the same degree to the value of q_M as they are to q_W. It also seems likely that an absence of connection between wages and material usage affects also the workers' own evaluation of different levels of usage. In what way it will affect their acceptance of the goals, programs etc. for material usage that are prescribed by management, planning or foremen, cannot however be indicated without the support of empirical studies.

5.4 ATTRIBUTES OF FOREMEN

The analysis of variations from standard costs is regarded in the first place, according to the literature (cf. pp. 26—8), as an aid in the control of the activities of foremen. This means that it must be possible to use the model for explanations and predictions of these activities. At the same time the literature has less to say about the construction of those parts of the model that concern Foremen than about those parts concerned with Workers. In his study of supervisors and their activities, Wirdenius [1958] mentions on several occasions the lack of "... documented theory in the field of supervisor behavior ..." (p. 26).[6] The discussion in this section is therefore even more tentative than in the previous section.

Foremen's Performance

From (5.2) we have now assigned the attributes working time per unit manufactured, q_W, and material usage per unit manufactured, q_M, to Workers and we have left wages per hour, p_W, material price per unit of material, p_M, and number of units manufactured, x. Although wages are to a great extent decided by negotiation between representatives of management and the workers, the foremen can have some influence on p_W. This influence can be relatively large if the foremen engage their own personnel or more restricted if they only allocate the work (cf. p. 12). In the case of material price, the influence of the foremen seems to be weaker than in the case of wage rates and the number of units manufactured is probably determined wholly by other organizational units. Of the three variables mentioned we shall choose only wages per hour, p_W, as an attribute of Foremen. But, according to the configuration of schemata, Foremen can influence Workers and thus, indirectly, the s-values of the variables q_W and q_M. We must therefore examine the possibility of incorporating this influence in the model.

We can see something of the way in which foremen can influence working time and material usage, if we refer to our earlier account of how the s-values of these

[6] Wirdenius seems to include the contents of a description in a theory, thus using the term *theory* in a wider sense than we do. From our present point of view this would imply an even greater limitation in available knowledge.

variables are determined. The s-value of working time, q_W, is determined for a given technique, a particular arrangement of tools, on the condition that certain instructions have been given, etc. and the s-value of material usage, q_M, for a certain quality of material, fixed production methods etc. (cf. pp. 11 f.). It can probably be assumed, even if it is not openly stated, that the foremen's task is to see that these conditions are fulfilled every time a manufacturing operation is carried out. Some more ways in which foremen may influence workers are illustrated in the *list of causes* of differences between standard and observed working time (Figure 2.1). Here we find reference to the planning of the work (utilizing the set-up for several manufacturing series), special supervision, quality control and care of tools etc. None of this, however, can provide an adequate base for defining the attributes of Foremen nor, even less, for constructing relations between these and the actions or performance of Workers. In the previous section we mentioned some of the problems involved in specifying workers' actions and in using time studies to obtain an adequate description of regularities between actions and output. This makes it difficult, in the present context, to apply the criteria indicated for the choice of attributes. To this must be added that the actions of foremen are not explicitly specified in connection with time studies.

Westerlund & Strömberg [1960] had as one of their aims to investigate

... whether such variables as the quantity and quality of production, absence from work, personnel turnover, accident frequency, costs etc. in a foreman's department are correlated with the foreman's own characteristics such as his education, age, years of service, what his superiors think of him, etc. (*Ibid.*, p. 5.) (*Our translation.*)

If it is possible to regard these characteristics as indicators of the foreman's performance, a study of regularities between the indicators and workers' performance can illustrate the desired relation between Foremen's and Workers' activities. But in conclusion we might perhaps point out that, from the departments studied by Westerlund & Strömberg [1960], it was not possible to obtain support for these hypotheses.

Foremen's Actions

Wirdenius [1958] classifies the activities of foremen in eleven main categories. His classification has been governed by the possibility of direct observation and eight of the categories are said to demand little inference on the part of the observer. Examples: place where an activity occurs, physical action (sitting, standing etc.), number of contacts and method of communication (face-to-face talk, telephone call etc.).

But even though each of them [the eight categories] helps to portray a concrete picture of what the supervisor does, the picture remains incomplete, uncertain, superficial, gross and blurred. For instance, we are still very much in the dark about the purpose or intent of behavior or about the kinds of duties or functions a supervisor discharges. (*Ibid.*, p. 92.)

To give a more complete picture of the activities of the foremen, three more categories are introduced — function, time dimension of activity and method of performing function — all of which require a greater degree of inference on the part of the observer. The most important of these categories is function, which

> ... may be regarded as the nucleus of our classification system. What we are trying to get at is the organizational "function" which the activity is satisfying or attempting to satisfy. (*Ibid.*, p. 92.)

Within the classification, function has been specified in about twenty subsidiary groups, e.g. planning, distribution of work, general supervision of work, quality control, plant maintenance, work simplification, hiring, induction and training of personnel, wages and compensation etc. Because he wishes to restrict himself to the directly observable, Wirdenius abstains from studying the relation between an action (according to the classification) and performance and also the extent to which an action fulfils the given function.

Foremen's Frame of Reference

In view of what was said in the previous chapter, it is reasonable to suppose that a foreman's own attitudes, knowledge, motivations, valuations etc. will affect his performance. Since it is difficult to define a foreman's performance, we cannot know very much about how the frame of reference may affect it, nor is it easy to discuss how the actions and performance of foremen are affected by the various measures intended to influence their frame of reference (e.g. various formulations of a prescribed goal).

Choice of Attributes

Up to now we have been mainly occupied with the difficulties involved in trying to incorporate Foremen's activities into the model. Despite this it is essential for our purpose to select certain attributes, even if incompletely defined. Apart from wages per hour, p_W, we shall therefore also choose for our consideration an attribute *supervision*, designated A_F. Supervision can be exactly defined, for instance according to Wirdenius' classification above, but it is not possible to specify a relation between supervision and the actions of Workers, or between supervision and working time or material usage per unit manufactured. In the following discussion of the model we shall also need to refer, for instance, to the foremen's intended goals. We shall therefore select for Foremen a further attribute, *frame of reference*, G_F, without being able to provide, or refer the reader to, a complete definition.

5.5 ATTRIBUTES OF PLANNING

The configuration of schemata according to Figure 4.2 starts from Planning. It is possible to study in two stages the construction of the model used for the explanations and predictions of C_D: (i) explanation and prediction of C_D, assuming given actions on the part of Planning and (ii) explanation and prediction of Planning's actions. In an explanation or prediction of C_D assuming certain actions on the part of Planning, these actions are introduced as initial conditions. We shall study (i) and (ii) separately in this and the following sections respectively.

Effects of Planning's Activities

From (5.2) there now remain the variables x (number of units manufactured) and p_M (material price). These variables have been attributed to Planning because their values can be regarded as direct effects of the activities included in the schema.

The indirect influence of Planning on the ultimate effect, through its influence on Foremen and Workers, can be incorporated in the model in various ways. We have chosen *frame of reference* as an attribute of Foremen and Workers, thus including intended goals, knowledge etc. in these two schemata. In constructing the model we shall assume that Planning influences Foremen and Workers through their frames of reference. But it is difficult to determine empirically the frames of reference of individuals and organizational units, and so we shall consider simplified versions of the model where the influence of Planning operates direct on the actions of Foremen and Workers. Actions and the effects of actions are relative terms. A further simplification of the model may follow, in that Planning's influence on C_D operates through the direct effect of Foremen's and Workers' actions. We shall also consider a model of this type.

Planning's Actions

Our discussion of the activities of the planning departments in Chapter 4 was limited to the preparation of programs. We now assume that their actions consist of working out a program and passing it on to the foremen and to the workers (via the foremen).

We have already defined in general terms the possible content of the program for a single manufacturing operation under four headings:

(i) Design of the product (blueprints, quality norms etc.)

(ii) Manufacturing procedures (choice of machine, data on machine speeds, tools, type of material, motion chart for workers etc.)

(iii) Expected result from the execution of the manufacturing operation

(iv) Time fixed for starting (or completing) the manufacturing operation and the quantity manufactured.

Points (i) and (iv) include conditions which are outside the scope of our model since we are concerned with the ultimate effect, C_D, for a given design and regardless of when the manufacturing operation is performed. Apart from quantity manufactured we shall therefore disregard this part of the program content in the present context. Point (ii) includes items of the type already discussed in connection with the choice of Foremen's attributes. The same difficulties will apply here.

In the case of point (iii), expected result, the choice and definition of attributes is comparatively easy. We can utilize the s-values which most companies have readily available. It should be noted that the attribute consists of a predetermined (expected or prescribed) *value* of these variables. We shall call these attributes *prescribed goals* and shall refer to them by the symbols already assigned to the corresponding variables, but with the addition of a bar. The Foremen's and Workers' prescribed goals are concerned with working time and material usage per unit manufactured, $\bar{q}_W$ and $\bar{q}_M$, wages per hour, $\bar{p}_W$, and the direct manufacturing costs (with given length of series and material price), $\bar{C}_D$. We have excluded Purchasing from our model, for the sake of simplicity, and have instead attributed quantity of material purchased, Q_{MP}, to Planning. If a purchasing department is to be considered separately, and Purchasing is therefore included, it will be convenient to select material price as a prescribed goal, $\bar{p}_M$.

The attributes discussed here constitute a formulation of Planning's actions, A_P. In view of the difficulties mentioned above we shall have to use A_P as a kind of summarized attribute of Planning although we cannot advise the reader of any empirical basis for its definition. When we try to construct relations between prescribed goals and the actions of Foremen and Workers (or the effects of these actions), we must remember the connection between prescribed goals and review (see, e.g., pp. 2 f.). As a result of this connection, the two-way anticipations and reactions between Foremen/Workers and Planning will play an important part (cf. pp. 54 f.) and the relations will have to be formulated in accordance with the particular model under consideration. It is therefore difficult to discuss the relations separately.

Impact on the Company from Outside

Since the flow of activities studied in the configuration of schemata according to Figure 4.2 is initiated by Planning, it will be convenient to let any impact from outside operate through that schema. When we try to introduce external influences into the model we meet again the same problems in the choice and definition of attributes and the construction of relations. We cannot refer to empirical evidence of the way in which an organization member conceives and reacts to impact from outside, nor can we know what he regards as an impact. In a very general way we can distinguish the market price of material, negotiated wage rates, trends in price and in company sales etc. as being phenomena which can affect the ultimate effect,

C_D. Because of the lack of empirical evidence, we shall consider only two examples of attributes of this type in our model, e.g. negotiated wage rates, p_{WU} and a market price for material, p_{MP}. These two attributes have been chosen in view of our earlier discussion and are sufficient as an illustration.

5.6 EXPLANATION AND PREDICTION OF PLANNING'S ACTIONS

With the attributes so far discussed in this chapter we should now be able to discuss models for use in explanations and predictions of the ultimate effect, C_D, provided that Planning's actions are introduced as initial conditions.

An explanation and prediction of Planning's actions would require the introduction of a greater number of attributes and a more extensive model. Before returning to our main theme, we should perhaps mention some of the problems of formulation and the limitations that would arise in this case.

Top Management's Influence on Planning

We have already mentioned that it is difficult, within the limits of the configuration (Figure 4.2), to deal explicitly with influence exerted by Top Management (see Chapter 4 above). With reference to its influence on Planning, we must remember that influence is probably of a more general character the higher the position in the organization.[7] Instructions to the organizational units concerned with planning will in the main contain the desired result of their actions and only to a lesser extent any detailed rules of action. We have already mentioned in general terms that this gives rise to difficulties with regard to control. The remaining part of this chapter will further illustrate the difficulties involved in explaining and predicting actions, and results, on the basis of general instructions of this kind. We shall also indicate a possible way of getting round some of the difficulties.

Different organizational units, acting independently, can be coordinated if, for instance, top management provides each of them with rules for action in different situations or a goal at which they should aim, all geared to final achievement of the company's total goal. It can be difficult to formulate rules and goals if restrictions are imposed; for example, if the rules must be simplified or the goal must be related to the accounting (e.g. Faxén [1957], pp. 16 f.). In this study we shall disregard such difficulties. For the sake of simplicity we shall also disregard the fact that the planning departments and top management may each regard the given goal in a different light. We assume instead that Planning accepts (parts of) the company's or Top Management's goal as its own intended goal.

[7] Cf. Carlson [1951] p. 49.

Type of Explanation

The main element in an explanation or prediction of planning's actions is, as we interpret it, the departments' own intended goals. We assume that planning will take into consideration (i) what actions can be performed, (ii) what result(s) each of these actions will have and (iii) the desirability of each of these results. The essential point about an explanation of this type is that the observer (Analyst) refers to the intended goal and the degree of knowledge of the person who performed the actions concerned.

Faxén [1957] deals with this question by distinguishing

> ... between the idea which an analytical observer (e.g. a scientist) is able to form and the acting person's own conception of his situation. The analytical observer's idea of the situation will be called the *objective* partition tree, while the acting person's own conception is reproduced in the *subjective* partition tree. (*Ibid.*, p. 85.)

A partition tree will include the three considerations mentioned above. To explain or predict a single action the observer will make use of the subjective partition tree. If the observer also wishes to explain or predict the results of the actions, he may refer to an objective partition tree which deviates from the subjective tree in that it presumably provides a better prediction.[8] In an explanation or prediction of a sequence of actions, where it may be assumed that one action is influenced by the outcome of those preceding it, we may therefore have to resort to subjective and objective partition trees, constructed from different points of view. We have previously cited the difficulties that arise in a study of this type as the reason for restricting ourselves to a limited flow of activities, i.e. the flow of activities during period T_k (cf. e.g. pp. 49 f. and 52—4).[9]

Various attempts at constructing models based on a subjective partition tree have been described in the literature; they reveal many intricate problems. But in our limited study it should be possible to discuss explanation or prediction of Planning's actions without necessarily becoming involved in this type of generalized model. We shall therefore only mention a few points which affect or illuminate the problems that interest us.[10]

Determination of Planning's Actions

The Analyst's subjective partition tree for Planning contains the actions (or alternatives) which planning considers possible. With regard to determining these alternatives we can refer to the related problem, discussed above (pp. 42 f.), of deter-

[8] Because, for example, the results of the acting person's actions are influenced by the reactions of other people also included in the observer's study. Cf. Faxén [1957] pp. 91 f.

[9] An alternative would be to introduce the concept *strategy*, i.e. it is assumed that the subjective partition tree contains all the possible results of an action and the actions subsequent to each result. It is then possible to examine the studied person's choice of strategy as a single action.

[10] For more complete accounts of the general problem the reader is referred to Faxén [1957] and Luce [1959] and to further references given in these two works.

mining the nature of a means-end analysis. In the present case, however, we do not even have the help of a general idea of the institutional structure of the organization.

> Indeed, the whole problem still seems to be floundering at a conceptual level, with us hardly able to talk about it much less to know what experiments to perform (Luce [1959], p. 4).

In our study, as in the literature in general, we shall assume that the alternative courses of action are given. The alternatives for Planning consist of different formulations of the program, i.e. of different values of A_P.

The Relation between Planning's Actions and their Effects in the Subjective Partition Tree

When the relation between the actions and results of planning has to be represented in the Analyst's subjective partition tree, a model of the effect of the actions of the schema will be of great importance. This model could even be used by the planning departments, provided that the alternative courses of action can be defined in terms of the program content. However, it is difficult to generalize about whether planning uses the model or whether planning and Analyst interpret it alike (cf. note 6, p. 50). Although they are members of the same organization and are both influenced by top management, there would be difficulties for instance with regard to the frames of reference of the individual members. Nonetheless it seems reasonable to assume as a working hypothesis that Planning's actions can be explained and predicted with the help of the Analyst's model of their effect.[11]

Determination of Planning's Intended Goal

There has been much discussion in economic literature about the maximization of profits in companies and the related concept of rationality. Faxén [1957], for instance, emphasizes that concepts such as maximization and rationality are parts of the observer's explanation or prediction of the company's behavior. If, with a given model, certain behavior appears to be irrational, the observer/Analyst can hope to explain it as rational by changing the conditions governing the model. (*Ibid.*, pp. 51 f.)

The maximization argument can however be assigned different functions in the explanation. Faxén differentiates between analytical maximization and empirical maximization.

[11] Cf. however the objections raised by Luce [1959] to an interval scale of utility of the type first constructed by von Neumann & Morgenstern:

> ... they assume that subjects know and deal with the objective probabilities as such, rather than with some subjective measure of likelihood. Why, one cannot help asking, should a subject distort the money scale but not the probability scale? (*Ibid.*, p. 76.)

These objections raise some doubt as to the reasonableness of our hypothesis since the predictions obtained with the model's help could best be compared with von Neumann & Morgenstern's "objective probabilities".

In analytical maximization the concept is so formulated that the sentence "the firm maximizes its profits" or "the household maximizes its utility" invariably holds good out of logical necessity. . . .
In empirical maximization . . . the concept is such that the sentence "the firm maximizes its profits" or "the household maximizes its utility" expresses a relationship between observed data. (*Ibid.*, p. 37.)

Applying the terminology that we introduced in Chapter 3, we could possibly say that analytical maximization is a principle in a theory, i.e. a rule for the construction of models. In that case empirical maximization would be a hypothesis supporting a model. The difference between them is revealed if we assume for a moment that as a result of an unsuccessful prediction, a model has to be rejected and replaced by a new one. In the case of analytical maximization we shall try, in the first place, to change something other than the maximization argument, e.g. the definition of profit from short run profit to long run profit. In the case of empirical maximization we can consider rejecting the hypothesis that the studied people are maximizing a variable (cf., e.g., the hypothesis concerning *satisficing* in March & Simon [1958], pp. 140 f.). Because assumptions about maximization play such a predominant role in economic theory, it seems likely that economists conceive them as analytical maximization.

Is profit maximization (or minimization of the direct manufacturing costs) conceived as analytical maximization, an intended goal to which the Analyst can refer in explanation of Planning's actions? The answer to this question is not obvious even if we could construct a verified model of Planning's actions with the help of a principle of this type.

. . . a considerable part of classical as well as contemporary physical theory can be stated in the form of "extremal" principles. What these principles assert is that the actual development of a system is such as to minimize or maximize some magnitude which represents the possible configurations of the system.[1] [Note excluded.]
The discovery that the principles of mechanics can be given such extremal formulations was once considered as evidence . . . for the operation of a divine plan throughout nature. Such theological interpretations of extremal principles is now recognized almost universally to be entirely gratuitous; and no competent physicist to-day supposes that extremal principles entail the assumption of purposes animating physical processes. (Nagel [1953] p. 543.)

If we wish to refer to Planning's intended goals as an element in an explanation of the actions of the schema, it seems that we must assume empirical maximization. This should not be inherently difficult since Top Management, according to our configuration (Figure 4.1), prescribes the goal both for Planning and for the observer/Analyst. In fact when the Analyst tries to determine Planning's intended goals, he will face difficulties similar to those mentioned above with regard to the individual frames of reference.

Direct Manufacturing Costs as Planning's Intended Goal

The direct manufacturing costs of one manufacturing series in a single manufacturing operation, C_D, could be regarded as a measure of Planning's intended goal.

However, even if C_D is included in planning's intended goal, it is hardly likely that this is the whole extent of the goal. For instance we mentioned above that, by limiting our ultimate effect to C_D, we have also accepted the fact that some of the effects of the actions included in the model will be eliminated. It is therefore reasonable to suppose that the planning departments act with more extensive results than C_D in mind. They may sometimes have to consider not only how best to utilize foremen's work input and machine capacity but also their own work input: faced, for example, with the not unusual situation of having to choose between two time and methods studies, both of which can be expected to lead to the same reduction in working time and in C_D, but where one operation uses a more expensive and occupied machine than the other; the decision will be comparatively simple, and will be governed by an intended goal other than C_D.[12]

We do not intend to discuss here the formulation of the intended goal from the point of view of Planning. We shall merely examine some of the consequences of introducing a more extensive intended goal and a broader ultimate effect than C_D.[13] To begin with, if we assign to Planning an intended goal which is more extensive than the ultimate effect, the Analyst will not be able to use the model to express the relation between actions and intended goal in the subjective partition tree. On the other hand, if we extend the ultimate effect, we shall get into difficulties regarding our limited flow of activities. In the previous paragraph, for instance, we referred to two manufacturing operations and the flow of activities might have to be extended even further. If we introduce durable means of production into the discussion there will be further difficulties in evaluating the effect (e.g. a change in the economic life of a machine) of a limited flow of activities, e.g. the flow of activities during period T_k (cf. Figures 4.3 and 4.4). If, as a result of all this, the studied flow of activities is extended or prolonged, there may be new problems concerning repeatability.

The repeatability of our flow of activities is essential to the construction and testing of the models, and so we are faced here with a dilemma. With C_D as our ultimate effect, we can construct models in which the actions of Planning are introduced as initial conditions. The models can be used by the Analyst for expressing the relation between actions and intended goal in the Analyst's subjective partition tree, provided that the intended goal of Planning can be defined in terms of C_D. But it is extremely doubtful that this intended goal can be expressed by C_D. If, in consequence, we consider extending the ultimate effect, we must expect difficulties in constructing and testing the model and, indirectly, in expressing the relation between actions and intended goal in the subjective partition tree.

We have already stated that the ultimate effect has been limited to C_D. We must therefore refrain from discussing an explanation and prediction of Planning's actions in any but general terms.

[12] Obviously similar considerations have some relevance, though less decisively, also with regard to Foremen and possibly even Workers. The prescribed and intended goals of these two schemata, however, are probably more directly oriented towards C_D (cf. p. 67).

[13] For a discussion of the formulation of the intended goal the reader is referred to Faxén [1957], pp. 82—4, Savage [1954], pp. 15—7 and 82—91, Svennilson [1938], for instance pp. 18—20.

CHAPTER 6

The Models in the Analysis of Standard Costs

In this chapter we shall discuss three models as a basis for the analysis of standard costs. The first of these is directly related to the discussion in the previous chapter. What distinguishes this model from the other two is that it contains prescribed goals and intended goals for Foremen and Workers. It has therefore been designated *model G*. With this model as base, we can construct a model related to the type of analysis of variations from the s-values of unrelated variables which we discussed in our literary survey in Chapter 2. In this case we must assume that the Analyst uses the s-values as a prediction of the value of the variables under consideration. The second model is consequently designated *model S*. The third model has been developed from the second and is related to the type of analysis of variations from the s-values of related variables which is also discussed in Chapter 2. This model has been designated *model R*.

The models have been constructed from the Analyst's point of view (cf. Chapter 4). We also assume the existence of review. The model refers to a particular flow of activities, i.e. during period T_k. In Chapter 4 we explained that a model of this type can probably be used for explanation and prediction on a greater number of occasions than a model of a more extensive flow of activities. Although the lack of theoretical background makes it difficult to specify the limits within which a particular model of this type can be applied, it is reasonable to suppose that several of its elements will be applicable to more than one manufacturing operation in the company. On the other hand, by restricting ourselves to the flow of activities during period T_k, we have limited the possibilities of direct comparison with the analysis of standard costs as reported in Chapter 2. From now on our comparisons will be limited to the models discussed in this chapter.

6.1 MODEL *G*

In this section we shall outline an example of a model constructed on a basis of the attributes discussed in the previous chapter. Model *G* will be used in two contexts: (i) in our attempt at relating the discussion in Chapters 4 and 5 to the analysis of standard costs and (ii) in discussing changes is models S and R resulting from the analysis. Model G, which will be discussed in connection with Figure 6.1 (see inside back cover), starts from the actions assigned to Planning, A_P. According to Chapter 5 (pp. 65—7) the actions which we have chosen for consideration can be defined in terms of (i) a prescribed goal of Foremen, $\bar{G}_F$, which includes the desired value of the direct manufacturing costs, $\bar{C}_D$ given the value of the length of series, x, and the material price, p_M, (ii) a program including information on manufacturing procedures, material quality, etc., (iii) information about quantity to be manufactured, x, (iv) a prescribed goal of Workers, $\bar{G}_W$, including working time and material usage per unit manufactured, $\bar{q}_W$ and $\bar{q}_M$, (v) decisions regarding quantity of material to be purchased, Q_{MP}, and (vi) influence on the purchase price of material, p_M, for example by selection of, or by negotiation with, suppliers. Broken arrows are used between A_P and concepts (i)—(vi) in view of the difficulty of specifying A_P.

Planning influences Foremen in two ways (see Figure 6.1). In the first place the prescribed goal, $\bar{G}_F$, influences the intended goal of Foremen, included in G_F. Secondly A_F, the actions attributed to Foremen, are directly influenced by the program (information on quantity manufactured, x, and Workers' prescribed goal, $\bar{G}_W$). In so far as the knowledge attributed to Foremen is altered by the program, it might seem justified to include an influence relation from program to G_F (see the discussion on pp. 65—6). In support of our decision to adopt the present formulation we may cite the model in Stedry [1960][1] and the difficulty involved in specifying this influence.

Since it is assumed that there is a market price for material, p_{MP}, the influence which Planning exerts on the material price can be formulated as the determination of quantity to be purchased, Q_{MP}, and as an influence on the relation between p_{MP}, Q_{MP} and p_M.[2]

The actions assigned to Foremen, A_F, are divided into three groups: (i) those that influence Workers' frame of reference, G_W, (ii) those that directly influence Workers' actions, A_W, and (iii) those that influence the hourly wage rate, p_W. To group (i) we have assigned only Workers' prescribed goal, $\bar{G}_W$, although in view of the fact that it was assumed earlier that supervision influences the knowledge attributed to Workers, there could have been some justification for allowing also this to influence G_W. The reason for our simpler approach is the same as in the case of programs above.

By introducing Workers' prescribed goal, $\bar{G}_W$, as an element in Foremen's actions, it has been our intention to indicate that foremen may have the authority to alter the goal prescribed by planning, for example in the case of rush orders or faulty material. The influence that Foremen exercise on hourly wage rates has been

[1] It may be noted in passing that, in the present context, the model outlined here is more inclusive than Stedry's. It is difficult to make a direct comparison, however, since Stedry's model refers to a more extensive flow of activities. This means that assumptions concerning the adaptations which follow review and corrective action are implicitly included in his model (cf. *ibid.* pp. 17—42 and 14—5 above).

[2] If we were also explicitly considering Purchasing as a schema, the influence on the company's purchase price for material would have been assigned to that. We should then have had to introduce a relation from Purchasing to Planning in order to allow for the influence of material price on the formulation of the program, etc. (cf. p. 48).

formulated in the same way as the influence of Planning on material price. The basis for this formulation has been our assumption that foremen have certain opportunities for dividing work among workers who command different wages and for negotiating with the workers. The difficulties involved in a specification of the actions assigned to Foremen are the reason for the broken arrows between A_F and the concepts discussed here.

Despite similar difficulties in specifying the actions assigned to Workers, we have illustrated the relation between A_W and total material usage, Q_M, and total working time, Q_W, by means of a solid arrow. This indicates that there is a considerable difference in the degree of difficulty involved.

According to Figure 6.1 the direct manufacturing costs, C_D, are obtained from p_M, p_W, Q_M and Q_W. The relation has already been given in formula (5.2) on p. 59.

6.2 CONSTRUCTION OF MODEL *S*

According to the literary survey in Chapter 2 the analysis of variations from standard costs is carried out with explicit reference to the following variables:

volume of production, i.e. within the given limitation to number of units manufactured, x
material price, p_M
hourly wage rates, p_W
material usage per unit manufactured, q_M
working time per unit manufactured, q_W
direct material costs, c_M
direct labor costs, c_W, and
direct manufacturing costs, C_D

According to formulae (5.2), (5.3) and (5.5) the relations between these variables are

$$\left.\begin{array}{lll} Q_M = xq_M & & (5.5) \\ Q_W = xq_W & & (5.3) \\ c_M = Q_M p_M & & (6.13) \\ c_W = Q_W p_W & & (6.14) \\ C_D = c_M + c_W & & (6.15) \end{array}\right\} (6.1)$$

(Total material usage, Q_M, and total working time, Q_W, and formula (5.5) have been included in (6.1) in order to facilitate comparison with models *G* and *R*.)

According to the literature that we reviewed in Chapter 2, the analysis is concerned with the difference between the s-values and the observed values of the variables. In other words the Analyst uses the s-values as his prediction of the value of the observed variables. Cost accounting literature does not explicitly discuss the formulation of the model which is used in obtaining the prediction, but such general discussion as can be found on, for example, the attainability of the s-values and the *list of causes* reproduced in Figure 2.1 can be utilized to construct a model related to model *G*. Model *S* constitutes a simplified version of model *G* and will be discussed in connection with Figure 6.2.

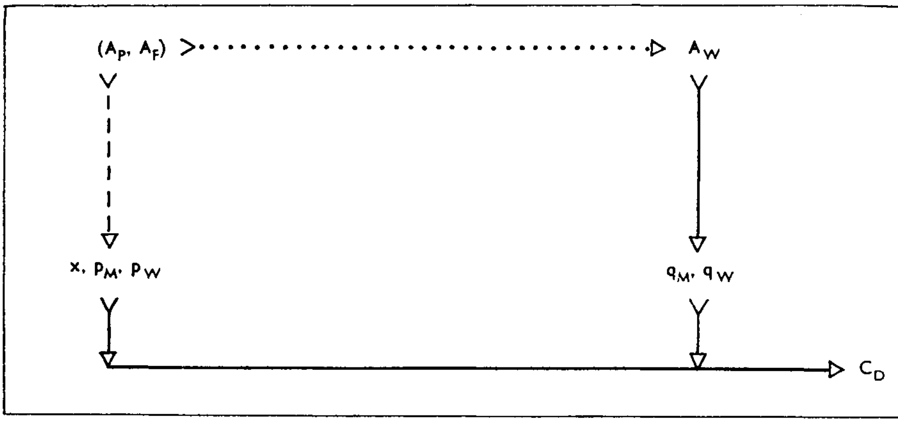

Figure 6.2 *Model S Constructed on a Basis of the Literature Reviewed in Chapter 2*

The literature does not provide an adequate basis for distinguishing Planning from Foremen (cf. p. 62—3). Apart from the ultimate effect, C_D, model *S* therefore includes only two schemata: (Planning, Foremen) and Workers. We have assigned to (Planning, Foremen), besides the above-mentioned variables x, p_M and p_W, only actions (program and supervision) designated (A_P, A_F). In the same way, apart from q_M and q_W, we have attributed only actions, A_W, to Workers. We cannot justify the inclusion of a prescribed goal, G_W, by citing our previous discussion of the attainability of the s-values, since the Analyst uses the s-values of q_M and q_W as his prediction.

The relations (6.1) have been illustrated by means of solid arrows. Broken arrows have been used between actions (A_P, A_F) and x, p_M and p_W for the same reason as in Figure 6.1, i.e. because it is difficult to specify the actions. The solid arrow for the relation between A_W and q_M/q_W also has its equivalent in Figure 6.1.

We have used a dotted arrow between (A_P, A_F) and A_W because any assumptions about these relations which can be found in cost accounting literature are couched in the most general terms. A few of the characteristics of a relation between A_P and A_W can thus be derived from our earlier discussion about how the s-values of q_M and q_W are determined. We have also inferred a relation between A_P and A_F (cf. p. 11—2 and 62—3). On the other hand we can find no support for constructing a relation between A_F and A_W.

6.3 MODEL R

As we saw in our review of the literature, the determination of the s-value of, for example, working time per unit manufactured will be affected by consideration of other variables, for instance the level of material usage per unit manufactured. When the Analyst uses a model of the kind discussed in the previous section as a basis for the analysis of variations from standard costs, he must consider this type of relation outside the analysis itself, perhaps when explaining the variations (cf. pp. 11—2 and 20). In our survey of the literature we also referred to the suggestion made by Coward [1953] for extending the analysis to include relations between variables (cf. pp. 20—3 above). Model R is a development of this idea. In view of the scant empirical base we shall use a fictitious example. The illustration will be supplemented in Chapter 8 by a numerical example.

Example of Relations

We are still assuming that the direct manufacturing costs, C_D, are equal to the sum of the material costs, c_M, and the labor costs, c_W. We also suppose, as in the other models, that these consist of material usage, Q_M, and working time, Q_W, multiplied by the material price, p_M, and wage rates, p_W, respectively. In other words the relations (6.13), (6.14) and (6.15) are adopted unchanged from the previous model.

According to (5.5) material usage, Q_M, is related only to the length of series, x. In explaining the observed variations outside the model, it is also usual to consider work input measured in working time, Q_W, and material quality. For the sake of simplicity we shall assume that changes in material quality may be incontrovertibly measured by the difference between the market price for material, p_{MP}, and the material price, p_M. This will mean that we need not explicitly introduce material quality into the model.

In formula (6.13), the material price, p_M, is included as an independent variable whose value is determined outside the relations (6.1). The above-mentioned assumption that there is a market price for material which does not necessarily agree with the company's purchase price for material, can be used as a basis for the formulation of a relation in which the material price, p_M, is included as a dependent variable. As a further factor which can influence the material price, the quantity purchased, Q_{MP}, is introduced.

According to (5.3), working time, Q_W, is related only to x. Here again material quality will be cited in connection with determining the s-value and in discussing the variations. In the latter case reference will also be made to the division of work among different workers (cf. p. 12). One way of incorporating the division of work into the model would be to include the negotiated wage rates, p_{WU}, and the hourly wage rates, p_W, in the relation (cf. treatment of material quality above). We therefore assume that Q_W is related to x, p_M, p_{MP}, p_W, and p_{WU}.

Lastly we can assume that the hourly wage rates, p_W, are related to the negotiated wage rates, p_{WU}. We have therefore included a relation for determining the value of p_W.

These relations, indicated here in general terms, can be illustrated as follows:

$$\left.\begin{aligned}
Q_M &= b_{10} + b_{11}x + b_{12}Q_W + b_{13}p_M + b_{14}p_{MP} && (6.21)\\
p_M &= b_{20} + b_{21}Q_{MP} + b_{22}p_{MP} && (6.22)\\
Q_W &= b_{30} + b_{31}x + b_{32}p_M + b_{33}p_W + b_{34}p_{MP} + b_{35}p_{WU} && (6.23)\\
p_W &= b_{40} + b_{41}p_{WU} && (6.24)\\
c_M &= Q_M p_M && (6.13)\\
c_W &= Q_W p_W && (6.14)\\
C_D &= c_M + c_W && (6.15)
\end{aligned}\right\} (6.2)$$

where b_{ij} are coefficients and the other symbols are as given in the *list of symbols* on p. 107.

We should like to repeat that the relations (6.2) are intended for use in discussion of some questions related to the analysis of standard costs. For the sake of simplicity they have, except in the case of (6.13) and (6.14), been formulated as linear expressions and error terms have been disregarded.

Construction of Model *R*

The relations (6.2) have been developed from the relations (6.1) and model *S* can therefore be developed into the more generalized model *R*. In Figure 6.3 we distinguish three schemata: Planning, Foremen and Workers.

The only variables distinguished in model *R*, apart from those included in the relations, are the actions assigned to the schemata concerned, i.e. A_P, A_F and A_W. The relations which were illustrated in (6.2) are shown in Figure 6.3 by solid arrows. The broken arrows from A_P and A_F and the solid arrow from A_W indicate how the actions of Planning, Foremen and Workers influence the variables and relations included in (6.2).

The values of x and Q_{MP} are determined as a result of A_P. The choice of supplier and the subsequent negotiations (cf. p. 73) are illustrated in Figure 6.3 by the broken arrow from A_P to the relation between p_{MP}, Q_{MP} and p_M. This indirect influence on p_M may also be formulated thus: that Planning can influence the value of the coefficients b_{20}, b_{21} and b_{22} in (6.22). It is assumed that foremen can influence wage rates by dividing the work among different workers or by negotiating with the workers (cf. p. 73). This influence is illustrated in Figure 6.3 by the broken arrow from A_F to the relation between p_{WU} and p_W and can be related to the relations (6.2) on the assumption that Foremen can influence the coefficients b_{40} and b_{41} in (6.24). The two remaining broken arrows from A_P and A_F indicate that Q_M and Q_W can be influenced indirectly by Planning and Foremen. According to the relations (6.2), the value of Q_M and Q_W is determined by formulae (6.21) and (6.23). This latter

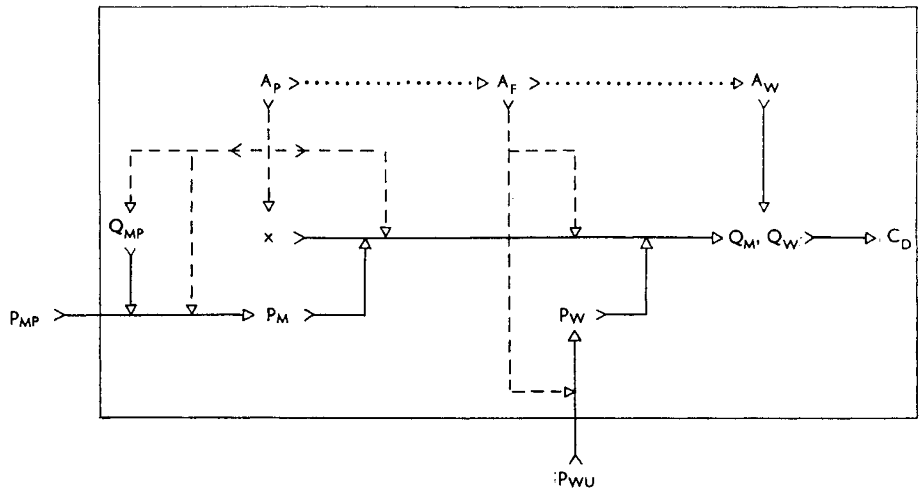

Figure 6.3 *Model R*

influence, together with the direct influence from Workers (solid arrow from A_W to Q_M and Q_W), will therefore appear in (6.2) as the influence on variables and coefficients in (6.21) and (6.22). We have already discussed the influence of Planning on p_M and x and of Foremen on p_W. As regards influence on the coefficients $b_{10} \ldots b_{14}$ and $b_{30} \ldots b_{35}$, we cannot distinguish between Planning, Foremen and Workers, since we cannot assign each coefficient to a particular schema.[3] So long as this difficulty exists, we cannot specify either the influence of A_P on A_F or of A_F on A_W. This is the reason for the dotted arrows from A_P to A_F and from A_F to A_W.

Causal Ordering in Model *R*

When relations of the type which constitute (6.2) are used as a basis for an analysis of variations from standard costs, it is essential that the Analyst be able to distinguish a direction in the relations (cf. p. 22). The relations (6.2) have therefore been formulated in such a way that the operation *causal ordering*, as described by Simon [1953], can be applied to them. This operation will be used in order to reveal which causal assumptions the relations (6.2) contain.

In Figure 6.3 the causal assumptions in model *R* have been indicated by means of one-way arrows. The basis for the assumptions is the same as in model *G* (cf. Figure 6.1), i.e. the discussion of the institutional structure and the activities of the organization in connection with the configuration of schemata in Chapter 4. The causal assumptions in model *G* are based on the influence of the schemata of superior organizational units on the schemata of subordinate organizational units. Influence in

[3] It might be possible to assign b_{30} to Foremen, if the foremen are in charge of setting up work.

the opposite direction, due to the superiors' anticipation of the reaction of their subordinates, has been eliminated in model *G* by its inclusion in a flow of activities where it is assumed that expectations concerning the reactions of subordinates are based on information from the Analyst. From the point of view of the Analyst the influence will thus be one-way. It is also essential to note that the assumptions refer to the schemata of organizational units and not to the units themselves. Only when the transition from the model back to the company has been made (reapplication; cf. (A 4) on p. 33 above), can the assumptions be made applicable to the organizational units.[4]

In model *G* this influence operates via $\bar{G}_F$ and $\bar{G}_W$ (intended goal of Foremen and Workers) (cf. pp. 57—8). It is the absence of these attributes in model *R* that motivates the indirect approach described above. To illustrate further the possibilities of incorporating different assumptions concerning influence into our simplified model *R*, we have assumed in formulating the relations (6.2) that working time influences material usage. In all three models, *G*, *S* and *R*, it is assumed that Workers can influence total working time, Q_W, and total material usage, Q_M. There is evidence in the literature sufficient to justify the assumption that Q_M and Q_W are related to one another, but not to justify any assumption on the direction of the relation. The direction which has been introduced into the relations (6.2) could, for example, be explained thus: workers' remuneration is related to working time per unit manufactured but not to material usage per unit manufactured, and so it can be assumed that workers will concentrate mainly on keeping down working time (cf. pp. 61—2). If work input precedes the usage of material, our formulation — that working time influences material usage — will follow. (Work input may precede the usage of material, for example in a manufacturing operation consisting of the turning of a section of a brass rod.)

It is, however, easy to put forward assumptions which mean that the relations (6.2) must be reformulated to reverse the direction between working time and material usage. The easiest way of doing this is, while retaining the assumption about the connection between remuneration and q_W, to assume that the time sequence between work input and material usage is reversed. We can cite from shoe manufacturing an example in which the usage of material precedes work input — the material for soles and uppers is cut, with allowance for seams, in previous operations; a further example is the machining of cast-metal products.

Model *R*, with its indirect consideration of the influence between schemata, cannot be as complete as model *G*. For instance, if we retain the original assumption concerning the time sequence of working time (work input) and material usage, but observe that Foremen are the subject of review also with regard to the level of material usage, we can reasonably suppose that the influence of Foremen on Workers will include material usage. In this case Workers are influenced both by remuneration, which is related to q_W, and by Foremen. But in order to incorporate this influence into a model of the same type as model *R*, it would presumably be necessary to formulate a supplementary relation from material usage, Q_M, to working time, Q_W.

[4] Cf. Törnebohm [1957] p. 120 (cf. also pp. 82—4). Cf. also the discussion in Simon [1953*a*] on the representation of influence by *asymmetrical* relations.

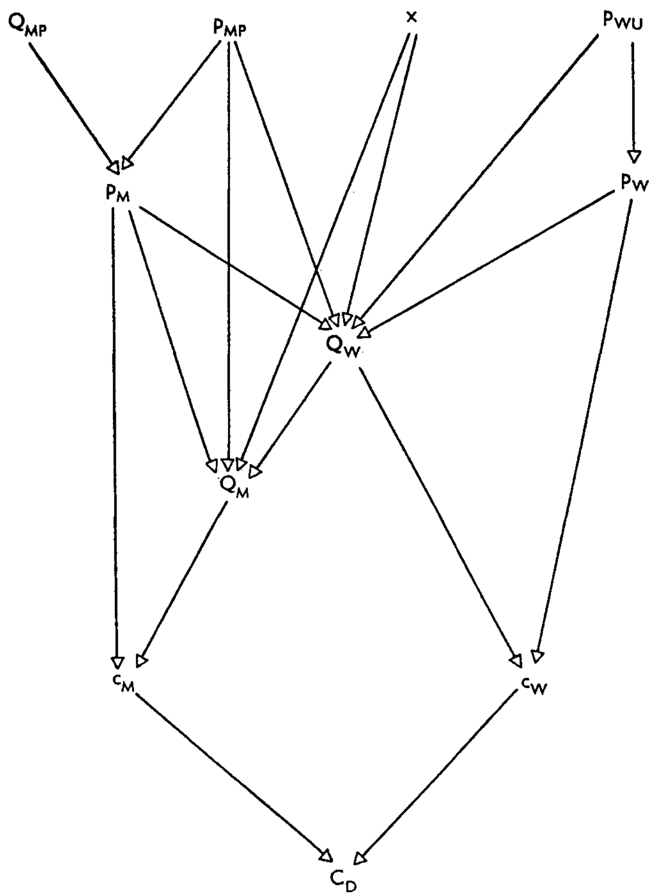

Figure 6.4 *Causal Ordering of the Variables in the Relations (6.2)*

In view of the shortage of empirical evidence we shall not elaborate the comparison between the two types of model, *G* and *R*. In conclusion we have illustrated in Figure 6.4 the result of applying the causal ordering to the relations (6.2).

CHAPTER 7

Observations

7.1 OBSERVATIONS IN THE ANALYSIS OF STANDARD COSTS

In the three previous chapters we have presented some of the material necessary for an explanation of a description of regularities between actions and results (cf. draft explanations A and C, stage (C2), in Chapter 3). The theoretical reflections alone are not sufficient for a specification of the relations in the model; these must be supplemented by descriptions before they can be used for explanations and predictions. The first stage in an analysis of variations from standard costs, moreover, consists of a comparison between observed values relating to the execution of a manufacturing operation and a description based on, among other things, observations of the operation on previous occasions, cf. stage (C1). This chapter may then conveniently furnish some comments on observations in relation to an analysis of standard costs.

Unlike the models, the descriptions refer to organizations or organizational units, or to the activities in the organizations or the units, etc. and not to schemata or the relations between schemata. The transition from a model back to an organization is made by means of reapplication and the operational definitions (cf. pp. 32—3 and 35).[1]

The reapplication is a reversal of the process of schematization and the rules therefore belong to the schematism of the theory. It is also desirable that the operational definitions be governed by the theory. In cases where the reapplication and operational definitions are prescribed by a fully formulated theory, it is possible to deduce a description which can be compared with an empirical description. In view of the incomplete nature of business economic theory, it is difficult to deal fully with these stages of explanation and prediction. For this reason we shall not discuss reapplication specifically. Instead we refer the reader to the passages on schematization

[1] Cf. Törnebohm [1957] pp. 135—7; cf. also the Swedish text pp. 76—80.

in Chapters 4 and 5 and, leaving aside the rules for deducing descriptions from the models discussed in the previous chapter, we shall simply comment on the observations which may occur in connection with an analysis of standard costs.

7.2 ON THE OPERATIONAL DEFINITIONS OF THE ULTIMATE EFFECT

In choosing and defining the variables in models G, S and R, we kept in mind their adaptability to observation and measurement. For that reason, in our discussion of the choice of attributes in Chapter 5, we made some mention of the rules for the measurement of certain of the concepts which were later introduced into the models as variables, i.e. their operational definitions. In the case of the operational definition of the ultimate effect we mentioned only that the direct manufacturing costs, C_D, unlike more comprehensive measures of the result, are observable. In order to demonstrate the possibilities of making operational definitions of effects in models of the type now under discussion, we shall return briefly to the theoretical discussion of the flow of activities.

The models are constructed for use in explanations and predictions of the flow of activities during period T_k. From the company's viewpoint, the cash flows related to a flow of activities can be conceived as its ultimate effect. Since the measurement of a company's payments (disbursements and receipts) demands a low degree of inference on the part of the observer, there is every reason to examine the possibilities of making them the basis for the definition of the ultimate effect of the flow of activities during period T_k.

If the flow of activities under consideration includes all the activities of a company during the whole of its life, there will be no difficulty in defining and measuring its ultimate effect in terms of all the payments made during that time. But as soon as we limit the time span of the flow of activities, we come up against the problem, well known in accounting theory, of how to limit the choice of payments. Shall we consider only those payments which occur during the limited time span, or shall we include cash flows extending beyond it, either before or after? A similar question arises if we are considering a flow of activities limited in its scope. In fact as soon as the flow of activities under consideration comprises anything less than the total activities of the company during the whole of its life, the question will arise of which payments to assign to the flow of activities.

The material in our previous chapters provides a basis for distinguishing the following types of payments in a company's cash flow: (i) workers' wages, (ii) remuneration of foremen and planning, (iii) disbursements to suppliers and transport firms for material purchased and (iv) disbursements to suppliers for tools and machines. Every one of these disbursements probably refers to a flow of activities more comprehensive than the one during period T_k and it is therefore necessary to make a further delimitation. Types (i) and (iii) lend themselves readily to this since the disbursements correspond to hours worked multiplied by an hourly wage rate[2] and material quantity multiplied by a material price. Disbursements of the same type as (ii) and (iv), on the other hand, are determined in such a way that they cannot be related to a model of the flow of activities during period T_k. This means that we cannot simply introduce variables such as *planning hours* or *foreman hours* into the model, since the remuneration of the planning departments and the foremen cannot be expected to bear any direct relation to these variables.

7.3 ON THE OBSERVATIONS RELATING TO THE ANALYSIS OF VARIATIONS FROM STANDARD COSTS

The term *observed values* in the analysis of variations from standard costs refers to values which are collected in relation to a particular flow of activities and reported to the Analyst at its conclusion. As we have already indicated, the Analyst can also use the observed values from previous flows of activities in the formulation of his prediction. A characteristic feature of the analysis of variations from standard costs is that the first of these types of observed values are collected, analyzed and reported within the framework or in relation to the company's accounting (cf. Chapter 2, pp. 15—6). This affects the choice of variables and the method of observation. In this section we shall present some comments on (i) the observed values received by the Analyst from the accounting and (ii) possible comparisons between observed values of working time, in cases where the methods of observation do not tally.

The Accounting as Source of Observed Values

In the financial accounting, disbursements and receipts are registered as they arise. The acquisition of goods and services etc. are also observed and registered at the time they occur. The latter registrations are called *expenditures* and are classified according to type of expenditure (i.e. for material, wages etc.). The various expendi-

[2] This applies to hourly wages. In the case of piece rates, for instance, the disbursement will correspond to the number of units manufactured times the price per piece. The disbursement can still be assigned to the flow of activities during period T_k, but the models will have to be changed or supplemented. In model S the change can be made simply by replacing the expression (6.14), which gives the labor costs, c_W, by

$$c_W = x\, p'_W \tag{7.1}$$

where x is number of units manufactured and p'_W the piece rate per unit manufactured. In model R there will have to be several changes. A replacement of (6.14) by (7.1) means, for instance, that it should be possible to use the model in a prediction (and explanation) of p'_W, i.e. (6.24) must also be replaced. The replacement of (6.24) may involve a reconsideration of the variables to be included, the direction between the variables, the form of the relation etc. and cannot be discussed here. In wage payments which combine time rates and piece rates the models will have to be similarly changed or supplemented so that they contain a relation which, like (6.14) or (7.1), corresponds to the way in which the disbursement is calculated.

ture items are then assigned to accounting periods corresponding to the utilization of goods and services during the particular period. The expenditures assigned in this way are known as ***expenses***. Two complementary ways of determining the utilization during an accounting period can be distinguished: (i) observation of the opening balance, registration of acquisitions during the period and observation of the closing balance, and (ii) direct observation of utilization. For certain types of utilization, e.g. material usage, both these methods can be used and checked against each other. The conversion to expenses can be regarded as an attempt at delimiting the studied cash flows in the way that we mentioned above. The difficulties of deciding which disbursements for remuneration to foremen and planning and which for tools and machines etc. should be included, have had to be resolved by conventions as yet unrelated to any formulated theory. In view of the restricted scope of this study, we shall disregard these conventions and discuss only direct material and direct wages.

The registration of the utilization of material and working time can be based on observations of each manufacturing series. As a rule the collection, analysis and reporting of these data is kept apart from the financial accounting in what is usually known as the cost accounting. Order tags, store requisitions and time cards, when filled in, supply data about the number of manufactured products passed into stock, the quantity of material handed out from supplies (with deductions for returns), working time utilized, wage rates etc. The time cards are often the basis for wage calculations and total direct wages can be computed from them alone, whereas store requisitions must be supplemented by details as to prices obtained from receipts, purchase cards, stock cards or similar sources, before the direct material costs can be calculated. These data are reported to the Analyst and he obtains from them the observed values of the direct manufacturing costs, C_D, the material costs, c_M, the labor costs, c_W, the total material usage for the manufacturing series, Q_M, the material price, p_M, the total working time for the manufacturing series, Q_W, and the wage rates, p_W.[3] It should be remembered that neither material usage per unit manufactured, q_M, nor working time per unit manufactured, q_W, are observed direct.

Two Operational Definitions of Working Time

The observations which provide the basis for the values reported by the accounting department have been made, to a great extent, by the very people whose activities are the object of the Analyst's study. From the Analyst's point of view, more controlled observations, made by independent observers, would be preferable. However, instead of discussing general desiderata for the form of the observations, we shall limit ourselves to comparing two of the currently employed ways of observing working time: (i) by time cards and (ii) by time studies. The comparison is of interest for the

[3] If the analysis is concerned with more than one manufacturing operation during a time period, the values are added together in the cost accounting before they are reported to the Analyst. Since we have limited ourselves here to the flow of activities during period T_k, we shall disregard the difficulties which might arise from summation.

analysis of variations from standard costs because the time studies, and sometimes the s-values of working time, may be included in the descriptions with which the Analyst supplements and specifies his model. The dual approach to observing working time results in the existence of two operational definitions, which in turn can lead to differences between the Analyst's prediction and the values as subsequently observed.

A time card is made out for every manufacturing series and is stamped on the time clock by the worker at the start and the finish of the operation. Time studies may be carried out by those organizational units which we have assigned to Planning with the help of, for example, a stop-watch or films. This technique makes it possible to observe and register the working time per unit manufactured (and, if required, for parts of the operation), but it also means that the observations must be limited to a few occasions for each manufacturing operation. The observations are therefore usually made when the s-values of working time are being determined or when a change in the s-values is under consideration.

The two operational definitions can lead to the registration of different quantities, although the actual working time may be the same and, conversely, similar registrations may correspond to differences in working time. For example, the stamping of the time card may be deferred: a new manufacturing series is started before the old one is delivered and neither the old nor the new time card is stamped. It is probable that such deferments, when they arise, are utilized by the workers to level off the working time between different manufacturing series and to bring the s-values and the observed values closer together. It is thus probable that the stability in working times which we mentioned previously (cf. p. 60) could be at any rate partially explained by reference to the operational definitions of the working time.

The length of the working time can also be affected by the method of observation. For example, it is probable that the presence of an observer — the time study man — influences the worker. Furthermore when the time studies are made, this may be regarded by the workers as a stage in negotiations (cf. Abruzzi [1952], pp. 16—8).

These examples will probably serve to show the importance of specifying the operational definitions in connection with the analysis of variations from standard costs. As was indicated in the previous paragraph, however, the operational definitions must be related to the total situation in which the observations are made. This may mean referring to models and theories other than those which are the main object of study (e.g. in order to obtain information about the influence of the observer). The development and formulation of the operational definitions for the concepts occurring in the analysis would therefore be a research program in its own right.

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CHAPTER 8

The Analysis of Standard Costs

8.1 STATEMENT OF THE PROBLEM

In this section we shall try to draw together all the threads from Chapters 3—7 and show how the material presented there can be used in the formulation of an analysis of standard costs.

As before we shall take as our starting-point the analysis of variations from standard costs as presented in Chapter 2. There we found that such an analysis consists of a comparison between the standard and the observed values of a company's total or partial result with the intention, mainly, of providing a signal of any differences which might call for further investigation. In view of our more comprehensive aim, we have examined possible ways of explaining differences and can now apply our material to explanations of variations from standard costs.

Explanations in Connection with an Analysis of Variations from Standard Costs

Draft explanations of differences can be constructed in various ways. An analyst might seek such further information about the difference as he considers significant (cf. p. 26). He may for example enquire about the quality of the material, or the worker's qualifications; he may discover that during the period a fuse had blown, a pulley had broken or a worker had been involved in an accident. Since the flow is already complete when the analysis is being made (cf. Figure 4.3 inside back cover), an analyst's chances of obtaining information will depend on whether conditions have been recorded in some way. The chances of explaining differences are greater if a comprehensive record can be obtained of those aspects of the flow which would otherwise have been registered only in the memories of the participants. An example of a move towards this type of recording system is the *list of causes* reproduced above (Figure 2.1, p. 25). The disadvantage of using the records only in this way is the risk of resulting *ad hoc* explanations.

Since we wished to investigate the possibilities of constructing explanations which could be applied more generally, we have assumed that the analysis and the subsequent attempts at explanation are made on repeated occasions, and have further supposed that they are concerned with similar flows of activities, i.e. in our case with one manufacturing series in a single manufacturing operation. By collating the observations and registrations from a number of flows, an analyst can discover regularities which he can formulate into a description. To prevent the description from becoming too comprehensive, conditions occurring in a few flows only (e.g. accidents) will have to be excluded, even though they may affect the result. The formula in the description must therefore include a residual item. The field of application for each of the descriptions which an analyst obtains in this way is, however, probably very restricted. A more serious disadvantage (cf. Chapter 3, p. 32) is that there are no fixed rules of demarcation so that the use of such descriptions follows no set pattern.

The explanation can, however, be carried a stage further. The description can in turn be explained by using a model or a theory, whereby an analyst can explain the selection of terms, the formulation of the formula etc. We have already mentioned that this stage in an explanation constitutes an essential part of our study.

From an Analysis of Variations from Standard Costs to an Analysis of Standard Costs

The construction of explanations of differences between s-values and observed values suggested above, can be used as a basis for a reformulation of the whole analysis of variations. The reformulation is based on the similarity between an explanation and a prediction (as discussed in Chapter 3). As a result of this the Analyst can use a description, formulated in connection with an explanation of stated differences, to make a prediction of, for example, the value of the direct manufacturing costs, C_D, in a future flow of activities. In the same way a model can be used in a prediction of regularities between, for example, actions and C_D, in a number of repeated flows.

A comparison between a predicted value and an observed value of a variable can be regarded as a test of the prediction. The relations between the prediction, the description, the model and the theory (if one exists), make it possible for the test to be extended to the latter. If there is a difference between the values, the prediction or the observations (or both) can be rejected and, with the wider range of the test, the description etc. may also be rejected. If one or more stages in a prediction/explanation are rejected, the next step will be an attempt at replacing it with a new or a changed one.

The comparison with observed values which an Analyst makes in an analysis of variations from standard costs can also be conceived as a test of a prediction and, indirectly, of a description, a model or a theory. If the Analyst conceives his task in this way, he will include in his analysis the way in which the studied values have been determined. We can then speak of an analysis of standard costs (cf. p. 6). The analysis of variations from standard costs as reported in Chapter 2, however, is concerned with a comparison between s-values and observed values. The suggested reformulation of the analysis therefore presupposes that the relation between the Analyst's prediction and the s-values has been specified.

Construction of Models

If attempts are to be made at explaining stated variations from s-values and if the analysis is to be reformulated as suggested above, it will be desirable to have formulated models as a basis. Moreover, if the relations between the Analyst's prediction and the s-values are to be specified, it will be necessary to study the position of the analysis of standard costs in the company's activities. As can be seen in Chapter 2, the models (and the descriptions) are implied rather than explicitly formulated in the literature of the subject. Before we could discuss the analysis of standard costs in this study, it was therefore necessary for us to construct a basis.

When testing reveals a difference between the prediction and the observed values, it is not immediately clear what the Analyst shall reject or change. We have previously pointed out that changes may be made in the method of observation and in the basis of the prediction, i.e. the description, the model or the theory (cf. e.g. Chapter 3, pp. 35—6 and Chapter 7, p. 85). In the latter case the Analyst usually has several possible changes from which to choose. So that it shall be possible to complete an analysis of standard costs from the starting-points indicated, we have discussed separately some of the stages which, according to Chapter 3, p. 33, are part of a complete prediction. Starting from general considerations about the possibilities of describing the activities of a company, we discussed the conversion from organizational units to schemata of organizational units and the relations between schemata from the point of view of an outside observer and from the point of view of the Analyst (Chapter 4). As further grounds for the construction of the models we discussed in Chapter 5 the choice of attributes of the schemata. Finally, in Chapter 6, we presented the three models *S*, *R* and *G*.

Model *S* is directly related to the analysis of variations from standard costs as reported in Chapter 2. Characteristic for the model is the fact that a prediction based on it will agree with the s-values. Consequently, differences from the s-values may, whenever they are considered significant, lead to the rejection of the prediction, description and the model.

Model *R* has been developed from model *S* by incorporating into it (i) some of the factors which are considered in determining the s-values (e.g. material quality and length of series) and (ii) some relations between the variables considered in explanations of differences. A prediction reached with the help of model *R* may agree with the s-values, providing the factors considered in determining the s-values agree with those which are incorporated into the model, but does not necessarily do so because the factors may since have changed. Model *R* can thus be used for an explanation of the differences, or rather part of the differences, from the s-values. A difference may also arise between this type of prediction and the s-values, when the latter have been determined in the light of their influence on the organization members. This difference cannot be considered within the framework of model *R*.

Regardless of whether the s-values have been determined in the light of their influence on the organization members or not, the publication of the s-values can be expected to have some influence in the company (cf. e.g. p. 14). There is reason to expect differences both from the predictions which are obtained with the help of models *S* and *R* and from the s-values. We have therefore tried to incorporate the influence of the s-values on the organization members into model *G* by using Foremen's and Workers' intended goals as variables in the model. An explanation obtained by using a model, in which variables of this type are included, is known as a final explanation. Some of the problems connected with final explanations have been discussed in Chapter 5 (particularly pp. 68—71). Similar problems will arise when model *G* is used for a prediction. In view of the difficulties discussed here, we have not tried to specify model *G* for use as a basis for prediction. Its most important function will instead appear in the discussion of the testing, where it will provide some guidance as to what shall be rejected or altered.

Formulation of the Analysis of Standard Costs

The analysis of standard costs can be divided into four stages:

(i) The Analyst makes a prediction of the values of the studied variables in the flow of activities under consideration. In reaching this prediction he uses a model which is supplemented by observed values from previously studied flows (cf. p. 81).

(ii) The prediction is compared with the observed values.

(a) If the prediction and the observed values agree within the permitted margins of error, then the observed values can be explained by the description which was used in reaching the prediction (cf. stage (Cl a), pp. 35—6).

(b) If the difference between the prediction and the observed values is greater than that allowed by the margins of error, then the prediction or the observations will be rejected; cf. stage (Cl b). When the prediction is rejected, the old description is replaced by a new one. In reaching the new description, attention must be paid not only to the last flow of activities studied but also to the earlier flows covered by the old description. If the observations are rejected, several changes may be contemplated, e.g. a change in the method of measurement, a change in the operational definitions or the addition of a further stage to the existing operational definitions.

(iii) The description is explained by the use of the model. This explanation corresponds to stage (C2). In this stage the Analyst will have to consider whether the model shall be retained or rejected and in the latter case also the formulation of a new or changed model.

(iv) The Analyst reports to Top Management who then takes any corrective action.

The incomplete theoretical background will cause the Analyst some difficulty in deciding where and how a change in the explanation/prediction shall be made. Every gap in the theory means that the procedure at one stage in the explanation/prediction must be based on incidental considerations.

In this chapter we shall discuss the execution of the analysis in relation to a numerical example. Our numerical example, which is related to models S and R, will be presented in the next section. We shall then discuss the analysis, referring also to model G.

8.2 NUMERICAL EXAMPLE OF AN ANALYSIS OF STANDARD COSTS

Stage 1: The Analyst's Prediction

As we have already mentioned several times, we lack rules for the transition from the models back to the flow of activities. In our discussion of the Analyst's prediction of the values of the studied variables, we have to confine ourselves to the transition from the model to the formula in the description thus disregarding the other parts in a full description.

Model R

When the coefficients b_{ij} have been replaced by numerical values, the expressions (6.2) in model R (pp. 76—7) constitute the formula in a description. We shall assume that the Analyst, on the evidence of his empirical studies, has formulated it as follows (the symbols are as given in the *list of symbols* on p. 107):

$$\left.\begin{aligned}
Q_M &= 0 + 0.9\,x - 1.0\,Q_W - 100\,p_M + 100\,p_M && (8.11)\\
p_M &= 0.3 - 0.0001\,Q_{MP} + 0.9\,p_{MP} && (8.12)\\
Q_W &= 10 + 0.05\,x - 20\,p_M - 2\,p_W + 20\,p_{MP} + 2\,p_{WU} && (8.13)\\
p_W &= 2 + 1.1\,p_{WU} && (8.14)\\
c_M &= Q_M p_M && (6.13)\\
c_W &= Q_W p_W && (6.14)\\
C_D &= c_M + c_W && (6.15)
\end{aligned}\right\}\ (8.1)$$

According to model R the values of the market price for material, p_{MP}, and the negotiated wage rates, p_{WU}, are determined outside the company. The values of the quantity of material purchased, Q_{MP}, and the number of units manufactured, x, are determined by Planning, whose activities are not the subject of the Analyst's study.

It is assumed that these variables are exogenous to the relations (8.1), which cannot therefore be used to provide a prediction of their values. Consequently the Analyst supplements the expressions (8.1) by an independent *forecast* of the value of the variables p_{MP}, p_{WU}, Q_{MP} and x.[1] The values assumed in the forecast can be seen in Table 8.1.

Table 8.1. *Forecasted Values of Exogenous Variables.*

Variable	p_{WU}	p_{MP}	Q_{MP}	x
Forecasted values........	5.00	1.00	2,000	1,000

If the forecasted values are introduced into (8.1), the Analyst can find the values of the remaining variables. If the Analyst uses model R as the basis for his analysis of standard costs, these values will form his prediction which, in the next stage of the analysis, will be compared with the observed values. The predicted values can be seen in Table 8.2.[2]

Table 8.2. *Original Prediction Obtained by Applying the Relations (8.1).*
Source: Appendix to Chapter 8, (i).

Variable	p_M	p_W	Q_W	Q_M	c_M	c_W	C_D
Original prediction	1.00	7.50	55.0	845.0	845.00	412.50	1,257.50

Model S

If the Analyst uses model S as the basis for the analysis, the prediction is based on the s-values. In order to obtain comparability we assume that the forecasted values and the original predicted values according to the two models are compatible with each other. The Analyst's prediction in terms of Q_M, Q_W, c_M, c_W and C_D will consequently be the same as that illustrated in Table 8.2. For purposes of comparison, the prediction when the Analyst uses model S has also been expressed in terms of Q_M and Q_W instead of q_M, material usage and q_W, working time per unit manufactured. The s-values of q_M and q_W are assumed to be 0.845 and 0.055. With these assumptions the formula in the Analyst's description will be as follows:

$$\left.\begin{array}{lll} Q_M = 0.845\,x & & (8.21) \\ Q_W = 0.055\,x & & (8.22) \\ c_M = Q_M p_M & & (6.13) \\ c_W = Q_W p_W & & (6.14) \\ C_D = c_M + c_W & & (6.15) \end{array}\right\} (8.2)$$

[1] We have chosen the term *forecast* to emphasize that we have taken no account of the way in which an analyst can determine these values. Two methods can be mentioned: (i) the Analyst has determined the values with the help of a model independent of model R and (ii) the Analyst has adopted certain desired or planned values from Top Management or Planning.

[2] The calculations on which the tables are based can be found in the Appendix to Chapter 8 (p. 103).

Stage 2 a: Comparison between the Original Prediction and the Observed Values; Description Retained

The original prediction in Table 8.2 is now compared with the observed values of the variables. According to the results of this comparison, the Analyst decides whether to accept or reject the prediction. Before a description is rejected, however, it is worth noting that, if we had taken as our initial condition other values of the exogenous variables than those forecasted, the prediction would have been different. Before determining the adequacy of the description (and the model), the prediction could well be adjusted with regard to the observed values of the exogenous variables.[3, 4] The assumed observed values of the exogenous variables can be seen in Table 8.3.

Table 8.3. *The Forecasted and Observed Values of the Variables Exogenous to Model R.*

Variable	p_{WU}	p_{MP}	Q_{MP}	x
Forecasted values........	5.00	1.00	2,000	1,000
Observed values.........	5.50	0.90	1,500	1,500

Model R

All the observed values differ from the forecast. We shall therefore adjust the original prediction. A collation of the adjusted predictions which the Analyst obtains when the observed values from Table 8.3 replace the forecasted values in formula (8.1) has been reproduced in Table 8.4. The table also contains the observed values assumed by us.

The adjusted prediction, when the forecasted values of the exogenous variables have been replaced by the corresponding observed values, can be seen in rows 2—5. The order of the adjustments is not given in model *R*. Row 5 contains a prediction of the value of p_M, p_W, Q_W, Q_M, c_M, c_W and C_D, based on the relations (8.1), with the observed values of p_{WU}, p_{MP}, Q_{MP} and x as initial conditions. A comparison with the observed values in the last row reveals relatively insignificant differences, i.e. less than 5 %, except in the case of labor costs, c_W (column 6).

Unless the Analyst considers that the finally adjusted prediction (row 5) and the observed values (row 6) differ to such an extent as to warrant the rejection of the description, he can explain the observed values of p_M, p_W, Q_W, Q_M, c_M, c_W and C_D by using the relations (8.1) and the observed values of p_{WU}, p_{MP}, Q_{MP} and x. This is an explanation of type (Cl a) in accordance with Chapter 3.

[3] Cf. *IUI:s konsumtionsprognos för år 1965. En granskning och revidering.* Stockholm 1960, pp. 14—7 and 92—3 (Summary in English). Here the same idea is used as a basis for testing the models on which were based the Institute's predictions of private consumption in Sweden in 1965.

[4] We use the terms *to adjust a prediction, adjusted prediction* etc. when observed values are included as initial conditions in a description. In this way we indicate the similarity to an adjusted budget.

Table 8.4. *Adjusted Predictions Obtained by Replacing the Forecasted Values by the Observed Values of the Variables Exogenous to Relations (8.1).*

Source of Original Prediction: Table 8.2, Appendix, (i).
Source of Cumulative Adjustment of Prediction: Appendix, (ii)—(v).

Variable	p_M	p_W	Q_W	Q_M	c_M	c_W	C_D
	1	2	3	4	5	6	7
1 Original prediction.......	1.00	7.50	55.0	845.0	845.00	412.50	1,257.50
Cumulative adjustment of prediction with regard to the observed values of:							
2 negotiated wage rates p_{WU}	1.00	8.05	54.9	845.1	845.10	441.95	1,287.05
3 market price for material .... p_{MP}	0.91	8.05	54.7	844.3	768.31	440.34	1,208.65
4 quantity of material purchased .... Q_{MP}	0.96	8.05	53.7	840.3	806.69	432.29	1,238.98
5 no. of units manufactured x	0.96	8.05	78.7	1,265.3	1,214.69	633.54	1,848.23
6 Observed values..........	1.00	8.00	75.0	1,265.0	1,265.00	600.00	1,865.00

Model S

The comparison between the Analyst's predictions and the observed values using formula (8.2) can be seen in Table 8.5. Only one exogenous variable is included in model S — the number of units manufactured, x — and the four successive adjustments of the prediction shown in Table 8.4 therefore correspond to one adjustment in the second row in Table 8.5.

Table 8.5. *Adjusted Prediction Using Formula (8.2), Obtained by Substituting the Observed Value for the Forecasted Value of x (No. of Units Manufactured).*

Variable	p_M	p_W	Q_W	Q_M	c_M	c_W	C_D
	1	2	3	4	5	6	7
Original prediction	1.00	7.50	55.0	845.0	845.00	412.50	1,257.50
Adjustment of prediction with regard to the observed value of:							
no. of units manufactured x	1.00	7.50	82.5	1,267.5	1,267.50	618.75	1,886.25
Observed values.........	1.00	8.00	75.0	1,265.0	1,265.00	600.00	1,865.00

Stage 2 b: Description Rejected and Changed

If the Analyst considers the remaining differences to be large but wishes to retain the observations, he will reject the description on which the original and adjusted predictions are based. To illustrate stage 2b we let the Analyst reject the description although the differences are comparatively small. Since our example does not contain any data on previous observations, we shall simply assume that the Analyst changes the description to make it compatible with the observed values from the latest flow of activities only. We shall now examine the explanation which the Analyst obtains when the description is changed in this way.

Model R

As before we shall use the similarity between an explanation and a prediction to mark the assumptions that are involved in an explanation of the present type. It is possible to calculate the prediction which the Analyst would have obtained if, for example, formula (8.12) had been made compatible with the observed value of p_M, without changing the remaining formulae. The computation consists of substituting the observed value of p_M for the predicted value in (8.11), (8.13) and (6.13). Similarly the effect on the Analyst's prediction of a change in (8.14) can be calculated by inserting the observed value of p_W in (8.13) and (6.14). The predictions which the Analyst would have obtained by making successive *adaptations*[5] with regard to the observed values of p_M, p_W, Q_W and Q_M are shown in Table 8.6.

Table 8.6. *Cumulatively Adapted Predictions Compatible with a Changed Description of Model R.*

Sources of Adjusted Prediction and Observed Values: Table 8.4.
Sources of Cumulatively Adapted Predictions: Appendix, (vi)—(viii).

Variable	p_M	p_W	Q_W	Q_M	c_M	c_W	C_D
	1	2	3	4	5	6	7
1 Adjusted prediction	0.96	8.05	78.7	1,265.3	1,214.69	633.54	1,848.23
2 Observed values..........	1.00	8.00	75.0	1,265.0	1,265.00	600.00	1,865.00
Cumulative adaptation of adjusted prediction with regard to the observed values of:							
3 material price ..... p_M		8.05	77.9	1,262.1	1,262.10	627.10	1,889.20
4 wage rates........ p_W			78.0	1,262.0	1,262.00	624.00	1,886.00
5 working time ..... Q_W				1,265.0	1,265.00	600.00	1,865.00
6 material usage .... Q_M					1,265.00	600.00	1,865.00

The difference between the first and third rows in Table 8.6 indicates the change in the prediction resulting from the change in the coefficient values in (8.12); the difference between the third and fourth rows can be referred to (8.14) etc. Since the relations (8.1) are causally ordered, further justification can be found for the cumulative adaptations in Table 8.6.

Since, for example, the observed material price (1.00) differs from the material price according to the adjusted prediction (0.96), the Analyst would have expected a difference also between the other values in the adjusted prediction and the cor-

[5] To distinguish the changes in the prediction made in stage 2b from those in stage 2a, we shall use the term *adapted prediction.*

responding observed values, providing he had known the value of the material price. The expected difference is the one that is obtained when the adjusted prediction is compared with the adapted prediction, in which the observed material price has replaced the material price according to the adjusted prediction. The last three rows in Table 8.6 show the predictions which the Analyst would have made if the finally adjusted predictions of wage rates, working time and material usage respectively had been the same as the subsequently observed values of these variables.

We now turn to the explanation which the Analyst can derive from his new description. If the Analyst had used the last adapted prediction as his original prediction, he would have had an explanation of the observed values of type (Cl a) (cf. stage 2 a). Two questions may then be posed: (i) in what circumstances is the Analyst prepared to accept the new description so that he can use it as a base for an explanation of the observed values and (ii) how can the Analyst utilize an explanation of the observed values in his report to Top Management? Since observations from several flows of activities have normally gone into the making of the new description (though not in our simplified example) it is probable that the Analyst will accept it unless he is considering changing the variables, the linear form of the relations, etc., in other words, if he is not contemplating a change in model *R*.

Model S

When using model *S*, the order of the corresponding adaptations (see Table 8.7) is not given (cf. the discussion of the placing of the residual *k*, in Chapter 2, p. 19). For purposes of comparison we have used the same order in Table 8.7 as in Table 8.6. The differences in working time and material usage are therefore valued at the observed prices, while the price differences are estimated in accordance with the s-values of the quantities (cf. (2.7 a), p. 19). In other words we have used the causal ordering from model *R* to determine the placing of the residual *k*. It is worth mentioning in passing that the placing of *k* can thus be interpreted as an assumption regarding the direction of the relations.

Table 8.7. *Cumulatively Adapted Predictions Compatible with a Changed Description of Model S.*

Variable	p_M	p_W	Q_W	Q_M	c_M	c_W	C_D
	1	2	3	4	5	6	7
1 Adjusted prediction	1.00	7.50	82.5	1,267.5	1,267.50	618.75	1,886.25
2 Observed values	1.00	8.00	75.0	1,265.0	1,265.00	600.00	1,865.00
Cumulative adaptation of adjusted prediction with regard to the observed values of:							
3 material price ...... p_M		7.50	82.5	1,267.5	1,267.50	618.75	1,886.25
4 wage rates .... p_W			82.5	1,267.5	1,267.50	660.00	1,927.50
5 working time per unit manufactured ...... q_W				1,267.5	1,267.50	600.00	1,867.50
6 material usage per unit manufactured .. q_M					1,265.00	600.00	1,865.00

Stage 3: The Description Explained by the Model

In Table 8.8 we have presented the Analyst's different predictions of material costs, c_M, and labor costs, c_W, using models *R* and *S* respectively, and the subsequently observed values of the variables (columns 2, 4, 6 and 8). So that we may more easily discuss the explanation available from each model, and the comparison between the models, we have also noted the differences between the successive predictions and between the original prediction and the observed values (columns 1, 3, 5 and 7).[6] Since the figures are fictitious, we shall not comment on the changes in the numerical data. We can, however, use the table to illustrate some points of interest concerning the explanation of the observed values.

In the case of c_M, the Analyst's prediction based on model *S* is closer to the observed values than the prediction based on model *R* (in both cases after adjustment

Table 8.8. *Comparison between an Analysis Using Model R and an Analysis Using Model S.*

Source of rows 1— 6, columns 2 and 6: Table 8.4.
1— 6, columns 4 and 8: Table 8.5.
7—10, 12, columns 2 and 6: Table 8.6.
7—10, 12, columns 4 and 8: Table 8.7.

Variable	Material costs (c_M)				Labor costs (c_W)			
	Model *R*		Model *S*		Model *R*		Model *S*	
	Difference	c_M	Difference	c_M	Difference	c_W	Difference	c_W
	1	2	3	4	5	6	7	8
1 Original Prediction ..		845.00		845.00		412.50		412.50
Difference assigned to:								
2 negotiated wage rates .... p_{WU}	− 0.10	845.10			− 29.45	441.95		
3 market price for material .. p_{MP}	+ 76.79	768.31			+ 1.61	440.34		
4 quantity of material purchased Q_{MP}	− 38.38	806.69			+ 8.05	432.29		
5 no. of units manufactured x	−408.00	1,214.69	−422.50	1,267.50	−201.25	633.54	−206.25	618.75
6 total exogenous variables	−369.69	1,214.69	−422.50	1,267.50	−221.04	633.54	−206.25	618.75
7 material price p_M	− 47.41	1,262.10	0	1,267.50	+ 6.44	627.10	0	618.75
8 wage rates.... p_W	+ 0.10	1,262.00	0	1,267.50	+ 3.10	624.00	− 41.25	660.00
9 working time.. Q_W	− 3.00	1,265.00	0	1,267.50	+ 24.00	600.00	+ 60.00	600.00
10 material usage Q_M	0	1,265.00	+ 2.50	1,265.00	0	600.00	0	600.00
11 Total differences......	−420.00		−420.00		−187.50		−187.50	
12 Observed values		1,265.00		1,265.00		600.00		600.00

[6] The difference assigned, for example, to the variation from the forecasted value of the quantity of material purchased, Q_{MP}, consists of an increase in c_M from 768.31 (row 3, column 2) to 806.69 (row 4, column 2), i.e. −38.38 and a decrease in c_W from 440.34 (row 3, column 6) to 432.29 (row 4, column 6), i.e. + 8.05. The total difference in direct manufacturing costs, C_D, assigned to Q_{MP} is thus 8.05 − 38.38 = − 30.33. Cf. also Appendix, (iv).

with regard to the exogenous variables; cf. row 6, columns 2 and 4 in Table 8.8). In the example, however, the market price for material has dropped and a smaller quantity has been purchased. According to model *R*, these two changes influence c_M in opposite directions. The agreement between predicted and observed values obtained from model *S* could therefore be assigned to the coincidence that these changes counterbalance each other. Also in the prediction of c_W, model *S* seems to lead to closer agreement than model *R* (cf. row 6, columns 5 and 7). Here, the coincidental factors are obvious: further analysis reveals that a decrease in (the adapted prediction of) working time and an increase in wage rates counterbalance each other (column 7, rows 8 and 9).

In practice, differences of this size would probably be considered insignificant in any assessment of the adequacy of the original descriptions, but that need not affect our illustration. The two examples suggest that the adequacy of a description and, thus, of a model, cannot be decided on the grounds of an isolated case of agreement with the observed values. Using the more comprehensive model *R*, the Analyst can consider changes in a greater number of factors and, taking an average for several occasions, can expect fewer variations from the observed values than when he uses model *S*.

If the description has to be rejected and changed at every — or almost every — analysis, the Analyst will consider rejecting the model too. If the Analyst uses model *S*, he might contemplate changing to a model of type *R*. If the Analyst uses model *R*, several alternatives are open to him. He may, for example, abandon the linear form of the relations, change the direction of the relations or include further factors as variables in the model.

If he chooses the last of these alternatives, he might consider an extension of the observations. Of the numerous factors which could be included in his model, we have mentioned the intended and prescribed goals of those involved in the flow of activities. Before an Analyst can observe and utilize concepts such as these he must, however, make further theoretical developments of model *G*. The very existence of a more comprehensive model than the one used in the analysis, for example our present model *G*, will also put a rein on the Analyst's confidence in the explanation provided by the original model.

Stage 4: Report to Top Management as a Basis for Corrective Action

Since the flow of activities under consideration is already complete when the analysis is made, the Analyst's chances of providing a basis for corrective action depend largely on his explanation of the observed values and of the differences between these and the s-values. In our example six possible draft explanations can be distinguished, since the Analyst can choose between two models and in each case can break off the analysis after stage 2a, 2b or 3.

If the Analyst retains the original description, he can, using model R, assign the difference to initial conditions, i.e. to the change in the value of the exogenous variables p_{WU}, p_{MP}, Q_{MP} and x. In view of this, various actions might be considered by Top Management, e.g. a change in quantity to be purchased or in the length of the series; adaptations to a new market price for material or to developments in negotiated wage rates. So long as the model does not indicate the order of the adjustments, Top Management should not overemphasize the importance of the size of the differences attributed to each variable. Using model S the difference can be assigned only to a change in the length of the series. The Analyst's report is therefore limited to this item.

In Table 8.6 the adaptation of the Analyst's prediction, resulting from the change in the description, is made in four stages (rows 3—6), where each of the stages corresponds to a relation in (8.1). In Chapter 6, in connection with the construction of model R, we discussed the way in which the actions assigned to Planning, Foremen and Workers, i.e. A_P, A_F and A_W, influence the variables and the relations (cf. Figure 6.3). Since, according to model R, A_P and A_F influence the relations (8.1), a change in the description, i.e. in the coefficient values of the relations, may be referred to A_P or A_F, providing the model is retained. Consequently, in his report, the Analyst can assign parts of the difference to various organization members or to organizational units, e.g. (i) the difference between rows 1 and 3 in Table 8.6 to the planning or purchasing departments and (ii) the difference between rows 3 and 4 to the foremen. In view of the formulation of the model, the rest of the difference is more difficult to allocate, because A_P, A_F and A_W will influence the relations (8.11) and (8.13). The Analyst will have to assign it, as a whole, to the planning departments, the foremen and the workers. Table 8.7 (rows 3—6) illustrates a corresponding allocation of the difference according to model S. Two ways in which the analyses based on models S and R differ from each other could well be re-emphasized here. In the case of model S the order of the successive adaptations of the prediction must be dictated from outside (in our example, from model R) and the value of either c_M or c_W — but never of both — is changed at each stage in the cumulative adaptation of the prediction. Let us look, for example, at row 9 in Table 8.8, where the prediction is being adapted with regard to the observed value of Q_W. In an analysis using model R, the prediction of c_W in column 6 and, via other variables, the prediction of c_M in column 2 are both changed; according to model S only the prediction of c_W in column 8 has changed. The disparities between the models can affect the size of the differences which are assigned to an organization member or an organizational unit.

When the Analyst rejects the model and formulates a new one he must, according to our premises, be able to use the new model in an explanation of the observed values which led to the rejection of the old one. The information in the Analyst's report to Top Management will therefore be dependent on the formulation of the new model.

8.3 CONCLUSIONS

Top Management is faced with the important problem of interpreting the information in the Analyst's report. Given the formulation of the analysis suggested in this study, the interpretation and assessment of such reports will coincide with the assessment of the adequacy of the explanations on which they are based. In conclusion we shall therefore mention some of the possibilities concerned with judging the adequacy of the Analyst's explanations.

As we have already implied, this will be simplest when the Analyst breaks off the analysis after stage 2a, i.e. when he retains the original description and only changes the initial conditions. Since, in stage 2a, the explanation has been used before, the agreement between the adjusted prediction and the observed values will increase the credibility of the prediction, the description, the model and, therefore, the explanation. Top Management will also be able to rely on the description as a basis for a new prediction with changed values in the initial conditions.

When the analysis has been broken off after stage 2b, the Analyst's explanation of the observed values will be based on a new description in which attention has been paid to the observations which are the subject of the explanation. It will therefore be much more difficult to assess the adequacy of the explanation and a number of circumstances will have to be considered, e.g. (i) whether the new description can also be used in an explanation of previous manufacturing series in the manufacturing operation, (ii) whether the description has already been changed several times in the past, (iii) whether the model from which the description is derived has been successfully applied in explanations and predictions of other manufacturing operations and (iv) whether more comprehensive models are available. The third and fourth of these points indicate that any assessment of the adequacy of a new description — and especially one which can be used also in explanations of previous flows of activities — depends on the credibility of the model.

The shape of the model is important in another respect, i.e. when Top Management wants to use the new description as a basis for a new prediction in connection with the decision concerning corrective action. When choosing among contemplated corrective actions the choice will be facilitated by a prediction of their consequences (cf. Figure 4.3 inside back cover). The corrective action could be aimed at changing the activities of the planning departments, the foremen or the workers, i.e. A_P, A_F or A_W. In terms of model R, this may mean a change in some or all of the relations (8.11)—(8.14). In fact corrective action aims at changing once again any new description based on model R. The same applies to a description based on model S. Only in the case of model G, where we have tried to specify the activities of Planning, Foremen and Workers by means of attributes, will it be possible to conceive corrective action which does not aim at changing the description. This alone is enough to justify the construction of a more comprehensive model, e.g. model G, even if both model S and model R have been found adequate.

These remarks can also apply to the third case, where the analysis proceeds to stage 3 and the Analyst's explanation of the observed values is based on a new model. To rely too much on predictions based on a model that has not yet been tested several times, would be somewhat over-confident. An essential task for the analysis of standard costs as conceived in this study is therefore to forward the creation of tested models. Top Management may contribute to this task by regarding corrective action as one stage in the testing of (new) descriptions and models. Using model G it is possible, for example, to vary the s-values announced to different organization members and to register the values of other variables which are related to them.

CHAPTER 9

Questions for Further Research

As a result of our conception of the analysis of standard costs, this study has developed into a discussion of research problems. It seems fitting to conclude by mentioning some of the most important of these. Our conception of the subject also means, and this is important from the present point of view, that an analysis of the type discussed here will in itself become a research procedure. We shall now turn our attention to some of the problems that arise in utilizing the analysis.

In the numerical example presented in Chapter 8, we presupposed a transition from organizational units to schemata and back again. The lack of rules for these transitions, i.e. the schematism in a theory, has led us to rely on traditional departmental divisions. This means that differences may occur between the predicted and observed values, as a result of varying definitions of the organizational units.

In the case of one of the organizational units considered in our formulation of the analysis, i.e. the analyst, we have observed the transition to a schema, i.e. the Analyst, but not the transition back again. We have thus assumed that ideally, when the analysis of standard costs is used in a company, no restrictions as to time, knowledge or money hamper the analysis from yielding full benefit.

We also came up against the related problem of repeatability. This question may be tackled from another direction: we do not enquire whether a particular flow of activities is repeated, but try to discover instead whether a particular model or description is applicable to a particular flow. It should perhaps be emphasized that the Analyst's decision to treat a description (model) as applicable or inapplicable will be of the utmost importance for an analysis of standard costs as conceived here. In the first case the analysis will proceed as reported in Chapter 8, whereas in the second case a new description (model) has to be evolved.

Although we are still without rules for these decisions, some indication of the applicability of the descriptions is implied by the models. A description should be applicable if it can be retained unaltered in the face of changing conditions. It should be possible to retain a description obtained from model S, regardless of changes in the number of units manufactured (x); or a description obtained from model R, regardless of changes in x, in negotiated wage rates (p_{WU}), in market price for material (p_{MP}) and in quantity of material purchased (Q_{MP}). A description obtained from model G should in addition be independent of changes in the s-values and in at least some of the actions. There are, of course, many possible changes which are *not* considered in any of our models, e.g. *technical development.* Here, two problems would face us: (i) how to establish rules by which an Analyst could determine whether a technical development (or other change) had in fact taken place, thus making at any rate the description inapplicable and (ii) how to incorporate technical development into the model. From the point of view of the analysis of standard costs the first problem is of more immediate import because, without rules, the Analyst has no other means of recognizing a technical development except by completing the analysis, taking note of a difference and attributing it to technical development. Needless to say, the second problem is in the long run equally important (cf. previous discussion of extensions to model G).

It should be clear from the above that, in practice, the full application of an analysis of standard costs as conceived in this study presupposes further theoretical research. If we acknowledge the natural limitations that restrict an analyst working in a company, the need for established rules of behavior at each stage of the analysis is thrown into even sharper relief and the call for theoretical develoment gains in strength.

APPENDIX TO CHAPTER 8

(i) *Calculations for the original prediction of* p_W, p_M, Q_M, Q_W, c_M, c_W *and* C_D, *using the relations (8.1) and taking into account the forecasted values of* x, Q_{MP}, p_{MP} *and* p_{WU} (Table 8.2, row 1 in Table 8.4)

$p_M = 0.3 - 0.0001 \cdot 2{,}000 + 0.9 \cdot 1.00$	$= 1.00$	from	(8.12)
$p_W = 2 + 1.1 \cdot 5.00$	$= 7.50$	»	(8.14)
$Q_W = 10 + 0.05 \cdot 1{,}000 - 20 \cdot 1.00 - 2 \cdot 7.50 + 20 \cdot 1.00 + 2 \cdot 5.00$	$= 55$	»	(8.13)
$Q_M = 0.9 \cdot 1{,}000 - 1.0 \cdot 55 - 100 \cdot 1.00 + 100 \cdot 1{,}00$	$= 845$	»	(8.11)
$c_M = 845 \cdot 1.00$	$= 845.00$	»	(6.13)
$c_W = 55 \cdot 7.50$	$= 412.50$	»	(6.14)
$C_D = 845.00 + 412.50$	$= 1{,}257.50$	»	(6.15)

(ii) *Adjustment of the prediction, taking into account the observed value of* p_{WU}[1] (row 2 in Table 8.4)

$$p_W = 2 + 1.1 \cdot 5.50 = 8.05$$
$$Q_W = 10 + 0.05 \cdot 1{,}000 - 20 \cdot 1.00 - 2 \cdot 8.05 + 20 \cdot 1.00 + 2 \cdot 5.50 = 54.9$$
$$Q_M = 0.9 \cdot 1{,}000 - 1.0 \cdot 54.9 - 100 \cdot 1.00 + 100 \cdot 1.00 = 845.1$$
$$c_M = 845.1 \cdot 1.00 = 845.10$$
$$c_W = 54.9 \cdot 8.05 = 441.95$$
$$C_D = 845.10 + 441.95 = 1{,}287.05$$

(iii) *Adjustment of the prediction, taking into account the observed values of* p_{MP} *and* p_{WU} (row 3 in Table 8.4)

$$p_M = 0.3 - 0.0001 \cdot 2{,}000 + 0.9 \cdot 0.90 = 0.91$$
$$Q_W = 10 + 0.05 \cdot 1{,}000 - 20 \cdot 0.91 - 2 \cdot 8.05 + 20 \cdot 0.90 + 2 \cdot 5.50 = 54.7$$
$$Q_M = 0.9 \cdot 1{,}000 - 1.0 \cdot 54.7 - 100 \cdot 0.91 + 100 \cdot 0.90 = 844.3$$
$$c_M = 844.3 \cdot 0.91 = 768.31$$
$$c_W = 54.7 \cdot 8.05 = 440.34$$
$$C_D = 768.31 + 440.34 = 1{,}208.65$$

[1] Only the calculations which have been changed are given here.

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(iv) *Adjustment of the predicition, taking into account the observed values of Q_{MP}, p_{WU} and p_{MP}*
(row 4 in Table 8.4)

$$p_M = 0.3 - 0.0001 \cdot 1{,}500 + 0.9 \cdot 0.90 = 0.96$$
$$Q_W = 10 + 0.05 \cdot 1{,}000 - 20 \cdot 0.96 - 2 \cdot 8.05 + 20 \cdot 0.90 + 2 \cdot 5.50 = 53.7$$
$$Q_M = 0.9 \cdot 1{,}000 - 1.0 \cdot 53.7 - 100 \cdot 0.96 + 100 \cdot 0.90 = 840.3$$
$$c_M = 840.3 \cdot 0.96 = 806.69$$
$$c_W = 53.7 \cdot 8.05 = 432.29$$
$$C_D = 806.69 + 432.29 = 1{,}238.98$$

(v) *Adjustment of the prediction, taking into account the observed values of x, p_{WU}, p_{MP} and Q_{MP}*
(row 5 in Table 8.4)

$$Q_W = 10 + 0.05 \cdot 1{,}500 - 20 \cdot 0.96 - 2 \cdot 8.05 + 20 \cdot 0.90 + 2 \cdot 5.50 = 78.7$$
$$Q_M = 0.9 \cdot 1{,}500 - 1.0 \cdot 78.7 - 100 \cdot 0.96 + 100 \cdot 0.90 = 1{,}265.3$$
$$c_M = 1{,}265.3 \cdot 0.96 = 1{,}214.69$$
$$c_W = 78.7 \cdot 8.05 = 633.54$$
$$C_D = 1{,}214.69 + 633.54 = 1{,}848.23$$

(vi) *Adaptation of the prediction, taking into account the observed values of p_M, p_{WU}, p_{MP} Q_{MP} and x*
(row 3 in Table 8.6)

$$Q_W = 10 + 0.05 \cdot 1{,}500 - 20 \cdot 1.0 - 2 \cdot 8.05 + 20 \cdot 0.90 + 2 \cdot 5.50 = 77.9$$
$$Q_M = 0.9 \cdot 1{,}500 - 1.0 \cdot 77.9 - 100 \cdot 1.00 + 100 \cdot 0.90 = 1{,}262.1$$
$$c_M = 1{,}262.1 \cdot 1.00 = 1{,}262.10$$
$$c_W = 77.9 \cdot 8.05 = 627.10$$
$$C_D = 1{,}262.10 + 627.10 = 1{,}889.20$$

(vii) *Adaptation of the prediction, taking into account the observed values of* p_W, p_{WU}, p_{MP}, Q_{MP}, x *and* p_M
(row 4 in Table 8.6)

$$Q_W = 10 + 0.05 \cdot 1{,}500 - 20 \cdot 1.00 - 2 \cdot 8.00 + 20 \cdot 0.90 + 2 \cdot 5.50 = 78.0$$
$$Q_M = 0.9 \cdot 1{,}500 - 1.0 \cdot 78.0 - 100 \cdot 1.00 + 100 \cdot 0.90 = 1{,}262.0$$
$$c_M = 1.262 \cdot 1.00 = 1{,}262.00$$
$$c_W = 78.0 \cdot 8.00 = 624.00$$
$$C_D = 1{,}262.00 + 432.00 = 1{,}886.00$$

(viii) *Adaptation of the prediction, taking into account the observed values of* Q_W, p_{WU}, p_{MP}, Q_{MP}, x, p_M *and* p_W
(row 5 in Table 8.6)

$$Q_M = 0.9 \cdot 1{,}500 - 1.0 \cdot 75 - 100 \cdot 1.00 + 100 \cdot 0.90 = 1{,}265.0$$
$$c_M = 1{,}265 \cdot 1.00 = 1{,}265.00$$
$$c_W = 75 \cdot 8.00 = 600.00$$
$$C_D = 1{,}265.00 + 600.00 = 1{,}865.00$$

LIST OF SYMBOLS

C	total manufacturing costs	
c_O	total indirect manufacturing costs	
C_D	(total)[1] direct manufacturing costs	
c_M	(total)[1] material costs	
c_W	(total)[1] labor costs	
p_M	material price	
p_W	wage rates	
q_M	material usage per unit of x	
Q_M	total material usage (i. e. for a whole manufacturing series)	
q_W	working time per unit of x	
Q_W	total working time (i. e. for a whole manufacturing series)	
x	quantity manufactured; no. of units manufactured, length of series	
p_{MP}	market price for material	
p_{WU}	negotiated wage rates	
Q_{MP}	quantity of material purchased	
A_W	Workers'[2] actions	
A_F	supervision (Foremen's actions)	
A_P	Planning's actions	
G_W	Workers' frame of reference	
G_F	Foremen's frame of reference	
$\bar{G}_W$	Workers' prescribed goal	
$\bar{G}_F$	Foremen's prescribed goal	
$\bar{C}_D$	direct manufacturing costs	
$\bar{p}_M$	material price	
$\bar{p}_W$	wages per hour	as prescribed goals
$\bar{q}_M$	material usage per unit manufactured	
$\bar{q}_W$	working time per unit manufactured	

[1] When these terms are preceded by *total* they refer to the costs of a number of operations during one calendar period.

[2] Schemata are distinguished from organizational units by the use of capital initials.

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